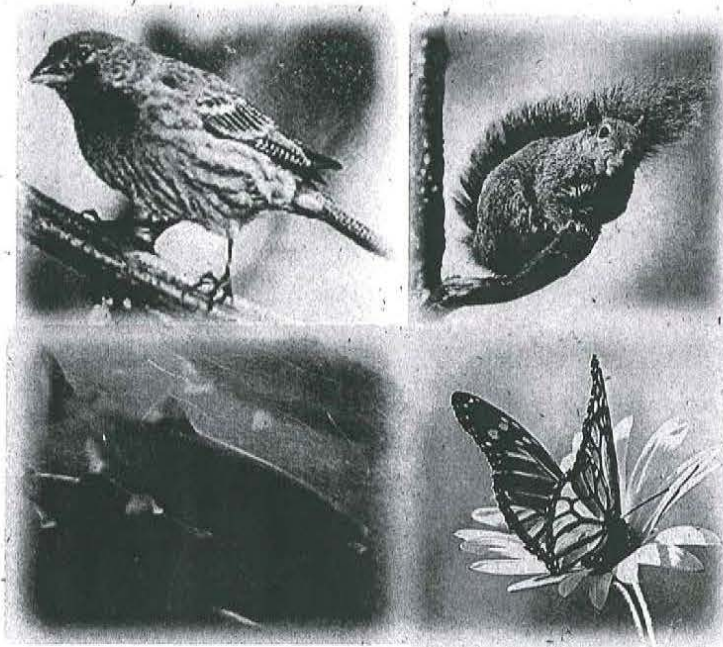


Scatter Creek Habitat Conservation Plan (HCP)

Associated Reports



Prepared for

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March 2003

Scatter Creek Habitat Conservation Plan Associated Reports:

**Species Accounts
Hydrology and Geomorphology
Prairie and Oak Woodland Habitat
Fisheries, Stream Habitat, and Surface Water Quality
Regulatory Review**

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TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS	ix
1. INTRODUCTION	1-1
2. STUDY AREA	2-1
2.1 TOPOGRAPHY AND VEGETATION	2-1
2.2 SCATTER CREEK	2-1
3. SPECIES ACCOUNTS	3-1
3.1 METHODS	3-1
3.1.1 Overview	3-1
3.1.2 Nomenclature	3-1
3.2 SPECIES ACCOUNTS	3-1
3.2.1 Bald Eagle	3-1
3.2.2 Northern Goshawk	3-4
3.2.3 Great Blue Heron	3-7
3.2.4 Oregon Vesper Sparrow	3-10
3.2.5 Slender-billed White-breasted Nuthatch	3-13
3.2.6 Western Gray Squirrel	3-15
3.2.7 Mazama Pocket Gopher	3-19
3.2.8 Oregon Spotted Frog	3-22
3.2.9 Mardon Skipper	3-25
3.2.10 Puget Blue Butterfly	3-28
3.2.11 Taylor's (Whulge) Checkerspot	3-30
3.2.12 Valley Silverspot	3-33
3.2.13 Chinook Salmon	3-36
3.2.14 Coho Salmon	3-41
3.2.15 Chum Salmon	3-46
3.2.16 Cutthroat Trout	3-49
3.2.17 Steelhead	3-53
3.2.18 Pacific Lamprey	3-56
3.2.19 River Lamprey	3-59
3.2.20 White-Top Aster	3-61
3.3 DATA GAPS	3-64
4. HYDROLOGY AND GEOMORPHOLOGY	4-1
4.1 METHODS	4-1
4.2 GEOLOGY	4-1
4.2.1 Introduction	4-1
4.2.2 Basin Landforms	4-3

TABLE OF CONTENTS (CONTINUED)

4.2.3	Bedrock Geology	4-3
4.2.4	Glacial Geology	4-6
4.2.5	Geohydrologic Units.....	4-15
4.2.6	Surface Geology and Soils.....	4-19
4.3	SCATTER CREEK CHANNELS	4-19
4.3.1	Landform Erosion.....	4-19
4.3.2	Scatter Creek Channels.....	4-21
4.3.3	Channel Types and Controls on Channel Processes.....	4-26
4.3.4	Hill Channel Types.....	4-27
4.3.5	Scatter Creek Channel Reaches	4-27
4.3.6	Beaver and Channel Morphology.....	4-30
4.4	HYDROLOGY	4-30
4.4.1	Watershed Area	4-30
4.4.2	Precipitation.....	4-31
4.4.3	Evaporation.....	4-34
4.4.4	Surface Runoff.....	4-35
4.4.5	Scatter Creek Streamflow	4-37
4.4.6	Comparison of Scatter Creek Gage Data to Other Sites.....	4-40
4.4.7	Groundwater	4-47
4.4.8	Aquifer Recharge.....	4-47
4.4.9	Scatter Creek Return Flow.....	4-57
4.4.10	Water Rights.....	4-58
4.4.11	Water Well Exemptions.....	4-62
4.4.12	Water Use	4-62
4.5	GROUNDWATER QUALITY	4-71
5.	PRAIRIE AND OAK WOODLAND HABITAT.....	5-1
5.1	METHODS.....	5-1
5.1.1	Review of Existing Materials	5-1
5.1.2	Field Reconnaissance	5-1
5.1.3	Review of Soils.....	5-1
5.1.4	Historic Habitat Types and Vegetation Map	5-1
5.1.5	Existing Vegetation Types and Vegetation Map.....	5-4
5.1.6	Comparison of Historic With Existing Vegetation.....	5-4
5.2	STUDY RESULTS.....	5-4
5.2.1	Geologic Landforms	5-4
5.2.2	Soils	5-4
5.2.3	Vegetation Habitat Types	5-9
5.2.4	Vegetation Distribution	5-14
5.2.5	Fire Disturbance Regime	5-18
5.2.6	Current Threats and Status for Prairie and Oak Habitats.....	5-20

TABLE OF CONTENTS (CONTINUED)

6.	FISHERIES, STREAM HABITAT, AND SURFACE WATER QUALITY	6-1
6.1	METHODS	6-1
6.1.1	Data Sources and Review	6-1
6.1.2	Field Reconnaissance	6-2
6.2	FISH SPECIES INFORMATION	6-2
6.2.1	Chinook Salmon	6-3
6.2.2	Coho Salmon	6-7
6.2.3	Chum Salmon	6-9
6.2.4	Cutthroat Trout	6-9
6.2.5	Steelhead Trout.....	6-9
6.2.6	Pacific Lamprey.....	6-10
6.2.7	River Lamprey	6-10
6.2.8	Olympic Mudminnow.....	6-10
6.2.9	Reticulate Sculpin.....	6-11
6.2.10	Additional Fish Species	6-13
6.2.11	Data Gaps	6-13
6.3	FISH HABITAT	6-14
6.3.1	Historic Conditions and Impacts	6-14
6.3.2	Existing Conditions and Impacts	6-16
6.4	SURFACE WATER QUALITY	6-26
6.4.1	Water Quantity	6-26
6.4.2	Water Quality	6-28
6.4.3	Data Gaps	6-38
6.5	FISHERIES MANAGEMENT.....	6-38
6.5.1	Federal	6-38
6.5.2	State	6-38
6.5.3	County	6-39
6.5.4	Tribal	6-39
6.5.5	Private.....	6-39
7.	REGULATORY REVIEW	7-1
7.1	SPECIES TO BE COVERED BY THE HCP	7-1
7.2	METHODS.....	7-2
7.3	FEDERAL LAWS AND POLICIES.....	7-2
7.3.1	Endangered Species Act	7-2
7.3.2	National Environmental Policy Act.....	7-3
7.3.3	Clean Water Act	7-4
7.3.4	Rivers and Harbors Act	7-5
7.3.5	Other Federal Laws	7-5
7.4	STATE AND LOCAL LAWS.....	7-6
7.4.1	State Environmental Policy Act.....	7-6

TABLE OF CONTENTS (CONTINUED)

7.4.2	State Hydraulic Code.....	7-7
7.4.3	Forest Practices Act.....	7-7
7.4.4	Water Pollution Control Act.....	7-8
7.4.5	Shoreline Management Act	7-9
7.4.6	State Laws Protecting Threatened and Endangered Species	7-10
7.4.7	Thurston County Critical Areas Regulations.....	7-10
7.5	MANAGEMENT PLANS AND POLICIES.....	7-13
7.5.1	Wild Salmonid Policy.....	7-13
7.5.2	Other State Salmon Recovery and Watershed Planning Efforts.....	7-13
7.6	SUMMARY.....	7-14
8.	REFERENCES	8-1
8.1	SPECIES ACCOUNTS	8-1
8.2	HYDROLOGY AND GEOMORPHOLOGY	8-13
8.3	PRAIRIE AND OAK WOODLAND HABITAT	8-16
8.4	FISHERIES, STREAM HABITAT, AND SURFACE WATER QUALITY	8-19
9.	GLOSSARY.....	9-1
LIST OF FIGURES		
2-1	Scatter Creek Watershed Project Location.....	2-3
3-1	Bald Eagle Breeding Distribution in Washington	3-3
3-2	Northern Goshawk Breeding Distribution in Washington State	3-5
3-3	Great Blue Heron Breeding Distribution in Washington State	3-8
3-4	Vesper Sparrow Breeding Distribution in Washington State.....	3-11
3-5	White-Breasted Nuthatch Breeding Distribution in Washington	3-14
3-6	Western Gray Squirrel Distribution in Washington State	3-17
3-7	Mazama Pocket Gopher Distribution in Washington State.....	3-20
3-8	Oregon Spotted Frog Distribution in Washington State.....	3-23
3-9	Mardon Skipper Butterfly Distribution in Washington State	3-26
3-10	Puget Blue Butterfly Distribution in Washington State	3-29
3-11	Taylor's Checkerspot Butterfly Distribution in Washington State	3-32
3-12	Valley Silverspot Butterfly Distribution in Washington State	3-35
3-13	Distribution of Fall Chinook Salmon in the Washington Coast Region	3-38
3-14	Distribution of Spring Chinook Salmon in the Washington Coast Region.....	3-39
3-15	Distribution of Coho Salmon in the Washington Coast Region.....	3-43
3-16	Distribution of Chum Salmon in the Washington Coast Region.....	3-47

TABLE OF CONTENTS (CONTINUED)

3-17	Location of 28 Washington River Drainages Where Coastal Cutthroat Trout Are Found.....	3-50
3-18	Distribution of Winter Steelhead in the Washington Coast Region.....	3-54
3-19	North American Distribution of Pacific Lamprey.....	3-57
3-20	North American Distribution of River Lamprey.....	3-60
3-21	White-Top Aster Distribution in Washington State.....	3-63
4-1	Puget Lobe of the Most Recent Vashon Stade of the Fraser Glaciation.....	4-2
4-2	Scatter Creek Valley Features.....	4-4
4-3	Aerial View of the Northern Part of Rock Prairie.....	4-5
4-4	Penultimate Glacial Ice Sheet.....	4-9
4-5	Maximum Extent of the Vashon Glacial Ice Sheet About 14,500 Years Ago.....	4-11
4-6	Initial Ice Retreat of the Vashon Glacial Ice Sheet About 14,000 Years Ago.....	4-12
4-7	Surface Geohydrologic Units and Mean Annual Precipitation in the Scatter Creek Area.....	4-14
4-8	Extent and Thickness of the Vashon Till.....	4-16
4-9	Extent and Thickness of the Vashon Advance Outwash.....	4-17
4-10	Extent and Thickness of the Penultimate Glacial Units in the Scatter Creek Area.....	4-18
4-11	Area of Scatter Creek Valley Vegetation Zones (Acres) Based on the 1854 Maps.....	4-20
4-12	Typical Wooded Channel That Would Form Along Much of the Mainstem if the Floodway Were Left Alone or Replanted.....	4-22
4-13	Pond Channel Form Created by Weirs or Beaver Dams.....	4-23
4-14	Typical Section of Logged and Dredged Channel.....	4-24
4-15	Typical Modified Scatter Creek Area Located in Reach SC2 with Limited Riparian or Channel Trees.....	4-25
4-16	Scatter Creek Channel Profile Based on 2-Ft Contour Lines.....	4-28
4-17	Annual Precipitation (Inches) at Olympia and Centralia, Washington.....	4-32
4-18	Daily Precipitation (Inches) at Tenino, Washington and Mean Daily Discharge (cfs) at the Thurston County Scatter Creek Gage at James Street, from September 1994 to December 1998.....	4-36
4-19	Mean Daily Flow Duration for Scatter Creek at James Street Bridge From September 1994 to December 1998.....	4-38
4-20	Low Flow Discharge (cfs) at the Scatter Creek Gage at James Street from September 1994 to December 1998.....	4-39
4-21	Comparison of Mean Daily Discharge (cfs) at the Skookumchuck River Gages Near Bucoda and Near Centralia, Washington.....	4-41

TABLE OF CONTENTS (CONTINUED)

4-22	Comparison of Mean Daily Discharge (cfs) at Skookumchuck River Near Bucoda and the Newaukum River, Washington.....	4-42
4-23	Comparison of Mean Daily Discharge (cfs) at Scatter Creek at James Street and the Skookumchuck River at Vail, Washington.....	4-43
4-24	Comparison of Daily Precipitation at Tenino, Washington (9/23/94 to 1/17/99) to Mean Daily Discharge (cfs) at the Scatter Creek Stream Gage at James Street.....	4-44
4-25	Mean Daily Discharge at Skookumchuck River Near Bucoda, Washington (cfs) Plotted with the Mean Daily Flows for Scatter Creek at James Street Bridge (cfs).....	4-45
4-26	Estimated Scatter Creek Mean Daily Discharge (cfs) for 33 Years Based on the Correlation with the Skookumchuck River at Bucoda, Washington.....	4-46
4-27	Valley Cross Sections and Approximate Valley Fill Depth in the Scatter Creek Valley at Tenino, Washington.....	4-48
4-28	Valley Cross Sections and Approximate Valley Fill Depth in the Scatter Creek Valley Across Rock and Mound Prairies	4-49
4-29	Valley Cross Section and Approximate Valley Fill Depth in the Scatter Creek Valley Across Grand Mound Prairie to the Black River Valley	4-50
4-30	Approximate Annual Water Balance for Scatter Creek Basin From 1969 to 1989.....	4-52
4-31	Annual Recharge as Percent of Annual Precipitation for Scatter Creek Basin	4-53
4-32	Annual Water Balance (in acre-ft) for Scatter Creek Basin	4-54
4-33	Estimated Annual Scatter Creek Aquifer Recharge Based on the Annual Centralia Precipitation	4-55
4-34	Approximate Saturated Aquifer Volume (ac-ft).....	4-56
4-35	Number of Water Right Certificates, Claims, and Permits for Surface Water and Groundwater Sources in the Scatter Creek Basin in October, 2002.....	4-59
4-36	Number of Well Water Right Certificates, Claims, and Permits in the Scatter Creek Basin in October, 2002.....	4-60
4-37	Number of Each Type of Water Right Source in the Scatter Creek Basin in October 2002.....	4-61
4-38	Number of Exempt Wells in the Scatter Creek Basin in October 2002	4-63
4-39	Well Diameters of Water Right Exemptions in the Scatter Creek Basin, October 2002.....	4-64
4-40	Depths of Exempt Wells in the Scatter Creek Basin, October 2002	4-65
4-41	Mean Depth of Exempt Wells for Each Section in the Scatter Creek Basin, October 2002.....	4-66
4-42	Maximum Depth of Exempt Wells for Each Section in the Scatter Creek Basin, October 2002	4-67
4-43	Exempt Well Completion Dates Show the Increase in Population in the Scatter Creek Basin	4-68

TABLE OF CONTENTS (CONTINUED)

4-44	Scatter Creek Basin Population Estimate	4-69
4-45	Domestic Water Use in the Scatter Creek Basin Based on 100 Gallons Per Day Use Per Person and Scatter Creek Basin Population Estimates.....	4-70
5-1	Scatter Creek Watershed – Historic Vegetation (Circa 1850s).....	5-2
5-2	Scatter Creek Watershed – Existing Vegetation	5-5
6-1	Scatter Creek Watershed Temperature Probes – WDFW Natural Heritage Water Quality Sampling Sites.....	6-12
6-2	Scatter Creek Watershed Land Use Segments, SHIAP Points, and SSHEAR Culverts	6-17
6-3	Scatter Creek Subbasin Streamside Vegetation Loss and Reduced Tree Canopy.....	6-18
6-4	Scatter Creek Subbasin Streambank Impacts Indirectly Limiting Fish Habitat	6-19
6-5	Scatter Creek Subbasin Water Quality Impacts Indirectly Limiting Fish Habitat	6-20
6-6	Scatter Creek Subbasin Bank Erosion, Deposited Sediment, and Related Impacts	6-21
6-7	Scatter Creek Subbasin Beaver Dam Effects on Fish Passage.....	6-22
6-8	Mean Daily Flows in Scatter Creek at James St. Bridge (River Mile 2.2) from June 1993 to May 1999	6-27
6-9	Maximum Water and Air Temperatures at Selected Temperature Monitoring Stations in Scatter Creek from 13 July to 5 August, 2002	6-36
6-10	Longitudinal Profile of Mean, Median, Maximum, and Minimum Monthly Stream Temperatures in Scatter Creek in July and August 2002	6-37

LIST OF TABLES

4-1	Geohydrologic Units in the Scatter Creek Valley	4-8
4-2	Mean Monthly Precipitation, Temperature Range, and Number of Wet Days for the Scatter Creek Basin	4-33
4-3	Water Balance for the Black River/Scatter Creek Area	4-34
5-1	Major Historic Habitat Types Identified	5-3
5-2	Soil Units Listed by Area in the Scatter Creek Basin	5-6
5-3	Area and Percent of Watershed Covered for Each Historic Habitat Type	5-14
5-4	Area and Percent of Watershed Covered for Each Existing Vegetation Type.....	5-15
5-5	Change in Vegetation Acreage From Historic to Existing Conditions	5-19
6-1	Numbers and Species of Fish Collected in the Downstream Migratory Smolt Trap Operated by WDFW at River Mile 0.5 on Scatter Creek from 1986 to 1991	6-4

TABLE OF CONTENTS (CONTINUED)

6-2	Releases of Hatchery Fish into the Scatter Creek Mainstem (Stream Number 23.0716) and an Unnamed Tributary of Scatter Creek (Stream Number 23.0719 from Williams et al. [1975]) During the Period of Record from 1976 to Present.....	6-5
6-3	Coho Salmon Escapement Estimates in Scatter Creek From 1984 to 2000.....	6-7
6-4	Results of In-stream Habitat Survey of Scatter Creek Conducted in 1999	6-24
6-5	Culverts with Identified Fish Use in the Scatter Creek Watershed	6-25
6-6	Water Quality Standards for Class A Waters of Washington State	6-28
6-7	Water Quality Nutrient Criteria for Nutrients in Rivers and Streams in Nutrient Ecoregion II.....	6-29
6-8	Summary of Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992.....	6-34
6-9	Summary of Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002.....	6-34
6-10	Monthly Mean, Median, Maximum, and Minimum Summer Water Temperatures at Temperature Monitoring Stations in Scatter Creek, 2002.....	6-35
7-1	Listing Status for Species Proposed to be Covered by the Scatter Creek HCP.....	7-1
7-2	Overview of Applicable Laws and Regulations for Species and Habitats Covered by the Scatter Creek HCP.....	7-14

APPENDICES

- A Plant Species of Western Washington Prairies
- B Plant Species Often Associated With Washington Oak Habitat East and West of the Cascades
- C Scatter Creek Habitat Data
- D Scatter Creek Water Quality Data From Chehalis River Water Quality Screening and Upper Chehalis River TMDL Studies
- E Water Quality Parameters From the Thurston County Environmental Health Division Database

ACRONYMS AND ABBREVIATIONS

/s	per second
ac	acres
ac-ft	acre-feet
cfs	cubic feet per second
cm	centimeters
dbh	diameter-at-breast-height
Corps	U.S. Army Corps of Engineers
CZMA	Coastal Zone Management Act
DO	dissolved oxygen
DPS	Distinct Population Segment
Ecology	Washington State Department of Ecology
ESU	Evolutionarily Significant Unit
ft	feet
ft ²	square feet
GIS	geographic information system
GLO	General Land Office
gpm	gallons per minute
HCP	Habitat Conservation Plan
HPA	Hydraulic Project Approval
km	kilometers
m	meters
m ³	cubic meters
mg/L	milligrams per liter
mi ²	square miles
mm	millimeters
NEPA	National Environmental Policy Act
NOAA	National Oceanic Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
PHS	priority habitats and species
PIF	Partners in Flight
ppm	parts per million

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RCW	Revised Code of Washington
RMZ	riparian management zone
s	seconds
SaSSI	Salmon and Steelhead Stock Inventory
SEPA	State Environmental Policy Act
SSHEAR	Salmonid Screening, Habitat Enhancement and Restoration
TCC	Thurston County Code
TCD	Thurston Conservation District
TMDL	total maximum daily load
U.S.C.	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WMZ	wetland management zone
WNHP	Washington Natural Heritage Program
WWTIT	Western Washington Treaty Indian Tribes

1. INTRODUCTION

The Thurston Conservation District (TCD) is coordinating the effort to develop a Habitat Conservation Plan (HCP) for the Scatter Creek watershed. The watershed is no longer performing some of the essential habitat functions for some of the species that live there, and a comprehensive effort to integrate conservation practices, natural processes, and ongoing land use activities is underway. Specific goals of the HCP are to:

- Provide properly functioning and sustainable habitat for covered species.
- Acknowledge the natural experience associated with the covered area.
- Voluntarily protect and improve the health and uniqueness of the Scatter Creek watershed.
- Ensure long-term regulatory certainty and economic opportunity for participating landowners in the covered area.

A key aspect of achieving these goals is the implementation of conservation and restoration strategies that are consistent with and complement existing regulatory mechanisms that protect habitats and species of concern within the Scatter Creek watershed. The primary regulatory statute driving the development of the HCP is the federal Endangered Species Act. If approved by the U.S. Fish and Wildlife Service (USFWS) and National Oceanic Atmospheric Administration (NOAA) Fisheries (also known as the National Marine Fisheries Service [NMFS]), the HCP would allow landowners who have agreed to the provisions of the plan to legally proceed with activities that would otherwise be prohibited under the Endangered Species Act. Although the HCP would not automatically guarantee relief from other regulations (such as state regulations and County critical areas regulations), the HCP Steering Committee intends to work with federal, state, and local jurisdictions with regulatory authority in the planning area and encourage them to participate in the HCP process. Cooperation among these diverse agencies and jurisdictions would increase certainty about the kinds of activities that can be legally conducted on land now and in the future (provisions will not change over the term of the HCP).

To support the HCP, this document provides information on various species and habitats within the watershed, including soil and vegetation types, and hydrology and geomorphology information. In addition, the regulatory processes that have an effect on the watershed are described. Following are summaries of each resource report included in this document.

Species Accounts (Section 3)

The Species Accounts Report provides a comprehensive summary of the status and threats for each of the following 20 species that are being considered for inclusion in the Scatter Creek HCP:

Wildlife	Butterflies	Fish	Plants
Bald eagle	Mardon skipper	Chinook salmon	White-top aster
Northern goshawk	Puget blue	Coho salmon	
Great blue heron	Taylor's checkerspot	Chum salmon	
Oregon vesper sparrow	Valley silverspot	Cutthroat trout	
Slender-billed white-breasted nuthatch		Steelhead	
Western pocket gopher		Pacific lamprey	
Western gray squirrel		River lamprey	
Oregon spotted frog			

The account for each species includes the species' legal status, population status and distribution, life history, habitat associations/requirements, habitat and occurrence in the Scatter Creek watershed vicinity, threats, and special needs. The information in the species accounts will guide the development of HCP conservation measures for each species.

Hydrology and Geomorphology (Section 4)

The purpose of the Hydrology and Geomorphology Report is to describe the hydrological functioning in the watershed, detail the processes connected to sustaining watershed habitats, and identify information that will be meaningful and useful in the development of an HCP.

The objectives of the report include the following:

- Describe and evaluate the prehistoric and historic factors affecting the Scatter Creek stream channel and riparian area, including (but not limited to) beaver activities and large wood recruitment.
- Review and compare historical and present stream functions.
- Describe the effects and condition of contributing tributary channels.
- Compile and describe watershed stream gage data and evaluate this information for the HCP.
- Conduct a groundwater/surface water assessment that includes an analysis of (1) current demand/supply conditions in the watershed and recharge relationships (well inventory), (2) well logs to indicate aquifer thickness and yield relationships, and (3) an overview of general hydrological relationships in the watershed.

Prairie and Oak Woodland Habitat (Section 5)

The Prairie and Oak Woodland Habitat Report was prepared to support the HCP by providing a comprehensive description of prairie and oak woodland habitats in the Scatter Creek watershed. In addition, the report provides information about the soil and vegetation types (habitats) in the watershed. To provide guidance and develop conservation measures for the Scatter Creek HCP, it is important to determine how prairie and oak woodland habitats have changed over time, and the ecological processes that sustain these habitats. The disturbance regimes and current threats are also identified.

This effort was achieved by gathering and reviewing existing materials on prairie and oak woodland habitats, reviewing and analyzing historic and existing habitat information within the Scatter Creek watershed, and comparing the historic vegetative conditions to current conditions. A map was created to depict likely historic habitat conditions (circa 1850s) and to assist in assessing the changes in habitat conditions from pre-European settlement to the present.

Fisheries, Stream Habitat, and Surface Water Quality (Section 6)

The Fisheries Report provides descriptions of the historical and existing fisheries and habitat conditions of Scatter Creek. The intent is to provide information relevant to fisheries resources in Scatter Creek that is of sufficient detail to assist in the development of an HCP for the Scatter Creek watershed. The objectives of this report are as follows:

- Provide information on use of Scatter Creek by fish species covered by the HCP (these species include chinook salmon, coho salmon, chum salmon, cutthroat trout, steelhead trout, Pacific lamprey, and river lamprey).
- Synthesize in-stream and riparian habitat information.
- Synthesize water quantity and water quality information.
- Summarize current and proposed fisheries management activities.
- Identify and summarize data gaps in knowledge of fisheries and fish habitat.

Regulatory Review (Section 7)

The Regulatory Review Report assesses general implications for land use planning and conservation. Specifically, the report describes the applicable laws and regulations that apply, or may apply, to resources of concern within the HCP planning area and/or to land uses or activities that may be covered by the HCP. The report is intended for general planning purposes and is not a legal document. Landowners should consult the appropriate regulatory agencies and review the individual statutes for additional information concerning regulated activities, permit requirements, penalties, and the like.

In addition to the resource reports, this document contains the following:

- Description of the study area (Section 2).
- References for each resource report (Section 8).
- A glossary (Section 9).

2. STUDY AREA

The Scatter Creek watershed northern periphery is located about 9 miles south of Olympia, Washington along the southcentral border of Thurston County. Major land holdings within 10 miles of the watershed include the Fort Lewis Military Reservation north of the watershed, the Gifford Pinchot National Forest south of the watershed, and the Black Hills Capitol State Forest northwest of the watershed. The watershed includes Scatter Creek from its headwaters to its junction with the Chehalis River, as well as tributaries to the creek. The watershed area comprises 27,923 acres (ac) and is primarily rural in character, excepting the area within the city of Tenino and the lower valley (Figure 2-1). Interstate 5 traverses the center of the watershed in a north/south direction. Other major highways that occur in the watershed include Old Military Road, Old Highway 99, U.S. Route 12, and State Route 507. Public lands within the watershed include the Washington Department of Fish and Wildlife (WDFW) Scatter Creek Wildlife Area and Washington Department of Natural Resources (WDNR) timberlands. The area includes Townships 15 and 16 North and Ranges 1 to 3 West.

2.1 TOPOGRAPHY AND VEGETATION

The Scatter Creek watershed contains varying landforms and soils that support a range of vegetation including unique prairie (type of grassland) and oak woodland habitat. The upper portion of the watershed (Tenino and east of Tenino) consists of a multitude of soils on varying topography that support primarily forested vegetation. These forests are dominated by conifers (mainly Douglas-fir [*Pseudotsuga menziesii*] and western red cedar [*Thuja plicata*]) with some hardwoods (bigleaf maple [*Acer macrophyllum*], red alder [*Alnus rubra*], Oregon ash [*Fraxinus latifolia*], and Oregon white oak [*Quercus garryana*]).

Topography in the middle and lower portions of the watershed (west of Tenino to the Chehalis River) is generally flat with undulating microtopographical mounds (Mima mounds) surrounded by low-lying hills. Excessively drained soils compose the substrate supporting the watershed's dominant vegetation type, dry grasses and soils. This land cover is defined by the Thurston Regional Planning Council (2001) as being a highly variable class composed of dry grasses, fields, recent clearcuts, dry agricultural lands, beaches, mudflats, and unvegetated soils. Although little native grassland or semi-native grassland remains within these areas, what little does remain is dominated by Roemer's fescue (*Festuca roemerii*) and other native grassland grasses and forbs. Nonnatives such as Scot's broom (*Cytisus scoparius*) and colonial bentgrass (*Agrostis capillaris*) are more widespread. The surrounding hills contain forest-conifer, forest-mixed, and forest-hardwood vegetation types. A few patches of oak-dominated woodlands are scattered throughout the watershed.

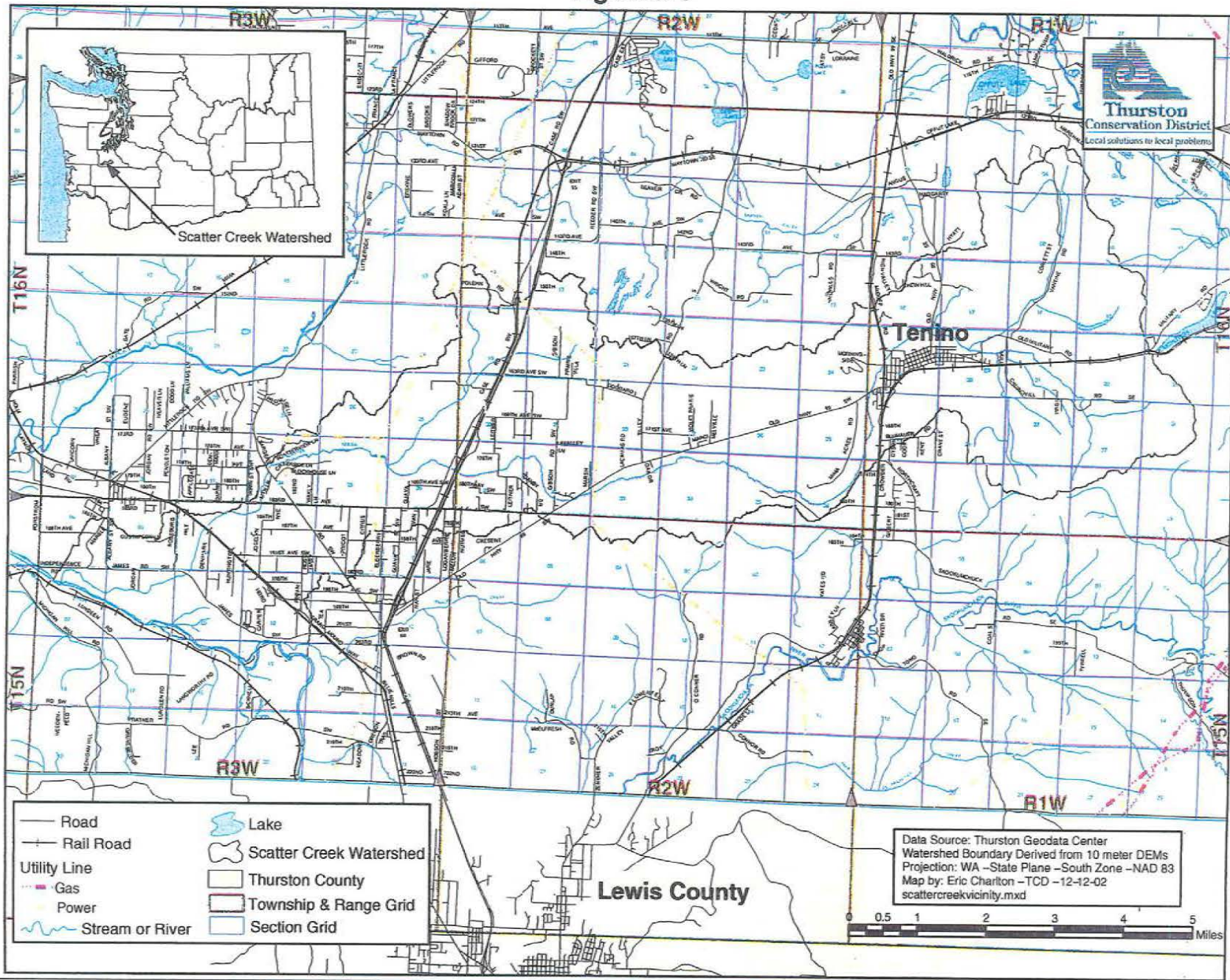
Vegetation along Scatter Creek is dominated by forest-hardwood vegetation in the less disturbed segments and non-forest vegetation (grasses) in the more disturbed segments. In the forest-hardwood areas, Oregon ash, red alder, Oregon white oak, Pacific willow (*Salix lasiandra*), and cascara (*Rhamnus purshiana*) typically dominate the overstory, and red-osier dogwood (*Cornus sericea*), snowberry (*Symphiocarpos albus*), Pacific ninebark (*Physocarpus capitatus*), rose (*Rosa* spp.), Douglas spirea (*Spiraea douglasii*), vine maple (*Acer circinatum*), and reed canarygrass (*Phalaris arundinacea*) typically dominate the understory. Reed canarygrass and domestic grasses from abutting pasturelands dominate non-forested vegetation adjacent to the creek.

2.2 SCATTER CREEK

Scatter Creek is 20.6 miles in length and includes an additional 9.5 miles of tributaries (Williams et al. 1975). From 1993 to 1999, the mean annual flow near the mouth was 79 cfs (maximum = 1,362 cfs,

minimum = 2.9 cfs). Winter flows generally fluctuate between 30 to 80 cfs. The lower 6 miles of Scatter Creek stays watered year-round. This is the result of pumped groundwater being delivered to the creek after being used and treated by a commercial fish farm. Upstream of this point, there are significant reaches of Scatter Creek that are dry during the summer. Reed canarygrass dominates the dry channels. Stream habitat conditions vary. Elevated water temperatures, sedimentation, little stream shading, low pool frequency, and lack of off-channel habitat are primary concerns. Other features, such as woody debris and streambank condition, are good in some areas, but locally degraded in other areas due to loss of riparian buffer and livestock activities. Reaches having beaver activity generally show the greatest habitat complexity and value as fish habitat.

Scatter Creek Watershed Project Location
Figure 2-1



3. SPECIES ACCOUNTS

3.1 METHODS

3.1.1 Overview

The methodology for preparing the species accounts included review of existing watershed data, assessment of watershed conditions through site reconnaissance, and review of published literature. Existing watershed data was gathered from TCD geographic information system (GIS) layers; WDFW priority habitats and species information; Washington Natural Heritage Program (WNHP) rare plant information; communications with agency representatives, landowners, and other individuals knowledgeable about the project area; and watershed-specific reports from various sources. Section 8.1 lists specific individuals contacted. The methodology for creating existing conditions vegetation GIS layers, which were used to assess habitat for the wildlife and butterfly species of interest, is described in the Prairie and Oak Woodland Habitat Report (Section 5.1.5). The site reconnaissance included a 2-day field visit in which biologists visited representative areas and major landholdings in the watershed. The literature review included a search for all relevant published articles and reports using a variety of library databases.

3.1.2 Nomenclature

Measurements used in this report to describe area, distance, volume, and temperature include both English and metric units, depending on the measurement system conventionally used for the specific parameter. For example, acres, not hectares, are used to describe a species' average home range, while Centigrade, not Fahrenheit, is used to describe stream temperature.

3.2 SPECIES ACCOUNTS

3.2.1 Bald Eagle

3.2.1.1 Legal Status

The bald eagle (*Haliaeetus leucocephalus*) is currently considered a federal and state threatened species. However, the species had been proposed for federal delisting and state down-listing to sensitive (USFWS 1999; Stinson et al. 2001).

3.2.1.2 Population Status and Distribution

Prior to the arrival of Euro-Americans, bald eagles were considered abundant in many parts of North America (Buehler 2000). In Washington State, the bald eagle breeding population when Euro-American settlers first arrived is estimated at approximately 6,500 birds (Stinson et al. 2001). Persecution, timber harvest, commercial salmon fishing, the use of the pesticide DDT, and other human activities severely reduced the Washington State bald eagle population, and only 105 breeding pairs were known to be present in 1980 (Stinson et al. 2001). With the banning of DDT in 1972 and a number of active recovery efforts, the population has recovered dramatically, and in 2001, 678 eagle breeding pairs were documented in the state (Brookshier 2003). The current Washington State breeding population is concentrated along the coastal areas and other large water bodies in the western portion of the state (Stinson et al. 2001) (Figure 3-1).

Washington State supports a large population of wintering bald eagles, with an estimated several thousand eagles wintering in the area (Stinson et al. 2001). Most of the wintering eagles occur in the western portion of the state; however, portions of eastern Washington support substantial numbers of wintering bald eagles as well (e.g., Columbia River reservoirs and major Columbia River tributaries) (Stinson et al. 2001).

3.2.1.3 Life History

Bald eagle pairs arrive on their nesting territories as early as December (Stinson et al. 2001). Each eagle pair maintains an active nest and often alternate nest(s) within its territory, and successful nests may be used over several successive years (Buehler 2000). Clutch size is usually two, and in western Washington, young hatch by late April, after approximately 35 days of incubation (Stinson et al. 2001). Young eagles fledge (grow feathers for flight) around 11 to 13 weeks of age, usually during early to mid-July in Washington. Eagles nesting in Washington, as well as fledglings, leave their territories in early fall and migrate north to British Columbia and southeast Alaska, where salmon runs provide prey concentrations. Adults generally return to their Washington breeding grounds by January, while juveniles usually return several months later. Bald eagles wintering in Washington State generally arrive from October to December and leave between January and April. These wintering birds nest in British Columbia, Alaska, the Northwest Territories, and the Yukon.

In western Washington, bald eagle diet during the nesting period consists primarily of fish, waterfowl, and gulls, although other prey, including mammals and invertebrates, are also taken (Stinson et al. 2001; McAllister 2003). During the wintering period, spawned salmon are the most important food source for eagles. When and where salmonid prey are not available, wintering eagles in western Washington primarily consume non-salmonid fish and waterfowl.

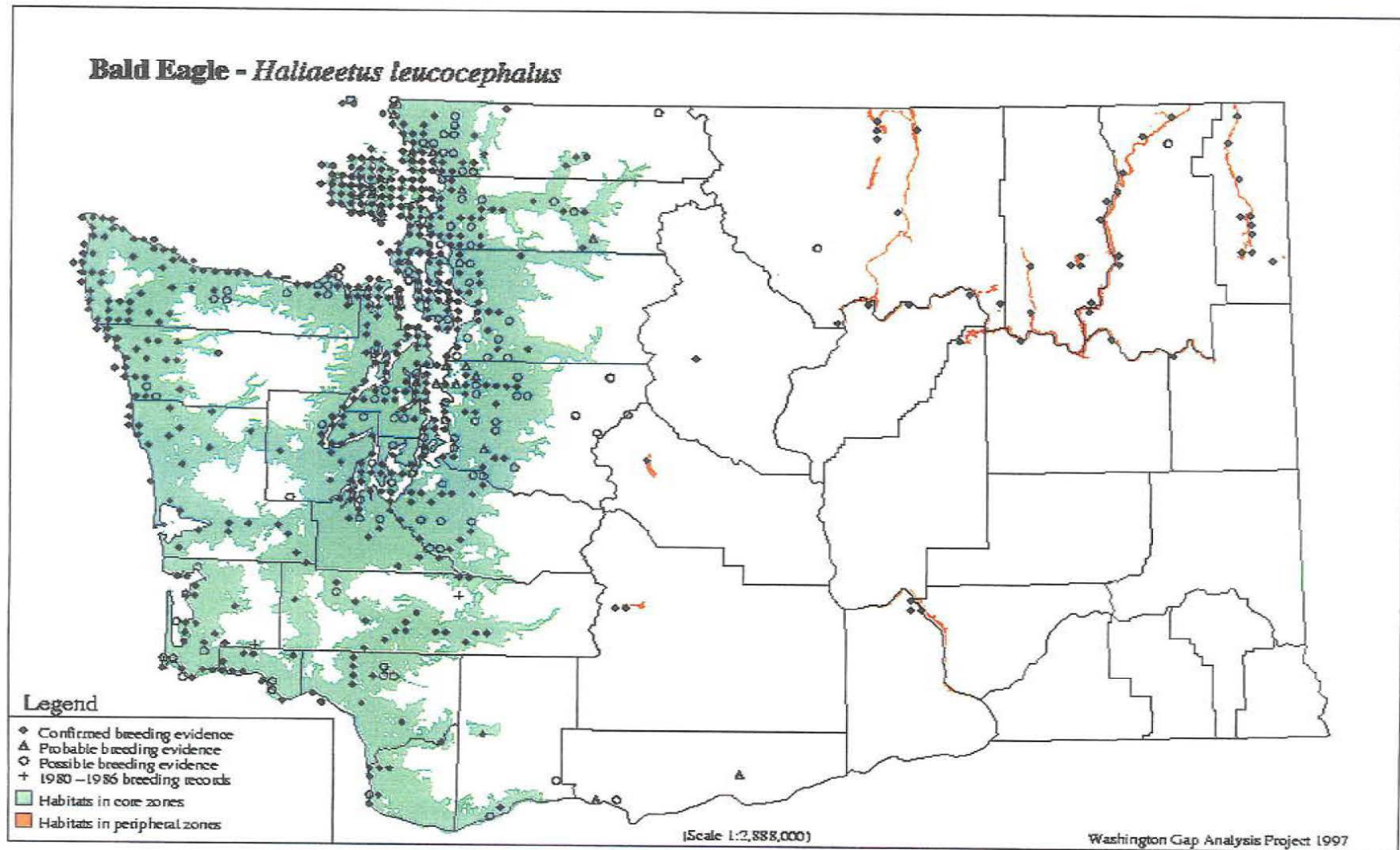
3.2.1.4 Habitat Associations/Requirements

Nesting Period

Important habitat components for bald eagles during the nesting season include adequate nest trees, perch trees, and foraging areas. Suitable nest and perch sites consist of large trees near open water (such as rivers, lakes, and bays) where prey (i.e., fish and waterfowl) are abundant (Stinson et al. 2001). In most areas, absence of intense human activity is also an important factor in nest site and perch site selection. Bald eagle home range during the nesting period averages approximately 2.6 mi² in the Puget Sound region (Watson and Pierce 1998).

Wintering Period

Important habitat components for wintering eagles include concentrations of prey in areas with suitable perch and roost sites (Stalmaster 1987; Stinson et al. 2001). As with the nesting period, the level of human disturbance also influences wintering habitat quality. In western Washington, wintering bald eagles generally congregate in areas where salmon prey are available, although as mentioned above, the birds will also winter in areas with abundant waterfowl and non-salmonid fish (Stinson et al. 2001). Requirements for winter perch sites are similar to nesting period perch site requirements. Roost sites can be either communal or individual and generally consist of stands of trees near foraging areas. In a study in northwestern Washington, all 26 roost sites were within 0.68 mile of foraging areas (Watson and Pierce 1998). Bald eagle wintering period home range varies considerably: average home range was 89 mi² to 113,365 mi² for wintering eagles on the Skagit River (Watson and Pierce 2001).



Source: Washington State Department of Fish and Wildlife, Gap data products (WDFW 2002a).

Figure 3-1. Bald Eagle Breeding Distribution in Washington

3.2.1.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Bald eagles use the Scatter Creek vicinity during winter, when salmonid prey, including coho salmon, coastal cutthroat trout, and possibly steelhead, are available. No winter roost sites have been identified in the watershed. Nesting eagles are not known to occur along Scatter Creek, likely due to inadequate prey availability. However, two bald eagle nest sites are known along the south side of the Chehalis River, adjacent to the boundary of the Scatter Creek watershed (WDFW 2002b).

3.2.1.6 Threats

The main threats to bald eagles in the watershed are reductions in prey and increases in human disturbance through development. The primary prey of bald eagles in the watershed are likely coho salmon and cutthroat trout. Indirect effects of increased development in the watershed, including changes in water quality and quantity, could result in declines in the abundance of these salmonids. Increased human activities in the vicinity of bald eagle habitat could also discourage bald eagle use. Additional potential effects of development include reduction in the availability of potential perch sites on Scatter Creek and potential perch and nest sites along the Chehalis River, through harvest of large riparian trees.

3.2.1.7 Special Needs

Protection needs for bald eagles in the watershed include controlling development to ensure the following conditions:

- Maintenance and recruitment of large trees along Scatter Creek and the Chehalis River for perching, nesting, and roosting. WDFW recommends leaving a 250-ft-wide strip of perch trees and protective buffer along shorelines within eagle nesting territories and winter feeding areas.
- Maintenance of fish (i.e., prey) populations.
- Minimal introduction of new human activities near bald eagle use (especially nest and roost) sites. USFWS guidelines (USFWS 1986) recommend maintaining a ¼-mile to ½-mile buffer around eagle nest and roost sites, with the buffer size dependent upon vegetation screening, eagle flight paths, individual tolerances of the eagles, and other factors. For bald eagle nest sites, WDFW recommends a nested buffer design, with a 400-ft primary protection area and a secondary protection area that extends 330 to 800 ft beyond the edge of the primary protection area (Watson and Rodrick 2001). WDFW recommends a 400-ft buffer for core communal roost sites. The agency also states that in foraging areas with little or no screening, feeding bald eagles should be allowed at least 1,500 ft from human activity and permanent structures.

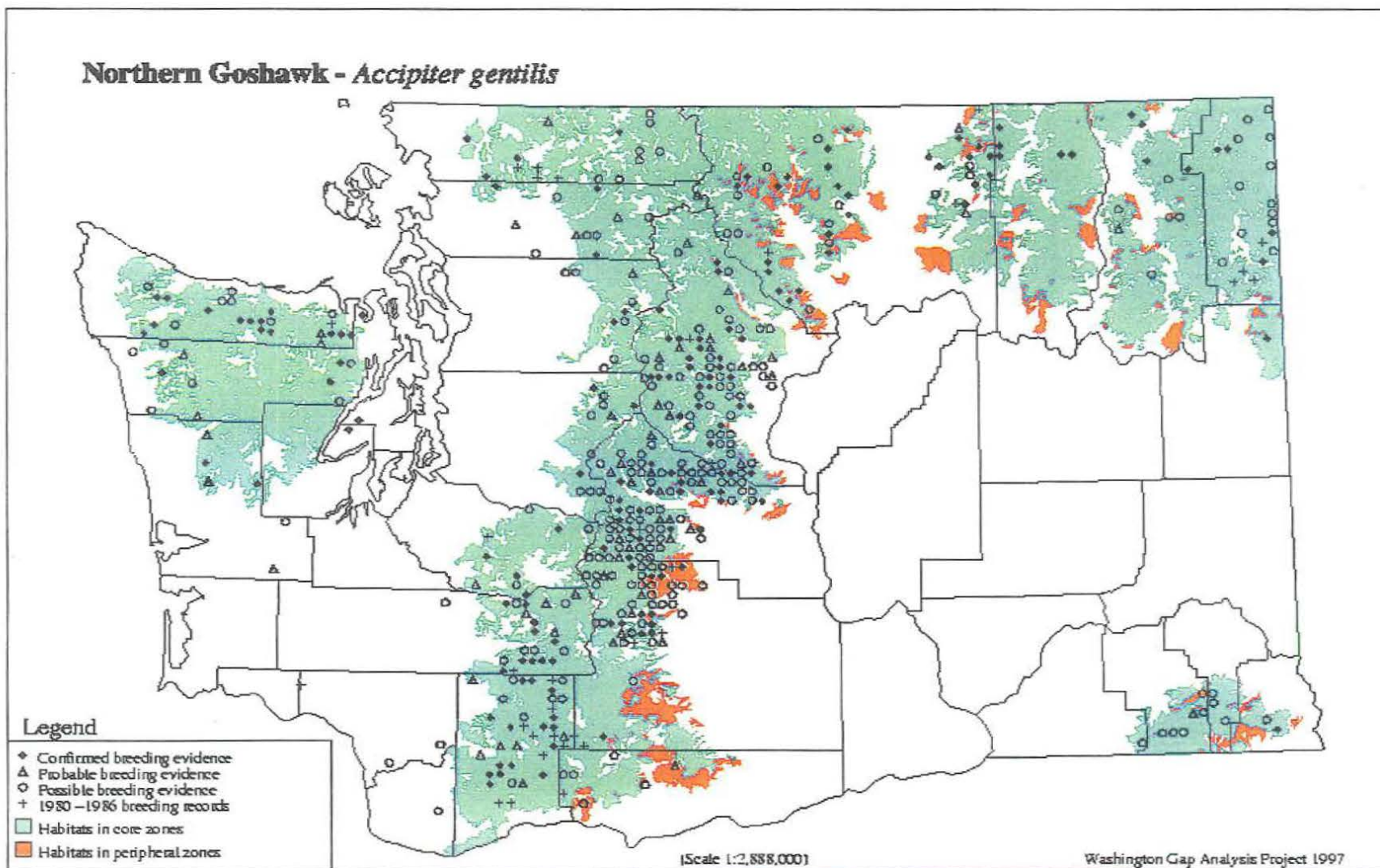
3.2.2 Northern Goshawk

3.2.2.1 Legal Status

The northern goshawk (*Accipiter gentilis*) is a federal species of concern and is a state candidate species.

3.2.2.2 Population Status and Distribution

Within North America, northern goshawks occur in Alaska and the northern and western United States (Squires and Reynolds 1997). Occasionally, wintering birds are observed in other portions of the United States. In Washington, goshawks are distributed throughout the state, with the breeding distribution generally restricted to mountainous areas (Figure 3-2) (Smith et al. 1997; Squires and Reynolds 1997).



Source: Washington State Department of Fish and Wildlife, Gap data products (WDFW 2002c).

Figure 3-2. Northern Goshawk Breeding Distribution in Washington State

Nesting density is higher on the eastern Cascades than on the west side (Smith et al. 1997). Population trends for goshawks in Washington State are not known. In their review of a petition to list the birds in the western United States, the USFWS found no evidence of a declining population trend for goshawks in the region, despite changes in forest structure (USFWS 1998).

3.2.2.3 Life History

In western Washington, northern goshawks are year-round residents whose nesting period begins around March, with young fledging by late May (Squires and Reynolds 1997). Nests are generally constructed in the largest trees available, and conifer trees are usually selected for nest sites (USFWS 1998). Typical nesting territories contain several alternate nests. Goshawks are sensitive to disturbance; timber harvest and camping near nests have been shown to cause nest failures (Squires and Reynolds 1997).

A recent study found that the diet of breeding northern goshawks in western Washington was approximately equally distributed (based on both prey biomass and frequency) between birds and mammals (Watson et al. 1998). Douglas' squirrels (*Tamiasciurus douglasii*) were the most frequently consumed mammals, while grouse were the most frequently consumed birds.

3.2.2.4 Habitat Associations/Requirements

In western Washington, goshawk nesting habitat generally consists of closed-canopy mature and old-growth conifer forests, although they have been documented nesting in younger (i.e., 40 to 54 years old) conifer stands as well (Fleming 1987; USFS 1994; Bosakowski et al. 1999; Finn et al. 2002). Nest stands are typically 25 to 250 ac in size (Squires and Reynolds 1997). Requirements for goshawk foraging are less rigid than for nesting habitat, although most studies indicate that goshawks do prefer older forests for foraging (Squires and Reynolds 1997; USFWS 1998; Finn et al. 2002). Goshawk home range size during the breeding season varies from 410 to 8,650 ac (Squires and Reynolds 1997). Core use areas, which include the nest site and primary foraging areas, compose approximately one-third of the home range. Winter home ranges for goshawks in North America have not been determined; studies in Europe indicate that winter home ranges average 13,300 to 14,100 ac in most areas.

3.2.2.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

There are no confirmed sightings of northern goshawks in the Scatter Creek watershed, although formal surveys have not been conducted in the area. Local watershed residents report the following sightings, both in 2001: (1) Chanele Holbrook of the Herneett Foundation reports a potential goshawk sighting on the Foundation property, near Tenino; and (2) Wendi Meador reports northern goshawk sightings at her bird feeder on her property, approximately ½ mile west of the Scatter Creek Wildlife Area. Potential goshawk habitat in the watershed is limited to conifer forest types. The Scatter Creek GIS vegetation data identifies 4,360 ac of conifer forest and 1,744 ac of young forest (mostly conifers) in the watershed. Because most of these areas are intensively managed for timber production and do not contain mature or old-growth habitat, these forests generally do not provide quality goshawk habitat.

3.2.2.6 Threats

The main threat to northern goshawks in the Scatter Creek watershed is continued timber harvest, as well as clearing of conifer forests for development. Human disturbance to potential nesting areas is also a threat to the birds.

3.2.2.7 Special Needs

Northern goshawk needs within the watershed can be summarized as follows:

- A 25- to 250-ac nest stand containing mature or old-growth forest (preferred) within a larger approximately 410- to 8,650-ac home range area within conifer forest. Note that Forest Service guidelines for goshawks in the southwest United States (guidelines in the Pacific Northwest are not available) include providing for a total of 6,000 ac per goshawk pair to include three nest areas and three alternate nest areas of 30 ac each, a post-fledging family area of 420 ac, and a foraging area of 5,400 ac (Reynolds et al. 1992).
- Freedom from disturbance at the nest site.

3.2.3 Great Blue Heron

3.2.3.1 Legal Status

The great blue heron (*Ardea herodias*) is a state monitor species and has no federal status.

3.2.3.2 Population Status and Distribution

The great blue heron occurs throughout most of the United States and southern Canada and in much of Central and South America (WDFW 1999). The birds are distributed throughout Washington State, with the breeding distribution concentrated around the Puget Sound and along major rivers (Smith et al. 1997) (Figure 3-3). In recent years, many of the great blue heron nesting colonies in western Washington have disappeared (McAllister 2002a). Potential reasons for their disappearances include predation by bald eagles, declines in prey populations, and human disturbance (McAllister 2002a; WDFW 1999).

3.2.3.3 Life History

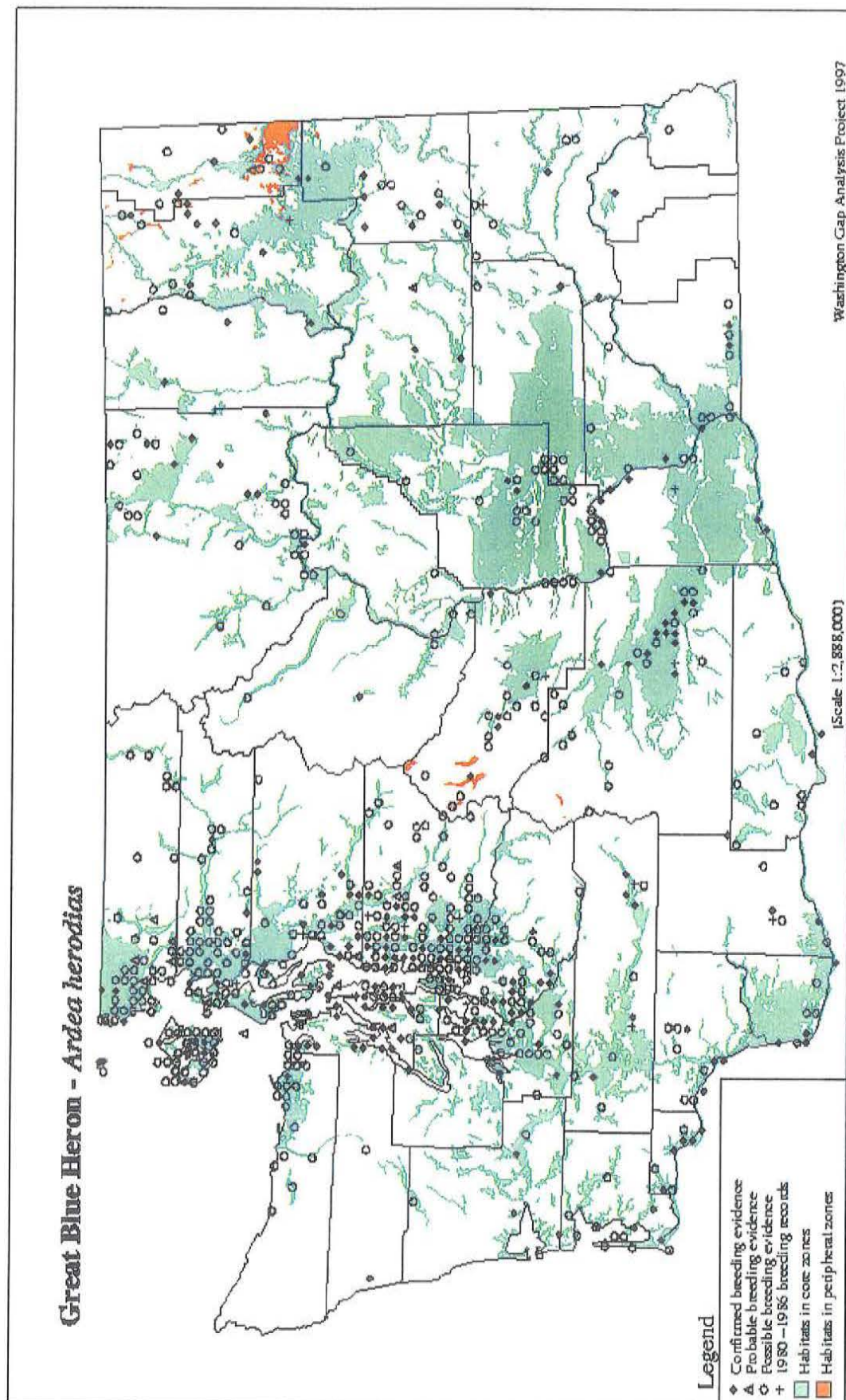
In western Washington, great blue herons are year-round residents whose nesting period begins in mid-February, with young fledging by the end of July (WDFW 1999). Nests are generally constructed in the largest trees available, and both deciduous and evergreen trees are selected for nest sites. Nesting colonies usually contain several hundred nesting pairs, and sites typically are used over successive years (Butler 1992). The diet of great blue herons is diverse and includes a variety of aquatic and marine animals, as well as small mammals.

3.2.3.4 Habitat Associations/Requirements

Great blue herons use both freshwater and saltwater habitats, including marshes, wet meadows, lakes, rivers, and ponds for foraging (Csuti et al. 1997; WDFW 1999). Nesting habitat generally consists of trees near water in areas with limited human disturbance. Nests are usually constructed in the tallest tree (either coniferous or deciduous) available, although the birds may nest in bushes or artificial structures when trees are not available (WDFW 1999). In most cases, nest height is at least 30 ft for nests occurring in trees. The proximity of nesting habitat to foraging habitat is a key limiting factor for the species (WDFW 1999). In King County, some great blue herons have abandoned colonies due to predation by bald eagles.

3.2.3.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Great blue herons are regularly sighted foraging along Scatter Creek and other waterbodies in the watershed, and the birds, especially juveniles, may also use the fields and pastures for hunting small mammals (Butler 1992). No nesting colonies are currently known from the area. The Scatter Creek Wildlife Area supported a nesting colony in the past. In addition, a great blue heron pair nested on the Heernett Foundation property near Tenino until around 2000. The disappearance of the nesting colony at



Source: Washington State Department of Fish and Wildlife, Gap data products (WDFW 2002d).

Figure 3-3. Great Blue Heron Breeding Distribution in Washington State.

the Scatter Creek Wildlife Area may be related to changes in the operations at the nearby fish hatchery, which made fish less available to the birds (McAllister 2002a). The reason for the disappearance of the nesting pair on the Heernett Foundation property is unknown.

Suitable nesting habitat for great blue heron colonies in the watershed is likely limited by relatively low prey density and human disturbance. Because individual heron pairs require less-concentrated prey availability than heron colonies, individual heron pairs may continue to occasionally nest in the watershed in areas where human activity levels are low and nest trees are available.

3.2.3.6 Life History

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3.2.3.9 Threats

The main threat to foraging great blue herons in the Scatter Creek watershed is reduction in prey availability through development and subsequent changes in water quality and/or quantity. Additionally, increased human activity associated with development may reduce great blue heron foraging use of the watershed, although foraging birds appear to be fairly tolerant of human activity. Human activity levels

and low prey densities are expected to continue to limit the potential for the watershed to support heron nesting colonies.

3.2.3.10 Special Needs

Protection needs for great blue herons in the watershed include controlling development to maintain the following conditions:

- Aquatic foraging areas with vertebrate and invertebrate prey (note that increasing prey abundance would likely benefit great blue herons).
- Clusters of trees near foraging areas for nesting. Note that WDFW (1999) recommends maintaining forest stands at least 10 ac in size with dominant trees at least 56 ft in height to provide nesting habitat.
- Limited disturbance near nesting colonies.

3.2.4 Oregon Vesper Sparrow

3.2.4.1 Legal Status

The Oregon vesper sparrow (*Pooecetes gramineus affinis*) is a federal species of concern and a state candidate species.

3.2.4.2 Population Status and Distribution

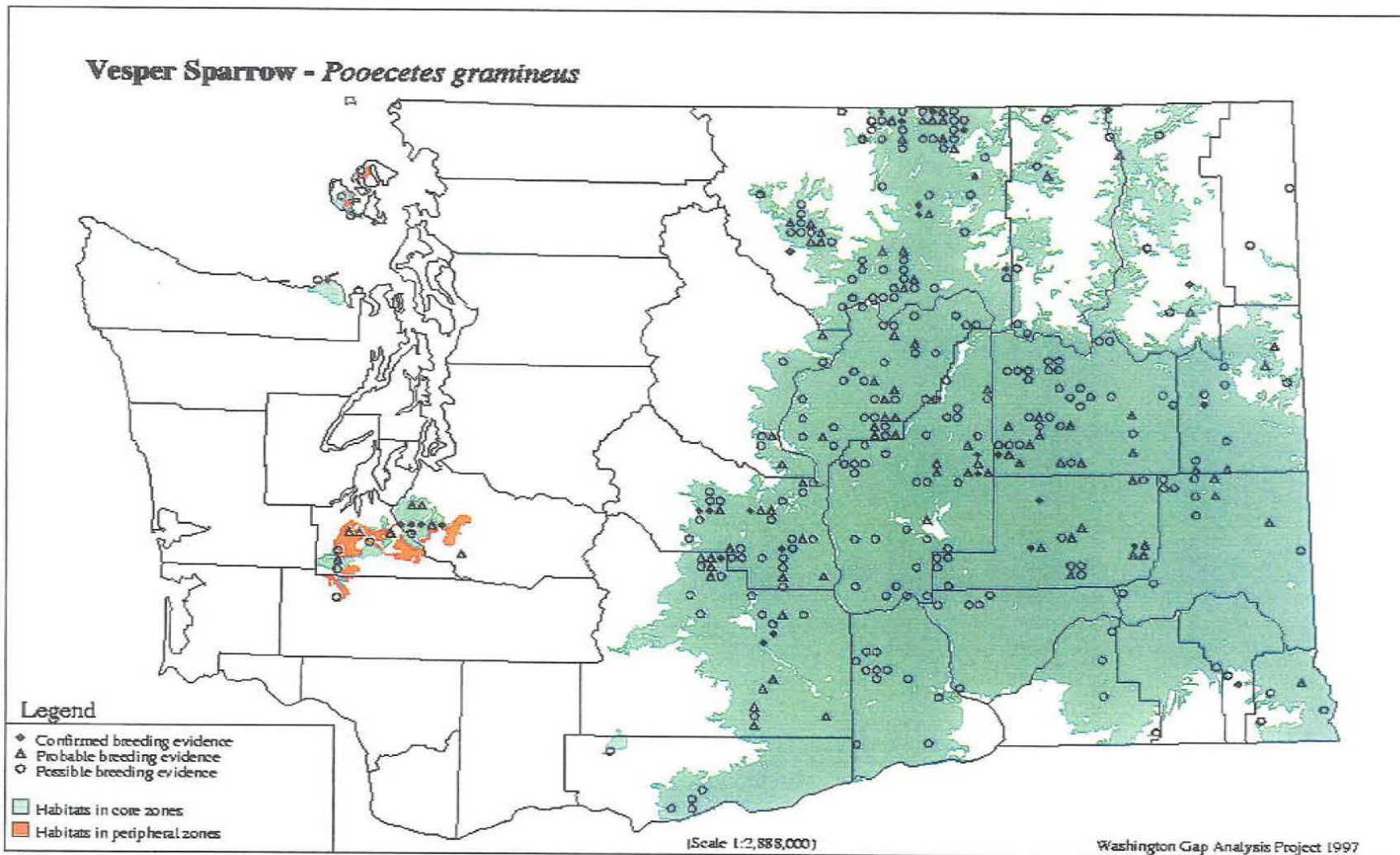
The Oregon vesper sparrow, one of three subspecies of vesper sparrow, breeds west of the Cascade Range, from British Columbia south to southwest Oregon (ODFW 1996). The birds winter from central California south to Mexico. In western Washington, Oregon vesper sparrows were historically common in grasslands, pastures, and farmlands (PIF 2001). However, the subspecies has become rarer, and in the Puget Lowlands, stable populations of Oregon vesper sparrows are known to occur only in the San Juan Islands and on the grasslands of Fort Lewis Military Reservation/McChord Air Force Base (Smith et al. 1997; Rogers 2000; PIF 2001) (Figure 3-4). Small populations of Oregon vesper sparrows have also been documented in Shelton, Scatter Creek, and the Mima Prairie (Smith et al. 1997). Potential factors in the birds' decline include changes in farming practices that resulted in reduction of fence row vegetation and other suitable perch sites, as well as reduction in weedy areas that provide cover (ODFW 1996). Habitat loss from urbanization is another key factor. According to Smith et al. (1997), the Oregon vesper sparrow is in danger of being extirpated from Washington State.

3.2.4.3 Life History

Oregon vesper sparrows usually arrive on their breeding grounds in early to mid-April and migrate south in late August (Rogers 2000). Nest site preferences for the subspecies are not known, although the species is known to construct ground nests under dead or live vegetation and near clods of soil, patches of bare ground, and other sparsely vegetated areas (Dechant et al. 2001). The birds' diet consists of insects and grass and forb seed (Ehrlich et al. 1988).

3.2.4.4 Habitat Associations/Requirements

Habitat associations for the Oregon vesper sparrow are based primarily on a study by Altman (1999, as summarized in PIF 2001) in agricultural grasslands in the Willamette Valley. Altman (1999, as



*Distribution of the Oregon vesper sparrow includes areas in the western portion of the state only.
 Source: Washington State Department of Fish and Wildlife, Gap data products (WDFW 2002e).

Figure 3-4. Vesper Sparrow Breeding Distribution In Washington State

summarized in PIF 2001) found that the birds occurred almost exclusively in the following two habitat types: (1) light to moderately grazed pastures with scattered shrubs and trees and with grass less than 2 ft in height (preferably less than 1 ft in height); and (2) Christmas tree farms, particularly those with scattered young trees and with a mixture of grasses, forbs, and bare ground. Presence of woody vegetation near nest sites was an important habitat factor in Altman's study, and nest sites averaged approximately 20 ft from the nearest tree/shrub. Nesting territories averaged 3.1 ac in size, and nesting pairs occurred within small habitat patches (i.e., less than 15 ac). Average ground cover values within nesting territories were as follows: 88 percent grass/forb, 6 percent shrub/tree, and 6 percent bare ground. Historic accounts of Oregon vesper sparrows indicate that they were often found along fence rows and pastures (Gabrielson and Jewett 1940). In an Oregon vesper sparrow foraging behavior study on Fort Lewis Military Reservation, Rogers (2000) found that the mean vegetation height of foraging areas was approximately 6 inches.

Studies of other vesper sparrow subspecies indicate habitat associations with short grass or weedy cover with singing perches (e.g., trees, shrubs, fences, or high weeds) (ODFW 1996; Dechant et al. 2001). In their summary of vesper sparrow habitat in the United States and southern Canada, Dechant et al. (2001) report that the species prefers "dry, open areas with short, sparse, and patchy vegetation ... but may be found in a variety of habitats, including shortgrass, mixed-grass, and tallgrass prairie; semidesert grasslands; sagebrush (*Artemesia*); pastures; hayland; planted cover; cropland; shrubby grasslands; old fields; orchards; woodland edges; shelterbelts; highway rights-of-way; and jack pine (*Pinus banksiana*) barrens." Reported average territory size for the species ranges from 1.2 to 8.8 ac (Dechant et al. 2001).

3.2.4.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Oregon vesper sparrows are known to breed along the border of the north unit of the Scatter Creek Wildlife Area (Grosboll 2002). In addition, biologist Russell Rogers (Rogers 2000) observed a singing male along Goddard Road SW in 1999 but didn't observe any other vesper sparrows in his surveys that included portions of the potentially suitable habitat in the Scatter Creek Watershed. Paul Hicks, a local resident and experienced birder, reports that singing Oregon vesper sparrows have been sighted on the Alpaca Farm at Rock Prairie, most recently in May and June 2000 (Hicks 2002 personal communication). No other recent sightings of the subspecies have been documented in the Scatter Creek watershed. In addition to the known sightings, Oregon vesper sparrows also may occur at Christmas tree farms in the watershed and in grasslands, pastures, and fields that contain adequate perch sites. The Scatter Creek GIS vegetation data identifies approximately 8,205 ac of grasslands and other open vegetation types. Areas near the watershed where nesting Oregon vesper sparrows have been documented include Fort Lewis Military Reservation, McChord Air Force Base, the Olympia Airport, Bucoda Christmas Tree Farm on Skookumchuck Road, Mima Mounds Natural Area Preserve, and Glacial Heritage County Park (Rogers et al. 1997; Rogers 2000; WDFW 2002b; Chappell 2003a).

3.2.4.6 Threats

The most obvious threat to Oregon vesper sparrow habitat in the Scatter Creek watershed is habitat loss and fragmentation from development. Invasion of Scot's broom and conifers into open areas also threatens vesper sparrow habitat, depending on the degree of invasion. Scattered Scot's broom and conifers may provide perch sites, while dense Scot's broom cover and forests do not provide the open habitat conditions that Oregon vesper sparrows require. Other land management activities that remove potential perch sites also are threats to Oregon vesper sparrow habitat. Human activity and disturbance may limit potential habitat for the birds, and depending on timing, mowing may threaten nesting vesper sparrows by destroying ground nests.

3.2.4.7 Special Needs

Recommendations for providing habitat for Oregon vesper sparrows, as provided by Partners in Flight (PIF 2001), include the following:

- Initiate actions in native grasslands, pastures, and fallow fields to maintain or provide scattered shrub cover of 5 to 15 percent, variable grass heights less than 18 inches tall with some areas of bare or sparsely vegetated ground, and patches of suitable habitat greater than 20 ac. According to Partners in Flight (PIF 2001), habitat patches greater than 20 ac may be sufficient to maintain a small Oregon vesper sparrow population even if the population is isolated.
- In addition, protection of nest sites from mowing or other nest-destroying activities and freedom from substantial human disturbance, particularly near nest sites, are also important for factors for maintaining Oregon vesper sparrows.

3.2.5 Slender-billed White-breasted Nuthatch

3.2.5.1 Legal Status

The slender-billed white-breasted nuthatch (*Sitta carolinensis aculeata*) is a federal species of concern and a state candidate species.

3.2.5.2 Population Status and Distribution

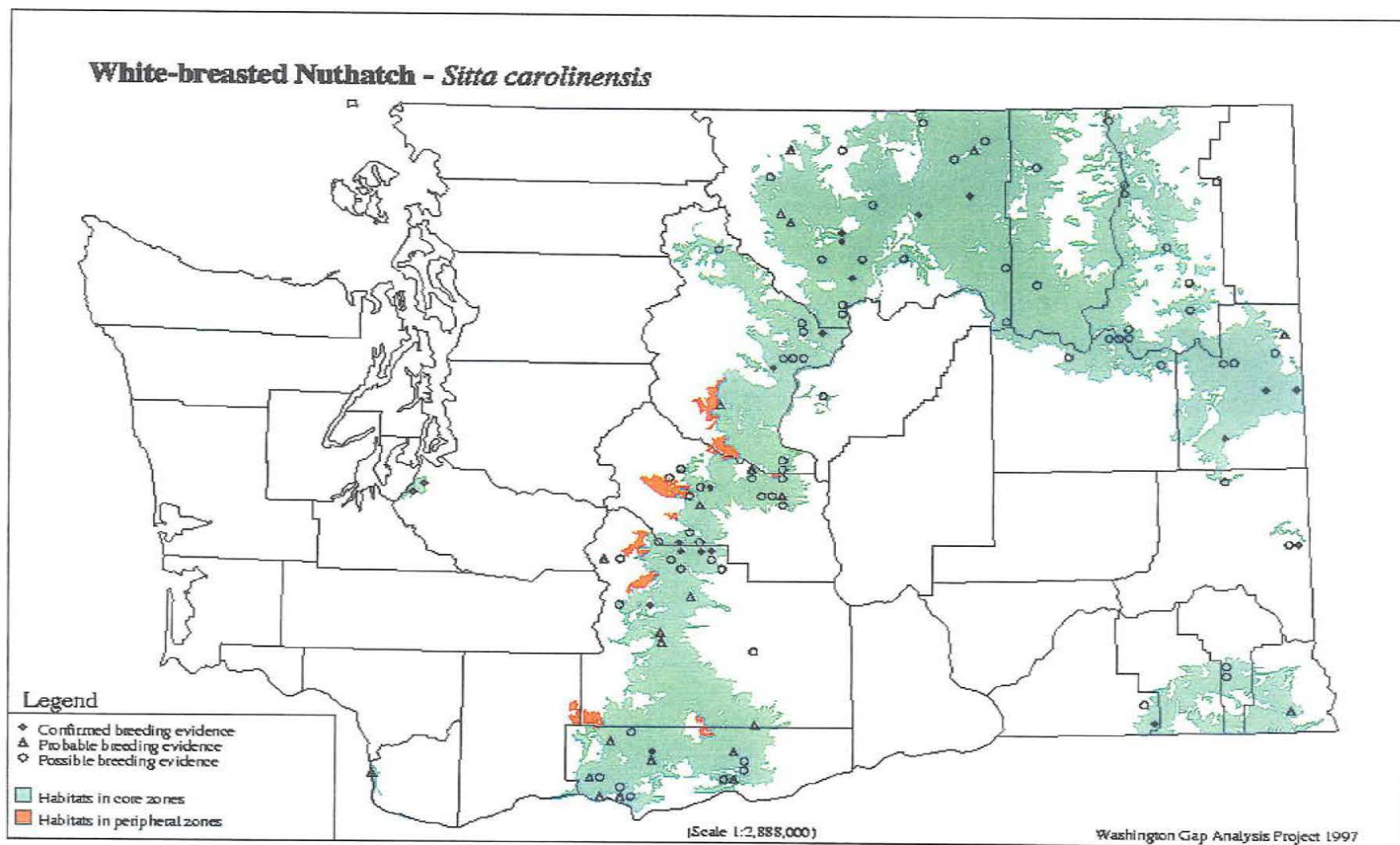
The slender-billed white-breasted nuthatch is a subspecies of the white-breasted nuthatch and ranges from the lowlands of northwestern Washington to southwestern California and northern Baja California (Pravosudov and Grubb 1993). In western Washington, the subspecies is considered very rare, seriously declining, and mostly confined to the plains around Vancouver in Clark County (Smith et al. 1997) (Figure 3-5).

3.2.5.3 Life History

White-breasted nuthatches are generally nonmigratory and live in pairs within permanent territories (Pravosudov and Grubb 1993). Pairs breed once per year, and average clutch size is seven eggs (Pravosudov and Grubb 1993). As secondary-cavity nesters, white-breasted nuthatches use existing natural cavities or old woodpecker cavities for nesting (Jewett et al. 1953; Pravosudov and Grubb 1993). Large, old trees are preferred (Pravosudov and Grubb 1993). Timing of breeding is unknown, although eggs have been observed in early April (Jewett et al. 1953). Diet consists primarily of insects, although plant material is also consumed (Pravosudov and Grubb 1993).

3.2.5.4 Habitat Associations/Requirements

The slender-billed white-breasted nuthatch occurs in oak and oak-conifer woodlands (Smith et al. 1997). Abundance is positively correlated with diameter of oak, dominance of oak, and stand size (PIF 2001). Information on territory size for the subspecies is not available. However, territory size for one of the inland subspecies is estimated at 25 to 37 ac in wooded areas and 50 ac in semi-wooded areas (Pravosudov and Grubb 1993). PIF (2001) recommends providing contiguous patches of oak woodlands in stands greater than 100 ac to provide habitat for the species. PIF (2001) also provides guidelines for oak size, canopy closure, and landscape composition, as described under Special Needs (Section 3.2.5.7).



*Distribution of the slender-billed white-breasted nuthatch includes areas in the western portion of the state only. Note that since the time of development of the map, no confirmed sightings of the birds have been documented in the southern Puget Sound (Chappell 2003b).
 Source: Washington State Department of Fish and Wildlife, Gap data products (WDFW 2002f).

Figure 3-5. White-Breasted Nuthatch Breeding Distribution in Washington

3.2.5.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

The slender-billed white-breasted nuthatch was once a resident of the Scatter Creek watershed. Confirmed sightings of the subspecies have not been reported in the watershed since 1980. However, Wendi Meador reports observing a white-breasted nuthatch on her property, approximately ½ mile west of the Scatter Creek Wildlife Area, in April 2001 (Smith et al. 1997). In bird surveys conducted on Fort Lewis Military Reservation and McChord Air Force Base from 1993 through 1996, no white-breasted nuthatches were sighted (TNC 1996; TNC and WNHP 1996). In addition, in the past approximately 5 years, the species has not been detected at any of the previously occupied sites in the Lakewood area (Chappell 2003b). The Scatter Creek watershed currently contains approximately 1,560 ac of oak and oak-conifer woodlands and forests, an unknown amount of which contains oaks of adequate size to provide potential habitat for slender-billed white-breasted nuthatches. There are no oak or oak-conifer patches greater than 100 ac, the minimum patch size recommended by PIF for the species.

3.2.5.6 Threats

Because the slender-billed white-breasted nuthatch appears to have been extirpated, or virtually extirpated, from the Scatter Creek watershed, threats pertain to issues regarding persistence of the species following reintroduction to the watershed. Given the fragmented nature and relatively small patch size of existing oak and oak-conifer woodlands with large oaks, as well as the relatively high levels of human activity, the ability of the watershed to support a reintroduced population is questionable.

If a population were reintroduced, key threats to the birds include continued habitat fragmentation and loss (through development, urbanization, fire suppression, and conversion of oak and oak-conifer habitats to conifer habitats) and human disturbance, especially near nest sites.

3.2.5.7 Special Needs

As mentioned above, the ability of the Scatter Creek watershed to support a reintroduced population of white-breasted nuthatches is questionable. Partners in Flight (PIF 2001) recommends the following to provide habitat for the subspecies:

- Contiguous patches of oak woodlands in stands greater than 100 ac.
- Oak stands with mean diameter-at-breast-height (dbh) of greater than 22 inches, with more than 20 percent of oaks with greater than 28-inch dbh.
- Mean stand-level canopy closure of 40 percent to 80 percent.
- Mean stand-level non-oak cover in canopy and subcanopy greater than 10 percent.
- No more than 10 percent of the landscape should be urban, residential, or high-density rural.

3.2.6 Western Gray Squirrel

3.2.6.1 Legal Status

The western gray squirrel (*Sciurus griseus*) is a federal species of concern in the State of Washington and is a state-listed threatened species. The USFWS is reviewing a petition to list the western gray squirrel as endangered or threatened under the Endangered Species Act.

3.2.6.2 Population Status and Distribution

Western gray squirrels occur from Washington south through Oregon and California and into the westernmost portion of Nevada (Verts and Carraway 1998). In Washington, the species has been eliminated from much of its former range and now occurs in three disjunct areas: (1) the Puget Trough; (2) Klickitat County, near the Columbia River and its tributaries; and (3) the northern Columbia River Basin, within Okanogan and Chelan Counties (Ryan and Carey 1995) (Figure 3-6).

The Puget Trough western gray squirrel population occurs primarily on the Fort Lewis Military Reservation and McChord Air Force Base. Extensive surveys for western gray squirrels were conducted on Fort Lewis in 1992-1993 and again in 1998-1999. Survey results indicate that the Puget Trough western gray squirrel population has declined severely in recent years (Bayrakçi et al. 2001). Potential causes of decline, as listed by Bayrakçi (1999, p. 34) include: "(1) poor acorn production and/or undependable food supplies; (2) drought and disappearance of water in many oak ecotones [i.e., transitional areas]; (3) death by motor vehicles; (4) competition with eastern gray and/or Douglas' squirrels; (5) reduction in oak habitat quality or quantity; (6) disease and/or parasites; (7) predation; and (8) military training."

3.2.6.3 Life History

Western gray squirrels are almost exclusively diurnal (active during the day) and are active year-round (Verts and Carraway 1998). They are considered an arboreal species (living in trees), although they forage predominantly on the ground (Ryan and Carey 1995a,b). Ryan and Carey (1995a, p. 12) report the diet of western gray squirrels on Fort Lewis as follows: "In general, . . . the diet consists of acorns from late summer through early spring; fungi, both mushrooms and truffles, mostly in spring and fall; Douglas-fir seed from late summer through fall; and succulent vegetation from late spring through early summer." Unlike other diet items, acorns and cone seeds gathered from late summer through fall can be stored for winter use (Ryan and Carey 1995a; Ryan 1997).

Western gray squirrels become sexually mature at 10 to 11 months, and most researchers believe that females produce one litter per year (Ryan and Carey 1995a). Breeding occurs from January to September in western Washington, and juveniles may be seen outside the nest starting around mid-March (Brown 1985; Ryan 1997). Tree cavities and stick nests are used for rearing young, as well as for winter den sites (Cross 1969; Maser et al. 1981; Foster 1992). The squirrels also construct platforms of leaves for temporary nests, summer nests, and alternative nests (Foster 1992). On Fort Lewis, stick and leaf nests were observed in Douglas-fir trees only (Ryan and Carey 1995a).

3.2.6.4 Habitat Associations/Requirements

The Puget Trough population of western gray squirrels is associated with mixed oak-conifer ecotones between Douglas-fir (*Pseudotsuga menziesii*) forests and prairies (Ryan and Carey 1995b, Bayrakçi et al. 2001). The mix of conifers (mostly Douglas-fir), oaks, and other hardwoods provides forage, cover, and nesting sites for the squirrels. Oak provides food (i.e., acorns), escape cover, and travel ways; and conifers provide year-round cover, nests sites, and cone seeds (Ryan and Carey 1995b). Both conifer and oak forests provide truffle forage for the squirrels. In their surveys on Fort Lewis Military Base, Ryan and Carey (1995b) found squirrels most often in oak-conifer stands at least 5 ac in size with an average tree composition of 34 percent oak, 53 percent Douglas-fir, and 13 percent other tree species, with a diversity of food-producing trees and shrubs (including big-leaf maple [*Acer macrophyllum*], Oregon ash [*Fraxinus latifolia*], and Indian plum [*Oemlaria cerasiformis*]). Adjacency of permanent water also was an important factor for detecting western gray squirrels on Fort Lewis: 84 percent of the 318 squirrel

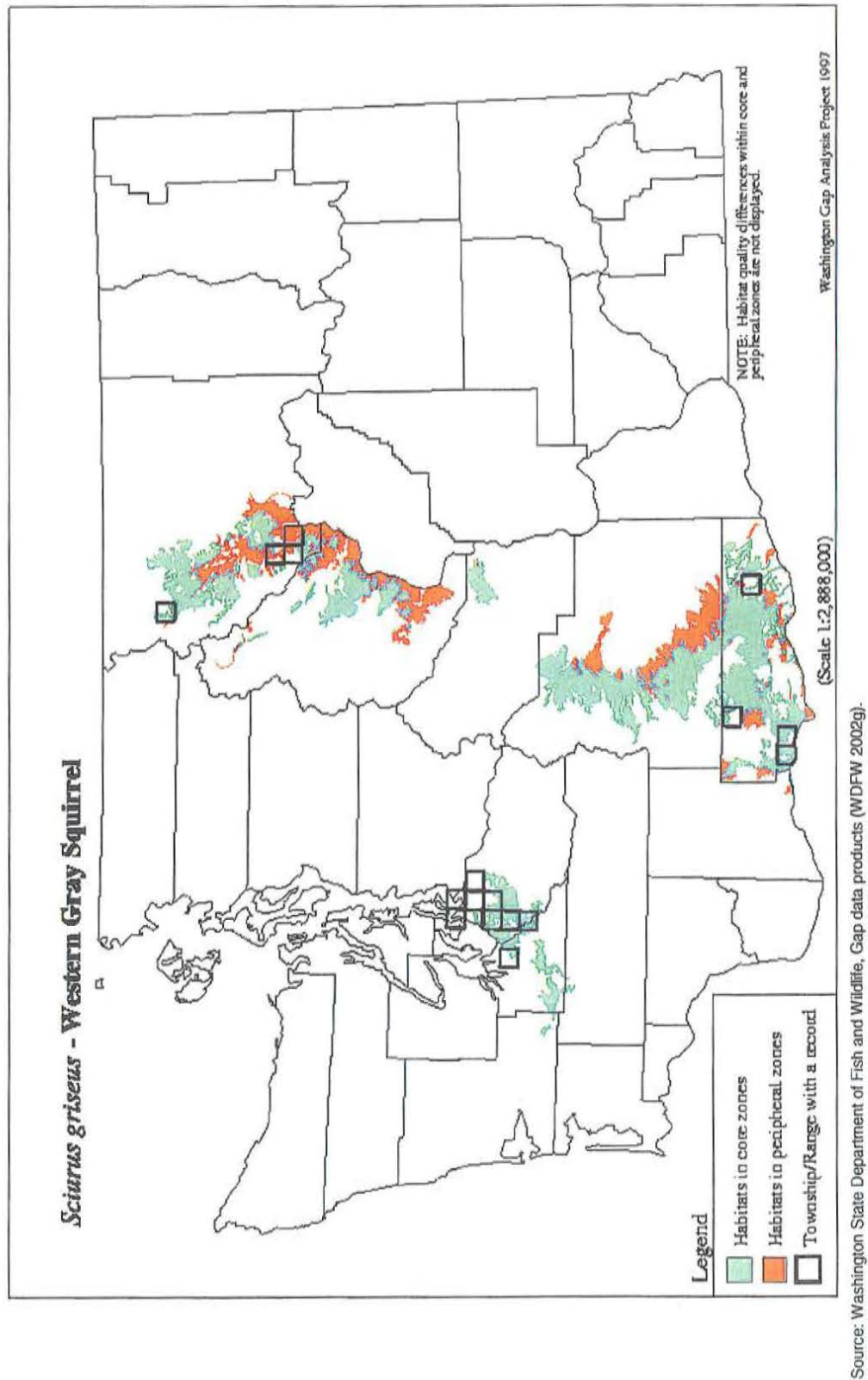


Figure 3-6. Western Gray Squirrel Distribution in Washington State

sightings by Ryan and Carey (1995b) were within approximately 425 yards (390 m) of water. Studies by Rodrick (1986) and Foster (1992) also indicate that proximity to water is an important habitat component for western gray squirrels. Home range estimates are not available for the Puget Trough western gray squirrel population.

3.2.6.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Western gray squirrels are not currently known to occur within the Scatter Creek watershed vicinity. The most recent confirmed western gray squirrel sightings in the watershed were at the Scatter Creek Wildlife Area in the 1980s (WDFW 2002b). In addition, landowners reported observing occasional western gray squirrels up until 2000: (1) Wendi Meador reported observations of western gray squirrels in 1999 on her property, approximately ½ mile west of the Scatter Creek Wildlife Area; (2) Bruce Morgan reported that in 1999, a western gray squirrel was using an abandoned building on his property, which is near Violet Prairie; and (3) Doug Sampson reported that he observed western gray squirrels from 1997 to 2000 on his property, near Rock Prairie.

The Scatter Creek watershed contains approximately 1,650 ac of oak and oak-conifer forests and woodlands that provide potential suitable habitat for western gray squirrels. Conifer forests near oak and oak-conifer habitats may also provide potential habitat for the squirrels. However, the fragmented nature of these forests and woodlands limits their quality as habitat for the species.

3.2.6.6 Threats

Because western gray squirrels appear to have been extirpated, or virtually extirpated, from the Scatter Creek watershed, threats described in this section pertain to issues regarding reintroduction and persistence of the species following reintroduction to the watershed.

If western gray squirrels become federally listed, reintroduction of the species to the Scatter Creek watershed would only be possible if studies determined that a genetically suitable source population was available for reintroduction.

If the species were reintroduced, various factors would threaten maintenance of a squirrel population in the area, including:

- Habitat fragmentation and loss: existing and continued habitat fragmentation and loss through development, urbanization, fire suppression, and conversion of oak and oak-conifer habitats to conifer habitats.
- Disturbance: western gray squirrels in Washington are sensitive to human disturbance, and unless a source of more tolerant squirrels (perhaps from Oregon) is deemed acceptable as a source population, human activity levels may preclude successful reintroduction. In addition, harassment by domestic dogs and cats could impact the squirrels.
- Vehicular traffic: mortality due to collisions with motor vehicles is a major threat to western gray squirrels (Ryan and Carey 1995b).
- Competition with eastern gray squirrels: some researchers have expressed concern that competition with eastern gray squirrels could negatively affect western gray squirrels (WDFW 1993). However, other researchers report no evidence for this type of effect (Bayrakçi 1999). Wendi Meador reports

observing eastern gray squirrels on her property, approximately ½ mile west of the Scatter Creek Wildlife Area sighting.

- Small population size: due to its small size and geographic isolation, the reintroduced population would be particularly susceptible to disease, low mast production (accumulation of nuts on the ground), and other environmental factors.

3.2.6.7 Special Needs

Protection needs for the western gray squirrel can be summarized as follows:

- Oak-conifer ecotones with a diversity of trees and/or shrubs for forage, preferably near water; in the study by Ryan and Carey (1995b) on Fort Lewis Military Reservation, over 92 percent of stands where western gray squirrels were observed were within 0.4 mile of water.
- Freedom from human disturbance.
- Protection from vehicular traffic.

Even with a variety of protection measures to prevent further oak and oak-conifer habitat loss and to control human disturbance and mortality from roadkill, the existing fragmented nature of oak and oak-conifer habitats in the watershed and the levels of human activity may prevent the Scatter Creek watershed from supporting a reintroduced population of western gray squirrels, as mentioned above.

3.2.7 Mazama Pocket Gopher

3.2.7.1 Legal Status

The Mazama pocket gopher (*Thomomys mazama*), also referred to as the western pocket gopher, is a federal and state candidate species.

3.2.7.2 Population Status and Distribution

The Mazama pocket gopher occurs in the Olympic Mountains, the Puget Lowlands, western Oregon, and northwestern California (Verts and Carraway 1998) (Figure 3-7). Information from Dalquest and Scheffer (1944) indicate that in the Puget Lowlands during the 1940s, the species occurred as disjunct populations that occupied non-forested areas, primarily glacial-outwash grasslands. Witmer et al. (1996) speculate that the distribution of pocket gophers may have become more widespread in the Puget Lowlands over the past 50 years, due to extensive deforestation. However, others suggest that urbanization, loss of ecological processes (such as fire), and other factors have resulted in a reduction of the species' distribution and abundance (USFWS 2001).

3.2.7.3 Life History

Mazama pocket gophers are generally solitary animals that are active year-round. Breeding activity occurs in late winter/early spring, and females usually have one litter of four to six young each year (Maser et al. 1981). Young disperse in summer. Mazama pocket gophers maintain extensive burrowing systems that include shallow tunnels for gathering food and deep tunnels for shelter, nesting, food storage, and elimination of bodily wastes (Maser 1988). Diet consists of roots and bulbs, as well as aboveground vegetation, including forbs, grasses, and other plants (Maser 1998; Verts and Carraway 1998). In addition to humans, the main predators of Mazama pocket gophers are owls, coyotes (*Canis*

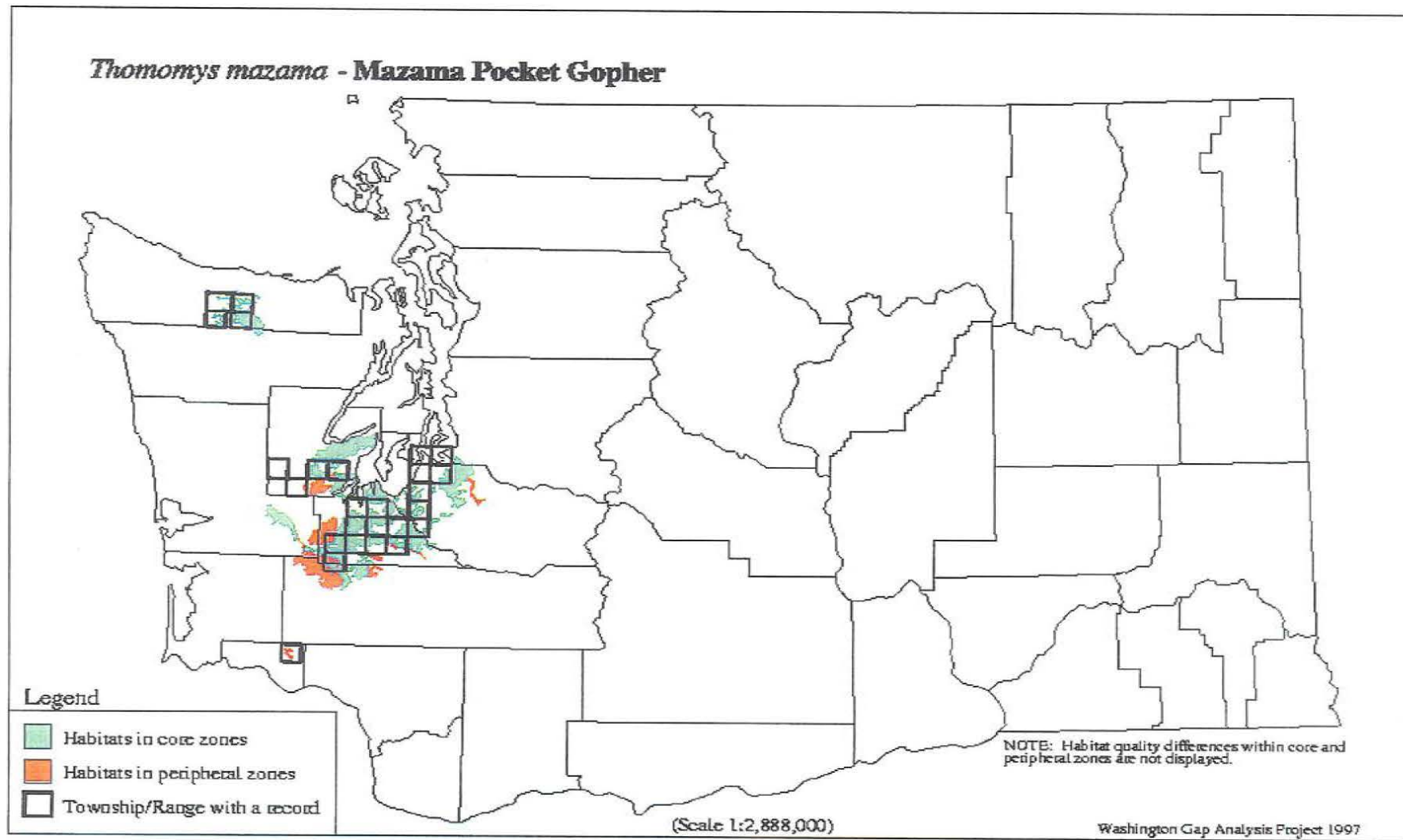


Figure 3-7. Mazama Pocket Gopher Distribution In Washington State

latrans), bobcats (*Lynx rufus*), long-tailed weasels (*Mustela frenata*), and domestic dogs and cats (Maser et al. 1981).

