City of Shoreline

Boeing Creek Basin Characterization Report

May 2004

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CITY OF SHORELINE

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Prepared for:
City of Shoreline
Shoreline, WA

Prepared by:

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Project #3320005

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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.

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1. INTRODUCTION

This basin characterization report for the Boeing Creek drainage basin 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.

Several of the basins are combined into a single characterization report, including Thornton Creek with West Lake Washington; McAleer Creek with Lyon Creek; and the Middle Puget Sound Basins with Bitter Lake and Seattle Golf Course. The accompanying appendices provide supporting information.

Each characterization report includes a description of streams, wetlands, fish use 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 the 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:

- *Shoreview Park Capital Project Final and Draft Environmental Impact Statements*. Adolfson and Associates. 1999.
- *Wetland Delineation Report for the Hidden Lake Restoration Project*. King County SWM. 1994.
- *City of Shoreline Comprehensive Plan. November 23, 1998.*
- *Boeing Creek Hidden Lake Restoration Operation and Maintenance Manual*. King County. 1998.
- *Geotechnical Engineering Report for the Hidden Lake Restoration Project*. Shannon and Wilson. 1995.
- *Dam Safety Analysis for Pan-Terra Regional Stormwater Detention Pond Draft*. Otak. 2000.
- *Third Avenue NW Drainage Study, Volumes I and II*. Otak. 2000.
- *Final Channel Erosion Study in Shorewood Hills Ravine. Otak. February 2000.*
- *King County Sensitive Areas Map Folio. 1990.*

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 separate drainage basins (see Figure 2-1). The Boeing Creek Basin, the second largest basin in the City, encompasses approximately 1,600 acres over four subbasins. The basin, approximately 90 percent developed, lies primarily west of Aurora Avenue North and drains to Puget Sound.

The length of the main stem of Boeing Creek is approximately 1.55 miles long. This estimate is measured from the beginning of the identifiable channel at the intersection of Carlyle Road and Greenwood Avenue North to the mouth of the creek. Upstream of the intersection of Carlyle Road and Greenwood Avenue North, the original creek is contained primarily in pipes that drain a large area, including the commercial development around Aurora Square. The associated north tributary, including both an eastern and western stem, is almost entirely piped.

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 Boeing Creek Basin 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 Boeing Creek Basin boundary was 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.

Topography defines basin and subbasins limits. Subbasins in the northern portion of the basin (above North 175th Street) were delineated based on an engineering report addressing stormwater flooding by OTAK (July 2000). Subbasins below North 175th Street were created using the King County Drainage Map (1984) and the King County Aerial Survey (2001). The Boeing Creek subbasins are shown in Figure 2-2.

Stream Reach Planning Units

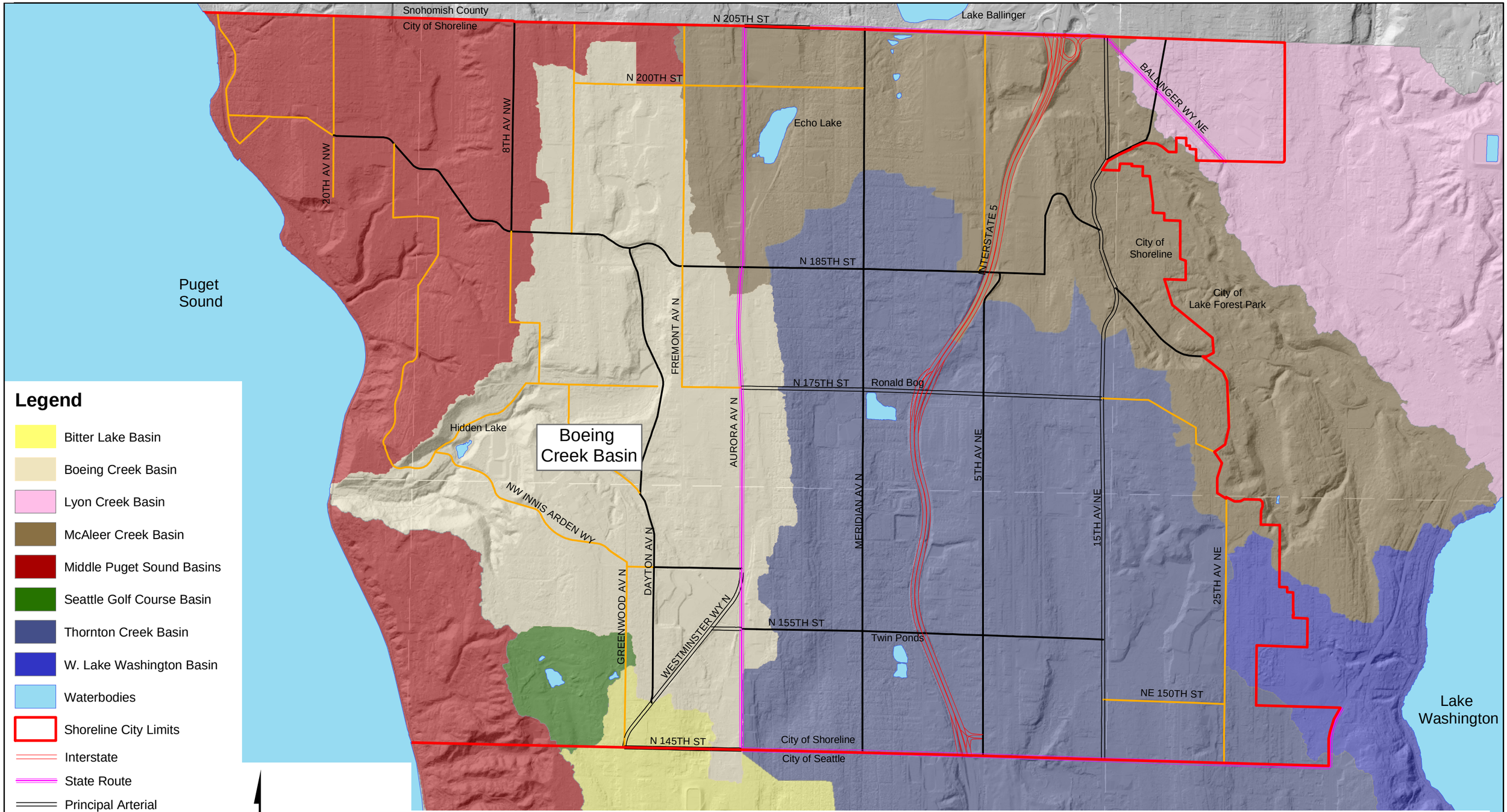
Dividing a stream into reaches provides a structure for recording stream habitat information and for prioritizing improvement projects. Preliminary stream reaches were defined in the office using topographic and hydrographic data from the City of Shoreline Geographic Information System (GIS). Uniform 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 legends, was designated as a reach. This includes sections that are obviously ditched or channelized. 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 course 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 Boeing Creek are shown in Figure 2-3.

HISTORICAL STREAM ASSESSMENT

Over the years, natural water courses have been modified into ditches or placed into pipes as the City of Shoreline experienced residential and commercial development and construction of its road network. Aerial photos and other historical information from Shoreline's Historical Museum were examined to assess the historical locations of streams in order to help classify the current water courses. Currently, a large portion of the former headwaters of Boeing Creek are piped water courses. Aerial photography suggests that prior to the construction of Aurora Avenue, a system of channels existed that once naturally connected streams in the area around North 183rd Street to Boeing Creek and to Puget Sound.



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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 2-1
Drainage Basins

Snohomish County

City of Shoreline

N 205TH ST

N 200TH ST

N192ND ST

N 185TH ST

N 175TH ST

N 155TH ST

N 145TH ST

15TH AV NW

12TH AV NW

8TH AV NW

6TH AV NW

3RD AV NW

1ST AV NW

GREENWOOD AV N

DAYTON AV N

FREMONT AV N

LINDON AV N

AURORA AV N

ASHWORTH AV N

WESTMINSTER WY N

CARLYLE HALL RD

NW INNIS ARDEN WY

Echo Lake

Hidden Lake

BC-A

BC-B

BC-C

BC-D

City of Shoreline

City of Seattle

Legend

- Subbasin BC-A
- Subbasin BC-B
- Subbasin BC-C
- Subbasin BC-D
- Waterbodies
- Piped Water Course
- Open Water Course
- Shoreline City Limits
- Interstate
- State Route
- Principal Arterial
- Minor Arterial
- Collector Arterial
- Residential Street

N

1,200 600 0 1,200 Feet

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Figure 2-2
Subbasins

Snohomish County
City of Shoreline
N 205TH ST
GREENWOOD AV N
DAYTON AV N
N 200TH ST
15TH AV NW
12TH AV NW
8TH AV NW
Echo Lake
N195TH ST
Hillwood Park
N192ND ST
Crista Pond
BC12
Pan Terra Pond
N 185TH ST
6TH AV NW
3RD AV NW
1ST AV NW
FREMONT AV N
LINDON AV N
ASHWORTH AV N
North Pond
BC11
N 175TH ST
BC7
BC6
BC8
M1 Dam
Hidden Lake
WL-A
Shoreview Park
BC5
BC9
AURORA AV N
BC4
BC2
BC1A
BC1
BC3
Steel-Pile Dam
WL-B
NW INNIS ARDEN WY
CARLYLE HALL RD
Darnell Park
BC10
DAYTON AV N
GREENWOOD AV N
WESTMINSTER WY N
N 155TH ST
N 145TH ST
City of Shoreline
City of Seattle

Legend

- Open Water Course
- Piped Water Course
- Wetlands
- Parks
- WL-A Wetland ID
- BC4 Reach ID
- Reach Start Points
- Fish Passage Barrier
- Detention Pond
- Boeing Creek Basin
- Waterbodies
- Shoreline City Limits
- Interstate
- State Route
- Principal Arterial
- Minor Arterial
- Collector Arterial
- Residential Street

N

1,200 600 0 1,200 Feet

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Figure 2-3

Stream Reaches, Wetlands and Fish Passage Barriers

Hidden Lake

Hidden Lake was constructed from the natural streambed and associated wetlands and beaver ponds of Hidden Creek (now called Boeing Creek) as a construction project of William Boeing. Boeing who began living in the Highlands in 1914 and acquired much of the property near that community. Including associated wetlands, Hidden Lake occupies approximately 2.1 acres. Shoreline Community College, Shoreview Park, the Sears shopping mall and the Innis Arden housing development are all former William Boeing holdings. The man-made lake in the center of a game preserve owned by Boeing was stocked with trout for fishing. By the early 1990s, the lake had filled with silt and was no longer visibly a lake. It was subsequently reconstructed by dredging in 1996, and again after a storm-induced washout refilled the lake with debris in January 1997.