3.2.7.4 Habitat Associations/Requirements

In lowland areas, the Mazama pocket gopher occurs primarily in grassland habitats (Dalquest and Scheffer 1944; Maser 1998; USFWS 2001). Relatively dry, loose soils and substantial herb growth are important habitat components for the species (WDFW 1991). A study in the south Puget Sound found that pocket gophers were more likely to be present in grasslands with a relatively low density of rocks, compared to grasslands with a higher density of rocks (Steinberg 1996). While open forests with widely spaced trees are used by Mazama pocket gophers, dense forests are avoided. In a pocket gopher study at two sites near Olympia, the mean home range was approximately 1,160 square feet (ft²) for males and 1,040 ft² for females (Witmer et al. 1996).

3.2.7.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

In the vicinity of the watershed, Mazama pocket gophers have been documented on the Fort Lewis Military Reservation and adjacent lands, the Washington Department of Natural Resources (WDNR) nursery on Meridian Rd, Webster Tree Nursery on Lathrop Rd, the Olympia Airport and southwest of the airport, and near Bush Prairie (WDFW 2002b). Within the Scatter Creek watershed, Mazama pocket gophers have been documented on the South Unit of the Scatter Creek Wildlife Area, at two sites on Rock Prairie, and at one site near James Rd SW in the southwestern portion of the watershed (WDFW 2002b). Because surveys for the species have not been conducted in other parts of the watershed, their occurrence in these areas is unknown. Based on habitat, Mazama pocket gophers may occur in portions of the watershed that contain grasslands, pastures, and fields with dry, loose soil types (i.e., Nisqually loamy fine sand; Spanaway gravelly sandy loam; or Spanaway-Nisqually complex). Christmas tree farms may also provide habitat. Based on the Scatter Creek GIS vegetation data, the watershed contains approximately 6,940 ac of grasslands, pastures, and other open habitat types that are within dry, loose soil types. In addition to soils and vegetation, other potential factors influencing the current distribution of pocket gophers in the watershed include human activities (as described under Section 3.2.7.6).

3.2.7.6 Threats

The main threats to Mazama pocket gophers in the watershed are loss of habitat (through development and through conifer and Scot's broom encroachment into grasslands) and landowner intolerance (i.e., trapping and poisoning the animals). Plant diversity is important, so application of herbicides that kill broadleaf plants is detrimental to habitat suitability. Herbicide and pesticide use, heavy grazing (which removes gopher forage), and predation by domestic dogs and cats are also threats to the species.

3.2.7.7 Special Needs

Protection needs for the Mazama pocket gopher in the watershed include controlling development and other human activities to ensure the following conditions:

- Preservation of grasslands and other open areas with relatively dry, loose soils and substantial herb growth (restoration of these habitats is also a possibility).
- Elimination of human persecution (i.e., trapping or poisoning) and limited predation by domestic dogs and cats.

3.2.8 Oregon Spotted Frog

3.2.8.1 Legal Status

The Oregon spotted frog (*Rana pretiosa*) is a federal candidate species and is listed as endangered by the State of Washington.

3.2.8.2 Population Status and Distribution

The historic range of the Oregon spotted frog extended from southwestern British Columbia through western Washington and Oregon and into the northeast corner of California (McAllister and Leonard 1997). In Washington State, the species occurred in the lowlands in the western part of the state and in the southern portion of the Cascade Mountains (Figure 3-8). In the past 60 years, the Oregon spotted frog has experienced a dramatic decline and has disappeared from more than 90 percent of its probable former range (British Columbia Ministry 2002). Potential factors in the species' decline include habitat loss, hydrological alterations, changes in water quality, spread of nonnative plants, and introduction of nonnative animals (i.e., fish and bullfrogs) (McAllister and Leonard 1997). In Washington State, Oregon spotted frogs are currently known to occur in four locations: two in the south Puget Sound Lowlands (Dempsey Creek and Beaver Creek in the Black River watershed) and two in the Cascades (Conboy Lake and Trout Lake) (Luginbuhl et al. 2001) (see Figure 3-8).

3.2.8.3 Life History

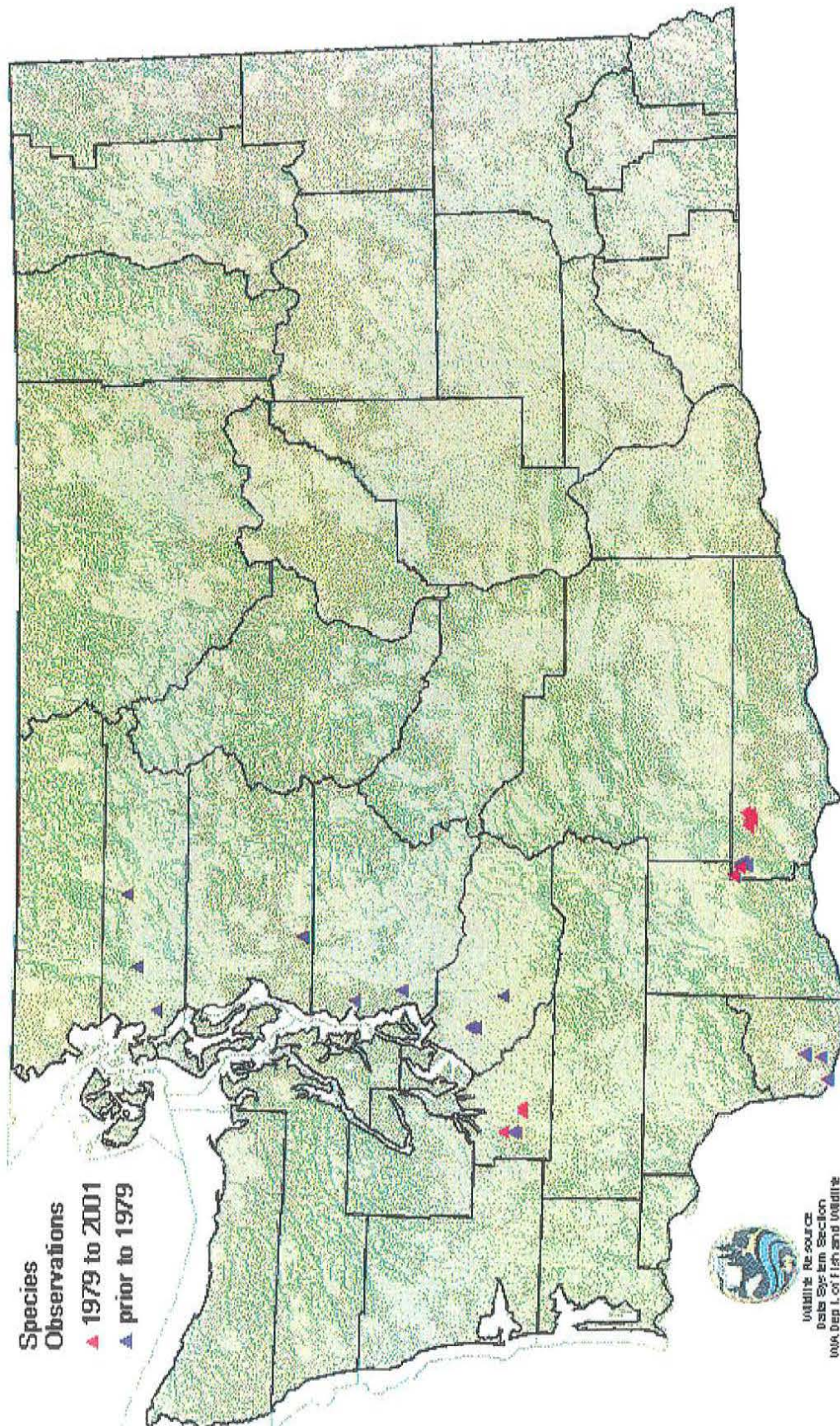
In lower elevation areas, Oregon spotted frogs begin breeding around February or March (Watson et al. 2000; Amphibia Web 2002). Eggs are laid communally, generally over a 2- to 3-week period. Egg masses are deposited in still, shallow waters with submergent herbaceous vegetation or emergent vegetation. Tadpoles emerge after a few weeks and metamorphose in their first summer or fall. Because breeding ponds are typically dry by mid- to late-summer, adults and juveniles move to deeper remnant pools during the dry season (June through August) and return to breeding areas and peripheral shallow areas during the wet season (generally September through January).

The diet of adult spotted frogs includes arthropods, earthworms, and other invertebrates. Tadpoles consume plant material, bacteria, algae, detritus, and probably carrion (Luginbuhl et al. 2001). Predators of adult frogs include mink, river otter, raccoons, herons, bitterns, corvids (crows and ravens), and garter snakes. Predators of eggs and tadpoles include dragonflies, beetles, fish, garter snakes, and herons and other wading birds (Amphibia Web 2002).

3.2.8.4 Habitat Associations/Requirements

Oregon spotted frogs are associated with relatively large wetland complexes that contain shallow, mostly unshaded emergent wetlands (Amphibia Web 2002). Breeding habitat consists of ponds that are usually 2 to 14 inches deep during the breeding season (February through May). As mentioned above in the life History section, deeper remnant pools are used during the dry season (June through August). A recent spotted frog study conducted at Dempsey Creek in the Black River watershed provides more detailed information on spotted frog habitat use and selection, as described further below (Watson et al. 2000).

At Dempsey Creek, frogs selected shallow waters with sedges and rushes during the breeding season. During the dry season, Douglas spirea (*Spiraea douglasii*) shaded and maintained remnant pools and therefore was an important vegetation component. The frogs preferred a moderate to high degree of water surface exposure (i.e., 50 percent to 75 percent), and dense reed canarygrass (*Phalaris arundinacea*) was avoided. Average water depth of areas where frogs were located was 7.5 inches (mean



Source: Washington Herp Atlas 2002.

Figure 3-8. Oregon Spotted Frog Distribution In Washington State

monthly range = 3.3 to 10.3 inches), with average surface temperatures of 14.7°C (mean monthly range = 5.6° to 19.1°C). Average home range, based on a sample size of four frogs, was 5.4 ac.

3.2.8.5 *Habitat and Occurrence in the Scatter Creek Watershed Vicinity*

Historic records and recent communications with spotted frog expert Kelly McAllister indicate no confirmed sightings of Oregon spotted frogs in the Scatter Creek watershed (McAllister 1995, 2002b; Dvornich et al. 1997). However, the extent of historic survey effort in the area is unknown. Based on the historic hydrologic patterns, the watershed likely contained limited areas with suitable habitat conditions (especially year-round open water) for the frogs. In recent years, survey effort for spotted frogs in the watershed has been limited to the Scatter Creek Wildlife Area (McAllister 2002b). Current habitat conditions for spotted frogs in Scatter Creek are generally poor, due to extensive invasion by reed canarygrass and limited shallow, open, ponded areas for egg-laying and development (McAllister 2002b.). In addition, the scarcity of open water during the dry season may limit potential spotted frog habitat in the area.

3.2.8.6 *Threats*

Potential spotted frog habitat in the Scatter Creek watershed has been impacted by invasion of reed canarygrass, and this nonnative plant continues to be a threat. In addition, human activity in the watershed has resulted in changes to the hydrology of Scatter Creek, which has changed the availability of permanent water for the frogs in many locations. Continued human development could impact potential spotted frog habitat through changes in water quality and quantity. Nonnative fish and bullfrogs are also predatory threats to the frogs. Sunfish are known to occur in the watershed, although the presence of other nonnative fish and bullfrogs is unknown. Depending on intensity levels, grazing can affect potential spotted frog habitat. Light grazing can have beneficial effects by helping to control reed canarygrass, while intensive grazing can cause inadequate aquatic vegetation cover and water quality degradation.

3.2.8.7 *Special Needs*

Success of protection and habitat restoration/enhancement needs for the Oregon spotted frog in the Scatter Creek watershed would be limited by the soils and include the following:

- Provide additional areas of shallow (i.e., 2 to 14 inches deep during February through May), slow-moving or still water with sedges, rushes, and adequate water surface exposure (i.e., 50 to 75 percent) for egg deposition sites.
- Provide additional areas of permanent water for year-round refuge (these areas should be located near areas suitable for egg deposition). Note that large emergent wetland complexes are generally not sustainable in this watershed because of permeable soils. Consequently, establishing adequate quantities of this habitat type to support an Oregon spotted frog population may not be feasible.
- Prevent or control predation by bullfrogs and nonnative fish.

3.2.9 Mardon Skipper

3.2.9.1 Legal Status

The mardon skipper butterfly (*Polites mardon*) is a federal candidate species and a state-listed endangered species.

3.2.9.2 Population Status and Distribution

The mardon skipper, a dull orange and brown skipper, is now one of Washington State's rarest butterflies (Dunn and Fleckenstein, in Dunn and Ewing 1997). Mattoon et al. (1998) proposed that the mardon skipper be separated into two subspecies, the Washington subspecies (*Polites mardon mardon*) and the Oregon/California subspecies (*Polites mardon klamathensis*) (Mattoon et al. 1998). This report focuses on the Washington mardon skipper in the south Puget Sound grasslands, though the mardon skipper is also found in the southern Cascades. Figure 3-9 provides the distribution of the mardon skipper within Washington State. We now have information from three known sites in the Puget Trough and approximately 40 sites have been identified in the southern Cascades of Washington (USFWS 2003). Two of the three extant south Puget Sound sites are within the Scatter Creek watershed. The mardon skipper has a declining global trend (NatureServe Explorer 2001), and the south Puget Sound population is seriously threatened with extinction due to small population size, limited distribution, isolation, and the numerous factors threatening the species and its remaining habitat (Potter et al. 1999). On December 10, 2002, The Xerces Society and other conservation organizations petitioned the USFWS to list the mardon skipper as threatened or endangered under the Endangered Species Act.

3.2.9.3 Life History

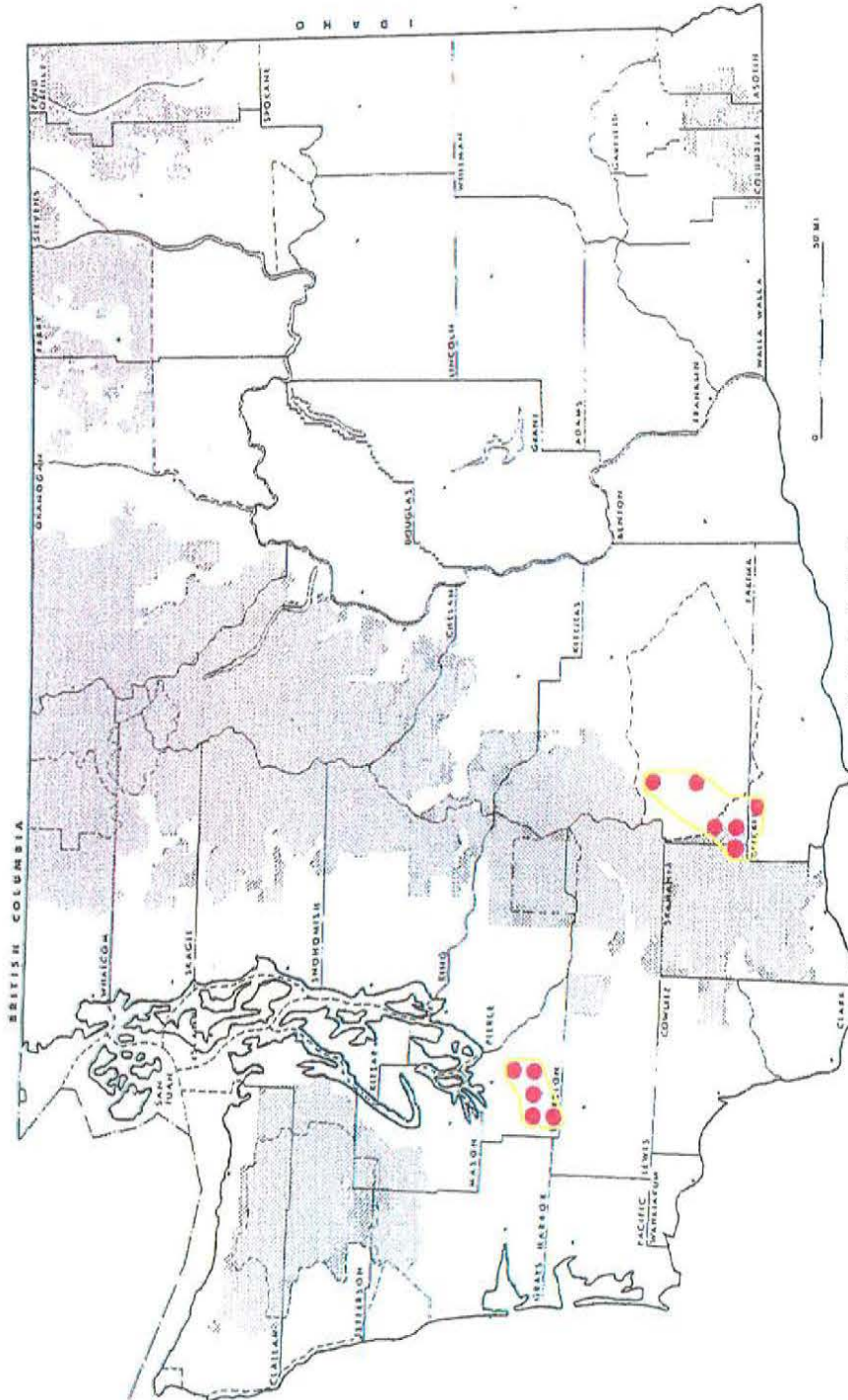
Mardon skippers complete one life cycle annually, with adults in the south Puget Sound typically emerging in May and being active for approximately 1 month. Dispersal distance is unknown, but is believed to be limited (Potter et al. 1999). The larval food plant for this species is Roemer's fescue and possibly red fescue (*Festuca rubra*). Males perch and wait to seek females for mating (Opler 1995). Following mating, females deposit eggs on native fescues (*Festuca* spp.) where the eggs later hatch (Potter et al. 1999). Larvae feed and entirely exist on fescue grass at ground level for about 3 months during the spring and early summer, and pupae hibernate as a chrysalis from late summer through early spring. Adult butterflies in the south Puget Sound region typically feed on nectar from early blue violet (*Viola adunca*), but may also obtain nectar from common vetch (*Vicia sativa*), prairie lupine (*Lupinus lepidus*), and Idaho blue-eyed grass (*Sisyrinchium idahoense*). Adults in the southern Cascades feed on nectar from vetch (*Vicia* spp.), penstemon (*Penstemon* spp.), sego lily (*Calochortus* spp.), and wallflower (*Erysimum capitatum*) (Potter et al. 1999).

3.2.9.4 Habitat Associations/Requirements

South Puget Sound populations inhabit glacial outwash grasslands dominated by Roemer's fescue, generally avoiding areas with tall pasture grasses. The southern Cascades populations are found in open, grassland sites dominated by Roemer's fescue within the Ponderosa pine (*Pinus ponderosa*) savanna/woodland (Potter et al. 1999). Other plants commonly associated with the mardon skipper include any of the nectar plants. Results from Hays et al. (2000) show habitat selection by the mardon skipper was for higher-quality patches (dominated by Roemer's fescue) within a landscape mixed with high-quality and disturbed habitat.

MARDON SKIPPER

Polites mardon



Source: Hinchliff (1996)

Figure 3-9. Mardon Skipper Butterfly Distribution in Washington State

3.2.9.5 *Habitat and Species Occurrence in the Scatter Creek Watershed Vicinity*

Mardon skipper habitat in the Scatter Creek watershed is typical for south Puget Sound region populations consisting of native grasslands dominated by Roemer's fescue. Historically, this species was likely found in all grasslands containing Roemer's fescue (Potter 2002 personal communication). There are three areas where this butterfly has been documented within the Scatter Creek watershed. Two areas are in the northwestern portion of the watershed (west of Interstate 5), and one area is in the southeastern portion of the watershed (east of Interstate 5) (WDFW 1998; Potter 2002 personal communication; The Evergreen Aurelians 1996). The last recorded observance of this butterfly at the two areas in the northwestern portion of the watershed was in 2002, and the last recorded observance of this butterfly at the area in the southeastern portion of the watershed was in 1992 (Potter 2002 personal communication; The Evergreen Aurelians 1996).

3.2.9.6 *Threats*

General Threats

Significant threats to mardon skipper populations generally include loss and degradation of their habitat. This includes human-related disturbance (land conversion of grassland to agriculture or development), invasions of exotic plants including nonnative grass species, and encroachment of shrubs and Douglas-fir. Other threats include herbicide treatment (affecting host plants), insecticide treatment targeting other invertebrates (inadvertently affecting nontarget butterflies), grazing, and recreational activities such as walking, horseback riding, and off-road vehicle driving. Indiscriminant use of prescribed fire can also be detrimental to small populations. Historically, frequent, low-intensity fires contributed to the process of grassland maintenance. However, direct contact with fire is likely lethal to mardon skippers. Prescribed fire may be a helpful grassland restoration practice; however, special effort must be made to avoid or greatly minimize the burn footprint in areas occupied by mardon skippers. In addition, some populations may be susceptible to overcollection.

Specific Threats Within the Watershed

Factors that degrade mardon skipper obligate grasslands and further loss and fragmentation of habitat limit this species (Pyle 1989; Larsen et al. 1995). Factors affecting continued existence for south Puget Sound sites include nonnative plants, agricultural practices, development, fire, recreational activities, pesticides, grazing, collection, and natural succession (Potter et al. 1999). Large portions of historic native grasslands within the Scatter Creek watershed have been altered by land conversion and development, and this threat is ongoing. Infestations by nonnative plant species, especially Scot's broom and nonnative grasses, have established in many of these remaining grasslands and pose a threat. Encroachment by Douglas-fir from natural succession and the use of herbicide treatments threaten mardon skipper habitat within the watershed.

3.2.9.7 *Special Needs*

The protection of native grasslands and associated plant species (Roemer's fescue and early blue violet) is critical to the survival of this species since this butterfly is nonmigratory. Development (roads, houses, and other structures) and agriculture have fragmented and isolated the remaining grasslands. Protection should include prevention or reduction of further development and agricultural sprawl. Protection of associated plant species requires management of nonnative plants without causing adverse effects to butterflies. Methods should include the judicious application of pesticides and carefully prescribed small-scale burns that avoid or minimize fire in mardon skipper high-density areas. Recreation and other uses

that disturb soil and native vegetation should also be minimized or reduced. Special efforts should be undertaken to restore grassland sites by reestablishing native fescues and forbs.

3.2.10 Puget Blue Butterfly

3.2.10.1 Legal Status

The Puget blue butterfly (*Plebejus icarioides blackmorei* or *Icaricia icarioides blackmorei*) has no federal status and is a state candidate species.

3.2.10.2 Population Status and Distribution

The Puget blue butterfly is endemic to the Pacific Northwest, with populations limited to Vancouver Island south to meadows near the Olympic Mountains and grasslands in the south Puget Sound. These butterflies have been recorded in only 11 Washington locations, including six populations in the Puget Sound prairie areas (Dunn and Fleckenstein, in Dunn and Ewing 1997). Figure 3-10 provides the distribution of the Puget blue butterfly within Washington State. Although colonial, Puget blue butterflies are typically not rare where they occur (Pyle 1989; Larsen et al. 1995). Status trends are unknown; however, this subspecies is globally ranked vulnerable to imperiled, meaning vulnerable to very vulnerable to extinction or elimination (DNR, WNHP 2002a).

3.2.10.3 Life History

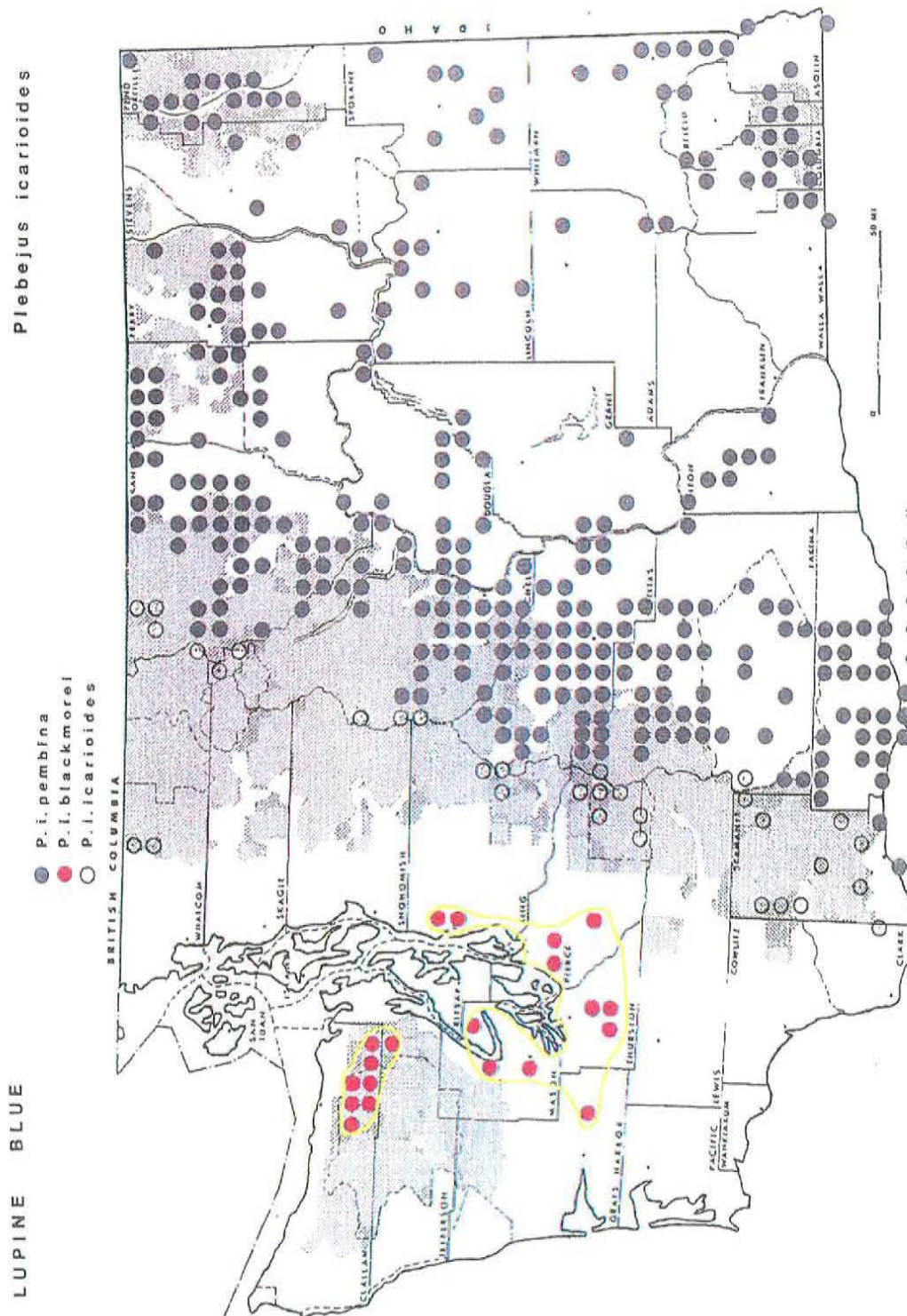
Puget blue butterflies are nonmigratory and complete one life cycle annually, with adults flying in mid-May to June. Puget blue butterflies can be identified by their silvery-blue upperside with wide dark borders, small black spots on the underside of the forewing, and absence of black spots from the underside of the hindwing (Scott 1986). During the day, males patrol for females near sickle-keeled lupine (*Lupinus albicaulis*), which is where south Puget Sound females lay their eggs. Larvae exist entirely on or near sickle-keeled lupine, feeding on leaves, flowers, and seedpods. Larvae have a mutualistic relationship with ants. This interaction involves ants defending the butterfly larvae in exchange for harvesting a sugary substance secreted by the larvae (Hays et al. 2000). Second-stage larvae hibernate, usually in litter (Scott 1986). Adult butterflies typically feed on nectar from unopened flowers of sickle-keeled lupine, but may also feed on other lupines (*Lupinus* spp.), the introduced common vetch (*Vicia sativa*), and the native manroot (*Marah oreganus*) (Hays et al. 2000). Arctic lupine (*Lupinus latifolius*) is also a known host plant for Puget blues, but this plant is not known to occur in the south Puget Sound prairies (Pyle 1989; Barrett 1986 in Hays et al. 2000). Arctic lupine may be a larval food plant in other portions of the Puget blue's range.

3.2.10.4 Habitat Associations/Requirements

Habitat for Puget blue butterflies includes Puget Sound grasslands and adjacent forest edges, powerline cuts, unsprayed railroad rights-of-way, and other forest clearings containing the host lupine (Hays et al. 2000). This subspecies is strongly associated with its host plant, sickle-keeled lupine.

3.2.10.5 Habitat and Species Occurrence in the Scatter Creek Watershed Vicinity

Typical south Puget Sound native grasslands containing sickle-keeled lupine provide potential habitat within the Scatter Creek watershed. Historically, this subspecies was likely found in all native grassland areas within the watershed (Potter 2002 personal communication). This butterfly has been documented at three locations within the Scatter Creek watershed: two areas in the northwestern portion of the



Source: Hinchliff (1996)

Figure 3-10. Puget Blue Butterfly Distribution In Washington State

watershed (west of Interstate 5), and one area in the southeastern portion of the watershed (east of Interstate 5) (WDFW 1998; Potter 2002 personal communication; The Evergreen Aurelians 1996). This butterfly was last observed in 2002 at the northwestern location and last observed in 1983 at the southeastern location (Potter 2002 personal communication; The Evergreen Aurelians 1996).

3.2.10.6 Threats

General Threats

The most common threats to this butterfly's survival are human related. This includes land conversion of grassland to agriculture or development; recreational activities such as walking, horseback riding, and off-road vehicle driving; herbicide treatment (affecting host plants); and insecticide treatment targeting other invertebrates (inadvertently affecting nontarget butterflies). Other threats to habitat are grazing, nonnative plant species infestations including nonnative grasses, and shrub and Douglas-fir encroachment. Indiscriminate use of prescribed fire may also be detrimental to small populations. Historically, frequent, low-intensity fires contributed to the process of grassland maintenance. However, direct contact with fire is likely lethal to Puget blues. Prescribed fire may be a helpful grassland restoration practice; however, special effort must be made to avoid or greatly minimize the burn footprint in areas occupied by Puget blues. Small Puget blue populations may be adversely affected by overcollection.

Specific Threats Within the Watershed

Specific threats to the Puget blue butterfly in the Scatter Creek watershed are further loss and fragmentation of habitat through conversion of grassland to agricultural production or development, grazing, encroachment of shrub and Douglas-fir, nonnative plant infestations (Scot's broom and nonnative grasses) and herbicide treatment. The host plant, lupine, is particularly threatened in pastures because it is targeted for removal due to toxicity to livestock. Individuals are also threatened directly by fire, recreational activities, insecticide spraying treatments, and collection.

3.2.10.7 Special Needs

Protection and restoration of lupine stands to increase this plant's numbers, patch size, and distribution, is critical to the preservation of Puget blue butterflies. Larsen et al. (1995) recommends maintaining lupine stands and controlling succession by cutting and/or burning. Protection of associated plants requires management of nonnative plants without causing adverse affects to butterflies. Methods should limit pesticide use and include carefully prescribed small-scale burns that avoid or minimize fire in Puget blue high-density areas. Recreation and other uses that disturb soil and lupine patches should also be minimized or reduced, especially during July through May when larvae are located near the base of the plant, just under the soil surface.

3.2.11 Taylor's (Whulge) Checkerspot

3.2.11.1 Legal Status

The Taylor's checkerspot butterfly (*Euphydryas editha taylori*), a subspecies of Edith's checkerspot, is a federal and state candidate species.

3.2.11.2 Population Status and Distribution

The Taylor's checkerspot has a current distribution ranging from Hornsby Island, British Columbia to the San Juan Islands south through the Puget Trough and southwest Washington to Oregon's Willamette Valley (Pyle 2002). The historic range and abundance of this butterfly is not precisely known because exhaustive surveys did not occur until recently. However, before its dramatic decline, the Taylor's checkerspot was recorded at more than 70 sites in British Columbia, Washington, and Oregon, with 33 sites located in Washington (Xerces Society 2002b). Based on 2002 surveys, only four populations remain: one in Oregon and three in Washington (all populations are believed extirpated from British Columbia). The three remaining populations in Washington contain less than 50 individuals (Xerces Society 2002b). Figure 3-11 provides the distribution of the Taylor's checkerspot butterfly within Washington State. On December 10, 2002, The Xerces Society and other conservation organizations petitioned the USFWS to list the Taylor's checkerspot as threatened or endangered under the Endangered Species Act.

3.2.11.3 Life History

Like all subspecies of Edith's checkerspot, the Taylor's checkerspot completes one life cycle annually. Flight period for this nonmigratory butterfly ranges from late April through early June. According to Scott (1986), 1 week is the average adult life span for Edith's checkerspots. Taylor's checkerspots generally disperse only about 200 to 300 feet from where they emerge (CWS 2002). Adult males seek females throughout the day by either perching or patrolling the associated habitat containing host plants. English plantain (*Plantago lanceolata*) and the native harsh paintbrush (*Castilleja hispida*) have been identified as plants used for laying eggs and larval food (Hays et al. 2000). Females lay eggs on the underside of leaves of host plants (Opler et al. 1995). Immature life forms exist entirely at or near the soil surface, and overwinter as larvae. Before hibernating, larvae live in loose silk webs for the first three stages as a caterpillar with a diet consisting primarily of host plant leaves and occasionally flowers or the rest of the host plant. Common camas (*Camassia quamash*) and nine-leaved lomatium (*Lomatium triternatum*) have been previously identified as adult nectar sources (Hays et al. 2000). Additional nectar plants include sea blush (*Plectritis congesta*), Deltoid balsamroot (*Balsamorhiza deltoidea*), and spring-gold (*Lomatium utriculatum*).

3.2.11.4 Habitat Associations/Requirements

Taylor's checkerspots require open grassland areas containing both host and nectar plants. Typical habitats include maritime prairies and shorelines along the Strait of Juan de Fuca, open island prairies dominated by native vegetation, and post-glacial gravelly outwash prairies of the Puget Trough and Willamette Valley (Larsen et al. 1995).

3.2.11.5 Habitat and Species Occurrence in the Scatter Creek Watershed Vicinity

Habitat within the Scatter Creek watershed includes typical south Puget Sound grassland areas with English plantain, harsh paintbrush, common camas, and nine-leaved lomatium. Oregon white oaks (*Quercus garryana*) are commonly found within or surrounding these grasslands. Historic populations of this subspecies likely inhabited all native grassland areas within the watershed (Potter 2002 personal communication). Currently, Taylor's checkerspot populations have been documented to occur at three locations in the watershed: two areas in the northwestern portion of the watershed (west of Interstate 5), and one area in the southeastern portion of the watershed (east of Interstate 5) (WDFW 1998; Potter 2002 personal communication; The Evergreen Aurelians 1996). This subspecies was last observed in 2000 at the two northwestern locations and last observed in 1986 at the southeastern location (Potter 2002 personal communication; The Evergreen Aurelians 1996).

3.2.11.6 Threats

General Threats

Loss of individuals and/or fragmentation of habitat are primarily threatened by human activities. The major human-related threats are land conversion of grassland to agriculture or development; recreational activities such as walking, horseback riding, and off-road vehicle driving; herbicide treatment (affecting host plants); and insecticide treatment targeting other invertebrates (inadvertently affecting nontarget butterflies). Other threats to habitat are grazing, nonnative plant species infestations including nonnative grasses, and succession of grasslands brought on by encroachment of shrubs and Douglas-fir. Indiscriminate use of prescribed fire may also adversely affect small populations. Historically, frequent, low-intensity fires contributed to the process of grassland maintenance. However, direct contact with fires is likely lethal to Taylor's checkerspot. Prescribed fire may be a helpful grassland restoration practice; however, special effort must be made to avoid or greatly minimize the burn footprint in areas occupied by Taylor's checkerspot. Overcollection of this species may also be detrimental to these small populations.

Specific Threats Within the Watershed

Threats within the watershed that potentially limit or diminish existing populations and cause further loss and/or fragmentation of habitat are the same as the general threats described above. These include threats to habitat such as grazing, conversion of land or development, nonnative plant infestations (Scot's broom and nonnative grasses), succession of grasslands, and herbicide treatment; and threats to individuals such as fire, recreational activities, insecticide spraying treatments, and collection. In addition, the larval food plant, harsh paintbrush, is an uncommon species within the south Puget Sound and may be susceptible to population reduction.

3.2.11.7 Special Needs

Protection of habitat and the restoration of harsh paintbrush to increase this plant's numbers, patch size, and distribution are critical to sustaining this butterfly's existence. Protection of associated plants requires management of nonnative plants without causing adverse effects to butterflies. Methods should limit pesticide use and include carefully prescribed small-scale burns that avoid or minimize fire in Taylor's checkerspot high-density areas. Human disturbance, including recreation and vehicle use, should be minimized to preserve grasslands from soil disturbance and protect Taylor's checkerspot from trampling.

3.2.12 Valley Silverspot

3.2.12.1 Legal Status

The valley silverspot butterfly (*Speyeria zerene bremnerii*) is a federal species of concern and a state candidate species.

3.2.12.2 Population Status and Distribution

The valley silverspot is a subspecies of the zerene fritillary and closely related to the federally threatened Washington State endangered Oregon silverspot (*Speyeria zerene hippolyta*). This butterfly was historically distributed from southwestern British Columbia south through the San Juan Islands, Puget Trough, northeastern Olympics, Willapa Hills, and western Cascades and Oregon's Willamette Valley. Populations in Oregon are extinct, and populations on the San Juan Islands are thought to be extinct.

(Dunn and Fleckenstein, in Dunn and Ewing 1997). Valley silverspot populations have been documented in 12 Washington locations, including eight Puget prairie populations (Dunn and Fleckenstein, in Dunn and Ewing 1997). Figure 3-12 provides the distribution of the valley silverspot butterfly within Washington State. Its population status documents declining concentrations of this subspecies in Washington (Pyle 1989; Larsen et al. 1995).

3.2.12.3 Life History

Valley silverspots are nonmigratory and complete one life cycle annually with a flight period from late June through mid-September. Males seek females by patrolling throughout the day. Adult females may hunt over turf for violet scent in late fall to lay eggs on or around the host plant, early blue violet (Pyle 2002). Unfed first-stage caterpillars overwinter on a thin silk mat and feed on early blue violet leaves upon emergence in spring. Immature life forms exist entirely at or near the soil surface on or around early blue violet. Nectar from white-top aster (*Aster curtus*) and the nonnative Canada thistle (*Cirsium arvense*) are major adult food sources in the Puget Sound grassland populations. Valley silverspots have also been observed eating nectar on showy fleabane (*Erigeron speciosus*) and less often on the nonnative tansy ragwort (*Senecio jacobaea*) (Hays et al. 2000).

3.2.12.4 Habitat Associations/Requirements

Habitat for valley silverspots includes open prairies, and in the Olympic Mountain Range, subalpine glades and mid-elevation roadsides and clearings (Pyle 1989; Larsen et al. 1995). These butterflies require abundant, high-density early blue violets and nectar plants, including white-top aster and Canada thistle (Dunn and Fleckenstein, in Dunn and Ewing 1997). As observed by Hays et al. (2000), the valley silverspot's intensive use of Canada thistle has important management implications, since control of this nonnative species may adversely affect this butterfly, as well as other butterflies.

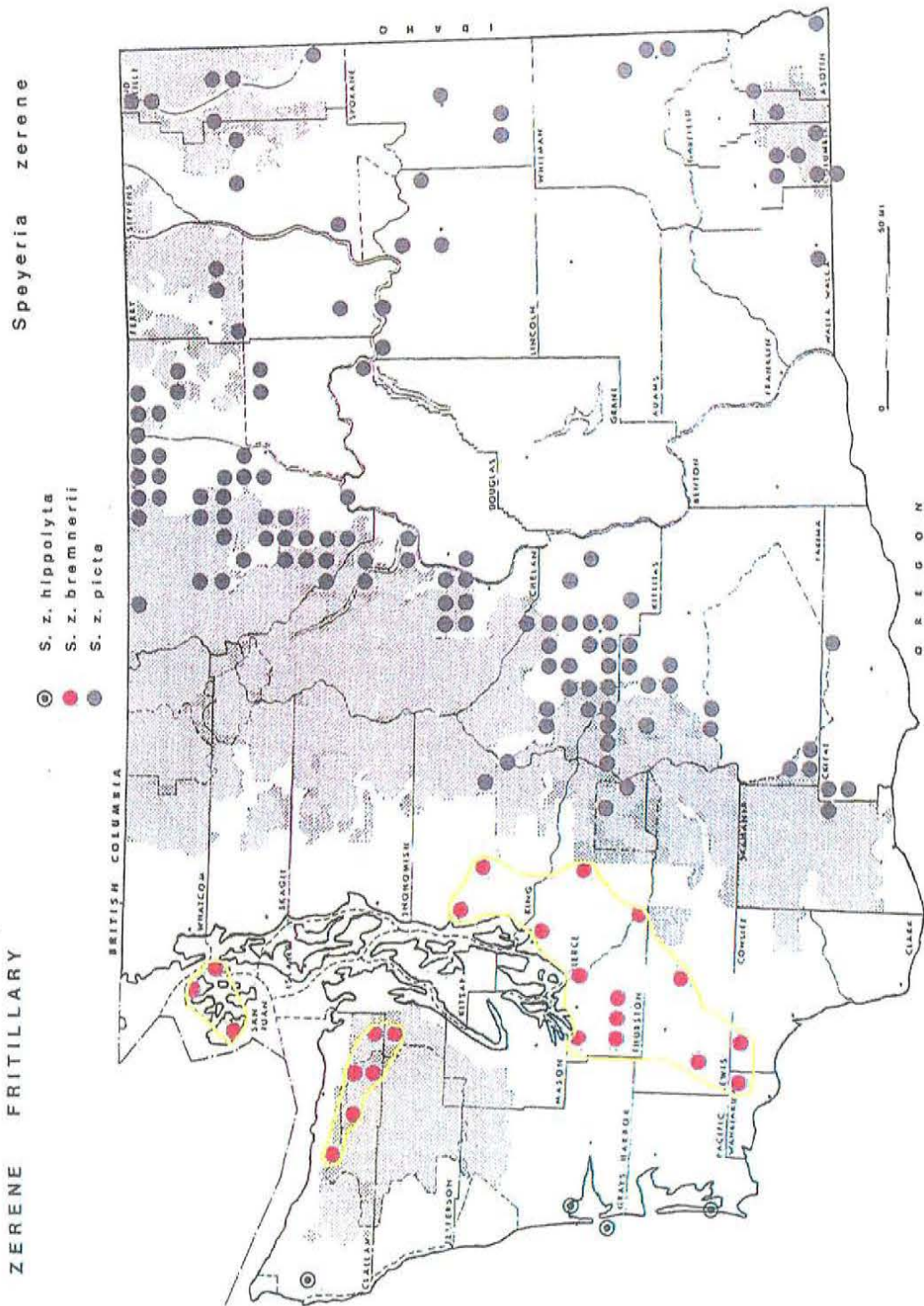
3.2.12.5 Habitat and Species Occurrence in the Scatter Creek Watershed Vicinity

Valley silverspot populations inhabit typical south Puget Sound grasslands with early blue violet and white-top aster and/or Canada thistle. Historically, this butterfly likely occurred in all native grassland areas within the watershed (Potter 2002 personal communication). Current populations have been documented in four locations within the Scatter Creek watershed. Two are located in the northwestern portion of the watershed (west of Interstate 5), one is located in the northern portion of the watershed (east of Interstate 5), and one is located in the eastern portion of the watershed near the city of Tenino (WDFW 1998, Potter 2002 personal communication; The Evergreen Aurelians 1996). This butterfly was last observed in 2002 at the two northwestern locations, last observed in 1983 at the northern location, and last observed in 1990 at the eastern location (Potter 2002 personal communication; The Evergreen Aurelians 1996). The latter two sites were surveyed since the last observations, but no valley silverspot butterflies were observed.

3.2.12.6 Threats

General Threats

The greatest threat to valley silverspots is loss of early blue violets and encroachment of vegetation that obscures the butterfly's access to the larval host. According to Hays et al. (2000), early blue violet populations have likely declined in western Washington grasslands due to competition with introduced weeds. Other general threats to these butterflies and associated habitat include human activities such as land conversion of grassland to agriculture or development; recreational activities such as walking, horseback riding, and off-road vehicle driving; herbicide and insecticide treatment (affecting host plants



Source: Hinchliff (1996)

Figure 3-12. Valley Silverspot Butterfly Distribution in Washington State

and inadvertently affecting nontarget butterflies), and grazing. Succession of grasslands (brought on by encroachment from shrubs and Douglas-fir) and nonnative plant species infestations (including Scot's broom and nonnative grasses) also threaten habitat loss, and overcollection may directly affect valley silverspot populations. In addition, indiscriminate use of prescribed fire may be detrimental to small populations. Historically, frequent, low-intensity fires contributed to the process of grassland maintenance. However, direct contact with fires is likely lethal to valley silverspots. Prescribed fire may be a helpful grassland restoration practice; however, special effort must be made to avoid or greatly minimize the burn footprint in areas occupied by valley silverspots.

Specific Threats Within the Watershed

Within the watershed, specific threats include further loss and fragmentation of habitat and larval host plants, predominantly by nonnative plant infestations (Scot's broom and nonnative grasses). However, habitat is also threatened by conversion of grassland to agricultural production or development, grazing, succession of grassland, and herbicide treatment. Individuals are also threatened directly by recreational activities, fire, insecticide spraying treatments, and collection.

3.2.12.7 Special Needs

Protection, expansion, and reestablishment of native grassland habitat, especially dense patches of early blue violets, and the prevention of further fragmentation in remaining grassland areas are critical for perpetuation of the valley silverspot. The intensive use of Canada thistle as a nectar source has important management implications (Hays et al. 2000). Control or removal of Canada thistle may limit available adult food sources. Implementation of nonnative plant management that is not detrimental to valley silverspots or their associated habitat (including small-scale, carefully located prescribed burns and limiting pesticide use) must be considered to protect existing populations. Recreation and other uses that disturb soil and native vegetation should also be minimized or reduced.

3.2.13 Chinook Salmon

3.2.13.1 Legal Status

Chinook salmon (*Oncorhynchus tshawytscha*) of the Chehalis River and tributaries belong to the Washington Coast Evolutionarily Significant Unit (ESU)¹. On March 9, 1998, NOAA Fisheries determined that listing under the Endangered Species Act was not warranted for this ESU (Federal Register Vol. 63, No. 45, p. 11,482).

3.2.13.2 Population Status and Distribution

Spawning populations of chinook salmon range from central California north to Alaska in the Eastern Pacific, and from the island of Hokkaido (Japan) north to the Bering Sea in the Western Pacific (Healy 1991). Naturally spawning populations are also established in New Zealand and the Great Lakes through introductions (Healey 1991).

Chinook salmon are widely distributed throughout the Washington coast region (Figures 3-13 and 3-14). Washington Department of Fisheries (WDF) et al. (1993) evaluated 31 chinook salmon stocks within the

¹ Evolutionarily Significant Units are defined by NOAA Fisheries policy to be equivalent to "distinct population segments," which are treated as species under the Endangered Species Act.

Washington coast region. Of those, 18 were reported to be of native origin and predominantly of natural production. The status of these 18 stocks was 11 healthy stocks, 4 depressed stocks, and 3 of unknown status. The status of the nonnative stocks was nine healthy stocks, two depressed stocks, and two of unknown status. Chehalis River fall chinook salmon are considered a hybrid stock with significant genetic characteristics. This stock is found throughout the Chehalis River Basin and populations are considered healthy (Figure 3-13). Chehalis River spring chinook salmon are found primarily in the Skookumchuck, Newaukum, and upper mainstem Chehalis Rivers (Figure 3-14). They are of native origin, and populations are considered healthy (WDF et al. 1993).

3.2.13.3 Life History

As with all Pacific salmon, chinook salmon exhibit an anadromous life history. Chinook salmon adults migrate upstream into freshwater rivers to spawn. After hatching, juveniles spend a period of time (that varies by stock) rearing in freshwater before emigrating downstream to the ocean, where they live for 1 to 6 years before maturing and returning to freshwater to spawn, thus completing the life cycle. All chinook salmon die after spawning. The anadromous life history of salmon is thought to be a response to the relatively poor productivity or instability of freshwater environments relative to the marine habitat (Miller and Brannon 1982).

Chinook salmon exhibit two general life-history patterns: stream-type (spring-run) and ocean-type (fall-run). These life-history strategies differ in timing of upstream adult spawning migrations and juvenile outmigration to the ocean. Stream-type chinook salmon enter freshwater on spawning migrations in the spring or early summer as sexually immature adults (so-called "bright fish"), migrate far upriver, and then spawn in the late summer and autumn. Juvenile stream-type chinook then reside in freshwater for about a year after hatching prior to migrating to the ocean. In contrast, ocean-type chinook salmon enter freshwater on spawning migrations in a relatively sexually mature condition later in the summer, move rapidly to their spawning areas in mainstem or lower tributaries of the rivers, and spawn shortly thereafter (Healey 1991). After hatching, juvenile ocean-type chinook quickly migrate to the ocean, spending relatively little time rearing in freshwater. However, many variations of stream-type and ocean-type migration timing have been described, with spawning occurring as late as December (Healey 1991).

Differences in juvenile life-history strategies are likely due to environmental factors (e.g., distance of migration, stream stability, stream flow, temperature regimes, stream productivity, estuary productivity) and genetic factors. Therefore, ocean- and stream-type chinook salmon populations exhibit a fairly distinct geographical distribution. In general, chinook salmon stocks north of the 55th parallel in Asia, Alaska, and Canada (as well as those spawning in high-elevation headwaters of large river systems such as the Fraser and Columbia Rivers) exhibit a stream-type life history, while populations south of the 55th parallel generally exhibit an ocean-type life history (Healey 1991).

Most chinook salmon populations of the coastal drainages of Washington have ocean-type life histories. Two spring-run, four summer-run, four spring/summer-run, and 23 fall-run stocks have been recognized on the Washington coast (WDF et al. 1993). As previously mentioned, ocean-type chinook salmon reenter freshwater as relatively mature fish, rapidly move to their spawning areas in mainstem or lower tributaries of the rivers, and spawn shortly after freshwater entry (Healey 1991). Washington coastal streams tend to be short with low gradients, and chinook salmon prefer spawning in the lower-gradient reaches of these systems. The relatively small size of these rivers, however, often limits the amount of available spawning habitat. The Chehalis River Basin is physically larger than most other coastal basins, but does not support proportionately larger chinook salmon runs (Myers et al. 1998).

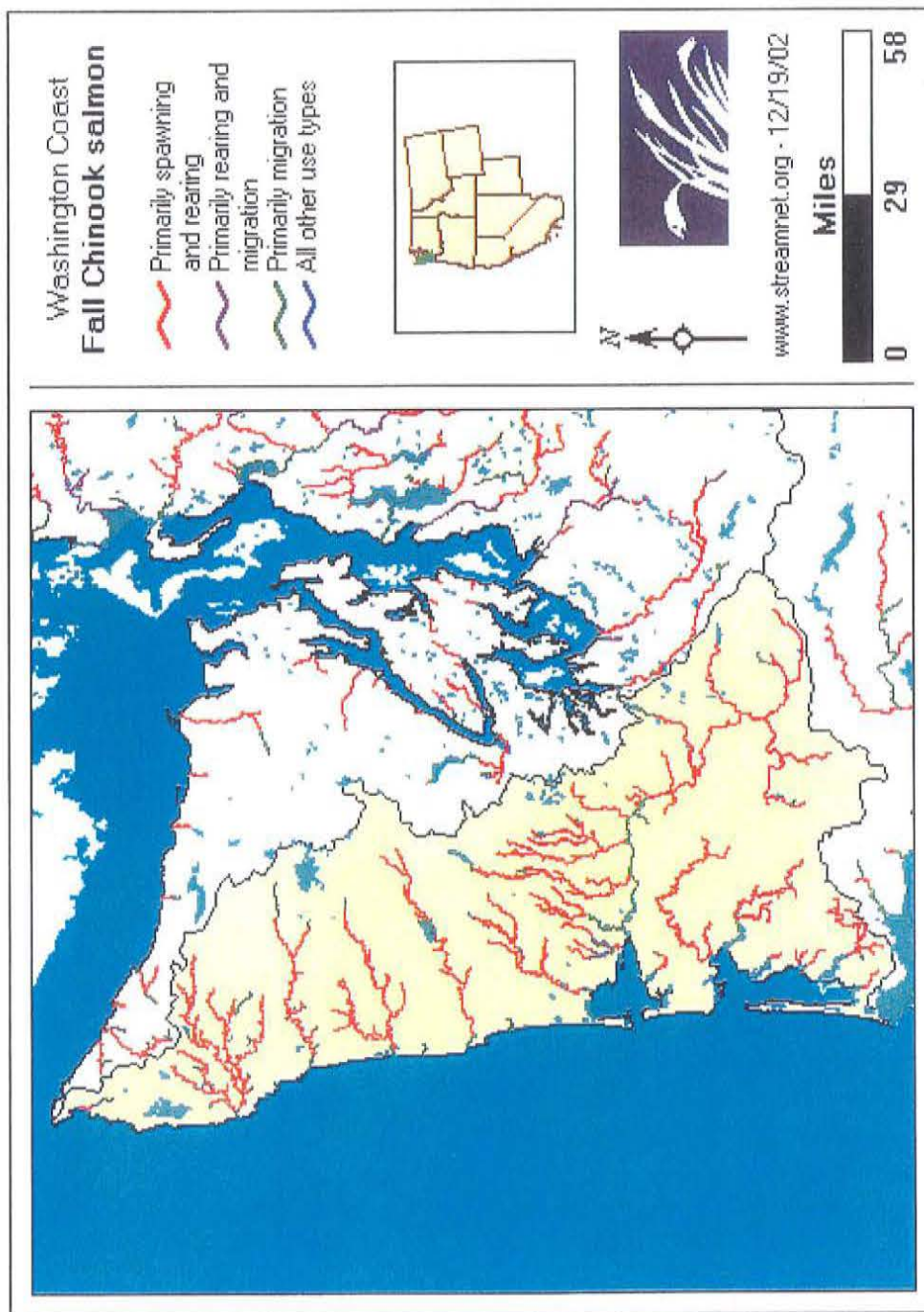


Figure 3-13. Distribution of Fall Chinook Salmon in the Washington Coast Region

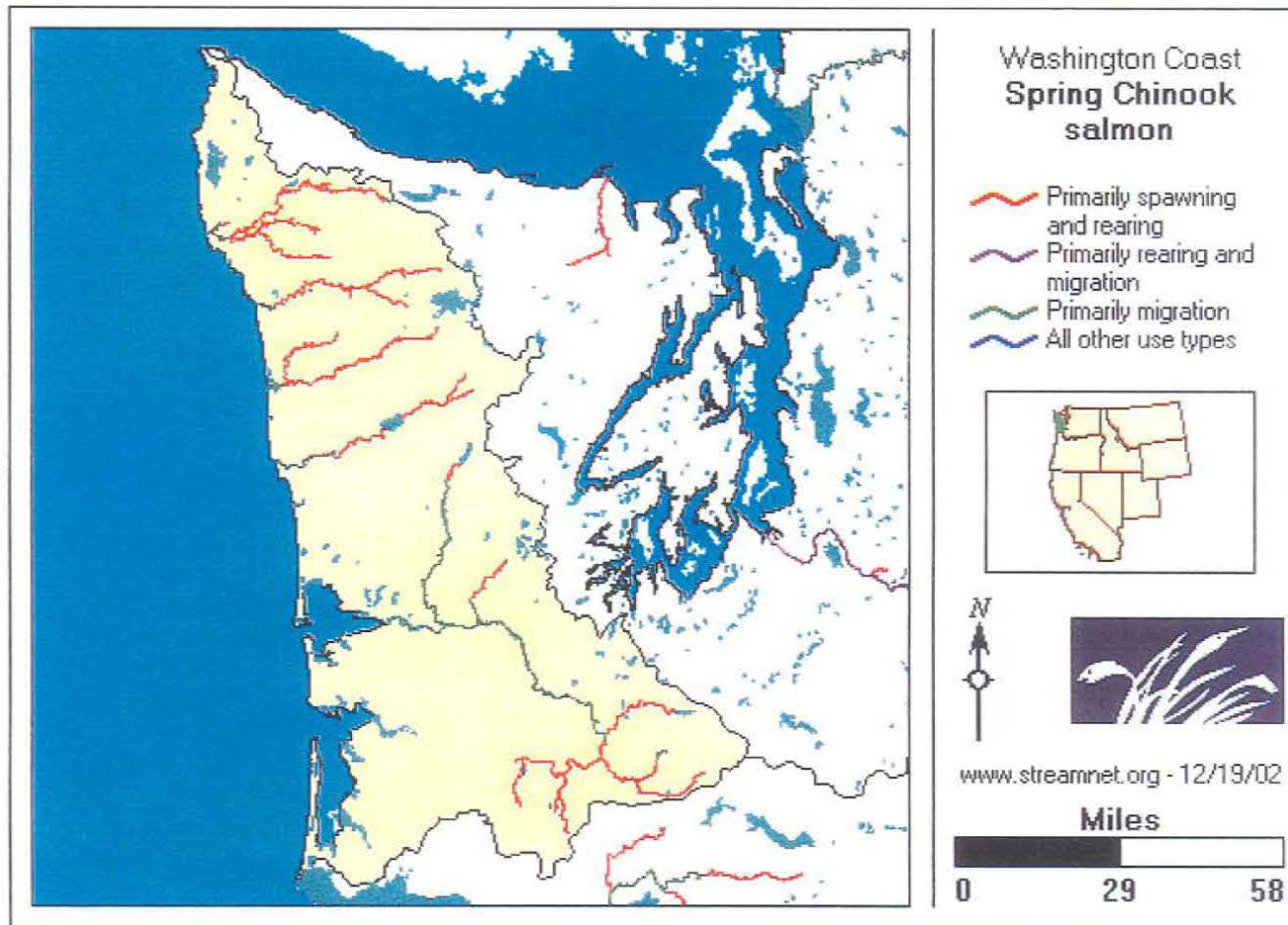


Figure 3-14. Distribution of Spring Chinook Salmon in the Washington Coast Region

Chinook salmon of the Chehalis River and its tributaries are within the Washington Coast ESU. Washington Coast ESU populations generally mature at ages 3, 4, and 5. However, as is common in all chinook populations, some males mature at an early age and return in their first or second ocean years (these fish are commonly known as jacks). Peak spawning periods for Washington coastal fall chinook salmon occurs from late October to early December, with a tendency for later spawning in more southerly rivers (Myers et al. 1998). Differences in the timing of river entry and spawning are also related to local water temperature and flow regimes (Miller and Brannon 1982). Flow regimes are important because low river flows can block upstream migration (Healey 1991). After reentry into freshwater, adults utilize resting pools, which provide refuge from river currents and high water temperatures often encountered in the summer and early autumn (Berman and Quinn 1991; Hockersmith et al. 1994).

When spawning, adult females dig redds in gravel and cobble substrate, generally in riffle areas, and deposit anywhere from fewer than 2000 to 17,000 eggs. The number of eggs is primarily determined by the size of the female (Healey 1991). Though spawning is often in riffles, a wide range of current velocities (10 to 189 cm/second [cm/s]) and depths (5 to 720 cm) have been reported, with larger adults able to utilize larger substrate sizes and current velocities (Healey 1991). After spawning, the female covers the eggs with substrate, where they remain to incubate. Chinook egg incubation times vary with temperature. Eggs hatch in about 159 days at 3°C, and in about 32 days at 16°C (Healey 1991). Prior to emerging, the young remain in the gravel for 2 to 3 weeks after hatching (Wydoski and Whitney 1979).

After hatching and emergence, ocean-type chinook salmon migrate to the ocean during one of three distinct phases. Some populations migrate soon after yolk resorption (at 30 to 45 mm in length), but most ocean-type populations migrate as fry (60 to 150 days post-hatching) or as fingerlings, which migrate in the late summer or autumn of their first year (Healey 1991). Seasonal flood cycles or flow may act as a cue to begin downstream migration (Healey 1991). After seawater entry, ocean-type chinook salmon extensively utilize estuaries and coastal areas to feed and rear for several months to a year (Healey 1991). Younger juveniles reside in estuaries longer than older juveniles, and the timing of entry into the open ocean appears to be determined in large part by the size of juveniles (Kjelson et al. 1982; Levy and Northcote 1982; Healey 1991). After this rearing period, juveniles enter the open ocean to feed for 1 to 4 years until ready to migrate back to natal streams and spawn.

3.2.13.4 Habitat Associations/Requirements

Both juvenile and adult chinook salmon require cold (generally less than 14°C), well-oxygenated water (NOAA Fisheries 1996; Healey 1991). Important habitat components include suitable spawning, rearing, and migration habitat. Chinook salmon generally spawn in riffle areas, and successful spawning is associated with clean gravel and cobble substrates, which allow adequate flow of well-oxygenated water to incubating eggs. Juvenile chinook salmon may utilize a variety of available habitats such as pools and in-stream cover such as large woody debris, spaces among cobbles, and undercut banks as resting areas and/or for refuge from predators (Healey 1991). As summarized in Bjornn and Reiser (1991), subyearling chinook salmon generally utilize depths of less than 60 cm (24 inches) and velocities of less than 30 cm/s (1 ft/s). During the winter, off-channel habitat such as secondary channels, backwaters, or ponds can provide important refuge from flows, particularly for stream-type chinook. Overwintering stream-type chinook salmon are also known to use spaces among cobble substrate as refuge (Bjornn 1971). After river entry, adults on spawning migration utilize resting pools, which provide refuge from river currents and high water temperatures that are often encountered in the summer and early autumn (Berman and Quinn 1991; Hockersmith et al. 1994).

3.2.13.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Scatter Creek may have once supported a small spawning population of chinook salmon, but currently chinook salmon are not known to spawn in Scatter Creek. However, juvenile chinook do inhabit low-gradient downstream reaches of Scatter Creek. Smolt trap surveys conducted from 1986 through 1991 by WDF collected anywhere from 69 to 3,945 age-0 (subyearling) outmigrating chinook salmon. This smolt trap was located at River Mile 0.5 on Scatter Creek. Given that there are no recent reports of spawning chinook salmon in Scatter Creek, these fish likely originated from other streams and moved into Scatter Creek to rear.

3.2.13.6 Threats

To a varying degree, all streams within the Washington coast region have been affected by habitat degradation due to forest practices or other land uses. Clearing of land and riparian areas can result in sedimentation in spawning grounds, lack of large woody debris, and lack of streamside shade that helps maintain cool water temperatures (Myers et al. 1998). Clearing of in-stream wood was a common practice until the 1970s, resulting in channel downcutting and bedload scour and fill which, along with fine sediments, can affect egg survival. Other general threats to salmonid populations include overfishing, artificial propagation, poor ocean conditions, altered flow regimes (due to land use and/or water use), high water temperatures, estuarine loss, habitat access (barriers), loss of pool habitat, and loss of off-channel habitat due to widespread channel straightening and floodplain development (Myers et al. 1998).

Scatter Creek has experienced a loss of large woody debris and pool habitat through the loss of natural wood recruitment (from reduction of riparian vegetation), removal of in-stream wood, and reduction of beaver populations. Secondary channels and other off-channel habitat types are lacking, and sediment quantity has been rated as poor (i.e., too much fine sediment) (Smith and Wenger 2001; TCD 1999). Portions of Scatter Creek typically dry up during summer months, which may be exacerbated by water withdrawals.

Scatter Creek has experienced elevated water temperatures as high as 24°C and is on the 1998 303(d) list for both water temperature and pH. Elevated stream temperatures in the Chehalis River watershed are frequently due to low flows and the loss of riparian vegetation necessary for stream shading (Envirovision 2000). Loss of riparian vegetation also reduces nutrient input necessary for food production for juvenile chinook salmon.

3.2.13.7 Special Needs

As with all salmonids, chinook salmon require cold, well-oxygenated water, clean gravel and cobble substrate, and habitat features such as undercut banks, pools, and large woody debris. These features would need to be available in the lower reaches of Scatter Creek that are utilized by juvenile chinook salmon.

3.2.14 Coho Salmon

3.2.14.1 Legal Status

Coho salmon (*Oncorhynchus kisutch*) of the Chehalis River and tributaries belong to the Lower Columbia River/Southwest Washington ESU. On July 25, 1995, NOAA Fisheries determined that listing was not warranted for this ESU (Federal Register Vol. 60, No. 142, p. 38,011). However, the ESU is designated as a candidate for listing.

3.2.14.2 Population Status and Distribution

The natural distribution of coho salmon spawning populations is similar to that of chinook salmon, ranging from Japan north around the Pacific Rim to central California; coho salmon are most common in coastal streams (Sandercock 1991). Nehlsen et al. (1991) identified 35 stocks of coho salmon that are at short-term risk of extinction in Washington, Oregon, Idaho, and California and 15 stocks that are extinct in California, southern Oregon, and the Columbia River. In the Washington coast region, coho salmon are widely distributed (Figure 3-15). WDFW and Western Washington Treaty Indian Tribes (WWTIT) (1994) evaluated 26 wild coho salmon stocks in the Washington coast region. Of those, 17 stocks were reported to be healthy and 9 stocks of unknown status. Chehalis River coho salmon are a mixed-origin stock that is considered healthy.

3.2.14.3 Life History

Coho salmon exhibit an anadromous life history. Adults migrate upstream into freshwater rivers to spawn, after which all adults die. After hatching, juveniles spend a period of time rearing in freshwater before emigrating downstream to the ocean to grow and mature for a period of years before returning to freshwater to spawn. Unlike chinook salmon, which exhibit both stream-type and ocean-type life-history strategies, coho salmon only have a stream-type life history. South of central British Columbia, most coho salmon adults are 3-year-old fish. That is, after hatching, they spend approximately 18 months in freshwater and 18 months in saltwater (Sandercock 1991). As with chinook salmon, a portion of the population return as jacks, which are sexually mature males that return to freshwater to spawn after only 5 to 7 months in the ocean.

Most west coast coho salmon enter rivers in October and spawn from November to December, and sometimes into January. However, river entry and spawn timing show considerable variability. Some populations enter rivers later and spawn shortly after entering the river, and some systems in British Columbia, Washington, and the Columbia River often have very early runs (entering rivers in July or August) and late runs (spawning into March) in addition to normally timed runs. In general, coho salmon that migrate earlier spawn farther upstream within a basin than later migrating fish, which enter rivers in a more advanced state of sexual maturity (Sandercock 1991). Coho salmon often wait for fall freshets before entering rivers, and a delay in fall rains may delay river entry and spawn timing for up to a month (Sandercock 1991). Elevated water temperatures (greater than 18°C) may also delay spawning (Weitkamp et al. 1995).

Coho salmon in the Chehalis River Basin exhibit two distinct run timings: a normal run that spawns in early December throughout the basin, and a late run that spawns in January and February in some lower Chehalis River tributaries. It is believed that the normal run is composed of a mixture of hatchery and naturally spawned fish, while the late run is virtually all naturally spawned fish (Hiss and Knudsen 1993). Coho salmon in Scatter Creek exhibit normal run timing.

When spawning, adult females dig redds in gravel and cobble substrate, generally in riffle areas, and deposit eggs, which are usually fertilized by a dominant male. Suitable substrate sizes range from about 4 to 14 cm and water velocities at redd sites range from about 0.3 to 0.75 m/s (Sandercock 1991). After spawning, the female covers the eggs with substrate where they incubate. Coho egg incubation times vary with temperature, ranging from about 38 days at 10.7°C to 137 days at 2.2°C (Sandercock 1991). Prior to emerging, the young remain in the gravel for 2 to 3 weeks after hatching (Wydoski and Whitney 1979).

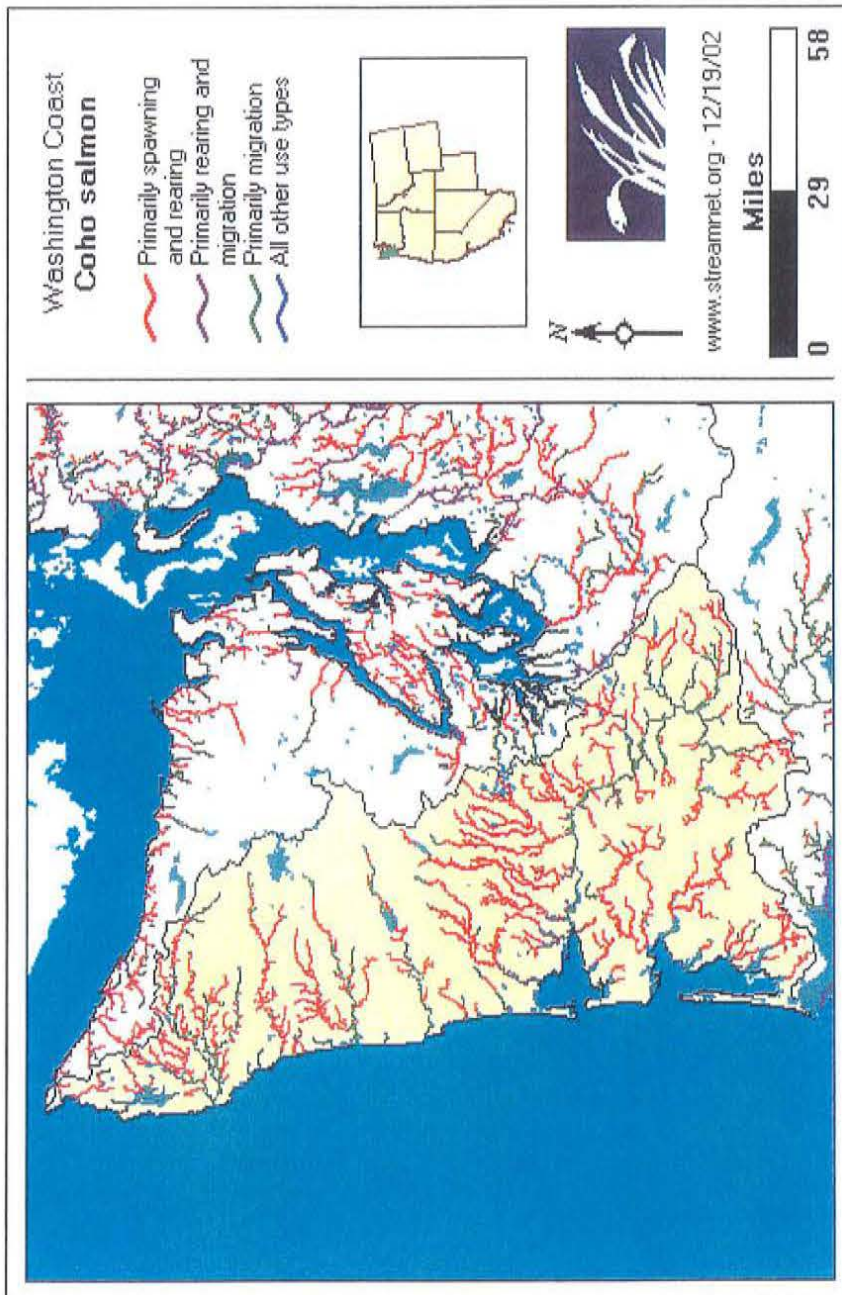


Figure 3-15. Distribution of Coho Salmon in the Washington Coast Region

After emergence, juvenile coho salmon remain in freshwater for a period of about 18 months before migrating to the ocean. During this period, they utilize cobble and other forms of habitat (such as large woody debris) for cover and feed on aquatic invertebrates. Because coho salmon overwinter in freshwater, overwintering habitat is of particular importance for survival, especially in coastal streams subject to high fall and winter flows. During the winter, coho salmon utilize off-channel habitat (such as side channels, flooded wetlands, and ponds) that are connected to the stream channel, but provide refuge from the high flows (Sandercock 1991).

During the period of seaward migration, juveniles undergo physical changes associated with the transition from a freshwater to marine existence. This process is called smoltification, and migrating stream-type juveniles are called smolts. Though sizes vary, most migrating coho salmon smolts measure from 90 to 115 mm in fork length (measured from the snout to the fork in the tail). Peak outmigration of smolts generally occurs in May; however, peak outmigration timing can vary by up to a month among coho salmon populations and between years (Sandercock 1991). After seawater entry, juvenile coho salmon utilize the estuary and coastal areas to feed. Coho salmon remain in these areas for approximately a year before entering the open ocean.

Differences in both smolt size and outmigration timing appear to respond to differences in habitat. For example, smolts residing in ponds or lakes may have different sizes and outmigration timing than stream resident smolts in the same drainage (Irvine and Ward 1989; Nielsen 1994). Because of their responses to habitat variability, human activities such as habitat degradation, restoration, or changes in flow may influence smolt size and outmigration timing (Sandercock 1991; Fraser et al. 1983).

As with other salmon species, coho salmon are declining in size over time throughout their range (Weitkamp et al. 1995). A decline in adult size has direct implications for individual reproductive success. Small reductions in adult size can lead to a substantial reduction in egg production (Sandercock 1991). Also, smaller coho salmon females dig fewer and shallower redds than do larger females, which are subjected to greater risk of destruction by scouring from floods. In addition, smaller coho salmon may be more susceptible to predation, may not be able to consume prey items available to larger individuals, and may be at a disadvantage when making long strenuous migrations (Sandercock 1991).

3.2.14.4 Habitat Associations/Requirements

The habitat requirements of all salmonids are generally similar, and there is considerable overlap in the range of habitat variables utilized by different salmonid species. Both juvenile and adult coho salmon require cold (generally less than 14°C), well-oxygenated water (NOAA Fisheries 1996; Sandercock 1991). Important habitat components include suitable spawning, rearing, and migration habitat. As with chinook salmon, coho salmon generally spawn in riffle areas, and successful spawning is associated with clean gravel and cobble substrates. Juvenile coho salmon utilize pool habitat and in-stream cover such as large woody debris, spaces among cobbles, and undercut banks as resting areas and/or for refuge from predators (Sandercock 1991). Juvenile coho salmon are generally found in depths less than 60 cm (24 inches) and velocities less than 30 cm/s (1 ft/s) (Bjornn and Reiser 1991). Because coho salmon overwinter in freshwater, overwinter habitat is of particular importance for survival, especially in coastal streams subject to high fall and winter flows. Studies have shown that pools with adequate cover are the most important habitat elements used by juvenile coho in the winter (Bustard and Narver 1975; Tschaplinski and Hartman 1983; Murphy et al. 1984). In addition, coho salmon utilize off-channel habitat during the winter, such as side channels, flooded wetlands, and ponds (including beaver ponds), that are connected to the stream channel but provide refuge from the high flows (Everest et al. 1985; Sandercock 1991).

After river entry, adults on spawning migrations utilize resting pools, which provide refuge from river currents and high water temperatures that are often encountered in the summer and early autumn (Berman and Quinn 1991; Hockersmith et al. 1994).

3.2.14.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Numbers of coho salmon adults returning to Scatter Creek ranged from 178 to 1,853 individuals between 1984 and 1999. The number of outmigrating coho salmon smolts was fairly consistent from 1986 to 1991, ranging from 34,577 to 42,485 fish, except in 1989 when only 9,614 coho salmon were collected. While the smolt trap catch is the best available indication of juvenile coho salmon production in Scatter Creek, the numbers do not represent the entire outmigration of coho smolts (due to trapping inefficiency or timing), nor do all the smolts collected originate from Scatter Creek. Juvenile coho salmon will move around among low-gradient tributaries of the Chehalis River during periods of high flows in the winter. Therefore, it is likely that coho salmon originating from other natal streams within the Chehalis River watershed utilize Scatter Creek as rearing habitat. Refer to Section 6.2.2 of this document for a more detailed description of Scatter Creek coho salmon populations (including data sources).

Coho salmon spawn throughout almost the entire length of Scatter Creek when habitat is accessible. During the summer months, sections of Scatter Creek typically go dry, which limits the amount of available rearing habitat. Based on observations in November 2002, areas that provide potential year-round rearing habitat include:

- Approximately the lower 5 miles of Scatter Creek located downstream of the Cypress Island Fish Farm near the WDFW South Wildlife Management Area at River Mile 6, which remains watered year-round due to the release of return water from a fish farm into Scatter Creek.
- Approximately 3 to 4 miles of Scatter Creek extending from just downstream of the city of Tenino to immediately downstream of the Fred Colvin property (about River Mile 11). A portion of the reach located on the Colvin property is perhaps the highest quality coho salmon habitat in Scatter Creek, owed in large part to beaver activity, riparian vegetation, and abundant in-stream wood.
- Portions of some upper watershed tributaries.

3.2.14.6 Threats

To a varying degree, all streams and salmon populations in the Washington coast region have been affected by habitat degradation such as sedimentation in spawning grounds, lack of large woody debris, loss of riparian vegetation, overfishing, artificial propagation, poor ocean conditions, altered flow regimes, high water temperatures, estuarine loss, habitat access (barriers), and loss of pool habitat (Weitkamp et al. 1995).

Scatter Creek has likely experienced a loss of large woody debris and pool habitat through the loss of natural wood recruitment (from reduction of riparian vegetation), removal of in-stream wood, and a reduction of beaver populations. Secondary channels and other off-channel habitat types are lacking, and sediment quantity has been rated as poor (Smith and Wenger 2001; TCD 1999). In addition, portions of Scatter Creek typically dry up during summer months, which may be exacerbated by water withdrawals. These low-flow conditions limit available rearing habitat and are perhaps the most significant limiting factor for coho salmon populations in Scatter Creek. Refer to Section 6.3 of this report for a more detailed description of fish habitat in Scatter Creek.

3.2.14.7 Special Needs

As with all salmonids, coho salmon require cold, well-oxygenated water, clean gravel and cobble substrate, and habitat features such as undercut banks, pools, and large woody debris. Because coho salmon overwinter in freshwater, overwinter habitat is of particular importance for survival, especially in coastal streams subject to high fall and winter flows. During the winter, coho salmon utilize off-channel habitat such as side channels, flooded wetlands, and ponds that are connected to the stream channel but provide refuge from the high flows (Sandercock 1991).

3.2.15 Chum Salmon

3.2.15.1 Legal Status

Chum salmon (*Oncorhynchus keta*) in the Chehalis River Basin belong to the Pacific Coast ESU. On March 10, 1998, NOAA Fisheries determined that listing of chum salmon was not warranted for this ESU (Federal Register Vol. 63, No. 46, p. 11,774).

3.2.15.2 Population Status and Distribution

Chum salmon have a broader spawning distribution than any other species of Pacific salmon. In Asia, they commonly spawn as far south as Korea and extend north to along the edge of the Arctic Ocean, where juvenile outmigration often occurs beneath the ice (Salo 1991). In North America, chum salmon range from the arctic coast of Alaska to as far south as Monterey, California. Chum salmon are found throughout lower Chehalis River tributaries (Figure 3-16), but relative abundance among various systems within the basin is limited (WDFW and WWTIT 1994). The current stock is considered native and healthy.

3.2.15.3 Life History

As with other Pacific salmon species, adult chum salmon return to natal spawning streams progressively later as latitude decreases. Only summer-run fish are found as far north as the Bering Sea; summer and fall runs occur in southeast Alaska and British Columbia, and fall-run fish are most common south of Vancouver Island. There is some variation though. Of the 72 recognized runs of chum salmon in Washington, 62 are classified as fall runs, two as winter runs (both in southern Puget Sound), and eight as summer runs (four in southern Puget Sound and four in Hood Canal/Strait of Juan de Fuca) (WDF et al. 1993). Spawning of fall-run chum salmon occurs as late as December in Washington coastal streams.

Chum salmon may enter natal river systems from June to March, depending on characteristics of the population or geographic location. In the Chehalis River Basin, chum salmon typically enter rivers in October and November and spawn in November and December (Johnson et al. 1997). However, all species of anadromous salmonids may delay their entry into freshwater or into terminal spawning areas as they approach the mouths of their natal rivers at the end of the marine phase of their life cycle. The exact timing of river entry is often determined by degree of maturation, water temperature, and river flows. Adults often move into rivers when river flows increase after a period of rain. Chum salmon most commonly spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea (Salo 1991). However, some populations are known to travel long distances upstream. For example, chum salmon routinely migrate over 170 km in the Skagit River of Washington and migrate more than 2,500 km inland in both the Yukon River, Alaska and the Amur River in the Russian Federation (Johnson et al. 1997). However, rivers where long chum salmon migrations occur are characterized by low gradients.

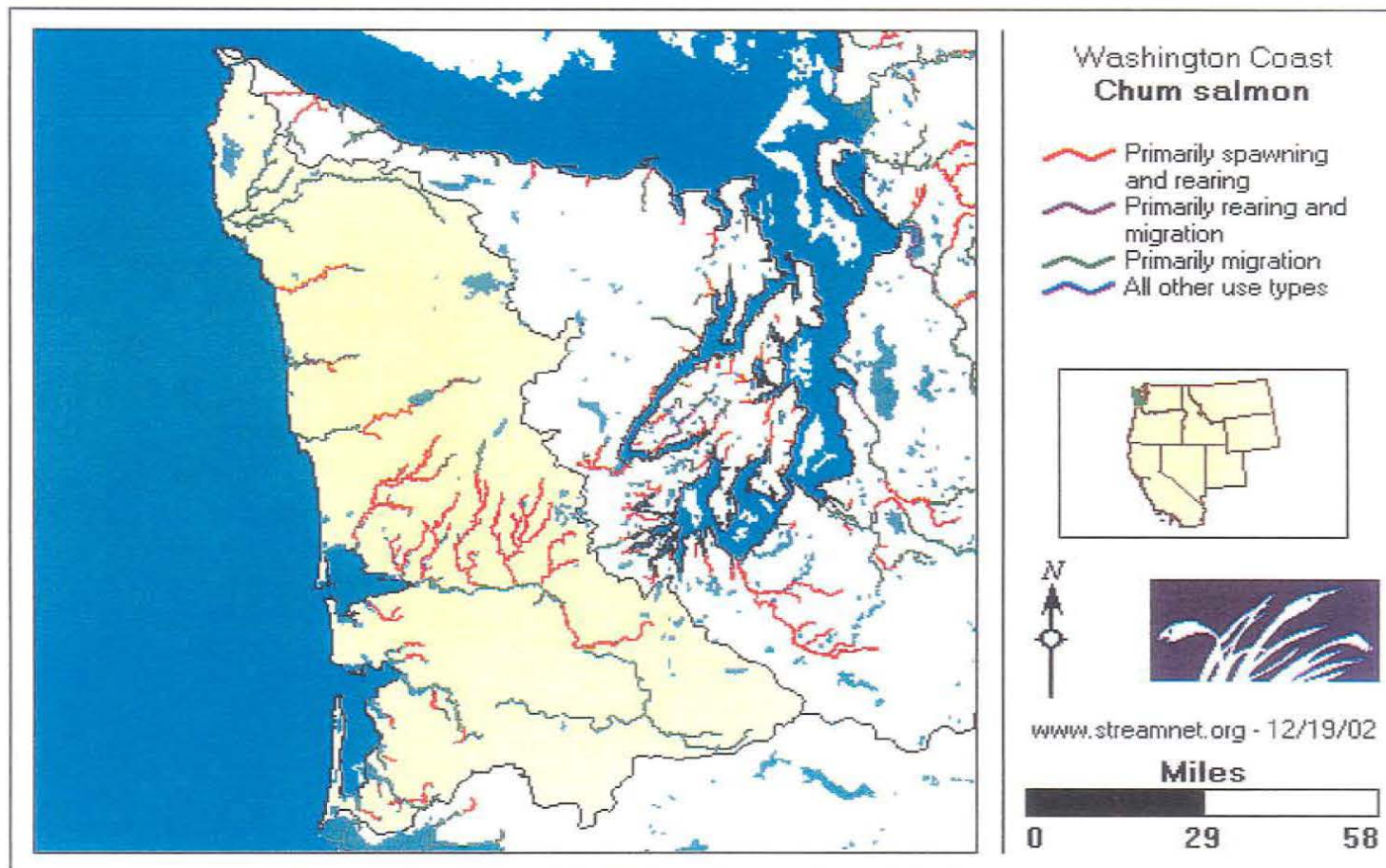


Figure 3-16. Distribution of Chum Salmon in the Washington Coast Region

Chum salmon are reported to spawn in shallower, slower-running streams and side channels more frequently than do other salmonid species, perhaps to avoid competition with pink salmon (Salo 1991). They usually spawn at the head of riffles and in areas of upwelling groundwater, but may even spawn in intertidal zones of streams at low tide (Salo 1991). Preferred water velocities for spawning widely vary. Johnson et al. (1971) measured water velocities near 1,000 chum salmon redds in Washington and found that velocities varied from 0.0 to 167.6 cm/s. Over 80 percent these fish spawned in velocities between 21.3 and 83.8 cm/s, which is similar to the range of spawning water velocities found for other salmon species (Salo 1991).

The rate of embryonic development in chum salmon is influenced most by water temperature (Koski 1975; Salo 1991). Lower water temperatures can prolong the time required from fertilization to hatching by 1.5 to 4.5 months. For example, fertilized eggs hatch in about 100 to 150 days at 4°C, but hatch in only 26 to 40 days at 15°C. Other factors (such as dissolved oxygen, gravel size, salinity, nutritional condition) and even the behavior of alevins (larval salmon) in the gravel can influence the time to hatching or emergence from the gravel (Salo 1991).

Chum salmon are capable of adapting to saltwater soon after emerging from gravel and only rear in freshwater for a few days to weeks before migrating downstream to saltwater. In Washington, chum may reside in freshwater for a month or more (Salo 1991). Downstream migration may take only a few hours or days in rivers where spawning sites are close to the mouth of the river, or may take several months if migration distance is great. In Washington, downstream migration occurs from late January through May. The timing of downstream migration can be affected by numerous factors, including time of adult spawning; stream temperature; fry size, nutritional condition, food availability, population density, stream discharge, turbidity, tidal cycles, and day length (Salo 1991).

Chum salmon juveniles, like other anadromous salmonids, use estuaries to feed before beginning long-distance oceanic migrations. However, chum and ocean-type chinook salmon usually have longer residence times in estuaries than do other anadromous salmonids (Salo 1991). The period of estuarine residence appears to be the most critical phase in the life history of chum salmon and appears to play a major role in determining the size of the subsequent adult run back to freshwater (Salo 1991). Migration of chum salmon juveniles out of estuaries appears to be closely correlated with prey availability, and larger individuals move offshore earlier.

In both Asia and North America, most chum salmon mature between 3 and 5 years of age, with 60 to 90 percent of the fish maturing at 4 years of age. However, there is a higher proportion of 5-year-old fish in the north (northern British Columbia and Alaska), and a higher proportion of 3-year-old fish in the south (southern British Columbia, Washington, Oregon) (Salo 1991). In general, average size for chum salmon of all ages increases from north to south, and age at maturity decreases from north to south (Salo 1991). This is attributed to the longer growing season and earlier maturation of southern populations.

3.2.15.4 Habitat Associations/Requirements

Because chum salmon only rear in freshwater for a few days to weeks before migrating downstream to saltwater, juveniles have limited habitat needs in freshwater. In-stream habitat needs primarily include resting pools for migrating spawning adults, and cold, well-oxygenated water and clean gravel spawning substrate. Chum salmon spawn in a wide variety of locations, but generally show little persistence in surmounting river blockages and often spawn in shallower, slower-running streams and side channels in low gradient lower reaches of rivers (Salo 1991). They also often spawn at the head of riffles, in areas of upwelling groundwater and in intertidal zones of streams at low tide (Salo 1991).

3.2.15.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Chum salmon are found throughout lower Chehalis River Basin tributaries and there have been few introductions of nonnative stocks. It is believed that Scatter Creek once supported a small to moderate run of chum salmon (Royal 1931; Tollefson 1969; Williams et al. 1975), but Scatter Creek does not currently support a spawning population of chum salmon (WDFW and WWTIT 1994; StreamNet 2002), and no chum salmon are released into Scatter Creek.

3.2.15.6 Threats

As with most salmonid populations in the Washington coast region, chum salmon populations have been affected by such factors as sedimentation in spawning grounds, lack of large woody debris, loss of riparian vegetation, overfishing, artificial propagation, poor ocean conditions, altered flow regimes, high water temperatures, estuarine loss, habitat access (barriers), and loss of pool habitat (Johnson et al. 1997). Scatter Creek has experienced habitat degradations similar to other streams, but chum salmon are not known to spawn or rear in Scatter Creek. Therefore, no threats to chum salmon associated with Scatter Creek are identified.

3.2.15.7 Special Needs

As with all salmonids, chum salmon require cold, well-oxygenated water and clean gravel and cobble substrate for spawning. Chum salmon do not rear in freshwater, and in-stream habitat is not as critical as for other salmonid species.

3.2.16 Cutthroat Trout

3.2.16.1 Legal Status

Coastal cutthroat trout (*Oncorhynchus clarki*) in the Chehalis River Basin belong to the Southwestern Washington/Columbia River Distinct Population Segment (DPS). On July 5, 2002, this DPS was designated as Not Listed (Resolved Taxon) (Federal Register Vol. 67, No. 129, p. 44,933).

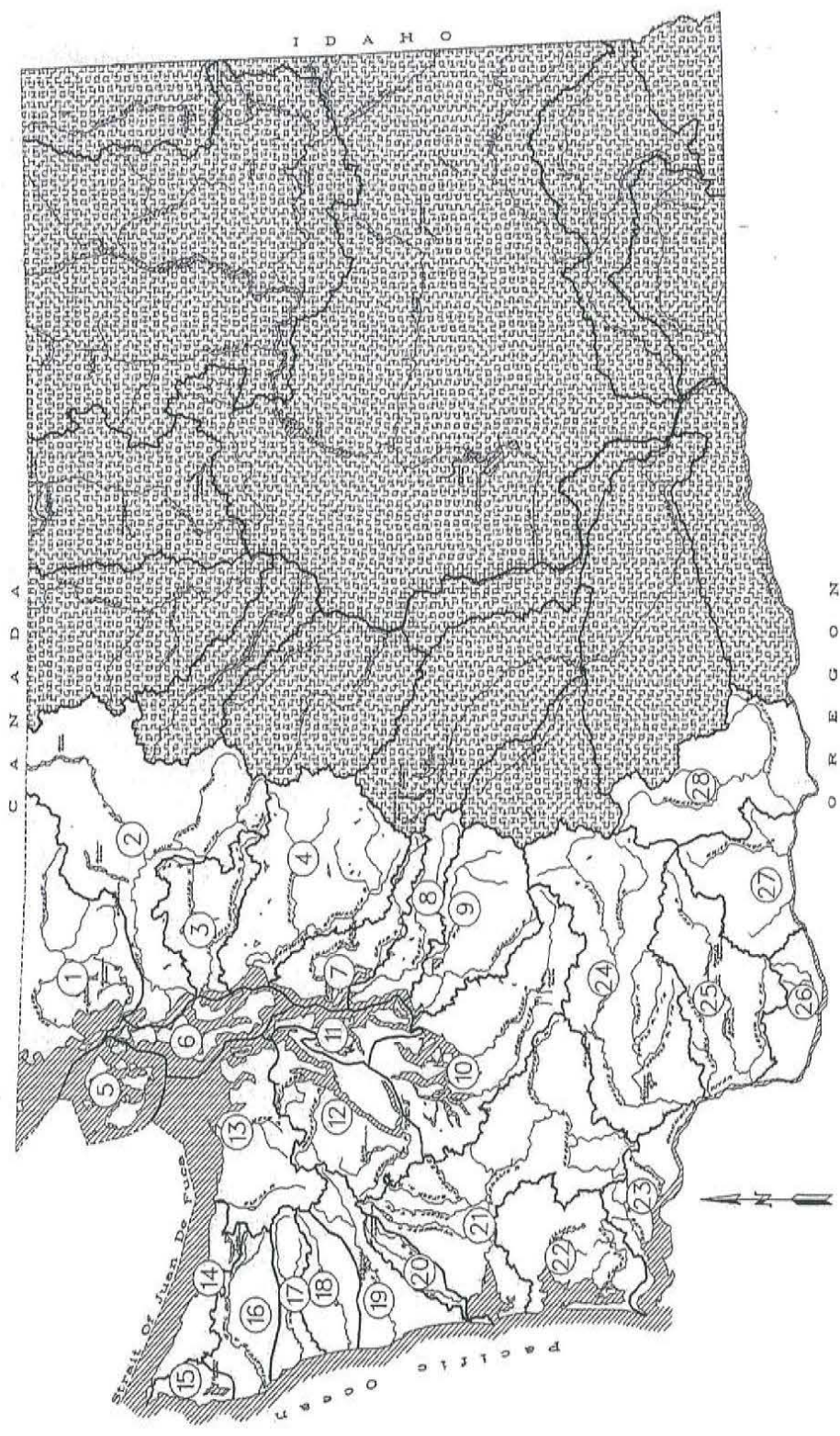
3.2.16.2 Population Status and Distribution

Coastal cutthroat trout are found in most coastal streams from northern California to southeast Alaska (Wydoski and Whitney 1979). Coastal cutthroat trout are present in virtually all perennial tributaries (streams that flow into larger streams year-round) and mainstem reaches of the Chehalis River Basin. They are of native stock of wild production, but the exact status of populations in the Chehalis River Basin is unknown (Blakley et al. 2000). The distribution of coastal cutthroat trout in Washington is presented in Figure 3-17.

3.2.16.3 Life History

The life history of coastal cutthroat trout is perhaps the most complex of the Pacific salmonids. Whereas with most Pacific salmonid species, all individuals are anadromous (e.g., chum, pink, coho, and chinook salmon, and steelhead trout), coastal cutthroat trout populations may contain migratory and nonmigratory individuals within the same population.

A status review of coastal cutthroat trout populations conducted by NOAA Fisheries identified three general life-history forms as follows (Johnson et al. 1999):



Source: Blakley et al. (2000).

Figure 3-17. Location of 28 Washington River Drainages Where Coastal Cutthroat Trout Are Found

Nonmigratory (Resident) Coastal Cutthroat Trout - This life-history form is generally found in small streams and headwater tributaries. These fish may undertake small-scale migrations within natal streams (e.g. short upstream spawning migrations), but they basically inhabit relatively small home territories near spawning and rearing areas. In general, nonmigratory coastal cutthroat trout grow more slowly than migratory forms and are smaller at sexual maturity (seldom larger than 150 to 200 mm in length) (Trotter 1989).

Freshwater-Migratory (Fluvial) Coastal Cutthroat Trout - This life-history form includes fish that may undertake a variety of fairly extensive migrations entirely within freshwater. Migration patterns include migrating from natal streams downstream into larger rivers without entering seawater, migrating from large tributaries to small tributaries to spawn, and populations that inhabit lakes and then migrate into lake inlets or outlets to spawn (Varley and Gresswell 1988; Trotter 1997).

Saltwater-Migratory (Anadromous) Coastal Cutthroat Trout - This is the most familiar life-history form of coastal cutthroat trout. These fish migrate from freshwater rivers in the late winter and spring to feed in estuarine and nearshore marine environments during the summer, and then reenter freshwater in the winter to seek refuge, feed, and/or spawn.

It is difficult to determine the proportion of nonmigratory and migratory coastal cutthroat trout within a population because all forms may exist in the same watershed or even in the same stream (Trotter 1989; Johnston 1982). Differences in the timing and location of spawning may separate life-history forms, but environmental conditions may also promote overlap of spawning between the different forms. Even among resident populations, some proportion is likely to be anadromous if there is access to seawater. The migratory behavior of individuals may even be flexible. For instance, individuals believed to be freshwater forms one year may migrate to sea another year, while some sea-run cutthroat trout may not enter saltwater every year after their initial smolt migration, but may instead stay in freshwater some years (Johnston 1982). Therefore, even though populations may be primarily migratory or nonmigratory, it may be that individuals modify their behavior in response to environmental factors (e.g., food supply or temperature) along migratory routes, thus promoting either residency or migration. This diversity of coastal cutthroat trout life-history forms may be an adaptive generalist strategy that allows them to exploit habitats not fully utilized by other salmonids (Northcote 1997).