Darnell Park

An aerial photograph from 1936 suggests the past existence of a stream channel beginning near and winding south around the current Fremont Avenue North. A line of trees and shrubs meanders from North 183rd Street toward the area that is now Darnell Park.

Hillwood Park

The City of Shoreline Historical Museum director, Victoria Stiles, recalled oral history from Mel Anthony, a former resident whose family owned a chicken farm southwest of Hillwood Park. Mr. Anthony spoke of a time when he and his boyhood friends would follow a stream channel from the Hillwood Park area all the way west to Boeing Creek (personal communication, Victoria Stiles, Shoreline Historical Museum Director, November 29, 2001).

LAND USE

Existing Land Use

The Boeing Creek Basin is approximately 90 percent developed. Land use in the basin is mostly single-family residential; other uses are roads, open space, schools, and commercial/ industrial development. A small portion is being used for multi-family or high-density housing. Figure 2-4 shows the existing land use patterns in the basin.

Shoreline Community College covers a large area within the basin; an almost equally large area is taken up by the adjacent Shoreview Park and recently designated Boeing Creek Park. Shoreview Park is a 47.5-acre park in the Innis Arden neighborhood. Commercial areas are mostly along Aurora Avenue North. Major roads in the basin include Aurora Avenue North, Dayton Avenue North, and North Richmond Beach Road.

Subbasins vary as to the proportions of land use type (Figure 2-4). Subbasins BC-A and BC-B are characterized by large areas of open space and large residential lots. Subbasin BC-D consists primarily of single family homes on standard sized lots with apartments and businesses along North Richmond Beach Road. Subbasin BC-C has a variety of land uses including parks, large residential lots and Shoreline Community College in the lower section, homes on standard sized lots in the central portion and intensive commercial uses with some apartments along the Aurora 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.

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.

The weighted average of the existing percent impervious values for the Boeing Creek Basin is 44 percent. The weighting includes a factor for the subbasin area. The majority of the impervious surface is in subbasins BC-C, with a TIA percentage of 51 percent, and BC-D,

McAleer Creek Basin

Middle Puget
Sound Basin

Puget
Sound

Seattle Golf
Course Basin

City of Shoreline

City of Seattle

Legend

- Commercial
- Developed Parks and Cemeteries
- Institution
- Open Space
- Public Facilities
- Residential-Multi Family
- Residential-Single Family
- Transportation (includes ROW)
- Vacant
- Waterbodies
- Shoreline City Limits

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

N

1200 0 1200 Feet

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Figure 2-4
Existing Land Use

with a TIA percentage of 44 percent. These subbasins are in the upper part of the basin, so runoff from them affects the entire stream network. Subbasins BC-A and BC-B have lower amounts of impervious surface, but are much smaller, so they do not significantly reduce the average basin TIA.

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 5,000 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 43560 SF)	17

Source: City of Shoreline

TABLE 2-2.
EXISTING PERCENT IMPERVIOUS VALUES FOR BOEING CREEK SUBBASINS

Subbasin Identification	Percent Impervious
BC-A	15
BC-B	23
BC-C	51
BC-D	44

Future Land Use

The City's zoning plan specifies the current potential for future land use in the basin. Under current zoning, as shown in Figure 2-5, low-density residential zoning (R-4 and R-6) makes up the largest area in the basin. However, the upper basin also contains a large area of commercially zoned and developed properties along the Aurora Avenue corridor, which have a large impact on the basin's overall hydrology.

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 Boeing Creek Basin were computed using the ArcView GIS software program. Future impervious surface area was calculated for each parcel in the Boeing Creek Basin 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.

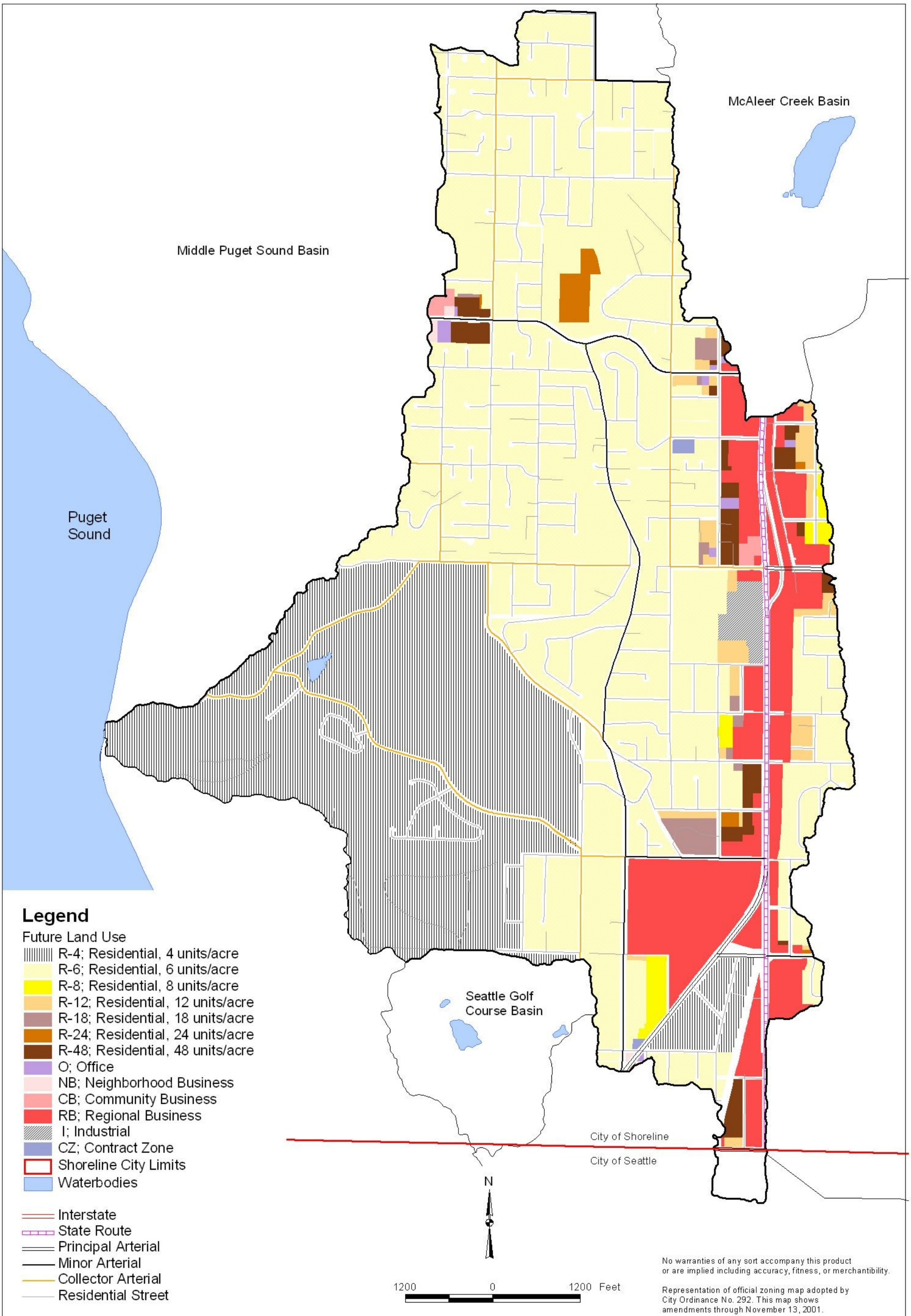

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Figure 2-5
Future Land Use
Based on 2001 Zoning

TABLE 2-4.
FUTURE PERCENT IMPERVIOUS VALUES
FOR BOEING CREEK SUBBASINS
AT BUILDOUT

Subbasin Identification	Percent Impervious
BC-A	37.9
BC-B	44.2
BC-C	60.9
BC-D	57.4

Under buildout conditions, the future TIA is expected to increase to a weighted average of 57 percent. Existing zoning would allow the impervious area in Subbasins BC-A and BC-B to approximately double. Actual future TIA may be lower due to private covenants that restrict development and the presence of areas that are too steep to be developed. In the upper portion of the basin, Subbasins BC-C and BC-D, the amount of impervious area is expected to increase, although not as dramatically. This is due to the fact that much of this area has already been built out.