In the Chehalis River Basin, river entry for spawning is from October through April (Blakley et al. 2000), and spawning of different life-history forms occurs from January through mid-April. Individuals may return to freshwater from June through the following April though, with large numbers migrating at the onset of fall rains in November (Giger 1972). In general, coastal cutthroat trout exhibit considerable variation in age and size at maturity. Nonmigratory coastal cutthroat trout typically mature at an early age (2 to 3 years), whereas sea-run cutthroat trout rarely spawn before age 4. Spawning by individual females may extend over a period of 2 to 3 days (Trotter 1997) and generally occurs upstream of coho salmon and steelhead spawning areas with some overlap (Johnston 1982). This utilization of spawning areas upstream of other salmonids may have evolved in response to competition for suitable spawning sites. In addition, coastal cutthroat trout fry are smaller than salmon fry and typically emerge later (Johnston 1982). Therefore, the separation of spawning habitat also serves to reduce competition with juvenile salmon. Optimum temperatures for spawning range from 6.1° to 17.2°C and for egg incubation from 4.4° to 12.7°C (Trotter 1997). Eggs begin to hatch within 6 to 7 weeks of spawning, depending on temperature; alevins emerge as fry between March and June, with peak emergence in mid-April (Giger 1972; Scott and Crossman 1973). This is comparable to embryos incubating for 30 days at 10°C, with emergence occurring 15 to 20 days later.

Cutthroat trout spawn more than once. The incidence of repeat spawning appears to be higher than in steelhead, with some cutthroat trout documented to spawn each year for 5 years (Giger 1972; Busby et al. 1996). Some adults do not spawn every year, and other adults do not return to seawater after spawning but instead remain in freshwater for at least a year (Giger 1972). However, spawners may experience high post-spawning mortality due to loss of body weight and other factors (Giger 1972; Scott and Crossman 1973).

Coastal cutthroat trout parr generally remain in upper tributaries until they are 1 year of age, when they may begin moving more extensively throughout river systems. Juvenile sea-run cutthroat trout will generally rear in streams for 2 or more years, where they prefer pools and other slow-water habitats that have rootwads and large wood for cover (Trotter 1997). Downstream movements often begin with spring rains, with some fish entering estuaries without migrating to the open ocean (Giger 1972). Coastal cutthroat trout that enter the sea generally do so after 2 to 4 years in freshwater, but may be as old as 6 years (Giger 1972). The average length of smolts is 160 mm (Johnson 1982). The time of initial seawater entry occurs from March to mid-June (Giger 1972; Johnston 1982).

Anadromous coastal cutthroat trout reportedly enter nearshore waters and move moderate distances along shorelines, often remaining in areas of reduced salinity (Trotter 1997), and generally do not cross large bodies of open water (Pearcy 1997). Gravel beaches with upland vegetation and nearshore areas containing large logs and other large woody debris are used during the marine residency phase. However, they have been known to migrate as far as 290 km (Pearcy et al. 1990). It is not clear how far offshore coastal cutthroat trout migrate because it can be difficult to distinguish offshore cutthroat trout from steelhead (Pearcy 1997).

3.2.16.4 Habitat Associations/Requirements

Cutthroat trout have habitat requirements similar to other salmonids. Cutthroat trout primarily spawn in the tails of pools in low-gradient streams with low flows (usually less than 0.3 cubic meters per second [m^3/s] during the summer) (Johnston 1982). The preferred spawning substrate is pea- to walnut-sized gravel, in 15 to 45 cm (6 to 18 inches) of water, with pools nearby for escape cover. At emergence, fry quickly migrate to channel margins and backwaters, where they remain throughout the summer (Moore and Gregory 1988). When they are the only salmonid in the stream, coastal cutthroat trout fry are most abundant in pools (Glova 1984). However, when inhabiting a stream with coho salmon and sculpins, coastal cutthroat trout are fairly evenly distributed among pools, glides, and riffles (Glova 1987). Other studies have found that subyearling coastal cutthroat trout select the shallower and faster waters in riffles but may reduce their use of this habitat type in the presence of steelhead (Bisson et al. 1982). In winter, coastal cutthroat trout move to pools near log jams or overhanging banks (Bustard and Narver 1975).

3.2.16.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

In the Chehalis River Basin, migratory forms inhabit the mainstem and accessible tributary reaches, while resident forms inhabit areas upstream of barriers and downstream where they coexist with the migratory forms. All three forms likely reside in Scatter Creek, but the proportions of these life-history forms is unknown. While Scatter Creek historically and currently supports a coastal cutthroat trout population (Blakley et al. 2000), there is no available population data. However, cutthroat trout densities are reportedly higher in the Chehalis River Basin than in other watersheds in western Washington (Blakley et al. 2000).

3.2.16.6 Threats

Streams and salmonid populations in the Washington coast region, including Scatter Creek, have been affected by such factors as sedimentation, lack of large woody debris, loss of riparian vegetation, poor ocean conditions, altered flow regimes, high water temperatures, estuarine loss, habitat access (barriers), and loss of pool habitat (Johnson et al. 1999). Cutthroat trout are susceptible to the effects of these habitat impacts. In addition, some populations may be susceptible to hybridization with rainbow trout (Johnson et al. 1999).

Another distinction between cutthroat trout and other salmonids is that cutthroat trout spend more time in freshwater and more extensively use a large variety of freshwater habitats than most other Pacific salmonids. Some stocks may have unique life histories that are particularly sensitive to alterations in some freshwater environments (Johnson et al. 1999).

3.2.16.7 Special Needs

As with all salmonids, coastal cutthroat trout require cold, well-oxygenated water, clean gravel and cobble substrate, and habitat features such as undercut banks, pools, and large woody debris. These habitat features are particularly important for overwintering.

3.2.17 Steelhead

3.2.17.1 Legal Status

Steelhead trout (*Oncorhynchus mykiss*) of the Chehalis River Basin belong to the Southwest Washington ESU. On August 9, 1996, NOAA Fisheries determined that listing was not warranted for this ESU (Federal Register Vol. 61, No. 155, p. 41,541).

3.2.17.2 Population Status and Distribution

Winter steelhead are widely distributed throughout the Washington coast region (Figure 3-18). A total of 40 winter steelhead stocks were identified in the Washington coast region (WDFW and WWTIT 1994). Of those stocks, 18 were healthy, 2 were depressed, and 20 were of unknown status. Chehalis River winter steelhead are native, and the stock is considered healthy.

3.2.17.3 Life History

Steelhead life histories can generally be divided into two basic reproductive types based on sexual maturity at the time of river entry and the duration of the spawning migration. The stream-maturing type (known as summer steelhead in the Pacific Northwest) enters freshwater in a sexually immature condition and remains in freshwater to mature for several months prior to spawning in the spring. The ocean-maturing type (known as winter steelhead in the Pacific Northwest) enters freshwater as relatively mature fish and spawn shortly thereafter.

Steelhead entering freshwater between May and October are considered summer steelhead, and steelhead that enter freshwater between November and May are considered winter steelhead. The most widespread run type of steelhead is the winter (ocean-maturing) steelhead. Winter steelhead occur in essentially all coastal rivers of Washington, and most steelhead stocks of the Chehalis River Basin are considered winter steelhead (WDF et al. 1993). Run timing of winter steelhead in the Chehalis River Basin is from December through May, and spawn timing is from mid-February through early June.

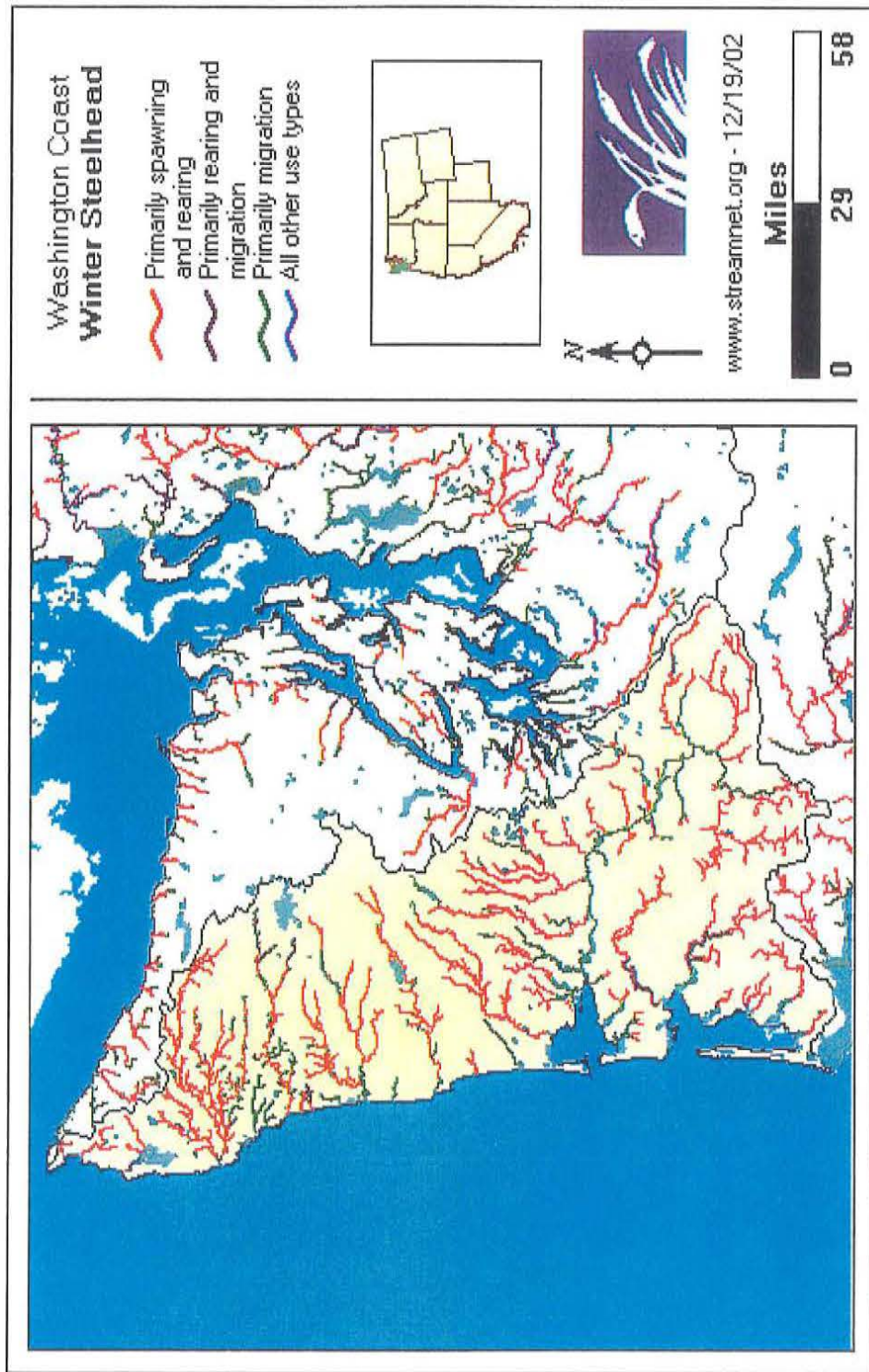


Figure 3-18. Distribution of Winter Steelhead in the Washington Coast Region

As with other salmonids, females excavate redds where eggs are deposited, fertilized, and then covered up by gravel substrate. Steelhead are capable of repeat spawning, although the incidence is relatively low and they will rarely spawn more than twice before dying (Wydoski and Whitney 1979). Steelhead fry typically emerge 40 to 80 days after spawning, but incubation rates vary with water temperature.

Juvenile steelhead rear in freshwater for one or more years before migrating to the ocean. Smolt outmigration generally occurs from April through June (Wydoski and Whitney 1979). As with other anadromous salmonids, steelhead smolts utilize estuaries and nearshore areas to feed for a period of several months to a year before moving out to the open ocean. Steelhead most commonly spend 2 years in the ocean before entering freshwater to spawn (Busby et al. 1996).

3.2.17.4 Habitat Associations/Requirements

During upstream migration, steelhead require holding or resting sites, often formed by large wood, in-stream boulders, or other structures (Spence et al. 1996). Steelhead also require habitat for feeding during their extended adult freshwater phase. Preferred feeding areas are often slower-velocity water adjacent to faster water (Spence et al. 1996). Steelhead frequently spawn in fast, relatively shallow water in mainstem or tributary streams (Everest and Chapman 1972). Spawning substrate is predominantly large gravel, with some small cobble ranging from about 1 to 12 cm in diameter. While in streams, steelhead have been documented to utilize areas over cobbles in water velocities of less than 0.5 ft/s, depths of 15 to 30 cm (Everest and Chapman 1972), stream margins, and submerged rootwads (Bustard and Narver 1975).

3.2.17.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

Early reports do not describe steelhead spawning in Scatter Creek (Royal 1931; Tollefson 1969). Currently, it is unclear whether steelhead spawn in Scatter Creek. A map of upper Chehalis River winter steelhead distribution in the Washington Salmon and Steelhead Stock Inventory Report indicates that winter steelhead do not spawn in Scatter Creek (WDFW and WWTIT 1994). A spawner survey conducted by the Quinault Tribe in May of 1990 did not locate any steelhead or steelhead redds in the lower 0.7 mile of Scatter Creek (data provided by Rob Rhodes, Quinault Tribal Fisheries Biologist). Yet another source (StreamNet 2002) indicates that a run of winter steelhead spawns in Scatter Creek from River Mile 0.0 to 0.4. This estimate may be supported by Scatter Creek smolt trap collections of steelhead from 1986 to 1991, but those steelhead may be moving from the Chehalis River into Scatter Creek to rear, as is likely the case with some other salmonid species.

3.2.17.6 Threats

All streams and salmon populations in the Washington coast region have been affected to some extent by habitat degradation such as sedimentation in spawning grounds, lack of large woody debris, loss of riparian vegetation, overfishing, artificial propagation, poor ocean conditions, altered flow regimes, high water temperatures, estuarine loss, habitat access (barriers), and loss of pool habitat (Smith and Wenger 2001). Scatter Creek has experienced a loss of large woody debris and pool habitat through the loss of natural wood recruitment (from reduction of riparian vegetation), removal of in-stream wood, and reduction of beaver populations. Secondary channels and other off-channel habitat types are lacking, sediment quantity has been rated as poor, and high water temperatures are a concern (Smith and Wenger 2001; TCD 1999).

Portions of Scatter Creek typically dry up during summer months, which may be exacerbated by water withdrawals. Portions of Scatter Creek are, therefore, excluded from use as rearing habitat. On the other

hand, based on existing information, steelhead spawning in Scatter Creek (if it occurs) is likely limited to the lower reaches that remain watered year-round.

3.2.17.7 Special Needs

As with all salmonids, steelhead trout require cold, well-oxygenated water, clean gravel and cobble substrate, and habitat features such as undercut banks, pools, and large woody debris. These features would need to be available in the lower reaches of Scatter Creek that are utilized by juvenile steelhead trout.

3.2.18 Pacific Lamprey

3.2.18.1 Legal Status

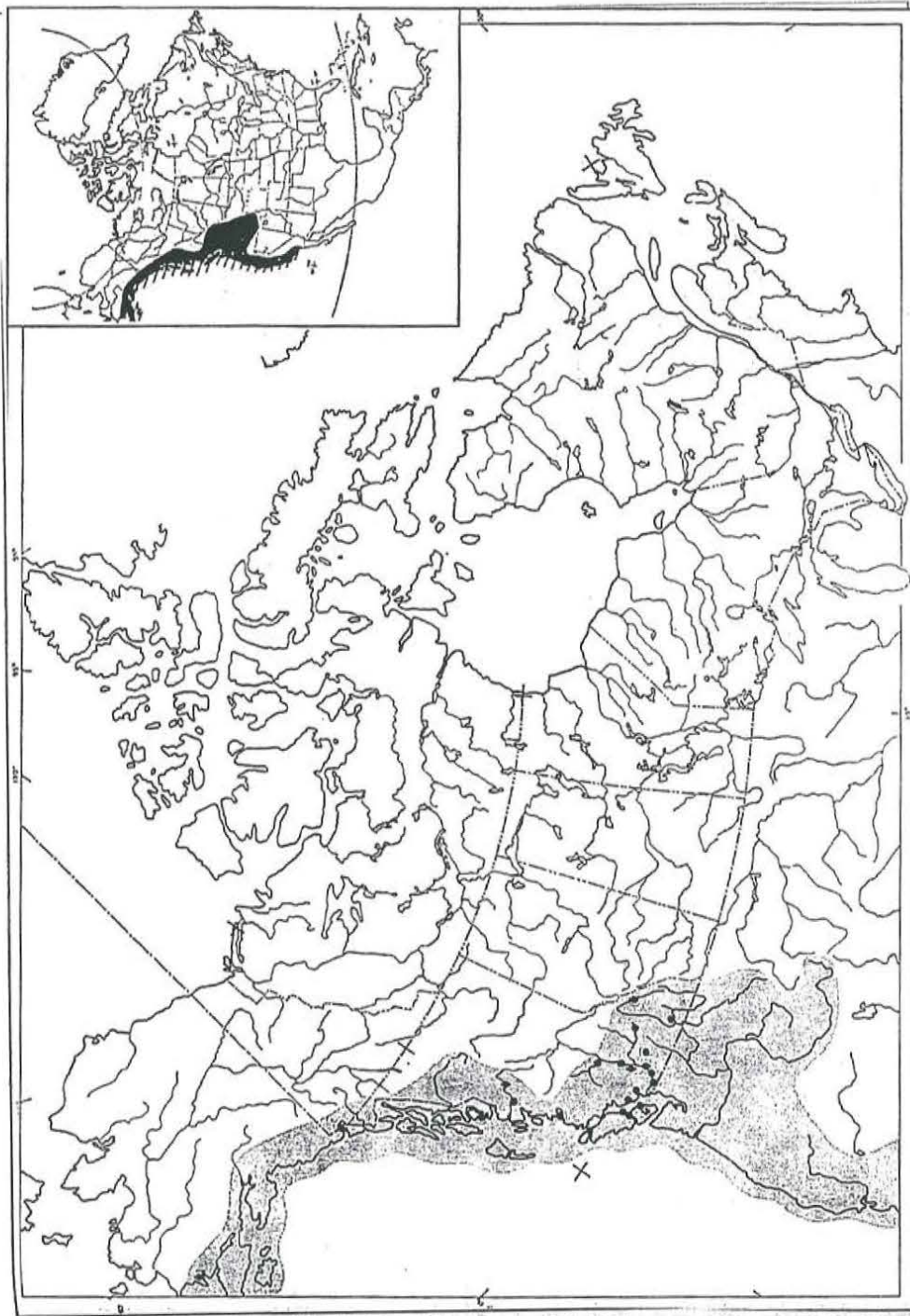
The Pacific lamprey (*Lampetra tridentata*) is a federal species of concern under the jurisdiction of the USFWS.

3.2.18.2 Population Status and Distribution

Pacific lamprey are found in coastal streams from southern California to the Gulf of Alaska (Wydoski and Whitney 1979; Figure 3-19). Current Pacific lamprey populations in the Pacific Northwest are depressed (Close et al. 1995). The historical lack of interest in lamprey population monitoring and impact assessments has hindered the status of lamprey populations (Close et al. 1995).

3.2.18.3 Life History

Pacific lamprey are anadromous fish that spawn and rear in freshwater streams (Wydoski and Whitney 1979). Adult Pacific lamprey enter rivers from July to October, then overwinter in freshwater before spawning in May when water temperatures are between 10° and 15°C (Close et al. 1995). They do not feed during the spawning migration. Adults of both sexes construct shallow nests in stream gravel in low-gradient stream reaches, and eggs are covered with gravel after spawning. Adults die shortly after spawning (Moyle 1976).



Source: Scott and Crossman 1973

Figure 3-19. North American Distribution Of Pacific Lamprey

Juvenile Pacific lamprey (called ammocoetes) emerge from the nest and then burrow into mud or sand to feed by filtering organic matter and algae (Moyle 1976). The ammocoetes generally remain buried in the substrate for 5 or 6 years, occasionally moving from site to site (Wydoski and Whitney 1979). This extended freshwater existence makes lamprey particularly vulnerable to degradations of water quality or habitat. Ammocoetes transform into parasitic juveniles from July through October (Close et al. 1995). It is in this transformation that lamprey develop teeth, tongue, eyes, and the ability to adapt to saltwater. Parasitic juveniles remain in freshwater for up to 10 months before migrating to the ocean in late winter or early spring (Wydoski and Whitney 1979). Pacific lamprey remain in saltwater for up to 3.5 years, where they parasitically feed on fish (Close et al. 1995). At maturity, Pacific lamprey may reach a size of approximately 70 cm, or over 2 ft in length (Hart 1973).

3.2.18.4 Habitat Associations/Requirements

Spawning habitat requirements of lamprey are similar to those of salmonids. Pacific lamprey require clean gravel substrate for spawning and egg incubation. In particular, lamprey ammocoetes typically spend a period of years before transforming into juveniles; therefore, lamprey require relatively stable habitat conditions in areas where ammocoetes bury into silt and mud stream bottoms. Off-channel habitats often provide habitat for lamprey ammocoetes (Close et al 1995).

3.2.18.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

The historic and current numbers and distribution of Pacific lamprey in Scatter Creek are unknown. No population estimates have ever been conducted, but Pacific lamprey are known to spawn in Scatter Creek. In steelhead redd-count surveys conducted in Scatter Creek from River Mile 0.0 to 0.7 in May of 1990 by the Quinault Tribe (data provided by Rob Rhodes, Quinault Nation Fisheries Biologist), approximately 30 lamprey redds were observed. It was not known at the time whether these redds were from Pacific lamprey or river lamprey, but the general consensus was that they were from Pacific lamprey. In addition, Pacific lamprey were collected during smolt trap surveys from 1986 to 1991, but numbers of lamprey were not counted (Pat Hanratty, WDFW, personal communication).

Available Pacific lamprey habitat in Scatter Creek is unknown, but presumably spawning would be limited to areas of gravel and rearing, which would occur along silty stream margins and in off-channel habitats such as beaver ponds and secondary channels.

3.2.18.6 Threats

Pacific lamprey have similar spawning habitat requirements as Pacific salmon and therefore face similar habitat problems affecting salmonid abundance and distribution. In particular, habitat problems include increased sediment in spawning gravels, migration barriers, elevated water temperatures (greater than 20°C), and a decrease in off-channel habitats (such as beaver ponds and secondary channels) due to widespread channel straightening and floodplain development (Close et al. 1995). The extended freshwater existence of lamprey ammocoetes leaves them particularly vulnerable to degradations of water quality or habitat.

3.2.18.7 Special Needs

Pacific lamprey require cold, well-oxygenated water and clean gravel spawning substrate. In addition, developing lamprey ammocoetes require relatively stable areas of fine sediments along stream margins or in off-channel habitats.

3.2.19 River Lamprey

3.2.19.1 Legal Status

The river lamprey (*Lampetra ayresi*) is a federal species of concern under the jurisdiction of the USFWS and is a state candidate species.

3.2.19.2 Population Status and Distribution

The river lamprey is found in coastal streams from northern California to southeastern Alaska (Wydoski and Whitney 1979; Figure 3-20). There is very little information regarding the population status of river lamprey in Washington. The decline of Pacific lamprey populations (Close et al. 1995) warrants concern for existing river lamprey populations due to the similarity in life history and habitat requirements.

3.2.19.3 Life History

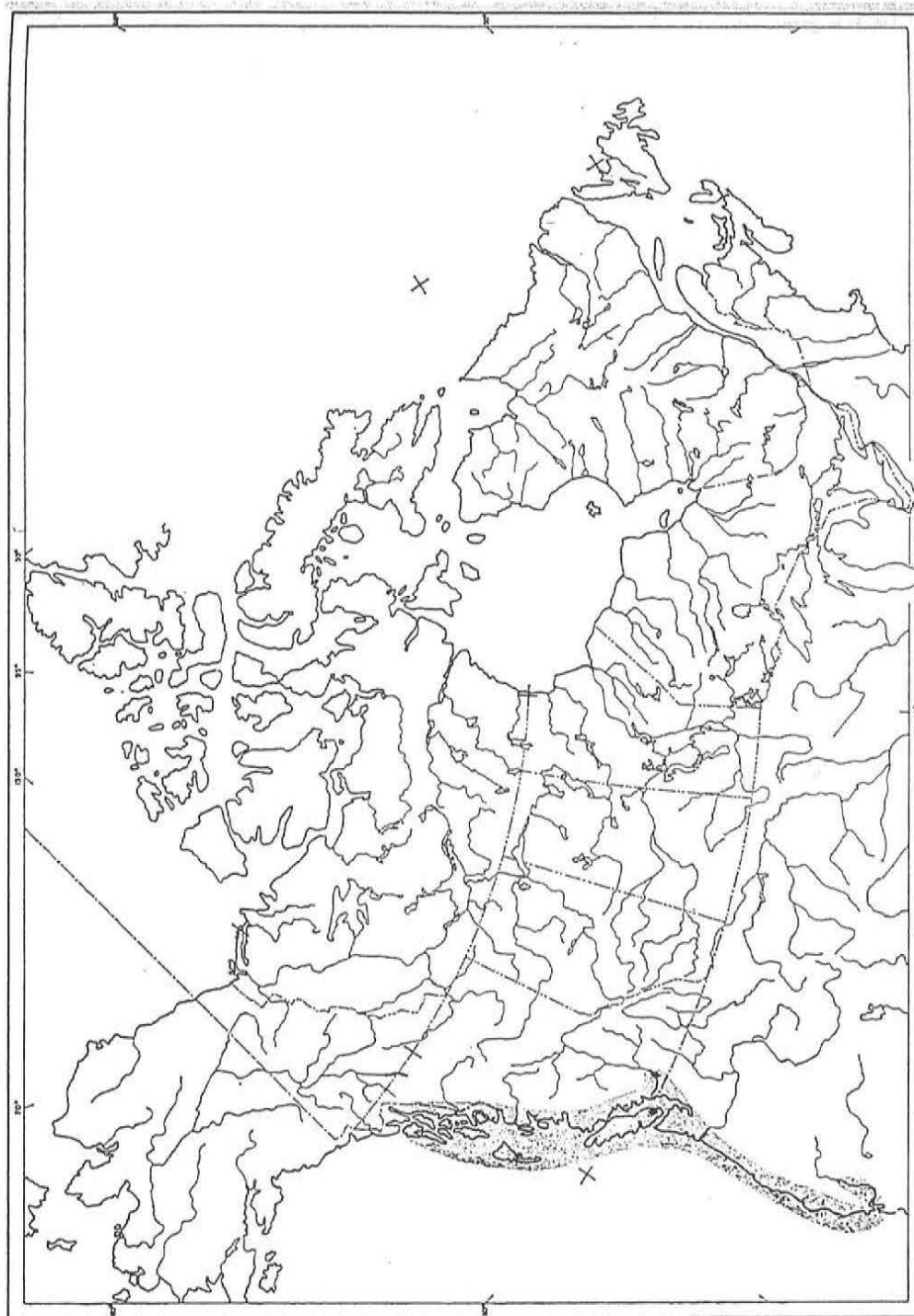
This species exhibits an anadromous life history similar to Pacific lamprey. They migrate up small freshwater streams in the fall and spawn in the winter and spring over clean gravel. Juveniles (ammocoetes) burrow into sandy or muddy substrates near streambanks, where they filter-feed on microscopic plants and animals (Scott and Crossman 1973; Hart 1973). This ammocoete stage lasts several years and is difficult to distinguish from Pacific lamprey ammocoetes (Hart 1973). Ammocoetes transform into adults when as small as 11.7 cm (4.6 inches) in length (Wydoski and Whitney 1979). After transformation, they become parasitic and begin feeding on fish (including juvenile salmon), even in freshwater. River lamprey migrate into saltwater from December through June and spend approximately 3 to 4 months in saltwater feeding on fish before migrating back into freshwater (Beamish 1980). The life span of river lamprey from metamorphosis to death after spawning is approximately 2 years (Beamish 1980), and they attain a maximum length of only about 30 cm (a little less than 1 ft) (Hart 1973).

3.2.19.4 Habitat Associations/Requirements

River lamprey require clean gravel substrate for spawning and egg incubation. Lamprey ammocoetes typically spend a period of years before transforming into juveniles; therefore, lamprey require relatively stable habitat conditions in areas where ammocoetes bury into silt and mud stream bottoms. Off-channel habitats often provide habitat for lamprey ammocoetes (Close et al 1995).

3.2.19.5 Habitat and Occurrence in the Scatter Creek Watershed Vicinity

There are no confirmed reports of river lamprey in Scatter Creek and the occurrence of river lamprey in the Scatter Creek watershed is unknown. Scatter Creek is within the range of river lamprey and no surveys have been conducted to specifically determine the presence of river lamprey. Lamprey redds have been observed in Scatter Creek, but these were believed to have been made by Pacific lamprey (Rob Rhodes, Quinault Tribe, personal communication). Brook lamprey (*Lampetra richardsoni*) were also collected at a smolt trap operated from April to June in 1986 through 1991. It is possible that some river lamprey were confused with brook lamprey. Available river lamprey habitat in Scatter Creek is unknown, but presumably spawning would be limited to areas of gravel, and rearing would occur along silty stream margins and in off-channel habitats such as beaver ponds and secondary channels.



Source: Scott and Grossman 1973

Figure 3-20. North American Distribution of River Lamprey

3.2.19.6 Threats

Because river lamprey are not known to occur in Scatter Creek, no specific threats in the Scatter Creek watershed have been identified. Due to similarities in habitat requirements, those threats common to salmonid populations and Pacific lamprey would also affect river lamprey. These include decreases in off-channel rearing habitats, migration barriers, elevated water temperatures, and sedimentation.

3.2.19.7 Special Needs

River lamprey require cold, well-oxygenated water and clean gravel spawning substrate. In addition, developing lamprey ammocoetes require relatively stable areas of fine sediments along stream margins or in off-channel habitats.

3.2.20 White-Top Aster

3.2.20.1 Legal Status

The white-top aster (*Aster curtus*) is a federal species of concern and a state-listed sensitive species.

3.2.20.2 Population Status and Distribution

Over 80 occurrences of white-top aster are known in Washington, but many are very small, occur in fragmented and isolated habitat patches, and are under ongoing threats (DNR, WNHP 2000). Figure 3-21 provides the distribution of the white-top aster within Washington State. This species occurs from southwestern Vancouver Island to western Washington's Puget Trough to western Oregon's Willamette Valley. The largest populations are found on Fort Lewis Military Base in Pierce and Thurston Counties, Washington (Gamon and Salstrom 1992). Due to limited knowledge, it is unclear whether white-top aster populations are increasing or decreasing; however, preliminary results from a population survival model, being developed by the Land Condition Trend Analysis (LCTA) of Fort Lewis and The Nature Conservancy, show that populations are increasing at Fort Lewis (Lombardi 2003 personal communication). This model uses data on monitoring white-top aster populations and current land use practices.

3.2.20.3 Life History

White-top aster is a small, perennial herb (a plant that lives 3 years or more) in the Aster family (Asteraceae), which persists primarily through rhizome production (horizontal underground stems that send out new roots and shoots). Alternate-leaved stems (i.e., stems with one leaf per node on different sides and at different heights) topped by a tight, head-shaped cluster of flowers (called a capitulum) are produced from the slender rhizomes, creating colonies of 50 to 200 or more shoots (DNR, WNHP 2000). New shoots emerge in March and become prominent in late spring, and flowering occurs from late July through early September, with early flowers being strongly protandrous (i.e., they release pollen before they are receptive to pollen) (Giblin, in Dunn and Ewing 1997). Only 10 to 30 percent of the shoots in typical colonies bear flowering heads (DNR, WNHP 2000). Stem lengths for flowering shoots usually range from 4 to 12 inches, with non-flowering shoots reaching stem lengths less than half that. Generally, each capitulum will consist of three inconspicuous white ray flowers (strap- or ribbon-shaped outer flowers) and 13 disk flowers (tubular inner flowers that produce seeds). Effective pollination is achieved by three to four bee species, though butterflies do visit flowers that are fully open (Giblin, in Dunn and Ewing 1997). It has been shown that white-top aster produces reasonable quantities of viable seeds (capable of growing) when the flowers are accessible to pollinating insects, and that these seeds germinate

(sprout and grow) under a range of conditions when exposed to light (Giblin, in Dunn and Ewing 1997). Recent studies by Bigger (1999) found seed viability to be 39 percent, varying by site and/or year. This variation may be associated with differences in local plant communities, such as the availability of alternative nectar sources, surrounding vegetation, and abundance of pollinators (Bigger 1999). Achenes (small, dry, one-seeded fruits [like sunflower seeds]) are produced after pollination and are dispersed by the wind in September and October. White-top aster grows very slowly from seed (Clampitt 1984, in Gamon and Salstrom 1992).

3.2.20.4 Habitat Associations/Requirements

White-top aster is endemic (native) to lowland grasslands of the Puget Trough and Willamette Valley. Most populations occur in gravelly, glacial outwash soils; however, in the southern and northern portions of its range, it occurs in clayey and exposed bedrock habitat, respectively (DNR, WNHP 2000). Spanaway is the typical soil series, which consists of very deep, somewhat excessively drained, droughty soils that formed in glacial outwash and volcanic ash (Pringle 1990). This species occurs at low elevations ranging from 100 to 550 ft above sea level. Historically, the Washington populations have shown a preference for the undulating topographical rises and swales of the Mima mounds and particularly thrive in areas where pocket gophers tunnel, creating favorable microsites. This aster usually requires a seasonally mesic (moderately moist) habitat that is dry during the summer (Gamon and Salstrom 1992). White-top aster generally persists in open grasslands dominated by greater than 50 percent native grasses and herbs. It also may be found in partially wooded areas such as Oregon white oak or Douglas-fir woodlands and savannas. Thomas and Carey (1996) found canopy cover above white-top aster ranged from full sun (open grasslands) to 30 percent shade (mixed woodland/shrub grasslands). Roemer's fescue, Oregon sunshine (*Eriophyllum lanatum*), spikelike goldenrod (*Solidago spathulata* var. *neomexicana*), and kinnikinnick (*Arctostaphylos uva-ursi*) are the most frequently encountered associated species (Thomas and Carey 1996). Other associated species within the grassland habitat include native early blue violet, balsamroot (*Balsamorhiza deltoidea*), and yarrow (*Achillea millefolium*); and nonnative Scot's broom, hairy cat's ear (*Hypochaeris radicata*), St. John's wort (*Hypericum perforatum*), and colonial bentgrass (*Agrostis capillaris*) (DNR, WNHP 2000).

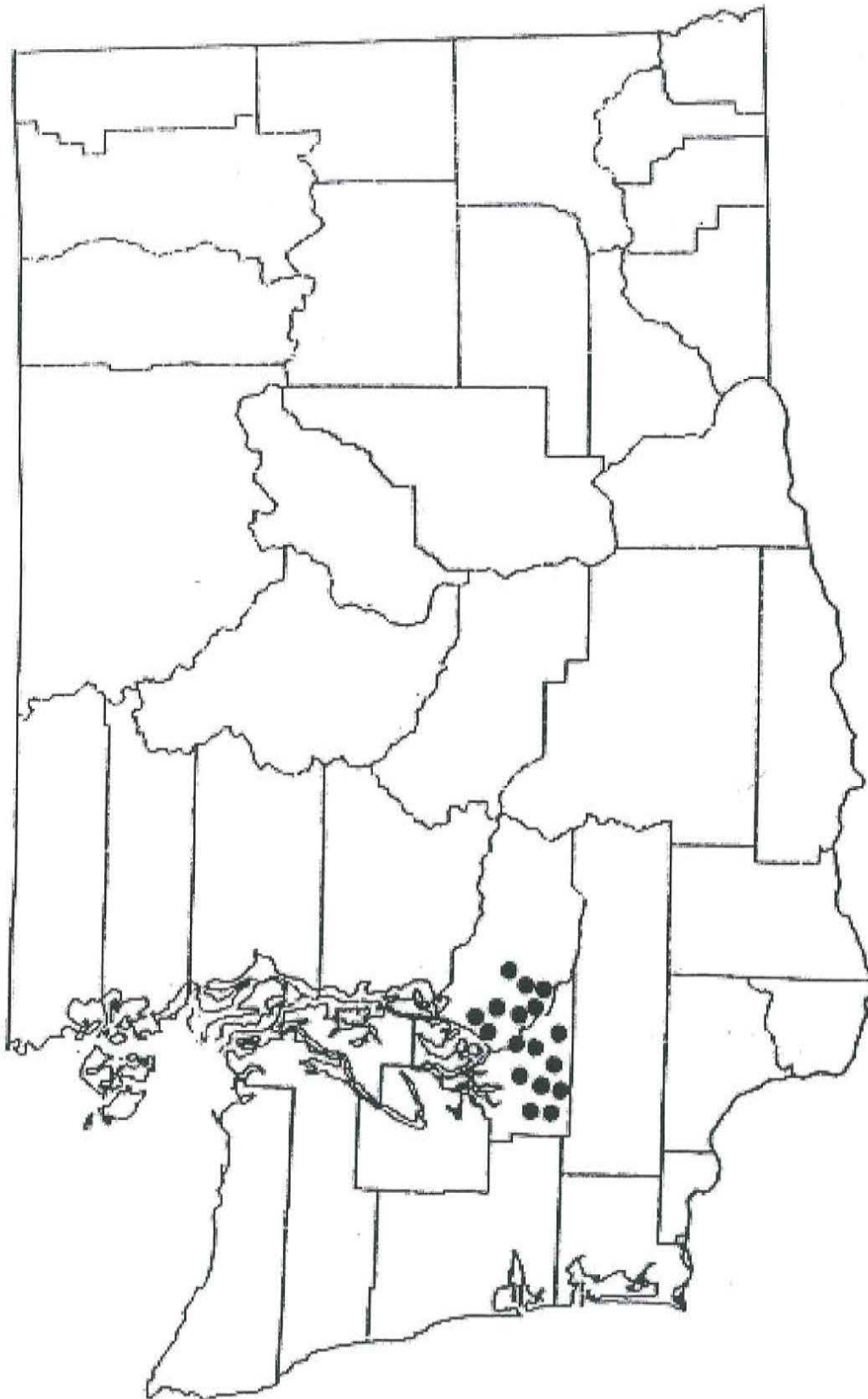
3.2.20.5 Habitat and Species Occurrence in the Scatter Creek Watershed

The Scatter Creek watershed contains typical south Puget Sound grassland areas with native and nonnative grassland species as mentioned above, along with other plants commonly found in grasslands, such as Canada thistle (*Cirsium arvense*), sweet vernalgrass (*Anthoxanthum odoratum*), common velvetgrass (*Holcus lanatus*), English plantain (*Plantago lanceolata*), self-heal (*Prunella vulgaris*), bracken fern (*Pteridium aquilinum*), and narrow-leaved mule's-ears (*Wyethia angustifolia*). Any remnant native grasslands or possibly degraded grasslands in Thurston County may provide potential habitat for the white-top aster (DNR, WNHP 2002b). Nine white-top aster population occurrences totaling approximately 100,000 shoots have been documented within the vicinity of the Scatter Creek watershed (DNR, WNHP 2002b). These populations are scattered throughout the central and western portions of the watershed. Prior to European settlement, this aster likely inhabited all native grassland areas within the watershed.

3.2.20.6 Threats

General Threats

The greatest threats to populations are habitat destruction, invasion of exotic species, and Douglas-fir encroachment as a result of fire suppression. Exotic species and Douglas-fir outcompete and shade out native grasses and herbs. In order to accommodate human population growth in western Washington, land use continues to change, resulting in habitat destruction. Native grasslands were converted to



Source: Washington Department of Natural Resources

Figure 3-21. White-Top Aster Distribution in Washington State

agricultural use and crop production and commercial and residential development. At least 97 percent of prairie habitat in the south Puget Sound region has been destroyed, with this destruction still ongoing (Dunn and Ewing 1997). Both the invasion of exotic species and encroachment of Douglas-fir are significant threats to remaining white-top aster habitat. Scot's broom, the most threatening exotic species, creates a monotypic shrubland. Since the removal of fire, Douglas-fir is able to encroach grasslands.

Specific Threats Within the Watershed

Much of the native grassland within the Scatter Creek watershed has been destroyed. Land use conversion of remnant native grasslands is still a threat to existing white-top aster populations. However, Scot's broom infestations have invaded large portions of these remnant grasslands, and continue to be an immediate threat to all native grasslands in the watershed. Douglas-fir encroachment does occur along the grassland/forest ecotone, causing a long-term threat to this species' habitat.

3.2.20.7 Special Needs

Special needs of white-top aster are protection and management of extant (existing) populations and associated habitat within the watershed through rehabilitation and restoration. Mechanical removal and prescribed fire are two management tools that should be considered for control of nonnative species (DNR, WNHP 2000). Prescribed fires also help maintain grasslands, and small disturbances may support seedling establishment and clonal expansion (Gamon and Salstrom 1992). Creation and application of an integrated pest management plan may also prove beneficial. Planting of associated native species (i.e., Roemer's fescue) should be used in conjunction with nonnative species management for restoration. Additional research and monitoring of known populations and surveys for unknown populations may assist in gaining knowledge on population limiting factors and current status trends.

3.3 DATA GAPS

The collection of additional information regarding habitat and species use in the Scatter Creek watershed would be helpful for determining which species to include in the HCP and for the development of HCP conservation measures. In particular, site surveys of specific habitat conditions (i.e., age of oak and conifer stands; native forb composition in grasslands and other open areas), as well as surveys for various wildlife and butterfly species, should be conducted in appropriate habitat on both public and private lands.

4. HYDROLOGY AND GEOMORPHOLOGY

4.1 METHODS

This assessment of the Scatter Creek watershed was based on review and interpretation of existing literature of the area, review and some analysis of precipitation and streamflow gages in the area, and several days of field review. Landforms were observed in field visits, on aerial photographs, and on 2-ft contour interval topographic maps.

The geology and hydrology of the Scatter Creek valley were assessed based primarily on existing literature. In particular, the geologic mapping of Lea (1984); the aquifer analysis of Hirschey and Sinclair (1992); the U.S. Geological Survey (USGS) groundwater model of Drost et al. (1999); and the compilation and analysis of aquifer information by Mead, Darin, and Tayne (1996) were reviewed. The work of Noble and Wallace (1966) provided a broad wealth of information on the region. Historic maps and aerial photographs were reviewed for the years 1854, 1856, 1931, 1941, and 1999.

Stream gages in the Chehalis Basin were reviewed to compare runoff patterns and estimate the likely range of streamflows based on the short Scatter Creek record, which was used to describe the hydrological functioning of the watershed and how it relates to the watershed habitats and current physical conditions. Present and ancient conditions of the Scatter Creek Basin were evaluated in relation to the site geology, landforms, and hydrology.

The well logs for the Scatter Creek watershed were inventoried using the Washington State Department of Ecology (Ecology) Database. The agency has scanned all of the well records, starting with those recorded after 1972. Wells prior to this time were identified with water rights records. The records were queried for each section in the Scatter Creek watershed and the scanned well logs were downloaded. The well records were sorted by location, depth, source, diameter, and construction date. The well records, in conjunction with the watershed geologic information, were used to assess groundwater conditions of the basin.

4.2 GEOLOGY

4.2.1 Introduction

The Scatter Creek watershed is located at the southwest edge of the Puget Lowland of western Washington. Multiple advances of the Puget lobe of the Cordilleran Ice Sheet created or modified nearly the entire Puget Lowland land surface below about 1,000 m elevation (3,280 ft) (Armstrong et al. 1965; Booth 1987, 1994; Easterbrook 1969, 1986; Proter 1976). The present Puget Lowland landscape displays the effects of massive proglacial infilling followed by subglacial and proglacial scour from multiple glacial advances during the Pleistocene Epoch (2.5 million years to 10,000 years ago).

The watershed is located at the maximum southwest terminus of the Vashon Stade of the Fraser Glaciation and the much earlier Penultimate glacial advance (Lea 1984; Bretz 1913). The most recent glacial advance, the Vashon Stade of the Fraser Glaciation, left most of the surface materials and major landforms in the Scatter Creek Basin. The Vashon maximum glacial advance into the Puget Lowland was about 15,000 years ago (Booth 1994) (Figure 4-1).



Figure 4-1. Puget Lobe of the Most Recent Vashon Stade of the Fraser Glaciation

Note: Tenino and the Scatter Creek watershed are located at the maximum southwest extent of the ice sheet about 15,000 years ago. Large rivers from under the melting ice and along the west slope of the Cascade Mountains drained through the Scatter Creek, Skookumchuck River, and Black River valleys to the Chehalis River. The rivers and coast line shown in this drawing are for the present conditions; at the time of the Vashon Ice Sheet, the coast line was about 15 miles further west and very large rivers drained the glacier and west slope of the Cascades. (Source: Galster and Coombs 1989, modified from Cary 1968)

A much earlier advance, the Pre-Fraser Penultimate glacial stage (Lea 1984), sculpted and eroded the main low areas where the much later Vashon glacier and drainage channels were located. The Penultimate Glaciation occurred prior to the last interglacial period more than 125,000 years ago.

Scatter Creek and its tributaries flow over glacial sediments deposited during the most recent glacial advance into the Puget Lowland, the Vashon Stage of the Fraser Glaciation (Armstrong et al. 1965; Booth 1987; Easterbrook 1986). The Vashon glacier and large rivers flowing from the melting ice and runoff from the west slope of the Cascades flowed out the drainages that formed the present Scatter Creek landforms. The present Scatter Creek Basin landforms, surface and groundwater hydrology, and ecological zones are greatly influenced by the glacial-age deposits (Figure 4-2).

4.2.2 Basin Landforms

Landforms are the features that make up the earth's surface, such as plains, mountains, or valleys. Landforms are the result of natural geologic processes and manmade modifications. The main landforms in the Scatter Creek watershed include the outwash plains built by a large river flowing from the Vashon Ice Sheet, the hill areas that were modified by the ice sheet, alluvial fans (fan shaped deposits of sediment left by a stream) that form at the tributary mouths along the base of the hills, and present-day river channels and floodplains that have only moderately modified the glacial-age landforms. In the Scatter Creek Basin, the dominant landform consists of relatively level glacial outwash plains locally named the Grand Mound, Mound, Violet, Rock, and Frost Prairies (see Figure 4-2). The prairie surface was formed about 14,000 years ago by great rivers flowing off of the southern end of the great Vashon Ice Sheet. The main and side channels, overbank areas, and migration zone of the great ice-age drainage ways are still well preserved on the outwash surfaces and have only been moderately modified by surface processes and land modification since formed (Figure 4-3).

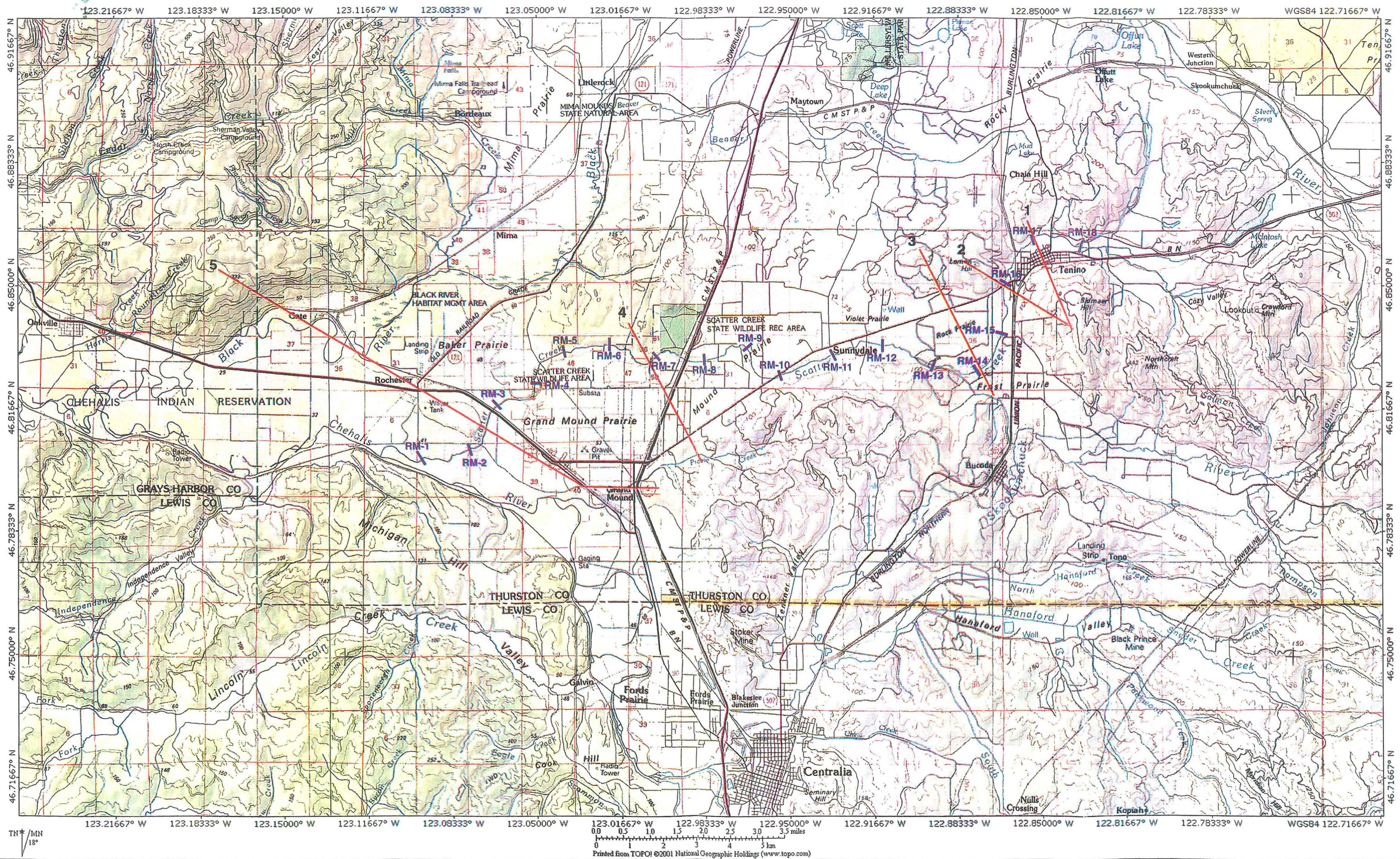
The outwash prairie landform constitutes about 12,500 ac or about 45 percent of the Scatter Creek Basin. Lack of surface drainage and abandoned terraces across much of the outwash prairies indicate that the Scatter Creek channel has been in the same area without significant erosion and incision across the full width of the valley bottom.

4.2.3 Bedrock Geology

The bedrock formations in the Scatter Creek valley and southwestern Thurston County were deposited in the late Eocene Epoch (38 to 55 million years ago) through the early Pleistocene (2.5 million years ago). The bedrock of the Scatter Creek region consists of sedimentary and volcanic rocks of middle to late Eocene age that were folded in the early Miocene, mostly along northwest-southwest trending folds and faults (Snively et al. 1958). The Black Hills, Bald Hills, Michigan Hill, and Maytown Upland that surround the Scatter Creek region are formed from uplifted, faulted, and folded bedrock that was rounded by the great ice sheet advances into the region. Bedrock formations in the Scatter Creek Valley are described below.

4.2.3.1 Logan Hill Formation

The Logan Hill Formation consists of Early to Middle Pleistocene alpine outwash sand and gravel with minor interbedded (layered) silt and clay (Weigel and Foxworthy 1962). The unit is distinct from other glacial units because it is deeply weathered, often mantled with 6 to 13 ft of silt and clay. Total thickness of the formation is from 6 to 150 ft near Chehalis (Snively et al 1958) and up to 250 ft thick south of the Centralia quadrangle (Roberts 1958). The Logan Hill Formation outcrops mostly south of the



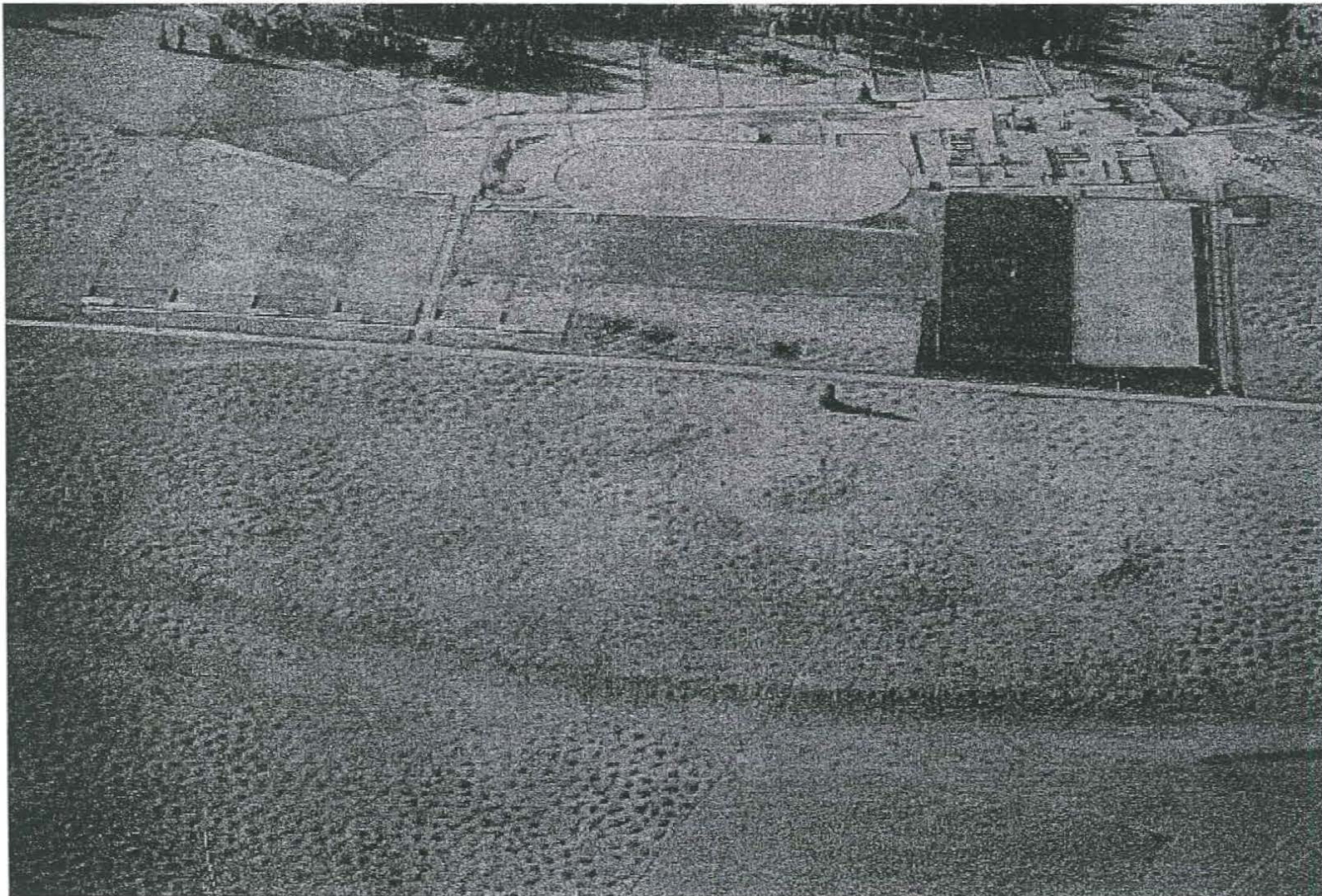


Figure 4-3. Aerial View of the Northern Part of Rock Prairie

Note: Photograph includes a large longitudinal river bar formed by the great river flowing through the Tenino outwash channel. Glacial-age river channel features, Mima mounds, and other periglacial features are well preserved on the outwash surface. (Source: Lea 1984)

Skookumchuck River, in the uplands of Michigan Hill and on the Maytown Upland, and forms the low hill by Rochester and Grand Mound at the lower end of the Scatter Creek valley. The Logan Hill Formation is a confining bed and not a significant aquifer in the region.

4.2.3.2 Lincoln Creek Formation

The Lincoln Creek Formation conformably overlies the Skookumchuck Formation and reaches a maximum known thickness of 2,000 ft. The formation consists of upper Eocene to Oligocene tuffaceous silty sandstone and siltstone that formed mostly in a shallow-water, offshore-marine environment and contains marine invertebrate fossils (Noble and Wallace 1966). The formation is exposed on Michigan Hill and in small outcrops south of Rochester. The Lincoln Creek Formation underlies the Scatter Creek Basin. The Lincoln Creek Formation is not a significant aquifer in the region.

4.2.3.3 Skookumchuck Formation

The Skookumchuck Formation of middle to upper Eocene age reaches a maximum known thickness of about 3,500 ft (Noble and Wallace 1966). The Skookumchuck Formation outcrops along the Skookumchuck River and consists of marine, nonmarine, and brackish-water sedimentary deposits. The formation mostly consists of siltstone and plagioclase-rich arkosic sandstone and is often interbedded with coal seams. The unit outcrops along the western end of the Bald Hills, in the Maytown Upland, and about a mile north of Grand Mound. The Skookumchuck Formation underlies the Scatter Creek Basin. The Skookumchuck Formation is not a significant aquifer in the region.

4.2.3.4 Northcraft Formation

The Northcraft Formation, of probable upper Eocene age (Schasse 1987), may be as much as 1,000 ft thick and conformably overlies the McIntosh Formation. The formation consists mostly of andesitic and basaltic lava flows and flow breccias. The lower portion of the formation consists of basaltic conglomerate, basaltic sandstone, and pyroclastic rocks. The formation is on the south flank of Lemon Hill west of Tenino; there are a few outcrops in the Maytown Upland. The Northcraft Formation yields little water and is not a significant aquifer in the region.

4.2.3.5 McIntosh Formation

The oldest rocks in the area are from the McIntosh Formation of middle to upper Eocene age and consist primarily of dark gray, hardened, tuffaceous siltstone and claystone interbedded with thin tuff layers and vesicular basalt flows. Near Tenino, the upper several hundred feet of this unit consists of massive arkosic sandstone. Pillow basalts were observed in the cut southwest of McIntosh Lake. Further to the south and west, the formation is finer grained. The McIntosh Formation yields little water and is not a significant aquifer in the region.

4.2.4 Glacial Geology

The Puget Lowland of western Washington was glaciated by the Puget lobe of the Cordilleran Ice Sheet that advanced multiple times out of the coastal mountains of British Columbia (Crandell 1965; Easterbrook 1969, 1976; Porter 1976; Waitt and Thorson 1982). These glacial advances are described below.

4.2.4.1 Penultimate Glacial Stage

The Penultimate glacial drift in the Scatter Creek area represents the only known advance of the Puget lobe beyond the latest Vashon glacial drift (Lea 1984). The age of the Penultimate drift is tentatively correlated with the Double Bluff drift and is thought to be older than 125,000 years, or about 100,000 years before the last (Vashon) glacial advance.

The Penultimate glacial drift forms discontinuous till and outwash deposits that range in thickness from 1.5 ft to about 20 ft thick in the Scatter Creek valley. The Penultimate till is interspersed with poorly sorted, nonstratified outwash and ice contact sands and gravels that are 3 to 20 ft thick (Lea 1984) (Table 4-1). The Penultimate drift underlies most of the Scatter Creek prairies. The unit is distinguished from the underlying Logan Hill Formation and by the much younger Vashon glacial drift by pebble lithology, differences in weathering rinds on pebbles, and degree of soil development. The Penultimate drift was partly scoured out and covered by deposits during the much younger Vashon glacial advance into the Puget Lowland.

The maximum advance of the Penultimate glacier crossed the Scatter Creek valley and stopped against the hills to the south of the valley and on Michigan Hill across the Chehalis River (Figure 4-4). The Penultimate Ice Sheet and runoff eroded and smoothed out the preexisting hills and valleys and formed the basic bedrock valleys of the area that the much later Vashon glacial advance and runoff channels would follow.

As the Penultimate glacier receded from the area, tributary valleys like Cozy Creek were blocked at the mouth by delta and river deposits forming lakes and infilling the lower valleys with fine-grained sediment. The Penultimate glacial drift beneath the Scatter Creek prairies is an important Scatter Creek valley aquifer.

4.2.4.2 Vashon Glaciation

For about 2,000 to 3,000 years starting about 17,000 years ago, the Vashon Ice Sheet advanced down the Puget Lowland (see Figure 4-1). Great rivers flowing from beneath and along the edges of the glacier deposited a low-gradient advance outwash plain in the Puget Lowland named the "great lowland fill" by Booth (1994). Deposition in glacial lakes and rivers began in southern Puget Sound when the ice sheet blocked the Strait of Juan de Fuca about 16,000 years ago (Booth 1994). Great rivers discharging from the melting ice were forced south over the low hills of the Maytown Upland to the Chehalis River.

In the Scatter Creek watershed, the main deposition period for Vashon advance outwash and till was from about 15,000 to 14,000 years ago when the Vashon Ice Sheet was near and at its maximum. After the glacial maximum, as the ice sheet began to recede, great rivers running from under the ice scoured and deposited alluvial gravels in large, mostly braided channels in the Scatter Creek valley. Rivers flowing from beneath and along the edges of the melting ice sheet had a combined discharge of about 100,000 cubic feet per second (cfs) (3,000 m³/s) (Booth 1986). This large water discharge from the receding ice sheet scoured out valleys under the ice and deposited river alluvium in large channels that grade to Grays Harbor. The deposits were built from the very high sediment transport typical of glacial runoff rivers (Booth 1994).

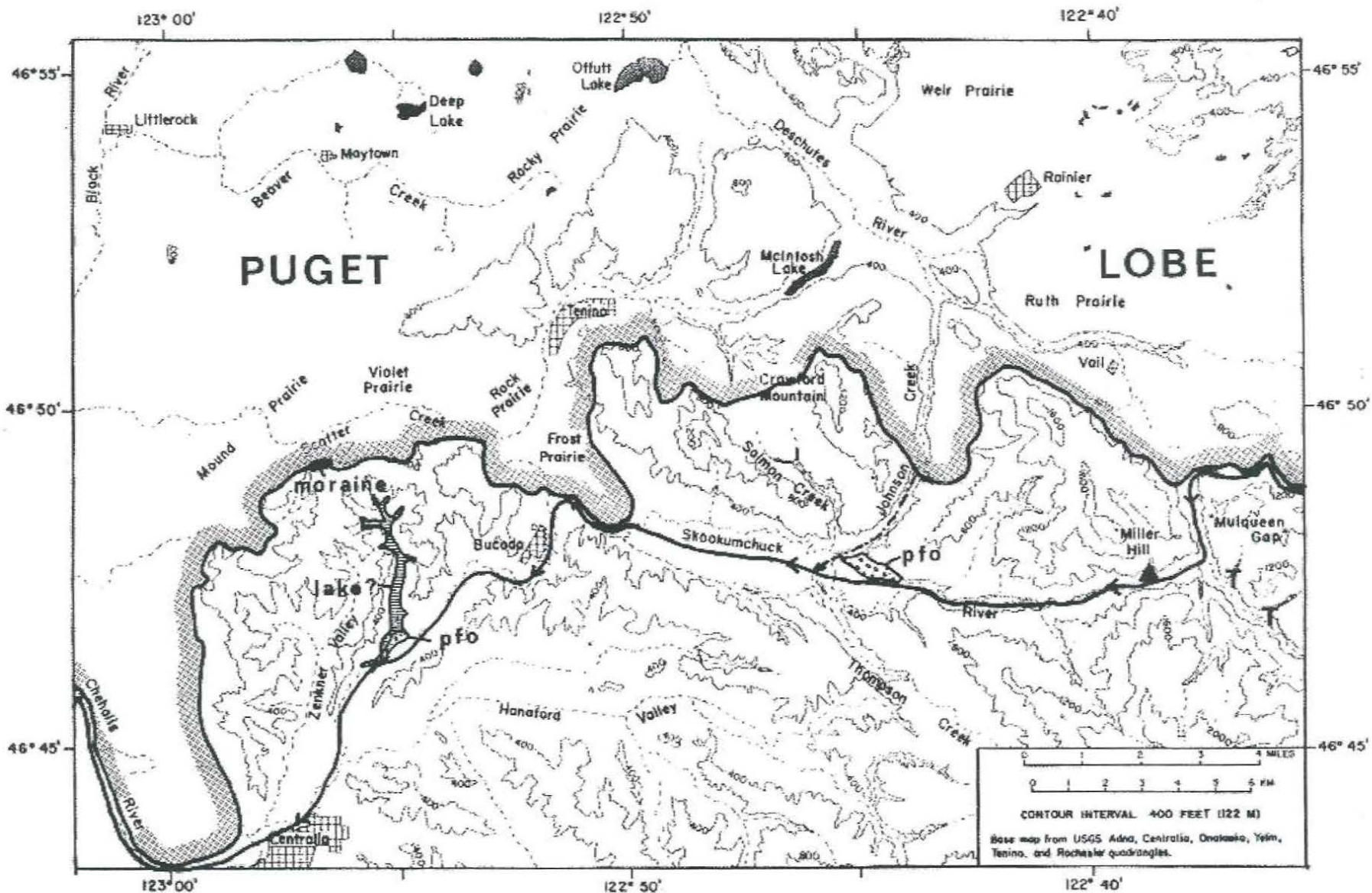
Table 4-1. Geohydrologic Units in the Scatter Creek Valley

Age	Series	Geologic Unit		Geo-hydrologic Unit Symbol	Typical Thickness	Lithologic Characteristics	Hydrologic Characteristic	Hydraulic Conductivity (ft/day) ²	
								Range	Median
Quaternary	Holocene 10,000 years to present		Alluvium	Qal	5 - 10	Well sorted, loose river sand and sandy gravel with silty sand overbank and backwater/beaver dam organic rich fine deposits	Generally saturated or damp, generally high permeability; surface unit goes dry some reaches	14 - 2,100	150
	Pleistocene 2.5 million to 10,000 years	Vashon Drift	Recessional Outwash	Qvr	25	River and delta sands and gravel along major glacial channels; moderately to well-sorted	Mostly unconfined aquifer; perched conditions locally	14 - 2,100	150
			Till	Qvt (1)	25	Typically dense, poorly sorted sand, gravel, and boulders in clay and silt matrix,	Confining bed; can yield unstable amounts of water from thin lenses of clean sand and gravel	5.2 - 89	14
			Advance Outwash	Qva	10 - 50	Poorly to moderately well-sorted, well-rounded gravel in a matrix of sand with some sand lenses	Groundwater mostly confined; major aquifer	6.8 - 130,000	180
		Penultimate Glaciation (Lea 1984)		Qc	10 - 20	Coarse sand and gravel, deeply stained with red or brown iron oxides	Water is confined; used extensively for water supply	1.9 - 12,000	150
		Logan Hill Formation		Qf ¹	20-70	Predominantly clay and silt, with some layers of sand and gravel; minor amounts of peat and wood	Confining bed; not an aquifer	0.5 - 62	17
		Undifferentiated Deposits		TQu ¹ Tb	Unknown	Includes glacial and non-glacial clay, silt, sand, and gravel	Contains aquifers and confining beds; water may be confined; poorly permeable; locally an aquifer, but unreliable; water contained in fractures and joints; well yields small	1.2 - 4,200	78
Tertiary	Miocene and Eocene	Bedrock Units		Tb	Unknown	Sedimentary rocks, clay stone, siltstone, sandstone, and minor coal	Poorly permeable; locally an aquifer, but unreliable; water contained in fractures and joints; well yields small	0.0025 - 450	0.88

Modified: from Drost et al. (1999).

¹ Also includes some lake deposits and earlier tills.

² From Drost et al. (1999).



Parametrix Scatter Creek 553-4335-001/01(10) 01/03 (K)

Note: Maximum extent of the Penultimate glacial ice sheet over 125,000 years ago that first scoured out the main valleys and rounded the hills in the Scatter Creek valley. The Penultimate deposits are an important water supply aquifer in the Scatter Creek area (from Lea 1984).

Figure 4-4
Penultimate Glacial
Ice Sheet Maximum



The Vashon Ice Sheet advanced over the advance outwash and deposited a layer of lodgment till partway into the Scatter Creek valley at the glacial maximum around 14,500 years ago (Booth 1987) (Figure 4-5). At the glacial maximum, the Scatter Creek valley was covered with ice up to about the present location of Scatter Creek and forced drainage from the entire west slope of the Cascades through the Johnson Creek valley and upper Scatter Creek valley from McIntosh Lake to below the valley of Tenino (Figure 4-5). When the ice blocked flow out of the Scatter Creek valley, a large alluvial fan formed across Rock and Frost Prairies. Discharge with high sediment flowed through the Tenino drainage and joined the flow down the Johnson Creek valley and the enlarged lower Skookumchuck valley (Figure 4-5).

As the ice sheet receded from the glacial maximum, drainage shifted from the Skookumchuck to the Scatter Creek valley with the main discharge flowing through the narrow bedrock controlled Tenino cut (Figure 4-6). The outwash channels from this stage built the outwash surface that is the present Rock, Violet, Frost, Mound, and Grand Mound Prairies. The main glacial runoff channel eventually scoured into the Rock/Frost Prairies alluvial fan forming the incised big bend portion of Scatter Creek between River Mile 12.5 and River Mile 13 and sending all of the surface runoff west down the Scatter Creek valley.

As the ice continued to recede, drainage shifted further north and formed the Beaver Creek valley. Continued recession shifted the entire glacial runoff northwest up the Deschutes River valley and out the Black Creek valley, building the Rocky and Mima Prairies. This left the large Scatter Creek glacial outwash channel with only local surface and groundwater drainage. For about the past 13,500 years, Scatter Creek has been a small, low-gradient creek flowing in the lower part of the very large glacial-age runoff channels formed during the early stages of retreat of the Vashon Ice Sheet.

Much of the prairies are covered with a layer of dark brown, pebbly, silt that forms nearly symmetrical mounds, locally known as Mima mounds. The mounds are found on glacial-age channel bottoms, as well as bar tops across the Vashon-age outwash plains (see Figure 4-3). The soils in the mound outwash areas are classified as Spanaway-Nisqually complex with 2 to 10 percent slopes and occupy 9,975 ac or 2 percent of Thurston County and 3,144 ac or 11 percent of the Scatter Creek Basin. A similar soil unit without the Mima mounds, the Spanaway gravelly sandy loam with 0 to 3 percent slopes is the main soil unit in the Scatter Creek Basin, occupying 6,472 ac or 23 percent of the basin. Soils are discussed further in Section 5.2.2.

The Mima mounds and other similar permafrost-related periglacial landforms formed on the outwash surface after the glacial drainage abandoned the area but likely before the Chehalis River eroded down into the glacial valley fill to its present level (Washburn 1973, 1980, 1997). Vashon deposits along the Chehalis River valley are found 20 to 40 ft above the present floodplain (Lea 1984), representing the original outwash surface prior to about 14,000 years of erosion to the present Chehalis River grade level. Prior to the Chehalis River cutting down into the loose outwash, the groundwater table would have been higher in the prairies and conducive to formation of patterned ground and other permafrost and periglacial features.

The glacial-age landforms, Mima mounds, river channels, deltas, and other fluvial features preserved on the outwash surface show there has been little modification since they were formed. The streambank and channel features of the glacial-age rivers were steep to near vertical when abandoned but now have been smoothed out by wind, soil creep, rainsplash, trampling, plowing, and similar processes. The low stream density on the prairies and relative lack of modification of the glacial-age landforms indicates that nearly all of the precipitation that does not evaporate soaks into the ground. Scatter Creek has been dominated by groundwater flow for the past 14,000 years. Very little of the old glacial channel has been modified by Scatter Creek.

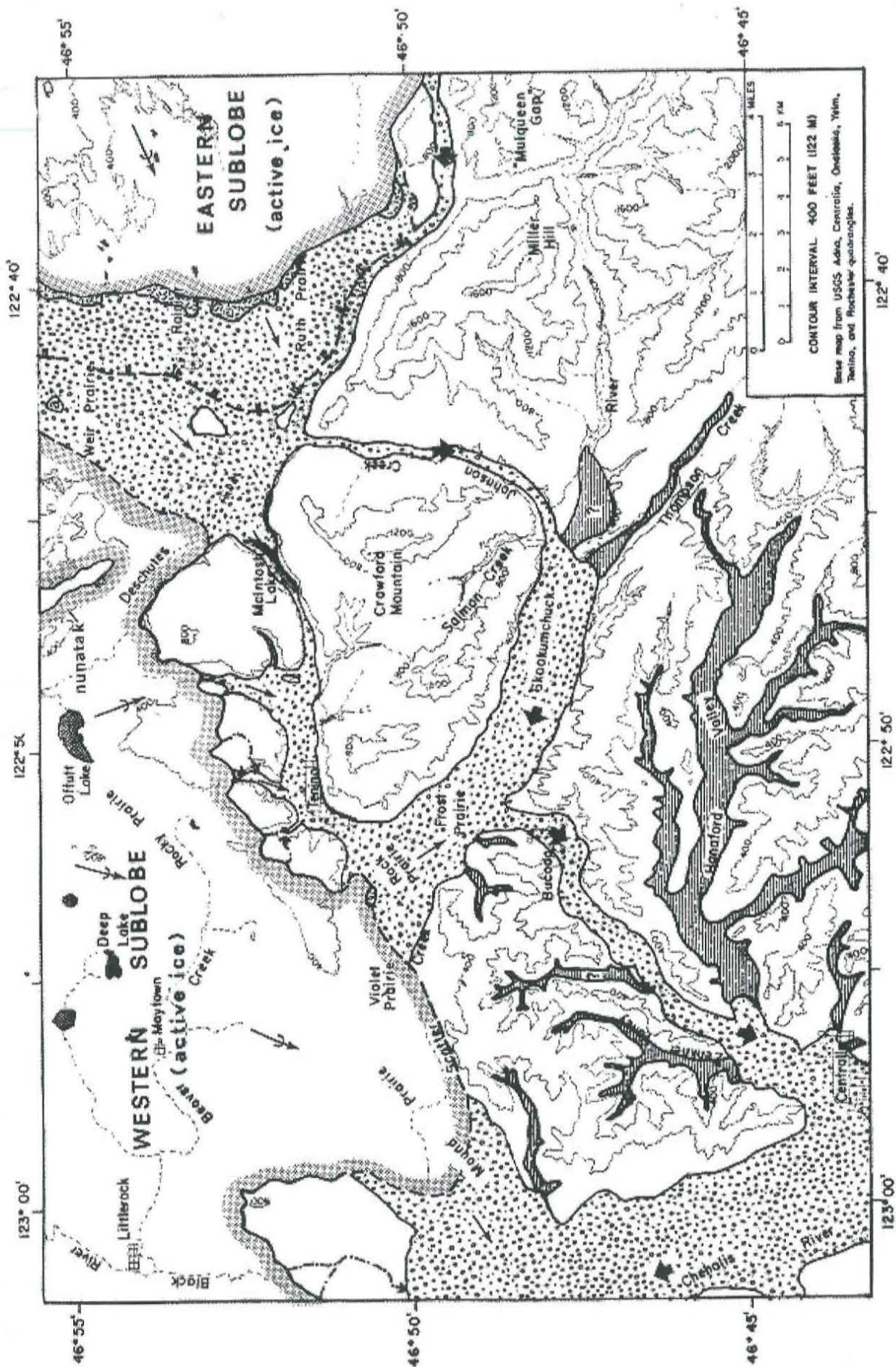


Figure 4-5
Maximum Extent of the Vashon Glacial
Ice Sheet About 14,500 Years Ago

Source: Lea 1984

Parametrix Scatter Creek 553-4335-001/01/10/01/03 (K)



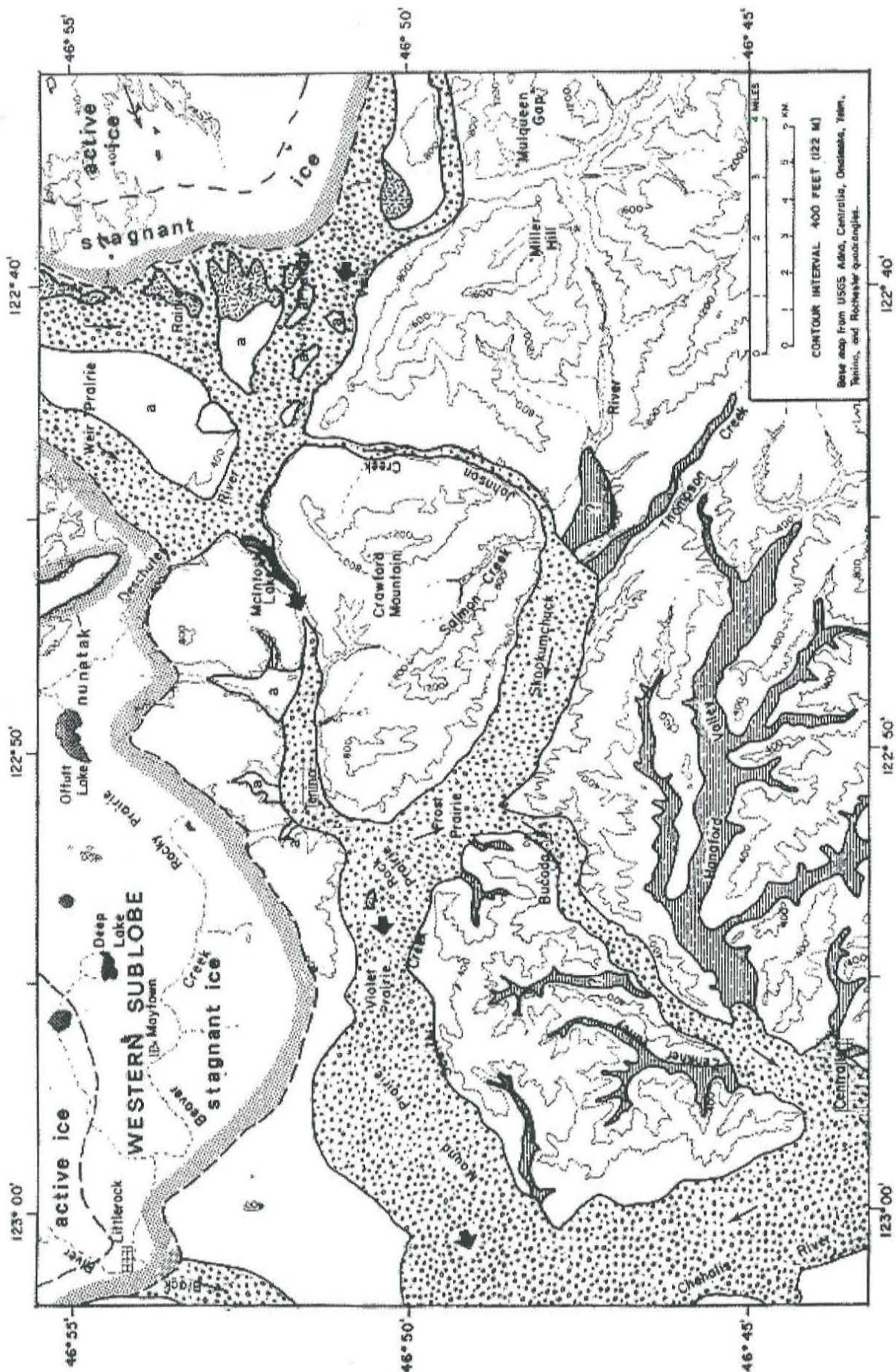


Figure 4-6
Initial Ice Retreat of the Vashon Ice Sheet About 14,000 Years Ago

Source: Lea 1984

Parametrix Scatter Creek 553-4335-001/01/03 (K)



4.2.4.3 Glacial Age Geologic Units

In general, glacial sediments occur in a layer sequence common throughout the Puget Lowland. Glacial lake clays and silt deposited in front of the advancing ice once the Strait of Juan de Fuca was blocked. As the ice sheet advanced closer to an area, advance outwash was deposited. Advance outwash typically consists of silt and fine to medium sand at first, and often grades upward to coarser sand and gravely sand. Eventually the ice overran the Puget Lowland area and deposited a dense, poorly sorted lodgment till over the surface of the advance outwash. As the ice melted away, rivers flowing from the receding glacier eroded into the earlier deposits and deposited sand and gravel in front of the receding ice. The ice and river processes that form glacial deposits are energetic and change as the ice sheet advances and retreats, so the lateral extent, thickness, compactness, and grain size distribution of layers vary by cross section and across the landscape.

Rocks and unconsolidated materials are divided into geologic units based on their relative position, age, and rock types. The main geologic units found in the Scatter Creek basin and nearby areas are briefly described in the following sections, starting with the most recent to the oldest.

Holocene Deposits (formed within the last 10,000 years)

Modified Lands: Filling and grading has occurred in developed portions of the Scatter Creek valley and floodway, especially around Tenino and the Grand Mound Prairie.

Young Alluvium: This unit consists of loose, poorly to well-sorted sand, gravely sand, and organic rich fines deposited by the present river channel. The alluvium is derived from the local outwash along the channel. The streambed is predominantly sand to gravely sand with silt, clay, and plant detritus in low-gradient and dammed sections. The narrow floodplains are composed primarily of fine to medium sand and silty sand. The current streambed alluvium is generally limited to the present-day migration zone, which is similar to the 100-year floodplain. The young alluvium forms the present floodplain and the first terrace typically between 1 to 3 ft above the channel.

Mass Wastage: This unit is recent to ancient, loose to medium compact deposits from landslides and hillslope erosion in the hills of the Scatter Creek Basin.

Colluvium: This unit covers the valley walls in most locations. Colluvium is material derived from the hillslope and moved downhill by gravity. Colluvium is of a similar age to the young to older alluvium and is often inter-mixed with layers deposited from landslides.

Vashon Glacial Deposits (roughly 10,000 to 15,000 years old)

Vashon Recessional Outwash: This outwash is loose to medium compact, stratified, moderately to well-sorted pebble, cobble, and boulder sandy gravel to gravely sand. Recessional outwash forms the prairie surface in the Scatter Creek Basin. The deposit formed from minor meltwater river channels derived from local melting of the ice and primarily from major meltwater drainage from the eastern margin of the ice sheet (Lea 1984). The outwash has very rapid drainage, so precipitation and local stormwater runoff from small valley edge tributaries and developed areas can infiltrate relatively quickly. This unit is about 25 ft thick in the Scatter Creek valley and covers most of the prairies (Figure 4-7).

Glacial Till (Vashon Till): Glacial till consists of a poorly sorted mixture of sand, silt, clay, and gravel deposited by the glacier. Till deposits were overridden by the ice, forming a dense to very dense consistency. Glacial till is compact to very compact due to the weight of the overriding ice, and is erosion

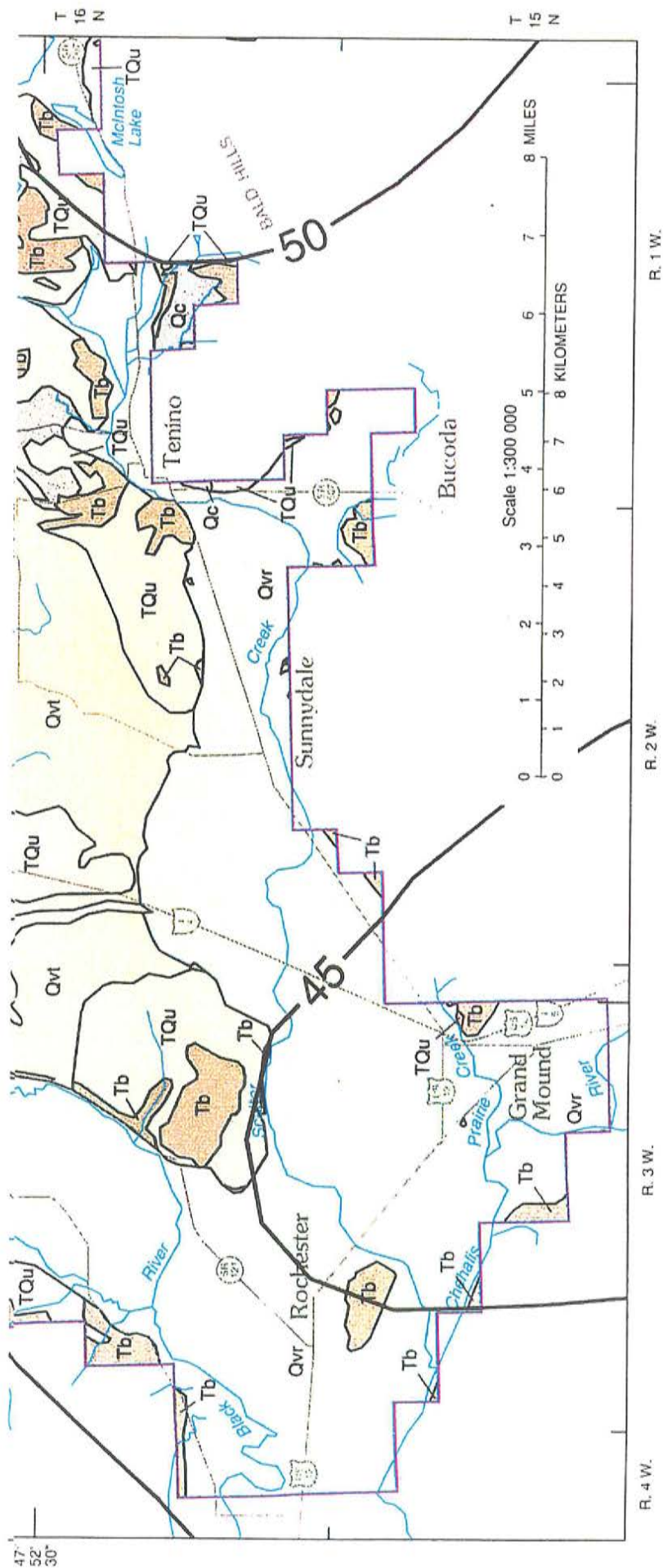


Figure 4-7
Surface Geohydrologic Units and Mean Annual
Precipitation (Inches) in the Scatter Creek Watershed

Source: Drost et al 1999

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resistant and nearly impermeable to water. Till is exposed at or near the surface in the hills and is typically encountered in wells on the prairies at a depth of 10 to 40 ft. The Vashon till unit is typically between 20 and 25 ft thick (Figure 4-8), has a low permeability, and often forms a perched water table that creates the static water level in shallow wells on the Scatter Creek prairies.

Vashon Advance Outwash: This outwash is medium dense to dense, well to moderately well sorted, mostly stratified sands and some gravel deposited by rivers emanating from the advancing glacier, then overridden and compacted by the glacier. Although dense due to the glacial consolidation, Vashon outwash is generally permeable and non-cohesive. Vashon advance outwash is not common in surface exposures but is found at depth in the Scatter Creek valley and forms a major aquifer unit that is about 50 ft thick (Figure 4-9).

Vashon Glacial Lake Sediment: This sediment is laminated, dense to very dense, with gray silts and clay deposited in proglacial lakes, then overridden and compacted by the glacier. As the ice sheet advanced and retreated, many small to large lakes formed, depositing scattered layers of silt and clay found in the other glacial units.

Northcraft Formation: Beneath the Vashon advance outwash and lake sediments is a layer of deeply weathered mostly clay and silt sediments with minor sand, gravel, peat, and wood. This unit is thought to be mostly of non-glacial origin. The formation is exposed at the surface on Michigan Hill and the Maytown Uplands and does not appear to be widespread beneath the Scatter Creek prairies. The unit is a confining bed and is not a significant aquifer in the area. The unit is typically between 20 and 70 ft thick where exposed.

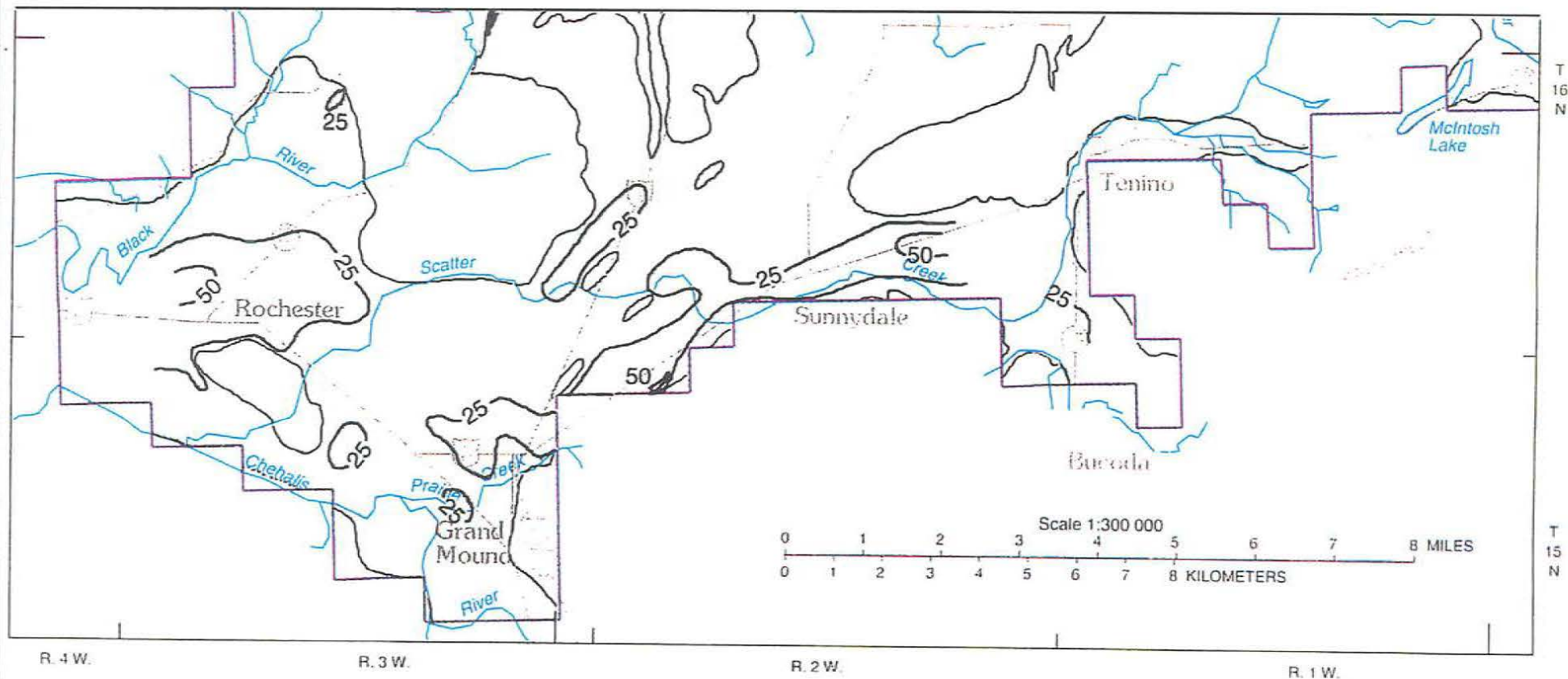
Pre-Fraser Deposits from the Penultimate Glaciation

The Penultimate glacial deposits follow the same general pattern as the Vashon deposits, except the ice extended further south and the deposits were eroded, modified by over 100,000 years of weathering, and scoured and modified by the Vashon Ice Sheet and runoff channels.

The Penultimate deposits beneath the Scatter Creek prairies are overlain by various layers of the Vashon-age advance outwash, Vashon till in part of the area, Vashon recessional outwash, and limited modern river and alluvial fan deposits. The top of the Penultimate unit starts about 50 ft beneath Grand Mound and Violet Prairies, about 50 ft beneath the south side of Rock Prairie, and up to about 100 ft beneath the northern higher-elevation portion of Rock Prairie (Figure 4-10). The unit is typically between 10 and 20 ft thick. The Penultimate unit includes tills 1.5 to 20 ft thick and layers of poorly sorted sand and gravel outwash 3 to 20 ft thick (Lea 1984). In the Scatter Creek watershed hills, there are scattered deposits of Penultimate till, ice contact, and outwash that are near or at the surface, along with the Vashon-age deposits. Wells in the Scatter Creek valley hit bedrock below the Penultimate deposits between 45 and 161 ft deep.

4.2.5 Geohydrologic Units

The geologic units of the Scatter Creek Basin can be classified into those units that are a good source of groundwater and those that are poor to very poor groundwater sources (see Table 4-1). The Vashon recessional outwash and the Vashon advance outwash and Penultimate units are the main aquifer units in the Scatter Creek valley. The bedrock units described in the previous section all have very low groundwater yields compared to the unconsolidated glacial units. Groundwater from the bedrock units comes primarily from the fractures and joints in the rock.



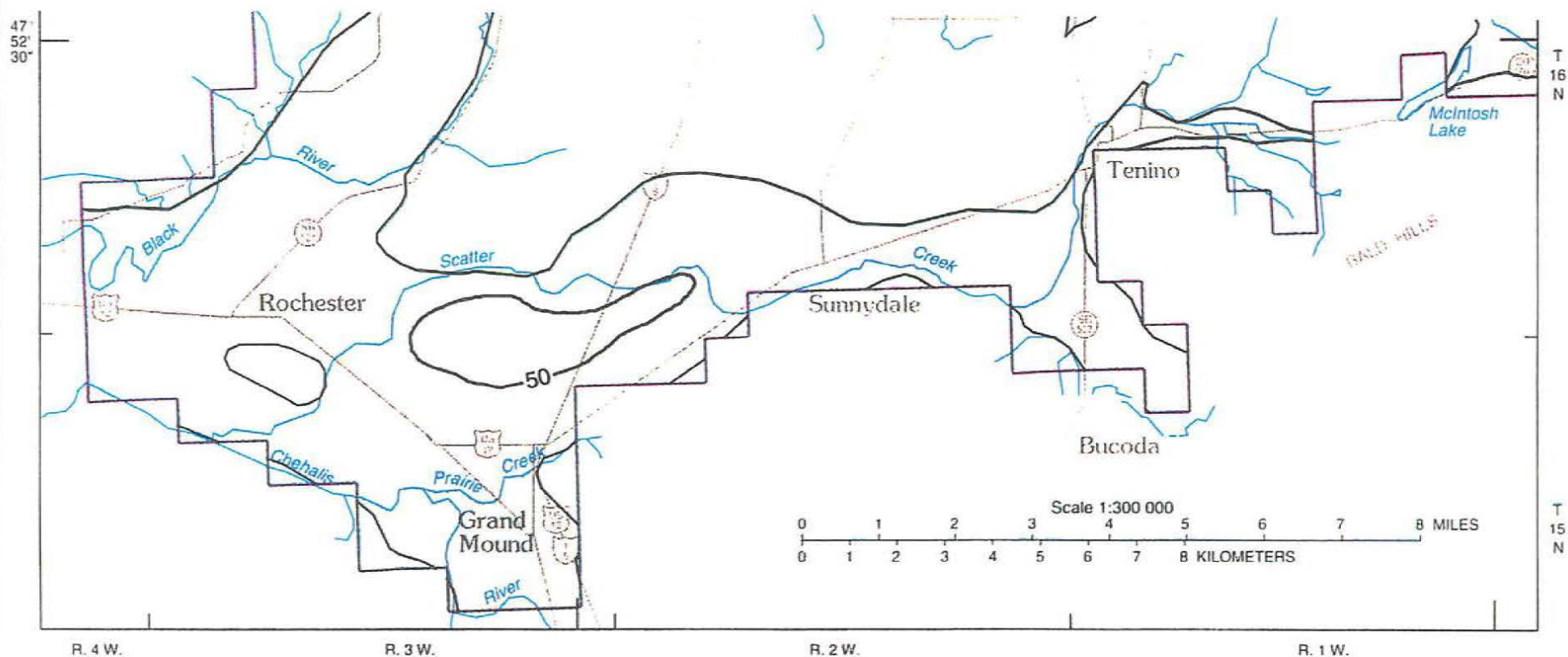
Source: Drost et al 1999

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Note: The Vashon till (Qvt) is found beneath the younger deposits of recessional outwash and modern alluvium in the Scatter Creek watershed.