CLIMATE

The characteristic weather of the Boeing Creek Basin 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 1997 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 Boeing Creek Basin.

Geology

The Boeing Creek Basin's topography results from sedimentation, folding, volcanic activity and glacial advances and retreats. Glacial activity from 2.5 million to 11,000 years ago caused glacial scour, till and outwash. Till, often referred to as hardpan, is an impermeable layer formed by glacial compression that contains clay and fine sediment and is associated with higher runoff rates. Outwash consists of rocks and soil deposited by advancing and retreating glaciers.

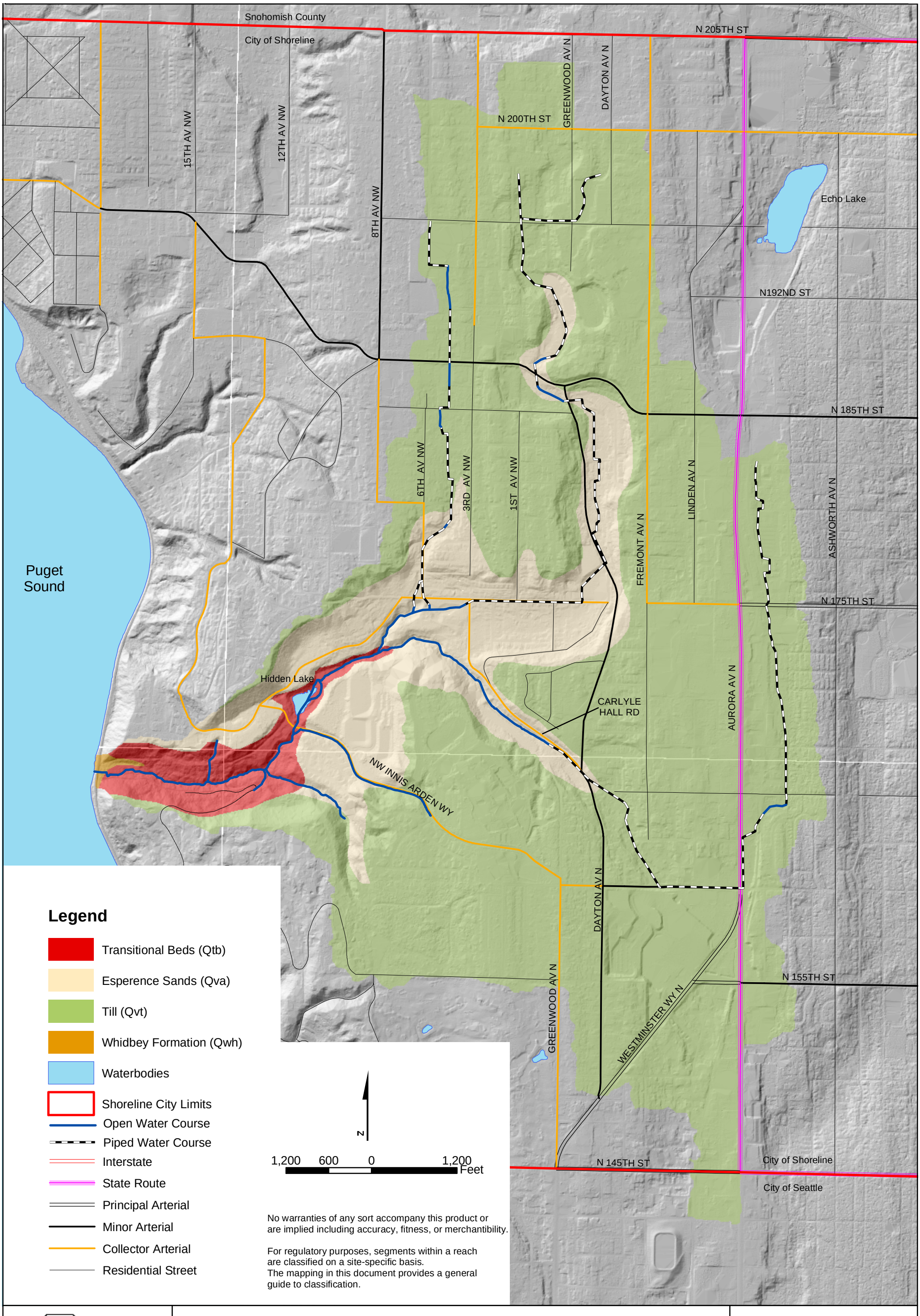
Till is resistant to infiltration and provides the best locations for retention/detention mitigation projects. The sand and gravel layers have high infiltration rates and are best suited as locations for infiltration ponds. Caution should be used in locating infiltration ponds; surcharging the groundwater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

King County (1994) describes the geology of Boeing Creek.

> "The Boeing Creek drainage basin is entirely underlain by glacial deposits. Vashon till covered uplands are underlain by advanced outwash (Esperance sand equivalents) which, in turn, overlay transitional beds (lacustrine Lawton clay equivalents and sands). Following the Vashon Ice retreat (post-glacial), Boeing Creek incised through these glacial deposits, forming a ravine which has exposed the highly erodible advanced sands and lacustrine beds. Within the ravine, where advanced outwash sands are overlain on transition bed clays, perched groundwater has created areas of slope failures. Through both slope failures and fluvial transport, the deposits of erodible sand and clay materials exposed within the ravine are recruited into the stream and stream bed.
>
> Layers of glacial outwash and till are the most significant glacial structures in the Boeing Creek area. Glacial outwash is easily erodible when subject to high runoff velocities that can develop in unmitigated urban drainage systems. Till is significant because it resists infiltration and seepage and acts as an impervious layer that, when below ground, can cause groundwater to flow laterally and produce hillside springs. An example of this is the area around the M1 Dam. In this area, Esperance sand (glacial outwash) is the predominant geologic unit. Water collecting behind the dam will infiltrate through the layer of Esperance and flow below ground, eventually emerging into the channel several hundred feet below the dam location."

Soils

The soil types present in the Boeing Creek Basin were summarized from the soil survey compiled in 1952 by the U.S. Soil Conservation Service. The majority of soil (approximately 80 percent) in the Boeing Creek Basin is Alderwood gravelly sandy loam. This basin also has 6 percent Everett gravelly sandy loam, rolling and 10 percent Everett gravelly loamy sand, rolling. There was only 4 percent Norma fine sandy loam. No significant areas of hydric soil are indicated.



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

Boeing Creek Basin Characterization Report

Figure 2-6
Surficial Geology

Removal of trees, shrubs and other vegetation exposes soil to stormwater runoff and consequent erosion. Alderwood soils can have drainage problems during heavy rains. Because of the highly developed nature of the upper basin and large volumes of stormwater runoff generated, erosion potential is high.

The lower basin has much steeper slopes and is more susceptible to landslides. Soils are quickly eroded from steep slopes that have been logged over the years and experience the high peak flows generated from the upper basin.

3. DRAINAGE CHARACTERISTICS

The drainage system in the upper portions of the Boeing Creek Basin consists primarily of piped stormwater conveyance. The piped stormwater systems drain into Boeing Creek or one of its tributaries. Natural watercourses and wetlands are largely absent from the upper basin because of extensive human alteration. The loss of these natural habitat features means the loss of natural runoff storage, infiltration, and flow reduction. The lower portions of the basin still contain streams and wetlands, and the drainage system resembles a more natural pattern.

Urbanization of the drainage basin without mitigation to address runoff impacts has led to higher peak flows with resulting increases in erosion and sedimentation. Urbanization has also eliminated or severely negatively impacted fish and wildlife habitat as streams were channelized or diverted into pipes and riparian habitat was removed. These changes have resulted in a loss of total stream length and degradation of the stream sections that remain. Residential development along stream banks has further degraded the natural environment around open channel sections. Table 3-1 contains a brief summary of the Boeing Creek Basin's drainage-related history.

STREAM SYSTEM

Boeing Creek Main Stem

The length of the main stem of Boeing Creek is approximately 1.55 miles long – measured from the beginning of the identifiable channel at the intersection of Carlyle Road and Greenwood Avenue North to its confluence with Puget Sound. Boeing Creek enters Puget Sound through a large box culvert under the Burlington Northern Santa Fe (BNSF) railroad track constructed in 1995. The lower portion of the stream (Reach BC1A) is tidally influenced at high tides. From the mouth, the stream ascends 2,300 feet through old growth forest and mature secondary forest to a steel-pile dam that acts as a barrier to upstream fish passage. The dam was once used for irrigation of the Seattle Golf and Country Club. It is no longer in use and has fallen into disrepair. Sediments have filled in behind the dam, and there is now a drop of approximately 15 feet downstream of the dam. The stream channel below the dam (Reach BC1) is characterized by steep incised channels with moderate-to-severe erosion of the channel beds and banks. Many sections below the dam have experienced slope failure, and the substrate is generally embedded having been filled in with sediment, providing poor spawning habitat for salmonids (King County 1994).

Upstream of the dam, the stream passes though a culvert under NW Innis Arden Way. This section has a steep gradient; several weirs have been constructed to reduce erosion. Hidden Lake is approximately 100 feet upstream of NW Innis Arden Way at the west end of Shoreview Park, near the intersection of NW Innis Arden Way and 166th Street NW. This small man-made lake is bordered by private property, Shoreview Park, and NW Innis Arden Way. It provides storm and flood water storage, moderate water quality improvement, low ground water exchange, and moderate biological habitat (City of Shoreline 1997). From Hidden Lake, the Boeing Creek main stem ascends through 1,600 feet of forested ravines to its confluence with the North Fork.

TABLE 3-1.
SUMMARY OF BOEING CREEK BASIN DRAINAGE-RELATED HISTORY

circa 1910	• Highlands water system built.
1920 - 1924	• Hidden Lake enlarged for fishing pond. • Two silt dams built, above and below the lake.
1964 - 1965	• Sears development, wetlands filled. • Stormwater discharged to unprotected channel at Greenwood Avenue North and North Carlyle Hall Road.
1970	• Hidden Lake Dam fails, major slides; Highlands, Beach Road washed out.
1971	• Highlands sewer line washed out.
1974	• Erosion protection installed at Shoreline Community College, washed out later that year.
1976	• Highlands water system abandoned.
1978	• Northwest Carlyle Hall Road damaged.
1979 - 1981	• Shoreview Park acquired.
1980 - 1988	• Upstream stormwater improvements installed: North Richmond Beach Road and First Avenue North (Crista Regional Pond) and North 185th Street and Dayton Avenue North (Pan Terra Regional Pond).
1983	• Construction of M1 Dam on the main stem of Boeing Creek.
1988	• Slide gate installed on M1 Dam.
1991	• Construction of North Pond.
1992	• Construction of storm sewer system to protect St. Lukes and Happy Valley neighborhoods.
1995	• Construction of Fremont Tracts drainage improvement.
1996	• Hidden Lake reconstructed.
1997	• North 175th Street washed out during stormwater; sediment fills Hidden Lake.
1997-Present	• Ongoing maintenance in Hidden Lake including sediment removal.

Source: King County 1990.

Just upstream of the steel-pile dam, a small tributary enters the mainstem. This unnamed tributary (Reach BC3) begins in a ravine west of the Shorewood Hills community and collects a portion of its stormwater. The tributary travels for approximately 1,400 feet down the ravine before joining with the main stem.

Upstream of the confluence with the North Fork. The identifiable stream bed of the main stem begins at the outfall of a 48-inch diameter storm drain southwest of the intersection of Carlyle Hall Road NW and Greenwood Avenue North. The drainage area for the piped section (Reach BC10) includes the large commercial area surrounding the Aurora Square shopping center, most of the Aurora Avenue commercial corridor between North 185th and 145th Streets and the northeast portion of Shoreline Community College. This is the most

densely developed commercial area within the city limits and includes the heavily traveled Aurora Avenue North (Highway 99). Below the storm drain outfall for the piped Reach 10, Boeing Creek (Reach BC9) flows generally west to the M1 Dam, a detention pond.

Below the M1 Dam, the creek continues to meander west to its confluence with the North Tributary approximately 1,800 feet downstream. In the absence of stormwater, base flow in the creek starts as groundwater seepage approximately 700 feet upstream of the confluence with the North Fork. Typically, storm runoff contributions to Boeing Creek disappear by late spring and do not reoccur until the rainy season begins in the fall (King County 1994).

Flow increases as the stream flows west and is significantly augmented by flow from the North Tributary (Reaches BC11 and BC12) entering the creek southwest of 6th Avenue NW and NW 175th Street. Flow records suggest substantial groundwater inflows approximately 600 feet downstream of the dam where a consistent base flow to the creek is encountered (Brown and Caldwell 1979). The section of stream below the dam and above the confluence is a heavily riprapped, steep forested ravine, with numerous cascades (4 to 12 percent gradient) and abundant amounts of large wood (LW) that help control the grade of the channel (King County 1994).

North Tributary

The North Tributary includes an eastern stem (BC11) and a western stem (BC12). Both stems are almost entirely piped and are described below in the section on constructed stormwater features.

Stormwater flows in the North Tributary are directed through several regional detention ponds. The Crista and Pan Terra ponds are on the eastern stem and service the northeast portion of the area, approximately bounded by Richmond Beach Road North and 2nd Avenue NW (King County 1994). The western stem follows 6th Avenue NW and drains the northwest portion of the basin. Both stems of the North Tributary drain into the Shoreview (North) Regional Retention/Detention Pond south of the intersection of 6th Avenue NW and NW 175th Street.

Below the North Pond, the channel is confined and its banks are artificially hardened with riprap. Quarry spalls are also present in the channel in this section. The North Tributary joins the South Tributary approximately 730 feet below the North Pond.

CONSTRUCTED STORMWATER FEATURES

Boeing Creek Main Stem

Hidden Lake is the only significant stormwater feature on the Boeing Creek main stem. It was built in 1924 by constructing an earthen dam across the creek just upstream of Innis Arden Way (Shannon and Wilson 1995). After 1965, when the Sears shopping center was completed on Aurora Avenue North, increased runoff and sedimentation significantly impacted the creek. The increased sediment transported by Boeing Creek accumulated in the lake and decreased its storage capacity. As a result, the Hidden Lake Dam failed in 1970, washing out the Highlands Beach Road near Reach BC1 in Subbasin BC-A and causing significant downstream erosion. Plans were drawn up to reconstruct the lake, but

for the next 25 years the former lake developed into a forested wetland (City of Shoreline 1999). The lake was reconstructed by King County in 1996; however, a storm during the 1997 New Year's holiday washed out North 175th Street, and again filled Hidden Lake with sediment. The sediment from the 1997 storm has subsequently been removed and open water has been restored. The most recent reconstruction of Hidden Lake has been designed to provide a 25-year level of protection to downstream properties. The City of Shoreline maintains Hidden Lake, including removing accumulated sediment from its sediment trap.

South Tributary

Pipe Network

The majority of the South Tributary pipe network is in the commercial area along Aurora Avenue North. Major drainage systems exist along Highway 99 and North 160th Street, and between Dayton Avenue North and Fremont Avenue North south of North Richmond Beach Road. The drainage network in residential areas is less extensive and is made up of mostly small pipe systems with some open ditches.

The main trunk of the drainage system begins just east of the intersection of Midvale Avenue North and North 183rd Street. The system continues south, picking up the drainage from the commercial and residential areas surrounding Aurora Avenue North. The system daylights for about 250 feet in Darnell Park below North 165th Street near Stone Avenue North. Downstream of the daylighted section, conveyance pipe continues south to North 160th Street, then turns east, picking up substantial flow from the Aurora Square shopping center. The trunk line then heads northeast before discharging into the South Tributary channel at the intersection of Carlyle Hall Road NW and Greenwood Avenue North on the campus of Shoreline Community College.

Detention Ponds

M1 Dam

The M1 Dam forms the only constructed detention pond along the drainage course of the south tributary and was constructed in the channel of Boeing Creek southwest of Carlyle Hall Road NW and northeast of the Shoreline Community College parking lot. This pond, with a maximum storage of 14 acre-feet, was created in 1983 to reduce peak flows in the downstream reaches of Boeing Creek for storms up to the 2-year event. The 2-year event protection corresponds to the 10-inch opening in the outlet control structure.

165th Street and Stone Avenue

A site at North 165th Street and Stone Avenue North in Darnell Park is not a constructed detention pond, but it functions as one when flows exceed the capacity of the downstream 18-inch pipe. The open channel upstream of the pipe has some capacity to store the pipe's overflow, attenuating downstream flows. Although this site has been observed to behave as a detention pond, there is no documented information on its hydraulic characteristics.

North Tributary

Pipe Network

The North Tributary drainage system consists of east and west stems discharging into the North Detention Pond at Shoreview Park. The main trunk of the east stem begins in the area north of North 195th Street between 2nd Avenue NW and Dayton Avenue North. The main trunk heads generally south and flows into two detention ponds: the Crista Pond north of the intersection of NW Richmond Beach Road and Dayton Avenue North; and the Pan Terra Regional Pond at 18500 Dayton Avenue North.

The main drainage trunk of the west stem begins near 5th Avenue NW and NW 195th Street. The system heads south paralleling 3rd Avenue NW and discharges into the North Detention Pond at Shoreview Park. A high flow bypass is located on 6th Avenue NW near NW 175th Court. Currently high flows from Reach BC12 are diverted into the North Pond. However, the base flows in Reach BC12 bypass the pond and discharge directly into Reach BC7 through a culvert under NW 175th Street.

Detention Ponds

The Crista and Pan Terra ponds were constructed to provide stormwater detention. They provide a significant amount of flow rate reduction and some infiltration for storm flows in the North Tributary (King County 1994). The Crista Pond is designed to store 2.4 acre-feet (ac-ft) of water during the 25-year peak storm event.

The Pan Terra Pond can store 3.7 ac-ft of water during a 100-year storm event under normal operation. A 1999 study by the City to address flooding experienced by residents immediately downstream of the pond concluded that excavating the pond to increase its active storage volume and installing a new flow control device would eliminate the downstream flooding. This project has not yet been implemented.