Figure 4-8
Extent and Thickness of the Vashon Till





Note: The Vashon Advance Outwash (Qva) is found beneath the younger deposits of till (where present), recessional outwash, and modern alluvium in the Scatter Creek Watershed.

Figure 4-9
Extent and Thickness of the
Vashon Advance Outwash



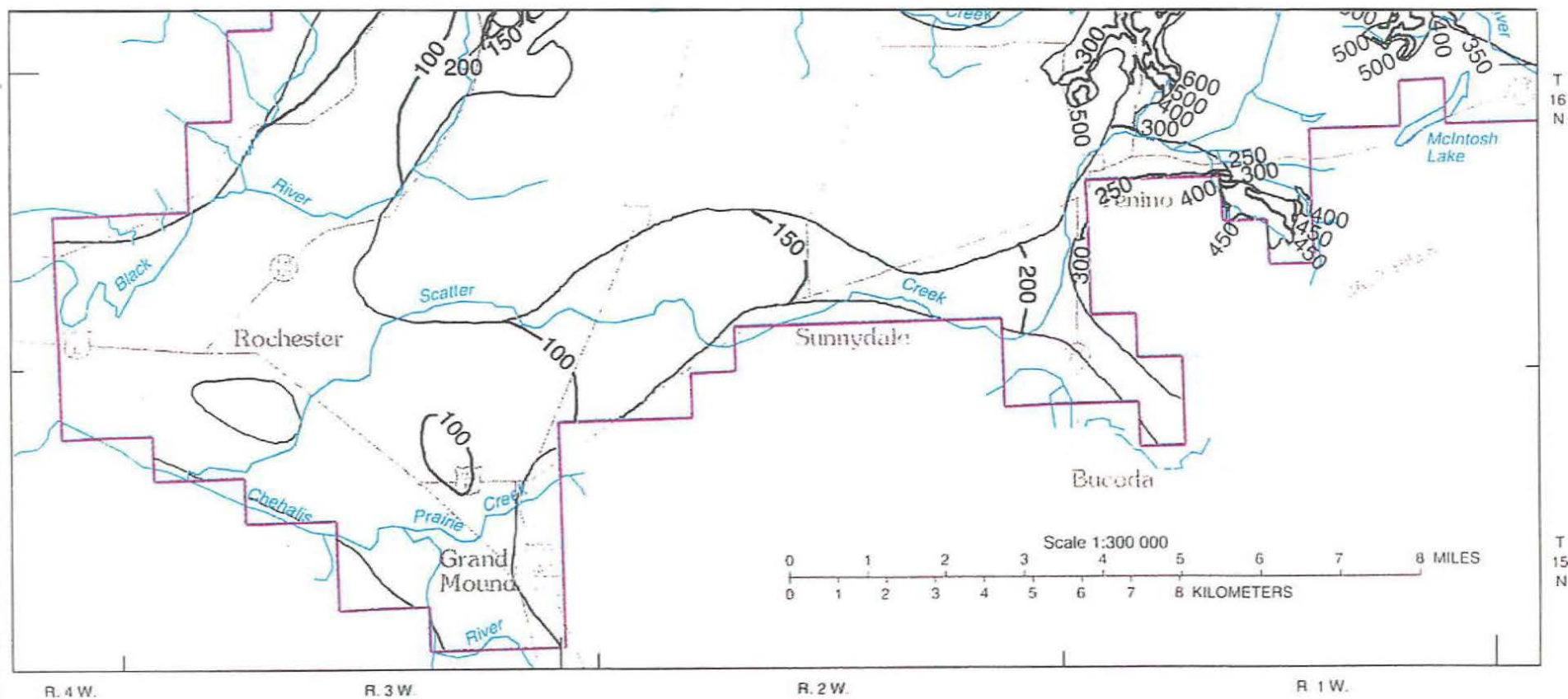


Figure 4-10
Extent and Thickness of the
Penultimate Glacial Units in
the Scatter Creek Watershed



4.2.6 Surface Geology and Soils

Surface materials are derived from the weathering, mechanical breaking, and transport of bedrock materials by the action of gravity, surface and groundwater, freezing and thawing, and glaciers. The term soil has different meanings dependent on use. Sometimes the term soil is used to describe the unconsolidated surface materials, such as colluvium, alluvium, and slide debris. For use in this document, soil refers to the layers (soil horizons) of mineral and/or organic constituents of variable thickness that differ from the parent materials in their morphological, physical, chemical, mineralogical, or biological characteristics (Birkeland 1999). Soil horizons form from physical, chemical, and biological modification of the surface colluvium and alluvial material. Soil formation varies by climate conditions, landscape type, parent materials, and age of the landscape surface. Soil surveys are used to identify the potential and limitations of areas for vegetation growth, drainage characteristics, and engineering properties, such as road-fill potential or stability for various uses. The presence and degree of soil development is also used to identify and date the ages of river, landslide, and glacier deposits.

Soils are formed based on the cumulative weather conditions following a landscape surface formation. The outwash plains and hills in the Scatter Creek Basin began to form about 12,000 to 13,000 years ago. The climate was colder then, with plants similar to northern Canada or Alaska that presently grow between 5,000 and 6,000 ft elevation in this region. Once the ice sheet retreated, the climate warmed. The present vegetation conditions follow quite closely to soil types because both are partly controlled by the landforms, surface geologic units, and related moisture conditions. The vegetation units on the prairies include prairie, prairie-oak-savannah, oak-woodland, agriculture fields, and a portion of the oak-ash and riparian-conifer-hardwood zone along the creeks. The prairie vegetation zones based on the conditions in 1854 have a total area of about 12,544 ac (Figure 4-11). The main soil units on the prairies are the Spanaway soils with 10,553 ac and other prairie and channel soils that total about 13,128 ac (see Section 5.2.2).

4.3 SCATTER CREEK CHANNELS

4.3.1 Landform Erosion

Precipitation, wind, temperature conditions, and gravity all modify the land surface. Precipitation, related runoff, and gravity dominate present surface processes in the Scatter Creek region. In the hills, valley wall and channel erosion are active and have eroded many small v-shaped valleys. The slope, ample rainfall, surface materials, and presence of surface runoff all contribute to erosion in the hills. The surface of the prairies has only been slightly modified by erosion, deposition, and mass wasting in the 13,000 years since the ice sheet receded from the basin. Surface erosion of the outwash prairies has been slow and limited because of the porous soils that minimize surface runoff and erosion, low slopes, and dense vegetation that protects the surface from erosion. Soils developed on the prairies on all except the most recent alluvium and the preserved outwash surface features indicate that most of the 6 to 50 ft of incision of the Scatter Creek channel occurred very long ago. The Scatter Creek channel has basically been located in the same valley bottom area for at least the past 10,000 years.

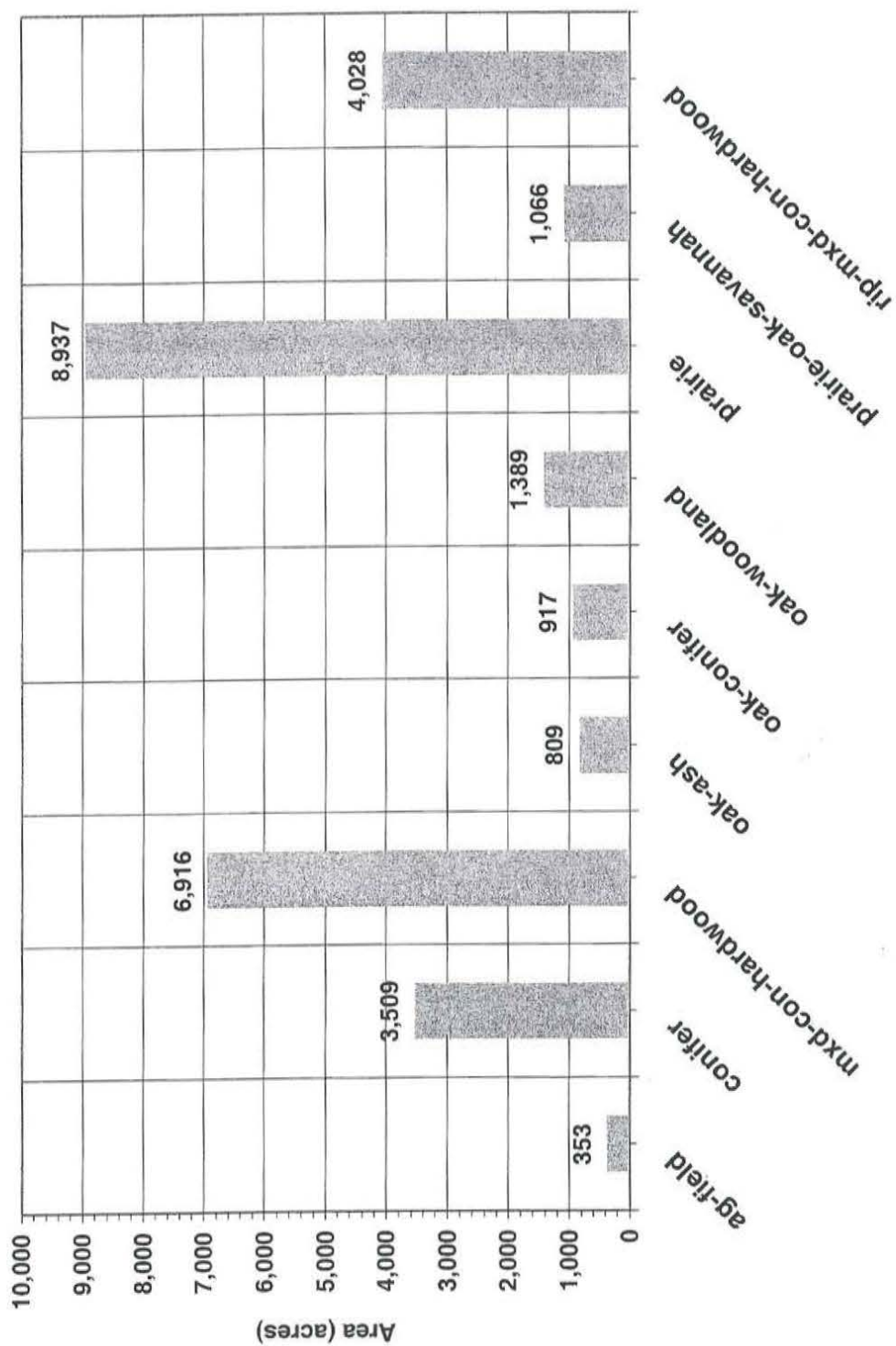


Figure 4-11. Area of Scatter Creek Valley Vegetation Zones (Acres) Based on the 1854 Maps

4.3.2 Scatter Creek Channels

The Scatter Creek mainstem channel is about 18 miles long. In the Tenino area, five tributary creeks flow onto the valley bottom and join Scatter Creek. The tributaries drain hills with relatively steep to rolling slopes and are confined to fairly wide valley bottoms. Surface stormflow runoff and shallow groundwater return flow are generated from the hill subbasins. This surface runoff has incised through glacial outwash terraces along the valley edges, forming confined gravel reaches and log jam prone reaches before the flow reaches the valley floor.

There are seven primary tributaries draining the hill areas of the Scatter Creek Basin. There are about 60 small valleys from the hills that are drained by seasonally wet swales and small creeks, most of which do not make it across the prairies to Scatter Creek.

The present channel conditions along Scatter Creek have three basic forms: forested, pond, and wetland. The forested channel sections have ash trees growing in and along the channel (Figure 4-12). In the dry season, flow consists of ½- to 1-ft-deep pools behind logs, roots, and low, partially managed beaver dams. Flow breaks around, under, and over the trees and roots in small steps, short riffles, and gravel patches. The substrate is a mix of sand and gravel of local reworked glacial outwash. Floods wash the substrate and locally scour and fill patches of bedload sediment. Much of the bed has a layer of silt and organic detritus, with occasional sandy gravel patches.

The second common channel form for Scatter Creek includes areas with beaver dam complexes that have large to small ponds that gradually fill with sand, fines, organic detritus, and logs (Figure 4-13). Ponds from beaver dam complexes would possibly dominate the channel if beaver had not been hunted and managed at various levels in the past, and if portions of the channel had not been modified by clearing the trees or excavation.

A third common channel form for Scatter Creek occurs where the channel width spreads out, forming a wetland that in some reaches dries out in the dry season. This occurs in some areas that are flatter or filled in by downstream grade controls (like beaver dams) and in the wider and flatter segments of the glacial-age braided channel. When a long-term dam fails or is breached, the channel cuts into the pond deposits and leaves a flat valley bottom wetland area. Wetland and riparian vegetation and commonly reed canarygrass fills in over time. Over many decades, trees would gradually grow back along the edges of the wetland area.

All three of these basic channel conditions were modified in many sections along the channel by clearing and/or dredging the channel and banks to clean out the creek (Figures 4-14 and 4-15). This practice was common in the past. Recently, a variety of studies have shown that complex channel conditions like those shown in Figure 4-12 are important features for many aquatic and riparian species. Vegetation along and in a stream channel greatly influences channel shape and processes (Montgomery and Buffington 1993). Root strength of vegetation along and in the channel contributes to bank stability and channel shape and forms grade controls along the channel.

Alluvial channels and especially low-gradient unconfined reaches are quite sensitive to riparian vegetation. Loss of bank reinforcement can result in channel widening that spreads the streamflow. Abundant dense riparian and in-channel trees, along with fallen trees and roots, create steps, pools, and riffles in great variety along the channel. In-channel and floodway trees, beaver dams, modified beaver dams, and constructed weirs all slow the flow from the channel and aquifer, and can also enhance recharge during part of the year.



Figure 4-12. Typical Wooded Channel That Would Form Along Much of the Mainstem if the Floodway Were Left Alone or Replanted

Note: Scatter Creek channel photograph taken 11/5/2002 at about River Mile 11.6, after most of the leaves had dropped. This channel section has had limited disturbance in the past 150 years and is typical of what would form if the 100-year floodway were left alone. Most of the trees are live ash. The photograph was taken after a dry summer and fall and prior to the start of the wet season rains.

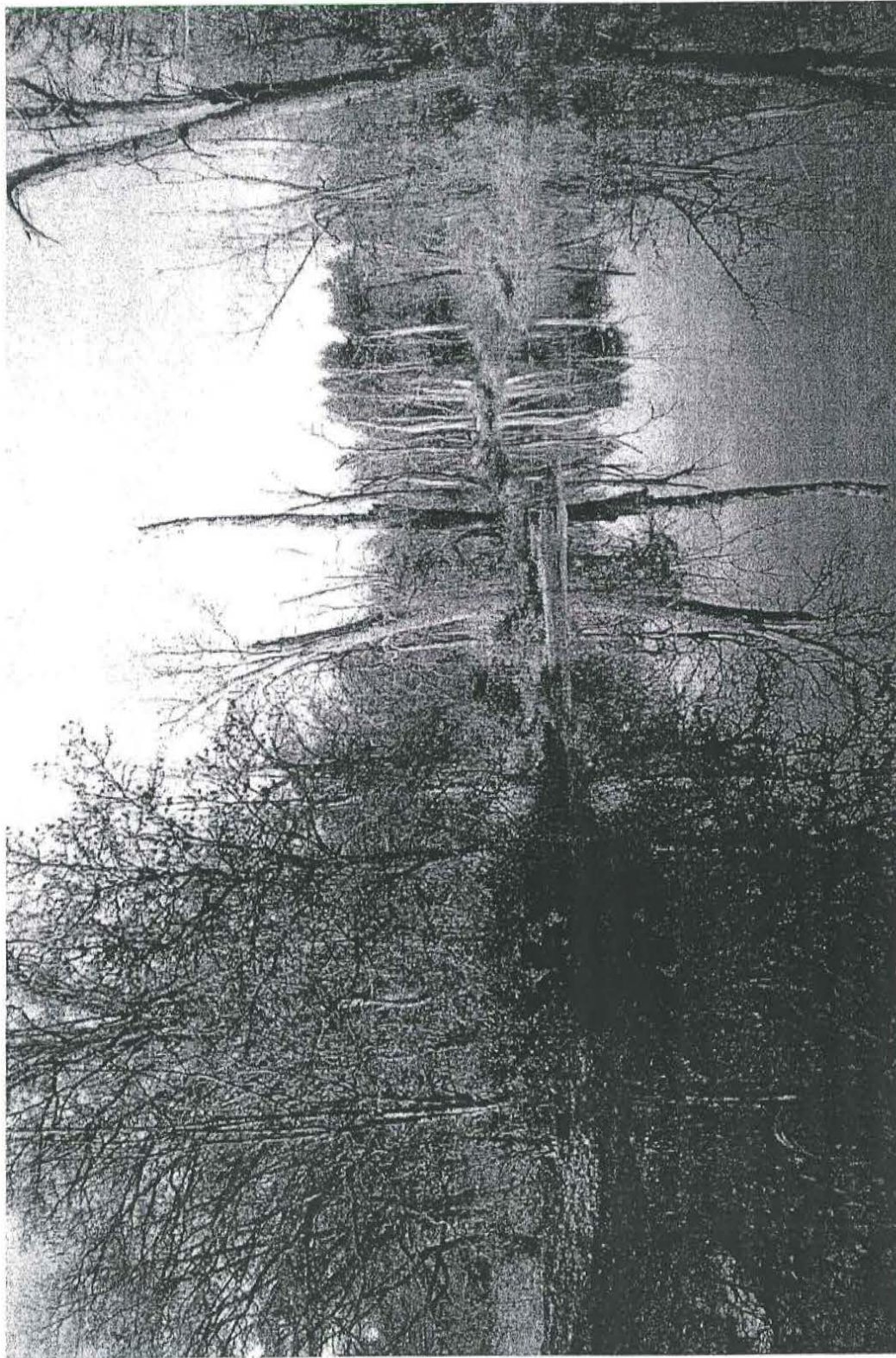


Figure 4-13. Pond Channel Form Created by Weirs or Beaver Dams
Note: This pond is 1 mile downstream of the fish farm discharge; thus, it has an additional 16 cfs flowing year-round.

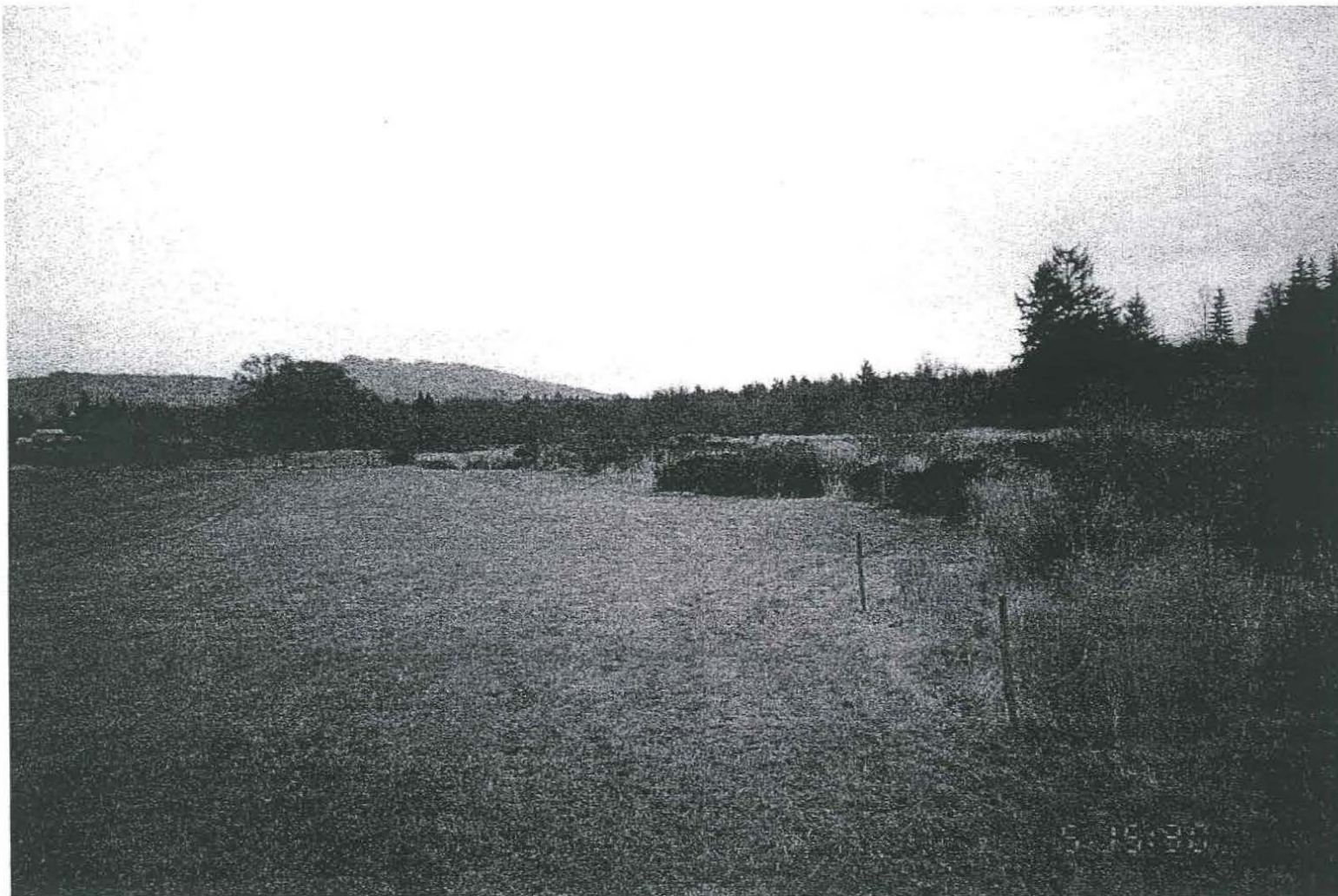


Figure 4-14. Typical Section of Logged and Dredged Channel

Note: The channel is in the taller brush on the right. This section of channel, in Reach SC4, is just upstream of the forested channel in Figure 4-12. This area was dredged in about 1950 and is typical of the modified channel condition along Scatter Creek. The wet width is 10 to 20 ft and the low flow depth is 2 to 3 ft, with sand and mud bottom.

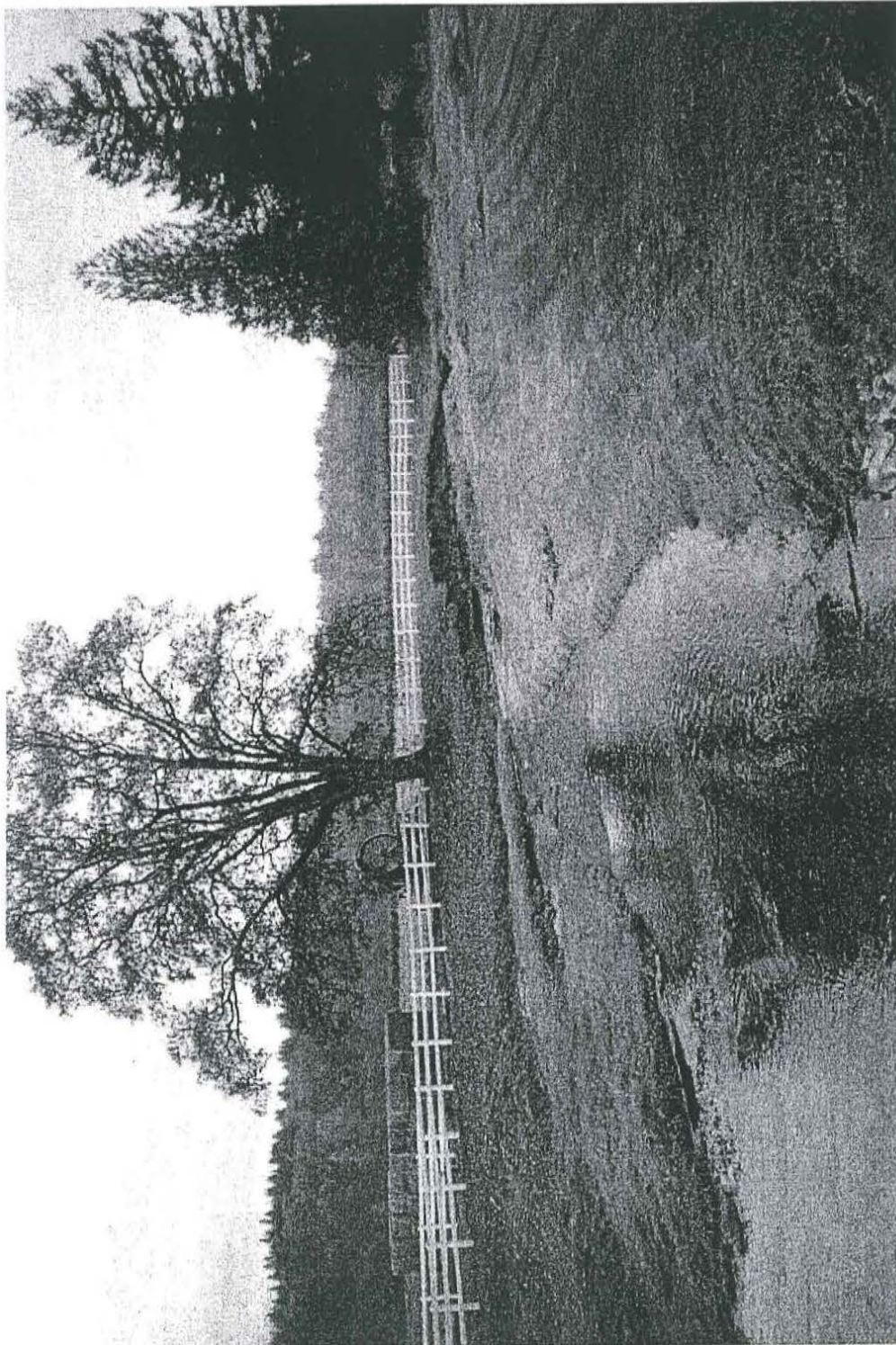


Figure 4-15. Typical Modified Scatter Creek Area Located in Reach SC2 with Limited Riparian or Channel Trees

The bottom lands along the Scatter Creek channel are located in an area that has some of the most productive soils in the basin for hay and other crops. The prairie surface soils are usually dry during the summer and fall without irrigation, but the bottoms along the creek remain moist much of the growing season. The overbank flood deposits along the valley bottom also help by producing a good, fairly rich, and somewhat drained soil along the floodplain of Scatter Creek. These soils are typically 1 to 4 ft above the channel and roughly match the 100-year floodplain.

The Scatter Creek channel was cleared along many portions for wood, agriculture, drainage improvement, fish passage, road or utility crossings, and residential development. The 1850s maps indicate that the channel was once within the forested area for the entire length. By the 1930s and 1940s, the channel and floodway were cleared in many areas, resulting in small trees and brush occurring on the channel banks. By the 1940s, many sections of the channel riparian zone had been logged at least once in the previous 100 years. Presently, there are more channel bank areas with partial trees than during some earlier periods.

4.3.3 Channel Types and Controls on Channel Processes

Channel networks can be classified into three general zones based on position and sediment transport characteristics: (1) channel reaches that are source areas for sediment, (2) reaches that transport sediment from nearby source areas, and (3) response reaches that are low-gradient and transport-limited channels that respond to upstream sediment supply and flow changes (Montgomery and Buffington 1993, 1997). Traversing from the headwaters of the small tributary valleys in the hills around the Scatter Creek valley, the channel types change from source to transport in the hill tributaries and to response along the lower gradient reaches approaching the valley bottoms.

Some Scatter Creek valley wall source areas and headwater tributary channels are steep (slopes greater than 20 percent) and typically have portions that are confined in narrow valley bottoms with steep to fairly steep valley wall slopes. Trees growing from the channel and banks, fallen trees and stumps, and large boulders are important in source areas for supporting the slopes, channel banks, and bed. Intermittent debris slides and flows, slumps, and tree falls all contribute sediment to hillsides and channels, and occasional high flows move the sediment along the relatively high-gradient channel. Source areas have hillslopes, bedrock hollows, and colluvial hollows that deliver to the valley bottoms of the small tributary basins in the hills surrounding the Scatter Creek prairies.

Transport reaches are steep to moderately steep with enough flow to transport sediment supplied from upstream, upslope from valley walls, and from sediment storage along the channel. Transport reaches typically have slopes between 3 and 30 percent. Transport reaches form cascade and step-pool channels.

Response reaches have slopes less than 3 percent and change if discharge or sediment supply changes. In response reaches, if upstream supply of sediment increases, more sediment is deposited and the channel can shift. If less sediment arrives, the channel may incise or remain about the same, and if sediment supply is stable the channel remains about the same. Response portions of streams can have plane-bed and pool-riffle channel types typically in the range of 1 to 3 percent channel slope and regime channels have slopes less than 0.1 percent.

The small valleys in the hills around Scatter Creek valley are source areas that deliver to short transport reaches before the toe of the hill, where a response reach in the form of an alluvial or debris fan is built. Most of the bedload sediment moved in the hill tributary channels deposits on the alluvial fans, and only limited fines continue downstream to the Scatter Creek channel. These fines deposit in the first several downstream pools at moderate flows or on the floodplain at higher flows. The lower and sometimes

middle reaches of the main tributaries and the Scatter Creek channel are response channels by position in the watershed and gradient but have little to respond to. The low Scatter Creek gradient (0.2 to 0.3 percent) and lack of tributary and bank bedload sediment supply reduces channel migration.

4.3.4 Hill Channel Types

4.3.4.1 North Side Hills

The tributary valleys along the north side of Scatter Creek valley, in the Maytown Uplands, were originally eroded by subglacial rivers at the termination of the ice sheets. Surface runoff continued as the ice sheet receded until flow diverted to other routes, leaving only the local drainage basin to generate runoff. The main tributaries in the northern hills have a valley fill of outwash over a mix of tills, ice contact deposits, and bedrock. The tributaries were formed initially as outwash drainages from the glaciers. Secondary valleys were eroded into the valley walls of the main glacial-age valleys and form a concave valley shape. These secondary valleys provide an indication of the amount of erosion that can occur if there is surface runoff and enough gradient to move material. The hills experienced a similar weather pattern but, because they have stormflow runoff during wet periods, they were dissected between 50 and 200 ft and developed a fairly dense drainage network.

Drainage is intermittent in most of the small tributary drainages because of limited soil thickness over tills, and the bedrock and steeper gradient moves surface and shallow groundwater faster. The higher-gradient portions of the main tributaries have enough flow to have eroded through outwash terraces along the valley bottom edges and have some fluvial transport, but are mostly response channel types. Most of the hills' water storage is along the main tributaries in low wet areas and valley fill.

4.3.4.2 South Side Hills

The hills along the south side of Scatter Creek formed under conditions quite different from the northern hills. The maximum ice advance pushed right up against the southern hills, damming up the small pre-glacial drainages and depositing a mix of ice contact, outwash, and lake deposits. Subglacial and surface runoff occurred laterally along the end of the ice flowing to the east out the Skookumchuck River outlet at Bucoda and out lower Scatter Creek valley to the west. Landslides are common in the hills south of Scatter Creek because of the steep weathered slopes, geologic materials, and action of the glacier.

4.3.5 Scatter Creek Channel Reaches

The Scatter Creek channel network can be divided into reaches based on the gradient and landform (Figure 4-16). The Chehalis River has eroded about 40 ft into the glacial valley fill sediments, creating a migration zone and floodway about 1 mile wide. Reach SC1 of Scatter Creek flows across the lowest part of the Chehalis River valley bottom from the Scatter Creek mouth to about River Mile 0.9. The Scatter Creek channel meets side channels on the floodplain and follows these channels to the main Chehalis River channel.

Reach SC2 goes from River Mile 0.9 to about River Mile 2.8. The Scatter Creek channel climbs 10 ft in elevation on the next higher Chehalis River floodplain and from there climbs the Chehalis River valley wall up to the top of the glacial-age valley fill about 40 ft above the Chehalis River bottom. The lower creek is less likely to dry out because it flows down the glacial deposits, and the creek channel will meet the groundwater draining out of the glacial deposits somewhere along this reach.

In Scatter Creek Reach SC3 (River Mile 2.8 to River Mile 12), the profile is controlled by the glacial-age outwash surface. The Scatter Creek channel is incised about 12 ft into the bottom of the large braided

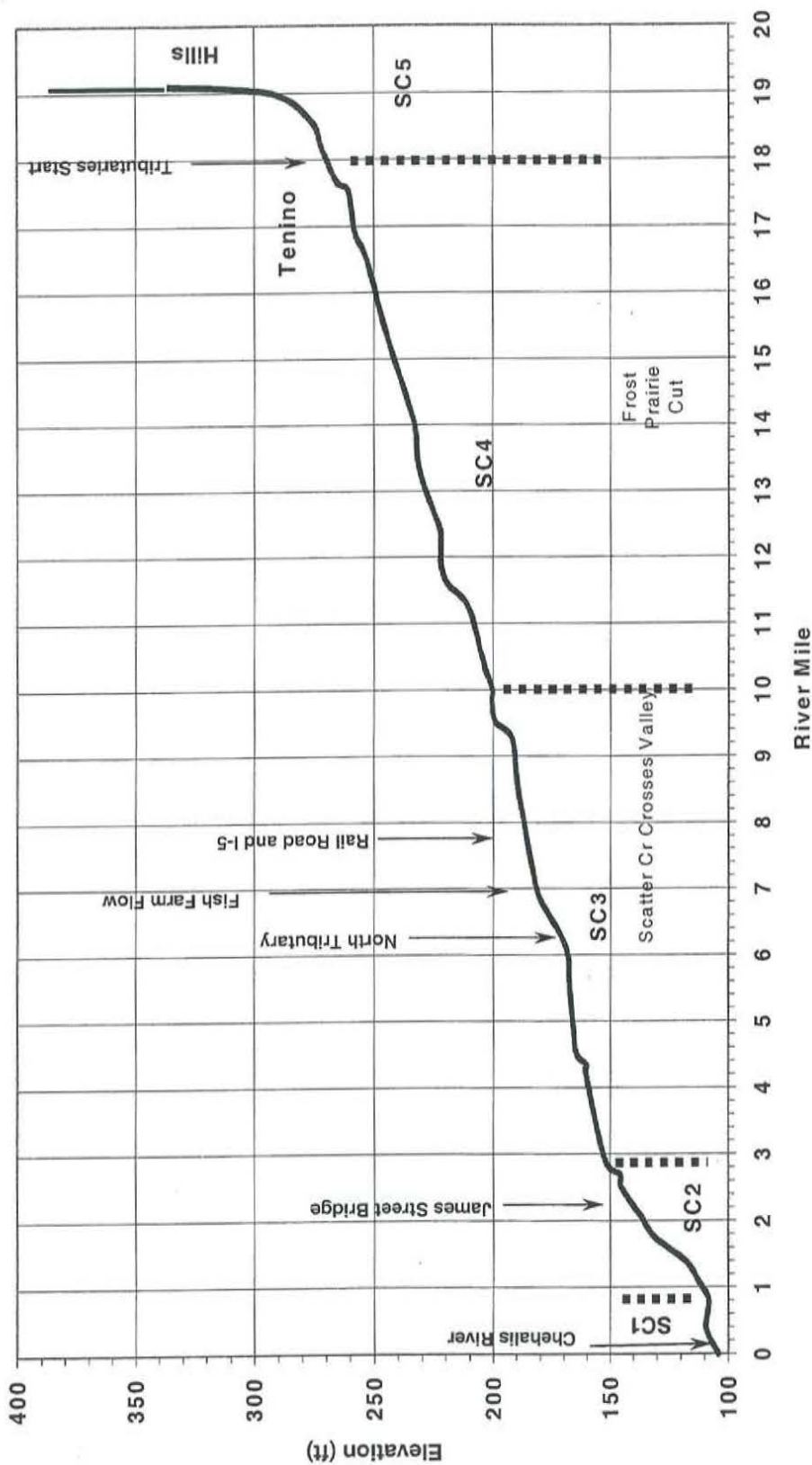


Figure 4-16. Scatter Creek Channel Profile Based on 2-Ft Contour Lines

channels across the Grand Mound and Mound Prairies. Reach SC3 is the second lowest gradient reach of Scatter Creek, with a slope of 0.1 percent. From River Mile 6 to River Mile 10, the channel is cutting across the valley fill and has a slightly lower slope than the reaches heading straight down the valley. Groundwater flow is now intermittent in portions of reach SC3 and is at least partly caused by the channel being nearer the top of the old outwash surface. When the groundwater drops from reduced dry season recharge or pumping, the channel bottom is left dry. This dry season condition is mitigated by the fish farm discharge into Scatter Creek at River Mile 7 that has been pumping about 17 to 20 cfs since 1978.

In Reach SC4, from River Mile 12 to River Mile 17.9, the creek incised 30 to 50 ft into the Rock Prairie glacial outwash fan that originally spilled across both the Skookumchuck River and Scatter Creek valleys. SC4 is on the south side of the valley against the hills. Recharge from the Skookumchuck and two small tributaries feed the groundwater in this reach from about River Mile 13.6 to River Mile 15.5. Groundwater flow direction from the northwest portion of Frost Prairie is likely towards the Scatter Creek valley bottom, helping to explain why this portion of the river flows year-round. Much of the groundwater and surface flow from the main upland hill tributaries near Tenino also flow into the upper part of Reach SC4.

Reach SC4 ends where the mainstem splits into five tributary basins. Reach SC5 represents these five tributaries that split off around Tenino. The tributaries have moderately steep slopes and wet season flows from surface runoff and shallow groundwater return flow. In Tenino, the channel goes dry in summer months; this is probably related to the thickness of the outwash, the limited water storage along the tributary valleys, the rapid rate that water flows through the generally porous deposits, and pumping.

The valley bottom of most of Scatter Creek is incised between 5 ft and 50 ft into the glacial-age surface. This floodway and relatively narrow channel migration zone is infilled with fines (Lea 1984) that have accumulated from flood overbank deposits behind accumulations of live and fallen trees and beaver dams. It is unknown if the Scatter Creek incision occurred all at once or in several events, perhaps soon after glacial conditions receded, or gradually over many thousands of years. If the incision were gradual, it would average 0.7 ft per 1,000 years, a very slow rate of incision. Soils on the floodplain areas of the present channel indicate the incision mostly occurred long ago.

The Scatter Creek channel is stable and only occasionally moves around in a fairly limited channel migration zone. Fallen trees, fires, clearing, and beavers have a far greater control on the channel than erosion or sediment transport. The lack of surface runoff to the channel along most of its length limits the introduction of sediment to very low amounts from areas right along the floodway. The low channel gradient and grade controls, including channel trees, fallen trees, beaver dams, and constructed weirs, trap most of the sediment that enters. Typically, low turbidity measured at various stations along the channel is a result of limited surface erosion on the prairies.

The relatively stable channel profile and channel migration zone is indicated by forested conditions along the channel in the 1854 maps. The 1850s channel is mapped within the current floodway area, except near the mouth where the channel is not clearly shown. The long-term presence of a relatively stable channel profile and channel migration zone is also indicated by the limited extent of post-glacial channel incision and likely favorable conditions for trees and beavers along the channel. The channel gradient and location of Scatter Creek have been controlled primarily by the shape of the old glacial channels, growing and fallen trees, and beaver dams for as long as forest conditions and beavers have been present in the area. Trees and the dramatic range of late Pleistocene mammals living just south of the glaciated area and in the region as the ice sheet receded, indicate a low-gradient channel like Scatter Creek was present as long as 13,000 years ago.

4.3.6 Beaver and Channel Morphology

Numerous large and small mammals were present at the edges of the Vashon Ice Sheet and along area rivers and lakes. There were at least five species types of beaver in North America in the Pleistocene: *Castor*, *Dipoides*, *Procastoroides*, *Castorides* (giant beaver), and *Paradipoides*. Only *Castor* beavers survived to recent times (Flint 1971). Both large and small game and fish were hunted in the past as indicated by a spear point found stuck in the rib of a 12,000-year-old mastodon soon after retreat of the Juan de Fuca lobe of the Vashon glacier near Sequim, Washington (Kirk and Daugherty 1978). It would seem possible that a beaver population would be fairly common in the Scatter Creek valley. There have probably been good conditions for beaver along Scatter Creek and in nearby areas along the Black River, Beaver Creek, and other creeks and wetlands in the region.

The Scatter Creek surface conditions and groundwater system were likely similar to the current condition since the Chehalis River incised 40 ft into the glacial valley fill forming the present-day grade line of Scatter Creek. This occurred sometime after 10,500 to 7,500 years ago (Peterson and Phipps 1992). Since that time, it appears likely Scatter Creek has had a channel form dominated by groundwater flow with seasonal stormflow runoff and a mix of forested channel and beaver ponds that were modified intermittently by fires, extended drought periods, wood harvest, and beaver trapping. Beavers coexist with and create outstanding habitat for coho salmon and numerous other aquatic species if there is a strong riparian and channel forest present. Beavers originally had an influence on the Scatter Creek channel from the river mouth to the main tributaries (Williams et al. 1975). Presently, beavers have a strong influence on limited portions of the channel (see Figure 6-7) (Wampler et al. 1993).

4.4 HYDROLOGY

4.4.1 Watershed Area

The Scatter Creek watershed boundary and specifically the groundwater drainage basin is not easily delineated. The main Scatter Creek valley aquifer begins as a narrow valley fill above Tenino and opens into the wide aquifer below Tenino where Rock Prairie begins. Scatter Creek groundwater flows down the relatively thin valley fill (typically 100 to 140 ft thick) at a low gradient with a 150-ft elevation change in about 18 miles of valley distance. Groundwater flow direction is generally downvalley. Flow direction varies locally near streams. At the lower end of Scatter Creek valley, groundwater flows around both sides of the low hill by Rochester into the lower end of the Black River and Chehalis River valley fill. At the lower end of Scatter Creek valley, the aquifer is joined by surface and groundwater flow from down the Chehalis valley and from the Prairie Creek drainage on the south side of Grand Mound (the hill).

The present drainage basin in the hills around Tenino is fairly well defined by the topography. The southwest end of McIntosh Lake has been modified by the old railroad grade and roads. It was not clear from a field inspection whether the area had been filled or excavated from original conditions. Bedrock outcrops indicate there may have been a bedrock saddle prior to railroad and road construction. During the early retreat of the Vashon Ice Sheet, drainage formed the low wide channel on the northeast end of the lake, then flowed in a graded outwash plain to the Chehalis valley by way of Scatter Creek and Skookumchuck River valleys. The area on the southwest end of the lake was a bedrock grade control with ice contact, till, and recessional outwash all being deposited in a mix along upper Scatter Creek to the McIntosh Lake area. A mix of glacial deposits and bedrock was modified for the railroad and highways, leaving different cut and fill areas and resulting in an unclear depiction of the original surface without detailed surface and subsurface mapping of materials. For this report, it is assumed that surface

and groundwater flow is primarily into the Vashon outwash and Penultimate deposits to the northeast of the lake and into bedrock cracks.

The late glacial-age river through the Tenino drainage incised about 30 ft into the outwash plain and sent surface runoff west down the Scatter Creek valley. Flow from Frost Prairie probably has groundwater gradients and flow directions that vary depending on seasonal conditions, and it is likely some of the Skookumchuck groundwater flows to the Scatter Creek Basin. Because of this, wells in Section 36, T16N R2W were included in the well inventory.

The Maytown Uplands on the north of the basin, downvalley to about River Mile 11, clearly define the watershed boundary. In the low 2-mile-wide gap in these hills, the watershed is poorly defined. There are numerous low wetlands formed by subglacial scour and melting of the ice. Drainage is likely north to Beaver Creek valley and south to Scatter Creek valley. For this analysis, the surface watershed was drawn along the center of Sections 17 and 21 T16N R2W, but two wells in Section 17 and 18 wells in Section 21 T16N R2W were kept in the groundwater analysis because they probably influence recharge to the Scatter Creek portion of the aquifer. Surface water and groundwater from the Black River, Scatter Creek, and Skookumchuck River valleys all feed the Chehalis River valley aquifer that flows to the coast.

In lower Scatter Creek valley, the groundwater aquifer is difficult to separate between Prairie Creek and Scatter Creek. Scatter Creek drains the northern portion of the aquifer and Prairie Creek drains the southern portion. In Section 5, T15N R2W, 12 wells in the southwest corner were removed from this analysis because it was assumed that they mostly relate to the Prairie Creek portion of the aquifer. Five wells on the north half of Section 6 T15N R2W were kept in the well analysis because they are on the north side of the ridge dividing upper Prairie Creek from the Scatter Creek area. A ridge of confining bedrock between Grand Mound (the hill) and the nearby hills may separate some of the Prairie Creek and Scatter Creek subsurface flow, but generally, the whole valley fill is connected. In this area, all of the wells were kept in the analysis for Sections 1 and 11, T15N R3W because they are northeast of the subsurface ridge line.

4.4.2 Precipitation

The Scatter Creek Basin has a temperate maritime climate with wet, cool winters and dry, warm summers, typical of western Washington. Average annual precipitation at Rochester, Washington from 1980 to 1991 was 48 inches (Hirschey and Sinclair 1992). The U.S. Weather Bureau (1965) shows mean annual precipitation contours that range from 45 inches per year at Rochester, Washington at 150 ft elevation to 50 inches per year at the headwaters of Scatter Creek east of Tenino, Washington at 270 ft elevation (Figure 4-7).

The Olympia, Washington weather station has 124 years of data and is located about 14 miles north of Scatter Creek Basin. The Centralia weather station has data from 1890 to present, and is about 7 miles south of the Scatter Creek valley. Comparison of the annual precipitation from 1890 to 1989 shows that Olympia typically has 3 to 10 inches more rain per year, with only 6 years out of 97 when Centralia had more rain (Figure 4-17). The average annual precipitation in Centralia is 46 inches compared to 52 inches in Olympia. The minimum annual precipitation for both areas is similar, 29 inches for Centralia and 30 inches for Olympia. Olympia had a maximum annual precipitation of 74 inches in 1879. The trend lines shown in Figure 4-17 provide a general comparison in precipitation between Olympia and Centralia and also indicate differences between decades.

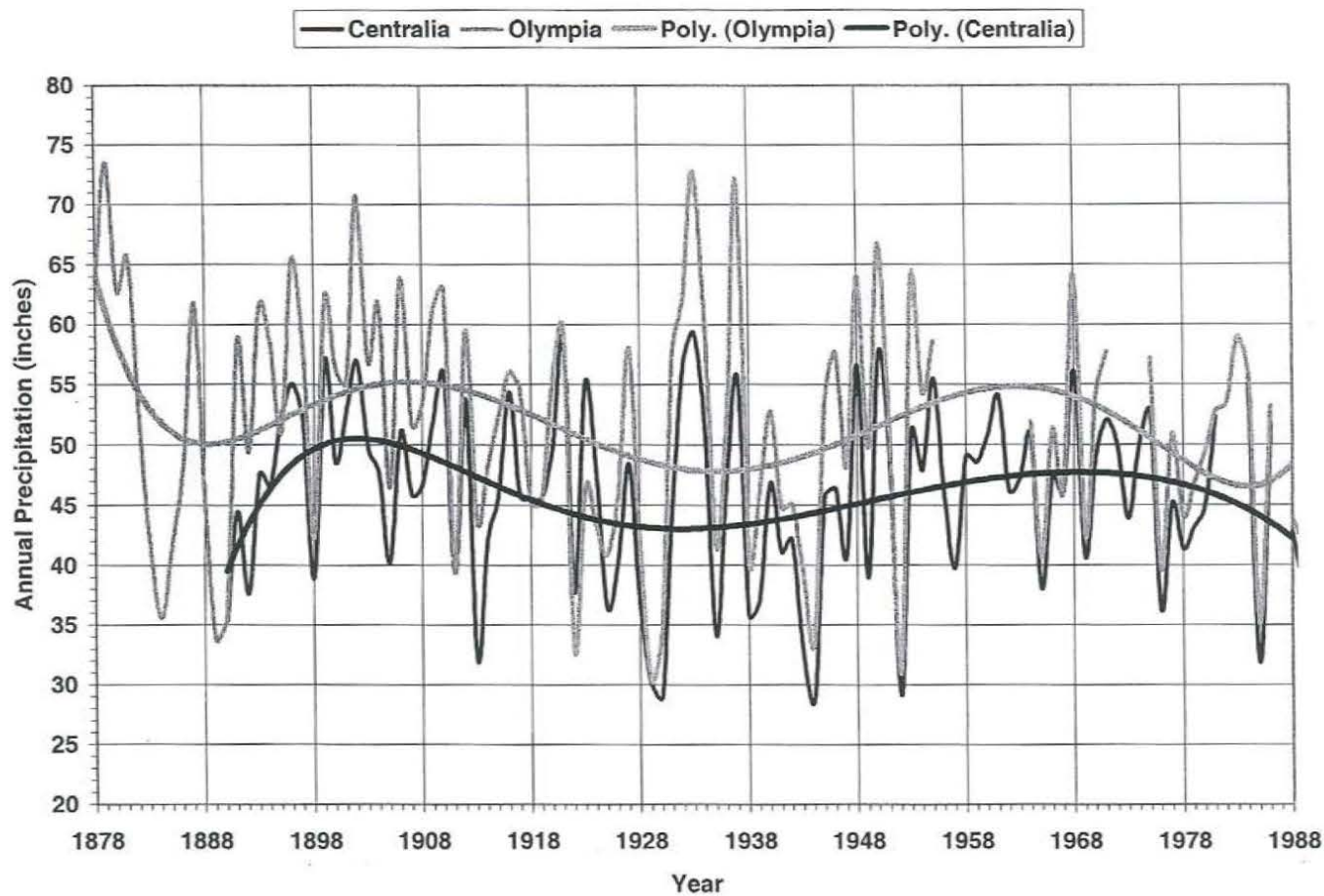


Figure 4-17. Annual Precipitation (Inches) at Olympia and Centralia, Washington

Note: The trend lines help display the difference in precipitation between the two cities and between decades.

Annual weather conditions in the Scatter Creek valley would typically be somewhere between but similar to conditions in Olympia and Centralia. Data from other gages in the region indicate there is a strong east-west precipitation gradient in this area. The Scatter Creek Basin would likely have a climate closer to the Centralia conditions because it is closer, located along the Chehalis River on the south of the Black Hills and Maytown Uplands, at a similar distance from the Pacific Ocean, and not on Puget Sound. Precipitation data from these two cities are the best data for showing the general pattern of climate conditions in the Scatter Creek Basin during recent historic times.

The precipitation data for Olympia, Washington was adjusted for the Scatter Creek Basin based on the Rock:Clime Stochastic Weather Generator (Elliot and Hall 2000) (Table 4-2). The program uses a database that contains average monthly precipitation values and average elevations for a 2.5-minute grid covering the United States developed by interpolating and extrapolating precipitation amounts between weather stations. Factors to allow for elevation, aspect, and other local effects were considered in the development. The longer record provides a better estimate of conditions compared to the short-term record in the basin at Rochester and Tenino or by using just the Olympia or Centralia records.

In the Scatter Creek Basin, about 76 percent of the precipitation falls in the months from October to March (Table 4-2). About 44 percent of the year consists of wet days, with about 59 percent of the October to March days being wet. The mean monthly air temperatures range from 31° to 50.4°F in the winter months and from about 50° to 77°F in the summer months.

Table 4-2. Mean Monthly Precipitation, Temperature Range, and Number of Wet Days for the Scatter Creek Basin

Month	Mean Max. Temp. (°F)	Mean Min. Temp. (°F)	Mean Precipitation Modeled (Inches)	Average Precipitation in Centralia (inches)	Number of Wet Days	Avg. Number of Days with 0.1 inch or More Precipitation in Centralia	Average Snowfall in Centralia (inches)
January	44.0	31.1	7.69	7.63	19.7	16	5.0
February	49.1	32.7	5.65	4.85	17.1	12	2.2
March	53.1	33.5	5.31	4.80	17.7	13	1.1
April	59.0	36.2	3.41	3.04	14.2	9	0
May	65.8	41.2	2.17	2.05	10.8	7	0
June	71.0	46.5	1.80	1.78	9.0	6	0
July	77.0	49.1	0.84	0.84	4.9	3	0
August	76.9	49.4	1.32	1.49	6.0	4	0
September	71.3	45.2	2.31	2.18	8.6	6	0
October	60.6	39.6	4.25	4.16	13.7	10	0
November	50.4	35.6	7.60	6.52	19.5	14	0.5
December	44.7	32.7	7.82	7.57	21.1	16	0.4
Annual Total			50.18	46.91	162.4	116	9.2

Note: Estimates are based on the Olympia, Washington weather station adjusted for location based on the Rock:Clime model (Elliot and Hall 2000). Average precipitation and snowfall 1951 to 1978 (Pringle 1990).

4.4.3 Evaporation

Evaporation is difficult to measure because it varies considerably over time and is related to many factors, including wind, air and water temperature, solar radiation, humidity, vegetation, and surface conditions. Evaporation from the Scatter Creek Basin is primarily from open water in ponds, creeks, puddles, wet soil, water intercepted by vegetation, and plant transpiration.

In the Puget Lowland, evaporation and transpiration have been estimated based on average runoff and rainfall data (Bodhaine and Thomas 1964); average annual pan evaporation of 31 inches with a standard deviation of 2 to 4 inches (Dunne and Leopold 1978); average annual evaporation from shallow lakes of 25 inches (Kohler et al, 1959); and from water balance studies (Swank 1972). Evaporation and transpiration typically remove between 40 and 50 percent of annual precipitation from Puget Lowland watersheds.

Mean annual lake evaporation in the Scatter Creek area from 1946 to 1955 was approximately 20 to 22 inches, and average annual pan evaporation was approximately 27 inches (Dunne and Leopold 1978). Annual values of pan evaporation in the Pacific Northwest vary from about 23 to 35 inches. Actual evaporation is often different from measured pan or lake evaporation because conditions for evaporation may be present but little water may be present on the surface of the soil and plants to actually evaporate. Therefore, models are often used to estimate actual compared to potential evaporation for an area (Table 4-3).

Table 4-3. Water Balance for the Black River/Scatter Creek Area

Month	Precipitation (inches)	Potential Evaporation (inches)	Actual Evaporation (inches)	Surplus Moisture (inches)
October	4.07	0.48	0.48	6.04
November	8.43	0.64	0.64	4.68
December	6.62	1.28	1.28	3.24
January	5.96	1.92	1.92	2.56
February	5.01	2.96	2.80	0.00
March	4.14	3.76	2.68	0.00
April	4.53	4.56	1.40	0.00
May	1.88	4.20	0.96	0.00
June	1.84	3.08	2.16	0.00
July	0.91	1.76	1.76	0.36
August	0.79	0.96	0.96	7.60
September	2.04	0.36	0.36	6.76
Total	46.22	25.96	17.40	31.24
Percent of Total Precipitation		56	38	68

Note: Estimates from Hirschey and Sinclair (1992) are based on average precipitation at the Rochester gage from 1980 to 1991 and the WATBUG model used to estimate evaporation and basin recharge. These results are for a larger area than the Scatter Creek valley, with a slightly higher overall precipitation amount.

Compared to the Centralia precipitation from 1946 to 1955, annual mean percent evaporation would be about 54 percent, with a maximum of 61 percent in 1948 with 64 inches of precipitation; the minimum was in 1952, with 31 inches of precipitation and evaporation of about 24 percent of the annual precipitation.

Values of monthly potential and actual evaporation were estimated by Hirschey and Sinclair (1992) for the Black River and Scatter Creek area based on the WATBUG model (Willmot 1977) (see Table 4-3). Their analysis estimates about 31.2 inches per year of excess moisture from precipitation that can either flow out the creeks and rivers or soak into the ground. Their analysis indicates that there is a soil moisture deficit between May and September and soil moisture excess the rest of the year. They estimate 31 inches of recharge with potential evaporation losses of 26 inches (56 percent of precipitation) and actual losses of 17 inches (38 percent of the precipitation). This is slightly higher than the U.S. Geological Survey (USGS) estimate (Drost et al. 1999) of about 24 inches of recharge per year. The actual value for the Scatter Creek Basin likely varies within this range.

4.4.4 Surface Runoff

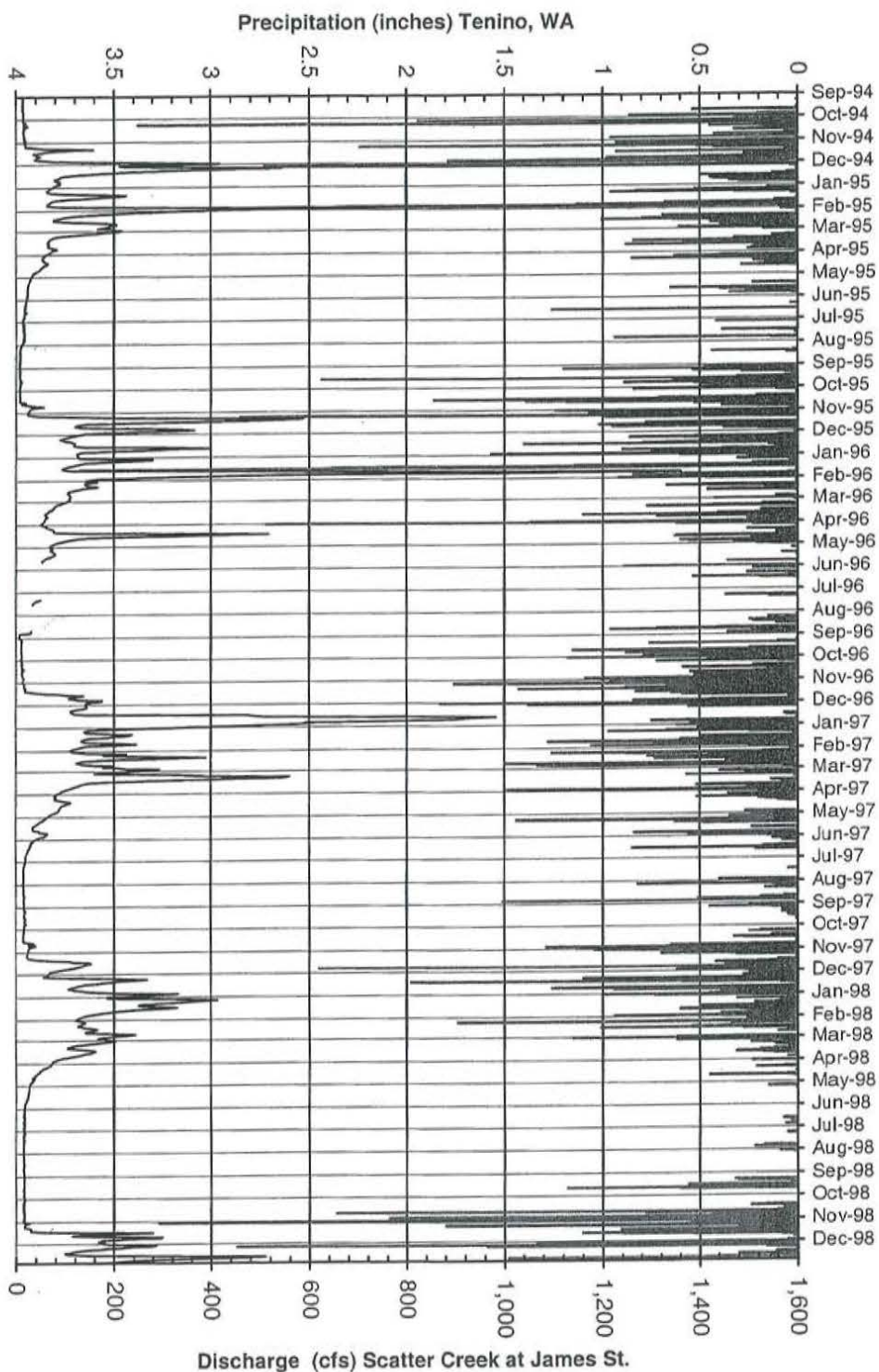
When precipitation exceeds the infiltration capacity of the surface materials, water begins to stand and flow across the surface. Precipitation is typically of low intensity in the Pacific Northwest, thus many areas with vegetation produce limited surface runoff. When the vegetation and loose duff layer is removed, many of the soils of western Washington will generate saturated overland flow and related surface erosion. The amount of runoff depends on the rainfall amount and rate, the initial moisture conditions of the soils, the soil type and condition, slope and texture of the surface, and subsurface materials.

Most of the Scatter Creek Basin hills (about 55 percent of the basin) are covered with a shallow layer of loose drift over thin, relatively impermeable glacial tills, ice contact deposits, and bedrock. Because soils on the hillslopes are thin, shallow groundwater quickly encounters impermeable till and bedrock and flows into the typically narrow valley bottoms within hours or weeks. As a wet period progresses, saturated areas in the tributary channels and swales expand. This creates an expanding saturated area where rainfall runs off. Peaks on the streamflow hydrograph are formed as the flows accumulate from the various swales and tributary channels of the basin (Figure 4-18). When the rainfall or snowmelt lessens, the runoff from shallow groundwater interflow to the channels and saturated areas lessens and the hydrograph gradually recedes.

The hill areas of the Scatter Creek Basin have a rainfall-runoff pattern typical of most of western Washington because the surface is dominated by thin glacial deposits and bedrock. The drainage density shows there is stormflow surface runoff that erodes the channels and deposits alluvial fans near the tributary mouths. Surface runoff from the main tributaries flows across alluvial fans, glacial outwash deposits, and the valley bottom in the lower portions of the glacial-age drainageways. Many of the small valleys in the hills are too small to generate surface flow much past their alluvial fans, and their wet season surface water and groundwater flow soaks into the outwash deposits along the valley bottom edge. Most of the stormflow and a portion of typical wet season flow in Scatter Creek is from runoff in the hills. The area with the most stormflow runoff is the hills around Tenino.

Runoff on the prairies is quite different because of the infiltration rate and water capacity of the glacial deposits that fill the valley bottom between the hills. Almost all of the water that falls onto the prairie surface infiltrates. Some water is pulled back out of the soil by plants and evaporation from the damp surface layer, but much of the precipitation soaks into the ground. The glacial-age channel and periglacial features on the prairie surfaces and very low drainage density show that this area has had minimal surface runoff and erosion. Of the total precipitation, about 30 to 50 percent is intercepted by vegetation or evaporates from the vegetation and ground surfaces. The remainder soaks into the ground, where it migrates to the water table or low permeable surface and migrates down the relatively low gradient towards the lower valley.

Figure 4-18. Daily Precipitation (Inches) at Tenino, Washington and Mean Daily Discharge (cfs) at the Thurston County Scatter Creek Gage at James Street, from September 1994 to December 1998



4.4.5 Scatter Creek Streamflow

Typical Flows

Streamflow data was available from September 23, 1994 through October 23, 1999, measured at the James Street bridge (River Mile 2.2) (Figures 4-18 through 4-20). The short-term Scatter Creek record shows wet season flow averages about 60 cfs, with most storm peaks ranging from 200 to 400 cfs. There is a steady decline in base flow starting about April as the tributary surface runoff and groundwater gradually decline. Streamflow on Scatter Creek rises and falls slower than on most rivers in western Washington. Comparison of the Scatter Creek gage data to other nearby gages shows Scatter Creek is strongly influenced by groundwater flow.

Base Flow

The monthly mean base flow contribution to streamflow for the low-flow period (July through October) averaged 86 percent in an analysis of Pacific Northwest rivers (Ecology 1999). Scatter Creek is predominantly controlled by groundwater during the dry season and probably gets over 90 percent of its flow from groundwater during much of July through October, with the exception of recharge from the fish farm since 1978.

Flood Flows

Wet season flows typically are in the range of 80 to 400 cfs, with less frequent peaks in the range of 400 to 1,400 cfs. The maximum mean daily discharge during 1994 to 1998 was 1,362 cfs on February 14, 1996; flows of more than 200 cfs occurred an average of 34 days per year. During this 5-year period, there were 13 days with flows over 600 cfs. About 50 percent of the basin delivers stormflow runoff to the valley bottom from the hill portions of the basin. This flow is mostly delivered from seven tributary creeks that enter Scatter Creek and elevated groundwater return flow. If stormflow runoff enters from the tributaries after a dry summer, it takes a while to fill the local groundwater and channel areas. Stormflow onto wet basin conditions creates the largest stormflow peaks. There are insufficient years of recorded flows on Scatter Creek to determine the relationship between flood frequency and magnitude.

Low Flows

From April to May, the flow begins to drop from the steady wet season minimum of about 40 cfs to between 10 cfs and 16 cfs (Figure 4-20). The low-flow hydrograph is partly from the fish farm and partly from groundwater seepage into and out of the channel.

The upper portion of the annual dry season hydrograph recession limb drops rapidly because tributary flow is quickly falling, ponds and side channel areas are quickly draining, and groundwater return flow is gradually dropping. As the dry season weeks and months continue with only minor rainfall, tributary input is approaching a minimum, and the groundwater table along the channel continues to gradually drop. The lower portion of the dry season hydrograph recession reflects the gradual decline in groundwater return flow.

Scatter Creek at James St. Bridge

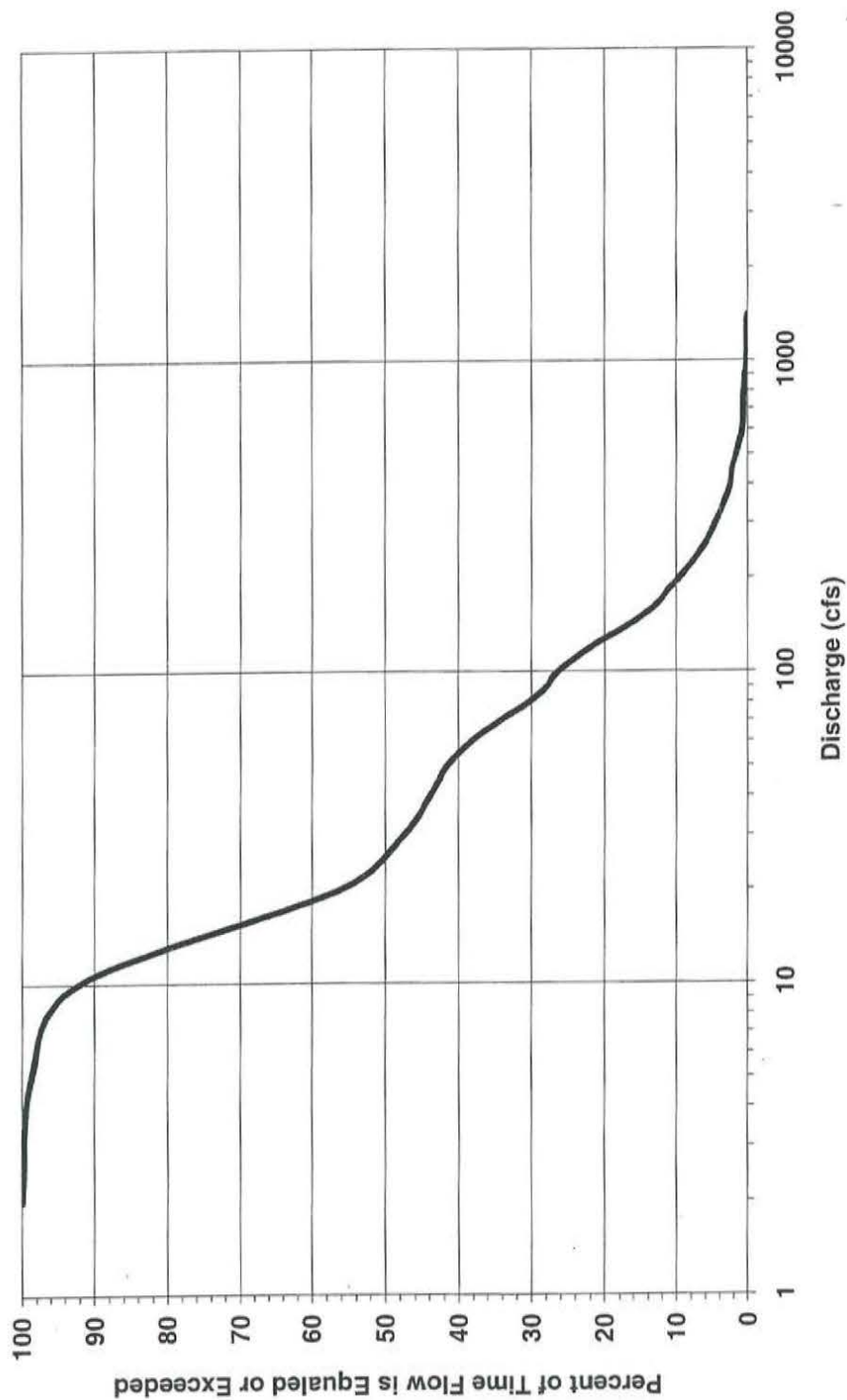


Figure 4-19. Mean Daily Flow Duration for Scatter Creek at James Street Bridge From September 1994 to December 1998

Scatter Creek At James Road Bridge

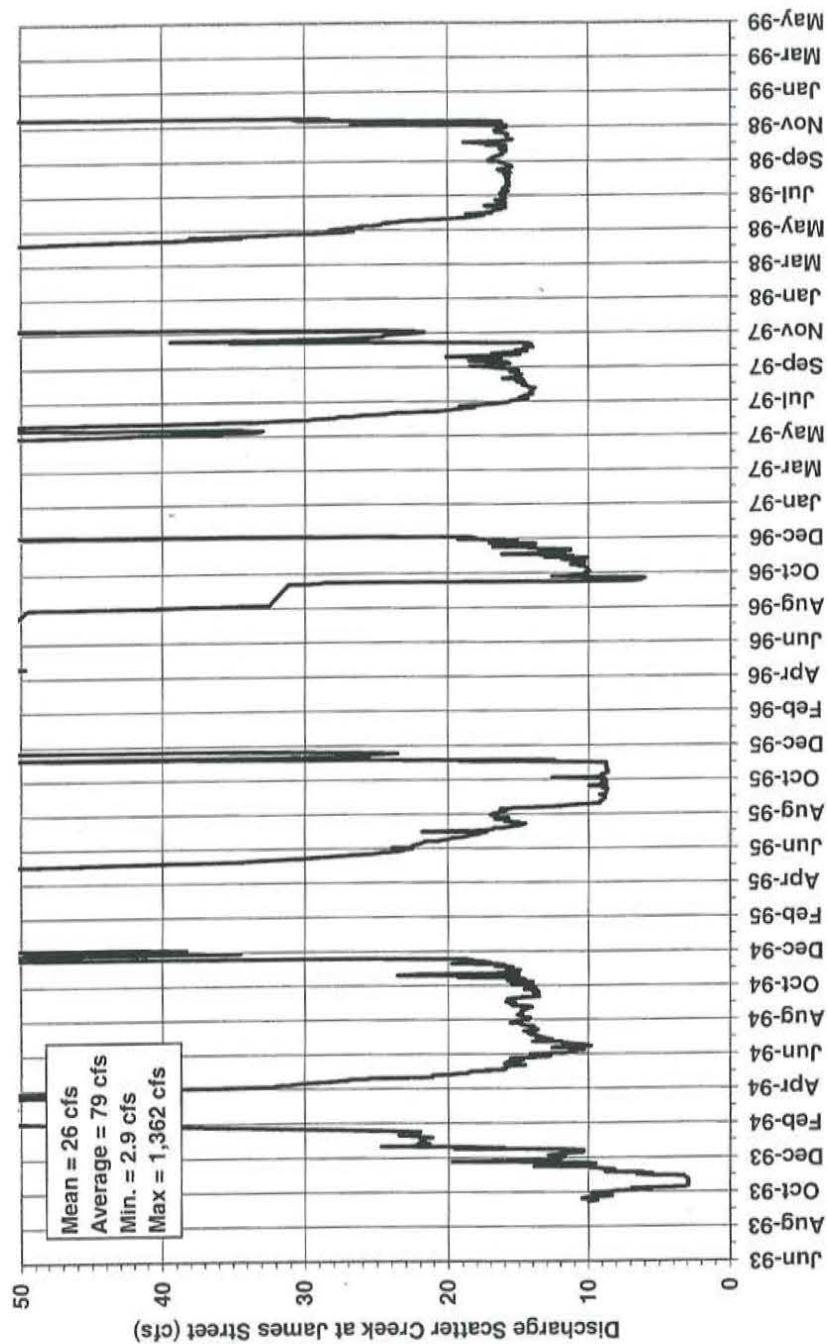


Figure 4-20. Low Flow Discharge (cfs) at the Scatter Creek Gage at James Street from September 1994 to December 1998

Note: Scatter Creek discharge showing low flows are mostly between 8 and 15 cfs because of the addition of about 16 cfs from the fish farm near River Mile 7. Minimum discharge of 2.4 cfs occurs when the fish farm flows mostly soak in between River Mile 7 and the gage site.

4.4.6 Comparison of Scatter Creek Gage Data to Other Sites

Comparing the short-term Scatter Creek gage record to other precipitation and stream gage records provides a better review of the range of weather conditions that can be expected. Estimating a longer-term flow record would be of benefit because it can be used to help estimate how much of the precipitation infiltrates. Nearby gages include four gages on the Skookumchuck River and three gages on the Newaukum River. Only the middle portion of the Skookumchuck River has groundwater conditions similar to Scatter Creek; the rest of the area drains upland hills. The Skookumchuck has had a storage reservoir since 1970 that modifies flow patterns in the records.

To find a relationship for extending the flow record, data from each gage were plotted together. If the points are scattered across a broad width, a simple equation to extend the record cannot be developed. Finding the best fit for various possible equations provides a convenient comparison between gage sites. If there is a perfect fit between the data from the two gage sites, plotted points all fall on the line for that equation and the R-squared value is equal to 1.0. If very few of the points correlate, then the R-squared value is very low. For example, comparing the daily streamflow between the Skookumchuck River gage at Bucoda and the next upstream gage shows a good correlation with an R-squared value of 0.94, about the best correlation to be expected with this approach (Figure 4-21).

Comparing the daily streamflow for the Skookumchuck River and Newaukum River shows a relatively good correlation with an R-squared value of 0.83 (Figure 4-22). This shows that the two basins are fairly similar, even with the Skookumchuck flow regulation.

In a similar manner, comparing the 5 years of Scatter Creek flow data with data from gages on other nearby streams shows that it is not similar to other streams in the area. The Vail gage on the Skookumchuck River is one of the closer unregulated gages but is further east. Comparing the Scatter Creek gage data with the Vail gage data shows a very poor correlation and indicates the basins and runoff processes are not similar (Figure 4-23). The best comparison of Scatter Creek with the Newaukum River is the gage near Newaukum, which shows a poor correlation with an R-squared value of 0.46.

Comparison of 5 years of daily precipitation data from Tenino to the Scatter Creek daily streamflows also shows a very poor correlation, further indicating the very strong influence of the landforms and groundwater aquifer on Scatter Creek discharge (Figure 4-24). The Skookumchuck gage at Bucoda provides the best, but relatively poor, comparison with the Scatter Creek flow data with an R-squared value of 0.66 (Figure 4-25).

Based on the regression equation with the Bucoda gage, a rough estimate of what flows on Scatter Creek were like between 1967 and 1993 can be made (Figure 4-26). This provides 26 years of estimated stream flows for Scatter Creek. This is an estimate based on the patterns in the nearby river. This extension of the record based on a nearby gage provides a better estimate of the possible range to expect for the mean annual flow rate. The storage in the Skookumchuck reservoir after 1970, along with the groundwater influence across Frost Prairie, is probably why the Bucoda gage responds more like the Scatter Creek data than other gages in the area. With this extended Scatter Creek flow data, an estimate of the Scatter Creek Basin water balance for 21 years from 1968 to 1989 can be developed.

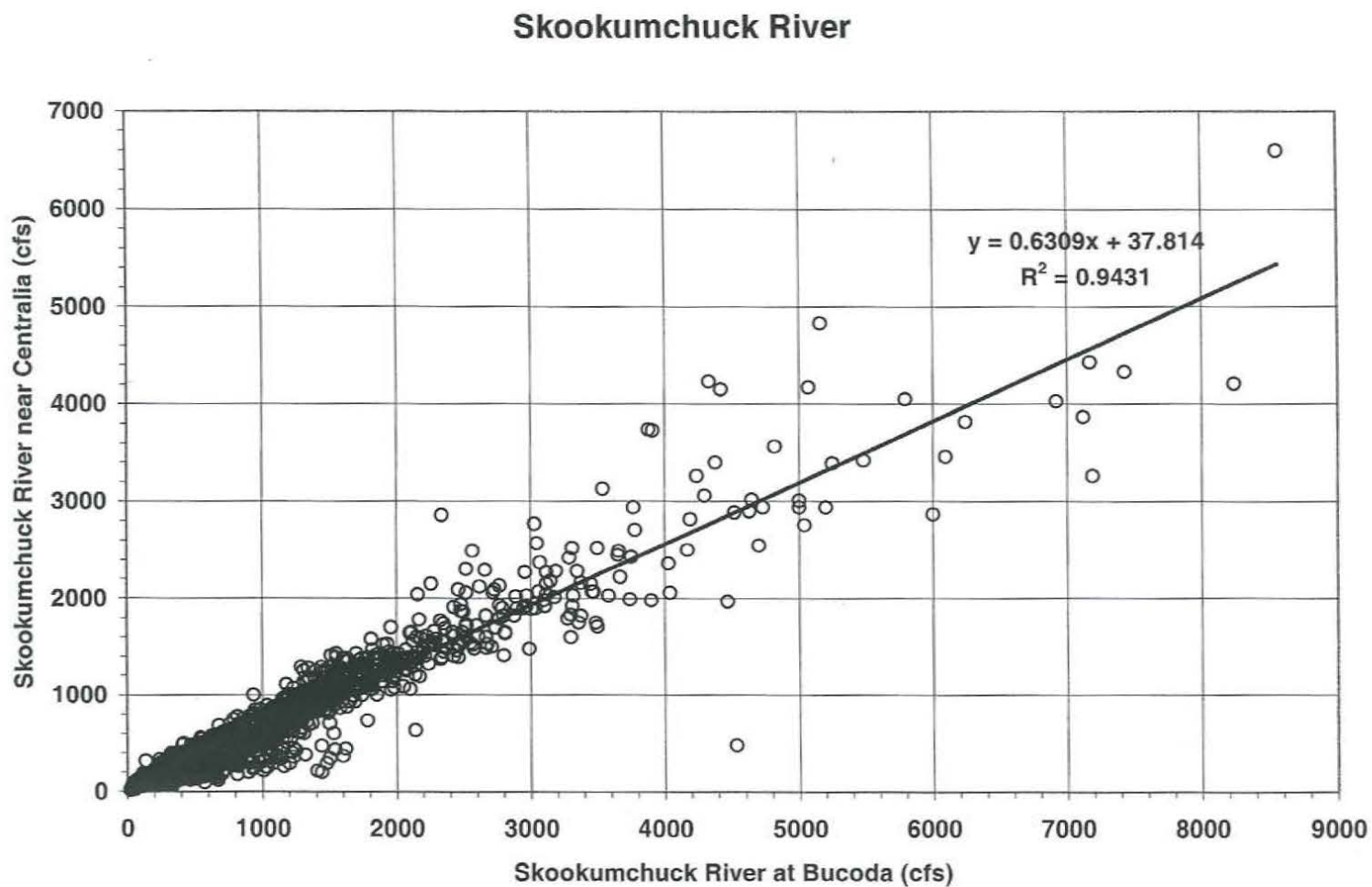


Figure 4-21. Comparison of Mean Daily Discharge (cfs) at the Skookumchuck River Gages Near Bucoda and Near Centralia, Washington

Note: The data points cluster around the line of best fit and have an R-squared value of 0.9, indicating that the equation for the line provides a fairly good estimate of flow at one station based on the other.

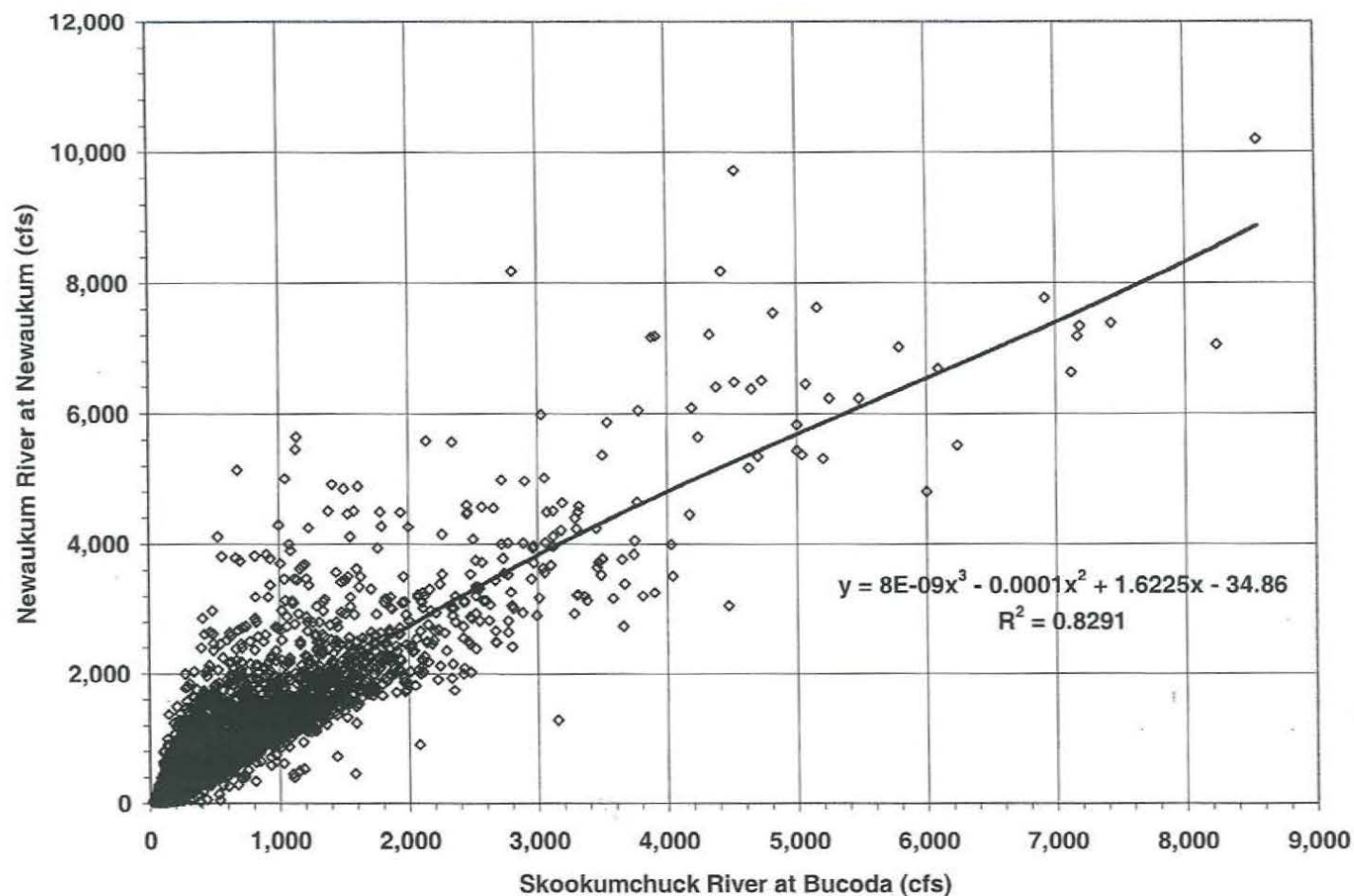


Figure 4-22. Comparison of Mean Daily Discharge (cfs) at Skookumchuck River Near Bucoda and the Newaukum River, Washington

Note: The data points do not cluster around the line of best fit as well as the two gages on the same river and have a lower R-squared value of 0.8, indicating there is a little more scatter and less correlation between the gages.

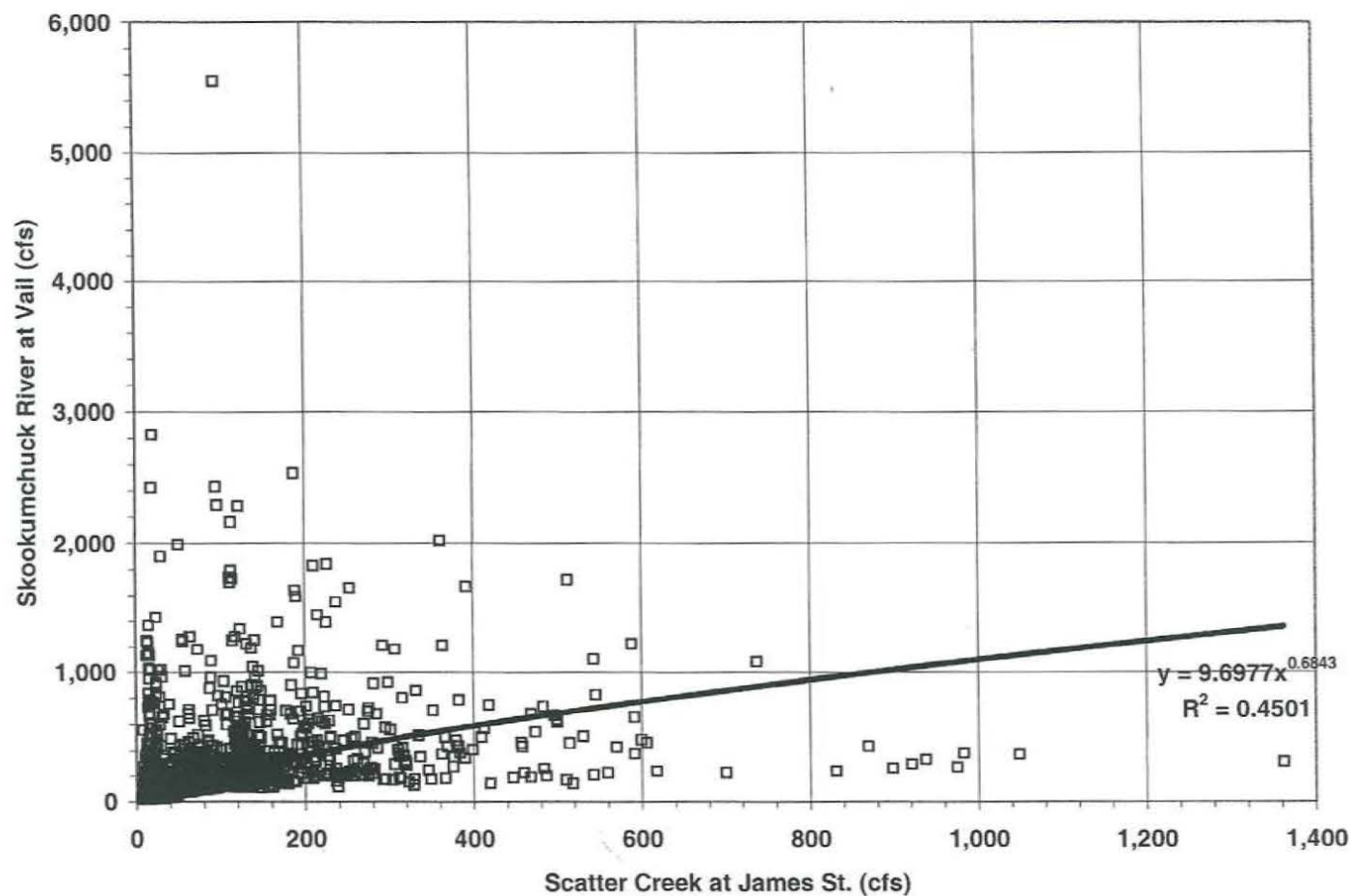


Figure 4-23. Comparison of Mean Daily Discharge (cfs) at Scatter Creek at James Street and the Skookumchuck River at Vail, Washington

Note: The data points do not cluster closely around the line of best fit and have a low R-squared value of 0.4, indicating there is considerable scatter and minimal correlation between the gages.

Scatter Creek Watershed 9/23/94 to 1/17/99

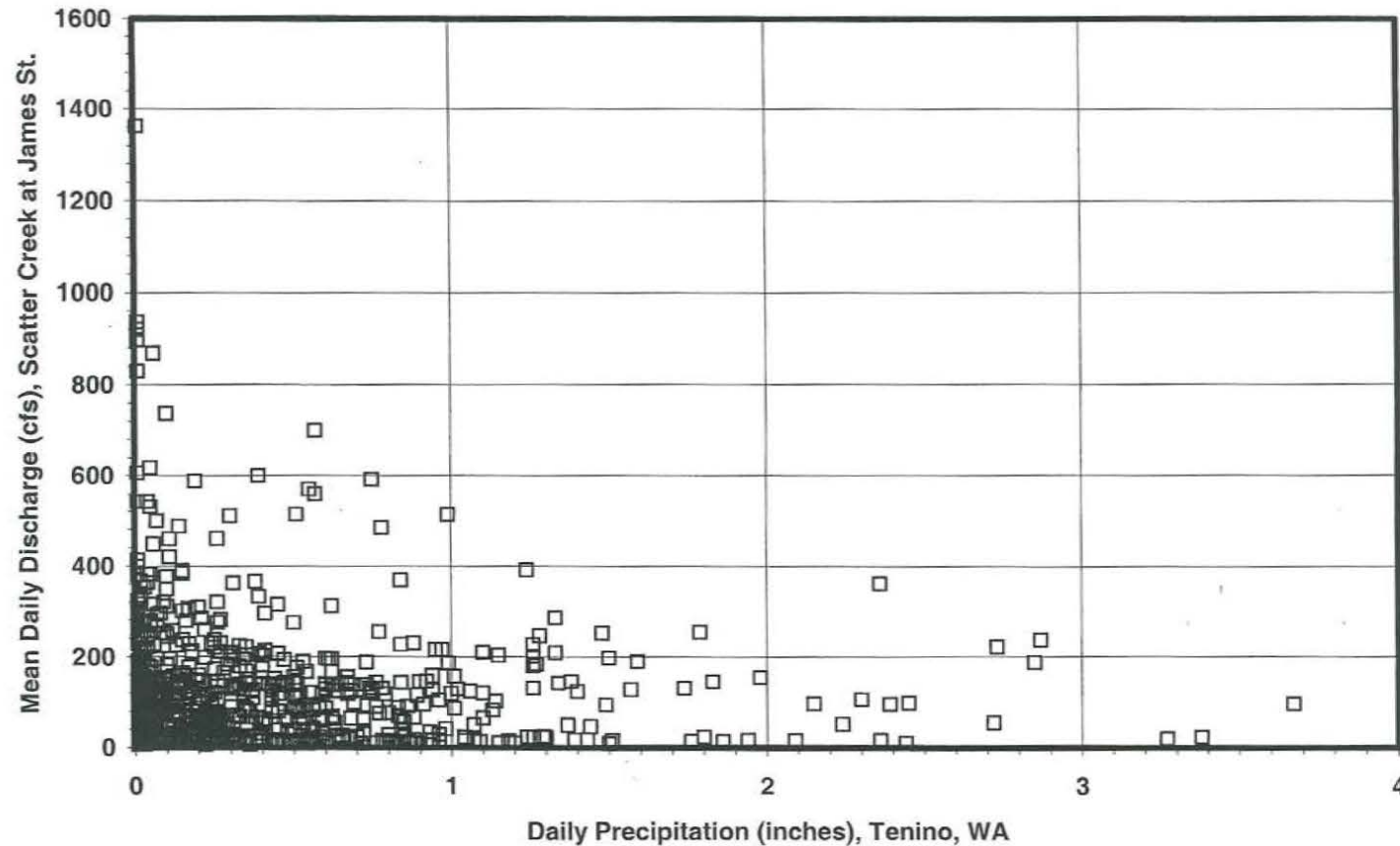


Figure 4-24. Comparison of Daily Precipitation at Tenino, Washington (9/23/94 to 1/17/99) to Mean Daily Discharge (cfs) at the Scatter Creek Stream Gage at James Street

Note: There is more scatter in this data than for any of the other regression parameters, indicating that precipitation and discharge do not correlate in the Scatter Creek Basin. As indicated by the basin landforms and geologic materials, this scatter in the data points was expected.

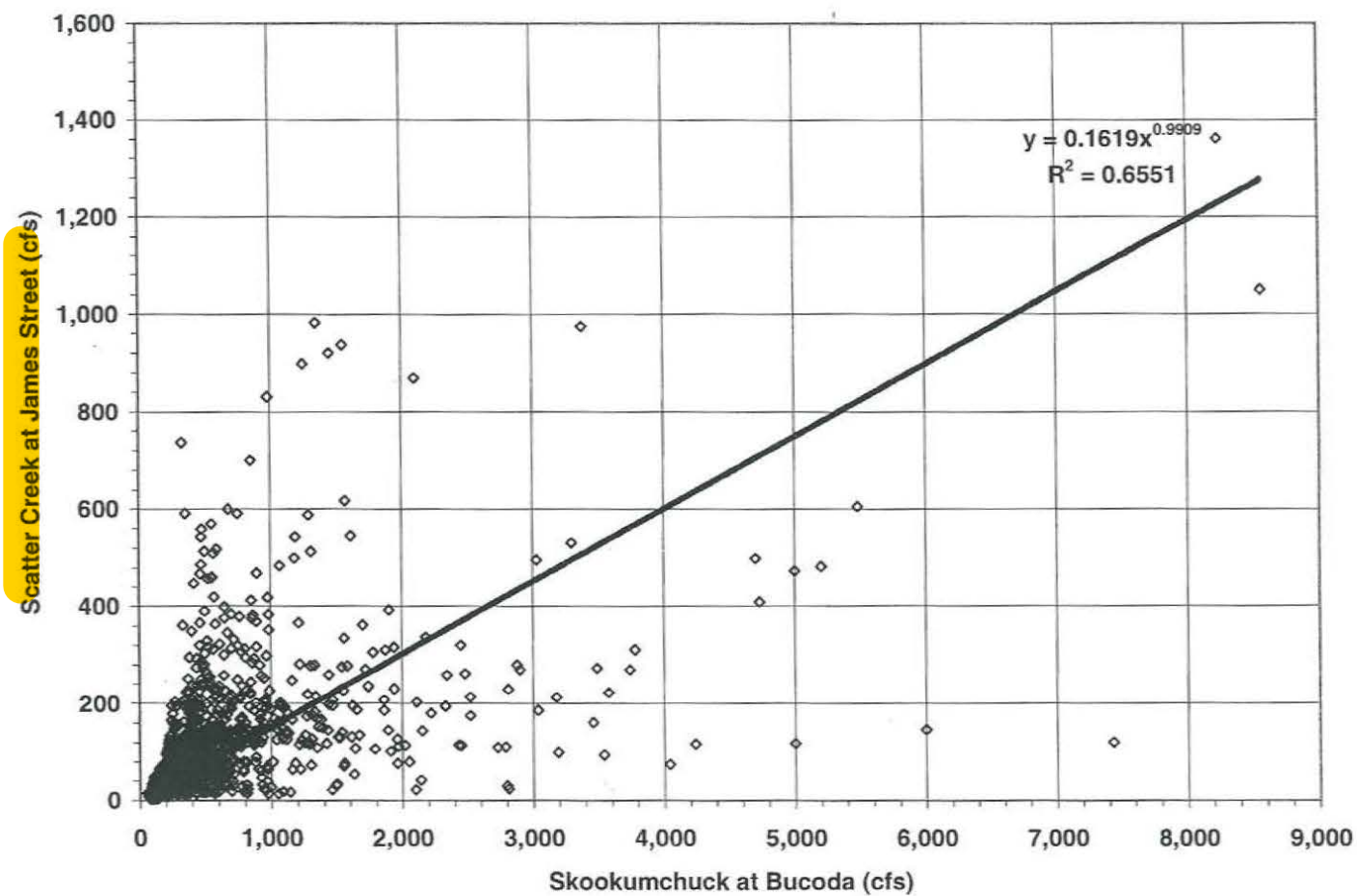


Figure 4-25. Mean Daily Discharge at Skookumchuck River Near Bucoda, Washington (cfs) Plotted with the Mean Daily Flows for Scatter Creek at James Street Bridge (cfs)

Note: This correlation was found to be the best fit that could be found between Scatter Creek streamflow and other gages in the area.

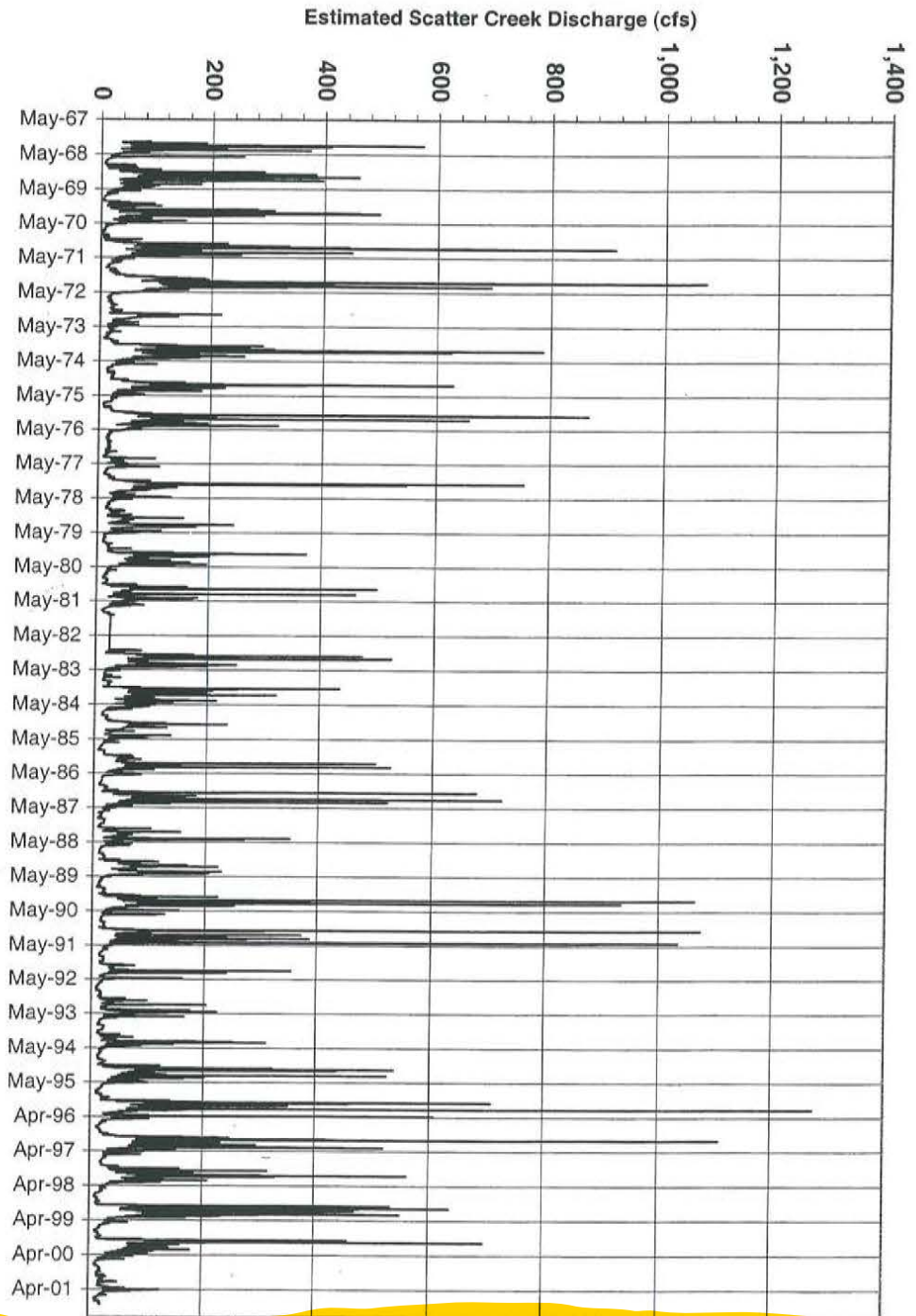


Figure 4-26. Estimated Scatter Creek Mean Daily Discharge (cfs) for 33 Years Based on the Correlation with the Skookumchuck River at Bucoda, Washington

4.4.7 Groundwater

In the Scatter Creek area, and downstream to the Pacific coast, the Chehalis River valley was incised much deeper than present and later filled-in by sediment-charged glacial runoff from the Penultimate and Vashon Ice Sheets as they advanced and receded into the Puget Lowland. This glacial-age sediment forms a continuous valley fill and groundwater aquifer from offshore of Grays Harbor up the Chehalis River valley and up the Black River, Scatter Creek, and Skookumchuck River valleys.

The Scatter Creek aquifer is in the glacial sediments that partially fill wide, shallow, and generally u-shaped bedrock valleys between the Maytown Upland and the western part of the Bald Hills between the Scatter Creek prairies and the Skookumchuck River valley (Figures 4-27 through 4-29). The extent of the Vashon outwash surface defines the main water recharge area for the aquifer. Water supply to the recharge area occurs primarily as infiltration of precipitation on the prairies and seepage from alluvial fans and tributary channels that cross the prairies. Flow into and out of the Scatter Creek channel, depending on the season and level of the groundwater surface along the creek channel bottom, distributes surface runoff from the hills onto the prairies and into the aquifer.

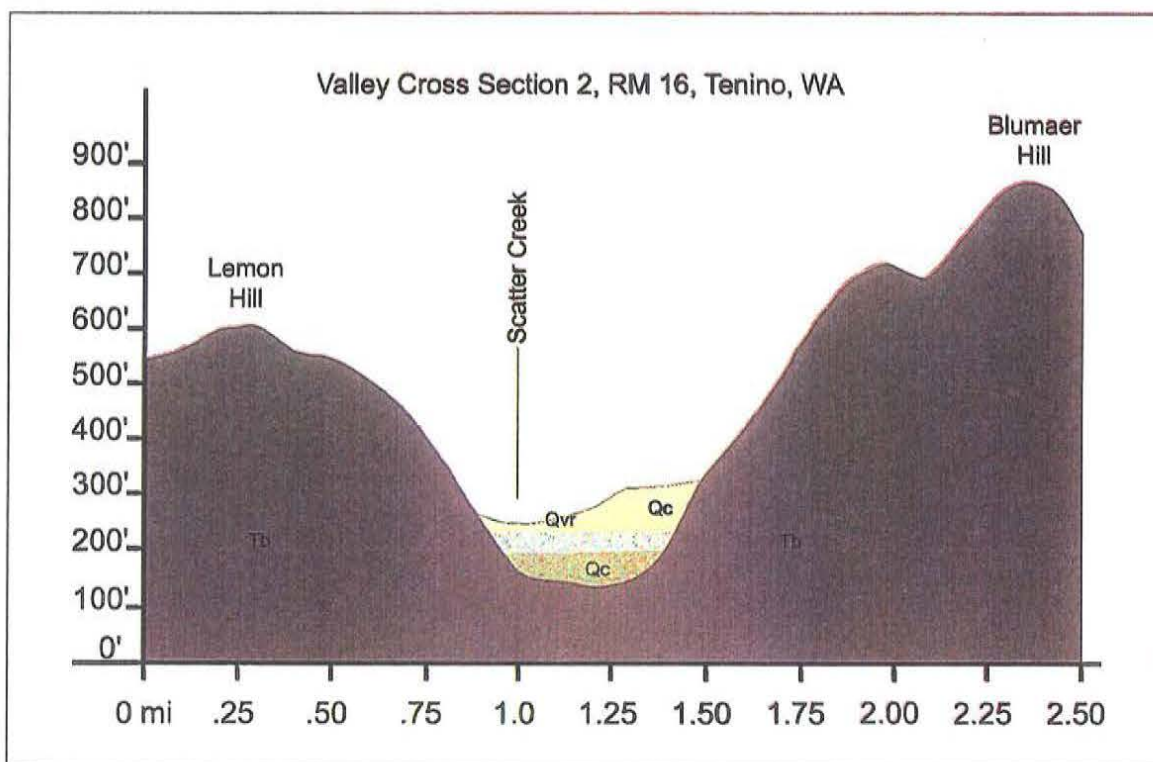
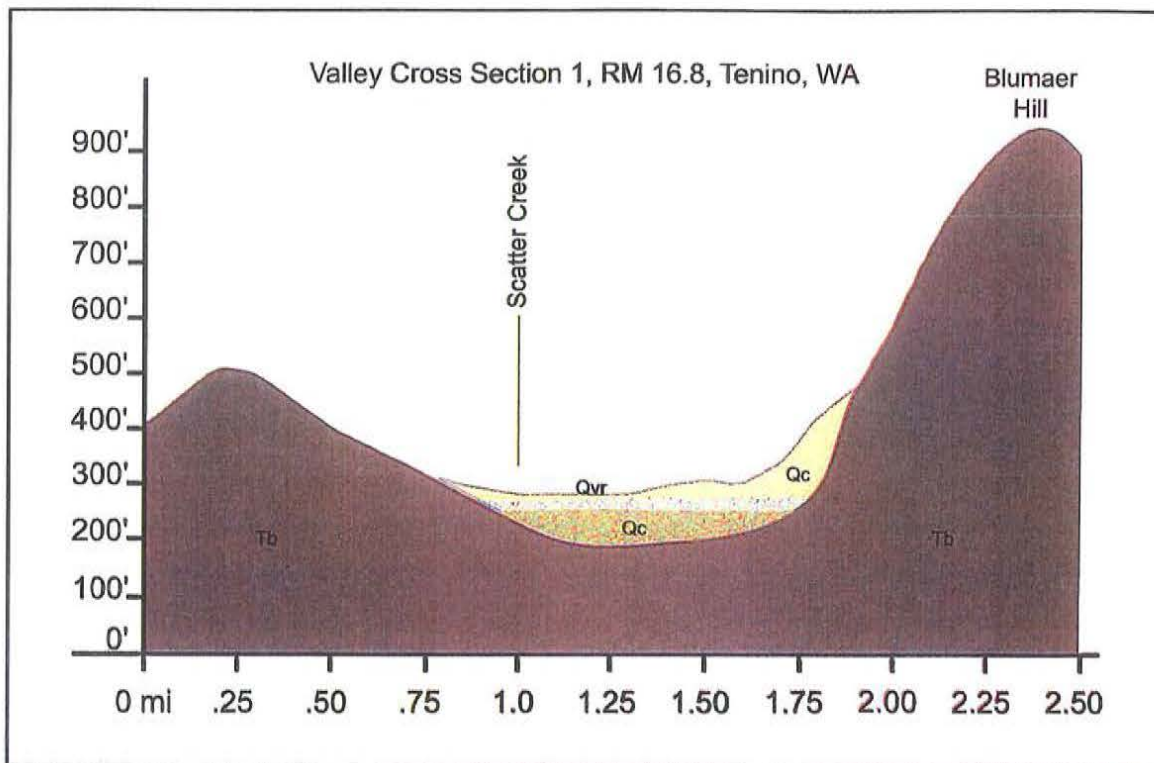
Water enters the upper end of the Scatter Creek aquifer from precipitation and surface runoff from the tributaries around Tenino. The valley fill is about 100 ft deep and ½ mile wide (Figure 4-27). The aquifer widens across Rock Prairie to about 1.5 miles wide (Figure 4-28). Scatter Creek is incised about 30 ft into the old glacial outwash plain, and the river is confined in the old outwash surface from River Mile 12 to River Mile 16 and likely is near the confining till contact.

The Skookumchuck River where it exits Frost Prairie is in a narrow valley with a relatively small cross section, compared to the northeast portion towards Scatter Creek. It is likely that some groundwater flow from the Skookumchuck Frost Prairie aquifer flows northeast to Scatter Creek and supports flow in the Big Bend reach from about River Mile 15 to River Mile 13.7. The Skookumchuck River exits from the Johnson Creek area at about 300 ft elevation and drops to 243 ft where it exits to Bucoda. The small unnamed creek from the hills on the southwest edge of Frost Prairie flows from around 263 ft elevation down to the Skookumchuck River at 243 ft. This small tributary is 0.4 mile from Scatter Creek, which is at 240 ft elevation in this area. Some of the groundwater recharge in this area likely flows towards Scatter Creek, especially during the wet season. The groundwater from this area helps support the perennial flow of Scatter Creek in this area. A similar situation likely occurs along the hills on the north side of Frost Prairie where another small tributary enters the valley bottom near Scatter Creek.

4.4.8 Aquifer Recharge

The groundwater model developed for Thurston County by the USGS (USGS model) (Drost et al. 1999) includes the main portion of the Scatter Creek aquifer and provides a very good tool for assessing the groundwater conditions in the region. The USGS model estimates recharge in the Scatter Creek Basin at about 28 inches per year on Rock, Violet, and Mound Prairies; about 25 inches per year on Grand Mound Prairie; and about 16 inches per year in the hills around the Scatter Creek valley.

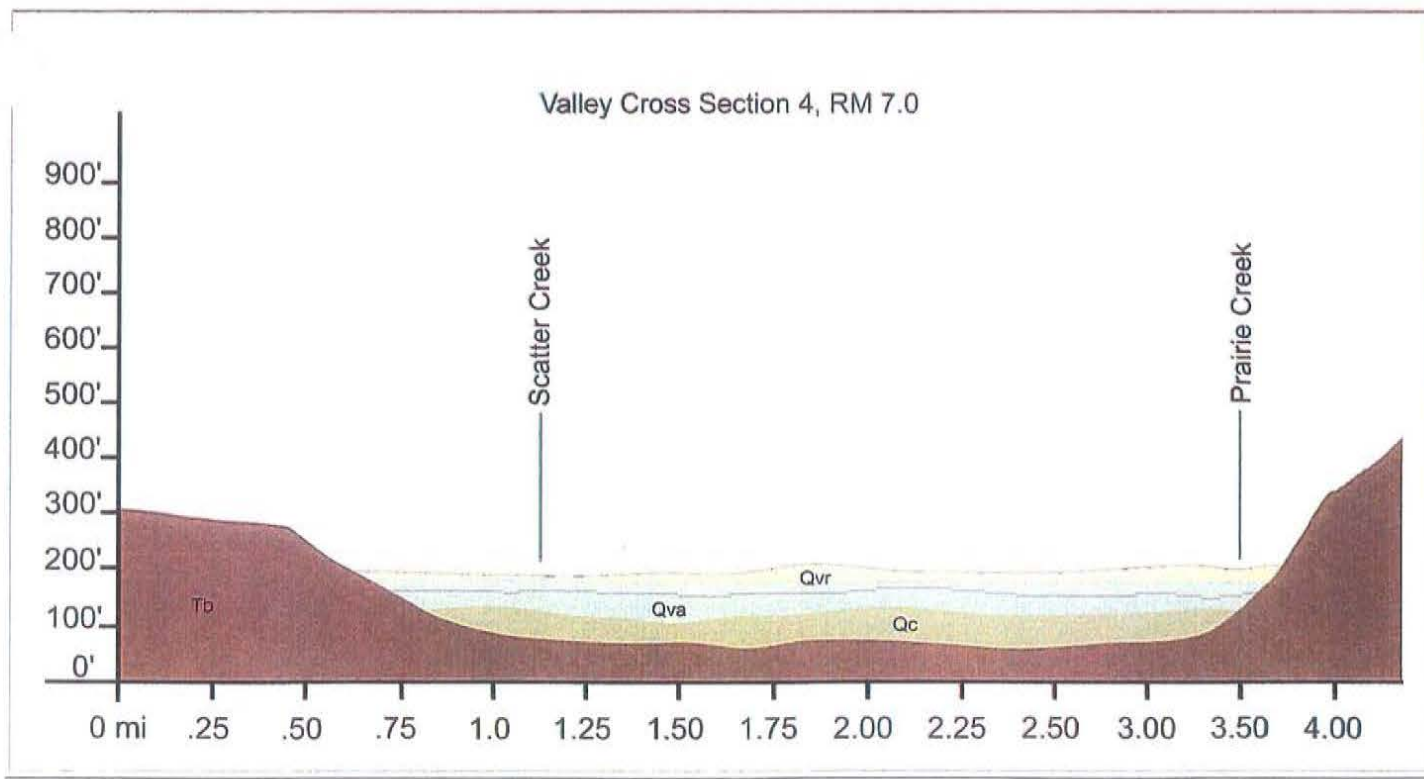
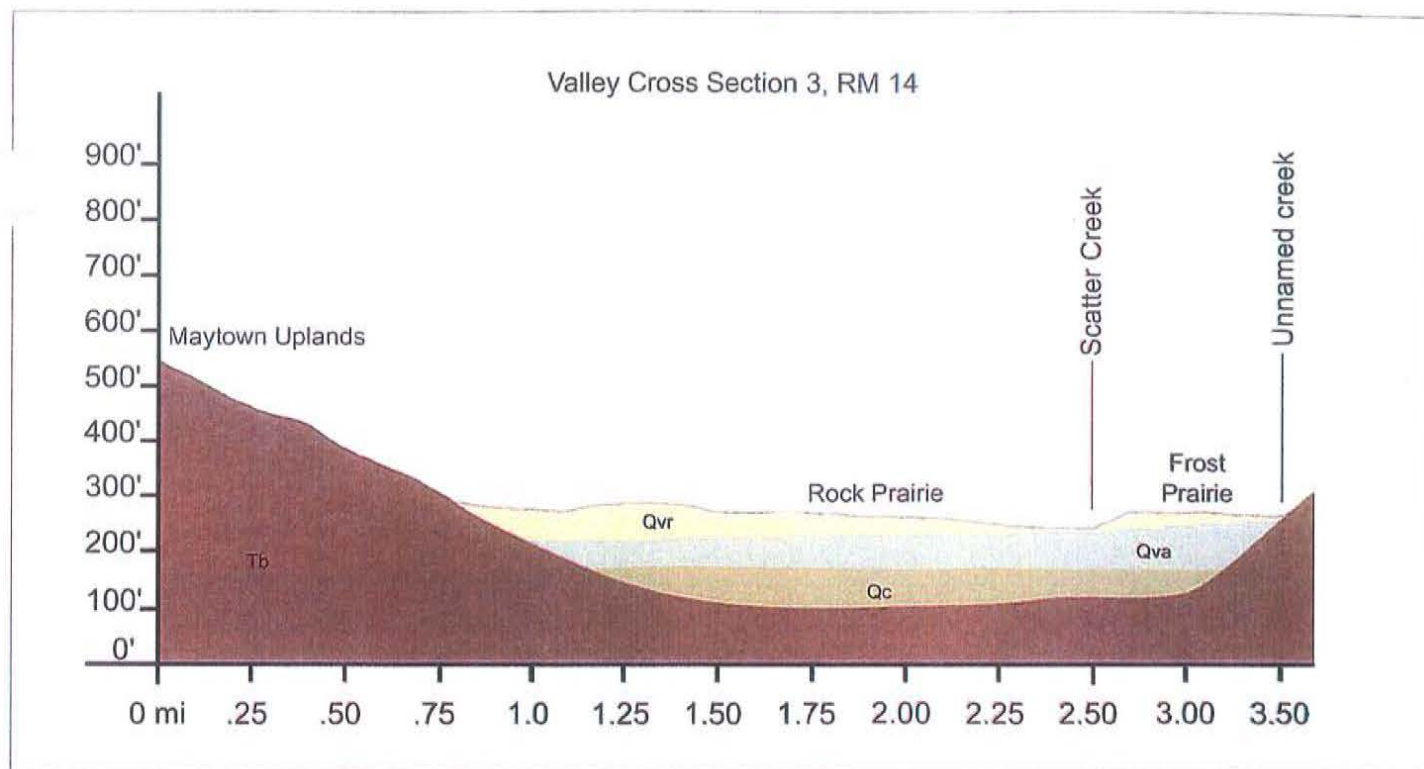
The prairies have an area of approximately 12,800 ac based on vegetation and soils mapping (Pringle 1990). This area times the 25 inches of recharge per year, plus the area of hills, times 16 inches recharge per year, equals approximately 20,500 acre-feet (ac-ft, the amount of water required to cover 1 ac to a depth of 1 ft) of recharge in the hills and about 26,600 ac-ft to the outwash prairies, for a total of about 47,000 ac-ft. Subtracting the mean 36,000 ac-ft per year of Scatter Creek discharge leaves a mean for recharge to the aquifer of 11,000 ac-ft, with a range of 24,000 ac-ft to minus 10,000 ac-ft per year change in annual aquifer groundwater storage.



Parametrix Scatter Creek 553-4335-001/01(10) 01/03 (K)

Note: Valley Cross Section River Mile 16.8 (top),
River Mile 16.0 (bottom).
Cross section locations are shown in
Figure 3.

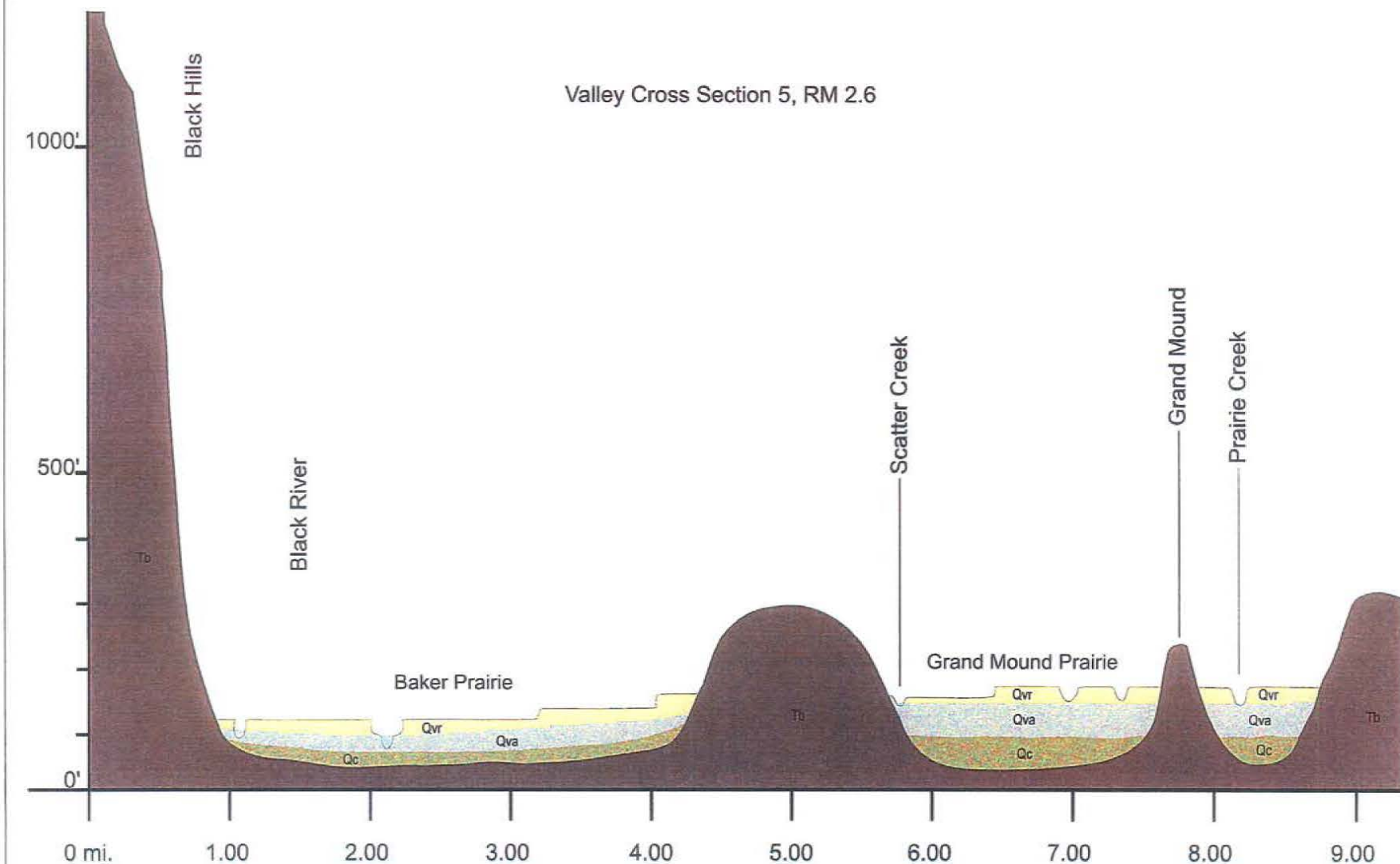
Figure 4-27
Valley Cross Section and Approximate
Valley Fill Depth in the Scatter Creek
Valley at Tenino, Washington



Parametrix Scatter Creek 553-4335-001/01(10) 01/03 (K)

Note: Rock Prairie River Mile 14 (top), and Mound Prairie at River Mile 7.0 (bottom). Cross section locations are shown in Figure 3.

Figure 4-28
Valley Cross Sections and Approximate Valley Fill Depth in the Scatter Creek Valley Across Rock and Mound Prairies



arametrix Scatter Creek 553-4335-001/01(10) 01/03 (K)

Note: Valley Cross Section River Mile 2.6.
Cross section locations are shown in
Figure 3.

Figure 4-29
Valley Cross Section and Approximate Valley
Fill Depth in the Scatter Creek VALLEY Across
Grand Mound Prairie to the Black River Valley

This can be compared to a general water balance for Scatter Creek Basin based on the 1969 to 1989 data and an estimated evaporation loss rate between 38 percent effective evaporation (Hirschey and Sinclair 1992) to around 50 percent for total evaporation potential (Dunne and Leopold 1978). Using the Tenino annual precipitation, Scatter Creek annual discharge, and drainage basin area, the amount of recharge to temporary storage in the aquifer can be estimated. This general estimate based on the short-term Scatter Creek water balance indicates a mean annual recharge to Scatter Creek aquifer storage of 16,300 ac-ft, with a minimum of 350 ac-ft and a maximum of 22,400 ac-ft (Figures 4-30 and 4-31). This is similar to the recharge rates used in the USGS model.

The annual recharge volume is around 10 to 20 percent of the total annual precipitation with 50 percent evaporation (Figure 4-32). Because the Chehalis precipitation record is considered a good representation of precipitation in the Scatter Creek valley, a longer-term annual infiltration volume can be roughly estimated based on the annual precipitation (Figure 4-33).

Based on the 38 percent evaporation water balance, the 1969 to 1989 Scatter Creek recharge averaged 26,000 ac-ft annually and ranged from a minimum of 14,000 ac-ft to a maximum of 38,000 ac-ft (Figure 4-30). The extended record for the 38 percent evaporation water balance has a mean of 27,000 ac-ft, minimum of 17,000 ac-ft, maximum of 34,000 ac-ft, and average of 27,000 ac-ft (Figure 4-33). In a similar manner, the 50 percent evaporation water balance for the 1969 to 1989 Scatter Creek recharge averaged 15,000 ac-ft annually and ranged from a minimum of 345 ac-ft to a maximum of 22,000 ac-ft (Figure 4-30). The extended record for the 50 percent evaporation water balance has a mean of 14,000 ac-ft, minimum of 9,000 ac-ft, maximum of 34,000 ac-ft, and average similar to the mean (Figure 4-33). Actual recharge in the Scatter Creek Basin probably ranges somewhere between these water balance values on an annual basis.

The annual recharge in the Scatter Creek Basin mostly occurs during the months of November to May. Annually somewhere between 10,000 and 50,000 ac-ft is added to the water already stored in the aquifer. Some of this groundwater discharges to Scatter Creek from the upper part of the aquifer, some to the Chehalis River and lower Black River, and some to Grays Harbor and the deep groundwater aquifer in the bedrock cracks and older coastal sediment.

The average depth of the valley fill is about 106 ft, and the area of the aquifer is about 12,800 ac. Bedrock beneath Grand Mound Prairie is found between 45 and 140 ft down, with a typical depth of 90 to 120 ft (Hirschey and Sinclair 1992). In Tenino and Bucoda, Washington, the maximum thickness to bedrock is about 100 ft. Static water level is typically 20 to 30 ft deep with a range of 10 ft to about 40 ft. The typical thickness of the saturated aquifer is about 60 to 100 ft. The porosity of mixed-grain loose sand is around 0.4, and for mixed-grain dense sand it is around 0.3 (Peck et al. 1953). The main portion of the Scatter Creek aquifer is in the Vashon advance outwash and Penultimate units, which are generally dense compared to the loose Vashon recessional outwash and recent alluvium. The pore spaces between the sand and gravel particles in the Scatter Creek aquifer occupy between 30 and 35 percent of the saturated volume. A till layer about 25 ft thick is found in most portions of the aquifer (Drost et al. 1999). Till has a porosity of approximately 0.2, but the clay content limits flow and little of this water is actually available.

The saturated volume of the main Scatter Creek valley fill aquifer totals about 700,000 ac-ft, and the void spaces hold about 200,000 to 245,000 ac-ft (Figure 4-34). The estimated average annual recharge is roughly 4 to 10 percent of this volume. It takes about a decade of annual recharge to equal the volume of water that is typically stored in the Scatter Creek aquifer. Not all of this water is available because when a portion of the saturated zone drains, the material remains moist with quite a bit of the water still clinging on the grains and in some of the pore spaces by surface tension. The amount of water that actually would

Scatter Creek Water Balance 1969 to 1989

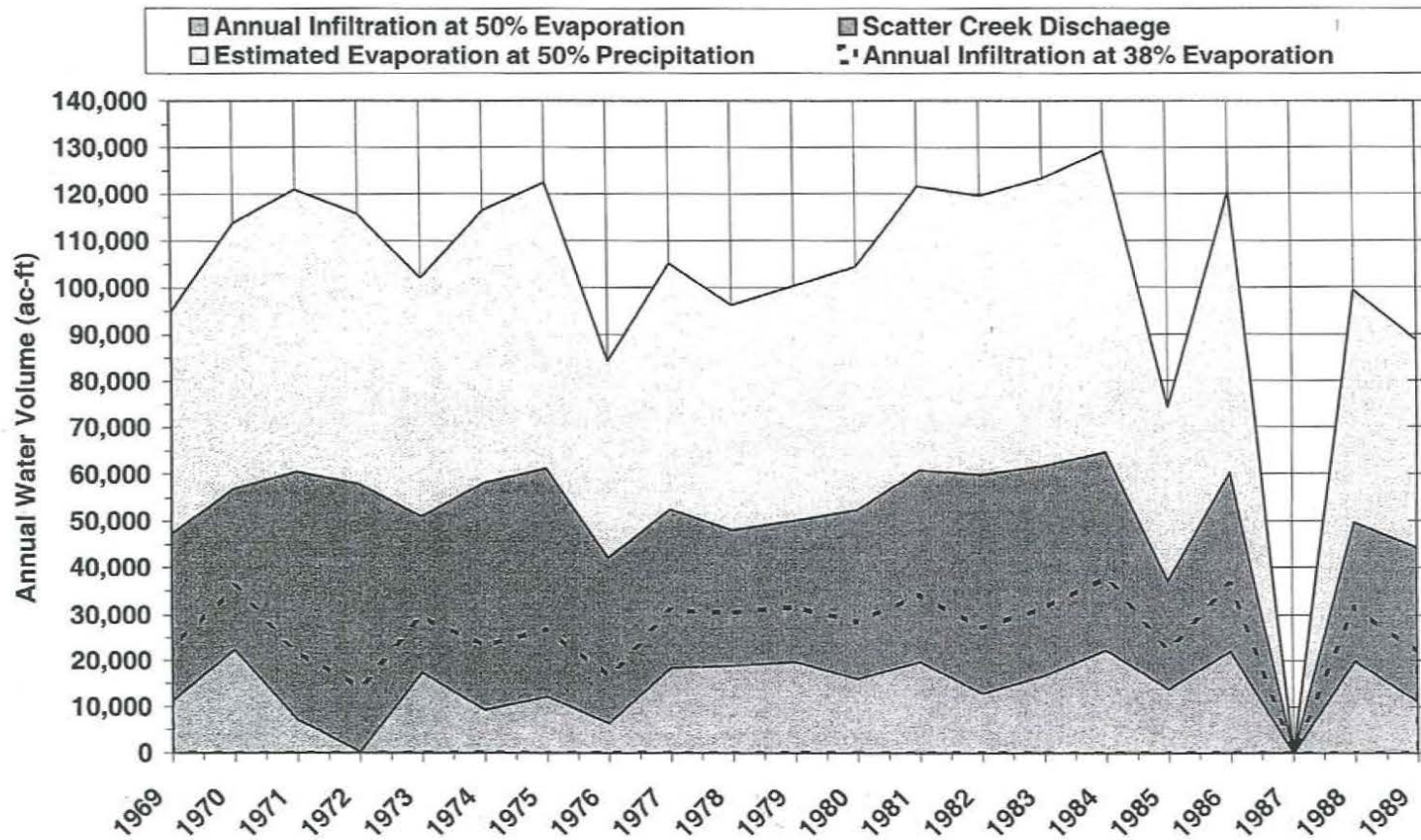


Figure 4-30. Approximate Annual Water Balance for Scatter Creek Basin From 1969 to 1989

Note: Annual recharge, shown in tan, based on Scatter Creek discharge, Tenino, Washington precipitation, and estimated total evaporation losses of 50 percent of annual precipitation. Recharge using evaporation at 38 percent of annual precipitation is shown with the dark dashed line. Data was missing for 1987.

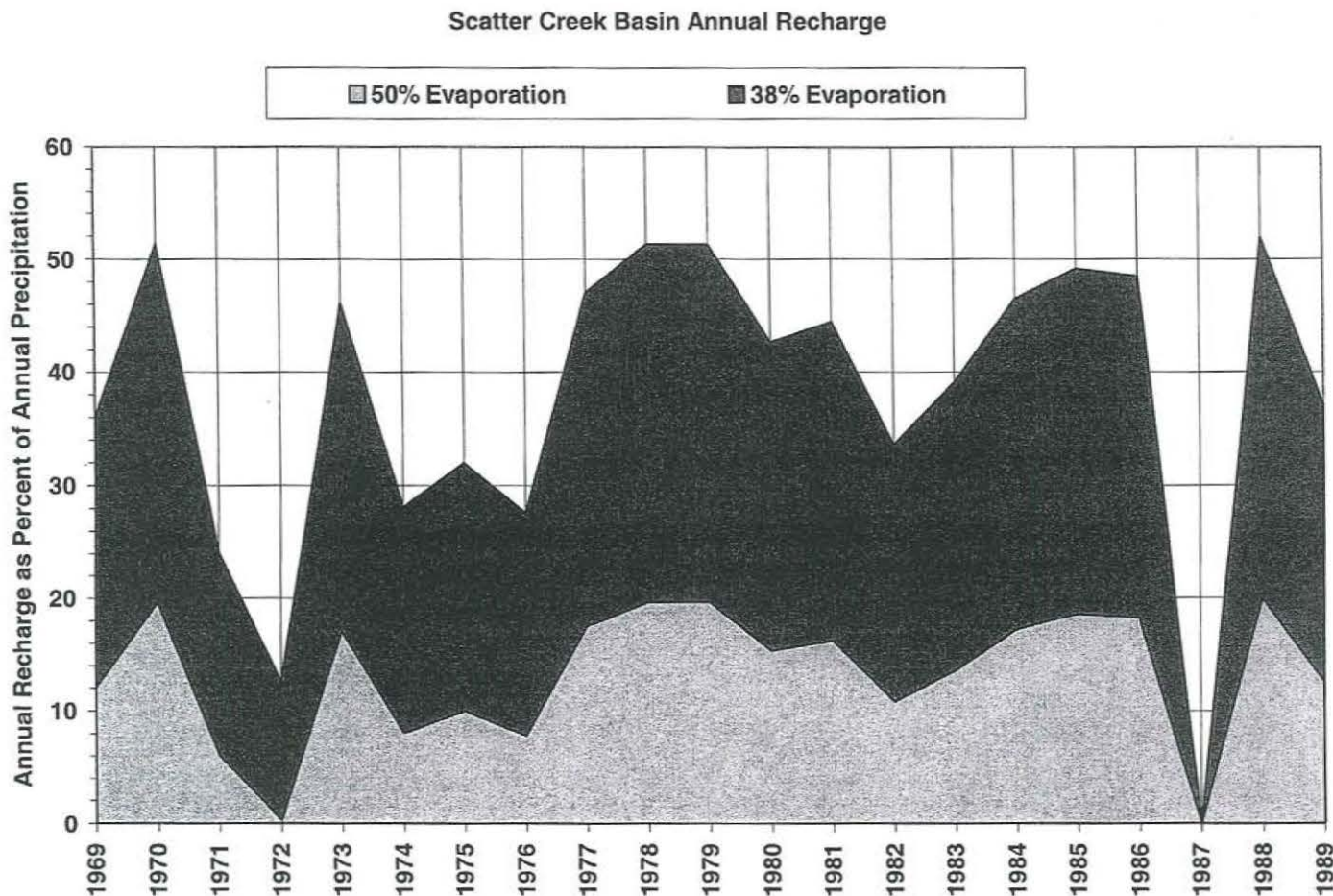


Figure 4-31. Annual Recharge as Percent of Annual Precipitation for Scatter Creek Basin

Note: Annual recharge as a percent of annual precipitation is estimated comparing annual evaporation rates of 50 percent and 38 percent of annual precipitation volume. Water balance is based on Scatter Creek discharge and Tenino, Washington precipitation. Data was missing for 1987.

Scatter Creek Water Balance 1968 to 1989

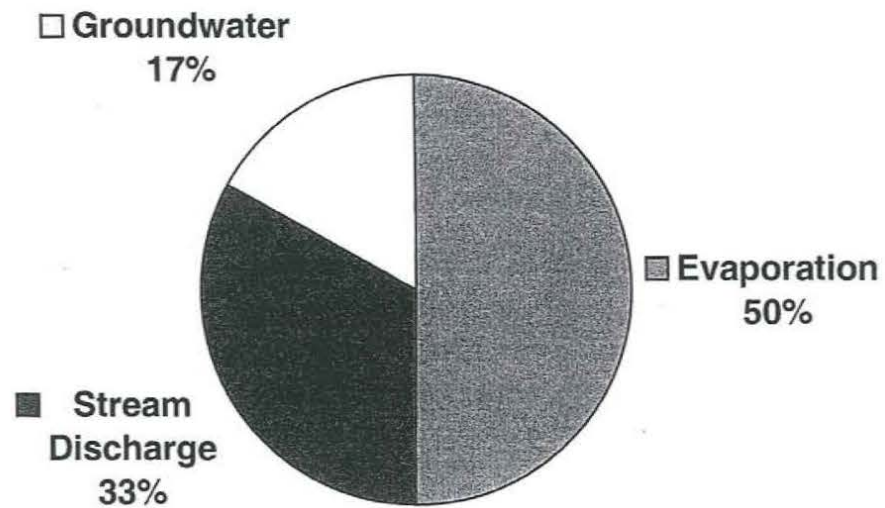


Figure 4-32. Annual Water Balance (in acre-ft) for Scatter Creek Basin

Note: Estimated annual infiltration based on Scatter Creek discharge, Tenino, Washington precipitation, and estimated total evaporation losses of 50 percent of annual precipitation.

Scatter Creek Basin Annual Recharge

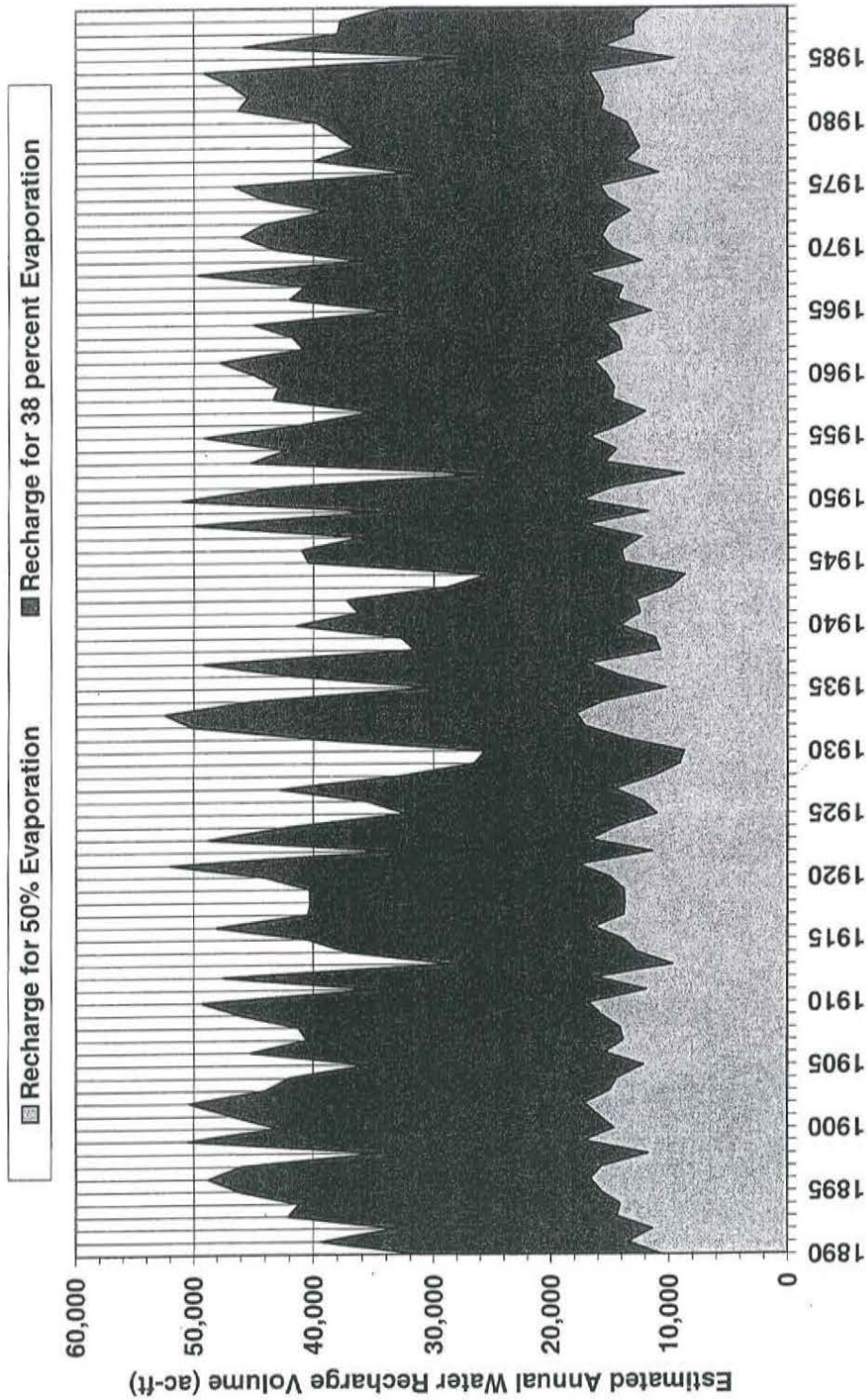


Figure 4-33. Estimated Annual Scatter Creek Aquifer Recharge Based on the Annual Centralia Precipitation

Note: Scatter Creek aquifer recharge is probably within this range of annual variation.

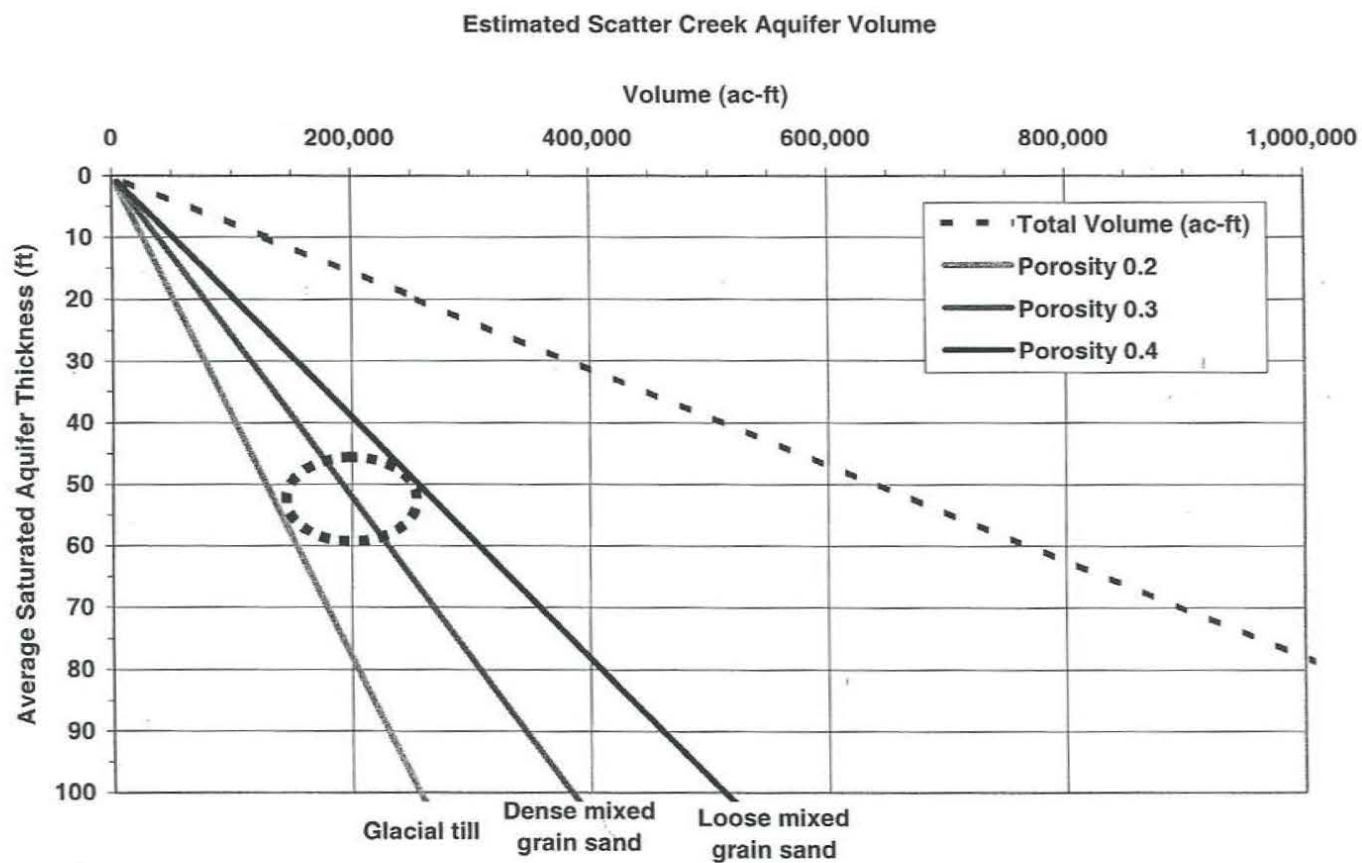


Figure 4-34. Approximate Saturated Aquifer Volume (ac-ft)

Note: The volume of pore space in the Scatter Creek aquifer is within the dashed oval on the graph, around 180,000 ac-ft to about 250,000 ac-ft. The volume of water that would drain from the aquifer is far less, only about 16 to 25 percent, because the grains and pore spaces hold on to some of the water, remaining moist.

drain from the aquifer is called the specific yield, and for sand and gravel it is typically around 16 to 25 percent of the aquifer volume (Linsley et al. 1982). This indicates that about 112,000 to 175,000 ac-ft would drain from the full depth of the aquifer, or roughly about 2,000 to 3,000 ac-ft per foot of saturated thickness that drains.

4.4.9 Scatter Creek Return Flow

Natural groundwater discharge to Scatter Creek is along the narrow incised valley bottom. The Chehalis and Black Rivers receive most of the summer discharge from the aquifer. The aquifer delivers almost all of the flow to Scatter Creek from June through October and much of its flow the rest of the year. Wet season (December through May) precipitation and stormflow runoff from the hills combine with elevated return flow from the aquifer to develop Scatter Creek flows in the range of 40 cfs and above. The upper portion of the saturated aquifer is important to sustaining low flows in Scatter Creek. During the wet season, once the upper aquifer has been recharged, flows in Scatter Creek remain even if there is no rain for several weeks.

The surface of the saturated layer has a gradient of about 0.001 to 0.002 (Hirschey and Sinclair 1992), similar to the gradient of the surface. The saturated aquifer surface elevation varies by season and year. Hirschey and Sinclair (1992) measured fluctuations of 6 to 27 ft in the area from 1975 to 1991. Variation in groundwater level was greatest in the central and eastern part of the Scatter Creek/Black River aquifer. In the western part of the Scatter Creek aquifer, the water table varied by 3 to 8 ft during the same period.

Measured water level changes were both up and down for wells in all of the various Scatter Creek Basin units and showed a median rise of 0.6 to 1.9 ft between 1988 and 1999 (Drost et al. 1999). Water levels from a public water supply in Tenino showed 6 to 8 ft of seasonal variation in the water level from 1941 to 1971.

Increased pumping from the aquifer changes the water balance and must be balanced by an increase in recharge, a decrease in the discharge of streams or springs, a loss of storage volume in the aquifer, or a combination of these factors. Recharge primarily changes with precipitation or by the use of storm and sanitary sewers. A gradual reduction in aquifer storage and a related decline in water levels is the likely result if actual withdrawals exceed recharge in the long term. Drawdown of the aquifer is not easily seen when flow rates through the aquifer are rapid, as in most of the Scatter Creek Basin. Water quickly flows to replace what was pulled out, distributing the drawdown over a large area.

With the USGS model for the full Thurston County area, Drost et al. (1999) assumed an increase in pumping of 35 percent above 1988 levels and found a 1-ft drop in the water level for the Scatter Creek Basin and much of the region. Their analysis indicates that roughly half of the increased withdrawal would come from reduced discharge of springs, seepage faces, and submarine seepage off the coast, and about 46 percent would come from reduced seepage to streams.

The more the channel is dammed or clogged-up, the slower the water drains out of the aquifer along the creek. If the bed were raised an average of 1 to 3 ft by return of wooded channels, large woody debris, beaver dams, and constructed weirs, the water table would tend to be slightly higher and would drain a little slower at the start of the dry season. One reference (WDFW 1931) indicates that the main channel may not have been dry part of the year in the past. The report of continuous habitat to about River Mile 4 is consistent with the lower reaches gaining flow that drains from the incised face of the Scatter Creek valley fill deposits.

4.4.10 Water Rights

Waters of the State of Washington collectively belong to the public and are not owned by any individual, group, or company (Ecology 2002). Water rights to use Washington State waters are granted by the state for individuals or groups to use surface water or groundwater for designated beneficial uses. Beneficial use involves the application of a reasonable quantity of water to a non-wasteful use like irrigation, livestock tanks, domestic water supply, industrial uses, and power generation.

Washington State laws and related administrative procedures require users of public water to receive approval from the state in the form of a water right permit, water right certificate, or water right exemption. Any use of surface water from lakes, ponds, rivers, streams, or springs that began after the state water code was enacted in 1917 requires a water right permit or certificate. Any use of groundwater withdrawals from 1945 onward, when the state groundwater code was enacted, require a water right permit, water right certificate, or an exemption. Priority dates on water right permits, certificates, and exemptions are based on the date when the beneficial use began, and earlier priority dates preempt later ones if available water quantities are less than granted rights, which is sometimes the case.

Groundwater exemptions (domestic exemptions) are granted for withdrawal of up to 5,000 gallons of water per day (5.602 ac-ft per year) from a well when the water is used for livestock watering, single or group domestic water supply, industrial purposes, or irrigation of no more than ½ ac of lawn or noncommercial garden (Ecology 2002).

There are also water right claims that are a statement of beneficial use of water that began prior to 1917 or use of groundwater prior to 1945. In 1967, the Claims Registration Act was passed to record the amount and location of vested water rights established by beneficial use prior to the enactment of the water codes. Water right claims remain valid until adjudication occurs, when the continuous beneficial use of valid claims must be proven before a court of law. Five or more years of non-use may invalidate a claim. Adjudication typically does not occur until there are significant problems with water supply in an area.

Ecology tracks water rights and permits in the Water Right Tracking System (WRATS) that is updated on a quarterly basis. Data for the Scatter Creek region that are summarized for this report were obtained from the WRATS database in October 2002.

There were a total of 988 information listings on water rights in the Ecology database for the Scatter Creek Basin, excluding the rejected and denied listings (Figure 4-35). In the Scatter Creek Basin, there were 257 water right certificates, 527 claims/L, 163 claims/S, 8 Claims/, 13 applications, 11 change applications, and 4 change certificates (Figure 4-35). Of these listings, 339 were for wells (Figure 4-36).

Wells were the main water source, with 585 (or 59 percent) of the total sources listed. Unknown sources accounted for 372 (or 39 percent) of the water right sources (Figure 4-37). The water right database includes information on the maximum flow rate or the total annual volume of pumping authorized by the water right. The authorized amount is listed for 88 percent of the water right certificates and totals 31,790 ac-ft per year. Claims/ account for 1,101 ac-ft per year, and permits add up to 3,242 ac-ft per year. This is a total volume of 36,133 ac-ft per year, or between 1.3 and 2.6 times the estimated Scatter Creek annual recharge.

Scatter Creek Basin Water Right Information in 2002

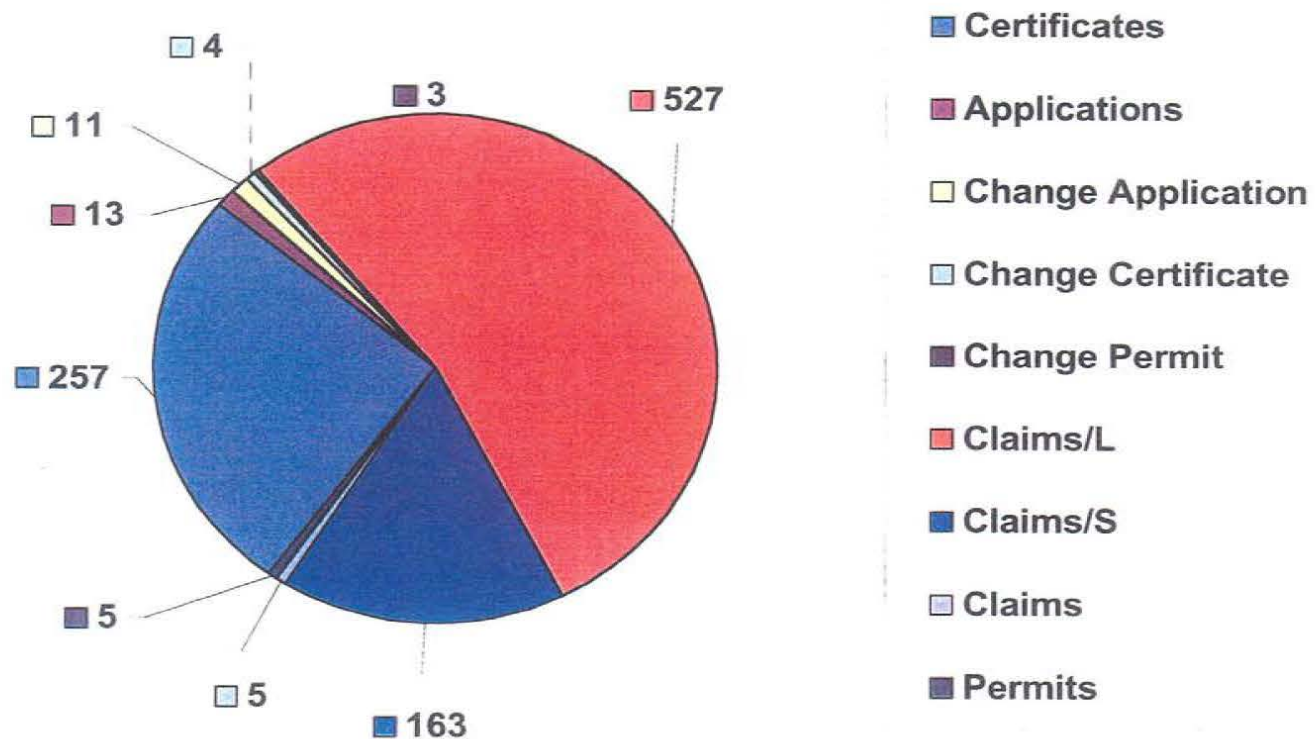


Figure 4-35. Number of Water Right Certificates, Claims, and Permits for Surface Water and Groundwater Sources in the Scatter Creek Basin in October, 2002

Scatter Creek Basin Well Water Rights Information in 2002

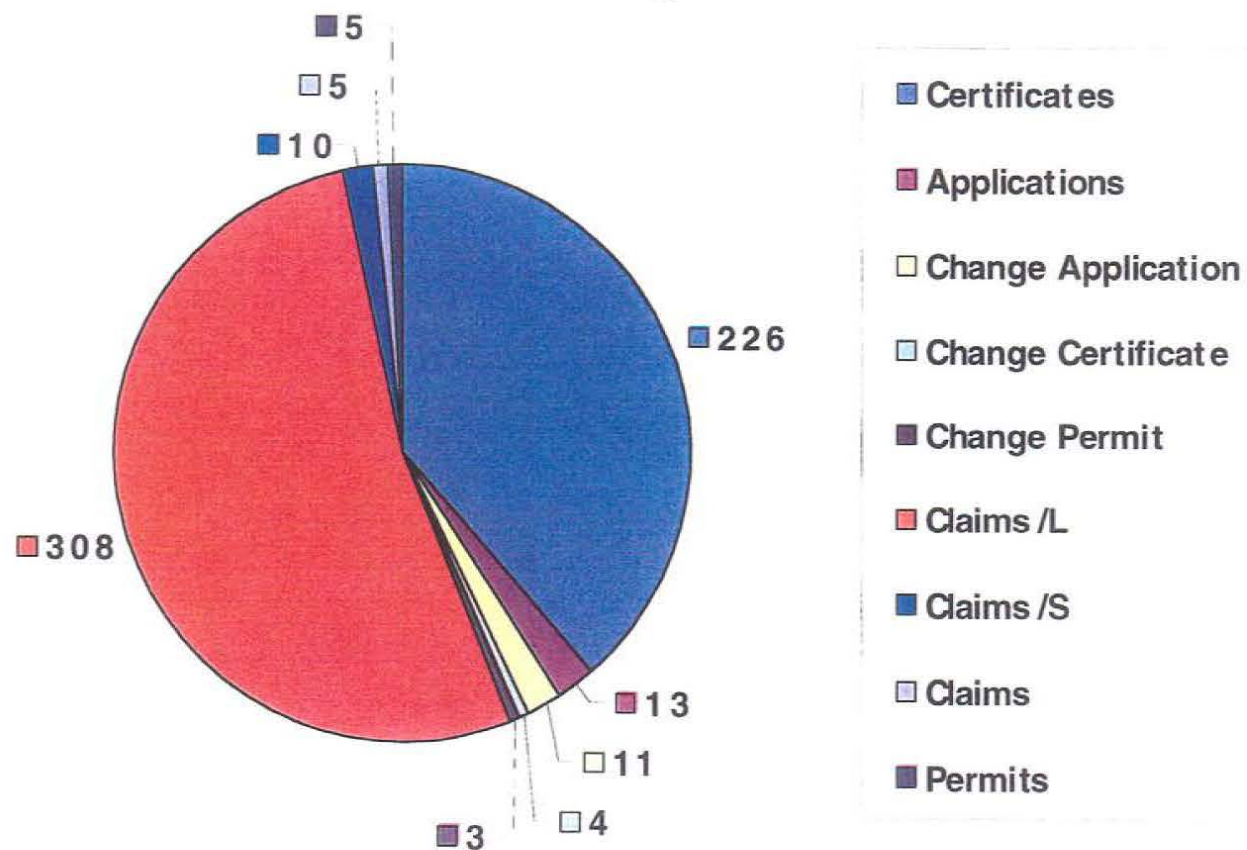


Figure 4-36. Number of Well Water Right Certificates, Claims, and Permits in the Scatter Creek Basin in October, 2002

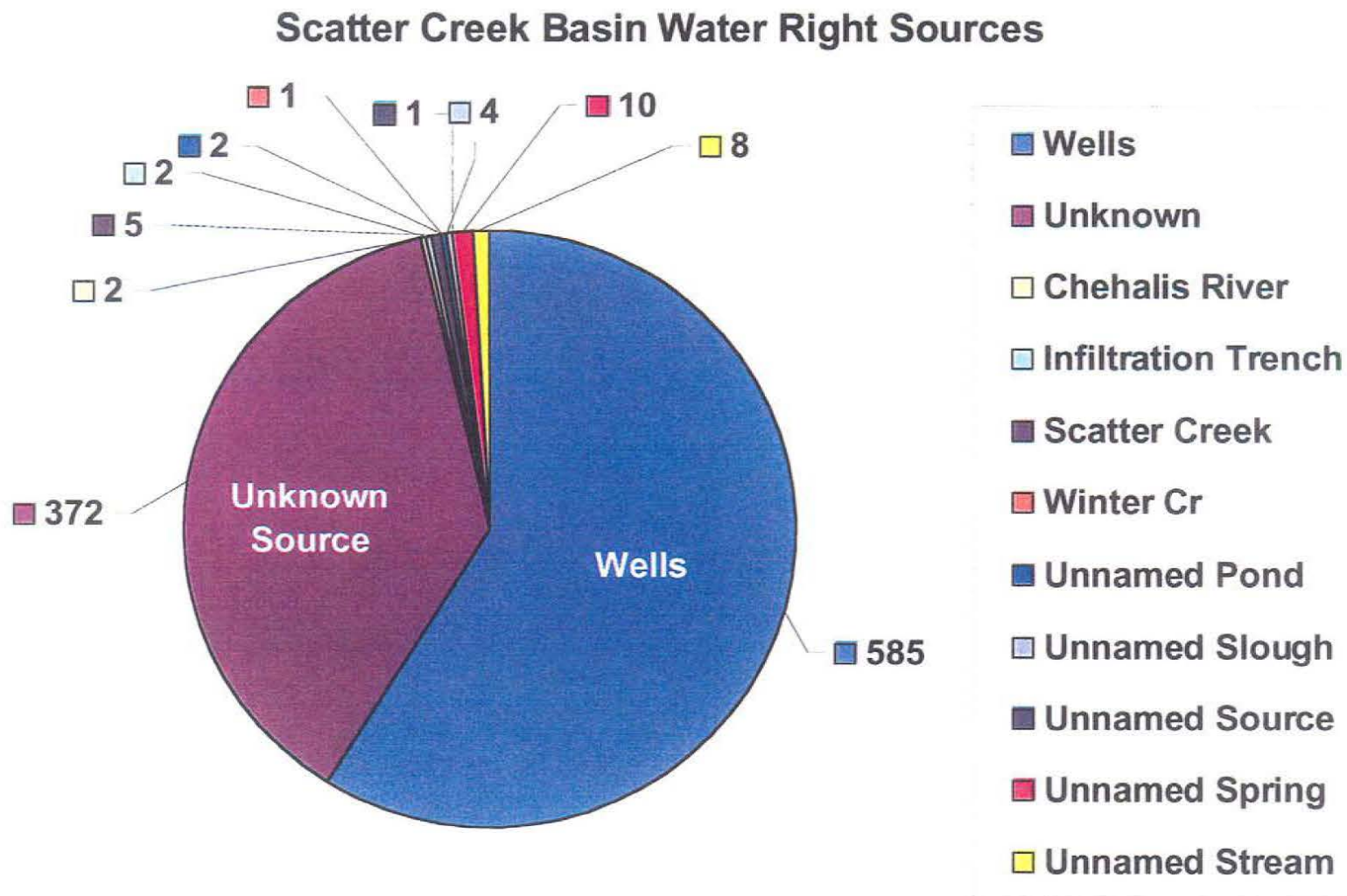


Figure 4-37. Number of Each Type of Water Right Source in the Scatter Creek Basin in October 2002

4.4.11 Water Well Exemptions

Data on groundwater exemptions (domestic exemptions) in the Scatter Creek Basin were collected from the Ecology database in October 2002. There were 1,349 groundwater right exemptions in the Scatter Creek Basin. The majority of the wells are located in the lower half of the basin on Mound and Grand Mound Prairies (Figure 4-38). Ninety-six percent of the exemptions are for 6- and 8-inch-diameter domestic wells, and 45 are for wells 10 inches or greater in diameter (Figure 4-39). Well depths show that most wells are drilled through the Vashon outwash and till into the Vashon advance outwash and Penultimate deposits (Figure 4-40). Forty-two percent of the wells are 60 ft deep. Wells on the prairies are generally 50 to 100 ft deep, and those in the hills are often over 100 ft and into bedrock formations (Figure 4-41). More wells in the eastern portion of the basin are deep due to populated hill watershed area (Figure 4-42).

Completion dates for water well exemptions reflect the trend in population growth in the Scatter Creek area (Figure 4-43). Total groundwater exemptions would add up to a total of 7,843 ac-ft per year if they were all fully utilized. This is about one-third to one-half of the estimated annual recharge for the Scatter Creek Basin.

4.4.12 Water Use

It is difficult to estimate actual water use rates for the Scatter Creek Basin because data are limited. Ecology (2002) estimates typical family water use at 300 gallons per day, and the USGS (Drost et al. 1999) indicate a similar use rate of 100 gallons per day per person. At an estimated 100 gallons per day per person, domestic water use, based on population (Figure 4-44), would total about 800 ac-ft per year in 2000 and 2001 and would increase to about 1,300 ac-ft per year by 2025 (Figure 4-45).

About 10 years ago, Hirschey and Sinclair (1992) found the total permitted groundwater volume for the Scatter Creek and Black River areas was around 35,278 ac-ft. They estimated that actual use was somewhere around 30 to 50 percent of permitted use. They also assessed the Washington State Department of Health records for public water supplies in the area and used a value of 450 gallons per day per connection for a total (for the public connections) of about half of the actual public permitted volume.

Hirschey and Sinclair (1992) estimate that domestic wells return as much as 70 to 90 percent of the water pumped through septic drain fields and ponds. This is perhaps a little high because some percent of the wells would also be used for dry season lawn and garden watering that can have a loss rate similar to evaporation. Aquaculture (growing fish for food) accounts for about 16,935 ac-ft out of 36,133 ac-ft of permitted water rights, or about 47 percent. This water is discharged to a series of ponds that flow to Scatter Creek and maintain year-round flow downstream of the discharge. Some of the water returns to the groundwater by recharge from the ponds, much of it flows downstream, and in the dry season, much of it soaks in along the river. Measured discharges at four locations on Scatter Creek downriver of the fish farm show loss of surface water flow of 6 cfs in July 1989, a gain of 6 cfs in August 1989, water loss of 3.3 cfs in October 1989, a balance of loss and gain in November 1989, and a gain of 16.4 cfs in March 1990. This indicates that in the wet season, the fish farm discharge adds to the gaining river flow, and in the dry season, it maintains surface flow and also recharges the groundwater. Overall, Hirschey and Sinclair (1992) conclude that consumptive use in the Scatter Creek Basin was less than about 34 percent of the total pumped volume.



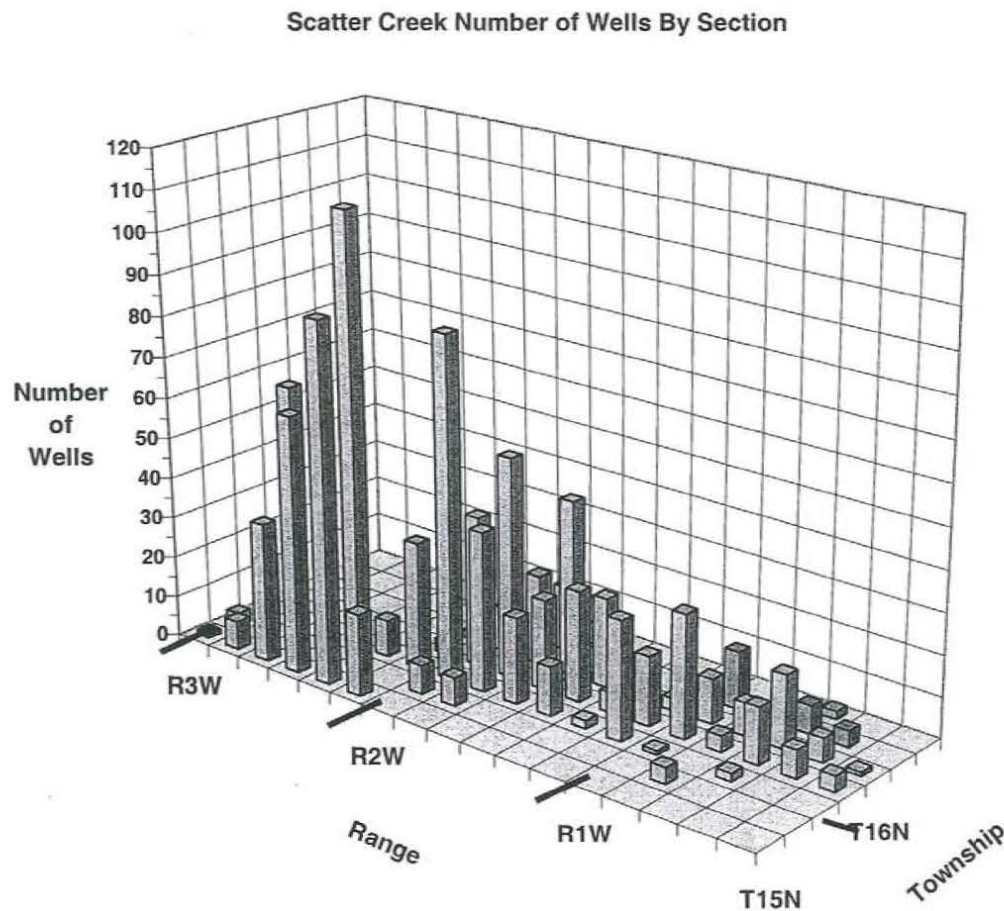


Figure 4-38. Number of Exempt Wells in the Scatter Creek Basin in October 2002

Note: Each column represents the number of wells in each section. Tenino, Washington and the east side of the basin is on the right and the Chehalis and lower Scatter Creek are on the left.

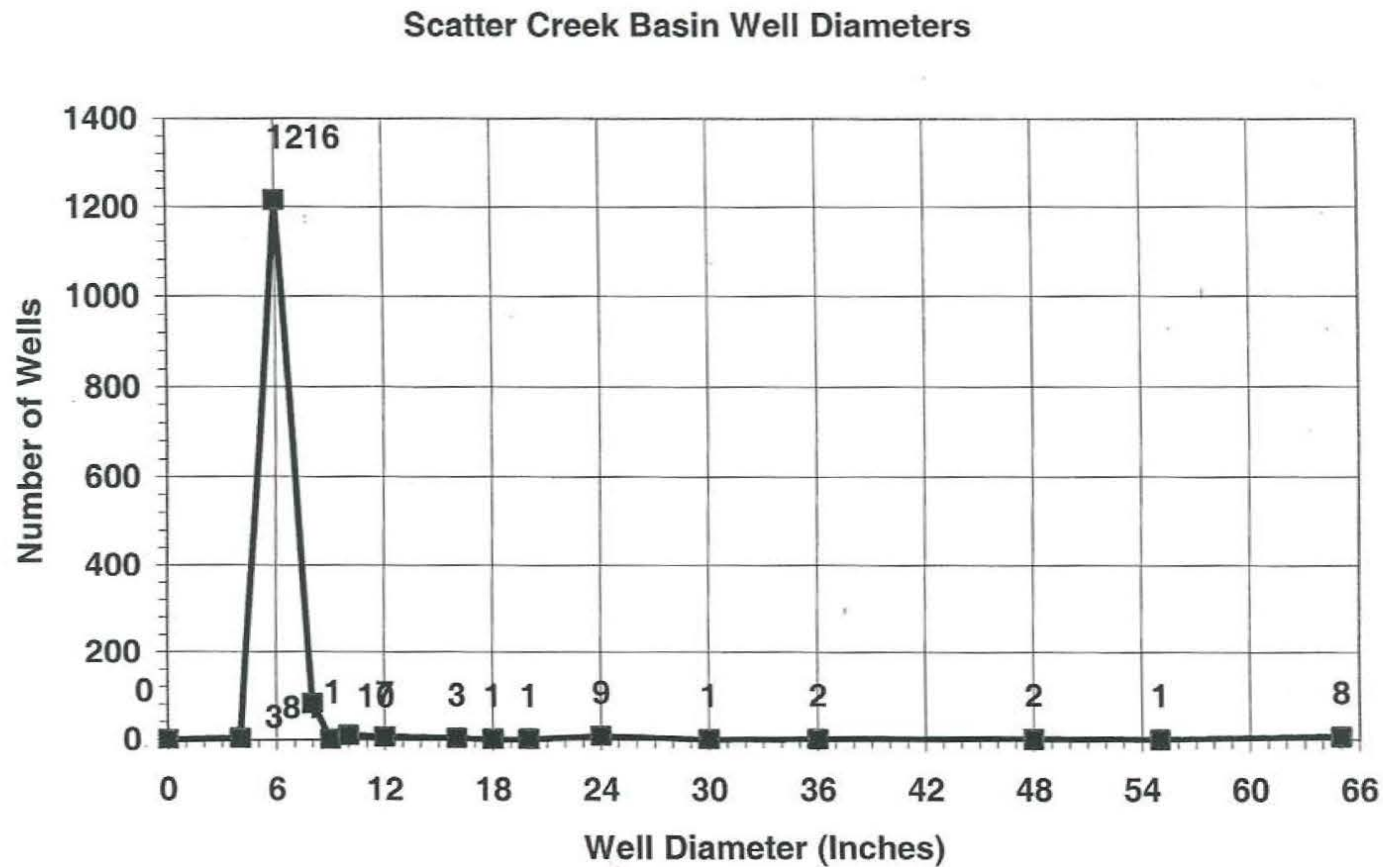


Figure 4-39. Well Diameters of Water Right Exemptions in the Scatter Creek Basin, October 2002

Note: Ninety-six percent of the wells are 6- and 8-inch diameter domestic wells.

Scatter Creek Watershed Well Depths

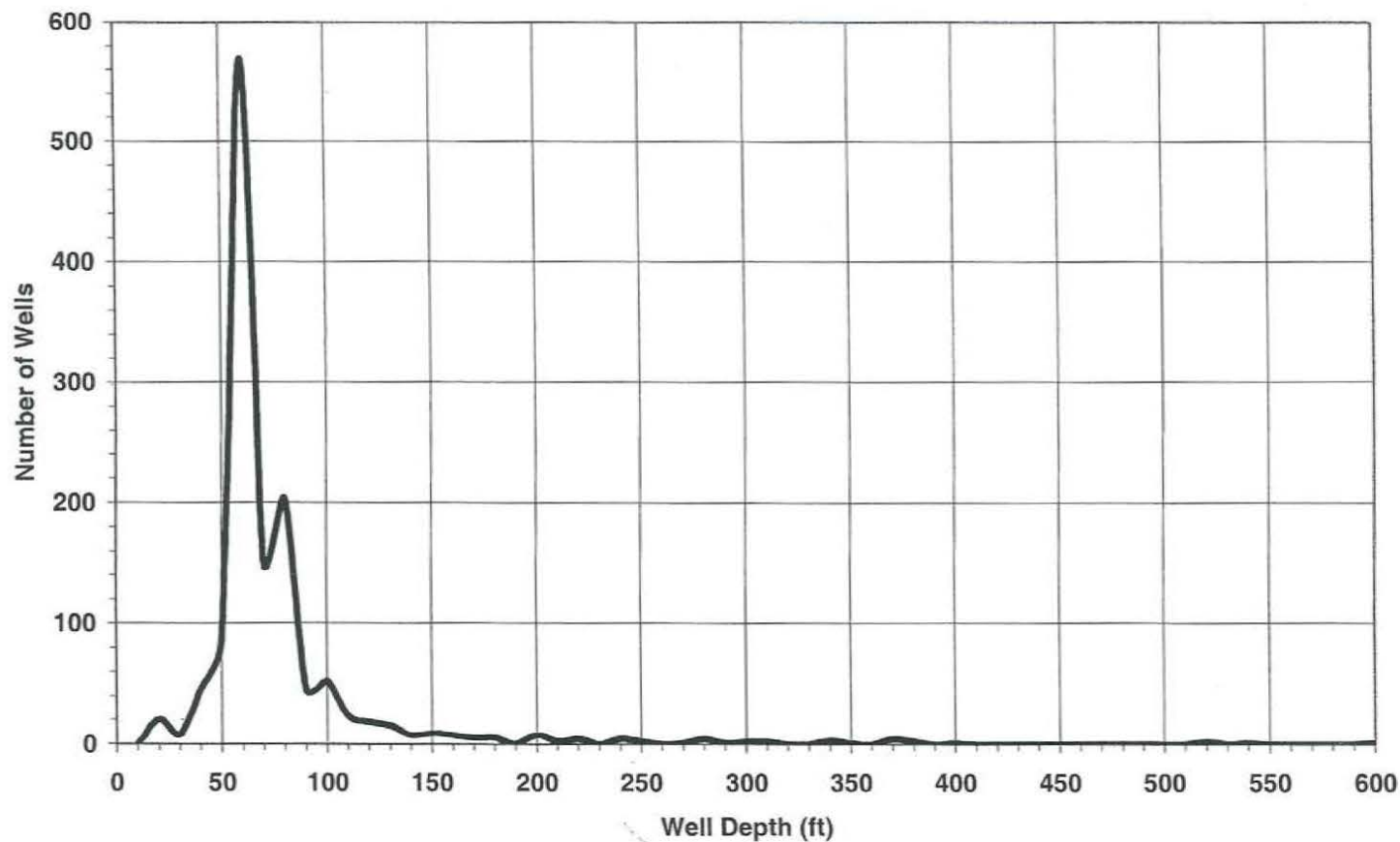


Figure 4-40. Depths of Exempt Wells in the Scatter Creek Basin, October 2002

Note: Most of the wells on the prairies are drilled between 50 and 100 ft into the Vashon advance outwash and Penultimate deposits.

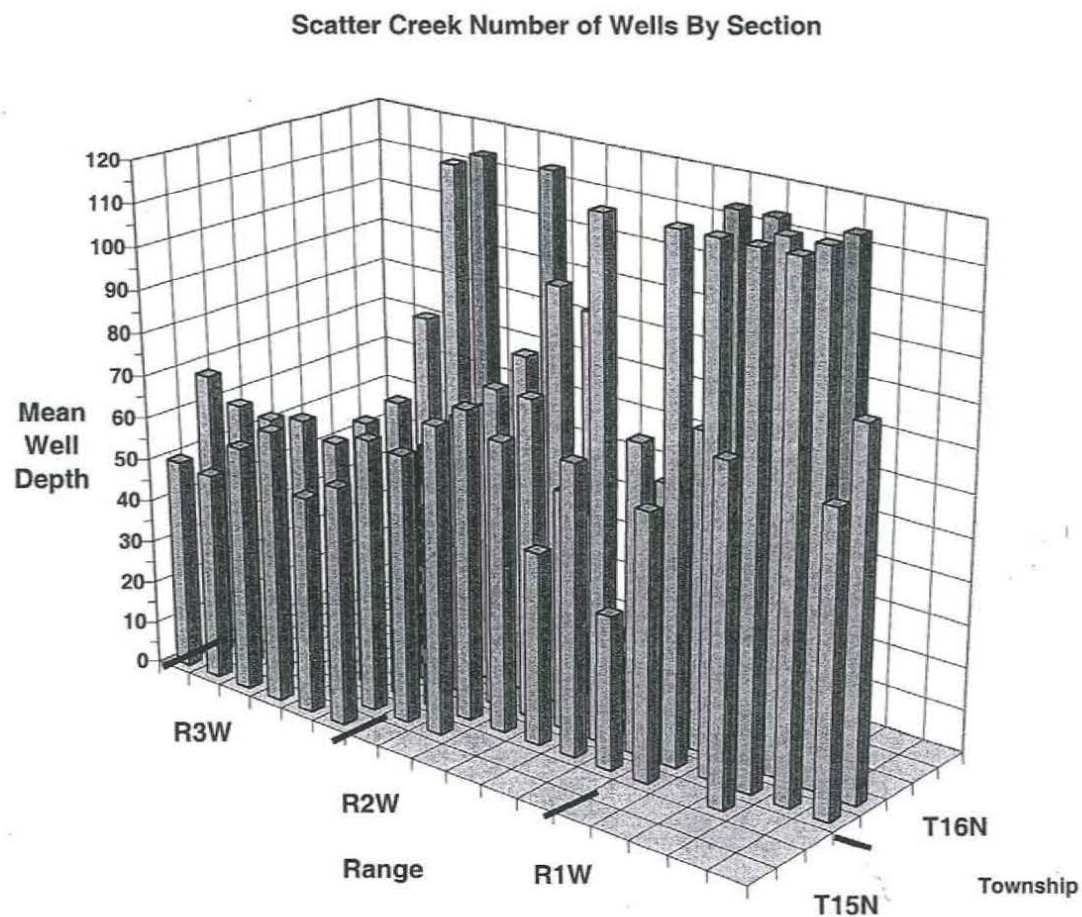


Figure 4-41. Mean Depth of Exempt Wells for Each Section in the Scatter Creek Basin, October 2002

Note: Each column represents the mean well depth (ft.) in each Section. Tenino, Washington and the east side of the basin are on the right, and the Chehalis and lower Scatter Creek are on the left.

Scatter Creek Maximum Well Depth By Section

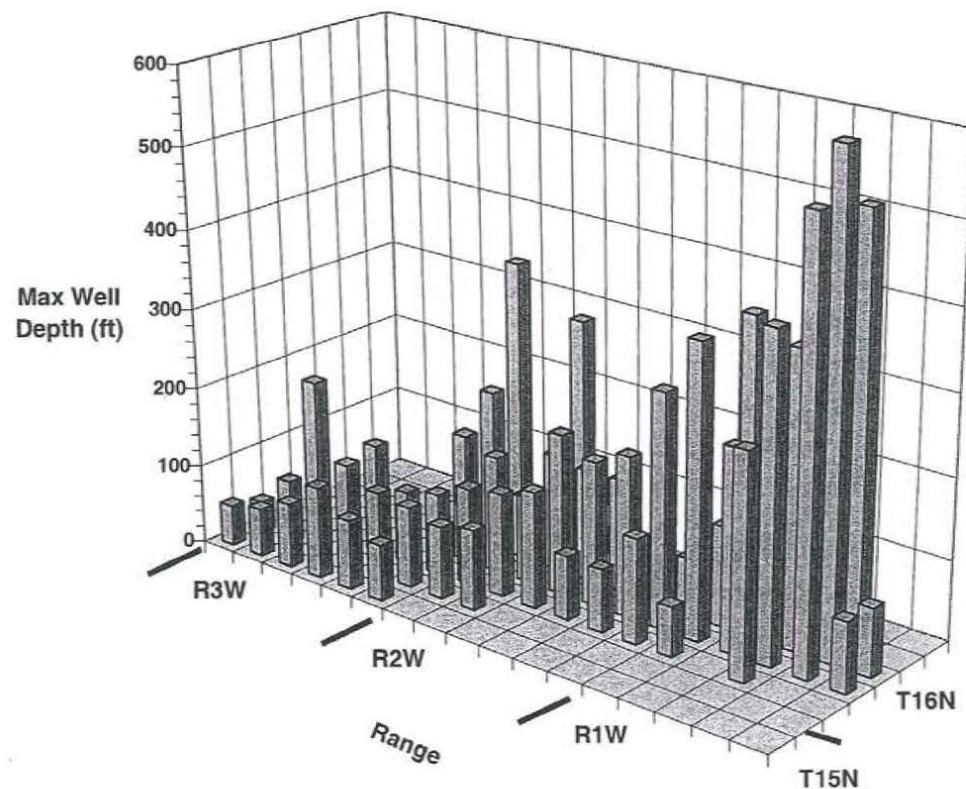


Figure 4-42. Maximum Depth of Exempt Wells for Each Section in the Scatter Creek Basin, October 2002

Note: Each column represents the maximum well depth in each Section. Tenino and the east side of the basin are on the right and the Chehalis and lower Scatter Creek on the left.

Scatter Creek Basin
Number of New Wells per Decade

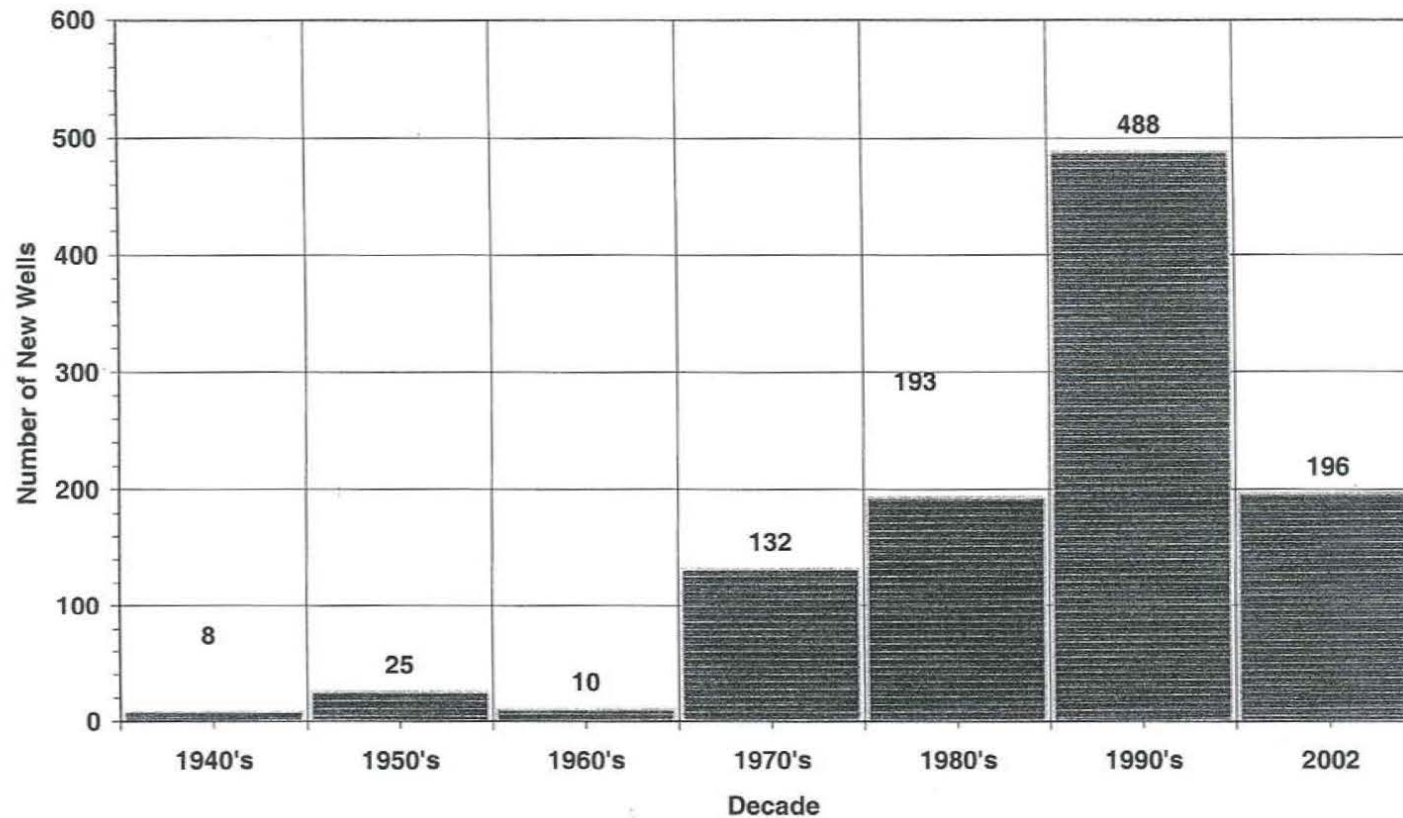


Figure 4-43. Exempt Well Completion Dates Show the Increase in Population in the Scatter Creek Basin

Note: There were 1,052 wells out of the total of 1,349 in the basin with completion dates listed in the database.

Estimated Population Scatter Creek Basin

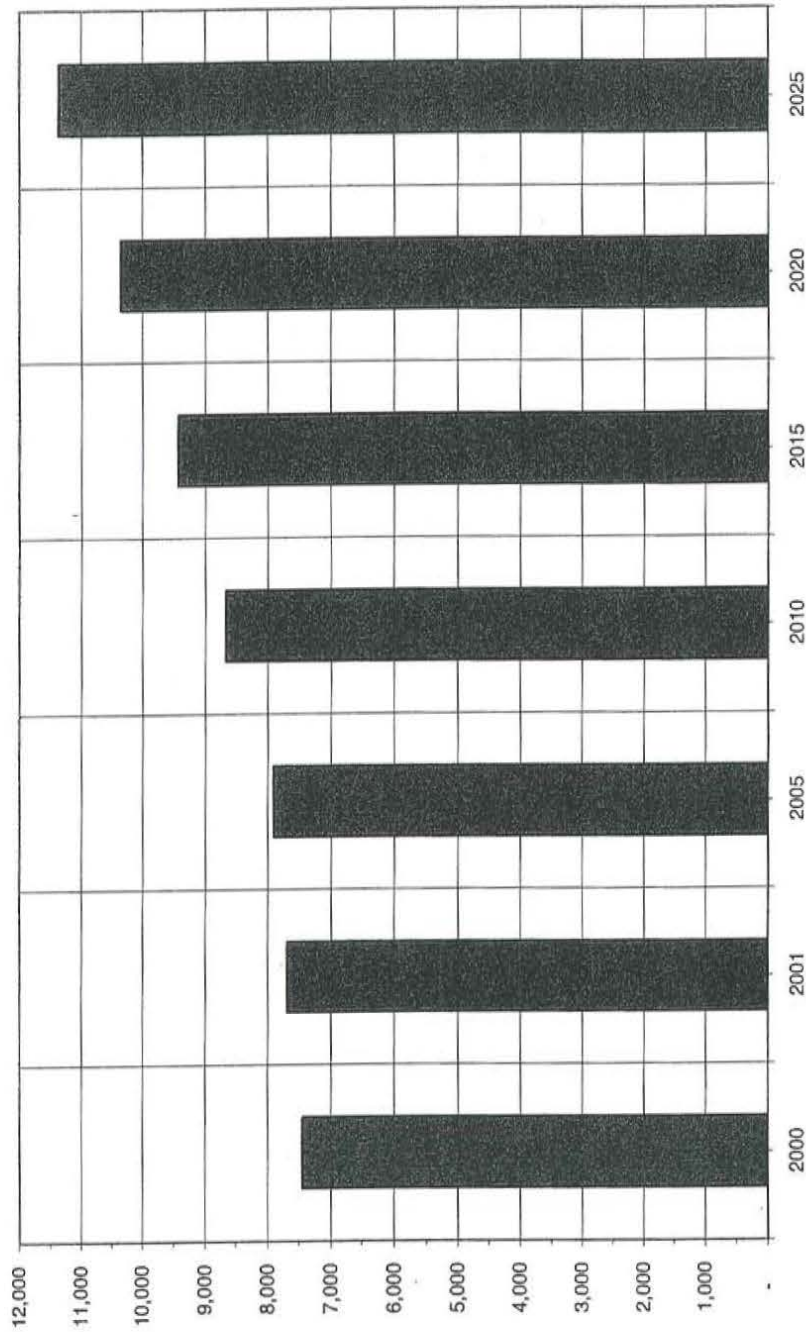


Figure 4-44. Scatter Creek Basin Population Estimate

Source: Thurston County Regional Planning Council (2002).

Scatter Creek Basin

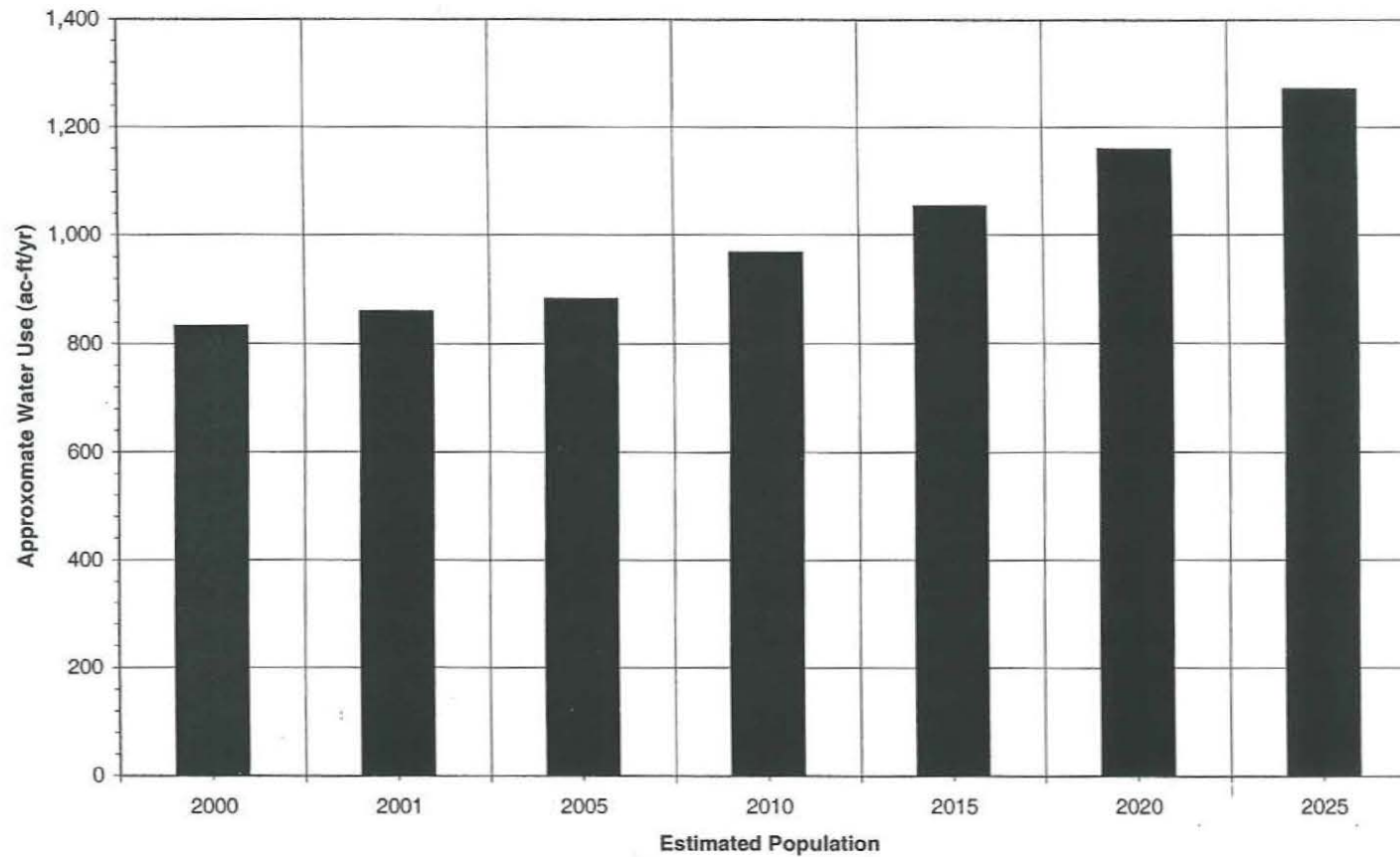


Figure 4-45. Domestic Water Use in the Scatter Creek Basin Based on 100 Gallons Per Day Use Per Person and Scatter Creek Basin Population Estimates

Source: Thurston County Regional Planning Council (2002).

The total annual volume of permitted water rights and water well exemptions in the Scatter Creek basin in 2002 was more than 43,976 ac-ft. The total permitted volume is somewhat more than this because 12 percent of the water rights did not list an amount in the database. The permitted water is on the higher end of the estimated range of annual aquifer recharge (see Figure 33). Actual use in 2002 is estimated at about 30,000 ac-ft, and up to 70 to 90 percent of this soaks back into the ground. This means that on average roughly 30,000 ac-ft of water is pumped from the aquifer each year, and about 24,000 ac-ft of this water soaks back in. Average annual recharge from precipitation of 10,000 to 50,000 ac-ft combines with the recharge of about 24,000 ac-ft per year from the main water uses. The recharge from the water uses is about the same magnitude as the annual recharge.

The relatively rapid flow of water in much of the Scatter Creek valley aquifer (median hydraulic conductivity of 864 ft/day) (Hirschey and Sinclair 1992) yields 2,500 gallons per minute (gpm) or more with about 20 ft of drawdown, and indicates that well interference would not typically be a problem because the aquifer transmits water quickly. However, wells pulling water from above the Vashon till at relatively shallow depth and also near Scatter Creek could locally drawdown a section of the creek during the dry season when the water table is already low.