The North Pond detention facility in Shoreview Park, south of NW 175th Street and between 6th and 3rd Avenue NW, was originally built in 1991 to attenuate peak flow from a large area north of NW 172nd Street, south of NW 205th Street, and between 8th Avenue NW and Stone Avenue North. The northwest portion of this pond's embankment was washed out during the January 1997 storm event. The pond was reconstructed in 1999; improvements included construction of an emergency spillway and regulation of flow through the overflow control structure. All flows from the North Pond discharge through an energy dissipater into Reach BC7 just downstream of the culvert at NW 175th Street. A study that resulted from the 1996 storm concluded that the North Pond detention facility would provide protection for up to approximately the 25-year peak storm event (Otak 2000).

4. HABITAT CHARACTERISTICS

This chapter addresses habitat characteristics in the Boeing Creek Basin. Streams are described by individual reach. In addition, 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 aquatic habitat in the Boeing Creek Basin. The Tri-County Urban Stream Baseline Evaluation Method (USBEM; R2 Resource Consultants 2000) was adapted for the stream reconnaissance. 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 dams. 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 watershed alteration is high for the watershed as a whole and for all the reaches, with the exception of reaches BC1 and BC2, which have a moderate level of alteration. Although significantly altered by high flows and dams, these reaches have retained much of their natural character.

Benthic Invertebrate Analysis

Six benthic invertebrate samples were collected at suitable locations along Boeing Creek. 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]
BC1	46	4	2	34
BC2	51	4	1	29
BC6	54	6	2	41
BC7	111	4	2	41
BC8a[c]	20	2	1	41
BC8b[c]	37	4	1	38

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.
c. Two samples were taken in this reach of Boeing Creek.

The benthic invertebrate bioassessment revealed that many samples (with index numbers less than 40) contained an invertebrate community composed of a very low diversity of species. Reaches BC6, BC7 and BC8a had an index number of 41. The species present in the greatest numbers were those that are tolerant of toxic conditions. The reaches sampled were observed to have a very sandy, unstable substrate and a severely stressed habitat as a result of bank erosion and landslides due to the high peak flows in the basin. The low index number for BC1 which has good riparian habitat could show the influence of upstream conditions far from the reach itself. It is likely that these conditions 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 completely 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 Boeing 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.

Boeing Creek Reach 1

Boeing Creek Reach 1 (BC1) extends from the upstream end of Reach BC1A to the steel-pile dam behind the property at the end of NW 166th Street. The dam prevents fish access to upstream reaches. Riparian condition along this open water course was good, with a large, dense growth of native hardwoods with a medium potential for recruitment of large wood (LW). Bank conditions were good due to little exposed soil or artificial hardening. However, erosion and slumping were evident on the steeper ravine banks. LW abundance was good, although most wood was smaller than key piece size (20 inches in diameter). Embeddedness was fair. 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. Substrate composition was dominated by gravel or cobble in the upper portion of the reach; downstream, sand or silt became the dominant substrate type. Much of the reach consisted of step cascades and small, shallow pools, which indicates poor frequency of pools suitably sized for salmonid habitat.

A small seep enters the creek from the north approximately 750 feet upstream of the mouth. Its primary flow appears to originate from stormwater runoff created by the streets and residences above the slope (NW 167th Street).

The lower portion of this reach (approximately 70 feet) is inundated by high tides and is discussed below as Boeing Creek Reach 1A.

Boeing Creek Reach 1A

Boeing Creek Reach 1A (BC1A) extends about 70 feet upstream from the creek's mouth at Puget Sound. This open water course flows through a box culvert under the BNSF railroad that was constructed in 1995 to improve fish access. The south half of the culvert provides a low flow channel and fish access. The north half provides overflow capacity and pedestrian access. Older twin culverts to the south that previously carried all of the creek flow also accommodate high flows.

High tides can sweep into the lower portions of this reach, influencing stream depth over the length of this reach. The lack of estuarine vegetation in this reach suggests that the saline influence of the high tides is of a short duration. Bank restoration has improved the aquatic and riparian habitat in portions of this area. The riprap along the bank, however, does not enhance habitat.

Boeing Creek Reach 2

Boeing Creek Reach 2 (BC2) is a 680-foot reach between the steel-pile dam and Innis Arden Road. It is directly behind several privately owned parcels. The mix of native conifers and hardwoods along this reach is low and sparse, with moderate potential for LW recruitment. Riparian condition and LW abundance are fair. The remainder of the conditions were rated poor. Landslides are common, sand and silt dominate the substrate, a cascade bedform is dominant, and pool frequency is very low as a result of filling from landslides.

This reach includes two consecutive weirs upstream of the steel-pile dam. Incision is severe downstream of the weirs. A culvert under NW Innis Arden Way and the Hidden Lake outlet are velocity barriers to adult and juvenile fish.

A small seep enters this reach just above the steel-pile dam. Its primary flow appears to originate from stormwater runoff created by the streets and residences above the slope along Beach Drive.

Boeing Creek Reach 3

Boeing Creek Reach 3 (BC3) is the lower segment of a tributary that enters the main stem of Boeing Creek on the left bank above the sheet-pile dam on BC1. It is an intermittent stream that runs through a steep ravine in the lower reaches. Only its bank conditions warrant a good rating; vegetation exists along the majority of both banks and a minimal length of the bank is artificially hardened. Poor ratings are given for the sand/silt dominant substrate, poorly formed pool-riffle stream morphology, and lack of pools and LW. Riparian conditions were rated fair, owing to the immature but native composition of conifers and hardwoods. Fish passage may be limited by seasonally dry or low-flow conditions.

Boeing Creek Reach 4

Boeing Creek Reach 4 (BC4) is a small intermittent tributary which drains a portion of Innis Arden. It discharges to BC1 approximately 800 feet downstream of the steel-pile dam on the north bank. It has a steep slope in a stair-step pattern. Its overall habitat assessment was rated as poor due to actively eroding and incised banks and low amounts of large wood. Riparian vegetation including salmonberry, thimbleberry, ocean spray and small alders provide dense cover.

Boeing Creek Reach 5

Boeing Creek Reach 5 (BC5) extends along NW Innis Arden Way from just east of NW 166th Street to east of 6th Avenue NW. This reach is piped or in a grass-lined or rock-lined channel without natural substrate. There was flow in this open water course, approximately 1-inch in depth, only in the portion near the junction with the main stem and originated from the bottom of the ditch. It is likely that there are a number of seeps along the adjacent hillside. The only riparian vegetation was from the side away from the road consisting of saplings growing on the slope of the hillside. Substrate was dominated by silt with quarry spalls spread the length.

Boeing Creek Reach 6

Boeing Creek Reach 6 (BC6) is a highly modified segment of open water course between NW Innis Arden Way and the confluence of BC7 and BC 8 that includes Hidden Lake. The right bank is private property and much of the area has hiking trails. Although riparian condition is similar to that of Reach BC2 (fair), the amount of shading and LW is minimal. Sand and silt are dominant in the substrate and embeddedness or percentage of fines is more than 40 percent in riffles and pools. A moderate amount of riprap bank stabilization has been placed in this reach to stabilize landslides. Several small springs are present on the left bank, but they do not form defined channels.

Large slope failures occur in this area due to sandy soils and high peak flows. Mountain beavers burrowing into the banks create a point of erosion during storm events that likely contributes additional sand into the creek, although this impact is minor in comparison to the high peak flows. In addition, young people using the area for recreation have constructed tunnels in the sandy ravine slope above the creek channel and exposed significant areas to erosion.

Two concrete weirs, 12 and 30 inches high, are present in this reach upstream of Hidden Lake. The weirs may be fish passage barriers during low flows.

Hidden Lake is at the downstream end of this reach. Approximately 2.1 acres, this lake was built in 1924 by constructing an earthen dam across the creek upstream of NW Innis Arden Way. It currently contains an engineered sediment trap. A 24-inch culvert on the left bank of the main channel just upstream of Hidden Lake acts as a bypass channel for diverting water beneath a sand berm to the east side of the lake during dredging. The City maintains the trap by dredging every year. There is some concern within the City that dredging degrades the aquatic habitat in the lake. Table 3-1 provides a history of Hidden Lake.

Boeing Creek Reach 7

Boeing Creek Reach 7 (BC7) is a short open water course along the edge of Shoreview Park from the confluence with the main stem to near NW 175th Street and the North Pond. The right bank is bordered by private property and access is limited. All criteria were rated fair or poor for this reach. Riparian condition is poor, with much of the bank zone dominated by small or sparse native hardwoods and grass. Both banks are artificially hardened with riprap downstream of the North Pond detention basin. Quarry spalls are present in the channel. LW and pools are very low in number and of unsuitable size to provide cover.

The detention basin and three log weirs, with jumping heights between 15 and 30 inches, could impede upstream fish passage, especially at low flows. Removal of the log weirs may improve juvenile fish passage, but would only provide an additional 400 feet of access upstream from the most upstream weir. Weirs may be providing essential erosion control in the channel.

Boeing Creek Reach 8

Boeing Creek Reach 8 (BC8) is a branch of Boeing Creek that enters the main channel from the left bank. This open water course extends between the western edge of Shoreview Park

and the M1 Dam near the intersection of Carlyle Hall Road NW and NW 172nd Street. Native conifers and hardwoods were present but sparse, providing moderate potential for LW recruitment. LW abundance was at fair levels, with a small number of key pieces, primarily in the upper end of the reach. The reach was sinuous with a poorly defined step-pool bedform and infrequent shallow pools. A compromised score of fair was given for the substrate, since sand and gravel were present in equal proportion.