Based on the studies of Drost et al. (1999), Hirschey and Sinclair (1992), Noble and Wallace (1966), and the tally of present-day wells and water rights, it appears that wet season recharge to the aquifer, surface runoff from the tributaries, and groundwater return flow to the Scatter Creek channel is capable of maintaining steady flows along the full channel. In the dry season, the fish farm surface discharge is large enough to maintain flow to the mouth. Upstream of this input (River Mile 7), Scatter Creek goes dry part of the summer until the rains recharge it again in November or December.

There clearly is not enough groundwater recharge to maintain perennial flow in portions of Scatter Creek from River Mile 7 to about River Mile 12 and again from about River Mile 15.5 upstream. Between these two areas, inflow from the northwest part of the aquifer under Frost Prairie may in part be why that portion of the channel is perennial. From about River Mile 7 to River Mile 12 the channel flows on top of the glacial-age outwash surface rather than incised 30 ft to 50 ft into it, as occurs from River Mile 12 to River Mile 15.5. The thicker outwash layer over the Vashon till or Penultimate beds may help explain the dry periods. The creek tends to go dry upstream of River Mile 16 during the dry season where the creek is again higher on the outwash surface. Downstream of about River Mile 3 to River Mile 4, the groundwater is approaching the face cut in the valley fill by the Chehalis River. Flows would likely be perennial in this reach even without the fish farm flow.

Clearing the channel of dense trees has occurred along many portions of the channel. This reduces hydraulic roughness and allows more water to flow out faster, and is similar to digging a ditch. A cleaned out ditch drains surface water and nearby shallow groundwater; an overgrown ditch drains the field poorly because the grade level is higher and the overall roughness greater. Clearing of many sections of the channel in past decades, 1,349 wells pumping on the order of the annual recharge, and river reaches with thick outwash and limited confining layers near the channel would tend to leave dry reaches in the low-precipitation months. It is not clear how much of the dry channel condition is related to each of these three main factors.

4.5 GROUNDWATER QUALITY

Water quickly soaks into the Vashon outwash to the till, advance outwash, or Penultimate deposits of the Scatter Creek aquifer. Flow through the aquifer is relatively rapid for groundwater flow because of the sand and gravel texture of the Vashon and Penultimate deposits. Water moves through the aquifer at

different rates depending on location and season, but averages between 10 and 20 ft per day. Rapid water infiltration and migration in the aquifer make it vulnerable to contamination from septic systems and land applications of manure or chemical fertilizers.

In their study of the Scatter Creek/Black River area, Hirschey and Sinclair (1992) tested well samples for alkalinity, orthophosphate, sulfate, nitrate, chloride, sodium, potassium, calcium, magnesium, iron, and silica. Specific conductance ranged from 120 to 203 microhms/cm, which is well below the state secondary maximum contaminant level standard of 700 microhms/cm. Water hardness ranged between 15 to 58.9 mg/l CaCO_3 . Calculated values for total dissolved solids were between 51.5 and 131 mg/l and are typical of groundwater with the specific conductance and hardness measured in the area. The Hirschey and Sinclair (1992) study concludes that all of the sampled constituents were found to be below state drinking water standards, except nitrate. With only elevated nitrate levels in the area, they concluded that the groundwater quality of the Scatter Creek Basin was good.

Water temperature in wells ranged between 8.8° and 11.6°C and typically is between 9° and 10°C (Mead et al. 1996). Groundwater return flow to the creek is similar to this temperature range and warms or cools depending on the air temperature, wind, vegetation cover, and sun exposure. Groundwater return flow is greatest during the wet season, but is also diluted by runoff and rainfall of varied temperatures. Scatter Creek surface water and groundwater pH is typical of areas around the region and ranges between 6.1 and 6.6.

Iron and Manganese

Distribution of iron and manganese in groundwater is controlled by the amount in the aquifer materials and the oxygen level. Water with low oxygen levels dissolves iron as the reduced ferrous form (Fe^{2+}). The iron remains dissolved until it moves to an area with oxygen, where the iron reverts back and typically precipitates. This often occurs at springs or seeps, forming a rust-brown color around the site. Iron and manganese are considered secondary contaminants under state and federal law because they are considered a taste and esthetics issue with drinking water. Iron concentrations vary between less than 0.01 and 0.042 parts per million (ppm) in the Scatter Creek area (Mead et al. 1996).

Chloride

Groundwater in the Scatter Creek area is low in chloride because almost all elevated levels are associated with the coast and seepage of seawater into aquifers or in bedrock formed by marine environments. Concentrations were from 0.7 to 15 ppm and are typically around 3 to 7 ppm (Mead et al. 1996).

Nitrates and Nitrites

Nitrate is easily transported by water and is a good indicator of the potential for introduction of contaminants to the Scatter Creek aquifer. Nitrate is present in soil naturally and is concentrated by Scot's broom, alders, and other plants. Nitrate is also introduced by drainage from septic systems and land application of manure or chemical fertilizers. At elevated concentrations, nitrate is also a potential health risk, thus a drinking water standard of approximately 10 ppm has often been used. Infants, individuals with reduced gastric acidity or a lack of methemoglobin reductase, and pregnant women may be at risk at nitrate levels over 10 ppm (Mead et al. 1996). Nitrate levels in the Scatter Creek Basin wells typically varied from 0.1 to 3 ppm, with maximum values from 3 to 10.8 ppm (Mead et al. 1996).

Variation in the nitrate in groundwater samples shows about how fast water moves through the aquifer. Wells in Violet Prairie had higher nitrate levels in early spring than in the early fall (Mead et al. 1996).

Mead et al. (1996) concluded that these results reflect the lag time between the build-up of residual nitrogen in the area soils, its conversion to nitrate, and the groundwater travel time to reach area wells.

Most of the water discharged from septic systems infiltrates to the groundwater above the till that usually is around 10 to 25 ft down. Rapid infiltration can reduce the effectiveness of the soil biological activity that works on the drain field discharge. Properly designed, constructed, and regularly maintained septic systems can minimize introduction of nitrates and other dissolved and small solids into the aquifer. However, there is a limit, and as drain field numbers and use rates increase, more substances are introduced to the main drinking water supply in the area. Use of livestock manure and chemical fertilizers on agriculture, yards, and gardens has many benefits but can also introduce significant amounts of nitrates to the groundwater if not limited based on soil testing, seasonal constraints, and climate conditions.

Both the Hirschey and Sinclair (1992) study and the Mead et al. (1996) assessment indicate that nitrate is elevated in the Scatter Creek aquifer. Interpretation of the groundwater data in the Mead et al. assessment indicates that land application of livestock waste appeared to be the source of some elevated nitrate sites and that septic systems contribute to the widespread slightly elevated nitrate levels in the Scatter Creek Basin.

5. PRAIRIE AND OAK WOODLAND HABITAT

5.1 METHODS

This report is based on a literature review of existing information on historic and current conditions of prairie and oak woodland habitat, an assessment of current vegetation in the watershed developed through a field reconnaissance and photo interpretation, and a comparison of current vegetation cover to historic vegetation conditions.

5.1.1 Review of Existing Materials

A variety of materials were reviewed to obtain existing vegetation data and information on prairie and oak woodland habitat types. The review ranged from general information on south Puget Sound prairies and oak woodlands to information specific to the Scatter Creek watershed vicinity. Materials and data sources were obtained from TCD GIS maps; WDFW priority habitats and species (PHS) information; communications with the HCP Steering Committee, agency representatives, and landowners on the watershed; and watershed-specific reports from various sources. The literature review consisted of library searches of various library databases for applicable prairie and oak woodland publications and reports specific to the south Puget Sound and the Scatter Creek watershed.

5.1.2 Field Reconnaissance

A 2-day field visit was conducted on November 4 and 5, 2002 to observe existing habitat types within the Scatter Creek watershed and to verify existing habitat information. The field visit included a drive-by overview of the Scatter Creek watershed as well as stops at specific points of interest. The drive-by overview consisted of driving the roads within the watershed and ground truthing (confirming from the ground) previously mapped habitat types. Sites surveyed included representative prairie, oak woodland, and other habitat areas and major landholdings in the watershed, such as the Scatter Creek Wildlife Area on Grand Mound Prairie; the Colvin property on Rock Prairie; Morgan's property on Rock Prairie and the hills to the south; and the Heernett Foundation property in Cozy Valley.

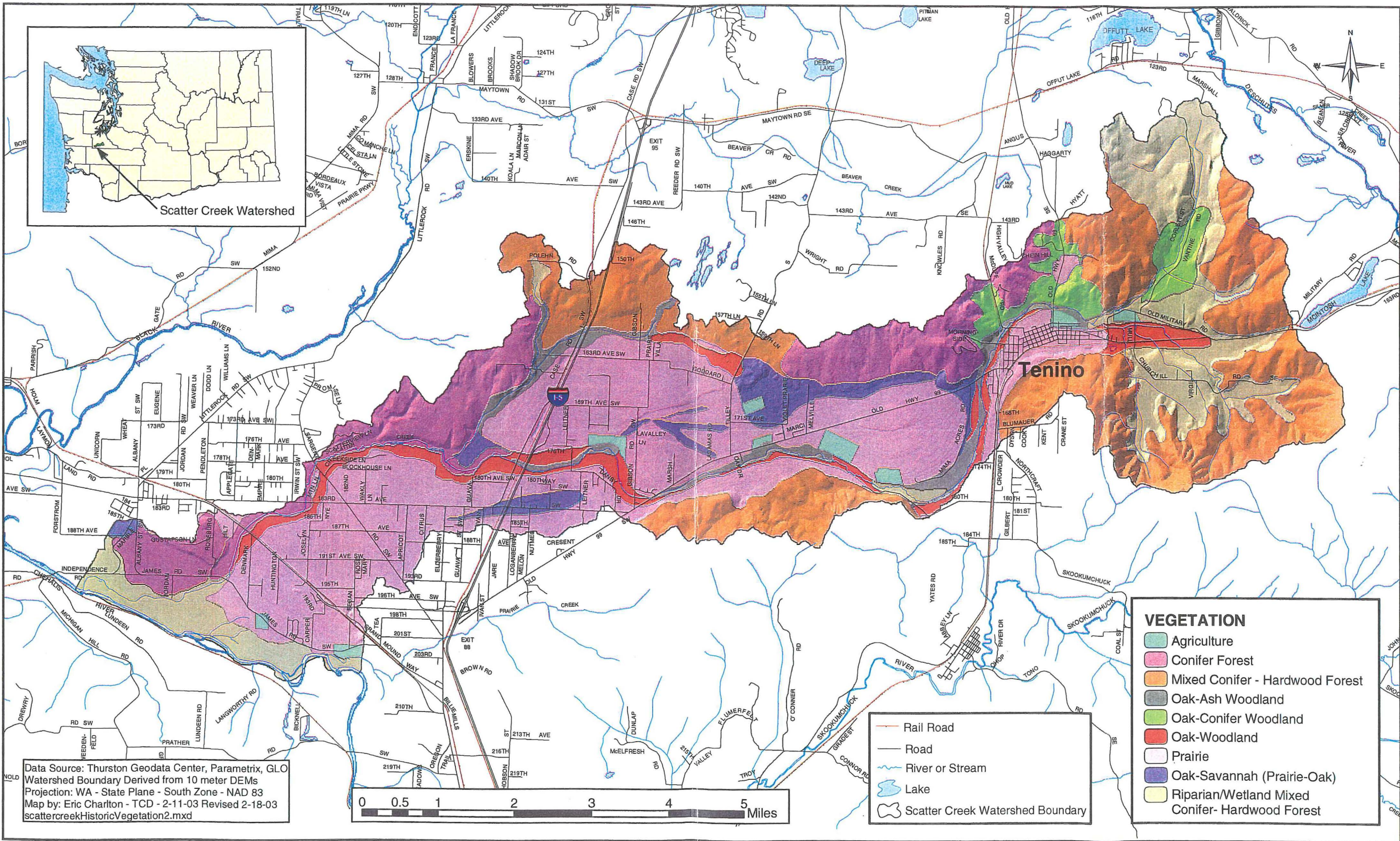
5.1.3 Review of Soils

The *Soil Survey of Thurston County, Washington* (Pringle 1990) was used to identify soils mapped in the Scatter Creek watershed vicinity and locate soils that have a soil-vegetation association.

5.1.4 Historic Habitat Types and Vegetation Map

Historic habitat types and a map of historic vegetation (Figure 5-1) were created to illustrate the extent and type of native vegetation present and the likely vegetative distribution in the area during the 1850s. The mapping effort focused on existing oak woodlands and prairies and those areas that potentially support these habitats, such as the locations of soils that are associated with prairies and oak woodlands. A review of General Land Office (GLO) notes and maps (Department of the Interior, GLO 1856) provided the principal source for developing the historic map. The GLO notes and maps are records of surveys that were performed in the mid 1850s. These surveys were conducted to provide for the orderly settlement of public land. Although surveyors usually were not botanists, general descriptions of the vegetation were prepared as the surveyors ran transects through pre-settlement areas. The transects primarily consisted of walking section boundary and property lines for new land claims. At section and quarter section corners, the surveyors recorded witness trees, which were the trees nearest to the boundary corner in each cardinal direction. Distance and bearing to each tree, diameter at breast height (dbh), and species were recorded. Claim surveys provided more detailed information on vegetation because corner posts and vegetation observations were at smaller property delineations.

Figure 5-1. Scatter Creek Watershed - Estimated Historic Vegetation Circa 1850



Interpretation of the GLO notes included evaluating species presence relative to abundance of witness tree locations for all habitats containing forested vegetation. For example, areas near witness tree locations containing one or two oak witness trees mapped on Spanaway/Nisqually soils or Spana soils in the flat valley bottom are classified as oak savanna; areas near witness tree locations with the same soil and geologic land formation containing more than two oak witness trees were classified as oak woodland. Areas identified and recorded in the GLO notes as 'prairie' were classified as prairies, but species were not recorded by the GLO surveyors. Nine habitat types were identified, with eight of these being major (Table 5-1). Boundaries surrounding these habitat types were drawn on watershed base maps.

Historic habitat types were primarily determined by interpreting the vegetation data of the GLO notes and maps; however, geologic landforms and soils mapped in the *Soil Survey of Thurston County, Washington* (Pringle 1990) were also reviewed for verification.

Table 5-1. Major Historic Habitat Types Identified

Habitat Type	Identification
Prairie	These areas were labeled 'prairie' in the GLO notes. However, it is likely that some areas labeled as 'prairie' in the GLO notes were actually oak savannas (see Oak Savanna). Prairies occur on Spanaway or Spanaway-Nisqually soils on flat valley bottoms or low terraces.
Oak Woodland	Areas were defined as oak woodland if more than two Oregon white oak (<i>Quercus garryana</i>) witness trees occurred near section or claims corners. Oak woodlands are associated with Everett and Nisqually soils and tend to occur in the riparian zone.
Oak-Ash Woodland	The GLO notes usually refer to this vegetation as 'timber' and there are typically more than two (e.g., three or four) witness trees near each section or quarter-section corner. Oak-ash vegetation as described in the GLO notes is typically associated with McKenna gravelly silt loam soils and occurs in the riparian zone.
Oak-Conifer Woodland	This habitat type is an oak-conifer mix typically found in the transition zone between prairie and uplands and occurs on Everett and/or Nisqually or Spanaway soils.
Oak Savanna (Prairie-Oak)	GLO notes usually referred to one or two oaks at a section, quarter section, or claims corner. The extent of this vegetation is difficult to estimate from the GLO surveys because the surveyors were not consistent in noting oaks that were scattered within prairie areas. ¹ However, scattered oaks are mentioned most frequently in areas that contain a mix of Spanaway/Nisqually or Spana soils. Only those areas where GLO notes specifically call out oaks within a prairie matrix (at corner sections or claims boundaries) are mapped as oak savanna – the actual extent of this habitat type may have been greater (based on the occurrence of Spana and Nisqually soils). Areas were mapped as oak savanna if oaks were recorded in the vicinity of section corners but only if one or two oaks were noted (more than two oaks near section corners were mapped as oak woodland).
Conifer Forest	Conifer forests primarily occur in the uplands and are dominated by Douglas-fir (<i>Pseudotsuga menziesii</i>) with abundant western hemlock (<i>Tsuga heterophylla</i>) and western red cedar (<i>Thuja plicata</i>).
Mixed Conifer-Hardwood Forest	Vegetation is mixed with Douglas-fir, western red cedar, western hemlock, and bigleaf maple (<i>Acer macrophyllum</i>). This habitat type is typically associated with Everett and Alderwood soils in the upland areas.
Riparian/Wetland Mixed Conifer-Hardwood Forest	These forests are located along the rivers and in wetlands and generally occur on poorly drained or somewhat poorly drained silt loam or clay loam soils that are frequently hydric. Most common species described in the GLO notes include red alder (<i>Alnus rubra</i>), willows (<i>Salix</i> spp.), Oregon ash (<i>Fraxinus latifolia</i>), Douglas-fir, western red cedar, black cottonwood (<i>Populus balsamifera</i>), and bigleaf maple.

¹ For example, the section surveys typically only noted when a surveyor entered or left prairie areas. Section posts or quarter-section posts in 'prairies' frequently did not mention any oak trees nearby. However, claims surveys in the same area frequently mentioned scattered oaks near claim corners or at section corners where the section surveyors did not record oaks.

5.1.5 Existing Vegetation Types and Vegetation Map

The existing vegetation map (Figure 5-2) comprises previously mapped vegetation types and other cover types from the *Land Cover Mapping of Thurston County* (Thurston Regional Planning Council 2001) and *Oak and Grassland Data* (WDNR, WNHP 1999). Vegetation types are areas that contain a plant species or group of plant species that differ from other vegetation types and are determined by the dominant vegetation in the upper canopy. Vegetation and other cover types on the *Land Cover Mapping of Thurston County* and the *Oak and Grassland Data* were derived and mapped using remote sensing data and photo interpretation. The development of a vegetation classification scheme was based on photo interpretation with field verification of some vegetation types. Descriptions of the vegetation types are provided in Section 5.2.3.

5.1.6 Comparison of Historic With Existing Vegetation

A comparison of the historic vegetation with the existing vegetation was conducted by calculating acreages of each vegetation type on the historic vegetation map (Figure 5-1) and on the existing vegetation map (Figure 5-2). Acreage of each vegetation type from the 1850s and the present were compared to evaluate the change in each vegetation type. Aerial photographs from the 1930s, 1940s, and the present also helped to review changes in habitat condition, disturbance regimes, distribution, and abundance.

5.2 STUDY RESULTS

5.2.1 Geologic Landforms

Geologic landforms are the topographic features that compose the land surface. Landforms are the result of natural geologic processes and manmade modifications. The primary landforms in the Scatter Creek watershed include outwash plains built by large river flows from the Vashon Ice Sheet, the hill areas modified by the ice sheet, alluvial fans that form at the tributary mouths along the base of the hills, and present-day river channels and floodplains that have only moderately modified the glacial-age landforms.

In the Scatter Creek Basin, the dominant landform consists of relatively level glacial outwash plains locally named the Grand Mound, Violet, Rock, and Frost Prairies. The prairie surface was formed about 14,000 years ago by great rivers flowing from the southern end of the great Vashon Ice Sheet. The outwash prairie landform is about 12,500 ac or about 45 percent of the Scatter Creek Basin. Lack of surface drainage and abandoned terraces across much of the outwash prairies indicate that the Scatter Creek channel has been in the same area with minimal erosion and incision across the width of the valley bottom.

5.2.2 Soils

Soils are formed from climate conditions, landscape type, parent materials, and age of the landscape surface. The outwash plains and hills in the Scatter Creek basin began to form about 12,000 to 13,000 years ago. The historic and present vegetation conditions follow closely to the soil types because both are partly controlled by the landforms, surface geologic units, and related moisture conditions. The main soil units on the prairies are the Spanaway soils (Soil Units 110, 111, and 114) with 10,553 ac (Table 5-2). Two important soil-vegetation associations occur in the watershed: (1) the Spanaway-Nisqually association (Soil Units 73, 74, 109, 110, 111, 112, 113, and 114), which is associated with prairies and oak savannas, and (2) the McKenna association (Soil Unit 65), which is associated with riparian vegetation.

Figure 5-2. Scatter Creek Watershed - Existing Vegetation (2000) and WDFW Identified Oak & Grassland (1999)

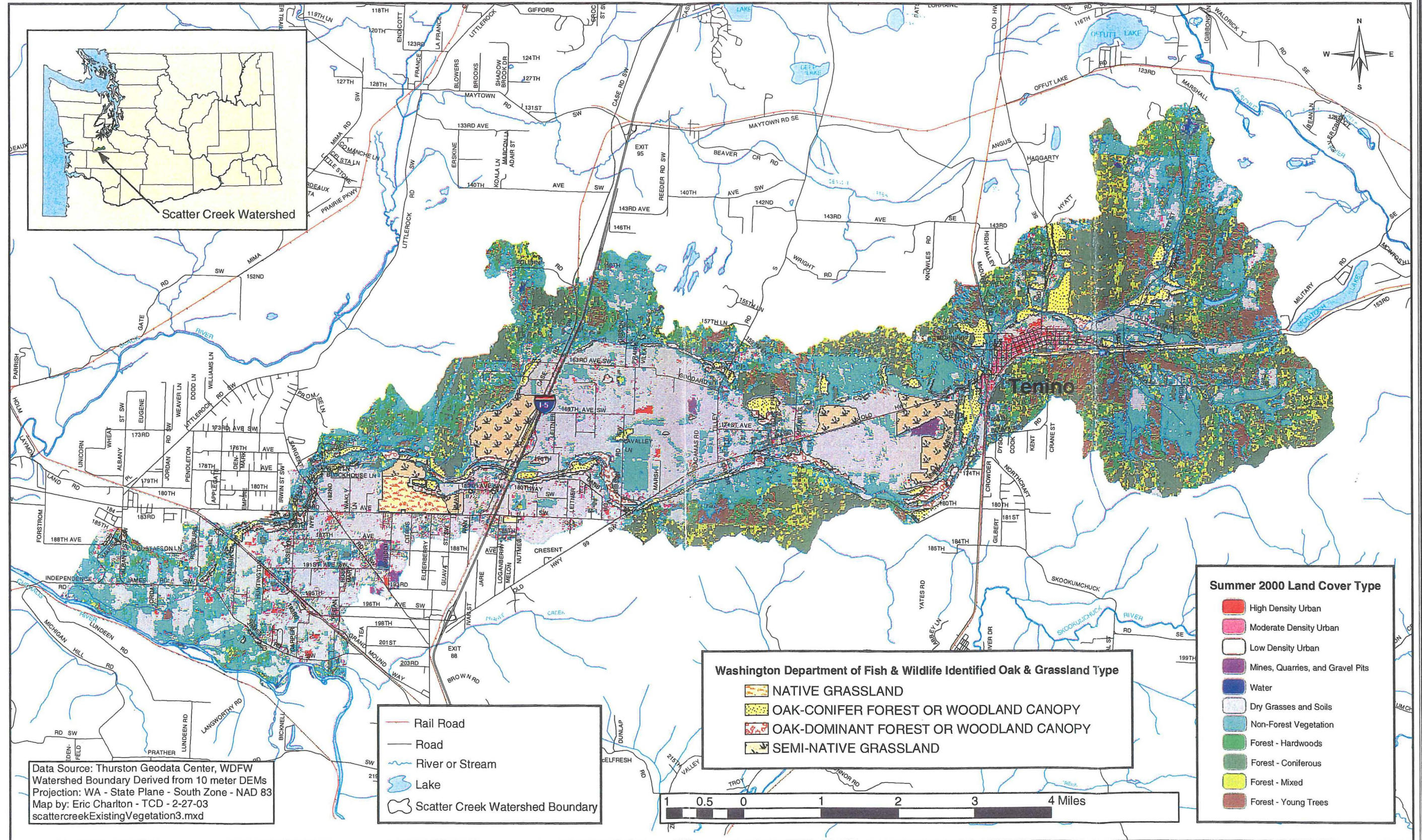


Table 5-2. Soil Units Listed by Area in the Scatter Creek Basin

Soil Unit	Soil Unit Name	Scatter Creek Soil Unit Area (Acres)	Percent of Total Basin
110	Spanaway Gravelly Sandy Loam, 0 to 3 Percent Slopes	6,472	23.2
114	Spanaway-Nisqually Complex, 2 to 10 Percent Slopes	3,144	11.3
21	Cathcart Gravelly Loam, 3 to 15 Percent Slopes	2,274	8.1
22	Cathcart Gravelly Loam, 15 to 35 Percent Slopes	1,607	5.8
118	Tenino Gravelly Loam, 15 to 30 Percent Slopes	1,475	5.3
67	Melbourne Silty Clay Loam, 20 to 40 Percent Slopes	1,383	5.0
68	Melbourne Silty Clay Loam, 40 to 65 Percent Slopes	1,140	4.1
111	Spanaway Gravelly Sandy Loam, 3 to 15 Percent Slopes	937	3.4
65	McKenna Gravelly Silt Loam, 0 to 5 Percent Slopes	859	3.1
76	Norma Silt Loam	690	2.5
117	Tenino Gravelly Loam, 3 to 15 Percent Slopes	658	2.4
32	Everett Very Gravelly Sandy Loam, 0 to 3 Percent Slopes	648	2.3
74	Nisqually Loamy Fine Sand, 3 to 15 Percent Slopes	624	2.2
26	Chehalis Silt Loam	516	1.8
66	Melbourne Silty Clay Loam, 5 to 20 Percent Slopes	406	1.5
2	Alderwood Gravelly Sandy Loam, 3 to 15 Percent Slopes	384	1.4
126	Yelm Fine Sandy Loam, 0 to 3 Percent Slopes	317	1.1
71	Newberg Fine Sandy Loam	280	1.00
75	Norma Fine Sandy Loam	260	0.93
33	Everett Very Gravelly Sandy Loam, 3 to 15 Percent Slopes	255	0.91
10	Baumgard Loam, 40 to 65 Percent Slopes	234	0.84
99	Salkum Silty Clay Loam, 15 to 30 Percent Slopes	221	0.79
119	Tenino Gravelly Loam, 30 to 60 Percent Slopes	218	0.78
98	Salkum Silty Clay Loam, 8 to 15 Percent Slopes	217	0.78
37	Galvin Silt Loam, 0 to 5 Percent Slopes	211	0.75
3	Alderwood Gravelly Sandy Loam, 15 to 30 Percent Slopes	203	0.73
97	Salkum Silty Clay Loam, 3 to 8 Percent Slopes	175	0.62
41	Godfrey Silty Clay Loam	160	0.57
31	Eld Loam	157	0.56
50	Kapowsin Silt Loam, 0 to 3 Percent Slopes	154	0.55
36	Everson Clay Loam	140	0.50
34	Everett Very Gravelly Sandy Loam, 15 to 30 Percent Slopes	136	0.49
72	Newberg Loam	132	0.47
9	Baumgard Loam, 10 to 40 Percent Slopes	120	0.43
W	Water	111	0.40
20	Cagey Loamy Sand	104	0.37
87	Prather Silty Clay Loam, 8 to 20 Percent Slopes	95	0.34
70	Mukilteo Muck, Drained	94	0.34
105	Shalcar Muck	87	0.31

Table 5-2. Soil Units Listed by Area in the Scatter Creek Basin (continued)

Soil Unit	Soil Unit Name	Scatter Creek Soil Unit Area (Acres)	Percent of Total Basin
69	Mukilteo Muck	75	0.27
4	Alderwood Gravelly Sandy Loam, 30 to 50 Percent Slopes	74	0.26
85	Pits, Gravel	68	0.24
124	Wilkeson Silt Loam, 20 to 40 Percent Slopes	65	0.23
104	Semiahmoo Muck	60	0.22
35	Everett Very Gravelly Sandy Loam, 30 to 50 Percent Slopes	50	0.18
86	Prather Silty Clay Loam, 3 to 8 Percent Slopes	48	0.17
14	Bellingham Silty Clay Loam	40	0.14
5	Baldhill Very Stony Sandy Loam, 0 to 3 Percent Slopes	33	0.12
64	Maytown Silt Loam	28	0.10
1	Alderwood Gravelly Sandy Loam, 0 to 3 Percent Slopes	21	0.07
6	Baldhill Very Stony Sandy Loam, 3 to 15 Percent Slopes	17	0.06
101	Scamman Silty Clay Loam, 5 to 20 Percent Slopes	16	0.06
123	Wilkeson Silt Loam, 5 to 20 Percent Slopes	14	0.05
127	Yelm Fine Sandy Loam, 3 to 15 Percent Slopes	7	0.02
125	Xerorthents, 0 to 5 Percent Slopes	7	0.02
80	Pheeneey Gravelly Loam, 30 to 65 Percent Slopes	4	0.01
84	Pilchuck Loamy Sand	1	0.005
120	Tisch Silt Loam	1	0.004

5.2.2.1 Spanaway-Nisqually Association

The Spanaway-Nisqually Association, which constitutes 40 percent of the soils in the Scatter Creek watershed, consists of the following soils and associated vegetation types:

Nisqually soils:

- Nisqually loamy fine sand, somewhat excessively drained, 0 to 3 percent slopes (Soil Unit 73) – support prairie vegetation.
- Nisqually loamy fine sand, 3 to 15 percent slopes, somewhat excessively drained (Soil Unit 74) – support prairie vegetation.

Spana soils:

- Spana gravelly loam, 0 to 3 percent slopes, somewhat poorly drained soil, elongated drainageways on glacial outwash plains (Soil Unit 109) – support oak woodland, oak-conifer woodland, and hardwood vegetation.
- Spanaway gravelly sandy loam, 0 to 3 percent slopes, somewhat excessively drained soils in glacial outwash terraces (Soil Unit 110) – support prairie and oak savanna vegetation.

- Spanaway gravelly sandy loam, 3 to 15 percent slopes, somewhat excessively drained soils in glacial outwash terraces (Soil Unit 111) – support prairie and oak savanna vegetation.
- Spanaway stony sandy loam, 0 to 3 percent slopes, somewhat excessively drained soils in glacial outwash terraces (Soil Unit 112) – support prairie and oak savanna vegetation.
- Spanaway stony sandy loam, 3 to 15 percent slopes, somewhat excessively drained soils in glacial outwash terraces (Soil Unit 113) – support prairie and oak savanna vegetation.
- Spanaway-Nisqually complex:
- Spanaway-Nisqually complex, 2 to 10 percent slopes, 60 percent Spanaway gravelly sandy loam and 30 percent Nisqually loamy fine sand, somewhat excessively drained (Soil Unit 114) – support prairie (Mima mounds) vegetation.

Spanaway-Nisqually Association soils formed on glacial outwash terraces and occur on nearly level or gently rolling topography. These soils are very deep, somewhat excessively drained soils. Spanaway-Nisqually soils are associated with prairie and oak savanna vegetation, and to a lesser extent with oak woodlands (Thyssel and Carey 2001; Chappell and Crawford 1997).

Spanaway soils formed in glacial outwash and are coarser textured than Nisqually soils. Spanaway soils typically have surface layers of gravelly sandy loam, and the subsoil is very gravelly sandy loam with a deep substratum of extremely gravelly sand. Nisqually soils formed in sandy glacial outwash and are somewhat finer textured than Spanaway soils. Nisqually soils typically have surface and subsoil layers of loamy fine sand with a deep substratum of loamy sand.

These well-drained, droughty soils support native xeric vegetation (adapted to an extremely dry habitat) dominated by native prairie grasses and forbs, oak savannas, and oak woodlands. Small areas within the Spanaway-Nisqually soils contain moderately well-drained to well-drained Cagey, Yelm, and Eld soils, as well as poorly drained Everson and McKenna soils and somewhat poorly drained Spana soils. Cagey, Yelm, and Eld soils support prairie, oak savanna, and oak woodlands, while the more poorly drained Everson, McKenna, and Spana soils support riparian oak-ash woodlands or wetland plant communities.

Native prairie vegetation and oak communities are restricted to prairie soils that are well-drained and experience periods of extended drought during the summer. Native prairie plants are adapted to the extended dry periods and to the periodic fires that are more typical of areas with prairie soils than in other areas. However, because fires are less frequent now than they have been in the past, many nonnative and native species that cannot tolerate fire are now able to invade and persist in prairie soil areas. In addition, prairie vegetation reached its greatest extent between about 9,500 to 4,500 years before present, when the climate was drier and warmer than it is now (Leopold and Boyd 1999). In the absence of periodic fire, current climatic conditions are such that many non-prairie plants, both native and nonnative, are able to persist on prairie soils. For example, both Douglas-fir and Scot's broom are now able to invade and thrive on prairie soils, largely due to the absence of fire (Leopold and Boyd 1999).

5.2.2.2 McKenna Association

McKenna gravelly silt loams (Soil Unit 65) compose 3 percent of the Scatter Creek watershed soils (see Table 5-2). This soil type is of moderately deep soils that formed in drainageways and depressions in glacial drift. These soils are poorly drained, hydric soils frequently associated with the floodplain or riparian zones along Scatter Creek. The surface layer is black gravelly silt loam with a subsoil of gravelly

to very gravelly silt loam overlying dense glacial till. The presence of the dense till layer results in a seasonally perched high water table near or above the surface from November to April. Native vegetation is predominantly hardwoods, including oak-ash woodlands and oak-conifer woodlands. Frequent species include Oregon ash, red alder, and Oregon white oak, with some western red cedar and western hemlock. Understory plants are typically salmonberry (*Rubus spectabilis*), snowberry (*Symphiocarpos albus*), vine maple (*Acer circinatum*), sedges (*Carex* spp.), and trailing blackberry (*Rubus ursinus*).

5.2.3 Vegetation Habitat Types

The following sections provide a description of prairie and oak woodland habitats, followed by descriptions of other vegetation types that currently occur or historically occurred within the Scatter Creek watershed. A total of nine historic habitat types were present in the mid 1800s.

5.2.3.1 Prairies

Northwest prairies are native grasslands restricted to the Puget Lowlands of Washington and the Willamette Valley of Oregon, with scattered grasslands in the Coast Range of Oregon, the western Columbia Gorge of Washington, and in southwestern British Columbia (Northwest Habitat Institute 2001). Existing prairies in Washington are concentrated in the south Puget Sound Lowlands and San Juan Islands. Glaciation, soils, climate, and fire were fundamental in the formation of prairies (Lang 1961). These native prairies provide important natural resource functions, such as critical habitat for wildlife unique to prairies, structural complexity (when combined with adjacent forests and woodlands), and ecosystem biodiversity (Ewing, in Dunn and Ewing 1997). The species proposed for inclusion in the Scatter Creek HCP, including the western pocket gopher, Oregon vesper sparrow, mardon skipper, Puget blue, Taylor's (Whulge) checkerspot, valley silverspot, and white-top aster (*Aster curtus*), are associated with native prairies in the Scatter Creek watershed and depend on native prairie vegetation for critical habitat requirements.

Topography of the prairies ranges from flat, to mounded or rolling, to steep slopes (Northwest Habitat Institute 2001). Within the Scatter Creek watershed, existing prairie topography is mounded or rolling with surrounding low-lying hills. The mounded areas are known as Mima mounds. These are microtopographical mounds found in a large gravelly outwash plain that originated about 12,000 years ago following the retreat of the Vashon Glacier (Del Moral and Deardorff 1976). In general, prairies occur at low elevations. Existing prairies within the Scatter Creek watershed occur at or near 200 ft above sea level. Typical soils of the south Puget Sound prairies belong to the Spanaway and Nisqually soil series (discussed in Section 5.2.2.1). These droughty soils are very deep, somewhat excessively drained soils on terraces that formed in glacial outwash and volcanic ash (Pringle 1990). The Spanaway and Nisqually soils typically have a gravelly sandy loam and loamy fine sand texture respectively, both containing little organic matter.

Existing Associated Plants

Prairie soils support unique vegetation with associated wildflowers, mosses, lichens, ferns, shrubs, and trees (WDFW 1995). Appendix A lists representative species of western Washington prairies as identified by the Washington Native Plant Society (2000). A variety of both native and nonnative species are dominant in these grassland areas.

Some common native species observed in the Scatter Creek prairies during the field visit include:

- Roemer's fescue (*Festuca roemerii*)
- Oregon sunshine (*Eriophyllum lanatum*)

- spikelike goldenrod (*Solidago spathulata* var. *neomexicana*)
- kinnikinnick (*Arctostaphylos uva-ursi*)
- early blue violet (*Viola adunca*)
- balsamroot (*Balsamorhiza deltoidea*)
- yarrow (*Achillea millefolium*)
- self-heal (*Prunella vulgaris*)
- bracken fern (*Pteridium aquilinum*)
- narrow-leaved mule's-ears (*Wyethia angustifolia*)

These species generally occur in dry, open areas and are fire-tolerant.

Nonnative species typically found in the Scatter Creek prairies are:

- Scot's broom (*Cytisus scoparius*)
- hairy cat's ear (*Hypochaeris radicata*)
- St. John's wort (*Hypericum perforatum*)
- colonial bentgrass (*Agrostis capillaris*)
- Canada thistle (*Cirsium arvense*)
- sweet vernalgrass (*Anthoxanthum odoratum*)
- common velvetgrass (*Holcus lanatus*)
- English plantain (*Plantago lanceolata*)

These species typically grow in pastures, fields, roadside clearings, and areas around human development and invade native grasslands. Scattered Oregon white oak and Douglas-fir frequently occur along prairie edges and sometimes within prairies.

Historic Prairie Habitat

The prairie vegetation descriptions provided by the GLO surveys contained little detail on plant associations and did not include information on species composition. These areas were simply labeled 'prairie' in the notes. It is likely that some areas labeled as 'prairie' in the GLO notes were actually oak savannas (see Oak Savanna description below). Prairies occurred on the flat valley bottoms or low terraces of the Scatter Creek, Black, and Chehalis River valleys. GLO notes frequently mention the pit and mound topography characteristic of this area.

5.2.3.2 Oak Woodlands

Oregon white oak (Garry oak), Washington State's only native oak, is either dominant in or a major component of oak woodlands. The range of Oregon white oak extends from southwestern British Columbia south to central California in the Coast Ranges and Sierra Nevada (Little 1980). The distribution of oak woodlands within Washington State ranges from the Puget Trough, Washington's south-central counties, along the Columbia Gorge, and northward along the east side of the Cascade Range (Larsen and Morgan 1998). Oak habitat provides areas for feeding, breeding, resting, and shelter for unique wildlife species, such as the western gray squirrel and slender-billed white-breasted nuthatch.

Although Oregon white oaks are tolerant of a variety of soil types, they tend to grow on well-drained, deep loam to gravelly soils (Larsen and Morgan 1998). The Everett and Nisqually soil series are usually

associated with oak habitat. Oaks are also able to persist on a wide array of topographic sites and grow from sea level up to 3,800 ft mean sea level. In addition, oak is both drought-resistant and flood-tolerant. Oaks usually occur on sites that are exposed or too droughty for other trees; however, they can also occur on mesic areas such as floodplains (U.S. Department of Agriculture [USDA] 2002). Average rainfall for oak woodlands in Washington ranges from 6.7 inches (east of the Cascades) to 103.5 inches (west of the Cascades) (USDA 2002).

Existing Associated Plants

Oaks are associated with multiple plant communities such as Douglas-fir, western red cedar, and snowberry, and grow in a variety of canopy cover conditions, thereby resulting in a variety of oak habitat associations that range from oak woodland to oak savanna (see Historic Oak Habitat descriptions below). Oaks growing adjacent to streams and wetlands generally are more dense and have a well-developed shrub layer (Chappell and Crawford, in Dunn and Ewing 1997; The Nature Conservancy 2002). Appendix B lists the plant species associated with Washington oak habitat east and west of the Cascades (Larsen and Morgan 1998). Nonnative species are now common in oak communities adjacent to disturbed areas, and include Scot's broom, colonial bentgrass, and reed canarygrass (*Phalaris arundinacea*).

Historic Oak Habitat

Described below are the four types of historic oak woodland habitat mapped from the GLO notes (see Figure 5-1).

Oak Woodland: Oak woodlands were dominated by Oregon white oak but also contained a mix of conifers, with conifers usually constituting a minor component. Conifers included Douglas-fir and occasionally western red cedar adjacent to the stream. Oak-dominated woodlands tended to occur in the riparian zone adjacent to Scatter Creek on or associated with Everett and Nisqually soils.

Oak-Ash Woodland: These woodlands were dominated by oak but contained a significant component of Oregon ash or are co-dominant with Oregon ash. This vegetation was typically found in the riparian zone of Scatter Creek, along the main channel or in side channels (swales, bottoms in the GLO notes). Oak-ash vegetation as described in the GLO notes was typically associated with McKenna gravelly silt loam soils. Based on the number of witness trees recorded at section and claims corners, these areas are probably closed-canopy forests.

Oak-Conifer Woodland: This habitat type consisted of an oak-conifer mix dominated primarily by Douglas-fir and western hemlock; some western red cedar trees were co-dominant with oak. This vegetation was less closely associated with the riparian zone but tended to occur on Everett and/or Nisqually or Spanaway soils. This vegetation mix typically occurred in the transition between prairie and uplands, or to a lesser extent between prairie and riparian oak communities.

Oak Savanna (Prairie-Oak): Oak savanna habitat was primarily prairie vegetation but may have included some oak trees. Scattered oak trees were most frequently associated with areas that contained a mix of Spanaway/Nisqually or Spana soils.

5.2.3.3 Other Historic Habitats

Other historic habitats that were developed from the GLO notes included forests and agricultural land as described below.

Conifer Forest

This habitat type consisted of conifer-dominated forests that primarily occurred in the uplands according to the GLO surveys. Douglas-fir dominated this habitat type, with abundant western hemlock and western red cedar.

Mixed Conifer-Hardwood Forest

This habitat type consisted of mixed forests of Douglas-fir, western red cedar, western hemlock, and bigleaf maple. These areas occurred primarily on Everett and Alderwood soils.

Riparian/Wetland Mixed Conifer-Hardwood Forest

This forest vegetation occurred along the larger rivers, in wetland areas scattered throughout the Chehalis and Black River floodplain, and in wetland depressions in uplands. Areas mapped in this unit probably included areas of shrub and/or emergent vegetation dominated by sedges, rushes, and willows. Typical soils associated with these forests were poorly drained or somewhat poorly drained silt loams or clay loams (e.g., Godfrey clay silt loam, Norma silt loam) and were frequently hydric soils (e.g., Norma silt loam, Mukilteo peat, Semiahmoo muck). The most common plant species included red alder, willows, Oregon ash, Douglas-fir, western red cedar, black cottonwood, and bigleaf maple.

Agriculture

These areas included settlement areas consisting of agriculture fields and pastures. The GLO notes do not describe the species that were planted; surveyors simply noted these areas as fields.

5.2.3.4 Other Existing Vegetation Types

Descriptions of existing vegetation types and other cover types were obtained from the *Land Cover Mapping of Thurston County* (Thurston Regional Planning Council 2001) and *Oak and Grassland Data* (WDNR, WNHP 1999). These habitat types correspond to the existing vegetation map (see Figure 5-2). A total of 15 other existing habitat types were identified as described below.

Grasslands

The *Oak and Grassland Data* (WDNR, WNHP 1999) did not include any areas mapped as prairie; however, the areas identified as native grassland and semi-native grassland vegetation types support the habitat conditions and vegetative characteristics of prairies. For this report, native grasslands and semi-native grasslands are considered prairies.

Native Grassland: These grasslands are remnant native prairies that consist of herbaceous vegetation dominated by native species. This vegetation type is located on glacial outwash in the Scatter Creek watershed.

Semi-Native Grassland: This vegetation type is a mixture of native and exotic species usually located on glacial outwash. Native species typically occupy a minimum of 10 percent canopy cover. Nonnative species may dominate the community, but a significant component of native grassland species are also present.

Oak Woodlands

Oak-Dominant Forest or Woodland Canopy: These woodlands have greater than 25 percent canopy cover of Oregon white oak in the main and upper canopy layers and less than 25 percent conifer canopy cover in the main and upper canopy layers. Broadleaf trees (e.g. Oregon ash, bigleaf maple, Pacific madrone [*Arbutus menziesii*]) other than oak may be co-dominant species. This vegetation type may contain houses in the understory.

Oak-Conifer Forest or Woodland Canopy: The main and upper canopy layers for this vegetation type are a mixture of Oregon white oak and conifers; each constituting at least 25 percent canopy cover. Broadleaf trees (e.g., Oregon ash, bigleaf maple, Pacific madrone) other than oak may also be co-dominant species. This vegetation type may contain houses in the understory.

Other Vegetation and Cover Types

Forest – Coniferous: These areas are dominated by coniferous species. Young conifer forests that have reached a relatively closed canopy stage are included in this type.

Forest – Mixed: These areas consist of mixed coniferous and hardwood forests.

Forest – Hardwoods: These areas are dominated by hardwood trees, such as red alder and bigleaf maple.

Forest – Young Trees: These areas are dominated by young coniferous or hardwood trees planted in uniform patches.

Non-Forest Vegetation: Shrubs, grasses, and other non-forest vegetation dominate this vegetation type. These areas include gardens and lawns in urban areas, clearcuts, pasturelands, and croplands. Non-forest vegetation is differentiated from dry grasses and soils by the presence of identifiable chlorophyll in the vegetation (green vegetation).

Dry Grasses and Soils: This is a highly variable class and is composed predominantly of dry grasses (including many lawns in the dry year of 2000), fields, recent clearcuts, and agricultural lands that are not irrigated.

Water: These areas include large bodies of water such as lakes, major rivers, and large areas of ponding water.

High Density Urban: These areas are developed and have little to no vegetation. This cover type includes major highways; commercial, industrial, and high-density residential properties; and large buildings in rural areas. Also included are areas currently under construction that were highly disturbed.

Moderate Density Urban: These areas are a mixture of developed and vegetated land. This cover type includes urban and suburban single-family residential neighborhoods and roads.

Low Density Urban: These areas have vegetation that is influenced by development, such as grasses that would occur surrounding a small home or along a logging road. This cover type is mainly found adjacent to moderate density urban areas, or scattered in rural areas.

Mines, Quarries, and Gravel Pits: These areas are lacking vegetation and are currently occupied by a mine, quarry, or gravel pit.

5.2.4 Vegetation Distribution

The following sections describe the historic (circa 1850s) and existing land cover and vegetation distribution. A summary of changes for each habitat type is also provided.

5.2.4.1 Historic Vegetation

Prior to European settlement, vegetation in the Scatter Creek watershed was composed primarily of prairie, oak savanna, and forest vegetation (Table 5-3 and see Figure 5-1). Prairies covered a large area of the watershed extending over an estimated 8,937 ac or 32 percent of the watershed. Total area for oak savannas was estimated at 1,066 ac or 4 percent.

Table 5-3. Area and Percent of Watershed Covered for Each Historic Habitat Type

Habitat Type		Area (acres)	Percent of Watershed Covered
Prairie	Prairie	8,937	32
Oak Savanna	Oak Savanna (Prairie-Oak)	1,066	4
Forest	Oak Woodland	1,389	5
	Oak-Ash Woodland	809	3
	Oak-Conifer Woodland	917	3
	Conifer Forest	3,509	13
	Mixed Conifer-Hardwood Forest	6,916	25
	Riparian/Wetland Mixed Conifer-Hardwood Forest	4,027	14
Agriculture	Agriculture	353	1
Total		27,923	100

Estimated cover for all forested vegetation is 17,567 ac or 63 percent of the watershed. Included are upland forests (mixed conifer-hardwood forest and conifer forest) that occurred on 10,425 ac or 38 percent of the total area. Riparian forests (riparian/wetland mixed conifer-hardwood forest) covered a total of 4,027 ac or 14 percent of the watershed. Oak woodlands (oak woodland, oak-ash woodland, oak-conifer woodland) occurred on 3,115 ac or 11 percent of the total area.

Only 353 ac or 1 percent of the land was used for agriculture during this time period since few parcels of land had been claimed prior to the completion of the GLO surveys.

Prairies extended across much of the watershed and were predominant in the western and central portions from the vicinity of James Road SW to the city of Tenino. The majority of the flood valley bottom to the base of the surrounding hills was likely open prairie, including the current locations of Grand Mound Prairie, Violet Prairie, and Rock Prairie. The area near the Tenino railroad tracks northeast to the city of Tenino was also prairie with a small isolated pocket north of town along what is now Old Highway 99 SE.

Oak savanna habitat was located in scattered patches within the prairies and along the prairie/upland forest transition zone. This habitat is generally found in the central portion of the watershed in the vicinity of Grand Mound Prairie, Violet Prairie, and Rock Prairie with one small, outlying area near the city of Rochester. Large tracts of oak woodlands occurred along Scatter Creek, along the edges of the prairies, and near the headwaters of Scatter Creek.

Upland forests, including mixed conifer-hardwood forest and conifer forest, occurred on the hills in the eastern portion of the watershed and north and south of the flood valley bottom in the central portion. Riparian/wetland mixed conifer-hardwood forests predominantly existed along the floodplain of the Chehalis River and at the headwaters of Scatter Creek, but occasionally occurred in other segments along the creek and in wetland areas.

5.2.4.2 Existing Vegetation

Post-European settlement resulted in changes in the vegetation as European settlers converted prairies and forests to agricultural and logging uses (Table 5-4 and see Figure 5-2). Along with agricultural and timber development came increasing urbanization and the clearing of vegetation to make way for towns, roads, and railroads. Some existing vegetation and other cover types did not occur historically. For example, dry grasses and soils and non-forest vegetation include vegetation such as grass lawns, irrigated pastures, and dry land that did not exist in the pre-settlement vegetation. Two existing habitat types, non-forest vegetation and dry grasses and soils, dominate the existing vegetation in the watershed covering a total of 14,132 ac or 50 percent of the area. Native grassland and semi-native grasslands contain 1,017 ac or approximately 4 percent of the area, with only 199 ac or less than 1 percent of the area dominated by native species. Cover for all forested vegetation is 11,387 ac or 40 percent of the watershed. Current oak habitat includes the oak-dominant forest or woodland canopy and oak-conifer forest or woodland canopy habitat types, which cover 1,561 ac or 5 percent of the watershed. These existing vegetation types may not provide the ecological functions that the historic oak habitats do, since these types contain houses in the understory. Unvegetated areas compose 1,387 ac or approximately 6 percent of the total area.

Table 5-4. Area and Percent of Watershed Covered for Each Existing Vegetation Type

Habitat Type		Area (acres)	Percent of Watershed Covered
Grassland	Native Grassland	199	Less than 1
	Semi-Native Grassland	818	3
Forest	Oak Dominant Forest or Woodland Canopy	599	2
	Oak-Conifer Forest or Woodland Canopy	962	3
	Forest – Coniferous	4,360	15
	Forest – Mixed	1,306	5
	Forest – Hardwoods	2,416	9
	Forest – Young Trees	1,744	6
Non-Forest	Non-Forest Vegetation	6,944	25
	Dry Grasses and Soils	7,188	25
Unvegetated	Water	105	Less than 1
	High Density Urban	272	1
	Moderate Density Urban	760	3
	Low Density Urban	146	Less than 1
	Mines, Quarries, and Gravel Pits	104	Less than 1
Total		27,923	100

Native grasslands are confined to the South Unit of the Scatter Creek Wildlife Area, a small area south of Scatter Creek and immediately east of Interstate 5, with semi-native grassland at both units of the Scatter Creek Wildlife Area and two other locations in Rock Prairie adjacent to Old Highway 99 SW. Oak

habitat (oak-dominant forest or woodland canopy and oak-conifer forest or woodland canopy) exists in scattered patches near native and nonnative grassland areas, particularly at the prairie/upland forest transition zone and along Scatter Creek.

Upland forests (including forest – coniferous, forest – mixed, forest – hardwoods, and forest – young trees) are mostly found on the hills in the eastern portion of the watershed and north and south of the flood valley bottom in the central portion. These forests are dominated by Douglas-fir and western red cedar with some bigleaf maple, red alder, and Oregon ash.

Vegetation along Scatter Creek is dominated by forest – hardwood vegetation in the less disturbed segments and non-forest vegetation (grasses) in the more disturbed segments. In these riparian forest – hardwood areas, Oregon ash, red alder, Oregon white oak, Pacific willow (*Salix lasiandra*), and cascara (*Rhamnus purshiana*) typically dominate the overstory, and red-osier dogwood (*Cornus sericea*), snowberry, Pacific ninebark (*Physocarpus capitatus*), rose (*Rosa* spp.), Douglas spirea (*Spiraea douglasii*), vine maple, and reed canarygrass typically dominate the understory. Reed canarygrass and domestic grasses from abutting pasturelands dominate non-forested vegetation adjacent to the creek.

Non-forest vegetation and dry grasses and soils are mostly at the lower elevations extending across much of the western and central portions of the watershed. The unvegetated areas, excepting water, are concentrated in the vicinity of the cities of Tenino and Grand Mound and scattered throughout the rest of the watershed.

5.2.4.3 Summary of Vegetation Changes

As settlement and development expanded into the Scatter Creek watershed, many of the historic habitat types were altered. This section provides a summary of the changes in habitat by comparing acreage from historic to existing conditions (Table 5-5). For a comparison of like habitats, some habitat types were combined. For example, when comparing oak habitat, the historic habitats (oak woodland, oak-ash woodland, oak-conifer woodland, and oak savanna) were combined and the existing habitats (oak dominant forest or woodland canopy and oak-conifer forest or woodland canopy) were combined. Some existing cover types, such as high density urban, did not occur in historic conditions and cannot be compared to a pre-existing habitat type. In addition, the water cover type was identified for the existing conditions, but we are not able to estimate the water area from the GLO notes.

Calculations of acreage for the historic and existing habitat types show a significant decrease in prairie and oak habitat. At present, only 11 percent of the historic prairie area within the Scatter Creek watershed remains as grassland, and only 2 percent of this area contains native grassland. This decline is consistent with other areas of south Puget Sound, where at least 97 percent of prairie habitat has been eliminated (Dunn and Ewing 1997). Remaining prairies at the historic locations of Grand Mound Prairie and Rock Prairie cover a fraction of the historic area, and prairies near Tenino and Violet Prairie have been lost as a result of land use conversion. No new prairies occur.

Overall, forests have declined by 65 percent, from 17,567 to 11,387 ac. This occurs for all forest vegetation types excepting conifer-only forests, which have increased by 24 percent from 3,509 to 4,360 ac. Conifer forests have encroached into historic prairie areas at Grand Mound Prairie, Violet Prairie, and Rock Prairie and have also expanded into the eastern portion of the watershed near Scatter Creek headwaters. This increase in conifers is most likely a result of land conversion to timber harvesting and tree farms and prairie succession due to fire suppression.

Table 5-5. Change in Vegetation Acreage From Historic to Existing Conditions

	Historic Habitat Type	Existing Habitat Type	Historic Area (acres) (1856)	Historic Percent of Watershed Covered	Existing Area (acres) (1999-2001)	Existing Percent of Watershed Covered	Acreage Change
Prairie and Grassland	Prairie	Native Grassland and Semi-Native Grassland	8,937	32	1,017	4	-7,920
Oak-Dominant or Co-dominant Forest	Oak Woodland, Oak-Ash Woodland, and Oak-Conifer Woodland	Oak-Dominant Forest or Woodland Canopy and Oak-Conifer Forest or Woodland Canopy	3,115	11	1,561	6	-1,554
Conifer Forest	Conifer Forest	Forest – Coniferous	3,509	13	4,360	15	+851
Mixed Forest	Mixed Conifer-Hardwood Forest, and Riparian/Wetland Mixed Conifer-Hardwood Forest	Forest – Mixed, Forest – Hardwoods, and Forest – Young Trees	10,943	39	5,466	20	-5,477
Oak Savanna	Oak Savanna		1,066	4	--	--	-1,066
Agriculture and Non-Forest	Agriculture	Non-Forest Vegetation and Dry Grasses and Soils	353	1	14,132	50	+13,779
Water		Water	--	--	105	<1	--
Unvegetated		High Density Urban, Moderate Density Urban, Low Density Urban, and Mines, Quarries, and Gravel Pits	--	--	1,282	5	+1,282
TOTAL			27,923	100	27,923	100	

Oak habitat (oak-dominant or co-dominant forests and savannas) has also declined by 63 percent from 4,181 ac in the 1850s to 1,561 ac. This decline includes the elimination of all historic oak savannas, an estimated 1,066 ac. Areas of scattered oak currently exist, although these areas are too small in acreage to be mapped as oak savannas. Remaining oak forests and woodlands are located in areas that historically supported this habitat type, such as areas adjacent to Scatter Creek and along the prairie/upland forest transition zone, but now cover a reduced portion of that area. No new oak habitats occur.

Prairie and oak habitats decreased as population growth and conversion of land to agriculture and urban areas increased. The Thurston Regional Planning Council estimated the population of the Scatter Creek watershed to be 7,686 people for 2001 and estimates that the population will reach 11,367 people by the year 2025 (Tabutt 2002 personal communication). Agriculture and non-forest vegetation has increased from 353 ac to 14,132 ac. This vegetation type has the most significant increase and covers more than 50 percent of the watershed. Agriculture and non-forest vegetation continued to occur in the historic agriculture areas and have substantially increased in area throughout the watershed, particularly in the central and western portions. Unvegetated areas (high density urban, moderate density urban, low density urban, and mines, quarries, and gravel pits) now cover 1,282 ac or 5 percent of the watershed.

5.2.5 Fire Disturbance Regime

Forces that have altered habitat in the watershed include changes in the historical fire regime and land use, and invasion of nonnative plants. This section provides a summary of the fire regime for prairie and oak woodland habitat in the south Puget Sound region. Local references are used when available. Land use and nonnative plants are discussed in Section 5.2.6.

Fire is a disturbance process that historically played an integral role in shaping the composition and structure of prairies, oak savannas and woodlands, and encroaching coniferous forests. The exclusion of fire, development, and the introduction of exotic plant species have altered the historical fire regime. Characterizing the historic and current role of fire provides insight into conservation and management of these ecosystems (Agee 1996).

The concept of a fire regime is used to characterize the effect of fire on vegetation and is explained as a function of plant adaptations and fire characteristics (Agee 1993). Fire characteristics discussed here include frequency, intensity and duration, extent, and season.

Fire history investigations often depend on information derived from fire-scarred trees to precisely determine fire frequency and seasonality. Methods to identify fire history include a review of tree growth rings to determine the year the fire occurred. The season of fire is determined by scar location relative to earlywood (less dense portion of annual ring related to the rapid springtime growing season) and latewood (more dense portion of annual ring related to the slow summertime/fall growing season). However, fire-scarred trees are rare in oak woodlands. The lack of fire scarring is not from a lack of fire, but from the combination of frequent flashy fires that are fueled by forbs and grasses and the insulating bark of oaks. Frequent fires encourage herbaceous plants and maintain low levels of woody fuels. Herbaceous fuel beds often burn at a high intensity, but for a very short duration. Thus, oaks with an insulating layer of bark and cork rarely record scars and therefore underestimate the frequency of fires (Agee 1993).

Reconstruction of historic fire frequency, season, and extent is primarily inferred from current and historic records of oak woodland flora composition and structure and from ethnological and historical

accounts of Native American management (Taylor and Boss 1975; White 1980; Agee 1993; Boyd 1999). The Cowlitz and Upper Chehalis Native Americans used fire to manage prairies and oak woodlands from Olympia south to Tenino and Centralia. Their intentions varied from promoting particular food plants and crops, to improving pasture for game. Later in the 1700s, Native Americans used fire to develop horse pastures (Leopold and Boyd 1999).

Frequency of Native American burning is not well documented. However, accounts by early explorers consistently make note of observed Native American burning. In some cases, annual burning was documented (Boyd 1999; Kay 1995). Some areas might have also been burned every 2 to 3 years to promote berry production (Leopold and Boyd 1999).

The acreage extent of fires probably varied greatly. Many early explorers noted fires that extended for great distances. Large fires were probably more likely where there were contiguous large patches of prairies and oak woodlands (Agee 1993). There is ethnological evidence that Native Americans controlled the extent of fire. Methods employed include seasonal timing of fire and natural fuel breaks such as topographic features and manmade breaks, such as trails (Leopold and Boyd 1999).

There is ethnographic evidence for early spring and fall burning by Native Americans; however, fall burning may have been more common. Fall burning would have coincided with lightning ignitions, however limited (Boyd 1999; Agee 1993).

In summary, evidence of the pre-European settlement fire regime in the south Puget Sound region (including the Scatter Creek watershed) indicates a low-severity regime, characterized by frequent fires of low intensity and duration, and locally small to large fires that occur predominantly in the fall, but also burn less frequently in spring. This low-severity fire regime promoted herbaceous plant species and discouraged woody plants.

Settlers began developing the prairies and oak woodlands in the mid-1830s. They made their homes, grazed sheep and livestock, cut timber for fuel and lumber, and farmed the prairies and oak woodlands. Settlers also set fires to improve grazing early on, but by the early 1900s fire exclusion became policy. In addition to these changes, there was an increasing rate of exotic plant species introduced into the region. These changes shifted the fire regime and the composition and form of plant communities.

The fire regime of prairie and oak woodlands in general has changed from a low-severity regime to a mixed-severity regime. With fire exclusion, species composition changes, and fuel loads (the quantity of material such as downed wood and dense understory vegetation that could serve as fuel for fires) increase in amount and character, which affects vegetation response to fire. Frequent fires encourage plant species that are adapted to low-intensity fire. These species include grasses and forbs that have perennating tissues (tissues that survive from one growing season to the next, often with a period of reduced or arrested growth between seasons) near or below the ground surface. Frequent fires will reduce abundance of most woody species (Agee 1993). However, some species, such as Oregon white oak, have heat-insulating bark, and when fire intensity and duration are increased, produce basal and epicormic shoots (shoots that enable the plant or tree to grow new leaves quickly) (Plumb 1980). In the absence of fire, species composition trends toward plants that are less tolerant to fire and have greater shade tolerance. In environments that support shrubs or conifers, encroachment occurs and there is an increase in woody fuels. The fire regime shifts to a mixed-severity fire regime; fires that generally burn with moderate to high intensity for a longer duration have a greater effect on species survival.

Nonnative species have also changed the character of fuels and fire behavior, most notably Scot's broom, which is a woody shrub that invades prairies and oak savannas. Scot's broom can form dense thickets, increase fuel bed height 3 to 9 ft, and inhibit native species (Tveten and Fonda 1999). Fires that burn in Scot's broom are of greater intensity and have longer flame lengths. In addition to changing fire behavior, exotic plants often alter the response of vegetation to fire, most notably by competitively excluding other plant species following fire. Using the concept of a fire regime is a useful approach to frame the historic and current role of fire on prairies, oak savannas, and woodlands.

Understanding the historic fire regime provides a set of conditions in which it is likely that native plants evolved and communities formed. Such information can be useful to managers; however, it is not enough to guide management. Land use patterns and the introduction of nonnative species have changed composition and structure of these ecosystems, and in turn have changed the fire regime.

5.2.6 Current Threats and Status for Prairie and Oak Habitats

Prairie and oak woodland habitats in the south Puget Sound region are some of the rarest habitats in the United States and have declined significantly from historic conditions (Dunn and Ewing 1997). These habitats were originally created in conditions and processes that involved porous soils formed of glacial outwash, droughty summer conditions, periodic fires (set by Native Americans and lightning), and soil disturbances (Dunn 1998, in The Nature Conservancy 2002). These two habitat types are significant because they provide biological support for unique vegetation and wildlife that may not occur elsewhere. Oak woodlands provide hunting opportunities for raptors and nesting and food sources for birds and small mammals, and prairies support host and nectar plants for invertebrates.

Prairie and oak woodlands in the Scatter Creek watershed provide important habitat for nine of the wildlife and plant species proposed for coverage under the Scatter Creek HCP, including the western gray squirrel, *Mazama* pocket gopher, slender-billed white-breasted nuthatch, Oregon vesper sparrow, mardon skipper, Taylor's checkerspot, Puget blue, valley silverspot, and white-top aster. A detailed discussion for each of these species is provided in Section 3 of this document.

The following sections discuss the general threats, local threats, and current status of prairie and oak habitats.

5.2.6.1 General Threats

General threats to prairie and oak habitat are fire management (suppression) and encroachment of Douglas-fir, changes in land use (land conversion and development), and the continued spread of nonnative plants. Prairies and oak woodlands thrive when subject to a low-intensity fire regime that occurs every few years (USDA 2002). Fire suppression has been an ongoing threat since European settlement altered the fire regime and has resulted in Douglas-fir encroachment, as well as providing opportunities for the establishment of nonnative plants. In the absence of fire, Douglas-fir encroaches on prairies resulting in the succession of grassland to forest. Over time, Douglas-fir trees eventually overtop oaks and shade the understory. Historic fire regimes to which prairie and oak woodland species were adapted were typically frequent, low-intensity events. If fire is used to manage prairie and oak habitats in the future, its reintroduction will have to consider likely effects on native species of concern (i.e., butterflies), as well as possible effects of the presence of nonnative species (e.g., Scot's broom) on fire intensities.

Oaks are relatively intolerant of shade and typically die or fail to reproduce when Douglas-fir trees shade them out. Oak seedlings and saplings grow more slowly than Douglas-fir seedlings (Sprague and Hansen

1946) and can be quickly overtopped and shaded out by faster-growing conifers. Under the shade of oak canopies, there is typically a lack of oak regeneration and more abundant Douglas-fir seedlings than oak seedlings (Barnhardt et al. 1987). Historically, oaks depended on fire to open gaps in the oak canopy for regeneration to occur. Mature oak are intolerant of shade and are unable to produce acorns and grow very slowly in the low light levels available under Douglas-fir canopies (Miller 1985; Kertis 1986).

Along with European settlement came conversion of native vegetation to agriculture and pastureland, as well as residential development. Conversion of prairies to other land uses continues to alter the historic prairie and oak habitat. European settlement during the 1800s introduced agriculture that decreased the overall area of native prairie habitat by land conversion to crops or pastures, which has resulted in heavy grazing and trampling from livestock. Nonnative grasses were also introduced to increase forage opportunity for pasture animals. These domestic grasses are typically sod-forming grasses that create a dense, continuous turf. This dense turf prevents the reproduction of native forbs (which may be important food plants for prairie butterflies) and can outcompete the native bunch grasses. In contrast, native prairies were dominated by bunch grasses such as Roemer's fescue, which typically have areas of bare, open ground between grass plants, where native forbs, mosses, and lichens grow (Dunn and Ewing 1997). This openness in the native prairie vegetation, and the resulting species diversity, is lost when nonnative grasses invade.

During the late 1800s, residential and rural development has allowed for further degradation of habitat quality through fragmentation and direct conversion of land. Fragmentation occurs when habitats are divided by roadways or buildings or through direct clearing of native vegetation. Loss of native vegetation occurs as residential developments and agriculture displace prime prairie in the south Puget Sound (The Nature Conservancy 2002).

Nonnative species have become established in many prairie and oak habitats in the south Puget Sound. These nonnative pest plants have the potential to change the composition, structure, and ecological processes of the native communities (The Nature Conservancy 2002). As mentioned above, nonnative grasses were introduced during European settlement for grazing and pasture purposes and eventually outcompeted native species in some locales. In addition, fire suppression and human disturbance have increased the opportunity for other nonnative plants to invade.

One of the most common and harmful invasive species in south Puget Sound prairies is Scot's broom. This plant thrives on the droughty, sandy prairie soils and other open areas where it shades out native species. Infestations of Scot's broom also alter the soil chemistry through nitrogen fixation (The Nature Conservancy 2002). The hypothesis that this nitrogen enrichment can favor establishment of other nonnative plants that require the additional nitrogen has been documented in other grassland ecosystems. A controlled experiment, designed by Scott Pearson of WDNr's Natural Areas Program, is now underway to test this hypothesis in southern Puget Sound prairies. Scot's broom reproduces by seed and has been reported to reproduce vegetatively from cuttings (Hoshovsky 2000). Seeds explode from seedpods and are dispersed by water (rivers and streams), vehicles, birds, and other animals. Scot's broom produces abundant seed, and disturbance of the soil associated with clearing areas of Scot's broom frequently results in a new infestation. When cut, Scot's broom sprouts aggressively from cut stumps. Loss of native vegetation to nonnatives displaces more than just prime prairie; degraded prairies that are good candidates for restoration efforts are also lost.

Other pest plants of Puget Sound prairies include colonial bentgrass, common velvetgrass, hairy cat's ear, St. John's wort, wild carrot (*Daucus carota*), sweet vernal grass (*Anthoxanthum odoratum*), ox-eye daisy

(*Chrysanthemum leucanthemum*) and tall oatgrass (*Arrhenatherum elatius*) (Buschmann, in Dunn and Ewing 1997).

- Colonial bentgrass is a thin-leaved, rhizomatous (i.e., spreading by underground stems), sod-forming grass that forms dense colonies, resulting in loss of native plants dependent on open soil. Colonial bentgrass seeds are easily dispersed by wind; they germinate in the fall or overwinter for a spring or summer germination.
- Common velvetgrass grows extremely well in disturbed areas and is tolerant of a wide range of environmental conditions. This grass can alter its fibrous root system depending on the presence or absence of water, nutrients, salt, and metals, which makes it a vigorous competitor (Buschmann, in Dunn and Ewing 1997). This perennial grows in clumps, reproducing primarily by seed, which is dispersed by wind or by attachment to fur and clothing.
- Hairy cat's ear does not grow in dense patches or pure stands because it is autotoxic (i.e., it produces substances that are poisonous to itself), but it does pose a threat because it produces rosettes with leaves growing so close to the ground that it excludes other adjacent plants. Hairy cat's ear is tolerant of a wide range of soil conditions but grows exceedingly well in poor soils.
- St. John's wort is a perennial herb that spreads by stolons (a shoot that bends to the ground or that grows horizontally above the ground and produces roots and shoots at the nodes), rhizomes (a horizontal underground stem that sends out roots and shoots from its nodes), and seed and thrives in disturbed sites such as roadside clearings, pastures, and fields.
- Wild carrot is a biennial herb (having a life cycle that normally takes 2 years to complete) that has the ability to grow in dense communities in disturbed roadsides and unused pastures. Mature seeds of wild carrot are easily transported by attaching themselves onto wildlife and humans with barbed prickles.
- Sweet vernal grass is a tufted grass that is tolerant of various soils and typically occurs in disturbed areas and pastures. Seeds are usually spread by adhering to vehicles, wildlife, or clothing, but may also be spread by wind and water.
- Ox-eye daisy spreads by seed and rhizome, forming dense colonies that outcompete natives. This aster is less widespread than the other two forbs (hairy cat's ear and St. John's wort) but is uncontrolled and rapidly increasing (Buschmann, in Dunn and Ewing 1997).
- Tall oatgrass is a nonnative grass that appears to be rapidly spreading in prairies in the Scatter Creek watershed and may be detrimental to native prairie vegetation.

The introduction and invasion of nonnative plants remains an ongoing threat.

5.2.6.2 Local Threats

Local threats within the watershed are consistent with the general threats mentioned above. The implementation of fire management eliminated the regular low-intensity burning that was present 150 years ago. Continued effects of fire suppression have resulted in conversion of many prairies and oak woodlands to a habitat with greater tree and shrub densities. However, prairies are most susceptible to agricultural and residential development and invasion of nonnative plants, and secondarily to forest

succession. Urban land uses within the watershed now cover 1,282 ac or 4.6 percent of the total area, and agriculture and non-forest vegetation covers 14,132 ac or 51 percent of the total area. These land uses are likely to increase as population growth and associated development increases, resulting in further decreases in prairie and oak woodland habitat cover. Nonnative species (including Scot's broom, colonial bentgrass, common velvetgrass, hairy cat's ear, and St. John's wort) have already established in most of the remaining prairies and are likely to become more widespread.

5.2.6.3 Status

Prairie and oak woodland habitats in the Scatter Creek watershed show a declining trend compared to acreages of these habitat types in the 19th century. As a result of changes to the fire regime, conversion to agriculture, urbanization, and invasion by nonnative species, existing prairie and oak woodland habitats are relatively limited in area and fragmented by development. Only 11 percent of the historic prairies and 37 percent of the historic oak woodlands remain in the Scatter Creek watershed, presently covering 1,017 and 1,561 ac, respectively. Land conversion has resulted in 13,779 acres of native habitat being converted to agriculture, which now covers over 50 percent of the watershed.

One important area, the Scatter Creek Wildlife Area, covers approximately 1,140 ac and offers the only publicly protected area for these habitats, including 593 ac of prairie and 114 ac of oak woodland. In 1995, WDFW developed a management plan for the wildlife area because of changing habitats and changes in public expectations and priorities. This plan was developed to incorporate protection and use of wildlife and habitats on WDFW lands that fulfills legislative and regulatory requirements and addresses local, regional, and statewide issues and concerns. Many of the regulatory requirements, issues, and concerns are applicable to all prairie and oak woodland areas within the watershed, including habitat management; public or commercial use conflicts; benefits of land use agreements; removal of non-renewable resources; threatened, endangered, and sensitive species management; cultural resources; wildfire management; weed control; road management; and native habitat.

6. FISHERIES, STREAM HABITAT, AND SURFACE WATER QUALITY

6.1 METHODS

6.1.1 Data Sources and Review

Numerous data sources were utilized to characterize Scatter Creek fisheries, stream habitat, and management activities. A literature review was conducted to locate all relevant published articles and reports using a variety of library databases. Extensive searches for relevant information on the internet were conducted. A substantial amount of data and maps reviewed were provided by the TCD. Numerous agency personnel were contacted (see list in Section 8.4). These agency personnel have specialized and local knowledge of salmonid populations, non-game fish species, fish propagation, in-stream habitat, riparian conditions, water quality, and land-use activities in Scatter Creek. They were the best source of data or knew of the locations of available data and reports. In addition, landowners were invaluable in providing local knowledge of the Scatter Creek watershed. Substantial effort was made to ensure that information important for developing the Scatter Creek HCP was not overlooked.

Data sources included but were not limited to (source in parentheses):

- Published literature (numerous sources).
- All available redd counts/escapement estimates (WDFW, the Chehalis Tribe, and Quinault Nation).
- All available smolt trap data to provide the best estimates of juvenile salmon production in Scatter Creek (WDFW).
- Snorkeling surveys of Scatter Creek fish species presence (USFWS).
- All available fish stocking records for Scatter Creek (WDFW).
- Survival estimates of coho salmon within other Chehalis River Basin streams (WDFW).
- The most recent federal and state reviews of salmonid populations (WDFW stock inventories and NOAA Fisheries status reviews).
- Water quality reports and data available from Ecology and Thurston County reports.
- Available Scatter Creek stream gage flow data (USGS and Thurston County).
- Natural Heritage Wildlife Database.
- Known Scatter Creek fisheries management reports dating back to 1931 (WDFW).
- StreamNet <www.streamnet.org>, a cooperative information management and dissemination project focused on fisheries and aquatic data in the Columbia River Basin and the Pacific Northwest.
- The most recent and comprehensive Scatter Creek in-stream habitat survey (TCD).

- Salmonid Screening, Habitat Enhancement and Restoration (SSHEAR) database of culverts, dams, and fishways.
- Watershed-wide aerial photographs from the 1930s, 1940s, and 1997 (TCD).
- GIS maps of habitat, land use, and species distributions (TCD).
- WRIA 22 and 23 Salmon and Steelhead Limiting Factors Report.

6.1.2 Field Reconnaissance

A field reconnaissance survey was conducted over a 2-day period on November 4 and 5, 2002. Biologists visited representative areas and major landholdings along with members of the Scatter Creek HCP Steering Committee and Technical Advisory Group. The site visit provided a broad overview of existing watershed conditions and factors that potentially affect fish resources in Scatter Creek. Observations, notes, and photographs were made of land-use patterns, human population densities, upland habitat, riparian habitat, and stream channel conditions at numerous locations along the entire length of Scatter Creek, including several tributaries and virtually all stream road crossings. Areas investigated in detail included WDFW Wildlife Management Areas, the property of Fred Colvin, and restoration projects coordinated through the Heernett Foundation in the Cozy Valley area.

6.2 FISH SPECIES INFORMATION

Accounts dating back to 1931 indicate that Scatter Creek has supported runs of coho salmon (*Oncorhynchus kisutch*), coastal cutthroat trout (*O. clarki clarki*), fall chinook salmon (*O. tshawytscha*), and chum salmon (*O. keta*). Scatter Creek currently supports a spawning population of coho salmon, coastal cutthroat trout, and perhaps a small run of winter steelhead trout (*O. mykiss*), but there is little evidence that spawning populations of chinook or chum salmon remain. None of these salmonid species are listed under the Endangered Species Act, but coho salmon are considered a candidate species for listing, and only coho salmon have been released into Scatter Creek by management agencies. All of these salmonids have an anadromous (ocean-going) life history (or at least for a component of the population as with cutthroat trout). In general, an anadromous life history involves constructing spawning redds (nests) in streams where the eggs are fertilized and incubated. Eggs hatch after an incubation period of roughly 2 to 4 months, after which juveniles spend a period of time rearing in freshwater before migrating to the ocean. After a period of one to several years in the ocean, adults return to the natal streams to spawn, thus completing the life cycle. Some species die after spawning (e.g., coho salmon), while other species may live to migrate back out to the ocean and return to spawn again (e.g., coastal cutthroat and steelhead trout). The duration and timing of this life cycle pattern varies between and within species.

The lower reaches of Scatter Creek provide rearing habitat for several salmonid species, including those that may or may not spawn in Scatter Creek, thus supporting many upper Chehalis River salmonid populations. Juveniles of mixed hatchery and wild origin move up into lower-gradient reaches of Scatter Creek from the Chehalis River seeking refuge and food resources, particularly during periods of high winter flows.

Other species known to occur in Scatter Creek include Pacific lamprey (*Lampetra tridentata*), Olympic mudminnow (*Novumbra hubbsi*), reticulate sculpin (*Cottus perplexus*), redbside shiner (*Richardsonius*

balteatus), suckers (unidentified species), three-spine stickleback (*Gasterosteus aculeatus*), northern pikeminnow (*Ptychocheilus oregonensis*), sunfish (unidentified species), mountain whitefish (*Prosopium williamsoni*), western brook lamprey (*Lampetra richardsoni*), Atlantic salmon (*Salmo salar*), and possibly river lamprey (*Lampetra ayresi*). Pacific lamprey and river lamprey are both USFWS species of concern. River lamprey are also a Washington State species of concern, as is the reticulate sculpin. Olympic mudminnow are considered a Washington State sensitive species. Little is known about the abundance or distribution of these species in Scatter Creek.

6.2.1 Chinook Salmon

6.2.1.1 Occurrence in Scatter Creek

According to a brief Washington Department of Fisheries (WDF) report dated June 10, 1931 (Royal 1931), Scatter Creek once supported a small run of fall chinook salmon, but there was no specific discussion of chinook salmon spawner numbers or distribution. However, it was reported that spawning habitat (though not specifically for chinook salmon) was continuous in the lower 4 miles of Scatter Creek and then present in riffles for an unspecified distance upstream of that point.

In a 1969 letter sent to the Mayor of Tenino from the State Director of Fisheries (Tollefson 1969), Scatter Creek was described as supporting coho salmon and “possibly a few chum salmon” with no mention of chinook salmon. Spot check reports from around the same period (WDF 1968) also report the presence of several fish species with no mention of the presence of chinook salmon. Assuming these accounts are accurate, Scatter Creek may have once supported a small spawning population of chinook salmon, which had disappeared by 1968. However, since there are no historical estimates of abundance, survival, or harvest available; it is difficult to determine the extent of historical chinook salmon use of Scatter Creek.

More recent data and observations by regional fisheries biologists indicate that Scatter Creek does not currently support a spawning chinook salmon population. In surveys conducted from 1985 to 2000 by WDFW, Chehalis Tribe, and Quinault Nation biologists to estimate coho salmon escapement,² there are no reported observations of spawning chinook salmon, chinook salmon redds, or chinook spawner carcasses. Additionally, no juvenile chinook salmon were observed during snorkeling surveys conducted by the USFWS in 1999 (USFWS 1999). Neither Williams et al. (1975) or the Washington State Salmon and Steelhead Stock Inventory (SaSSI) Reports (WDF 1993; WDFW and WWTIT 1994) list chinook salmon in Scatter Creek.

However, juvenile chinook salmon are found in Scatter Creek. Smolt trap surveys conducted from 1986 through 1991 by WDFW collected anywhere from 69 to 3,945 age-0 (subyearling) outmigrating chinook salmon (Table 6-1). This trapping effort likely undercounted the number of juvenile chinook salmon because the sampling schedule was focused on capturing outmigrating coho salmon and would have missed collecting chinook salmon that outmigrated after early June (Hanratty 2002 personal communication). While juvenile chinook salmon were migrating out of Scatter Creek, this is not necessarily an indication of chinook salmon spawning in Scatter Creek. Juvenile chinook salmon are known to disperse from spawning streams and seek out suitable rearing or refuge habitat (Healey 1991). This particular smolt trap was located at about River Mile 0.5 (Figure 4-2) within a low-gradient reach that is accessible to juvenile chinook from the Chehalis River, particularly during periods of high winter flows. Because there are no recent records of chinook spawners in Scatter Creek, it is likely that those

² Escapement is the number of fish that survive natural and human-caused mortality to spawn.

chinook salmon collected by the smolt trap originated from other streams in the upper Chehalis River Basin and migrated upstream into Scatter Creek. Nonetheless, Scatter Creek is providing important rearing habitat for chinook salmon, which helps support upper Chehalis River Basin populations.

Table 6-1. Numbers and Species of Fish Collected in the Downstream Migratory Smolt Trap Operated by WDFW at River Mile 0.5 on Scatter Creek from 1986 to 1991

Year	Date Range	Species					
		Coho Salmon ^a	Chinook Salmon ^b	Steelhead Trout	Cutthroat Trout	Northern Pikeminnow ^e	Atlantic Salmon ^e
1986	4/7 to 6/11	37,977	241	1235	16	na	na
1987	4/1 to 6/9	42,485	165	690	3	na	na
1988	4/1 to 6/23	34,577	69	46	5	na	na
1989	4/17 to 6/12	9,614	3945	69	10	na	na
1990	4/5 to 6/14	41,613	313	101	286	na	na
1991	4/20 to 6/6	37,337	1,039	171 ^c	192 ^d	33	20

^a Virtually all coho salmon were age-1 fish (yearling smolts), with age-0 (subyearlings) accounting for no more than 20 individuals in any given year.

^b All chinook salmon were subyearlings.

^c In 1991, 135 steelhead were naturally spawned and 36 were of hatchery origin. Steelhead were not distinguished by stock origin in previous years.

^d In 1991, 31 cutthroat trout were naturally spawned and 161 were of hatchery origin. Cutthroat trout were not distinguished by stock origin in previous years.

^e Numbers of northern pikeminnow and Atlantic salmon were only recorded in 1991.

Source: WDFW

6.2.1.2 Stock Origin

According to stocking records available from WDFW, no chinook salmon have been released in Scatter Creek (Table 6-2). Because there are no records to indicate that a spawning population of chinook salmon currently exists in Scatter Creek, it is unlikely that juveniles collected in smolt traps from 1986 through 1991 originated from Scatter Creek. The stock origin of those juvenile chinook salmon that presumably move up into Scatter Creek from the Chehalis River during periods of high flows is unknown and likely varies over time within and between years. However, fall chinook salmon of the upper Chehalis River Basin are almost all naturally spawned, except perhaps for some contributions from cooperative rearing projects (Hiss and Knudsen 1993). Therefore, juvenile chinook salmon that rear in Scatter Creek are likely naturally spawned fish.

Table 6-2. Releases of Hatchery Fish into the Scatter Creek Mainstem (Stream Number 23.0716) and an Unnamed Tributary of Scatter Creek (Stream Number 23.0719 from Williams et al. [1975]) During the Period of Record from 1976 to Present

Brood Year	Release Year	Release Location	Species	Release Stage	Number Released	Release Agency ^a	Hatchery of Origin	Hatchery Stock
1975	1976	Main	Coho	Fingerling	89250	WDFW	Bingham Cr	Skokomish R
1978	1980	Main	Coho	Smolt	30000	WDFW	Skookumchuck	Satsop Sprng
1979	1980	Main	Coho	Fingerling	11000	WDFW	Bingham Cr	Satsop Sprng
1979	1981	Main	Coho	Pre-smolt	27000	WDFW	Skookumchuck	Humptulips R
1982	1983	Main	Coho	Fed fry	20400	WDFW	Humptulips	Humptulips R
1982	1983	Main	Coho	Fed fry	32200	WDFW	Humptulips	Humptulips R
1982	1983	Main	Coho	Fed fry	41700	WDFW	Humptulips	Humptulips R
1982	1983	Trib	Coho	Fingerling	27500	WDFW	Humptulips	Humptulips R
1983	1984	Main	Coho	Fed fry	23458	COOP	Mariculture NW	Nemah R
1983	1984	Main	Coho	Fed fry	13328	COOP	Mariculture NW	Fork Cr
1983	1984	Main	Coho	Fed fry	1904	COOP	Mariculture NW	Naselle R
1983	1984	Main	Coho	Fed fry	16388	COOP	Mariculture NW	Nemah R
1983	1984	Main	Coho	Fed fry	9312	COOP	Mariculture NW	Fork Cr
1983	1984	Main	Coho	Fed fry	1330	COOP	Mariculture NW	Naselle R
1983	1984	Main	Coho	Fed fry	13818	COOP	Mariculture NW	Nemah R
1983	1984	Main	Coho	Fed fry	7851	COOP	Mariculture NW	Fork Cr
1983	1984	Main	Coho	Fed fry	1122	COOP	Mariculture NW	Naselle R
1983	1984	Trib	Coho	Fingerling	5784	COOP	Mariculture NW	Nemah R
1983	1984	Trib	Coho	Fingerling	3286	COOP	Mariculture NW	Fork Cr
1983	1984	Trib	Coho	Fingerling	469	COOP	Mariculture NW	Naselle R
1984	1985	Main	Coho	Fingerling	13304	CHEH	Chehalis Tribe	Satsop Sprng
1985	1986	Main	Coho	Fingerling	68100	WDFW	Bingham Cr	Satsop Sprng
1988	1989	Main	Coho	Emergent fry	15000	COOP	Tenino Middle Sch	Satsop Sprng
1989	1990	Main	Coho	Emergent fry	30000	COOP	Tenino Middle Sch	Satsop Sprng
1990	1991	Main	Coho	Emergent fry	20100	COOP	Tenino Middle Sch	Satsop Sprng
1990	1991	Main	Coho	Emergent fry	20100	COOP	Tenino Middle Sch	Satsop Sprng

Table 6-2. Releases of Hatchery Fish into the Scatter Creek Mainstem (Stream Number 23.0716) and a Tributary (Stream Number 23.0719) During the Period of Record from 1976 to Present (Continued)

Brood Year	Release Year	Release Location	Species	Release Stage	Number Released	Release Agency ^a	Hatchery of Origin	Hatchery Stock
1991	1991	Main	Coho	Emergent fry	1500	COOP	Tenino Middle Sch	Satsop Sprng
1992	1992	Main	Coho	Emergent fry	162000	COOP	Rochester FFA	Satsop Sprng
1993	1993	Main	Coho	Emergent fry	15000	COOP	Tenino Middle Sch	Satsop R
1993	1994	Main	Coho	Fingerling	250	COOP	Rochester FFA	Satsop R
1993	1994	Main	Coho	Fingerling	500	COOP	Tenino Middle Sch	Satsop R

^a COOP = Cooperative agreement among several entities; CHEH = Chehalis Tribe

Source: WDFW

6.2.2 Coho Salmon

6.2.2.1 Occurrence in Scatter Creek

A spawning coho salmon population has occurred in Scatter Creek since at least from 1931 to the present. A brief WDF report from 1931 (Royal 1931) noted that Scatter Creek supported a "medium to large" run of coho salmon. Though there was no specific description of coho distribution, spawning habitat for salmon was continuous in the lower 4 miles of Scatter Creek and then present in riffles for an unspecified distance upstream of that point. A 1969 letter to the Mayor of Tenino from the State Director of Fisheries (Tollefson 1969) also describes Scatter Creek supporting a run of coho salmon, and coho fry were observed in Scatter Creek during 1968 WDF spot check surveys (WDF 1968). No other information on historic coho salmon population numbers or distribution is available.

According to StreamNet (2002), coho salmon utilize Scatter Creek for rearing and spawning up to River Mile 12.2 (58 percent of the total stream length). However, coho salmon are frequently found upstream as far as the Cozy Valley area east of Tenino (Holbrook 2002 personal communication). This indicates that coho salmon utilize at least 20 miles of stream in the Scatter Creek watershed (see Figure 4-2 for river miles). Escapement (returning spawner) estimates based on redd count surveys are available from 1984 to 2000 (Table 6-3). Numbers of coho salmon adults returning to Scatter Creek have ranged from 178 to 1,853 individuals. This wide variation could be caused by any number of factors, including poor spawning, rearing, or ocean conditions. For example, late season low flows in Scatter Creek could prevent upstream migration of adults and restrict spawning in a given year. This would result in a low number of juveniles and ultimately a low adult return for that year.

Table 6-3. Coho Salmon Escapement Estimates in Scatter Creek From 1984 to 2000^a

Year	Escapement Estimate (Number of Fish)
1984	1587
1985	357
1986	368
1987	301
1988	1439
1989	859
1990	452
1991	1569
1992	326
1993	1045
1994	299
1995	178
1996	859
1997	326
1998	1853
1999	1511
2000	448

^a Escapement estimates are based on the cumulative redd-count data collected by WDFW, the Quinault Tribe, and the Chehalis Tribe. Data from 2001 is not yet available.

Source: WDFW

Outmigrating juvenile salmonids were collected from a smolt trap in Scatter Creek (at River Mile 0.5; see Figure 4-2) operated by the WDF during the months of April through mid-June from 1986 to 1991 (see Table 6-1). The numbers of outmigrating coho salmon smolts were fairly consistent from year to year, ranging from 34,577 to 42,485 fish, except for 1989 when only 9,614 coho salmon were collected. While the smolt trap catch is the best available indication of juvenile coho salmon production in Scatter Creek, the numbers do not represent the entire outmigration of coho smolts (due to trapping inefficiency or timing), nor do all the smolts collected originate from Scatter Creek. As with chinook salmon (see discussion in Section 6.2.1), juvenile coho salmon will move around among low-gradient streams during periods of high flows during the winter. This confounds the ability to predict adult returns based on collections of outmigrating juveniles. This is illustrated by comparing the numbers of coho salmon collected at the smolt trap to the estimated number of spawning adults 2 years later (when those same juveniles would be expected to return to Scatter Creek). For example, 34,577 coho salmon were collected at the smolt trap in 1988 (see Table 6-1). The subsequent estimated adult return for 1990 was 452 fish. In contrast, only 9,614 coho salmon were collected at the smolt trap in 1989, but 1,569 adults were estimated to have spawned in Scatter Creek 2 years later. Again, these numbers are influenced by limitations in how effectively numbers can be estimated and the many factors affecting survival to adult return.

Survival estimates for Scatter Creek coho salmon are unknown. Survival estimates are available for other Chehalis River Basin coho salmon stocks such as those returning to Bingham Creek, which is a tributary of the East Fork Satsop River. At Bingham Creek, wild coho salmon survival (from smolt outmigration to adult return) for brood years 1980 to 1999 averaged 4.5 percent (range = 0.6 to 11.6 percent), not including harvest (data provided by WDF). Harvest rates over this time period averaged 29.3 percent (range = 3.6 to 54 percent) of the total run. Escapement was therefore reduced by harvest to an average of 3.1 percent (range = 0.5 to 9.1 percent). It is worthwhile to note that, if 50 percent of a run is harvested in a given year, the escapement estimate is cut in half. Without sufficient data for Scatter Creek, it is reasonable to assume that survival rates for Scatter Creek exhibit a similar range of values as observed for the Bingham Creek stocks.

Another useful data set originates from a bull trout snorkeling survey conducted by the USFWS in 1999 (USFWS 1999). Transects were snorkeled in the vicinity of the mouth of Scatter Creek (T15N, R3W, S7), the south Wildlife Management Area (T16N, R3W, S36), Violet Prairie (T16N, R2W, S40), and the property of Fred Colvin (T16N, R2W, S38). Snorkeling efficiency was estimated to be 10 to 30 percent. A total number of 450 subyearling coho salmon were observed, for an average of 112 fish per 100 m (328 ft) of stream. An average of 39 yearlings (greater than 100 mm [3.9 inches] in length) per 100 m (328 ft) were also counted. No bull trout were observed. The majority of fish were observed in the Wildlife Management Area and Violet Prairie reaches.

6.2.2.2 Stock Origin

According to available WDFW records, varying numbers of coho salmon fry, fingerlings, and smolts were released into Scatter Creek most years from 1976 to 1994 (see Table 6-2). These fish were primarily Humptulips River, Satsop Spring, Nemah River, and Fork Creek stocks. Most fish were released into the mainstem, though there were some tributary releases. The survival of these hatchery fish and naturally spawned fish is unknown. Therefore, the proportion of adult coho salmon originating from hatchery or naturally spawned fish is unknown. The most recent stocking efforts have been annual stockings of eyed eggs for the past 4 or 5 years as part of Tenino Middle School class projects (see Table 6-2), but survival of these eggs is believed to be low (Aho 2002 personal communication).

Currently, it is likely that most coho salmon in Scatter Creek are naturally spawned. However, a portion of the existing naturally spawning population undoubtedly originated from past hatchery outplantings. Additionally, hatchery outplants and naturally spawned juveniles likely move into Scatter Creek from the Chehalis River for rearing. Therefore, the number and proportion of hatchery and naturally spawned juvenile coho salmon utilizing Scatter Creek as rearing habitat is unknown.

6.2.3 Chum Salmon

6.2.3.1 Occurrence in Scatter Creek

Chum salmon are found throughout lower Chehalis River Basin tributaries, and there have been few introductions of nonnative stocks. Chum salmon have not been released into Scatter Creek. A brief report from 1931 (Royal 1931) stated that Scatter Creek supported a medium-sized fall run of chum salmon, but there was no mention of population numbers or spawning distribution. In 1969 it was believed that a few chum salmon possibly spawned in Scatter Creek (Tollefson 1969), and Williams et al. (1975) lists chum salmon as a species of the mainstem of Scatter Creek. However, there are no recent records of chum salmon spawning in Scatter Creek, and they are not believed to inhabit Scatter Creek according to the Washington SaSSI Report (WDFW and WWTIT 1994).

6.2.4 Cutthroat Trout

6.2.4.1 Occurrence in Scatter Creek

Cutthroat trout are present in virtually all perennial tributaries and mainstem reaches of the Chehalis River Basin in one or more of their life-history forms. The migratory forms inhabit the mainstem and accessible tributary reaches. The resident form inhabits areas upstream of barriers and downstream where they coexist with the migratory forms. All three forms likely reside in Scatter Creek, but the proportion of these life-history forms is unknown. While Scatter Creek historically and currently supports a coastal cutthroat trout population (Royal 1931; WDF 1968; Tollefson 1969; Blakely et al. 2000), there is no available population data. However, cutthroat trout densities are reportedly higher in the Chehalis River Basin than in other watersheds in western Washington (Blakely et al. 2000).

6.2.4.2 Stock Origin

Until 1999, the Lake Aberdeen Hatchery on the lower Chehalis annually produced about 25,000 anadromous cutthroat trout smolts, and cutthroat trout have been released in the upper Skookumchuck River (Blakely et al. 2000). However, it is believed that few hatchery fish have contributed to naturally spawning stocks outside of the upper Skookumchuck River. There are no records of hatchery stocks of cutthroat trout being released into Scatter Creek, and the stock origin of coastal cutthroat trout in the Chehalis River Basin is considered native (Blakely et al. 2000).