Bank conditions were typically good, with perennial vegetation along approximately 80 percent of both banks and less than 20 percent of the banks artificially hardened. Large slope failures occur in the reach due to the high peak flows that erode the toe of already unstable slopes with exposed sands and clays. Groundwater seepage probably exacerbates consequent erosion and sedimentation in the reach. This area, along with much of the area in the lower basin, was mapped as a landslide hazard area. A small spring on the right bank contributed a negligible flow to the stream. A rough-skinned newt was observed at this reach. A small spring-fed tributary enters the right bank approximately 800 feet upstream of the confluence of BC7 and BC8. A culvert upstream of the spring-fed tributary is not a fish passage barrier.

The M1 Dam, approximately 50 feet high, at the upstream end of this reach is a passage barrier. No base flow occurs above the dam; groundwater seepage initiates a base flow approximately 600 feet below the dam.

Boeing Creek Reach 9

Boeing Creek Reach 9 (BC9) extends from the M1 Dam at the upper end of Reach 8 through the Shoreline Community College property and ends at the intersection of Greenwood Avenue North and Carlyle Hall Road NW. It is bordered on the right bank by Carlyle Hall Road NW and is primarily a grass-lined and channelized open water course with quarry spalls dominating the bottom substrate. A combination dirt and gravel parking lot on the Shoreline Community College Campus is within 50 feet of the left bank and contributes sediment to this reach which did not contain water on March 31, 2004. There is a dense growth of riparian vegetation on both sides of this reach approximately 30 feet in depth.

Boeing Creek Reach 10

Boeing Creek Reach 10 (BC10) begins at the intersection of Greenwood Avenue North and Carlyle Hall Road NW, extends along the east side of Aurora Avenue North, and ends near North 183rd Street. It is contained primarily in pipes with short sections of channelized open water courses including one through Darnell Park. No natural substrate was present.

Boeing Creek Reaches 11 and 12

Boeing Creek Reaches 11 and 12 (BC11 and BC12) are primarily piped water courses through developed residential or commercial areas north of North 175th Street.

Reach BC11 has a short portion of an open water course on the Cristwood Community property north of North Richmond Beach Road. On this property, runoff appears to collect in this channelized grass lined swale for approximately 200 feet. South of this area, mapping indicates that the creek runs through another open area, but water was not

observed there. Flows may have been obscured by vegetation or the reach may be piped. Access was prohibited by steep ravines and fencing.

BC12 has several short channelized open water course segments including one through Hillwood Park which is approximately 500 feet long and primarily grass-lined.

FISHERIES

The following discussion summarizes the *Fish Utilization in City of Shoreline Streams* report (Appendix C) as it relates to the streams in the Boeing Creek Basin.

Stream walks were conducted on Boeing Creek 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 basin. Figure 4-1 summarizes life cycle timing for fish in Boeing Creek and when certain species are in residence. Both coho salmon and searun cutthroat trout spend their first year rearing in Boeing Creek prior to outmigration. Resident cutthroat trout reside in the stream throughout their life cycle. Chinook salmon fry usually remain in the streams for three months after emerging from the gravels and migrate seaward from early March through early July.

According to Mr. Ed Barnes (personal communication, September 2001), a Shoreline resident involved in salmon enhancement activities, salmon use lower Boeing Creek (Reaches BC1 and BC1A) extensively. Mr. Barnes indicated that he has observed more than 100 adult chum salmon in addition to large numbers of adult coho salmon spawning in the reach below the steel-pile dam. Mr. Barnes has also observed chinook salmon and searun cutthroat trout in the lower reaches of Boeing Creek. He found a spawned-out chinook carcass during the fall of 2001. It is likely that many of these fish are the result of the "Salmon in the Classroom" program that is facilitated by a variety of local educators, including Dr. Matt Loper, an instructor at Shoreline Community College. The Reconnaissance Assessment for WRIA 8 (GLWTC 2001) notes that cutthroat have been found below and above the steel-pile dam; coho salmon have been found below the dam.

The lower creek was traversed from the mouth to the steel-pile dam. The dam blocks the upstream passage of adult and juvenile fish at all flows. Juvenile coho were observed in a pool just upstream of the footbridge east of the BNSF railroad tracks. The coho appeared to be recent swim-up fry from natural spawning in the creek. A significant amount of LW was found in most of the lower reaches of Boeing Creek and to a limited extent in the creek above Hidden Lake. Other definite barriers to fish passage on the Boeing Creek system are the Hidden Lake Dam, North Pond, a culvert under NW Innis Arden Way and the M1 Dam.

The large slope failures in the area above Hidden Lake provide evidence of significant erosion caused by the combination of high peak flows and erodible geology. Much of the sediment generated in this reach is captured by the sediment trap in Hidden Lake.

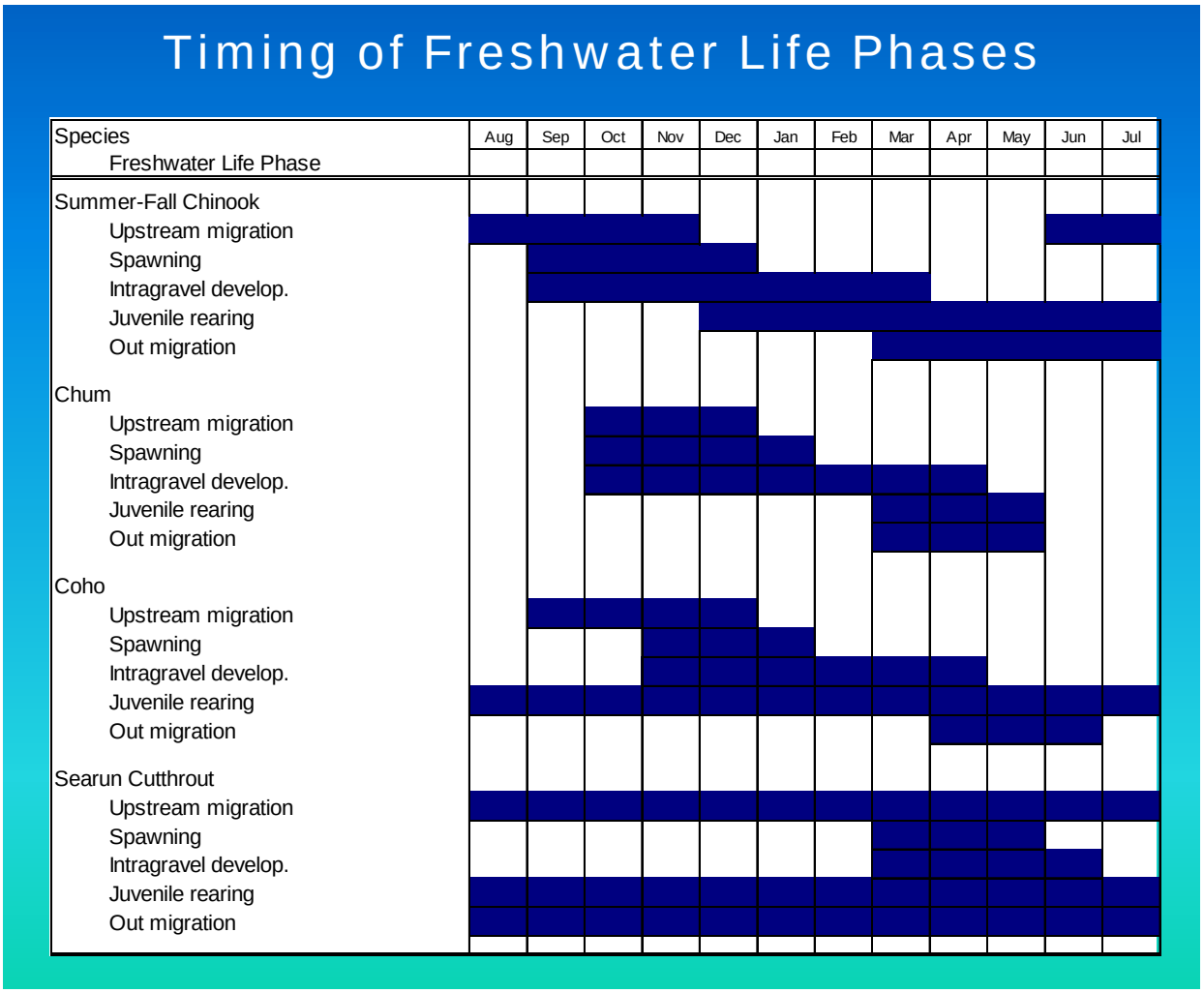


Figure 4-1. Life Cycle Timing for Fish in Boeing Creek Basin (Adapted from Williams 1995)

Evidence was found for the presence of salmonids in Hidden Lake. During the field investigation, a fish feeding in the lake was identified as a juvenile salmonid. Based on the reported activities of the Environmental Department of Shoreline Community College and the Salmon in the Classroom project, this fish was probably a coho salmon that was migrating downstream to Puget Sound.

High peak flows resulting from extensive impervious surface areas in the Boeing Creek Basin lead to bank erosion, sedimentation and the filling of pools and riffles in various stream reaches. Although the lower parts of Boeing Creek, including Reaches BC1, BC1A, BC2, BC3, BC6 and BC8 have moderate to high levels of riparian vegetation, these reaches have been highly modified with barriers, encroachment and bank hardening. The riparian vegetation provides some shading and LW. Fish habitat is compromised by low base flows during the summer, high flows during the winter and spring and the filling of pools and riffles due to bank erosion and landslides caused by high peak flows. Reaches BC1 and BC1A have the highest level of habitat quality for fish due to extensive undeveloped riparian areas.