6.2.5 Steelhead Trout

6.2.5.1 Occurrence in Scatter Creek

Early reports do not describe steelhead spawning in Scatter Creek (Royal 1931; WDF 1968; Tollefson 1969). Currently, it is unclear whether steelhead spawn in Scatter Creek. The map of upper Chehalis River winter steelhead distribution in the Washington SaSSI Report does not indicate that winter steelhead spawn in Scatter Creek (WDFW and WWTIT 1994). In addition, the Quinault Tribe conducted an extensive survey for wild steelhead from River Mile 0.0 to 0.7 on May 19, 1990, and no steelhead or visible redds were observed (data provided by Rob Rhodes, Quinault Tribal Fisheries Biologist). Yet,

according to StreamNet (2002), steelhead utilize Scatter Creek for rearing and spawning up to River Mile 2.1 (10 percent of the total stream length). This may be supported by Scatter Creek smolt trap collections of steelhead from 1986 to 1991 (see Table 6-1), but those steelhead may be moving from the Chehalis River into Scatter Creek to rear, as is likely the case with chinook salmon.

6.2.5.2 Stock Origin

There are no records of steelhead being released into Scatter Creek (see Table 6-2). Hatchery fish probably make up some proportion of those steelhead rearing in Scatter Creek. Hatchery fish compose approximately 30 percent of the winter steelhead in the Chehalis River Basin (Hiss and Knudsen 1993). As with other salmonids, juvenile steelhead likely move into the lower reaches of Scatter Creek. If steelhead do spawn in Scatter Creek (see discussion in previous section), a larger proportion of the population would be wild than if no spawning occurred, but some hatchery fish would still likely move into the lower reaches of Scatter Creek to rear. This is supported by smolt trap data from 1991, when 21 percent (36 of 171) of steelhead collected in Scatter Creek were of hatchery origin (see Table 6-1).

6.2.6 Pacific Lamprey

6.2.6.1 Occurrence in Scatter Creek

Pacific lamprey were once abundant, but current Pacific lamprey populations in the Pacific Northwest are depressed (Close et al. 1995). The historic and current numbers and distribution of Pacific lamprey in Scatter Creek are unknown. No population estimates have ever been conducted, but they are known to spawn in Scatter Creek. In steelhead redd-count surveys conducted in Scatter Creek from River Mile 0.0 to 0.7 in May of 1990 by the Quinault Tribe (data provided by Rob Rhodes, Quinault Nation Fisheries Biologist), it was noted that approximately 30 lamprey redds were observed. It was not known at the time whether these redds were made by Pacific lamprey or river lamprey, but the general consensus was that they were made by Pacific lamprey. In addition, lamprey (that were generally believed to be Pacific lamprey) were collected during April to June smolt trap surveys from 1986 to 1991. However, exact species, age-class, and numbers of lamprey were not documented (Hanratty 2002 personal communication).

6.2.7 River Lamprey

6.2.7.1 Occurrence in Scatter Creek

There are no definitive accounts of river lamprey inhabiting Scatter Creek. Lamprey redds have been documented and lamprey were collected in the Scatter Creek smolt trap (see discussion of historic and existing use by Pacific lamprey), but these individuals were believed to be either Pacific lamprey or western brook lamprey, and not river lamprey. However, there may be some overlap in the size of adult river lamprey (maximum length 12 inches), Pacific lamprey (maximum length 30 inches), and western brook lamprey (maximum length 7 inches), which could make identification of river lamprey difficult. Therefore, it is not known whether river lamprey inhabit Scatter Creek.

6.2.8 Olympic Mudminnow

6.2.8.1 Status and Life History

The Olympic mudminnow (*Novumbra hubbsi*) is a Washington State sensitive species and is only found in southwestern Washington. Olympic mudminnows inhabit slow-moving streams, wetlands, and ponds. Habitat requirements include little to no current velocity, mud-bottom substrate, and abundant aquatic

vegetation (as reviewed in Mongillo and Hallock 1999). This species has a relatively wide tolerance range for temperature and dissolved oxygen, but a fairly restrictive tolerance range for current velocity and salinity. Olympic mudminnows feed on a wide variety of aquatic invertebrates. Spawning occurs in November, subsides during the winter, resumes in March, and is over by mid-June. Peak spawning is in April and May. Water temperatures during spawning are 10° to 18°C. Adhesive eggs are deposited on vegetation near the bottom. Eggs have been documented to hatch in 9 days at 15° to 17°C.

6.2.8.2 Occurrence in Scatter Creek

Olympic mudminnow were collected by electrofishing in a Scatter Creek tributary north of the city of Tenino in 1997. In this electrofishing survey, 25 individuals were collected, indicating that Olympic mudminnow may be locally abundant in Scatter Creek, which is consistent with the spotty nature of their distribution (Mongillo and Hallock 1999). Olympic mudminnow were also observed in 1990 in the extreme lower end of the watershed near a commercial fish farm outfall that was associated with a wetland near Marble Road (Figure 6-1; WDFW 2002). This site was not connected to Scatter Creek. While Olympic mudminnow do occur in the watershed, the historic and existing population status is unknown.

6.2.9 Reticulate Sculpin

6.2.9.1 Status and Life History

The reticulate sculpin (*Cottus perplexus*) is a Washington State species of concern, but there is no federal listing status. Reticulate sculpin occur in Pacific coastal streams from northern California northward to the Snohomish River in Washington (Wydoski and Whitney 1979) and can be widely distributed and locally abundant within watersheds (Wentz et al. 1998; Graham and Ward 2002). Scatter Creek is near the northern edge of this species' range.

The reticulate sculpin reportedly grows very slowly and attains a maximum length of about 4 inches, with a life span of up to 7 years. Spawning occurs in the spring, and fish first spawn at age 2. They deposit adhesive eggs under rocks and other structures anywhere from close to shore to the middle of the channel, depending on local conditions. After spawning, males guard the nest, and guarding behavior may extend beyond hatching. Males spawn with more than one female, as evidenced by males guarding numbers of eggs greater than are produced by single females. Numbers of eggs per female depend on fish size and have been reported to range from 84 to 432 eggs. The food habits of reticulate sculpin are similar to other sculpin species. They opportunistically feed among the bottom substrate on immature aquatic insects, fish eggs, and fish fry, including salmonids and other sculpins.

The reticulate sculpin is found in riffle and pool habitats in narrow (less than 20 ft wide) Pacific coastal streams, but it inhabits a wide range of current velocities (Wydoski and Whitney 1979). This species prefers cobble and gravel bottom substrate, but is frequently found in slower moving water. The reticulate sculpin has also been known to be confined to pool habitat in the presence of other sculpin species that may outcompete the reticulate sculpin for riffle habitat. It is reported to be relatively tolerant of poor water quality and is frequently found in agricultural areas (Wentz et. al 1998) and urban streams (Graham and Ward 2002). The reticulate sculpin has been collected in water temperatures as warm as 25.5°C, but has usually been collected in water temperatures ranging from 10° to 18°C.

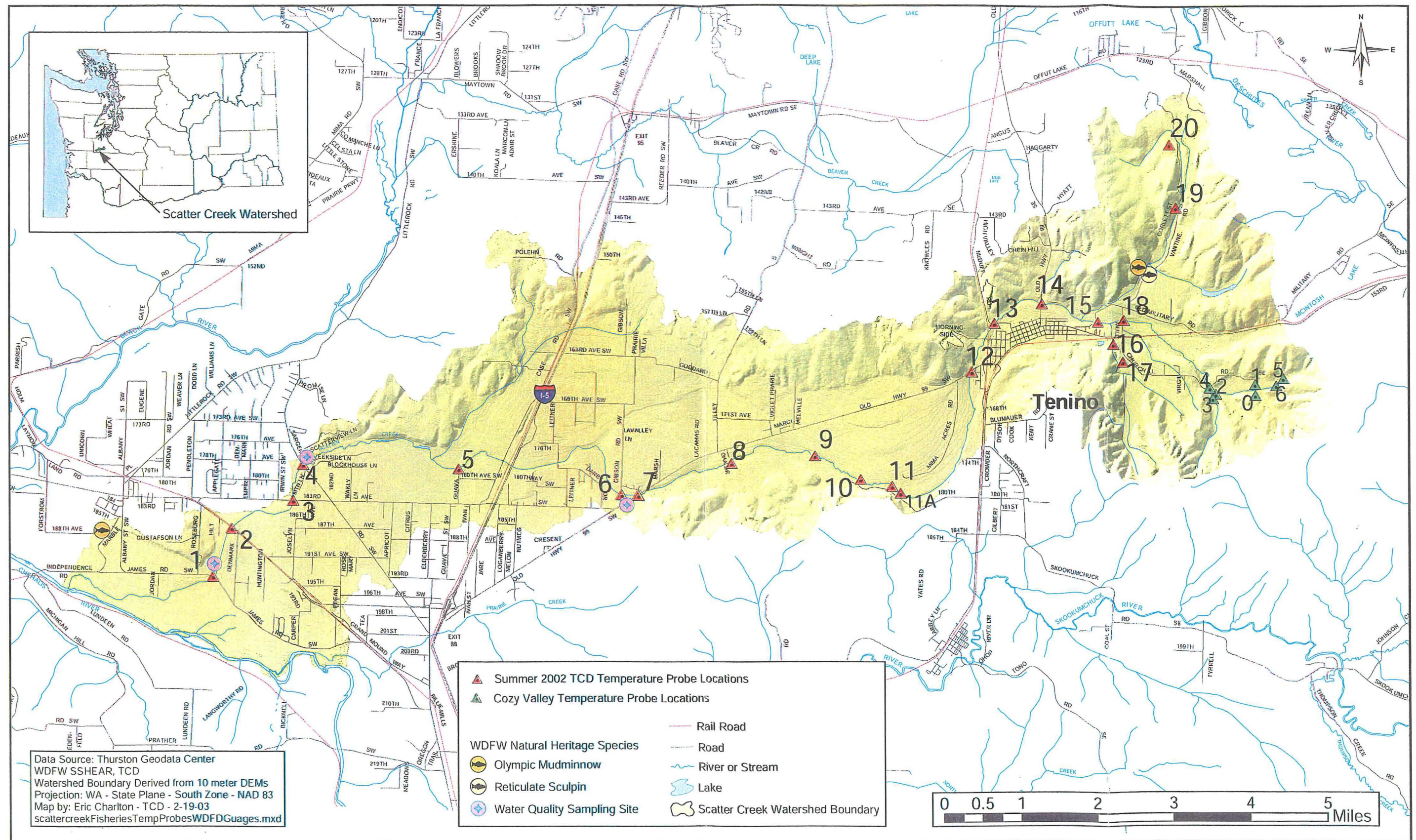


Figure 6-1
Scatter Creek Sub-basin
Temperature Probes, WDFW Natural
Heritage, Water Quality Sampling Sites

6.2.9.2 Occurrence in Scatter Creek

This species was collected in 1997 by electrofishing in a Scatter Creek tributary north of the city of Tenino (see Figure 6-1, WDFW 2002). Though reticulate sculpin reportedly occur in Scatter Creek, population abundance and distribution in Scatter Creek is unknown.

6.2.10 Additional Fish Species

Additional species known to occur in Scatter Creek through incidental observations include redbside shiner (*Richardsonius balteatus*), suckers (unknown species), three-spine stickleback (*Gasterosteus aculeatus*), northern pikeminnow (*Ptychocheilus Oregonensis*), sunfish (unknown species), mountain whitefish (*Prosopium williamsoni*), and western brook lamprey (*Lampetra richardsoni*). Scatter Creek is within the native range of all the above listed species except for the unknown sunfish species (there are no sunfish native to Washington; Wydoski and Whitney 1979). No information is available regarding the abundance or distribution of these species in Scatter Creek.

Atlantic salmon (*Salmo salar*) have also been observed in Scatter Creek (USFWS 1999). These fish are nonnative and originated as escapees from a commercial aquaculture facility sited near River Mile 7 in the proximity of the South WDFW Wildlife Management Area and Interstate 5 (see Figure 4-2 for river miles). This facility has been in operation since 1978, though ownership and name of the facility has changed several times over the years. This facility once produced coho salmon, but now produces approximately 3.5 million Atlantic salmon smolts to be later transferred to ocean net-pens where they are grown to market size. Fishery managers are concerned that escaped Atlantic salmon may impact native fish stocks. Potential impacts by escaped Atlantic salmon include competition, predation, disease transfer, hybridization, and colonization (EAO 1998). The primary regulatory authority over commercial farming of Atlantic salmon in Washington State is WDFW. There are no estimates of how many Atlantic salmon escape into Scatter Creek.

6.2.11 Data Gaps

A significant data gap is detailed knowledge of fish species occurrence, distribution, and abundance in Scatter Creek. In general, there is very little existing information on Scatter Creek fish populations. While there is data from a period of years on coho salmon escapement and juvenile outmigration numbers, there is little knowledge of in-stream habitat use by all fish species at different flows. For example, it is not known what reaches of Scatter Creek support the highest densities of juvenile coho salmon (or other fish species) during periods of low summer flows or high winter flows. Data on fish species other than coho salmon is particularly sparse and has only been collected incidentally. It is unknown or uncertain whether some species occur in the watershed (i.e., river lamprey and steelhead). Some other species are known to occur in Scatter Creek (i.e., Pacific lamprey, Olympic mudminnow, reticulate sculpin, juvenile chinook salmon, cutthroat trout), but how those species utilize Scatter Creek is unknown and no population data is available. River lamprey and Pacific lamprey are both USFWS species of concern, and river lamprey are also a Washington State species of concern. Olympic mudminnow, a state sensitive species, have been identified in the upper Scatter Creek watershed. Given the status of this species, knowledge of its distribution and abundance should be of particular concern. Without better knowledge of fish species use of Scatter Creek, identification of habitat management priorities will be difficult.

6.3 FISH HABITAT

6.3.1 Historic Conditions and Impacts

As summarized in Smith and Wenger (2001), stream and riparian impacts in the Scatter Creek watershed are similar to those found throughout the upper and middle Chehalis River Basin. Based on existing and historic land-uses, agriculture, livestock use, and logging are the primary impacts to Scatter Creek riparian areas. Effects on stream habitat often associated with agricultural development or other land uses include:

- **Clearing of riparian and upland vegetation:** Removal of the tree canopy has multiple effects on stream habitat. Stream shading is reduced, which increases stream temperatures and reduces organic nutrients. Large woody debris that provides fish habitat is reduced or eliminated. Additionally, streambank stabilization is reduced. Loss of bank stability leads to increased sedimentation and stream channel instability.
- **Clearing of in-stream wood:** Removal of in-stream wood eliminates important fish habitat features.
- **Straightening of stream channels:** This practice reduces the amount of stream area and reduces many important aquatic habitat features and natural habitat-forming stream processes.
- **Removal of side channels, sloughs, and ponds:** This practice eliminates important areas of rearing habitat for juvenile salmonids. Beaver removal has also been a common practice. Beaver ponds create habitat complexity, help retain streamflows, and create pool habitat important for juvenile salmonids.

There is little information on historic habitat conditions of Scatter Creek. Riparian buffers along Scatter Creek would have naturally been restricted by soil and water table conditions that are more conducive to the adjacent prairie habitat for most of its length (see Section 5 of this report). Exceptions include the forested upper watershed and the lower reach flowing through the Chehalis River floodplain. While the extent of riparian buffers from the stream edge would not have differed much from what is currently found along Scatter Creek, it is assumed that vegetation in the buffers would have been more continuous and of a different age structure (more mature vegetation due to lack of clearing for agriculture and development) and to some extent would have had a different species composition. A notable exception is the reach of Scatter Creek flowing through the Chehalis River floodplain. This area would have been extensively wooded (see Section 5 of this report), providing good fish habitat. Today, this area is almost entirely cleared of forest and is heavily used as agricultural and grazing land, with little of the historic benefits to fish being retained. Beaver were believed to be historically abundant in Scatter Creek, but populations are likely reduced due to control efforts and changes in riparian extent and/or conditions (Clemons 2002 personal communication).

Though a quantitative analysis was not conducted, a visual comparison of aerial photographs from 1999, 1947, and 1932 indicated that the extent of current riparian buffer widths appear to generally be similar to those of the 1930s and 1940s. That is, no obvious major reductions in buffer widths along Scatter Creek were observed from the aerial photos. By the 1930s, land had already been extensively cleared for agriculture, livestock use, and timber harvesting. Much of this area is still used for these same purposes, so further encroachment has generally not occurred. However, traditional uses are being supplanted by residential development and the associated clearing and/or alteration of additional riparian vegetation. Though the general extent of riparian buffers appears to have changed little over the period from 1932 to

1999, there is no information available or quantified to determine change in riparian condition or extent of conversion within the riparian areas over this time period.

Reports of habitat conditions and fish populations of Scatter Creek prior to the 1980s were limited to a few brief WDF accounts from 1931, 1968, and 1969. Royal (1931) is the earliest agency description of fish habitat in Scatter Creek. The creek was described as being more or less swampy in nature, having alternating areas of slow water and riffles. Spawning area was continuous from the mouth to about River Mile 4. Upstream of that point, spawning habitat was only found in intermittent riffles. At the time it was reported, portions of Scatter Creek had gone dry during the summer for the previous 3 years, but it infrequently did so prior to that according to local residents. As flows ceased, pools became stagnant and many fish in the pools died. This was cited as a cause for consideration in the issuance of future water rights. There were no significant obstructions to fish passage aside from low water conditions, and fish could access the headwaters. A couple of small water diversions (one diverting water into a small pond intended for a beaver farm) and a small dam located in the Rochester area were noted. An account from 1969 cites lack of juvenile rearing habitat during summer low flows as a limiting factor for coho salmon (Tollefson 1969).

Brief reports on Scatter Creek from 1968 (WDF 1968) list conditions at three specific Scatter Creek locations as follows:

- **August 9, bridge crossing of SR 507 at River Mile 9 (T16N, R2W, S32)** – Stream width of 21 ft, low gradient, slow water velocity, flow of 2 cfs, maximum depth of 2 ft, 90 percent pools, and 10 percent riffles. Substrate consisted of 30 percent sand, 10 percent gravel, 30 percent cobble, and 30 percent boulder. Fish species included coho salmon, suckers, and stickleback. The stream at this location was 30 percent shaded with little overhanging vegetation.
- **April 30, road crossing of Vantine Rd. (T16N, R1W, S9)** – low gradient, flow of 2 cfs, no spawning areas, channelized streambed, all mud substrate, alternating pasture land and mixed forest, 50 percent shaded, fish species included stickleback and cutthroat trout, several beaver dams, and noted that there was no gravel from this point downstream to SR 507.
- **April 30, road crossing of Old Hwy 99 (T16N, R1W, S19)** – low gradient, 95 percent pools, substrate was mud-covered gravel, well-shaded, and coho fry present.

These three sites are singled out because they are the only available source of site-specific fish and stream habitat information available for Scatter Creek prior to the 1980s.

There is some controversy as to whether McIntosh Lake was once the headwaters of Scatter Creek. One account stated that Scatter Creek flowed out of the lake through a control structure and then under the road and railroad grade. It was not clear from a field inspection or aerial photographs whether the area had been filled or excavated from original conditions. Currently, there is a channel at the west end of McIntosh Lake that travels under the existing railroad grade, but the channel flows east into the lake at a fairly steep gradient. A mix of glacial deposits and bedrock was modified for the railroad and highways at this location, leaving different cut and fill areas and resulting in an unclear depiction of the original surface without detailed surface and subsurface mapping of materials. The elevation of the existing culvert under the railroad grade is considerably higher (visually estimated to be about 20 or 30 ft) than the lake level, and the culvert is graded to flow easterly into the lake. In addition, the edge of the Scatter Creek watershed appeared to be very close to the same elevation as the railroad grade. In order for water to flow westerly out of the lake and into the current Scatter Creek watershed, the lake level would need to be considerably higher, perhaps even higher than the elevation of the existing railroad grade. Obviously,

the lake level did not exceed the level of the railroad grade. However, there has been speculation that the area around the west end of the lake has been extensively filled. It may have been possible for Scatter Creek to flow westerly out of McIntosh Lake only if the area across the railroad grade from the lake (on the current Scatter Creek side) had been extensively filled and if the culvert under the railroad grade was lower than the lake elevation. No information was found to indicate whether this was the case.

If McIntosh Lake was the historic source of Scatter Creek, then Scatter Creek may have once had a higher base flow. A higher base flow would provide cooler more stable stream temperatures from those currently observed and likely also provided more available year-round fish habitat. In particular, more juvenile rearing habitat may have been available. The area around the west end of the lake (including existing roads, the railroad grade, and potentially some residential and agricultural lands) would require extensive modifications to restore McIntosh Lake as the headwaters of Scatter Creek. However, more information would first be necessary to determine whether McIntosh Lake was indeed once the source of Scatter Creek.

6.3.2 Existing Conditions and Impacts

Most of the Chehalis River Basin (87 percent) is upland mixed species forestland, and an additional 7 percent of the land base is agriculture (Envirovision 2000). Commercial dairy, livestock, and crop farming operations are predominantly located in the low-lying valleys adjacent to the Chehalis River and its tributaries, including Scatter Creek. Land uses along Scatter Creek include large- and small-scale agricultural, residential, rural residential, forestry, and wildlife areas (Figure 6-2). Agriculture is the dominant land use along Scatter Creek in the Chehalis River floodplain and between Interstate 5 and the city of Tenino. Residential and rural residential/small-scale agriculture is concentrated around the cities of Rochester and Tenino. Upstream of Tenino, data is not available on land use types along Scatter Creek (see Figure 6-2), but observations indicate it is a mix of forestry, rural residential, and small-scale agriculture. Little forestry activity currently occurs along Scatter Creek. In addition, approximately 2 miles of Scatter Creek downstream of Interstate 5 is within a WDFW Wildlife Management Area.

6.3.2.1 Floodplain and Riparian Conditions

Several types of floodplain and riparian impacts have been identified. The USFWS, in conjunction with WDFW, conducted an extensive survey of most of the Chehalis River Basin upstream of the Humptulips River, including Scatter Creek, to identify specific habitat problems and compare to land uses where observed (Wampler et al. 1993). The most significant habitat problems or management issues in Scatter Creek and its tributaries identified in this study included the following³:

- Loss of stream canopy due to agricultural activities - 17.6 miles (58 percent) of Scatter Creek distributed throughout (Figure 6-3).
- Streamside vegetation loss - 13.2 miles in Prairie Creek and Scatter Creek (Figure 6-3).
- 5,659 ft of streambank hardening (riprap) was identified on an upper watershed tributary (Figure 6-4).

³ Wampler et al. (1993) included Prairie Creek in the Scatter Creek Subbasin. However, Prairie Creek is not included in the Scatter Creek HCP. Therefore, it has been indicated in this report when Prairie Creek data is included. When Prairie Creek data is included, refer to Figures 6-3 through 6-7 for distributions of impacts or land uses in the Scatter Creek watershed.

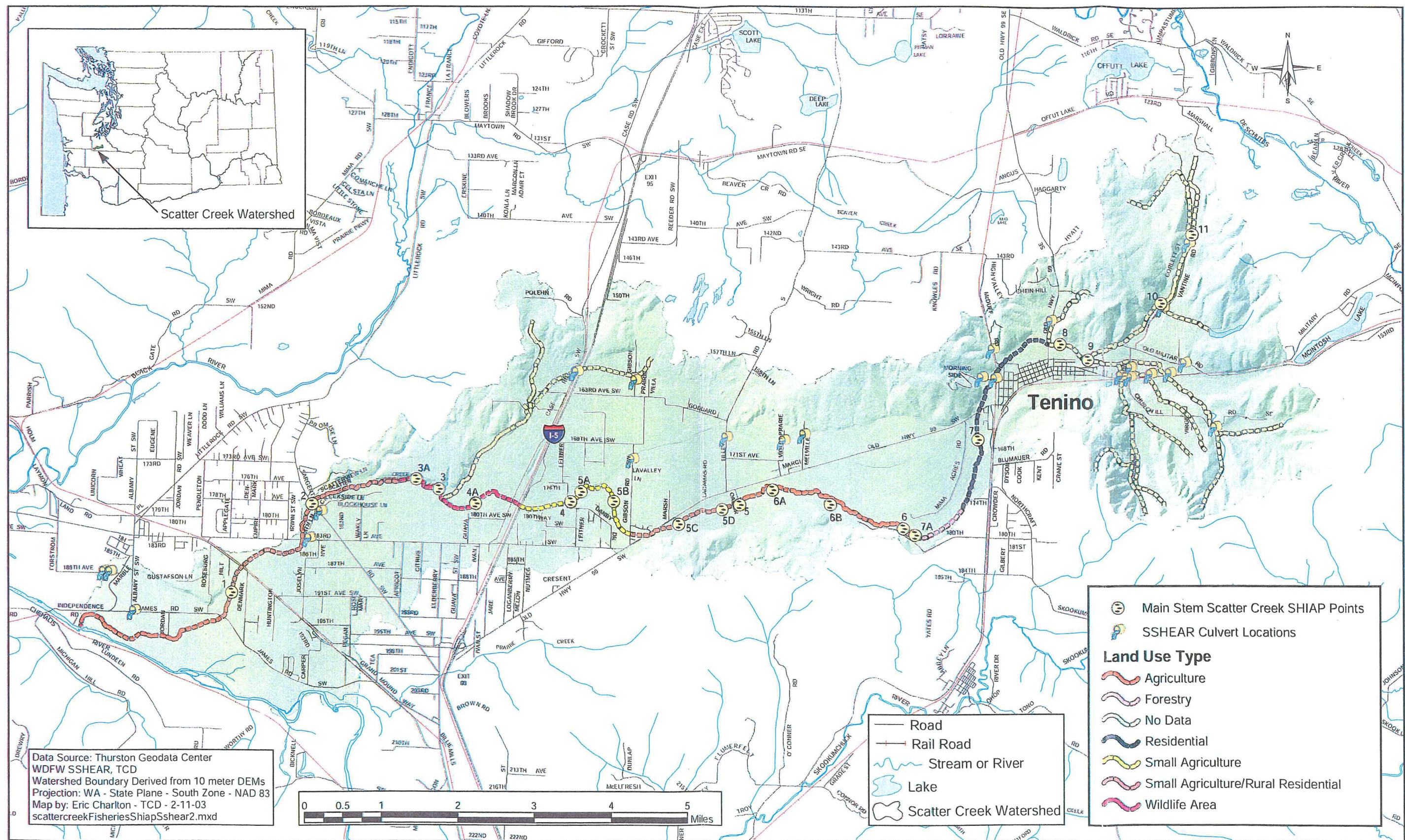
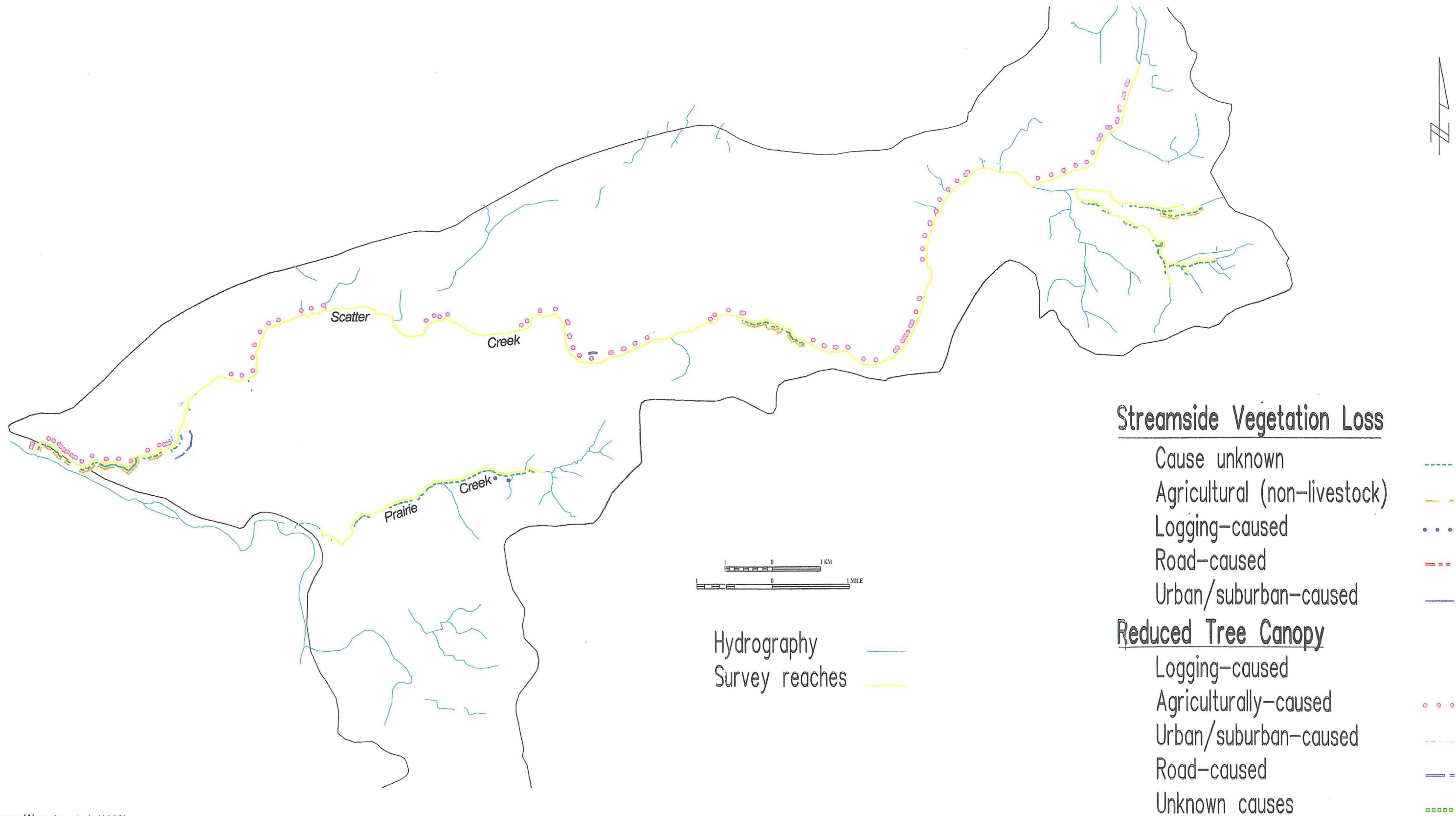
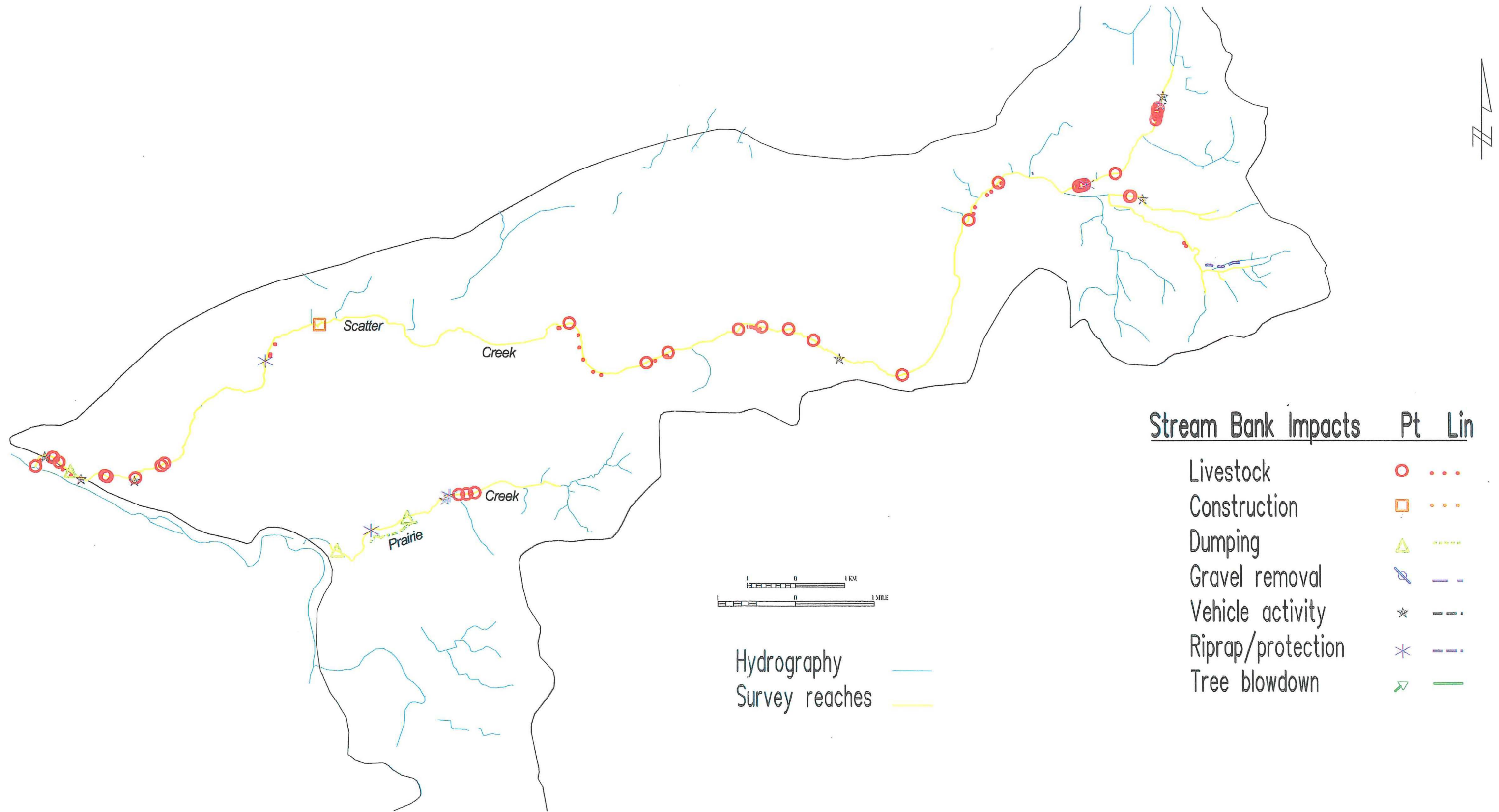


Figure 6-2
Scatter Creek Sub-basin
Land Use Segments, SHIAP
Points, SSHEAR Culverts



Source: Wampler, et.al. (1993)

Figure 6-3
Scatter Creek Sub-basin
Streamside Vegetation Loss
and Reduced Tree Canopy



Source: Wampler, et.al. (1993)

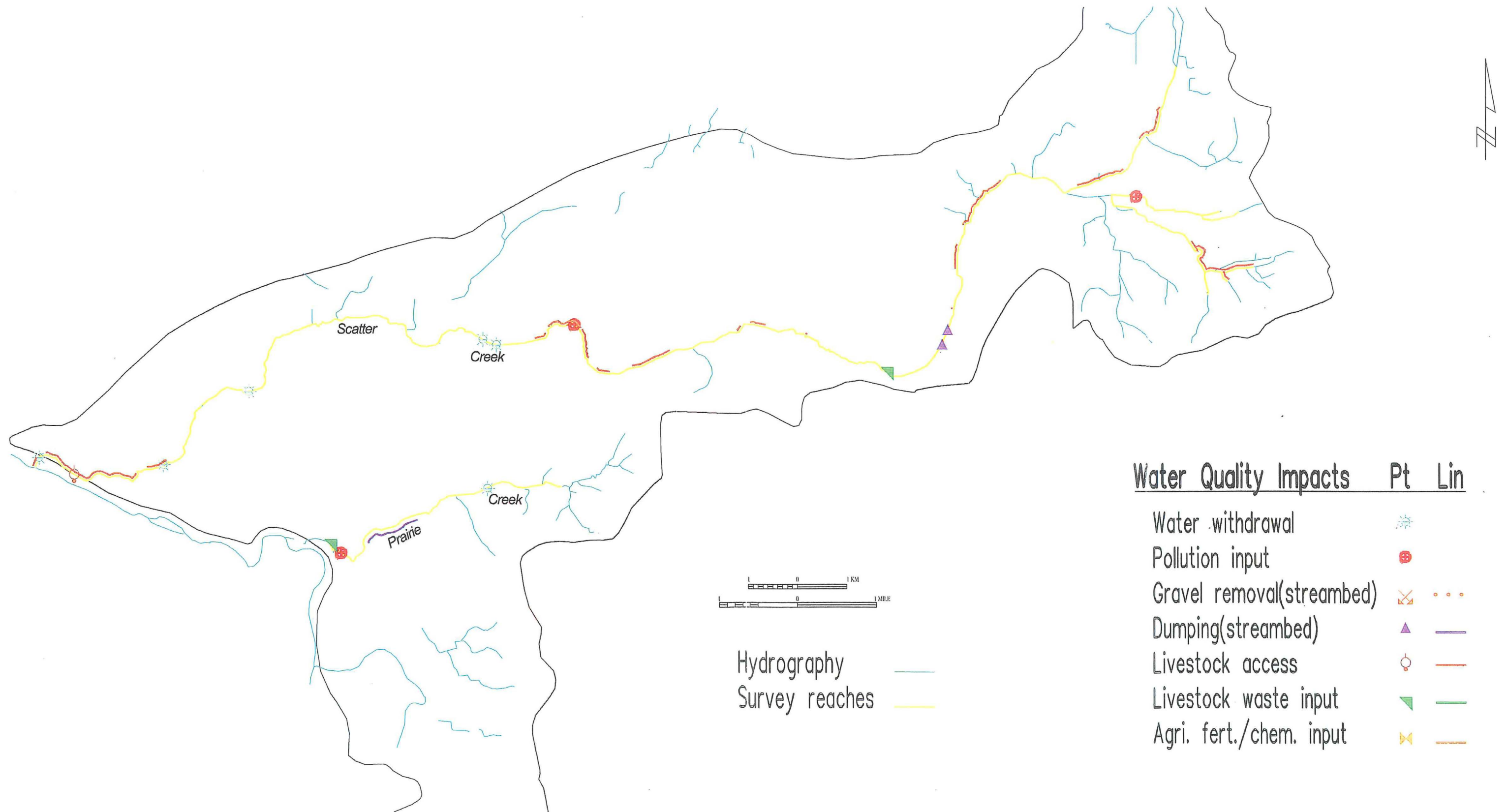
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Thurston Conservation District
Scatter Creek Habitat Conservation Plan
Associated Reports

6-19

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February 2003

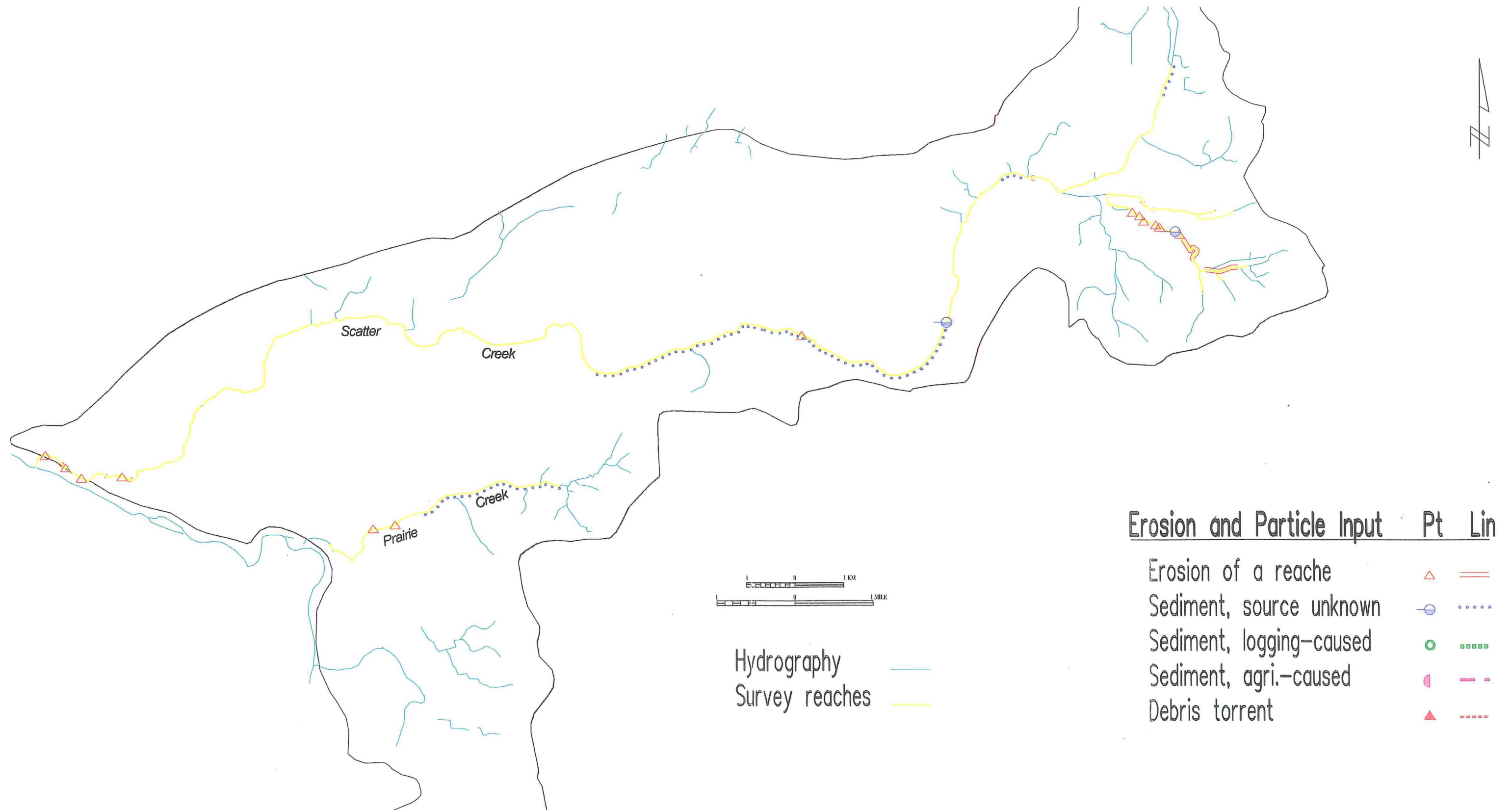
Figure 6-4
Scatter Creek Sub-basin
Stream Bank Impacts Indirectly
Limiting to Fish Habitat



Source: Wampler, et.al. (1993)

Parametrix Scatter Creek 553-4335-001/01(04) 02/03 (K)

Figure 6-5
Scatter Creek Sub-basin
Water Quality Impacts Indirectly
Limiting to Fish Habitat



Source: Wampler, et.al. (1993)

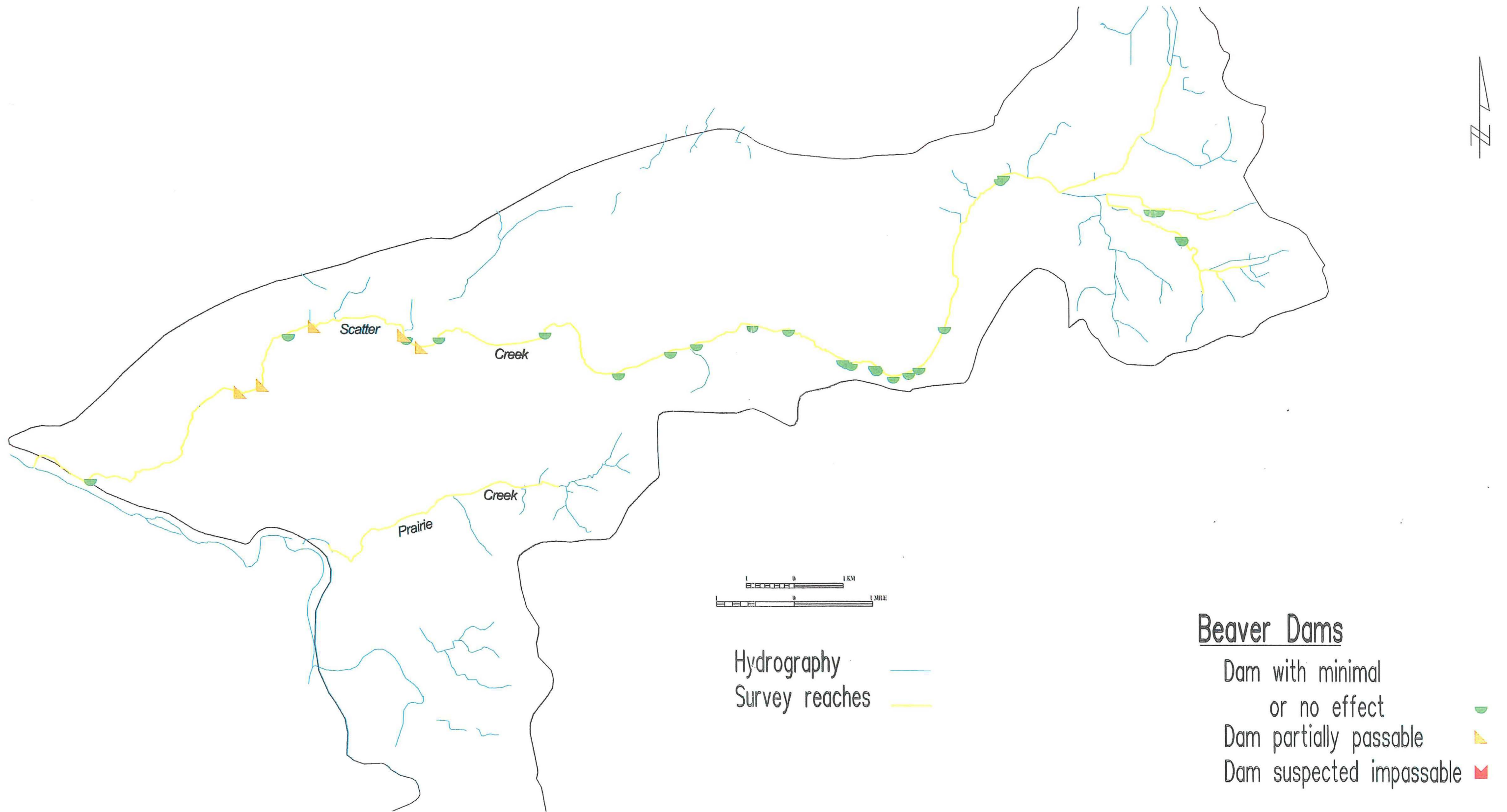
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Scatter Creek Habitat Conservation Plan
Associated Reports

6-21

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February 2003

Figure 6-6
Scatter Creek Sub-basin
Bank Erosion, Deposited
Sediment, and Related Impacts



Source: Wampler, et.al. (1993)

Parametrix Scatter Creek 553-4335-001/01(04) 02/03 (K)

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Associated Reports

Figure 6-7
Scatter Creek Sub-basin
Beaver Dam Affect on Fish Passage

- Streambank impacts by livestock - 3.1 miles (10 percent) of Scatter Creek in the upper watershed, the middle third of the mainstem, and in the Chehalis River floodplain reaches (Figure 6-4).
- Livestock access to the stream - 11.7 miles (39 percent) of Scatter Creek in the upper watershed, the middle third of the mainstem, and in the Chehalis River floodplain reaches (Figure 6-5).
- Six known and suspected water withdrawals (Figure 6-5).
- Excessive in-stream sediments - 8.5 miles in mid-Scatter Creek and Prairie Creek (Figure 6-6).

Several tributaries in the upper watershed have been modified. These channels were straightened to serve as drainage ditches, and some have been relocated. Side channel habitat is lacking in most reaches. It was speculated in the WRIA 23 Limiting Factors Analysis (Smith and Wenger 2001) that side channel habitat may have been naturally limited in Scatter Creek because of the lack of side channels in both developed and undeveloped reaches. However, portions of the Colvin property (SHIAP point 6B; see Figure 6-2) contains abundant side channel habitat as a result of abundant large woody debris, riparian vegetation (particularly trees growing out of the streambanks or directly out of the wetted channel), and beaver activity. Beavers create areas of ponding and side channels. In the early 1990s, beaver dams were found throughout Scatter Creek (Wampler et al. 1993; see Figure 6-7). In 2003, beaver activity was also observed. In general, reaches with beaver dams showed the greatest habitat complexity and value as fish habitat. Beavers reportedly were historically abundant in Scatter Creek, but populations have likely been reduced through control efforts (Clemons 2002 personal communication). These observations suggest that fish habitat may have been more abundant and of higher quality when beavers were more abundant, particularly in areas where riparian vegetation is found near and in the wetted channel.

Riparian vegetation along Scatter Creek is dominated primarily by forest – hardwood vegetation. Typical dominant species include Oregon ash (*Fraxinus latifolia*), red alder (*Alnus rubra*), Oregon white oak (*Quercus garryana*), Pacific willow (*Salix lasiandra*), and cascara (*Rhamnus purshiana*) in the overstory; and red-osier dogwood (*Cornus sericea*), vine maple (*Acer circinatum*), snowberry (*Symphiocarpus albus*), Pacific ninebark (*Physocarpus capitatus*), rose (*Rosa* spp.), Douglas spirea (*Spiraea douglasii*), and reed canarygrass (*Phalaris arundinacea*) in the understory. Riparian species composition is similar along the entire creek with the exception of some scattered disturbed segments. These segments are composed of non-forest vegetation (grasses) mainly from agriculture and pastureland abutting the creek. Dominant species are domestic grasses and reed canarygrass (see Section 5 of this report).

As previously discussed, riparian vegetation is naturally restricted by features that support prairie habitat rather than riparian habitat. Therefore, the lateral extent of riparian vegetation is likely similar to historical conditions, but probably not as continuous or mature as a result of land uses. Riparian buffer widths were estimated at stream survey locations in 1999 (see SHIAP points on Figure 6-2). Buffer widths were generally less than 15 m (49 ft) in Reaches 1 (near the mouth), 6, and 7 (Appendix C). In Reaches 3, 4, and 5, buffer widths widely fluctuated from less than 15 m (49 ft) to greater than 40 m (131 ft). Riparian trees were dominated by small to medium hardwoods (Appendix C) and canopy closure ranges from 24 to 69 percent (Table 6-4) (TCD 1999).

6.3.2.2 In-stream Habitat

Elevated water temperatures, sedimentation, little stream shading, low pool frequency, and lack of off-channel habitat are primary concerns for Scatter Creek (Envirovision 2000). Other features such as

woody debris and streambank condition are good in some areas, but locally degraded in other areas due to loss of riparian buffer and livestock activities.

There has been one comprehensive in-stream habitat survey conducted in Scatter Creek by the Thurston County Conservation District (TCD 1999). Data was collected at a number of locations extending from the mouth upstream to near the city of Tenino (see SHIAP points 1A through 7A in Figure 6-2). Results of the survey and determinations of overall condition (as presented in the report) are summarized in Table 6-4. Habitat ratings were based on two documents: the Washington State Standard Methodology for Conducting Watershed Analysis (WFPB 1997) and the NOAA Fisheries Matrix of Pathways and Indicators (NOAA Fisheries 1996).

Table 6-4. Results of In-stream Habitat Survey of Scatter Creek Conducted in 1999

Stream Segment	Total Habitat Units	Pool Frequency (BFW per Pool)	Percent Pool Area	Large Woody Debris (No. per BFW)	Width to Depth Ratio ^b	Mean Percent Fines	Mean Percent Canopy Closure
1A	6	5.7 poor	77.2 good	2 good	16.3 NPF	25.9 poor	32.1
3A	NA	NA	24.6 poor	3.5 good	29.9 NPF	15.5 fair	34.1
4A	1	55.3 poor	100 good	4.4 good	37.1 NPF	NA	46.8
5A	3	NA	NA	2.9 good	17.6 NPF	NA	59.9
5B	27	4.7 poor	51 fair	1.5 fair	30.2 NPF	44.9 poor	27.3
5C	10	8.2 poor	37.1 poor	0.3 poor	31.4 NPF	NA	24.2
5D	NA	NA	NA	7.4 good	64 NPF	NA	51.9
6A	9	38.6 poor	42.2 fair	2.5 good	22.8 NPF	NA	66.8
6B	141 ^a	3.5 fair	49 fair	1.4 fair	21.3 NPF	27.2 poor	65.1
7A	NA	NA	NA	1.7 fair	25.9 NPF	18.6 poor	27.4

^a Includes 99 main-channel, 14 secondary-channel, and 28 side channel units.

^b NPF = not properly functioning.

Source: TCD 1999

In general, the number of habitat units is low, indicating low habitat diversity. A notable exception is Reach 6B located on the Colvin property. This reach contained 141 total habitat units including, abundant secondary and side channel units (see Table 6-4). The buffer width along this reach is generally less than 15 m (49 ft) wide (see Reach 6 in Appendix C). But unlike most other reaches of Scatter Creek, some of which have much wider buffers, riparian trees in Reach 6 are growing out of the stream channel and the streambanks close to the channel, thus providing abundant in-channel wood and habitat diversity. In addition, beavers have created a series of pools and riffles that provide abundant coho salmon rearing habitat.

Ratings of pool frequency, width-to-depth ratio, and mean percent fines in all reaches were rated as poor or not properly functioning based on criteria described in NOAA Fisheries (1996) and WFPB (1997) (see

Table 6-4). Though pool frequency was rated poor, percent pool area was rated as good in Reaches 1A and 4A (other reaches were rated fair or poor). It should be noted that large woody debris was rated good in many reaches (1A, 3A, 4A, 5A, 5D, and 6A), several of which have been extensively cleared (e.g., Reach 1A near the mouth of Scatter Creek) and have narrow buffer widths that provide little wood recruitment potential. Additional data from the same stream survey reported large woody debris as being sparse in many of those reaches that rated good for large woody debris (Appendix C). Streambank stability was greater than 90 percent in virtually all reaches (Appendix C). Overhanging streambanks were lacking in all reaches other than Reach 6. Overhanging vegetation was also more abundant in Reach 6.

The habitat criteria described in NOAA Fisheries (1996) and WFPB (1997) were generally developed from data collected in forested headwater systems and are not necessarily applicable to many streams. In fact, these criteria are often intended to be modified based on expected natural conditions. Scatter Creek is a low-gradient prairie stream, and natural pool frequency or large woody debris conditions in Scatter Creek are not likely to be the same as in forested headwater systems. Therefore, ratings of Scatter Creek habitat conditions presented in TCD (1999) may yield misleading conclusions. Therefore, it may be necessary to better estimate natural habitat conditions or reevaluate existing habitat data for Scatter Creek to determine future management alternatives.

6.3.2.3 Habitat Access

Access to available habitat in Scatter Creek is good. No fish passage barriers were reported in TCD (1999), and no dams or fishways were identified for Scatter Creek in the SSHEAR database. A total of 24 culverts in the Scatter Creek watershed are identified in the SSHEAR database (see Figure 6-2; SSHEAR 2002). Of these, 14 were identified as having fish use (Table 6-5), and none of these were determined to be a barrier to fish passage. It is assumed that criteria used to determine fish use follow guidelines specified in the *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual* (WDFW 2000). All of the culverts in the SSHEAR database are publicly owned (city, county, or state). However, there are many privately owned culverts throughout the watershed that have not been assessed, and the fish passage status of these culverts is unknown. For example, a series of seven small culverts on Cozy Valley Creek just upstream of the confluence with Crawford Creek periodically fail and flood, stranding salmon.

6.3.2.4 Data Gaps

In-stream, floodplain, and riparian habitat have been fairly well investigated, primarily due to two significant assessments: Wampler et al. (1993) and TCD (1999). Identified data gaps or future data collections that would be useful for fish management include the following:

- Additional stream habitat surveys to further characterize stream habitat.
- Estimates of natural in-stream habitat criteria more specific to Scatter Creek to determine future management priorities and alternatives.
- An assessment of culverts and fish passage on private lands.
- Monitoring of stream habitat responses to restoration activities or significant changes in land uses.

Table 6-5. Culverts with Identified Fish Use in the Scatter Creek Watershed

Site ID	Road Name	Milepost	Stream	Fish Use	Owner	Shape ^a	Material	Barrier
3410052			Scatter Cr	yes	county	RND	PCC	no
3410050			Scatter Cr	yes	county	RND	PCC	no
3410050			Scatter Cr	yes	county	RND	PCC	no
3410500			Scatter Cr	yes	city	SQSH	CST	no
3410500			Scatter Cr	yes	city	RND	CST	no
340450	Churchill Rd SE	1.526	Trib to Scatter Cr	yes	county	RND	CST	no
3410075	Mull Rd SE		WRIA 23.0720 ^b	yes	county	RND	PCC	no
342111	Northcraft Rd SE	0.912	Trib to Scatter Cr	yes	county	RND	CST	no
342021	Morningside Dr SE	0.580	Trib to Scatter Cr	yes	county	RND	PCC	no
991662	SR 507	15.710	Trib to Scatter Cr	yes	state	BOX	PCC	no
991663	SR 507	16.100	Trib to Scatter Cr	yes	state	BOX	PCC	no
991664	SR 507	16.350	WRIA 23.0719 ^b	yes	state	RND	CST	no
343155	Vantine Rd SE	0.664	Scatter Cr	yes	county	RND	PCC	no
343162	Vantine Rd SE	1.616	Scatter Cr	yes	county	RND	CST	no

^a RND = round, SQSH = squashed, PCC = Polyethylene, CST = corrugated steel

^b Stream identification number is from Williams et al. (1975).

Source: SSHEAR (2002)

6.4 SURFACE WATER QUALITY

6.4.1 Water Quantity

From 1993 to 1999, the mean annual flow at the Thurston County James St. stream gage (River Mile 2.2⁴) was 78.9 cfs (maximum = 1,362 cfs, median = 26 cfs, minimum = 2.9 cfs; Figure 6-8). Significant portions of Scatter Creek typically are dry during summer months and remain dry until fall rains. Winter flows generally fluctuate between 80 and 300 cfs. Most of the Scatter Creek Basin is underlain by about 100 ft of Vashon outwash gravels. An extensive aquifer is associated with this glacial material, and this surficial aquifer provides a significant portion of the streamflow, particularly during low-flow periods. Refer to Section 4.4.5 for a more detailed discussion of low flows, base flows, and flood flows in Scatter Creek. During a site visit in early November of 2002, Scatter Creek was dry through the city of Tenino, and throughout a long stretch of stream extending from the Colvin property (between approximately River Mile 12 and 13) downstream to approximately River Mile 7 immediately downstream of a commercial aquaculture facility that has been in operation since 1978.

This commercial aquaculture facility has a significant effect on Scatter Creek. The facility continuously extracts 8,000 to 10,000 gallons of groundwater per minute during year-round operation. Though some water is lost in the process, much of it is treated and returned to Scatter Creek as surface water. As a result, approximately the lower 7 miles of Scatter Creek remains watered year-round and maintains rearing habitat during periods of low late-summer flow. Upstream of this point, there are significant reaches of Scatter Creek that are dry during the summer. Therefore, while much of Scatter Creek remains watered year-round, the release of water downstream from the aquaculture facility significantly increases

⁴ This river mileage is based on Figure 4-2 of this report.

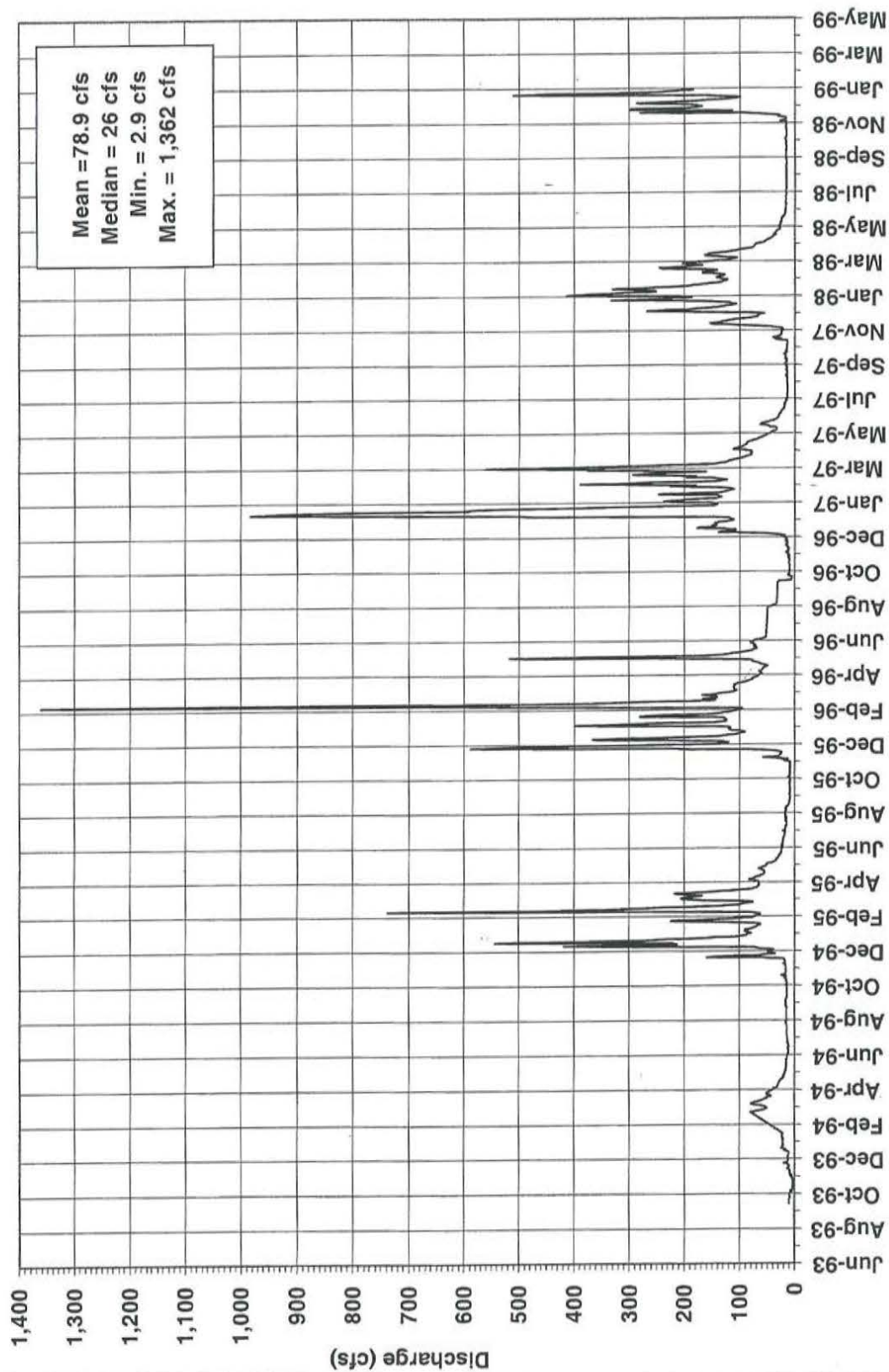


Figure 6-8. Mean Daily Flows in Scatter Creek at James St. Bridge (River Mile 2.2) from June 1993 to May 1999

Source: USGS

the overall amount of available fish habitat in Scatter Creek during critical dry summer months. The quantity and quality of water used by the fish farm is regulated by Ecology.

6.4.2 Water Quality

6.4.2.1 Water Quality Standards

Surface water quality standards have been established for different classes of water bodies in the State of Washington (WAC173-201A). Standards for rivers and streams range from Class AA (Extraordinary) to Class C (Fair). Stream class designations are based on present and potential benefits of the water, and class standards are used as guidance for meeting these potential benefits. Excursions from these standards warrant listing under Section 303(d) of the Clean Water Act. The most current 303(d) list of streams that do not meet water quality standards is from 1998, but a draft of an updated list is expected for public comment in the spring of 2003.

The majority of the Chehalis River Basin, including Scatter Creek, is defined as Class A (excellent) waters. Class A waterbody standards are presented in Table 6-6. Where applicable, the characteristic uses designated for protection in a Class A waterbody include water supply (domestic, industrial, agricultural), fish and shellfish use (including salmonid/nonsalmonid migration, rearing, spawning, and harvesting), wildlife habitat, recreation, commerce, and navigation (Washington Administrative Code [WAC] 173-201A-030).

Table 6-6. Water Quality Standards for Class A Waters of Washington State

Water Quality Parameter	Class A Waterbody Standard
Temperature	Temperature shall not exceed 18.0°C due to human activities. When natural conditions exceed 18.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C
pH	6.5 to 8.5 (freshwater), with a human-caused variation within the above range of less than 0.5 units
Fecal Coliform	Shall not exceed a geometric mean of 100 colonies/100mL and shall not have greater than 10 percent of all samples exceeding 200 colonies/100mL
Dissolved Oxygen	Shall exceed 8.0 mg/L
Turbidity	Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU

NTU = nephelometric turbidity units.

Source: WAC 173-201A.

Nutrient water quality criteria have been established for different nutrient ecoregions by the U.S. Environmental Protection Agency (USEPA 2000). The criteria for Nutrient Ecoregion II (which includes Scatter Creek) are presented in Table 6-7.

**Table 6-7. Water Quality Nutrient Criteria for Nutrients in Rivers and Streams
in Nutrient Ecoregion II**

Nutrient Parameter	Nutrient Reference Condition	Range of Reference Conditions
Total Phosphorus (mg/L)	0.01	0.003 – 0.0325
Total Nitrogen (mg/L)	0.12	0.0 – 0.53
Chlorophyll a (µg/L)	1.08	0.7 – 2.95
Turbidity (NTU)	1.3	0.25 – 5.5

Source: USEPA (2000).

6.4.2.2 Overview of Water Quality Problems of the Chehalis Basin

The following water quality problems have been identified in the Chehalis River Basin:

- Temperatures in excess of Class A standards (18°C) have been observed throughout the Chehalis River system in most years. High temperatures have been identified as one of the water quality problems restricting the effort to restore anadromous salmonid fisheries in the Chehalis Basin (Ecology 2001). Human activities have resulted in changes in the landscape (e.g., loss of riparian vegetation and development) that elevate water temperatures.
- Low dissolved oxygen (DO) was identified as a significant problem in many areas of the Chehalis system during low flows. Surface waters are often below oxygen saturation levels and bottom waters sometimes exhibit severely depressed or even oxygen-devoid conditions. DO levels of the Chehalis River in the vicinity of Scatter Creek and the Black River are the result of nutrient inputs. Nutrients are essential to the health and diversity of our surface waters. However, in excessive amounts, nutrients can result in overgrowth of plant life and increased sediment accumulation. Low DO concentrations can result from the high biological oxygen demand of bacteria that decompose algae and plant material. High biological oxygen demand also results from the decomposition of livestock waste (Jennings and Pickett 2000).
- Fecal coliform bacteria were identified as a widespread problem in the Chehalis River Basin. Fecal coliform bacteria originate from mammal wastes (including humans) and are primarily an indicator of conditions that are potentially hazardous to human health. Increases in stream concentrations are often associated with rainfall events that carry waste into streams through surface runoff (Envirovision 2000).
- There are high levels of turbidity associated with wet season runoff that may be associated with land use activities and non-source point pollution (Envirovision 2000).
- There are apparent violations, or potential for violation, of toxicity and metals water quality standards at several locations in the Chehalis River Basin.

6.4.2.3 Water Quality of Scatter Creek

Water quality problems in Scatter Creek are similar to those found elsewhere in the Chehalis River Basin. Key water quality parameters in Scatter Creek are discussed in the following sections. Other measured water quality parameters not discussed are included for reference in Tables 6-8 and 6-9 (at the end of this discussion) and Appendices D and E.

Generally, water quality criteria in this section are compared with existing Washington water quality standards (WAC 173-201A). In the current rule, each waterbody is assigned to one of five classes: Class AA, Class A, Class B, Class C, and Lake Class. Class AA and Lake Class are considered the highest quality waters and are clean enough to support all uses. A set of beneficial uses that must be protected and the amount of allowed pollution are associated with each water quality classification. Ecology is proposing to revise the existing water quality standards from a class-based system to a use-based system. The key difference between the class-based format and a use-based format is in the way uses are assigned for protection. Rather than assigning waters to classes of predetermined sets of beneficial uses, the new rules would assign beneficial uses (independent of other uses) to waterbodies based on what the waters are likely to potentially support. This method of applying standards also allows for greater flexibility in evaluating water quality conditions relative to biological requirements.

Water Temperature

Scatter Creek is on the 303(d) list for temperature based on exceedances of the Class A standard (18°C) during 1991 and 1992 (Pickett 1994). These maximum temperatures were greater than 20°C. Data collected as part of the Chehalis River Basin Water Quality Screening also documented maximum temperatures greater than 20°C (Table 6-8 and Appendix D). From 1993 to 2002, a maximum temperature of 20.3°C was also recorded (Table 6-9; Thurston County Environmental Health Division Database). Maximum recorded summer water temperatures exceeded the rearing standard for coho salmon (18°C; NOAA Fisheries 1996) and bull trout (12°C; USFWS 1998). Water temperatures recorded during salmonid spawning periods and winter months (November through May) were generally less than 10°C and suitable for salmonid spawning and incubation.

In 2002, the TCD monitored water temperature in June, July, and August at 20 stations extending from the mouth upstream into tributaries of the upper Scatter Creek watershed (see Figure 6-1).⁵ Mean and median temperatures ranged from 13° to 18°C for most sites (Table 6-10). All stations except Stations 5 and 8 recorded maximum temperatures that exceeded 18°C and often exceeded 20°C (Table 6-10). The highest temperatures were greater than 24°C at Stations 1, 2, and 17. From July 13 to August 5, similar trends in maximum daily water temperature were observed among stations that roughly mimicked the pattern of change in air temperature over that period (Figure 6-9). That is, as air temperature increased, water temperature also increased. However, water temperatures at Stations 5 and 8 were remarkably cool (maximum = 12° and 13.5°C respectively) and stable with little difference between the maximum and minimum temperatures (Figure 6-9, Figure 6-10, Table 6-10). Station 5 is located immediately downstream of the aquaculture facility at River Mile 7, where temperatures are cool and stable due to groundwater that is pumped and eventually released into Scatter Creek. A large influx of groundwater largely explains the observed temperatures at Station 8 (located in the Violet Prairie area), but the temperature gage at Station 8 was also located underneath a bridge, where water was constantly shaded. This may provide insight into the benefit of complete stream shading on water temperature, particularly in a system such as Scatter Creek that typically has very low summer flows and lengthy stream sections that dry up. As flows decrease, stream sections become shallow and ponded, with little to no current velocity. Shallow waters are highly susceptible to warming and becoming stagnant if unshaded. Any fish trapped in these areas are then subjected to unacceptably warm temperatures and low DO. Therefore, complete stream shading may be of greater importance for fish survival in Scatter Creek than it would be in streams having greater summer flows.

Wampler et al. (1993) reported riparian vegetation loss of 60 percent and a canopy reduction of 53 percent for Scatter Creek, which contributed to elevated water temperatures. The *Upper Chehalis River*

⁵ Stations 12 and 13 near the city of Tenino were excluded because they were known to have gone dry.

Basin Temperature Total Maximum Daily Load Study (Ecology 2001) recommends that a combination of passive restoration (letting trees grow to maturity where they exist) and active restoration (tree planting) be used to achieve the levels of riparian shade necessary to reduce water temperatures. The total maximum daily load (TMDL) study also recognized that restoring shade in the riparian zone won't happen immediately. It established a goal of reaching recommended shade levels by 2065 and predicted that allowing existing riparian vegetation along Scatter Creek to reach maturity (estimated time = 150 years) would not completely achieve the 18°C standard, but would reduce temperatures. The TMDL also recognized the effects of river flow on temperature, and recommended that if flows can't be increased from current levels, they at least be protected from further reduction. No detailed plans for restoration of Scatter Creek riparian areas were included in the TMDL study.

pH

Scatter Creek is on the 303(d) list for pH based on exceedances of Class A criteria (6.5 to 8.5) during 1991 and 1992 (Pickett 1994). This data is represented in Table 6-8 and Appendix D, where a maximum pH of 9.0 was recorded. Additionally, a minimum pH of 6.2 was recorded between 1993 and 2002, which is below the minimum Class A pH standard (Table 6-9; Appendix E).

Fecal Coliform Bacteria

Fecal coliform bacteria originate from mammals (including humans), but are most frequently associated with livestock waste in agricultural areas. Fecal coliform bacteria are not a direct health hazard to fish. Scatter Creek is on the 303(d) list for fecal coliform bacteria based on exceedances of the Class A criteria (100 colonies/100 mL) during 1991 and 1992 (Pickett 1994). Levels as high as 1,500 and 2,015 colonies/100mL were recorded (Tables 8 and 9; Appendices D and E). The highest concentrations of fecal coliform bacteria are generally associated with rainfall events that carry animal waste into streams as nonpoint source pollution via surface runoff (Envirovision 2000). A draft TMDL for fecal coliform bacteria in the Greys Harbor/Chehalis Basin, and load allocations and need reductions are planned for upper Chehalis River streams (Rountry and Pelletier 2002).

Best management practice programs have been implemented in the Scatter Creek watershed to help prevent input of livestock waste into Scatter Creek. The TCD has administered a cost-share grant program using state and federal money to help development of farm plans and the implementation of best management practices, such as fencing for livestock exclusion, gutters to keep water away from barnyard areas, and composting and storage of manure away from surface runoff areas (Ecology 2002).

Dissolved Oxygen

DO levels measured at the mouth of Scatter Creek in 1991 and 1992 ranged from 10 to 14 mg/L, which exceeds the Class A standard of 8 mg/L (Table 6-8; Appendix D) (Jennings and Pickett 2000). However, a total of 13 measurements less than 8 mg/L were recorded from 1994 to 2000, including a minimum of 2.4 mg/L (Table 6-9; Appendix E). These DO measurements were recorded at Leitner Rd., Sargent Rd., Gibson Rd., and Old Military Rd., and primarily in July and August. It appears that DO is adequate most of the year, but observed DO concentrations warrant 303(d) listing and may impact fish survival during summer low-flow months. No TMDL parameters for DO were identified for Scatter Creek in an Ecology TMDL study of the upper Chehalis River Basin (Jennings and Pickett 2000).

Turbidity

Turbidity is the extent to which light penetration in water is reduced from suspended materials such as sediment, water color, or plankton. Scatter Creek generally has low turbidity (i.e., clear water). From

1994 to 2000, 20 of 161 measurements exceeded 5 nephelometric turbidity units (NTUs), and of those, only four measurements exceeded 10 NTUs (Appendix E). With only one exception, all turbidity values greater than 5 NTUs were recorded during periods of high flows, and the maximum value was 17.5 NTUs (Table 6-9; Appendix E).

Nutrients

Scatter Creek was reported to have high nutrient (total phosphorus, inorganic nitrogen) levels (Envirovision 2000). Maximum and mean concentrations of nitrite-nitrate and total phosphorus measured from 1991 to 2002 (Tables 8 and 9; Appendices D and E) far exceeded USEPA nutrient reference conditions for this ecoregion (Table 6-6). Measured maximum nitrite-nitrate concentrations were 4.51 mg/L from 1991 to 1992 and 10.0 mg/L from 1993 to 2002. Measured maximum total phosphorus concentrations were 0.12 mg/L from 1991 to 1992 and 0.6 mg/L from 1993 to 2002. Chlorophyll *a* measured in 1991 and 1992 also exceeded nutrient reference conditions. The sources of these pollutants in the Scatter Creek watershed originate from nonpoint sources that are typical of the Chehalis River Basin. These include commercial dairy, livestock, and crop farming operations that are predominantly located in the low-lying valleys adjacent to the Chehalis River.

Pesticides

No data were found on concentrations of pesticides in Scatter Creek. Little information is available for the Chehalis River Basin, though pesticides are widely used throughout the basin for agricultural, commercial, and residential purposes (Envirovision 2000). The USGS National Water Quality Assessment (NAWQA) Program has conducted a study of pesticides in Puget Sound streams that provides useful insight (Bortleson and Davis 1997). In that study, concentrations of pesticides were generally low, and the most commonly detected pesticides in streams were those most heavily used in the basin. The most frequently detected pesticide was 2,4-D. No pesticide concentrations exceeded existing state or federal freshwater aquatic life criteria, but concentrations of diazinon, mevinphos, malathion, and diuron exceeded maximum concentrations recommended for the protection of aquatic life by the National Academy of Sciences (National Academy of Sciences 1973). Herbicides were detected more frequently than insecticides, accounting for 17 of the 23 detected pesticides. In general, more pesticides were detected in urban streams than in agricultural streams.

Currently banned pesticides in the U.S. were found in streambed sediments. The pesticide most commonly found in streambed sediments was the fungicide PCP (pentachlorophenol); the insecticides DDT and chlordane were also detected. These compounds are organochlorine pesticides that were once heavily used in the U.S. These compounds degrade slowly, and detection of these pesticides is common in stream sediments across the U.S. Though detected in sediments, small concentrations of these banned organochlorine pesticides probably do not have acute effects on aquatic organisms. These pesticides do, however, readily accumulate in fatty tissues of organisms (Bortleson and Davis 1997).

Fish Hatchery Effluents

A study conducted in 1988 measured the quality and fate of fish hatchery effluents on selected Washington streams (Kendra 1989). Two commercial hatcheries on Scatter Creek were included in the study. One (which is no longer in operation) was at River Mile 8, and the other was located at the site of the existing facility at River Mile 7.⁶ Sampling sites included stations upstream and downstream of the hatcheries. At the time of the study, there were no exceedances of Class A water quality standards for

⁶ Kendra (1989) referred to this site being located at River Mile 6.4. This has been updated to River Mile 7 based on Figure 4-2 of this report.

temperature, DO, or pH. Nutrient levels (total nitrogen and total phosphorus) were elevated and at levels similar to those measured from 1991 to 2002.

General conclusions of the study were that:

- Water passing through hatcheries generally had significantly elevated temperature (from solar heating), pH (from plant growth), suspended solids (from uneaten food and fish feces), ammonia (an excretory product of fish), and organic nitrogen and total phosphorus concentrations (feed components).
- Private hatchery discharges to streams cause significantly higher changes in temperature, suspended solids, ammonia, organic nitrogen, and total phosphorus during low-flow periods than state-run hatchery discharges due to higher fish loadings and lower dilution factors.
- Benthic macroinvertebrate species more tolerant of organic enrichment were found immediately downstream of hatchery discharges, but community structure usually recovered within a short distance downstream.

Specifically, both Scatter Creek hatcheries reduced stream temperatures (a benefit for fish) and elevated nitrite-nitrate concentrations. Both hatcheries sustained their operations using pumped groundwater. Hatchery operations did increase the temperature of water used, but not in excess of ambient stream temperatures. Therefore, water returned to Scatter Creek as surface water was higher in temperature than the original groundwater source, but lower in temperature than ambient stream temperatures, thus reducing overall stream temperatures. Ammonia, organic nitrogen, and total phosphorus concentrations in Scatter Creek were increased, but the hatcheries did not cause any violations of Class A standards. Many other chemicals, including antibiotics and pesticides, are approved for aquaculture use, but no data on the discharge or concentrations of such chemicals in Scatter Creek were identified.

Table 6-8. Summary of Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992

Water Quality Parameter	Mean	Median	Max	Min
Ammonia (mg/L)	0.03	0.01	0.12	0.01
Biochemical Oxygen Demand (mg/L)	1.53	1.35	2.90	0.70
Chloride (mg/L)	5.08	5.10	8.30	3.60
Chlorophyll (µg/L)	2.69	2.84	5.79	0.03
Conductivity (µmhos/cm)	117.88	131.00	153.00	80.10
Dissolved Oxygen (mg/L)	11.99	11.99	13.99	10.00
Fecal Coliform (#col/100ml)	179.85	8.00	1500.00	1.00
Nitrite-Nitrate (mg/L)	2.21	1.82	4.51	0.06
Ortho-Phosphate (mg/L)	0.04	0.03	0.07	0.01
pH	8.51	8.55	9.00	8.04
Total Dissolved Solids (mg/L)	111.40	113.50	135.00	88.00
Total Organic Carbon (mg/L)	2.91	3.08	5.70	1.00
Total Persulfate Nitrogen (mg/L)	3.26	3.78	4.53	0.67
Total Phosphorus (mg/L)	0.05	0.05	0.12	0.02
Total Suspended Solids (mg/L)	2.15	2.00	5.00	1.00
Turbidity (NTU)	1.26	1.20	2.60	0.20
Water Temperature (C)	14.28	15.70	21.10	4.80

Note: Refer to Appendix D for parameter values at specific locations and dates.

Source: Chehalis River Basin Water Quality Screening and Upper Chehalis River TMDL Studies.

Table 6-9. Summary of Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002

Water Quality Parameter	Mean	Median	Max	Min
Conductivity (µmhos/cm)	109.2	94	253	56
Dissolved Oxygen (mg/L)	10.6	10.7	14.2	2.4
Fecal Coliform (#col/100ml)	93.8	26.5	2015	0
Nitrite-Nitrate (mg/L)	2.1	1.5	10	0
pH	7.2	7.1	8.3	6.2
Total Phosphorus (mg/L)	0.1	0	0.6	0
Turbidity (NTU)	3	2.4	17.5	0
Water Temperature (°C)	9.5	8.7	20.3	2.2

Note: Refer to Appendix E for parameter values at specific locations and dates.

Source: Thurston County Environmental Health Division Database.

Table 6-10. Monthly Mean, Median, Maximum, and Minimum Summer Water Temperatures at Temperature Monitoring Stations in Scatter Creek, 2002

Temperature Station	Month	Mean	Median	Maximum	Minimum
1	July	17.1	16.9	24.5	13.9
1	August	14.7	14.7	17.1	12.4
2	July	17.0	16.8	24.5	13.8
2	August	14.7	14.5	17.4	12.4
3	July	15.9	15.7	24.3	13.2
3	August	13.9	13.8	16.1	11.9
4	July	15.0	15.0	17.5	12.6
4	August	13.4	13.3	15.5	11.7
5	July	12.0	11.9	13.5	10.9
5	August	11.5	11.5	12.6	10.7
6	July	18.4	18.5	21.7	14.8
6	August	17.7	17.5	20.6	15.4
7	July	17.1	17.1	20.1	14.4
7	August	15.6	15.5	18.2	13.3
8	July	10.7	10.6	12.0	10.2
8	August	10.7	10.6	12.0	9.9
9	June	16.9	16.6	20.0	15.2
9	July	17.1	17.2	20.8	13.0
9	August	15.3	15.3	17.5	13.3
10	June	16.6	16.1	19.7	14.2
10	July	18.0	18.5	22.9	13.7
10	August	16.1	16.1	19.3	13.6
11	June	15.8	15.5	20.7	13.4
11	July	17.2	17.2	22.7	12.0
11	August	15.6	15.6	18.7	12.7
14	June	14.0	14.1	16.0	12.4
14	July	15.9	16.5	20.0	11.6
14	August	15.9	15.9	17.8	13.8
15	July	17.0	17.0	20.5	13.8
15	August	13.8	13.8	16.3	11.7
16	June	14.7	14.3	17.5	13.4
16	July	15.1	15.3	19.3	11.1
16	August	13.1	13.1	15.7	10.9
17	July	15.9	15.6	24.6	13.2
17	August	13.0	13.1	15.4	11.4
18	June	16.5	16.4	18.4	15.3
18	July	16.6	16.4	22.3	13.5
18	August	13.4	14.5	19.3	6.0
19	June	14.7	14.4	15.6	14.1
19	July	14.6	14.5	21.9	9.0

Table 6-10. Monthly Mean, Median, Maximum, and Minimum Summer Water Temperatures at Temperature Monitoring Stations in Scatter Creek, 2002 (Continued)

Temperature Station	Month	Mean	Median	Maximum	Minimum
19	August	11.7	11.7	17.5	6.3
20	June	14.3	14.3	15.4	13.3
20	July	14.5	14.6	22.3	8.7
20	August	11.9	11.8	21.0	5.3
AIR	June	16.4	14.9	30.3	10.8
AIR	July	17.5	16.8	34.0	3.4
AIR	August	17.0	15.9	35.4	3.2

Note: Data collected by TCD; Refer to Figure 6-1 of this document for locations of temperature stations.

Source: TCD

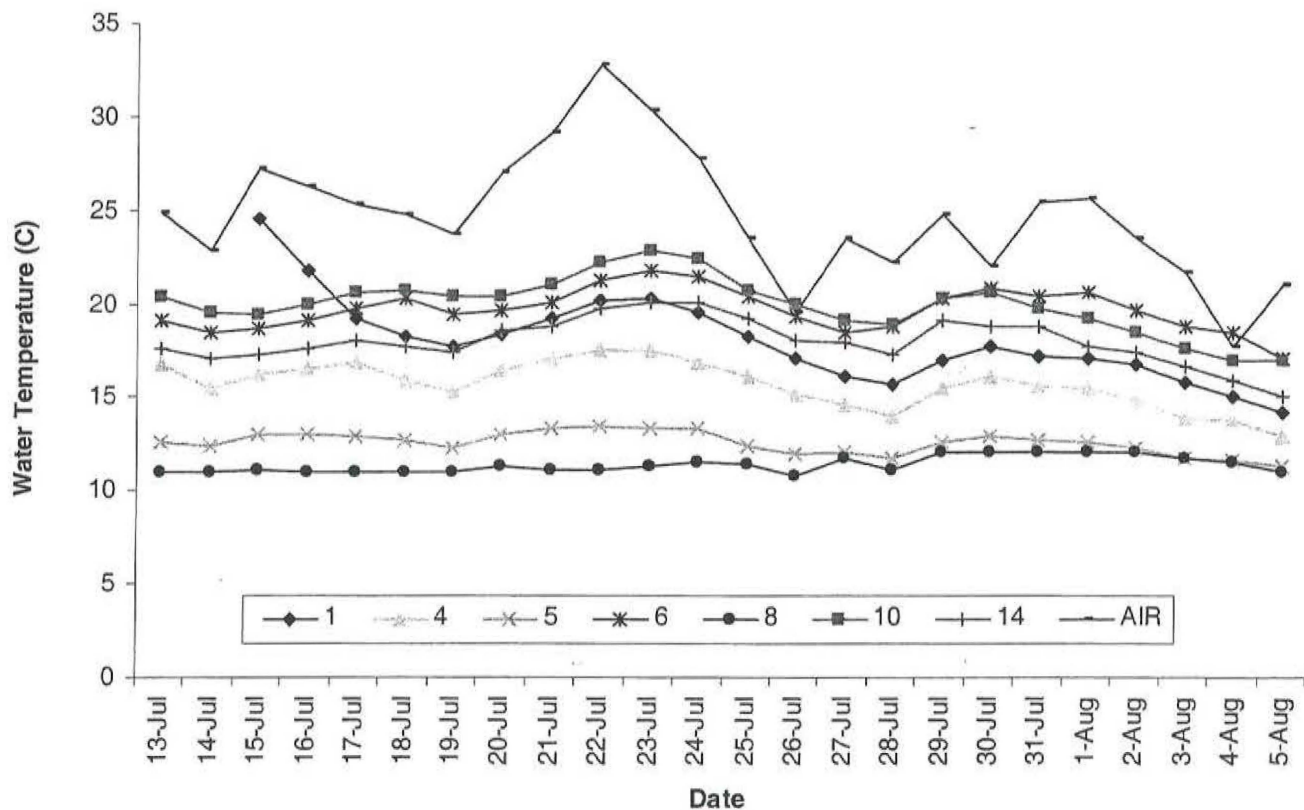


Figure 6-9. Maximum Water and Air Temperatures at Selected Temperature Monitoring Stations in Scatter Creek from 13 July to 5 August, 2002

Note: Not all sampling stations are represented. Stations presented in this figure were selected to illustrate changes in temperatures relative to location of each station in the watershed, where Station 1 is furthest downstream and Station 14 is furthest upstream. Stations 12 and 13 were excluded because they went dry during the sampling period. Refer to Figure 6.1 of this report for station locations.

Source: TCD

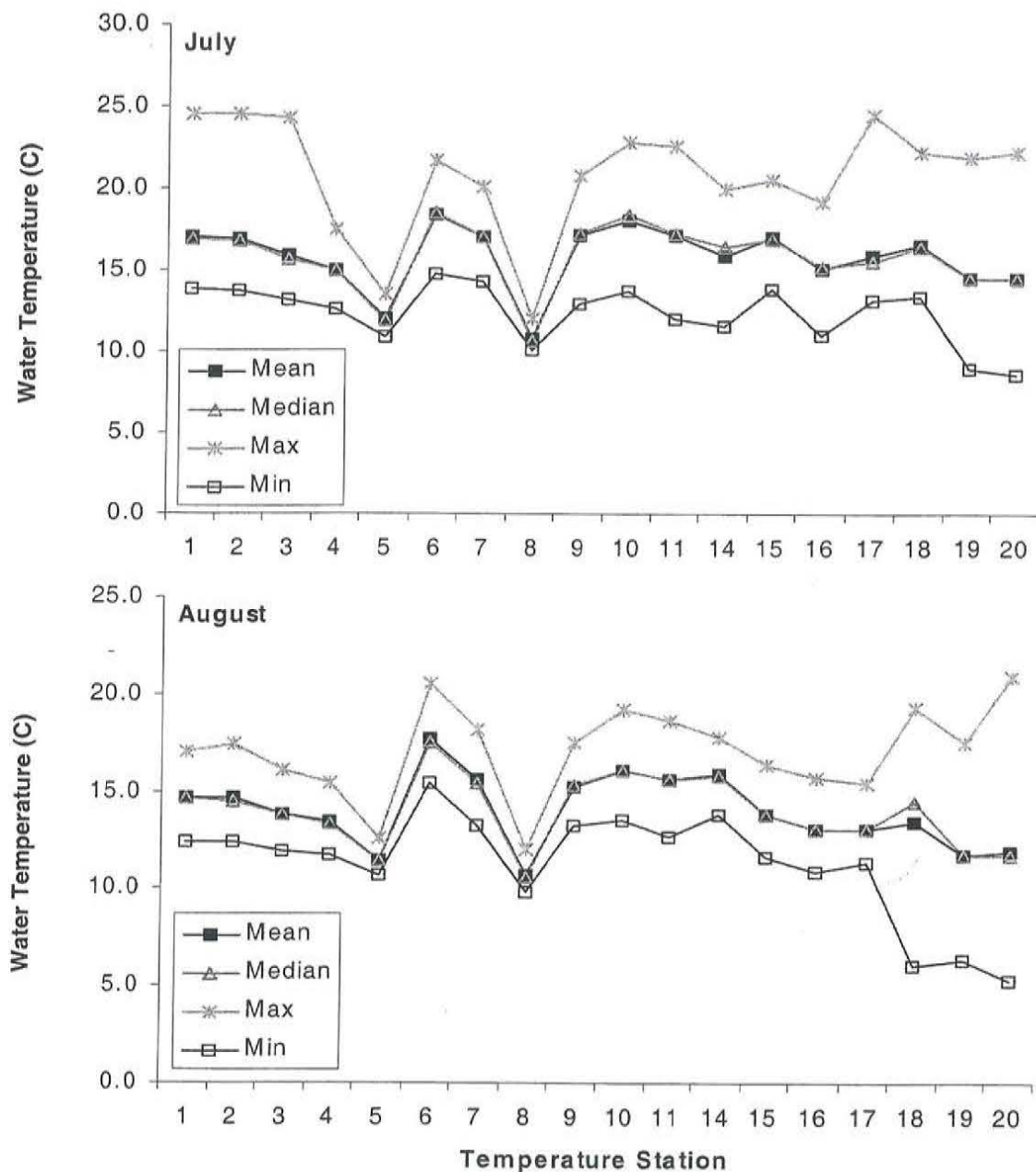


Figure 6-10. Longitudinal Profile of Mean, Median, Maximum, and Minimum Monthly Stream Temperatures in Scatter Creek in July and August 2002

Note: Station 1 is furthest downstream and Station 20 is furthest upstream (also refer to Figure 6-1 in this report for map of temperature station locations in the Scatter Creek watershed).

Source: TCD

6.4.3 Data Gaps

Flow, temperature, and water quality data sufficient to characterize Scatter Creek is currently available. Recommendations for gathering additional information useful for making management decisions for Scatter Creek include:

- Continued monitoring of temperature and water quality at points throughout the Scatter Creek watershed to better identify sources of impacts and to quantify changes in water quality with respect to flow and season.
- Monitoring of water quality responses to restoration activities and/or significant changes in land uses.
- Monitoring of streamflow at various points throughout the Scatter Creek watershed to quantify seasonal flows in relation to land use and fish populations (including accurately delineating those reaches that commonly go dry).
- Seasonal monitoring of pesticide and metal concentrations in surface waters and sediments of Scatter Creek.

6.5 FISHERIES MANAGEMENT

In general, relatively little attention has been given to management of Scatter Creek fisheries. Scatter Creek is a relatively small watershed with limited fish production capacity, particularly with respect to how low flows currently limit the amount of juvenile rearing habitat.

6.5.1 Federal

Management activities conducted by federal agencies have been limited. Several fish species found (or potentially found) in Scatter Creek are either federal species of concern (Pacific lamprey, river lamprey) or candidate species for listing (coho salmon), which provides a nexus for federal involvement in the management of Scatter Creek fish populations. See the species accounts in Section 3 for further discussion of listing status of Scatter Creek fish species.

A bull trout snorkeling survey was conducted by the USFWS in 1999. In this study, four reaches were snorkeled in an attempt to determine whether bull trout inhabit Scatter Creek. Other species were counted, which provided useful information on species occurrence. In addition, the USFWS, in conjunction with WDFW, conducted an extensive survey of most of the Chehalis River Basin upstream of the Humptulips River, including Scatter Creek, to identify and compare specific habitat problems with land uses where observed (Wampler et al. 1993). In addition, the USFWS and NOAA Fisheries have been involved with the Scatter Creek HCP process, providing guidance and expertise.

6.5.2 State

The majority of management activities have been conducted by the WDFW. These management efforts primarily involved coho salmon stocking and monitoring of coho salmon populations. WDFW (in conjunction with the Chehalis Tribe and the Quinault Nation) has monitored coho salmon escapement through redd counts and carcass counts from 1984 to present. Smolt trap surveys were conducted from 1986 to 1991 to estimate the number of coho salmon migrating out of Scatter Creek. Smolt trap estimates have a limited capacity to determine the actual coho salmon production of Scatter Creek due to trap

inefficiency and the influx of hatchery and wild juveniles from other Chehalis River streams that utilize Scatter Creek as rearing habitat, particularly during winter months. Fish collected at the trap were tagged, and the collection of those tags in ocean harvest or other trapping operations was monitored.

There were numerous releases of coho salmon in Scatter Creek from 1976 to 1994 (see Table 6-2). Most were conducted by WDFW or included WDFW efforts. Often, these releases were the result of having extra coho salmon at hatcheries available to be distributed to various watersheds (Aho 2002 personal communication). This may, in part, explain why the numbers of coho salmon released into Scatter Creek over the years have greatly fluctuated. In recent years, WDFW has supplied eyed eggs to Tenino Middle School, whose students release them into Scatter Creek as part of an annual class project.

In 1997, the Washington Department of Natural Resources participated in the livestock fencing of 500 ft of a Scatter Creek tributary, 0.6 ac of riparian planting, and placement of 10 large whole tree habitat structures (specific location unknown; described as OLC1000 Road tributary to Scatter Creek; Ecology 2001).

6.5.3 County

TCD conducted a comprehensive stream habitat survey in 1999 and a stream temperature monitoring study in 2002. These surveys are important contributions to fish management in Scatter Creek. In addition, TCD is involved with private landowners in habitat restoration activities and is leading the Scatter Creek HCP along with several cooperators. In 1995, TCD participated in riparian plantings of Scatter Creek (Ecology 2001), and TCD is currently conducting water temperature, quality, and quantity monitoring at several sites throughout the Scatter Creek watershed.

6.5.4 Tribal

The Chehalis Tribe and the Quinault Nation are extremely active in management of fish resources throughout the Chehalis River Basin. However, Scatter Creek has received relatively little attention. The two tribes conduct annual spawner/escapement surveys of coho salmon, and occasional steelhead spawner surveys, in conjunction with WDFW. This provides valuable information on salmon populations of Scatter Creek. Additionally, the Chehalis Tribe has participated in hatchery releases of coho salmon (see Table 6-2).