Many reaches of open water courses support fish such as sculpin, dace and stickleback and also 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 within its boundaries or within Boeing Creek. Based on other urban sampling programs, it is likely cutthroat trout occur in many of the open water course reaches and especially those that have developed in-stream and near-bank vegetation and have dense riparian vegetation. Salmonids have been documented in several open water course reaches including BC1, BC1A and BC6. City staff observed cutthroat redds in Boeing Creek approximately 400 feet downstream from the dam on March 22, 2004.

Fish Passage Barriers

Fish passage barriers prevent the movement of fish within a creek. Barriers can be man-made, such as the steel-pile dam on Reach BC1, or a steep natural gradient such as at the upstream end of Reach BC2. 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 Hidden Lake, steel-pile and M1 Dams, in addition to the NW Innis Arden Way culvert and North Pond. Potential fish passage barrier problems have been identified at eight locations in the Boeing Creek Basin. Table 4-2 summarizes definite and potential fish passage barriers identified in the Boeing Creek Basin. More detail is provided in the individual reach descriptions. Figure 2-3 shows the location of definite fish passage barriers.

TABLE 4-2.
FISH PASSAGE BARRIERS
BOEING CREEK

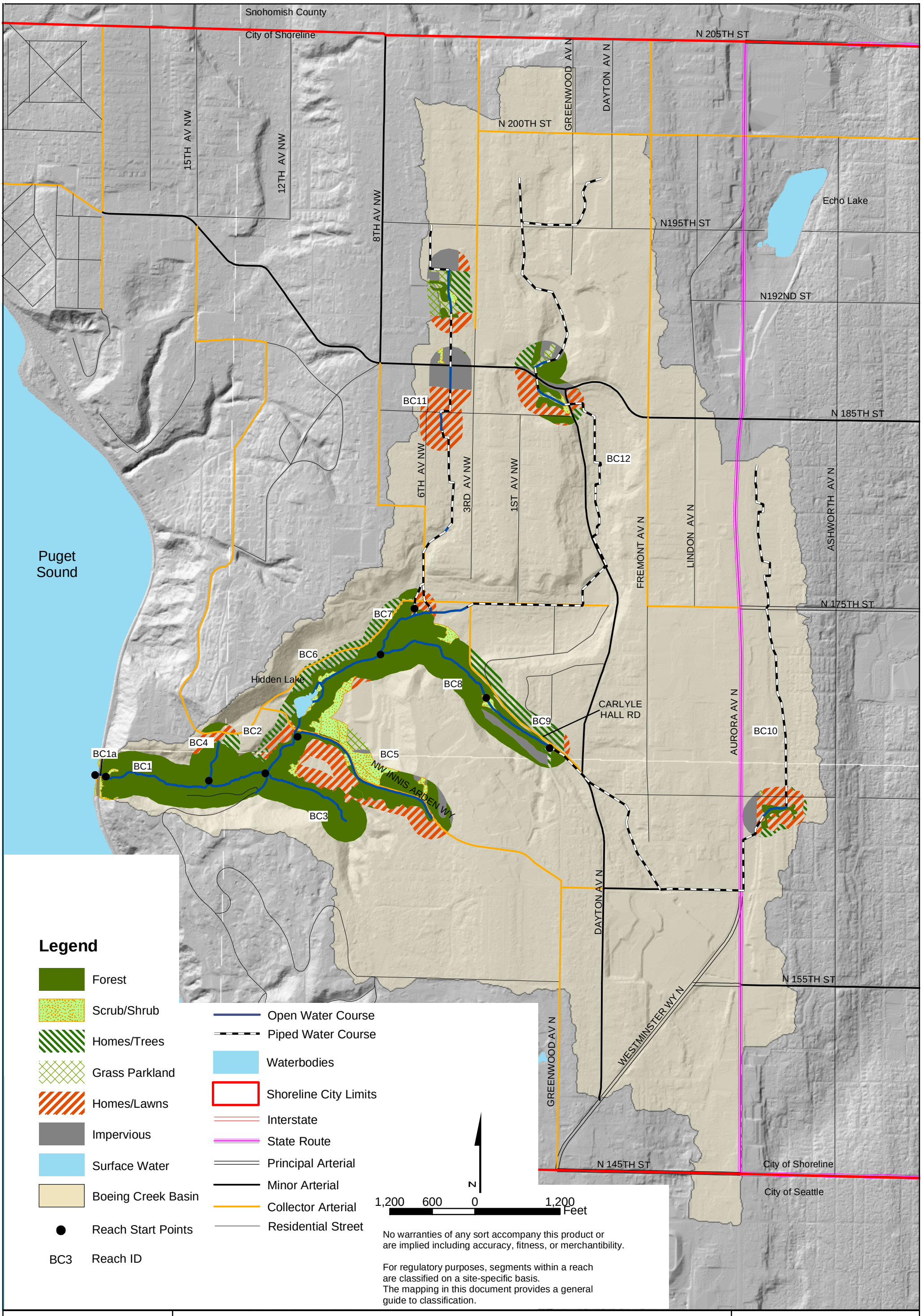
Reach	Barrier	Description
Definite Barriers		
BC1	Steel-Pile Dam	The dam prevents fish passage upstream at all flows
BC2	Culvert	Gradient and velocity of culvert at NW Innis Arden Way prevents fish passage
BC6	Dam	Earthen dam creating Hidden Lake prevents upstream passage at all flows.
BC7	Detention Pond	North Pond and a perched culvert at NW 175th prevent fish passage. Piped reaches upstream.
BC8	M1 Dam	M1 Dam prevents fish passage between reaches BC8 and BC9
Potential Barriers		
BC1A	Railroad Culvert	The culvert below the BNSF railroad at the beach may prevent fish passage at low flows and low tides.
BC2	Weirs	Two weirs used for grade control could pose seasonal blockage
BC6	Weirs	Two weirs used for bed control may pose barriers at low flows
BC7	Weirs	Three log weirs may be height barriers to juvenile fish

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 a number of structures and facilities around Shoreline have been constructed on filled wetlands, including those around Pan Terra Pond. As these wetlands became 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.



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1917 1st Avenue
Seattle WA, 98101

Boeing Creek Basin Characterization Report

Figure 4-2
Riparian Influence Area Characterization

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 of major wetlands and those wetlands for which the City had development reports is presented in Appendix B. The wetlands found within the Boeing Creek Basin are summarized below. Figure 2-3 shows the wetland locations.

Wetland Classification

The wetlands within the City were classified according to the U.S. Fish and Wildlife Service Classification System. This 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.

Wetland Descriptions

Nine areas were identified as potential unmapped wetlands in the Boeing Creek Basin. None of these areas were identified to be 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. A description of each wetland in the Boeing Creek Basin and its classification under the federal system is presented below and summarized in Table 4-3.

TABLE 4-3.
WETLAND CLASSIFICATIONS

Site	Location	Size (acres)	Wetland Classes Present (Cowardin, et al. 1979)
A	Hidden Lake	1.5	Palustrine Forested Palustrine Scrub-Shrub Palustrine Emergent
B	Boeing Creek Reach 3	<0.5	Palustrine Forested

Wetland A – Hidden Lake

Existing mapping for Hidden Lake, located in Reach BC6, shows that wetlands are present along the majority of the lake boundary. Total area of the lake and associated wetlands is 2.1 acres. Although the lake was artificially created when a dam was constructed, the wetlands have formed naturally under these conditions. Originally this area consisted of a small pond surrounded by a series of wetlands. In 1920, this area was dredged and enlarged to create a fishing pond. Both forested and emergent wetland classes are present around the periphery of the lake. King County (October 1994) described Hidden Lake as associated with three palustrine wetlands: scrub-shrub (0.16 acre); emergent/scrub-shrub (0.07 acre); and forested (1.29 acres). See Table 3-1 for more details on Hidden Lake.

Wetland B – Boeing Creek Reach 3

Previous mapping of this wetland indicated that it was adjacent to, but off-line from, Reach BC3, but the wetland was found to be directly adjacent to Boeing Creek. No flow was present in the creek at the time of survey, but soil was saturated and there were small pockets of standing water. The dominant species are red alder and cedar trees, with lesser coverage of salmonberry, elderberry, youth-on-age, and bracken fern. The wetland's area is less than 0.5 acres. The wetland class is palustrine forested.

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 influence areas for the Boeing Creek Basin are 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 in the 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. Predominantly piped reaches such as BC10, BC11 and BC12 have a small percentage of riparian habitat since the reach has only small sections of open water course. 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.

The lower reaches BC1, BC2, and BC3 provide the highest percentage of continuous high quality (forest and/or scrub-shrub) habitat. In general, there is a significant decline in the amount of good continuous riparian habitat proceeding upstream from the mouth of Boeing Creek. For example, in reach BC1 within 50 feet of the creek, almost 100 percent of the riparian habitat is of a high quality (forest or scrub-shrub); in reach BC12, only 22 percent of the riparian area in the reach is of a high quality. Development in the upper reaches encroaches much more closely on the open drainages, and this is reflected in the lower amount of forested and scrub-shrub habitat. The topography of the basin contributes to this trend, since the steep ravines that characterize the lower portion of the basin are essentially undevelopable.

TABLE 4-4.
RIPARIAN INFLUENCE AREA WITHIN 300-FOOT CORRIDOR FOR BOEING CREEK REACHES

Reach ID	Total Area Within 300-Foot Corridor (acres)	Reach Riparian Area (acres)	Riparian Area as Percentage of Total (%)	Predominant Stream Type
BC1	41	41	100	Open Water Course
BC2	15	15	100	Open Water Course
BC3	25	25	100	Open Water Course
BC4	15	15	100	Open Water Course
BC5	40	35	88	Open Water Course
BC6	31	31	100	Open Water Course
BC7	19	19	100	Open Water Course
BC8	33	33	100	Open Water Course
BC9	21	19	90	Open Water Course
BC10	148	11	8	Piped Water Course
BC11	159	18	12	Piped Water Course
BC12	88	33	37	Piped 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 Stream Type
BC1	2637	2637	100	Open Water Course
BC2	682	681	100	Open Water Course
BC3	1413	1413	100	Open Water Course
BC4	618	618	100	Open Water Course
BC5	2474	2474	100	Open Water Course
BC6	2219	2219	100	Open Water Course
BC7	937	937	100	Open Water Course
BC8	2003	2003	100	Open Water Course
BC9	1092	1092	100	Open Water Course
BC10	10643	370	3	Piped Water Course
BC11	11319	581	5	Piped Water Course
BC12	6208	1109	18	Piped 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
BC1	97.5	2.5	0.0	0.0	0.0	0.0	0.0
BC2	98.4	0.0	0.0	0.0	1.6	0.0	0.0
BC3	100.0	0.0	0.0	0.0	0.0	0.0	0.0
BC4	95.3	0.0	4.1	0.0	0.6	0.0	0.0
BC5	77.2	18.6	0.0	0.0	4.3	0.0	0.0
BC6	66.5	14.0	0.0	0.0	3.2	0.0	16.2
BC7	90.7	0.0	0.0	0.0	9.3	0.0	0.0
BC8	93.9	6.1	0.0	0.0	0.0	0.0	0.0
BC9	85.1	4.1	10.9	0.0	0.0	0.0	0.0
BC10	71.9	0.0	0.0	0.0	28.1	0.0	0.0
BC11	38.0	5.3	3.0	47.2	4.9	1.6	0.0
BC12	15.0	7.4	5.7	18.8	25.4	27.6	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
BC1	96.5	2.2	0.0	0.0	0.0	1.4	0.0
BC2	98.4	0.0	0.0	0.0	1.6	0.0	0.0
BC3	97.4	0.0	0.0	0.0	2.6	0.0	0.0
BC4	85.3	0.0	5.0	0.0	9.6	0.0	0.0
BC5	45.4	28.5	0.0	0.5	25.5	0.1	0.0
BC6	78.5	3.4	4.7	0.0	6.5	0.0	6.9
BC7	91.7	0.0	1.8	0.0	6.5	0.0	0.0
BC8	91.4	4.4	4.2	0.0	0.0	0.0	0.0
BC9	40.9	3.4	40.9	0.0	0.0	14.8	0.0
BC10	30.5	0.0	0.0	0.0	69.2	0.3	0.0
BC11	55.9	5.0	5.1	5.0	15.4	13.7	0.0
BC12	12.9	3.0	10.4	10.8	33.7	29.3	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
BC1	96.2	1.6	0.5	0.0	0.2	1.5	0.0
BC2	66.8	0.0	3.2	0.0	29.9	0.0	0.0
BC3	80.8	2.4	0.6	0.0	16.3	0.0	0.0
BC4	75.9	0.0	8.3	0.0	15.8	0.0	0.0
BC5	38.2	21.4	0.0	4.4	32.8	3.3	0.0
BC6	61.1	4.0	24.9	0.0	7.2	0.0	2.9
BC7	67.9	0.0	22.2	0.0	9.9	0.0	0.0
BC8	80.6	3.5	14.8	0.0	0.0	1.1	0.0
BC9	22.1	5.1	44.8	0.0	0.0	27.9	0.0
BC10	11.1	0.0	0.0	0.0	73.2	15.7	0.0
BC11	25.9	1.1	8.1	3.4	38.8	22.6	0.0
BC12	3.9	1.0	11.5	8.1	46.0	29.6	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
BC1	92.0	2.0	2.0	0.0	2.2	1.8	0.0
BC2	53.5	5.3	22.3	0.0	18.5	0.0	0.4
BC3	73.2	1.7	2.0	0.0	23.1	0.0	0.0
BC4	73.6	0.0	8.7	0.0	17.7	0.0	0.0
BC5	27.9	17.4	0.0	6.8	40.1	7.8	0.0
BC6	35.4	16.4	36.9	0.0	11.3	0.0	0.0
BC7	59.0	0.0	27.7	0.0	13.3	0.0	0.0
BC8	71.7	4.2	21.9	0.0	0.0	2.2	0.0
BC9	49.2	1.5	38.9	0.0	6.0	4.4	0.0
BC10	0.1	0.0	18.1	1.3	52.2	28.3	0.0
BC11	30.9	0.0	16.8	1.5	35.6	15.2	0.0
BC12	0.9	1.0	9.4	7.7	50.0	31.0	0.0

By definition, riparian influence areas do not exist without an open channel. The length of open water course is much less in the upper reaches than in the lower reaches. For example, reach BC12 has a total of 1,109 feet of open water course, but a total reach length of 6,208 feet. However, the entire 2,600 feet of BC1 is open water course.

Another general trend in the data is that the amount of good riparian area along the reaches declines with distance from the stream. For example, over 90 percent of the riparian habitat within 50 feet of reach BC5 is considered high quality. At a distance between 200 to 300 feet, the percentage of high quality habitat decreases to less than 50 percent, with the remainder of the habitat containing mostly residential development. As a general rule this trend holds for each reach in the basin.

TERRESTRIAL HABITAT

The biota and ecology of the Boeing Creek Basin 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.

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.

The Boeing Creek Basin is the most heavily forested basin in the City of Shoreline. Forested uplands along the southern edge of the Innis Arden Community and in the Highlands, Shoreview Park and Shoreline Community College make up the widest coverage of undisturbed vegetation within the city limits. Most of the forested areas are characterized by a conifer-deciduous upper canopy including western red cedar, Pacific madrone, Douglas fir, red alder and big leaf maple. Both Shoreview Park and the campus of Shoreline Community College have conifer forests.

Understory in this basin has been moderately disturbed with the introduction of non-native English ivy and Himalayan blackberry. However a full complement of native plants populate the less disturbed portions, including sword fern, huckleberry, hazelnut, vine maple, Oregon-grape, ocean spray and salal.

According to local residents, a variety of wildlife inhabits the Boeing Creek Basin. Appendix E contains a list of birds seen in the Shoreview Park area. A significant observation is that great blue herons nest in the Boeing Creek Basin (personal communication, Sylvia Moren, Shoreline Resident, April 2, 2001). Bald eagles and pileated woodpeckers are regularly observed in the area (personal communication, Ray Pelley, Shoreline Resident, April 2, 2001).

STATE AND FEDERAL 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 Boeing Creek Basin. Priority species have no federal or state regulatory status. Appendix I includes listed Washington State endangered, threatened 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, chinook and coho salmon and bald eagle have been documented in the Boeing Creek Basin. Because chinook have been found in the lower reaches of Boeing Creek (personal communication, Ed Barnes, September 2001), the area from the steel-pile dam downstream to the mouth was considered "designated critical habitat" for chinook salmon. Critical habitat for the Puget Sound chinook salmon includes all marine, estuarine and river reaches accessible to chinook salmon in Puget Sound (US Federal Register 7764). Based on a legal suit filed by the National Association of Homebuilders, this designation has been withdrawn for Puget Sound chinook pending reassessment by the National Marine Fisheries Service (NMFS) (personal communication, Brian Gorman, NMFS, January 30, 2003). Marbled murrelets have been documented in marine waters adjacent to the City.

Two Washington State Priority Species were observed in the Shoreview Park area, band-tailed pigeon and the pileated woodpecker (Adolfson 1999). 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. Great blue herons and cutthroat trout are quite common along streams and some wetlands in the City of Shoreline.

Priority Habitat and Species (PHS) data collected by the Department of Fish and Wildlife were also 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 Boeing Creek, Reaches BC1, BC2, BC6, BC8, and BC9 were identified as priority habitat and as reaches that contain resident fish. It is interesting that BC9 is included as priority habitat in that it is a riprapped grassy swale immediately upstream of the M1 Dam with a long piped reach upstream. Other than BC9, these data correspond to the other data and observations collected as part of this report.

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
FC = Federal candidate
ST = Washington State listed threatened
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 Pigeon

However, the PHS data does not include all of the data that has been identified for this report. For example, the only fish barrier documented in the PHS data is at the M1 Dam, whereas several other fish barriers have been documented in this report (the steel pile dam, for example). In addition, the priority habitat identified in Reach BC1 does not extend down to the mouth of the creek. Based on information collected for this report, all of Reach BC1 and BC1A should be considered priority habitat. 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 observed wildlife species in the Boeing Creek Basin. There was one priority wildlife sighting in the Boeing Creek Basin; purple martin nest structures were identified in the intertidal area near the mouth of Boeing Creek (Reach BC1A).

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