6.5.5 Private

The most significant fish management related actions being undertaken by private entities are habitat restoration activities. Most significant are those being undertaken by the Heernett Foundation. Examples of completed and ongoing fisheries-related Heernett Foundation projects and activities include the following:

- 12-ft squash culvert replacement on Mill Creek tributary
- Cozy Valley Pond riparian zone enhancement project
- Crawford Creek culvert clean-out and stream enhancement project
- West Crawford Creek culvert removal and stream enhancement
- Cozy Valley Creek riparian zone creation and enhancement project

- Scatter Creek stream bank stabilizations
- Scatter Creek headwater assessment and monitoring
- Collapsed earthen bridge removal and stream restoration project
- Native plant salvage and planting
- Habitat acquisitions
- Forest restoration

The Heernett Foundation also is supporting (1) an environmental internship program with Evergreen State College, (2) development of community participation enhancement projects for Scatter Creek, (3) creation of an environmental education center, (4) development of an HCP for the Scatter Creek Watershed, and (5) development of the Chehalis River Basin Watershed Management Plan.

Another habitat restoration activity being undertaken by private landowners in conjunction with fisheries biologists is the exclusion of livestock (cattle fencing) from riparian areas (McGinnis 2002 personal communication). Fencing can protect water quality and riparian habitat in areas having high animal densities. The Natural Resources Conservation Service (NRCS) and local conservation districts have established recommendations for riparian fencing. Specific information on fencing and farm plan best management practices are available from TCD.

7. REGULATORY REVIEW

7.1 SPECIES TO BE COVERED BY THE HCP

Species proposed to be covered by the HCP are listed in Table 7-1, along with their federal, state, and local (Thurston County) status. Refer to Section 3 of this report for additional information on these species.

Table 7-1. Listing Status for Species Proposed to be Covered by the Scatter Creek HCP

Species	Federal Status	State Status	County Status
Bald eagle	FT	ST	IS
Chinook salmon (Washington Coast ESU)	NW	SC	
Chum salmon (Pacific Coast ESU)	NW	SC	
Coho salmon (Lower Columbia River/ SW Washington ESU)	FC	NL	
Cutthroat trout (Lower Columbia River/ SW Washington DPS)	NL	NL	
Great blue heron	NL	NL	IS
Mardon skipper	FC	SE	
Mazama (western) pocket gopher	FC	SC	IS
Northern goshawk	SoC	SC	
Oregon spotted frog	FC	SE	IS
Oregon vesper sparrow	SoC	SC	
Pacific lamprey	SoC	NL	
Puget blue	NL	SC	
River lamprey	SoC	SC	
Slender-billed white-breasted nuthatch	SoC	SC	
Steelhead (Washington Coast ESU)	NW	SC	
Valley silverspot	SoC	SC	
Western gray squirrel	SoC (under review)	ST	IS
White-top aster	SoC	SS	
Taylor's (Whulge) checkerspot	FC	SC	IS

FC – Federal Candidate, FT – Federal Threatened, IS – Thurston County Important Species, NW – Not Warranted for Listing, NL – Not Listed, SC – State Candidate, SE – State Endangered, SS – State Sensitive, SoC – Federal Species of Concern

Habitats proposed to be covered by the HCP include:

- Outwash prairies
- Oak woodlands
- Riparian areas
- Conifer forests
- Wetlands, ponds, and lakes

7.2 METHODS

This report is based on a review of existing laws and policies that apply to species and resources within the Scatter Creek watershed. In addition, regional and municipal planning efforts related to fish and wildlife were also reviewed to identify potential relationships to habitats and species covered by the HCP.

7.3 FEDERAL LAWS AND POLICIES

The HCP is being prepared in accordance with the goals and policies of the federal Endangered Species Act and is subject to review under the National Environmental Policy Act (NEPA). In addition to these laws and their implementing regulations, there are myriad state and regional/local laws and policies that pertain to the HCP planning area; these are described in subsequent sections.

7.3.1 Endangered Species Act

With the passage of the Endangered Species Act in 1973, which replaced earlier laws enacted in 1966 and 1969, Congress recognized the need to provide meaningful protection for endangered and threatened species (U.S.C. 1531 et seq.). One of the stated goals of the Endangered Species Act is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Whether or not a species is listed under the Endangered Species Act depends on several factors, including the present or threatened destruction, modification, or loss of habitat or range; the adequacy of existing regulatory protections; and other manmade or natural factors affecting species survival. The USFWS and NOAA Fisheries jointly administer and implement the Endangered Species Act at the federal level.

7.3.1.1 Section 9

Section 9 of the Endangered Species Act prohibits activities that result in "take" of listed fish or wildlife species. Take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The USFWS further defines take to include significant modification or destruction of habitat where it actually kills or injures wildlife by impairing behaviors, such as breeding or feeding. For plants, the definition of take includes removing, cutting, digging up, or damaging/destroying listed species. The prohibition against take applies to activities on both federal and non-federal lands. Any person who knowingly violates any provision of the Endangered Species Act, or any provision of any permit or certificate issued thereunder, may be assessed a civil penalty of not more than \$25,000 for each violation. Penalties also may be imposed as a result of third-party lawsuits.

Currently, the bald eagle (threatened) is the only federally listed species known to occur within the HCP planning area. The western gray squirrel is a candidate for listing and is currently under review. The Mazama (western) pocket gopher, mardon skipper, Taylor's (Whulge) checkerspot, Oregon spotted frog, and coho salmon (Lower Columbia/Southwest Washington ESU) are candidates for federal listing. None of the other HCP-covered species are listed, proposed for listing, or candidates for federal listing at this time (see Table 7-1 and Section 3, Species Accounts). In the Scatter Creek watershed, the provisions regarding take apply only to the bald eagle, as it is the only federally listed species in the watershed.

The upper reaches of the Scatter Creek watershed include mature conifer forest stands that could provide potential habitat for the northern spotted owl, a federally threatened species; however, there are no known occurrences of the northern spotted owl in the watershed.

7.3.1.2 Incidental Take Permits

The Endangered Species Act requires that actions authorized, funded, or carried out by a federal agency do not jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of habitat critical to the survival of listed species [Section 7(a)(2)]. In 1982, Congress amended the Endangered Species Act to establish a provision [under Section 10(a)(1)(B)] that allows for the “incidental take” of endangered and threatened species by non-federal entities. Incidental take is defined as take that is “incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.” Prior to 1982, the Endangered Species Act only authorized take resulting from scientific research and other conservation actions. There was no recourse for non-federal parties undertaking otherwise lawful activities that were likely to result in take.

Pursuant to Section 10(a)(2)(A), applicants for an incidental take permit must submit a “conservation plan” or HCP that describes:

- Impacts likely to result from the activities for which the permit is being sought;
- Measures the applicant will employ to mitigate, minimize, and monitor the impacts, and the approach to addressing unforeseen circumstances;
- Alternatives the applicant considered that would not result in take, and the reasons why those alternatives can not be implemented; and
- Additional measures that may be appropriate for the purposes of the plan.

The purpose of an HCP is to reduce conflicts between listed species and economic development activities and to create a climate of cooperation with respect to conservation of federally listed species. Congress also intended that HCPs would include conservation measures for candidate species, proposed species, and other species not listed under the Endangered Species Act at the time an HCP is developed. In the 1982 amendments to the Endangered Species Act, Congress stated that HCPs would provide long-term commitments regarding conservation of multiple listed and non-listed species, and long-term assurances for permit applicants. As a result, the Endangered Species Act Section 10 provisions provide that, should an unlisted species become listed during the term of the HCP, no further mitigation requirements should be imposed on the permittee as long as the HCP addresses the conservation of the species as if the species were listed. This ensures the terms of an HCP will not change over time with subsequent species listings. The Section 10 rules also provide early protection for many species and may prevent the need to list some species. Landowners in the Scatter Creek watershed who participate in the HCP process and adhere to the HCP commitments will have increased regulatory certainty as a result of the Section 10 provisions and incidental take permit coverage.

7.3.2 National Environmental Policy Act

NEPA establishes the process whereby federal agencies must consider and evaluate the environmental impacts of their agency-sponsored projects (42 USC 4331 et seq.). Under NEPA, any project that could have significant adverse impacts must address and disclose the impacts in an environmental impact statement (EIS). Issuance of an incidental take permit under the Endangered Species Act would be a federal action subject to NEPA review. The agencies issuing the permit (USFWS and/or NOAA Fisheries) would be required to analyze the effects of the permit action against a reasonable set of alternatives including a no action alternative. The analysis must be made public before the decision to issue the permit is made. If, after considering public comments, the agency(ies) determine that the effects of the incidental take permit are not

significant or are adequately mitigated per the provisions of the HCP and issue a decision to that effect, the NEPA process is complete.

7.3.3 Clean Water Act

The Clean Water Act (also known as the Federal Water Pollution Control Act), which is administered jointly by the U.S. Army Corps of Engineers (Corps) and USEPA, is intended to protect the biological, physical, and chemical integrity of the nation's waters, including wetlands. Two key sections of the Clean Water Act that pertain to activities throughout the HCP planning area are Sections 404 and 401. Section 402 of the Clean Water Act may also pertain to some construction activities in the watershed.

7.3.3.1 Section 404

Section 404 regulates placement of dredge or fill material into waters of the U.S. including wetlands. Activities that constitute placement of fill include trenching, ditching, draining, and installing piers or pilings. Project proponents intending to undertake such activities must obtain a permit from the Corps prior to initiating work.

7.3.3.2 Section 401

The Section 401 water quality certification is a federal permit administered by the state (Ecology). The purpose of Section 401 is to ensure that federally permitted projects are consistent with state water quality standards. Activities (such as filling a wetland) that require a 404 permit generally must have a state water quality certification.

7.3.3.3 Section 402 – National Pollutant Discharge Elimination System

Section 402 of the Clean Water Act established the National Pollutant Discharge Elimination System (NPDES) program, which prohibits the discharge of pollutants to waters of the U.S. from point sources (such as outfall pipes) unless the discharge is in compliance with an NPDES permit. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In Washington State, the NPDES program is administered by Ecology.

The NPDES program also regulates stormwater discharges from industrial facilities and construction sites. In Washington, the specific permit requirements are complex and subject to change pending resolution of ongoing legal proceedings. In general, however, permits are required for industrial activities that discharge directly to surface waters, or indirectly through municipal storm drains, and for construction activities that disturb more than 5 ac of land (this could include residential construction sites). Permits are generally not required for activities where the stormwater is treated and retained on site (discharged to the ground) or discharged to a combined sewer (which goes to the wastewater treatment plant).

Ecology is in the process of updating/reissuing a general permit for stormwater discharges associated with construction activities known as the "Construction Stormwater General Permit." At this time, Ecology prohibits new coverage under the Construction Stormwater General Permit if:

- The construction activity discharges to a waterbody on the Clean Water Act list of impaired water bodies (known as the Section 303(d) list) and includes the pollutant for which the water body is listed, unless it can be documented that no water quality violation will occur; or

- The construction activity discharges to a waterbody subject to a total maximum daily load (TMDL) determination, unless the discharge would be in compliance with the TMDL. (A TMDL is a calculation of the maximum amount of a pollutant a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.)

Ecology has identified four pollutants that may be found in stormwater from construction sites for which there are 303(d) listed waters and TMDLs. These pollutants are phosphorus, pH (above water quality standards), turbidity, and fine sediments. The lower portion of Scatter Creek (Section 8 T15N R3W) is on the Section 303(d) list for high pH. Therefore, Ecology could only authorize a stormwater discharge to Scatter Creek if the discharge did not violate water quality standards for pH.

The landowners in the Scatter Creek watershed most likely to be affected by NPDES permit requirements are those who pursue construction activities with more than 5 ac of soil disturbance. Some of these activities could be covered under the Construction Stormwater General Permit, but owners of construction sites with more than 5 ac of soil disturbance and stormwater discharges to Scatter Creek would need to contact Ecology to determine permit requirements per the limitations of the Construction Stormwater General Permit described above.

7.3.4 Rivers and Harbors Act

The Rivers and Harbors Act of 1899 regulates activities in, over, and affecting navigable waters of the U.S., including Scatter Creek and its tributaries. Under Section 10 of the Act, the Corps defines navigability as presently, historically, or potentially navigable, including intertidal areas. The law is implemented through a permit process administered by the Corps. Activities that involve construction of bridges, levees, docks, piers, culverts, and other structures would require a Section 10 Rivers and Harbors Act permit. When reviewing permit applications, the Corps must evaluate the effects of the project on navigability. Other factors taken into consideration in the permit process include flood control, fish and wildlife habitat management, and other environmental impacts. Permits are typically issued in conjunction with the Clean Water Act Section 404 permit process since most activities that require one permit also require the other.

7.3.5 Other Federal Laws

Other federal laws pertaining to species covered by the Scatter Creek HCP include the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, the Coastal Zone Management Act (CZMA), the Anadromous Fish Conservation Act, and the Lacey Act.

The Migratory Bird Treaty Act, originally passed in 1918, implements the federal government's commitment to four bilateral treaties, or conventions, for the protection of a shared migratory bird resource. The law is similar to the Endangered Species Act in that it makes it unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried, or received any migratory bird, part, nest, egg, or product, manufactured or not. The Migratory Bird Treaty Act provisions would apply to all of the bird species covered by the HCP.

Under the Bald and Golden Eagle Protection Act, the USFWS issues permits to take, possess, and transport bald and golden eagles for scientific, educational, and Indian religious purposes, depredation, and falconry (golden eagles). No permit authorizes the sale, purchase, barter, trade, importation, or exportation of eagles or their parts or feathers.

Any federal project undertaken in one of Washington's 15 coastal counties must be reviewed for consistency with the Coastal Zone Management Act, even if the project does not directly affect the coastline. In Washington, the state Shoreline Management Act (see below) serves as the basis for the state's Coastal Zone

Management Plan; Ecology is responsible for determining if federal projects are consistent with the coastal zone management policies outlined in the plan (however, there is no direct link between the shoreline permit process and the CZMA consistency review). Local landowners would not be required to obtain a CZMA consistency determination for land use activities, but private activities subject to federal permit (e.g., filling wetlands) would be reviewed to ensure compliance with the plan. Therefore, Ecology would be required to make a CZMA consistency determination for any activity that required a Clean Water Act Section 404 permit.

The Anadromous Fish Conservation Act authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements with the states and other non-federal interests for conservation, development, and enhancement of anadromous fish, and to contribute up to 50 percent as the federal share of the cost of carrying out such agreements. The law authorizes investigations; engineering and biological surveys; research; stream clearance; and construction, maintenance, and operations of hatcheries and devices and structures for improving movement, feeding, and spawning conditions. Also authorized is construction by the Bureau of Reclamation and the Corps of water resource projects needed solely for anadromous fish. This law does not have any permit requirements and does not directly regulate private land use actions. It would most likely apply to large projects sponsored by state or local governments or other formal resource conservation entities. In this regard, the Anadromous Fish Conservation Act could favorably impact resources in the Scatter Creek watershed if agreements were formed to undertake special projects for anadromous fish.

The Lacey Act makes the import, export, transport, sale, receipt, acquisition, possession, or purchase of any fish, wildlife, or plant taken, possessed, transported, or sold in violation of any federal, state, foreign, or tribal law, treaty, or regulation a federal crime. This law covers all federally listed threatened or endangered species and species protected by state law. Therefore, all of the HCP-covered species (with the possible exception of the great blue heron and Pacific lamprey—see Table 7-1) are subject to the terms of the Lacey Act.

7.4 STATE AND LOCAL LAWS

The primary state regulations that could apply to the Scatter Creek watershed include the State Environmental Policy Act (SEPA), the Hydraulic Code, the Forest Practices Act, the State Water Pollution Control Act, the Shoreline Management Act, and several state laws that protect threatened and endangered species. At the local level, species and habitats within the Scatter Creek watershed are protected by the Thurston County Code (TCC). Titles 17 and 19 are the two primary titles of the Code that pertain to natural resources. In many cases, the regulations contained in the County Code overlap with other state and federal regulations described herein. Applicable sections of the Code are discussed below.

7.4.1 State Environmental Policy Act

SEPA is similar to NEPA but applies to state- or local agency-sponsored or approved projects. Before a state or local jurisdiction can issue a permit for an activity that would potentially impact the environment (e.g., wetland fill permit, Hydraulic Project Approval, short-plat approval) the agency or jurisdiction must evaluate and disclose impacts of the proposed activity in a SEPA checklist or other appropriate environmental document (environmental assessment or environmental impact statement) unless the activity is considered a Categorical Exclusion.

7.4.2 State Hydraulic Code

The state's Hydraulic Code is intended to protect fish, streams, and marine waters from degradation. The Code regulates work that uses, diverts, obstructs, or changes the natural flow of a water of the state (including wetlands). The Hydraulic Code is implemented through a permit process known as the Hydraulic Project Approval (HPA). Any person or agency proposing to conduct in-water work (work below the ordinary high water mark of a stream), such as bank armoring, culvert installation, channel dredging, and the like, is required to obtain an HPA from the WDFW. The technical criteria WDFW uses to evaluate an HPA for activities in freshwater are set forth in WAC 220-110-030 through 220-110-224. These sections define habitats of special concern; timing, location, and types of permitted construction activities; and the types of designs, construction materials, and allowed footprint. The WAC also specifies that hydraulic projects "shall incorporate mitigation measures as necessary to achieve no-net-loss of productive capacity of fish and shellfish habitat."

7.4.3 Forest Practices Act

The Forest Practices Act (76.09 RCW) was originally adopted in 1974 to govern activities related to growing, harvesting, or processing timber, including, but not limited to, road construction and maintenance, thinning, salvage, reforestation, brush control, and fertilizer or pesticide use. The Act, which was adopted pursuant to chapter 76.09 RCW, RCW 76.13.100 through 76.13.130, and RCW 77.85.180 through 77.85.190, establishes minimum standards for forest practices, provides procedures for the development of resource management plans and watershed analyses, and establishes riparian easement and open space programs. The Forest Practices Act regulates a wide variety of land use activities on forest lands and has special provisions to protect forested wetlands, riparian corridors, and habitats for threatened and endangered species, such as the northern spotted owl. The WDNR is responsible for issuing permits for forest practices in accordance with the forest practices rules established by the Forest Practices Board (WAC 222).

The forest practices rules define four classes of forest practices (WAC 222-16-050):

- Class I – operations that have no direct potential for damaging public resources. Examples are Christmas tree harvest, tree planting or seeding, cutting and removal of less than 5,000 board feet of timber for personal use, and maintenance of existing roads. These activities do not require a permit, but do require compliance with all other forest practices rules.
- Class II – practices that have less than ordinary potential to damage public resources, provided that the activity does not require an HPA and does not occur within a shoreline of the state. Examples are salvage of logging residue and some types of timber harvest that do not involve working in riparian management areas, streams, wetlands, or on steep slopes. These activities require a notification to the WDNR, and may begin 5 calendar days (or such lesser time as the WDNR may determine) after receipt of a notification by the Department.
- Class III – includes activities that require an HPA and/or occur within a shoreline of the state. Examples are most types of timber harvest, road construction/maintenance, and aerial application of chemicals. Class III forest practices must be approved or disapproved by the WDNR.
- Class IV – are divided into "Class IV - Special" and "Class IV - General." Class IV - Special actions are subject to SEPA review and include forest practices on public lands, lands deemed to be critical habitat, steep or unstable slopes, areas of cultural or archeological importance, and other sensitive sites. Class IV - General are forest practices on lands that are being converted to non-forest uses. These must be approved or disapproved by WDNR and/or Thurston County.

The forest practices rules also set up specific wetland and stream typing criteria and contain special provisions to protect forested wetlands and wetland and riparian management zones (known as WMZs and RMZs, respectively). Harvest methods in forested wetlands must use cable logging (instead of tracked or rubber-tired skidders) or other low-impact systems, and landowners are encouraged to retain wildlife reserve trees to minimize loss of habitat. There are similar limitations of harvest operations within bogs. Within WMZs, there are minimum thresholds for the number and size of leave trees (trees left behind after harvest) and restrictions on equipment use. WMZs have variable widths based on the size and type of wetland. The widths range from a minimum of 25 ft up to 200 ft in western Washington.

RMZs are identified for each stream type (WAC 222-30-021). Stream types reflect the physical characteristics of the stream channel (width, gradient, etc.), fish use, and other attributes (domestic water use). Each RMZ comprises a core area (closest to the water), inner, and outer zone. Dimensions of each zone vary according to the width of the stream, the type of harvest management, and the site potential of the land. In western Washington, RMZ widths range from 90 to 200 ft (total width of the zone). In general, there is no harvest allowed in the core area (except as allowed for some forest roads). Forest practices in the inner zone must be conducted to ensure achievement of desired future conditions (i.e., target tree density per acre). Harvesting on the outer zone must leave 20 riparian trees per acre after harvest. Landowners with parcels of 20 ac or less or with less than 80 ac total forest land are not required to comply with all of the RMZ requirements (WAC 222-30-023).

The Forest Practices Act also includes a program to acquire easements from small forest landowners along riparian areas and other areas essential to the protection of aquatic resources. There are several criteria that must be met before an easement is established. For example, the easements must include qualifying timber within riparian areas and may include other qualifying timber, and the landowner must be willing to sell or donate the easements to the state.

The Act also requires cities and counties to adopt and administer regulations that address general Class IV forest practices (practices that result in conversion of forest lands to non-forest uses). Chapter 17.26 of the Thurston County Code carries out the provisions of the Act by regulating the conversion of forest land to non-forestry uses, and Class I forest practices, such as road construction and timber harvesting that are not associated with commercial forest production. The County has set forth specific requirements for the primary urban growth areas, such as Lacey and Olympia, and outlying areas (including the Scatter Creek watershed). The regulations stipulate that the conversions comply with applicable chapters of the County Code, including the critical areas ordinance, shoreline master program, and drainage design and erosion control manual. In most cases, landowners planning to convert forest lands to non-forest uses must prepare a Conversion Option Harvest Plan for County review and approval.

7.4.4 Water Pollution Control Act

The purpose of the State Water Pollution Control Act (RCW 90.48) is to protect water quality for public health and fish and wildlife. The law is implemented through rules established by Ecology that define water quality, sedimentation management, and discharge standards. The USEPA has delegated Ecology as the state's water pollution control agency responsible for implementing all federal water pollution control laws and regulations, including Sections 401 and 402 of the Clean Water Act (as described above). Ecology has authority to evaluate proposed activities to determine if they would exceed water quality standards. Activities that would impact water quality through sedimentation or discharge of pollutants could require one or more water quality permits from the state. For example, activities that entail filling wetlands could require a Section 401 water quality certification, and activities that involve discharging stormwater from construction sites could require an NPDES permit.

7.4.5 Shoreline Management Act

This state law is implemented at the local level. The Shoreline Management Act requires that development of the state's shoreline be accomplished in a manner that promotes and enhances public interest and protects against adverse impact to the land and waters of the state. Under the Act, local governments prepare shoreline master programs that define appropriate uses and management policies for shoreline areas. Ecology is responsible for reviewing and approving each jurisdiction's master plan for compliance with state statutes. Development activities that occur within the shoreline zone (i.e., within 200 ft of the ordinary high water mark and/or within the 100-year floodplain or associated wetlands) are subject to specific permit requirements. Thurston County, in conjunction with Ecology, reviews shoreline development proposals and issues development permits for projects that are consistent with the County's master program.

Thurston County's Shoreline Master Program governs uses and activities along Scatter Creek from just upstream of Tenino to the mouth at the Chehalis River. This reach of Scatter Creek has a mean annual flow of 20 cfs or more and is considered a shoreline of the state (WAC 173-18-380). The shoreline zone along this reach has a "conservancy" designation, which generally means it is suited for low-intensity land uses. The upper reaches of Scatter Creek are not subject to the shoreline regulations.

The County's shoreline regulations are outlined in Title 19 of the County Code. These regulations may be modified following adoption of new shoreline guidelines adopted by Ecology in 2002. The guidelines, which established new policies for local jurisdictions to follow in managing the shoreline zone, are expected to be adopted in 2003.

The types of activities regulated by the County's Shoreline Master Program include home building, land clearing, and installing or replacing bulkheads, stairways, docks, and boathouses. Setbacks from the shoreline, maintenance or creation of native vegetation buffers, and erosion control are some of the methods used to minimize development impacts and protect public safety, water quality, and the environment. Land use activities that involve dumping, drilling, dredging, filling, placement or alteration of structures, creation of subdivisions, or any activity that interferes with normal public use of the shoreline, require one of the following permits:

- **Substantial Development Permit:** Required if the total cost of the project exceeds \$5,000 or will interfere with normal public use of the shoreline area.
- **Conditional Use Permit:** Required if the proposed use is not specifically addressed in the Shoreline Master Program.
- **Variance:** Allowed in extraordinary situations for relief from specific bulk, dimensional, or performance standards that would not allow reasonable use of the site due to the site's physical characteristics.
- **Administrative Exemption:** Required for development activities not extensive enough to require a Substantial Development Permit, but which are still subject to shoreline regulations.

Shoreline permits are typically issued by Thurston County; however, variance permits generally require review and approval from the County and Ecology. A shoreline permit does not trigger a CZMA review because it is not a federal action.

7.4.6 State Laws Protecting Threatened and Endangered Species

The Revised Code of Washington (RCW) 77.12.020(6) authorizes the designation of species threatened with extinction as endangered (WAC 232-12-014). The state also protects species that are threatened or sensitive (WAC-232-12-011). Threatened species are species likely to become endangered within the foreseeable future throughout a significant portion of their range without cooperative management or removal of threats. Sensitive species are vulnerable or declining and are likely to become endangered or threatened in a significant portion of their range without cooperative management or removal of threats. All of the species proposed for coverage under the HCP, except the great blue heron and the Pacific lamprey, are either listed or candidates for listing as endangered, threatened, or sensitive in the state of Washington and are therefore protected under state law.

The WDFW enforces the provisions of RCW Chapter 77, which prohibits the unlawful taking of listed or protected species. Failure to comply with the law constitutes a misdemeanor at best and a felony at worst.

The WDNR is authorized to enact a program for identifying natural heritage resources including plant species. WDNR can designate at risk plant species as endangered, threatened, or sensitive, but there are no formal regulatory mechanisms in place to protect such species.

HCPs are primarily geared toward reducing conflicts between proposed development activities and the laws and policies designed to protect federally listed species. Whether or not the Scatter Creek HCP serves a similar function for state listed species depends on the degree of cooperation and support provided by state agencies such as WDFW. Details will have to be worked out during the HCP development process.

7.4.7 Thurston County Critical Areas Regulations

Species and habitats within the Scatter Creek HCP planning area are subject to the requirements of Chapter 15.17 of the County Code—critical area regulations. These regulations establish the County's broad authority and responsibility to review and regulate land use activities that might affect critical areas and their buffers. The regulations define allowed uses/activities, performance standards, review procedures, report requirements, mitigation requirements, and other information that pertains to critical areas. They prohibit activities that result in alteration of critical areas except in compliance with the Code.

Compliance with critical areas regulations is triggered by any activity that requires County review or approval. Therefore, any development proposal that requires a County permit (such as a grading permit, building permit, subdivision permit, forest practices permit, shoreline substantial development permit, etc.) is subject to the critical areas regulations (certain activities are exempt). The County can approve, condition, or deny any permit or approval for any project that might adversely affect a critical area. As a result, these regulations provide a high degree of protection for resources of concern in the HCP planning area.

Because of their broad applicability, critical areas regulations have the potential to impact any private landowner engaged in routine land use and development activities. Thurston County is solely responsible for implementing and enforcing the Code. Failure to comply with the specific provisions of the Code or with permit conditions issued pursuant to the Code could result in a stop work order, a civil infraction, referral to the prosecuting attorney, and/or criminal prosecution.

The Scatter Creek watershed includes five designated critical areas as described below.

7.4.7.1 Aquifer Recharge Areas

Aquifer recharge areas make up a significant portion of the Scatter Creek watershed. Because of the underlying soil composition (outwash soils), the aquifer sensitivity ranges from moderate to high to extreme (classified as Category III, II and I, respectively) (TCC 15.17.505). The Code prohibits certain land use activities such as land filling, chemical manufacturing, and metal processing in aquifer recharge areas. Other uses (such as boat repair, mining, and storage tanks) are allowed subject to certain restrictions. In addition, the County has identified specific residential density requirements for aquifer recharge areas (for example, densities of greater than 1 unit per 0.49 ac are prohibited in Category I aquifer recharge areas). The intent of these regulations is to prevent groundwater degradation and balance competing needs for surface water and groundwater. As a result, landowners proposing to conduct land use practices in designated aquifer recharge areas may be required to obtain appropriate permits, prepare special reports/studies (such as a hydrogeological report), and comply with specific performance standards before proceeding with the activity.

7.4.7.2 Geologic Hazard Areas

Lands susceptible to erosion, seismic, or other geologic events are considered geologic hazard areas and are subject to TCC 17.15.600. The Code restricts certain activities/land uses within geologic hazard areas to minimize property damage, protect water quality, and prevent shoreline erosion. The County has not completed its inventory of geologic resources, so erosion hazard areas have not yet been identified in the Scatter Creek watershed. Seismic hazard areas have been identified to include wetlands, the filled areas of former wetlands, and areas within the 100-year floodplain of the major rivers in the County (e.g., the Black, Chehalis, Nisqually, Deschutes, and Skookumchuck Rivers). There are no volcanic, landslide, or mine hazard areas within the Scatter Creek watershed. Volcanic hazard areas are limited to the 500-year floodplain of the Nisqually River upstream of Alder Dam. Landslide hazard areas are defined based on the underlying soil types, and the majority of the soils types within the Scatter Creek watershed are not identified as landslide soils. Mine hazard areas are associated with coal mines, of which there are none within the Scatter Creek watershed.

7.4.7.3 Important Habitats and Species

Six of the animal species and all of the habitats covered by the HCP are protected as important species and habitats according to the County critical areas regulations (TCC 15.17.705). This includes the protected species Oregon spotted frog, bald eagle, great blue heron, western gray squirrel, Taylor's (Whulge) checkerspot, and western pocket gopher (see Table 7-1); and protected habitats, including native outwash prairies, oak woodlands, riparian areas, wetlands, and mature/old growth forests. Certain activities (such as construction of access roads for residential housing and creation of regional stormwater detention facilities) are prohibited from occurring in areas that support important species or habitats. Other activities (such as drainage ditch maintenance, vegetation removal, and construction of single-family residences) are allowed subject to compliance with the Code. The County can restrict or condition activities located up to 600 ft from the mapped location of an important species. Applicants for certain types of development permits (including but not limited to a commercial building permit, Class IV forest practices permit, planned residential development permit, or shoreline substantial development permit) may be required to prepare a habitat management plan describing the effects of the proposed activity on the species or habitat and how such effects will be mitigated. The habitat management plan must include information on WDFW management recommendations for the species or habitat of concern. The plan must also include an evaluation by WDFW or another qualified expert on the adequacy of the proposed measures to mitigate impacts to the species or habitat. Types of mitigation that may be required include establishing buffer zones, clustering development, preserving vegetation, and seasonal restriction of construction activity.

7.4.7.4 Special Management Areas

Summit Lake, Nisqually hillside overlay, noxious weed containment areas, high groundwater flood hazard areas, and wellhead protection areas are defined as special management areas in Thurston County (TCC 15.17.805). Of these designated special management areas, only groundwater flood hazard areas are of concern in the HCP planning area. Thurston County defines high groundwater flood hazard as:

“areas where subsurface geologic conditions prevent recharging water from moving downward or laterally as fast as it enters the ground water system. The result is a rise in the ground water table and accumulation of water on the surface that persists for over protracted periods of time.”

High groundwater flood hazard areas occur throughout the watershed, primarily along the Scatter Creek mainstem and its tributaries. Land use activities in these areas or within 300 ft of these areas are subject to the performance standards identified in TCC 15.17.865. For example, the Code places restrictions on timber harvesting, placement of fill material, creation of new impervious surface, and construction of new structures or buildings in and around groundwater flood hazard areas. Applications to undertake these types of activity in groundwater flood hazard areas must provide sufficient information such that the County is able to assess the effects of the activity and its conformity with Code provisions.

7.4.7.5 Floodplains, Streams, and Wetlands

Floodplains, streams, and wetlands are protected by the County Code to preserve flood control, stormwater functions, drainage patterns, and streamflows; protect stream quality for aquatic life; prevent wetland and water pollution and maintain associated habitat for wildlife; and minimize loss of wetlands and increase the quality and function of wetlands throughout the County (TCC 15.17.900). The Code sets forth criteria for classifying and rating streams and wetlands (e.g., Type 2 water, Category I wetland) and establishes allowed uses, buffer requirements, replacement ratios, and other regulations based on the rating designations. Buffer widths for streams range from 100 ft for Type 1, 2, and 3 streams (which would include Scatter Creek) to 25 ft for Type 5 streams. Any project requiring County approval or a County permit would need to adhere to the development restrictions, buffer standards, and mitigation requirements established by the Code.

Buffers for wetlands are defined based on the intensity of the adjoining land use (high or low). High quality (Class I) wetlands with high intensity adjoining land uses require a 300-ft buffer. The required buffer width is 200 ft for Class I wetlands if the adjoining land use is low intensity. For Class II wetlands, the buffers range from 100 to 200 ft, and for Class 3 wetlands, buffers range from 50 to 100 ft. These buffers can be reduced in special cases to accommodate some development limitations. Some small wetlands less than 2,500 ft² in size are not regulated by the County Code.

The Code prohibits placement of fill and construction of ponds, golf courses, and other facilities in wetlands and regulates other activities in or affecting wetlands and their buffers according to performance standards and mitigation requirements. Similarly, activities affecting streams and their buffers are regulated or restricted. Relocation of stream channels and removal of streamside vegetation are two types of activities that would be subject to County review and permit requirements.

7.5 MANAGEMENT PLANS AND POLICIES

7.5.1 Wild Salmonid Policy

The Wild Salmonid Policy guides the actions of the WDFW in managing commercial and sport fishing in state waters and hatcheries across the state. The goal of the policy is to restore Washington's wild salmon and steelhead stocks to healthy, harvestable runs.

The Wild Salmonid Policy addresses specific WDFW and tribal actions but does not directly regulate actions of other state agencies; federal, tribal, or local governments; or any private parties. Therefore, although the policy does not directly apply to land use activities in the Scatter Creek watershed, it may affect fish resources in the watershed by:

- Regulating salmon fishing seasons based on fish managers' best estimates of the timing and routes taken by migrating wild salmon.
- Placing salmon conservation before economic profit and interstate or international fish disputes.
- Implementing fishing regulations that will allow more large wild salmon to return to the spawning gravel.
- Managing fisheries to help more wild salmon reach and use all viable spawning habitat in the watersheds.
- Monitoring commercial catches at sea to ensure weak wild stocks are protected.
- Shifting hatchery operations to help restore wild runs.

7.5.2 Other State Salmon Recovery and Watershed Planning Efforts

The 1998 Salmon Recovery Planning Act established a program for developing and funding watershed restoration projects and created the Governor's Salmon Recovery Office to coordinate and assist in the development of salmon recovery plans.

The Statewide Strategy to Recover Salmon is also designed to improve watersheds, while the Watershed Planning Act encourages voluntary water resource planning by local governments, citizens, and Tribes in regards to water supply, water use, water quality, and habitat. The Salmon Recovery Funding Act established a board to approve local salmon recovery funding activities. The Salmon Recovery Funding Board has funded one project in the Scatter Creek watershed. It involved stream and pond restoration near Cozy Valley. A grant proposal has been submitted for some additional work downstream, and there are plans to apply for additional funding for acquisition and restoration of wetlands in that part of the basin (Holbrook 2002 personal communication).

WDFW and Tribal co-managers implemented the Wild Stock Recovery Initiative in 1992 and completed comprehensive management plans that identify limiting factors and habitat restoration activities. These plans also address harvest and hatchery actions.

Washington State's Forest and Fish Policy is designed to establish criteria for non-federal and private forest activities that will improve environmental conditions for listed species and minimize impacts to fish habitat through protection of riparian zones and in-stream flows.

Watershed planning projects are also being initiated by the Chehalis Basin Partnership. The Partnership was established to assess and manage the water resources of the Chehalis River Basin and to develop strategies to address water quantity, water quality, fish habitat, and in-stream flows. The Partnership is in the process of developing a watershed management plan for the basin, which will be issued in the fall of 2003. The Partnership identifies and ranks projects for salmon recovery funds. Currently, the Scatter Creek watershed is considered a medium priority for funding.

These laws and policies are not intended as regulatory controls with specific permit requirements or land use restrictions. However, they function to protect species and habitats covered under the HCP and are therefore relevant to the HCP planning process.

7.6 SUMMARY

A variety of overlapping federal, state, and local laws affect the resources of the Scatter Creek watershed. These laws protect and conserve important species and habitats by regulating land use activities and minimizing the impact of human actions. All of the HCP-covered species and habitats derive at least a moderate level of protection from these laws. Even species that are not currently designated for protection by federal, state, or local law derive some level of protection via the existing laws that protect their habitats. Given the breadth and depth of the existing regulatory controls, there are very few regulatory gaps for the HCP to address. A key issue in achieving the HCP goal of providing regulatory certainty for participating landowners will be ensuring the support and cooperation of state and local agencies, since these jurisdictions play a central role in regulating land use activities in the watershed.

Table 7-2 summarizes some of the key regulatory elements as they apply to the Scatter Creek watershed.

Table 7-2. Overview of Applicable Laws and Regulations for Species and Habitats Covered by the Scatter Creek HCP

Law/Policy	Responsible Agency/ Jurisdiction	Regulated Activities
Threatened, Endangered, and Sensitive Wildlife Species		
Federal Endangered Species Act	USFWS and NOAA Fisheries	Any activity that constitutes take of federally listed species or critical habitat
RCW 77.12	WDFW	Any activity that constitutes take of state-listed species
Lacey Act	USFWS	Import, export, sale, or possession of protected species
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of protected species or habitats and/or buffers
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices
At Risk Plant Species (including white-top aster)		
Washington Natural Heritage Program	WDNR	None
Migratory Birds (including all HCP-covered bird species)		
Migratory Bird Treaty Act	USFWS	Any activity that constitutes take
Bald Eagles, Golden Eagles		
Federal Endangered Species Act	USFWS and NOAA Fisheries	Take, possession, or transport of bald eagles
Bald and Golden Eagle Protection Act	USFWS	Possession, transport, or take of bald or golden eagles

Table 7-2. Overview of Applicable Laws and Regulations for Species and Habitats Covered by the Scatter Creek HCP (continued)

Law/Policy	Responsible Agency/ Jurisdiction	Regulated Activities
Amphibians (including the Oregon spotted frog)		
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of species, streams, or wetlands and/or buffers; activities that affect floodplains or shorelines
Hydraulic Code	WDFW	Activities that use, divert, obstruct, or change the flow of a water of the state; all in-water work
RCW 77.12		Any activity that constitutes take of state-listed species
Shoreline Management Act	Thurston County and Ecology	Residential construction and other land use activities within 200 ft of Scatter Creek, its floodplain, and/or associated wetlands
The Clean Water Act (Sections 401, 402, and 404)	Corps and Ecology	Filling wetlands, discharging stormwater or wastewater, modifying streams or waters of the U.S.
Salmon and Other Fish Species (including HCP-covered fish species)		
Hydraulic Code	WDFW	Activities that use, divert, obstruct, or change the flow of a water of the state; all in-water work
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of wetlands and streams and their buffers; activities that affect floodplains or shorelines
The Clean Water Act (Sections 401, 402 and 404)	WDFW	Filling wetlands, discharging stormwater or wastewater, modifying streams or waters of the U.S.
RCW 77.12	WDFW	Any activity that constitutes take of state-listed species
The Wild Salmonid Policy	WDFW, Tribes	None directly regulated
Rivers and Harbors Act (Section 10)	Corps	Activities in, over, and affecting navigable waters including Scatter Creek and its tributaries
Anadromous Fish Conservation Act	Departments of Commerce and Interior	None directly regulated
Forest and Fish Policy	WDFW	None directly regulated
Wild Stock Recovery Initiative	WDFW, Tribes	None directly regulated
Watershed Planning Act	WDFW, Tribes, and local jurisdictions	None directly regulated
Shoreline Management Act	Thurston County and Ecology	Residential construction and other land use activities within 200 ft of Scatter Creek, its floodplain, and/or associated wetlands
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices in or near streams
Wetlands and Streams		
Clean Water Act (Section 401)	Ecology	Filling wetlands, discharging stormwater or wastewater, modifying streams or waters of the U.S.
Hydraulic Code	WDFW	Activities that use, divert, obstruct, or change the flow of a water of the state; all in-water work
Clean Water Act (Section 402)	Ecology	Discharging stormwater or wastewater into waters of the state; construction activities that disturb more than 5 ac of soil
Clean Water Act (Section 404)	Corps	Placement of dredge or fill material into wetlands and waters of the U.S.
State Water Pollution Control	Ecology	Discharging stormwater or wastewater into waters of

Table 7-2. Overview of Applicable Laws and Regulations for Species and Habitats Covered by the Scatter Creek HCP (continued)

Law/Policy	Responsible Agency/ Jurisdiction	Regulated Activities
Act (RCW 90.48)		the state; construction activities affecting wetlands or streams
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of wetlands and streams, and their buffers, activities that affect floodplains or shorelines
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices in wetlands and riparian areas
Rivers and Harbors Act (Section 10)	Corps	Activities in, over, and affecting navigable waters including Scatter Creek and its tributaries
Oak Woodlands		
Thurston County Code (Title 17)	Thurston County	Modification or alteration of oak stands, including vegetation removal, residential construction, etc.
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices
Important Habitats and Species (includes all HCP-covered habitats and species)		
Thurston County Code (Title 17)	Thurston County	Modification or alteration of habitats or species or areas within 600 ft of species/habitats, including ditch maintenance, filling, vegetation removal, and residential construction
Outwash Prairies		
Thurston County Code (Title 17)	Thurston County	Modification or alteration of prairie habitats, including filling, vegetation removal, residential construction
Old Growth Forests		
Federal Endangered Species Act	USFWS and NOAA Fisheries	Any activity that constitutes take of federally listed species or critical habitat
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices that could affect listed species such as spotted owls
Thurston County Code (Title 17)	Thurston County	Modification or alteration of mature forests and their buffers; activities that affect protected species that require mature forest
Riparian Areas		
Forest Practices Act	WDNR	Timber harvest, vegetation clearing, road construction, herbicide use, and other forest practices near streams
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of wetland and streams and their buffers; activities that affect floodplains, shorelines, or protected species that require riparian habitats
Shoreline Management Act	Thurston County and Ecology	Residential construction and other land use activities within 200 ft of Scatter Creek, its floodplain, and/or associated wetlands
Special Management Areas (high groundwater flood hazard areas)		

**Table 7-2. Overview of Applicable Laws and Regulations for Species and Habitats
Covered by the Scatter Creek HCP (continued)**

Law/Policy	Responsible Agency/ Jurisdiction	Regulated Activities
Thurston County Code (Title 17)	Thurston County	Restrictions on timber harvesting, filling, creation of impervious surface, and building construction in or within 300 ft of high groundwater flood hazard areas (special reports required for some types of development)
Floodplains		
Thurston County Code (Titles 17 and 19)	Thurston County	Modification or alteration of wetland and streams and their buffers; activities that affect floodplains or shorelines
Aquifer Recharge Areas		
Thurston County Code (Title 17)	Thurston County	Some land uses prohibited in aquifer recharge areas
Geologic Hazard Areas		
Thurston County Code (Title 17)	Thurston County	Some land uses prohibited in aquifer recharge areas

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The following individuals were contacted to obtain information for the species accounts:

- Randy Aho, WDFW
- Chris Chappell, DNR
- Brody Cox, WDFW
- Paul Dahmer, WDFW
- John Fleckenstein, WNHP
- Jeff Foster, Fort Lewis
- David Giblin, University of Washington
- Dan Grosboll, The Nature Conservancy (TNC)
- Molly Hallock, WDFW
- Pat Hanratty, WDFW
- Curt Holt, WDFW
- Richard Kessler, WDFW
- Angela Lombardi, Fort Lewis Military Reservation
- Kelly McAllister, WDFW
- Susan Markey, WDFW
- Michael McGinnis, Chehalis Tribe
- Sandy Swope Moody, DNR
- Ann Potter, WDFW
- Elizabeth Rodrick, WDFW
- Rob Rhodes, Quinault Tribe
- Joanne Stellini, USFWS
- Landowners and other watershed residents (Paul Hicks, Chanele Holbrook, Wendi Meador, Bruce Morgan, Sally Ritter Alhadeff, Douglas Sampson, and Robert Sundstrom)

8.2 HYDROLOGY AND GEOMORPHOLOGY

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- Chris Clemons - NOAA Fisheries
- Brody Cox - WDFW
- Lonnie Crumley - Chehalis Basin Fisheries Task Force
- Craig Graber - Ecology
- Molly Hallock - WDFW
- Pat Hanratty - WDFW
- Mark Henry - WDFW
- Curt Holt - WDFW
- David Johnson - WDFW
- Susan Markey - WDFW
- Kelly McAllister - WDFW
- Mike McGinnis - Chehalis Tribe
- Brian Peck - USFWS
- Rob Rhodes - Quinault Nation
- Joanne Stellini - USFWS

9. GLOSSARY

Acre-foot (ac-ft)	The amount of water required to cover 1 acre to a depth of 1 foot. An acre-foot equals 325,851 gallons or 43,560 cubic feet.
Alevin	Larval salmonids that have hatched but have not yet completely absorbed their yolk sacs and usually have not yet emerged from the gravel. This is the second freshwater stage, between egg and fry. Sometimes called emergent fry .
Alluvial fan	A fan-shaped deposit of sand, gravel, and fine material made by a stream where it runs out onto a level plain or meets a slower stream.
Alluvium	Silt, sand, clay, gravel, or similar loose material deposited by flowing water, including the sediment laid down in riverbeds, floodplains, lakes, and at the foot of mountain slopes and estuaries.
Ammocoete	The larval young of the lamprey. Ammocoetes are blind, wormlike filter feeders that burrow in silt, often for years, before metamorphosing into adults.
Anadromous fish	Fish (such as salmon and steelhead) that hatch and spend part of their lives in freshwater, mature in saltwater, then migrate up rivers from the sea to spawn in freshwater.
Aquifer	A subsurface formation of rock, glacial material, or other deposits that contains water and is capable of storing and yielding water to a well or spring.
Arkosic	Derived from the disintegration of granite or gneiss and characterized by feldspar fragments.
Base flow	The portion of streamflow that is not runoff and results from seepage of water from the ground into a channel slowly over time; the primary source of running water in a stream during dry weather.
Bedload	Sediment particles that are carried by a water current along the floor or bed of a waterbody.
Best management practices	Practices used for the protection of water quality. BMPs are designed to prevent or reduce the amount of pollution from nonpoint sources or other adverse water quality impacts while meeting other goals and objectives. BMPs are standards to be achieved, not detailed or site-specific prescriptions or solutions.
Breccia	Rock composed of sharp-angled fragments embedded in a fine-grained matrix.
Colluvium	A loose deposit of rock debris accumulated through the action of gravity at the base of a cliff or slope.
Detritus	Accumulated organic debris from dead organisms, often an important source of nutrients in a food web.

Diameter at breast height (dbh)	The diameter of a standing tree at a point 4 ft, 6 inches from ground level.
Discharge	The volume of water that passes a given location within a given period of time. Usually expressed in cubic feet per second.
Duff	Decaying leaves and branches covering a forest floor.
Ecotone	A habitat created by the juxtaposition of distinctly different habitats; an edge habitat; or an ecological zone or boundary where two or more ecosystems meet. A transitional zone between two communities containing the characteristic species of each.
Emergent	A rooted herbaceous plant species that has parts extending above a water surface. Can pertain to a particular type of plant or a plant community (i.e., emergent wetland).
Emergent fry	See Alevin .
Endangered species	Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range.
Estuary	An ecological system at the mouth of a river or stream where freshwater and saltwater mix.
Exceedance	A sample that did not meet a water quality standard; it may have been higher than a given standard (e.g., too much bacteria in the water), or lower than a standard (e.g., too little oxygen in the water), or both (e.g., pH was either above or below the desired range).
Extirpated species	A species no longer surviving in regions that were once part of its range.
Fines	Fine sediments.
Fingerling	See Parr .
Flood, 100-year	A flood level with a 1 percent chance of being equaled or exceeded in any given year.
Forbs	A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow (generally small flowering plants).
Fry	The third freshwater stage of salmonid development, between the alevin and smolt. A fry is usually less than a year old, has absorbed its yolk sac, and is living in the stream. Sometimes called fed fry in hatchery release records.
Geographic information system (GIS)	A computerized map database used to store and evaluate site-specific information. A database of digital information on land-use, land cover, ecology, and other geographic attributes that can be overlaid, statistically analyzed, mathematically manipulated, and graphically displayed using maps, charts, and graphs.

Glacial advance	Glacial advance occurs when a glacier flows downvalley faster than the rate of ablation (melting) at its terminus.
Glacial drift	A load of rock material transported and deposited by a glacier, usually when the glacier begins to melt.
Glaciation	A long period of time (10,000+ years) characterized by climatic conditions associated with maximum glacial extent.
Grade control	Practices to maintain a desired streambed elevation.
Groundwater	Water that flows below the ground surface through saturated soil, glacial deposits, or rock.
Habitat fragmentation	Habitat fragmentation occurs when a barrier (house, roadway, etc.) is placed into the environment where a plant naturally grows or a species normally lives.
Herbaceous plant	A plant whose stem does not produce woody, persistent tissue and generally dies back at the end of each growing season.
Hydric	Relating to, characterized by, or requiring considerable moisture. Hydric soil forms under conditions of saturation, flooding, or ponding that last through enough of the growing season for the soil to develop anaerobic conditions in the upper part.
Hydrograph	A chart that measures the amount of water flowing past a point as a function of time.
Ice contact	Sediments deposited by streams in contact with ice.
Ice sheet	A dome-shaped glacier of considerable thickness and more than 50,000 square kilometers (12 million acres) in area, forming a continuous cover of snow and ice over a land surface, spreading outward in all directions and not confined by the underlying topography.
Impermeable	Not allowing fluids to pass through.
Infilling	Filling in.
Infiltration	The movement of water into rocks or soil through interstitial pores, small cracks, or crevices in the soil or rock.
Interbedded	Layered.
Interglacial	Occurring during a long period of time (10,000+ years) characterized by climatic conditions associated with minimum glacial extent.
Invasive species	Species that are not native to an area and are harmful or disruptive to the ecosystem.

Large woody debris	Any large piece of relatively stable woody material in bodies of water.
Larva (pl. larvae)	The newly hatched, earliest stage of any of various animals that undergo metamorphosis, differing markedly in form and appearance from the adult.
Limiting factor	A substance or condition whose absence or excessive concentration is incompatible with the needs or tolerance of a species or population and which may have a negative influence on their ability to thrive.
Lithology	The mineral constitution, classification, and mode of occurrence of rocks.
Mass wasting	A general term for the downslope movement of soil and rock material under the direct influence of gravity. The debris removed is not carried within, on, or under another medium. However, mass wasting debris added to a glacier or glacier margin may be incorporated into till.
Mean	
Mesic	Of, characterized by, or adapted to a moderately moist habitat.
Nonpoint source pollution	Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and manmade pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water.
Outwash	A load of sediment consisting of stratified (sorted) sand and gravel that is deposited by meltwater streams at the edge of a glacier.
Overstory	The portion of trees in a forest that forms the uppermost layer of foliage.
Parr	The fourth freshwater stage of salmonid development, when a characteristic "thumbprint" mark appears on the fish's sides and lateral stripes develop. Sometimes called fingerlings or pre-smolts .
Perennial	Continuing without cessation or intermission for more than 2 years.
Periglacial	Of or relating to the area around a glacier that is associated with cycles of intense freezing and thawing action.
Porosity	A measure of the water-bearing capacity of subsurface rock.
Pre-smolt	See Parr .
Proglacial	Of or relating to the area immediately adjacent to a glacier, or between the glacier and surrounding high ground.
Pyroclastic	Composed chiefly of rock fragments of volcanic origin.

Recharge	Water entering an underground aquifer through faults, fractures, or direct absorption.
Redd	A nest for egg deposition which the female salmon digs in the gravel on the river bottom using her tail.
Riffle	A place where the water in a stream ripples, as on a shallow rapid.
Riparian	Of, relating to, or located on the banks of a river or stream.
Rhizome	A horizontal underground stem that sends out roots and shoots from its nodes (a point from which a stem or branch grows).
Runoff	Water from rainfall, snowmelt, or discharges that flows across the ground surface instead of infiltrating the ground.
Salmonid	Fish in the Salmonidae family, including salmon, trout, char, and whitefish.
Scour	1) Abrasive effects of rocks and sediments incorporated in the ice base of a glacier. 2) The removal of sediment by streamflow.
Sensitive species	Animal and plant species identified as potentially susceptible or vulnerable to activity impacts or habitat alterations and, therefore, in need of special considerations during land management activity planning.
Smolt	A young salmonid ready for life in a saltwater environment.
Species of concern	Species that are believed to have declining populations and/or habitat, but because of a lack of scientific data, can not yet be categorized within the state or federal threatened, endangered, or candidate species lists. "Species of concern" is an informal term that refers to those species which USFWS or NOAA Fisheries believes might be in need of concentrated conservation actions. Such conservation actions vary depending on the health of the populations and degree and types of threats. At one extreme, there may only need to be periodic monitoring of populations and threats to the species and its habitat. At the other extreme, a species may need to be listed as a Federal threatened or endangered species. Species of concern receive no legal protection and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. Washington State species of concern include those species listed as State Endangered, State Threatened, State Sensitive, or State Candidate, as well as species listed or proposed for listing by the USFWS or NOAA Fisheries.
Stade	A short period of time (less than 10,000 years) characterized by climatic conditions associated with maximum glacial extent.
Subglacial	Occurring beneath a glacier.

Subspecies	An aggregate of similar populations of a species generally inhabiting a geographic subdivision of the range of the species and differing taxonomically (e.g., different size or color) from other populations of the species.
Substrate	The base on which an organism lives; streambed or other surface to which animals or plants attach, or on which they move.
Succession	The ecological progression of plant community change over time, characterized by displacements of species leading to a relatively stable climax community.
Surface water	Water that flows across the land surface in channels or is contained in depressions on the land surface (e.g., runoff, ponds, lakes, rivers, and streams).
Swale	A natural or manmade open depression or wide, shallow ditch that intermittently contains or conveys runoff.
Till	Unstratified sediment deposited directly by a glacier.
Threatened species	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
Transpiration	The process by which water that is absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface, generally through leaf pores.
Tributary	A river or stream that feeds into another, larger one and forms part of the larger river's watershed.
Tuffaceous	Of or relating to rock composed of compacted volcanic ash varying in size from fine sand to coarse gravel.
Understory	An underlying layer of vegetation, especially the plants that grow beneath a forest's canopy.
Watershed	The land area that drains water to a particular stream, river, or lake.
Wetlands	Areas that are inundated by surface water or groundwater with a frequency sufficient, under normal circumstances, to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.
Xeric	Of, characterized by, or adapted to an extremely dry habitat.

APPENDIX A

List of Plant Species of Western Washington Prairies

APPENDIX A

Table A-1. Plant Species of Western Washington Prairies

Genus	Species	Common Name
Family: Apiaceae		
<i>Lomatium</i>	<i>nudicaule</i>	Pestle parsnip
<i>Lomatium</i>	<i>triternatum</i>	Nine-leaf lomatium
		Pomo-celery lomatium
<i>Lomatium</i>	<i>utriculatum</i>	Spring gold
Apocynaceae		
<i>Apocynum</i>	<i>androsaemifolium</i>	Spreading dogbane
Asteraceae		
<i>Achillea</i>	<i>ageratifolia</i>	Yarrow
<i>Anaphalis</i>	<i>margaritacea</i>	Pearly everlasting
<i>Antennaria</i>	<i>microphylla</i>	Rosy pussytoes
<i>Balsamorhiza</i>	<i>deltoidea</i>	Puget balsamroot
<i>Erigeron</i>	<i>speciosus</i>	Showy fleabane
<i>Eriophyllum</i>	<i>lanatum</i>	Woolly sunflower
<i>Gaillardia</i>	<i>aristata</i>	Blanket flower
<i>Hieracium</i>	<i>cynoglossoides</i>	Hound's tongue hawkweed
<i>Hypochaeris</i>	<i>radicata</i>	Hairy catsear
<i>Leucanthemum</i>	<i>vulgare</i>	Oxeye daisy
<i>Microseris</i>	<i>laciniata</i>	Cut-leaf microseris
<i>Sericocarpus</i>	<i>green</i>	White-top aster
<i>Solidago</i>	<i>spathulata</i> var. <i>neomexicana</i>	Spikelike goldenrod
Berberidaceae		
<i>Mahonia</i> (=Berberis)	<i>aquifolium</i>	Tall Oregon grape
Brassicaceae		
<i>Teesdalia</i>	<i>nudicaulis</i>	Teesdalia
Campanulaceae		
<i>Campanula</i>	<i>rotundifolia</i>	Bluebells-of-Scotland
Caprifoliaceae		
<i>Symphoricarpos</i>	<i>albus</i> var. <i>laevigatus</i>	Snowberry
Caryophyllaceae		
<i>Silene</i>	<i>antirrhina</i>	Sleepy catchfly
<i>Silene</i>	<i>scouleri</i>	Scouler's silene
Clusiaceae		
<i>Hypericum</i>	<i>perforatum</i>	Common St. Johns Wort
Cyperaceae		
<i>Carex</i>	<i>inops</i> (=pennsylvanica)	Long-stolon sedge
Ericaceae		
<i>Arctostaphylos</i>	<i>uva-ursi</i>	Kinnikinnick

Table A-1. Plant Species of Western Washington Prairies (Continued)

Genus	Species	Common Name
Fabaceae		
<i>Cytisus</i>	<i>scoparius</i> (L.)	Scotch broom
<i>Lotus</i>	<i>micranthus</i>	Small-flowered deervetch
<i>Lupinus</i>	<i>albicaulis</i>	Sickle-keeled lupine
<i>Lupinus</i>	<i>bicolor</i>	Bicolor lupine
<i>Lupinus</i>	<i>lepidus</i>	Prairie lupine
<i>Rupertia</i> (= <i>Psoralea</i>)	<i>physodes</i>	Rupert's scurf-pea
Iridaceae		
<i>Sisyrinchium</i>	<i>angustifolium</i>	Blue-eyed grass
Juncaceae		
<i>Luzula</i>	<i>campestris</i>	Field woodrush
Lamiaceae		
<i>Prunella</i>	<i>vulgaris</i>	Self-heal
Liliaceae		
<i>Brodiaea</i>	<i>coronaria</i>	Harvest brodiaea
<i>Camassia</i>	<i>quamash</i>	Common camas
<i>Erythronium</i>	<i>oregonum</i>	Giant fawn lily
<i>Fritillaria</i>	<i>affinis</i> var. <i>affinis</i> (= <i>lanceolata</i>)	Chocolate lily
<i>Zigadenus</i>	<i>venenosus</i>	Death camas
Orchidaceae		
<i>Spiranthes</i>	<i>romanzoffiana</i>	Lady's tresses
Pinaceae		
<i>Pseudotsuga</i>	<i>menziesii</i>	Douglas-fir
Plumbaginaceae		
<i>Armeria</i>	<i>maritima</i>	Sea-pink
Poaceae		
<i>Aira</i>	<i>caryophyllea</i>	Silver hairgrass
<i>Agrostis</i>	<i>capillaries</i>	Colonial bentgrass
<i>Anthoxanthum</i>	<i>odoratum</i>	Sweet vernalgrass
<i>Arrhenatherum</i>	<i>elatius</i>	Tall oatgrass
<i>Dactylis</i>	<i>glomerata</i>	Orchardgrass
<i>Danthonia</i>	<i>californica</i>	California oatgrass
<i>Festuca</i>	<i>roemerii</i>	Roemer's fescue
<i>Holcus</i>	<i>lanatus</i>	Common velvetgrass
<i>Koeleria</i>	<i>macrantha</i> (= <i>cristata</i>)	Junegrass
<i>Panicum</i> (= <i>Dichanthelium</i>)	<i>acuminatum</i> (= <i>occidentale</i>)	Geyser's panicgrass
<i>Panicum</i> (= <i>Dichanthelium</i>)	<i>oligosanthes</i> var. <i>scribnerianum</i> (= <i>scribnerianum</i>)	Scribner's panicgrass
<i>Poa</i>	<i>pratensis</i>	Kentucky bluegrass
Polygonaceae		
<i>Rumex</i>	<i>acetosella</i>	Sheep sorrel

Table A-1. Plant Species of Western Washington Prairies (Continued)

Genus	Species	Common Name
Polypodiaceae		
<i>Pteridium</i>	<i>aquilinum</i>	Bracken fern
Primulaceae		
<i>Dodecatheon</i>	<i>hendersonii</i>	Henderson's shooting star
<i>Dodecatheon</i>	<i>pulchellum</i> (=pauciflorum)	Few-flowered shooting star
Ranunculaceae		
<i>Delphinium</i>	<i>nuttallii</i>	Nuttall's larkspur
<i>Ranunculus</i>	<i>occidentalis</i>	Western buttercup
Rhamnaceae		
<i>Rhamnus</i>	<i>cathartica</i>	Buckthorn
Rosaceae		
<i>Fragaria</i>	<i>vesca</i>	Woods strawberry
<i>Fragaria</i>	<i>virginiana</i> var. <i>platypetala</i>	Broadpetal strawberry
<i>Crataegus</i>	<i>douglasii</i> Lindl.	Black hawthorn
<i>Potentilla</i>	<i>gracilis</i>	Slender cinquefoil
<i>Rosa</i>	<i>nutkana</i> K. Presl	Nootka rose
<i>Amelanchier</i>	<i>alnifolia</i>	Western serviceberry
Saxifragaceae		
<i>Heuchera</i>	<i>chlorantha</i>	Meadow alumroot
<i>Lithophragma</i>	<i>parviflora</i>	Small-flowered prairiestar
<i>Saxifraga</i>	<i>integrifolia</i> var. <i>integrifolia</i>	Swamp saxifrage
Violaceae		
<i>Viola</i>	<i>adunca</i> var. <i>adunca</i>	Early blue violet
<i>Viola</i>	<i>nuttallii</i> var. <i>praemorsa</i>	Canary violet

Source: Washington Native Plant Society (WNPS 2000).

APPENDIX B

List of Plant Species Often Associated With Washington Oak Habitat East and West of the Cascades

APPENDIX B

**Table B-1. Plant Species Often Associated With Washington Oak Habitat
East and West of the Cascades**

Common Name	Genus/Species
Alaska oniongrass	<i>Melica subulata</i>
American vetch	<i>Vicia Americana</i>
Baldhip rose	
Balsamroot	<i>Balsamorhiza sagittata</i>
Bigleaf maple	<i>Acer macrophyllum</i>
Bigleaf sandwort	<i>Moehringia macrophylla</i>
Big sagebrush	<i>Artemesia tridentata</i>
Bitterbrush	<i>Purshia tridentata</i>
Blackberry	<i>Rubus ursinus</i>
Blackcap	
Black cottonwood	<i>Populus trichocarpa</i>
Black hawthorn	<i>Crataegus douglasii</i>
Blue wildrye	<i>Elymus glaucus</i>
Bluebells-of-Scotland	<i>Campanula rotundifolia</i>
Bluebunch wheatgrass	<i>Agropyron spicatum</i>
Braken	<i>Pteridium aquilinum</i>
Broadleaf starflower	<i>Trientalis borealis</i> Raf. ssp. <i>latifolia</i>
Broadpetal strawberry	<i>Fragaria virginiana</i> var. <i>platypetala</i>
Buckthorn	<i>Rhamnus cathartica</i>
California danthonia	<i>Danthonia californica</i> Boland.
California hazelnut	<i>Corylus cornuta</i>
Cascara buckthorn	<i>Rhamnus purshiana</i>
Catchweed bedstraw	
Cheatgrass	<i>Bromus tectorum</i>
Chickweed	<i>Cerastium</i> spp.
Chocolate lily	<i>Fritillaria biflora</i> Lindl.
Colonial bentgrass	<i>Agrostis capillaris</i>
Common camas	<i>Camassia</i> Lindl.
Common St. Johns wort	<i>Hypericum perforatum</i>
Common snowberry	<i>Symphoricarpos albus</i>
Common vetch	
Creeping snowberry	<i>Gaultheria hispidula</i> /Symphoricarpos <i>mollis</i>
Cutleaf microseris	<i>Microseris laciniata</i>
Domestic sweet cherry	<i>Prunus avium</i>
Douglas-fir	<i>Pseudotsuga menziesii</i>
Early blue violet	<i>Viola palmata</i>
Enchanter's nightshade	<i>Circaea</i>
Field woodrush	<i>Luzula campestris</i>
Roemer's fescue	<i>Festuca roemerii</i>

Common Name	Genus/Species
Hairy catsear	<i>Hypochaeris radicata</i>
Henderson's shooting star	<i>Dodecatheon hendersonii</i>
Houndstongue hawkweed	<i>Hieracium cynoglossoides</i>
Indian plum	<i>Oemleria cerasiformes</i>
Kentucky bluegrass	<i>Poa pratensis</i>
Kinnikinnick	<i>Arctostaphylos uva-ursi</i>
Licorice fern	<i>Polypodium glycyrrhiza</i>
Long-stoloned sedge	<i>Carex inops</i>
Lupine	<i>Lupinus</i> spp.
Meadow Death camas	<i>Zigadenus venenosus</i>
Mountain sweetcicely	<i>Osmorhiza berteroi</i>
Nootka rose	<i>Rosa nutkana</i>
Nuttall's peavine	<i>Labordia waiolani</i>
Ocean Spray	<i>Holodiscus discolor</i>
Orange Honeysuckle	<i>Lonicera ciliosa</i>
Orchard grass	<i>Dactylis glomerata</i>
Oregon ash	<i>Fraxinus latifolia</i>
Oregon manroot	<i>Marah oreganus</i>
Oregon white oak	<i>Quercus garryana</i>
Oval-leaf viburnum	<i>Viburnum ellipticum</i>
Oxeye daisy	<i>Leucanthemum vulgare</i>
Pacific dogwood	<i>Cornus nuttallii</i>
Pacific madrone	<i>Arbutus menziesii</i>
Pacific sanicle	<i>Sanicula crassicaulis</i>
Poison oak	<i>Rhus diversiloba</i>
Pomo-celery lomatium	
Ponderosa pine	<i>Pinus ponderosa</i>
Prairie junegrass	<i>Koeleria macrantha</i>
Puget balsamroot	<i>Balsamorhiza deltoidea</i>
Quaking aspen	<i>Populus tremuloides</i>
Red fescue	<i>Festuca rubra</i>
Roemer's fescue	<i>Festuca roemerii</i>
Scot's broom	<i>Cytisus scoparius</i>
Self heal	<i>Prunella vulgaris</i>
Serviceberry	<i>Amelanchier alnifolia</i>
Sheep sorrel	<i>Rumex acetosella</i>
Siberian minerslettuce	
Silver hairgrass	<i>Aira caryophyllea</i>
Slender cinquefoil	<i>Potentilla gracilis</i>
Small-flowered trillium	<i>Trillium parviflorum</i>
Smallflower nemophila	<i>Nemophila aphylla</i>
Spikelike goldenrod	<i>Solidago spathulata</i> var. <i>neomexicana</i>

Common Name	Genus/Species
Spring beauty	<i>Claytonia lanceolata</i>
Starry false solomons seal	<i>Polygonatum stellatum</i>
Swordfern	<i>Macrothelypteris torresiana</i>
Teesdalia	<i>Teesdalia nudicaulis</i>
Tall oatgrass	<i>Arrhenatherum elatius</i>
Tall Oregon grape	<i>Berberis aquifolium</i>
Trailing blackberry	<i>Rubus ursinus</i>
Velvet grass	<i>Holcus lanatus</i>
Western bittercress	<i>Cardamine oligosperma</i>
Western buttercup	<i>Ranunculus occidentalis</i>
Western crabapple	<i>Malus fusca</i>
Western wood strawberry	<i>Fragaria vesca</i>
Western hemlock	<i>Tsuga heterophylla</i>
Western ryegrass	<i>Elymus glaucus</i>
White-top aster	<i>Sericocarpus green</i>
Woods strawberry	<i>Fragaria vesca</i>
Woolly sunflower	<i>Eriophyllum lanatum</i>
Yarrow	<i>Achillea ageratifolia</i>
Yerba buena	<i>Clinopodium douglasii</i>

Source: Larsen and Morgan (1998).

APPENDIX C

Scatter Creek Habitat Data

Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
1	<15m	<15m	Hardwood	1.5	30	30-50cm (med)	<30m (smal)	Oregon ash, red alder, western red cedar	>90	sparse	none	sparse	moderate	moderate	sparse	Good
1	<15m	<15m	Hardwood	1	20		<30m (smal)	red osier dogwood, hawthorne, reed canary grass, snowberry, night shade, Himalayan blackberry, big leaf maple	>90	sparse	none	sparse	none	moderate	sparse	Good
1	15-20m	<15m	Hardwood	1.5	25			Oregon ash, red alder, cascara, red osier dogwood, hazelnut, hawthorne, elder berry, snow berry, reed canary grass, big leaf maple	>90	sparse	none	sparse	none	moderate	sparse	Good
1	<15m	<15m	Hardwood	4	30		<30m (smal)	Oregon ash, big leaf maple, cascara, red osier dogwood, reed canary grass, snow berry	>90	sparse	none	sparse	none	moderate	moderate	Good
1	<15m	<15m	Hardwood	2.5	20		<30m (smal)	red osier dogwood, Oregon ash, reed canary grass, night shade, pacific ninebark	>90	sparse	none	sparse	none	moderate	moderate	Good
3	<15m	>40m	Hardwood	2	11		30-50cm (med)	Oregon ash, garry oak, snowberry, black night shade	>90	sparse	none	sparse	none	none	sparse	Poor
3	<15m	>40m	Hardwood	2	11		30-50cm (med)	Oregon ash, garry oak	>90	none	none	none	none	none	sparse	Poor

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
3	<15m	15-20m	Hardwood	2	15		30-50cm (med)	Oregon ash, garry oak, black night shade	>90	sparse	none	sparse	none	none	sparse	Poor
3	<15m	15-20m	Hardwood	2	13		30-50cm (med)	Oregon ash, snowberry, garry oak	>90	sparse	none	sparse	sparse	none	sparse	Poor
3	<15m	>40m	Hardwood	2	13		30-50cm (med)	Oregon ash, garry oak, snowberry	>90	sparse	none	sparse	sparse	moderate	sparse	Poor
3	<15m	<15m	Hardwood	2	12		30-50cm (med)	Oregon ash, garry oak	>90	sparse	none	sparse	sparse	sparse	sparse	Poor
3	>40m	20-40m	Hardwood	2	13		30-50cm (med)	Oregon ash, garry oak, snowberry, black night shade, pacific ninebark	>90	abundant	none	moderate	none	none	moderate	Poor
3	>40m	15-20m	Hardwood	2	12		30-50cm (med)	Oregon ash, garry oak, snowberry, field mint	>90	moderate	none	moderate	sparse	none	moderate	Poor
3	>40m	<15m	Hardwood	1.5	18		<30m (smal)	oak, ash, snowberry, reed canary grass	<80	moderate	none	sparse	none	none		
3	>40m	<15m	Hardwood	2	15	30-50cm (med)	30-50cm (med)	Oregon ash, garry oak, snowberry, field mint	>90	sparse	none	sparse	none	none	moderate	Poor
3	>40m	>40m	Mixed	3	45	>50cm (large)	30-50cm (med)	Oregon ash, red osier dogwood, 25m past hardwood buffer conifers take over	>90	moderate		moderate	none	sparse	moderate	Good
3	>40m	>40m	Mixed	3	45	30-50cm (med)	30-50cm (med)	ash, pacific nine bark, alder, red osier dogwood, stinging nettle, night shade	>90	moderate	none	abundant	sparse	moderate	abundant	Good

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
3	>40m	>40m	Mixed	3	40	<30cm (small)	<30cm (smal)	nine bark, night shade, nettle, maple, ash, reed canary grass, douglas fir	>90	sparse	none	abundant	none	sparse	moderate	Good
3	<15m	>40m	Hardwood	2	30	30-50cm (med)	<30cm (smal)	Oregon ash, garry oak, douglas fir, red cedar, night shade, mint, reed canary grass, Himalayan blackberry, also evergreen	>90	sparse	none	sparse	none	moderate	none	Good
3	<15m	>40m	Hardwood	2	30	30-50cm (med)	<30cm (smal)	Oregon ash, reed canary grass, mint, douglas fir, western red cedar, stinging nettle, night shade, snowberry, Indian plum, vine maple	>90	sparse	none	sparse	none	moderate	none	Good
3	<15m	>40m	Hardwood	2	30	30-50cm (med)	30-50cm (med)	Oregon ash, garry oak, - on RB 10m into buffer mixed conifer forest begins. Snow-berry, reed canary grass, night shade, evergreen blackberry, stinging nettle, mint and service berry	>90	sparse	none	none		moderate	none	Good
3	<15m	>40m	Hardwood	2	25	30-50cm (med)	30-50cm (med)	Oregon ash, oak, conifer forest, snowberry, spirea, reed canary grass, Indian plum	>90	sparse	none	sparse	none	sparse	none	Good

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
4	>40m	<15m	Hardwood	1.8	7		<30m (smal)	oak, dogwood, ash, alder	>90	none	none	sparse	none	moderate	sparse	Good
4	>40m	15-20m	Conifer	2	10	<30cm (small)		reed canary grass, ash, oak, willow, cedar tree	>90		none	sparse	none	abundant	none	Good
4	>40m	20-40m	Hardwood	2	15		30-50cm (med)	oak, ash	>90	none	none	sparse	none	abundant	sparse	Good
4	<15m	20-40m	Hardwood	0.5	9		30-50cm (med)	Oregon ash, garry oak, thistle, Himalayan blackberry	>90	moderate	none	moderate	none	moderate	sparse	Good
4	<15m	15-20m	Hardwood	0.5	12		30-50cm (med)	ash, oak, rose	>90	sparse	none	moderate	sparse	moderate	moderate	Good
4	15-20m	15-20m	Hardwood	1	25	30-50cm (med)	<30m (smal)	ash, garry oak, reed canary grass, service berry, water narrow leaf burr weed	>90	sparse	none	sparse	none	sparse	sparse	Fair
4	15-20m	15-20m	Hardwood	2	25		30-50cm (med)	reed canary grass, dead duck weed, garry oak, Oregon ash, nine bark	>90	sparse	none	sparse	none	none	sparse	Fair
4	20-40m	20-40m	Hardwood	2	30		30-50cm (med)	ash, garry oak, reed canary grass, fern	>90	sparse	none	sparse	none	none	sparse	Fair
5	<15m	<15m	Hardwood	1.5	20		30-50cm (med)	Oregon ash, rose	>90	sparse	none	sparse	none	moderate	sparse	Good
5	<15m	<15m	Hardwood	1.5	20		30-50cm (med)	Oregon ash, snowberry, rose	>90	sparse	none	sparse	none	sparse	sparse	Good
5	<15m	<15m	Hardwood	1	13		<30m (smal)	Oregon ash, red osier dogwood, spirea	>90	sparse	none	sparse	none	moderate	none	Good
5	15-20m	>40m	Hardwood	1	30		30-50cm (med)	Oregon ash	>90	sparse	none	sparse	sparse	none	moderate	Poor
5	<15m	>40m	Hardwood	1.2	23		30-50cm (med)	ash, reed canary grass, cottonwood	>90	sparse	none	moderate	none	moderate	moderate	Fair

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
5	20-40m	20-40m	Hardwood	1.5	25	>50cm (large)	30-50cm (med)	reed canary grass, ash, cottonwood, willow, fir	80-90	abundant	none	abundant	none	abundant	moderate	Fair
5	>40m	>40m	Hardwood	1.2	23	>50cm (large)	30-50cm (med)	ash, willow, cottonwood, reed canary grass, fir	80-90	moderate	<25%	abundant	none	abundant	moderate	Fair
5	20-40m	20-40m	Hardwood	3	22		30-50cm (med)	red alder, Oregon ash, pacific ninebark, spirea, vine maple, black cottonwood, western dogwood	>90	moderate	<25%	moderate	none	moderate	abundant	Fair
5	<15m	15-20m	Hardwood	4	15		30-50cm (med)	red alder, black cottonwood, Oregon ash, black night shade, pacific ninebark	>90	moderate	none	moderate	none	moderate	abundant	Good
6	<15m	<15m	Hardwood	20	0		30-50cm (med)	Oregon ash, Nootka rose, sitka sedge, salmon berry, snowberry, western buttercup, reed canary grass	>90	sparse	none	moderate	none	abundant	abundant	Fair
6	<15m	<15m	Hardwood	1.5	20		30-50cm (med)	Oregon ash, snowberry, reed canary grass, sitka sedge, Nootka rose, western buttercup, black cottonwood	>90	sparse	none	moderate	none	moderate	abundant	Fair
6	<15m	<15m	Conifer	1.5	13	<30m (smal)		Oregon ash, Nootka rose, sedges, reed canary grass, snowberry	>90	sparse	none	sparse	sparse	moderate	moderate	Good
6	<15m	<15m	Hardwood	1	12	<30m (smal)		Oregon ash, snowberry, Nootka rose	>90	sparse	none	sparse	sparse	moderate	moderate	Good

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
6	<15m	<15m	Hardwood	1.5	12		<30m (smal)	Oregon ash, Nootka rose, sedge, snowberry	>90	sparse	none	sparse	sparse	moderate	moderate	Good
6	<15m	<15m	Hardwood	1.5	12		30-50cm (med)	Oregon ash, spirea, grasses	>90	sparse	none	sparse	moderate	moderate	moderate	Good
6	<15m	<15m	Hardwood	1	13.5		30-50cm (med)	Oregon ash, grasses, sedges	>90	moderate	none	moderate	sparse	sparse	moderate	Good
6	<15m	<15m	Hardwood	2	13		<30m (smal)	Oregon ash, red osier dogwood, spirea, sedges, grasses, ninebark, service berry, willow, rose speers	80-90	moderate	none	abundant	sparse	sparse	abundant	Good
6	<15m	<15m	Hardwood	2	12.5		<30cm (small)	Oregon ash, reed canary grass, sedges, fig wart, snow berry, garry oak, douglas fir	80-90	moderate	none	abundant	moderate	sparse	abundant	Good
6	<15m	<15m	Hardwood	2	12		30-50cm (med)	Oregon ash, garry oak, reed canary grass, sedges, snowberry	>90	moderate	none	moderate	sparse	sparse	abundant	Good
6	<15m	<15m	Hardwood	2	4		<30m (smal)	willow, spirea, reed canary grass, Oregon ash, snowberry, Nootka rose	>90	sparse	none	sparse	none	moderate	abundant	Good
6	<15m	<15m	Hardwood	2	4		<30m (smal)	ash, willow, spirea, snowberry, rose, nap weed, reed canary grass, blackberry, rushes, sedges	>90	sparse	none	moderate	abundant	abundant	abundant	Good

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
6	<15m	>40m	Hardwood	20	0		30-50cm (med)	Fraxinus latifolia, Nootka rose, night shade, snowberry, pacific willow, pacific ninebark	>90	moderate	none	moderate	none	abundant	moderate	Fair
6	<15m	<15m	Hardwood	1.5	4		<30m (smal)	willow, spirea, reed canary grass	>90	none	none	sparse	none	moderate	moderate	Good
6	<15m	<15m		1.5	3		<30m (smal)	willow, spirea, rose, duck weed, reed canary grass	>90	none	none	sparse	sparse	moderate	moderate	Good
6				2	3		<30m (smal)	douglas fir, spirea, reed canary grass, pacific willow	>90	sparse	none	moderate	sparse	moderate	sparse	Fair
6				2	4	<30cm (small)	<30m (smal)	Oregon ash, pacific willow	>90	sparse	none	abundant	sparse	moderate	sparse	Fair
6			Mixed	2	4	<30cm (small)	<30m (smal)	pacific willow, hawthorne, spirea, Oregon ash	>90	sparse	none	moderate	sparse	moderate	sparse	Good
6	<15m	<15m	Hardwood	1.5	20		30-50cm (med)	Oregon ash, Nootka rose, snowberry	80-90	sparse	none	moderate	moderate	sparse	moderate	Fair
6	<15m	>40m	Hardwood	1.5	23		30-50cm (med)	garry oak, snowberry, Nootka rose	>90	moderate	none	moderate	none	moderate	moderate	Good
6	<15m	<15m	Hardwood	1.5	20		30-50cm (med)	Oregon ash, reed canarygrass, symphoricarpos albus, rosa nutkana	80-90	sparse	none	sparse	moderate	sparse	sparse	Good
6	<15m	<15m	Hardwood	1.5	30	>50cm (large)	30-50cm (med)	Oregon ash, garry oak, Douglas fir, reed canary grass, snowberry, Nootka rose	80-90	moderate	none	moderate	moderate	moderate	abundant	Good

**Table C-1. Riparian, Stream Bank, and Fish Passage Conditions in SHIAP Stream Survey Reaches of Scatter Creek, 1999
(Continued)**

Sampling Reach	Buffer Width Left	Buffer Width Right	Buffer Composition	Dominant Veg Height-m	Dominant Tree Height-m	Ave Tree Size-conifer	Ave Tree Size-decid	Dominant Vegetation Species	Bank Stability	Habitat-LWD	Artificial Bank Protection	Small Organic Debris	Overhang Banks	Aquatic Veg	Overhang Veg	Fish Passage
6	<15m	<15m	Hardwood	1.5	13		30-50cm (med)	garry oak, Oregon ash, douglas fir, snowberry, rose, reed canary grass	80-90	sparse	none	moderate	abundant	moderate	abundant	Good
7	<15m	<15m	Hardwood	2.5	0			spirea	>90	sparse	none	sparse	sparse	moderate	sparse	Good
7	<15m	<15m	Hardwood	2	8		30-50cm (med)	Oregon ash, red alder	>90	none	none	sparse	moderate	moderate	sparse	Good
7			Hardwood	1.5	9		30-50cm (med)	Oregon ash, red alder, snow berry, Nootka rose, Himalayan blackberry, pacific ninebark	>90	sparse	none	moderate	none	sparse	moderate	Good
7	20-40m	<15m	Hardwood	0	0		30-50cm (med)	Oregon ash, red alder, black night shade, pacific nine bark		moderate	none	moderate	none	sparse	moderate	Good
7	<15m	<15m	Hardwood	2.5	0			spirea	>90	sparse	none	sparse	sparse	moderate	sparse	Good
7	<15m	<15m	Hardwood	2.5	0			spirea	>90	sparse	none	sparse	sparse	moderate	sparse	Good
7	<15m	<15m	Hardwood	0	5.5		<30m (smal)	Oregon ash, spirea	>90	sparse	none	sparse	sparse	moderate	sparse	Good
7	<15m	>40m	Hardwood	0	11	30-50cm (med)	30-50cm (med)	Oregon ash, black night shade, spirea, pacific ninebark	>90	abundant		sparse	none	abundant	moderate	Good
7	<15m	>40m	Hardwood	2	11	30-50cm (med)	30-50cm (med)	Oregon ash, pacific ninebark, black night shade	>90	moderate	none	moderate	sparse	moderate	abundant	Good

Source: Thurston County 1999 habitat survey

APPENDIX D

Scatter Creek Water Quality Data From Chehalis River Water Quality Screening and Upper Chehalis River TMDL Studies

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Ammonia (mg/L)	0.01
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Ammonia (mg/L)	0.01
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Ammonia (mg/L)	0.01
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Ammonia (mg/L)	0.009
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Ammonia (mg/L)	0.012
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Ammonia (mg/L)	0.012
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Ammonia (mg/L)	0.013
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Ammonia (mg/L)	0.124
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Ammonia (mg/L)	0.107
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Ammonia (mg/L)	0.121
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Ammonia (mg/L)	0.105
Scatter Creek (@ Chehalis Rm 55.207)	46.80283	123.08689	9/10/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.207)	46.80283	123.08689	9/11/91	Ammonia (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.207)	46.80283	123.08689	7/21/92	Ammonia (mg/L)	0.011
Scatter Creek (@ Chehalis Rm 55.207)	46.80283	123.08689	8/5/92	Ammonia (mg/L)	0.039
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Biochemical Oxygen Demand (mg/L)	0.8
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Biochemical Oxygen Demand (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Biochemical Oxygen Demand (mg/L)	1.7
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Biochemical Oxygen Demand (mg/L)	2.1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Biochemical Oxygen Demand (mg/L)	2.9
Scatter Creek (@ Chehalis Rm 55.207)	46.80283	123.08689	9/10/91	Biochemical Oxygen Demand (mg/L)	0.7
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Chloride (mg/L)	3.74
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Chloride (mg/L)	3.63

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Chloride (mg/L)	4.11
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Chloride (mg/L)	4.1
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Chloride (mg/L)	3.6
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Chloride (mg/L)	4.1
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Chloride (mg/L)	4
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Chloride (mg/L)	5.8
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Chloride (mg/L)	5.5
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Chloride (mg/L)	5.2
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Chloride (mg/L)	5.2
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Chloride (mg/L)	5.1
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Chloride (mg/L)	5.5
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Chloride (mg/L)	4.9
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Chloride (mg/L)	5
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Chloride (mg/L)	5.4
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Chloride (mg/L)	5.4
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Chloride (mg/L)	7.9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Chloride (mg/L)	8.3
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Chlorophyll (µg/L)	0.028
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Chlorophyll (µg/L)	3.803
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Chlorophyll (µg/L)	0.2
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Chlorophyll (µg/L)	4.427
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Chlorophyll (µg/L)	1.874
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Chlorophyll (µg/L)	5.789
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Conductivity (µmhos/cm)	88.1
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Conductivity (µmhos/cm)	82.4
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Conductivity (µmhos/cm)	80.1
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Conductivity (µmhos/cm)	94
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Conductivity (µmhos/cm)	82

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Conductivity (µmhos/cm)	81.3
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Conductivity (µmhos/cm)	81.9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/1/91	Conductivity (µmhos/cm)	119
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Conductivity (µmhos/cm)	153
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Conductivity (µmhos/cm)	153
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Conductivity (µmhos/cm)	133
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Conductivity (µmhos/cm)	138
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Conductivity (µmhos/cm)	151
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Conductivity (µmhos/cm)	152
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Conductivity (µmhos/cm)	138
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Conductivity (µmhos/cm)	133
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Conductivity (µmhos/cm)	130
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Conductivity (µmhos/cm)	132
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Dissolved Oxygen (mg/L)	13.95
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Dissolved Oxygen (mg/L)	12.65
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Dissolved Oxygen (mg/L)	11.05
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Dissolved Oxygen (mg/L)	12.8
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Dissolved Oxygen (mg/L)	11.65
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Dissolved Oxygen (mg/L)	10.45
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Dissolved Oxygen (mg/L)	10.5
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/1/91	Dissolved Oxygen (mg/L)	10
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Dissolved Oxygen (mg/L)	12.82
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Dissolved Oxygen (mg/L)	12.12
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Dissolved Oxygen (mg/L)	13.99
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Dissolved Oxygen (mg/L)	11.85
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Fecal Coliform (#col/100ml)	8
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Fecal Coliform (#col/100ml)	11
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Fecal Coliform (#col/100ml)	6

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Fecal Coliform (#col/100ml)	7
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Fecal Coliform (#col/100ml)	4
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Fecal Coliform (#col/100ml)	22
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Fecal Coliform (#col/100ml)	15
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Fecal Coliform (#col/100ml)	1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Fecal Coliform (#col/100ml)	3
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Fecal Coliform (#col/100ml)	20
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Fecal Coliform (#col/100ml)	1
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Fecal Coliform (#col/100ml)	740
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Fecal Coliform (#col/100ml)	1500
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Nitrite-Nitrate (mg/L)	1.23
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Nitrite-Nitrate (mg/L)	0.82
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Nitrite-Nitrate (mg/L)	0.69
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Nitrite-Nitrate (mg/L)	1.28
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Nitrite-Nitrate (mg/L)	0.627
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Nitrite-Nitrate (mg/L)	0.413
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Nitrite-Nitrate (mg/L)	0.413
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Nitrite-Nitrate (mg/L)	4.09
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Nitrite-Nitrate (mg/L)	3.76
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Nitrite-Nitrate (mg/L)	3
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Nitrite-Nitrate (mg/L)	4.46
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Nitrite-Nitrate (mg/L)	4.07
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Nitrite-Nitrate (mg/L)	3.87
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Nitrite-Nitrate (mg/L)	4.51
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Nitrite-Nitrate (mg/L)	3.25
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Nitrite-Nitrate (mg/L)	1.82
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Nitrite-Nitrate (mg/L)	1.9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Nitrite-Nitrate (mg/L)	1.65
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Nitrite-Nitrate (mg/L)	0.063

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Ortho-Phosphate (mg/L)	0.026
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Ortho-Phosphate (mg/L)	0.066
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Ortho-Phosphate (mg/L)	0.037
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Ortho-Phosphate (mg/L)	0.021
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Ortho-Phosphate (mg/L)	0.029
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Ortho-Phosphate (mg/L)	0.058
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Ortho-Phosphate (mg/L)	0.021
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Ortho-Phosphate (mg/L)	0.031
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Ortho-Phosphate (mg/L)	0.0348
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Ortho-Phosphate (mg/L)	0.0351
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Ortho-Phosphate (mg/L)	0.01
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Ortho-Phosphate (mg/L)	0.055
Scatter Cr James Rd	46.80256	123.08673	1/21/91	pH	8.81
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	pH	8.6
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	pH	8.5
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/1/91	pH	8.04
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	pH	8.34
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	pH	8.15
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	pH	9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	pH	8.6
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Water Temperature (C)	5.3
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Water Temperature (C)	5.8
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Water Temperature (C)	4.8
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/1/91	Water Temperature (C)	20.9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Water Temperature (C)	15.7
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Water Temperature (C)	15.7
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Water Temperature (C)	20.2
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Water Temperature (C)	21.1
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Water Temperature (C)	19

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Dissolved Solids (mg/L)	111
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Dissolved Solids (mg/L)	102
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Dissolved Solids (mg/L)	94
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Dissolved Solids (mg/L)	88
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Dissolved Solids (mg/L)	132
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Dissolved Solids (mg/L)	135
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Dissolved Solids (mg/L)	116
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Dissolved Solids (mg/L)	119
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Total Dissolved Solids (mg/L)	91
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Total Dissolved Solids (mg/L)	126
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Organic Carbon (mg/L)	2.2
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Organic Carbon (mg/L)	3.04
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Organic Carbon (mg/L)	4.12
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Organic Carbon (mg/L)	1.42
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Organic Carbon (mg/L)	2.16
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Organic Carbon (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Organic Carbon (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Organic Carbon (mg/L)	3.9
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Total Organic Carbon (mg/L)	3.29
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Total Organic Carbon (mg/L)	3.12
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Total Organic Carbon (mg/L)	4
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Total Organic Carbon (mg/L)	5.7
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Persulfate Nitrogen (mg/L)	4.11
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Persulfate Nitrogen (mg/L)	4.12
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Persulfate Nitrogen (mg/L)	3.49
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Persulfate Nitrogen (mg/L)	4.47
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Persulfate Nitrogen (mg/L)	4.17
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Persulfate Nitrogen (mg/L)	4.01
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Persulfate Nitrogen (mg/L)	4.53

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Creek(@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Persulfate Nitrogen (mg/L)	3.54
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Total Persulfate Nitrogen (mg/L)	1.96
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Total Persulfate Nitrogen (mg/L)	2.15
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Total Persulfate Nitrogen (mg/L)	1.91
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Total Persulfate Nitrogen (mg/L)	0.67
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Total Phosphorus (mg/L)	0.06
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Total Phosphorus (mg/L)	0.04
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Total Phosphorus (mg/L)	0.05
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Total Phosphorus (mg/L)	0.036
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Total Phosphorus (mg/L)	0.021
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Total Phosphorus (mg/L)	0.027
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Total Phosphorus (mg/L)	0.025
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Phosphorus (mg/L)	0.031
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Phosphorus (mg/L)	0.076
Scatter Creek(@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Phosphorus (mg/L)	0.059
Scatter Creek(@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Phosphorus (mg/L)	0.048
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Phosphorus (mg/L)	0.047
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Phosphorus (mg/L)	0.119
Scatter Creek(@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Phosphorus (mg/L)	0.089
Scatter Creek(@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Phosphorus (mg/L)	0.067
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Total Phosphorus (mg/L)	0.056
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Total Phosphorus (mg/L)	0.061
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	7/21/92	Total Phosphorus (mg/L)	0.022
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	8/5/92	Total Phosphorus (mg/L)	0.086
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Total Suspended Solids (mg/L)	2
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Total Suspended Solids (mg/L)	2
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Total Suspended Solids (mg/L)	5
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Total Suspended Solids (mg/L)	5
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Total Suspended Solids (mg/L)	1

Table D-1. Water Quality Parameters Collected at Various Locations in Scatter Creek in 1991 and 1992 (Continued)

Location	Latitude	Longitude	Date	Parameter (Units)	Value
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Total Suspended Solids (mg/L)	2
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Total Suspended Solids (mg/L)	3
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Total Suspended Solids (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Total Suspended Solids (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Total Suspended Solids (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Total Suspended Solids (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Total Suspended Solids (mg/L)	1
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Total Suspended Solids (mg/L)	3
Scatter Cr James Rd	46.80256	123.08673	1/21/91	Turbidity (NTU)	1.2
Scatter Cr Pacific Hwy	46.82495	122.95650	1/21/91	Turbidity (NTU)	1.2
Scatter Cr Above Tenino	46.86351	122.84680	1/21/91	Turbidity (NTU)	2.3
Scatter Cr James Rd	46.80256	123.08673	3/18/91	Turbidity (NTU)	1.6
Scatter Cr Pacific Hwy	46.82495	122.95650	3/18/91	Turbidity (NTU)	1.6
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Turbidity (NTU)	2.5
Scatter Cr Above Tenino	46.86351	122.84680	3/18/91	Turbidity (NTU)	2.6
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Turbidity (NTU)	1
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/9/91	Turbidity (NTU)	0.35
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Turbidity (NTU)	1.3
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/9/91	Turbidity (NTU)	0.4
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Turbidity (NTU)	0.35
Scatter Creek (@ Chehalis Rm 55.208)	46.83320	122.96757	9/10/91	Turbidity (NTU)	0.45
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Turbidity (NTU)	0.2
Scatter Creek (@ Chehalis Rm 55.206)	46.82919	123.00277	9/10/91	Turbidity (NTU)	1
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/10/91	Turbidity (NTU)	1.7
Scatter Creek (@ Chehalis Rm 55.2007)	46.80283	123.08689	9/11/91	Turbidity (NTU)	1.6

Source: Chehalis River Basin Water Quality Screening and Upper Chehalis River TMDL Studies

APPENDIX E

Water Quality Parameters From the Thurston County Environmental Health Division Database

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	Ammonia (mg/L)
GibsonRd	3/21/1994	12:00 PM	6.87	7.04	10.6	78			67.95			
GibsonRd	3/21/1994	12:30 PM	7.48	6.96	10.8	79	105	2.8	High Flow	0.031	0.692	
GibsonRd	10/3/1994						1		Dry			
GibsonRd	10/3/1994								Dry			
GibsonRd	11/7/1994						1		Dry			
GibsonRd	12/20/1994	1:30 PM	8.78	6.57	9.51	76	155	15	140.96	0.038	0.786	
GibsonRd	1/23/1995	12:25 PM	6.02	6.96	11.41	91	30	2.25	55.59	0.015	1.12	
GibsonRd	2/22/1995	11:40 AM	8.86	6.73	10.02	70	85	5.55	286.86	0.027	0.976	
GibsonRd	3/27/1995	2:35 PM	10.3	7.03	11.79	80	35	2.9	56.06	0.018	0.905	
GibsonRd	8/21/1995	11:35 AM	20.29	6.98	7.16	102	5	4.5	No flow	0.029	0.015	
LeitnerRd	9/14/1993	11:00 AM	13.27	6.88	8.05	103	2015	4.1	No flow	0.54	0.1	
LeitnerRd	2/1/1994	11:08 AM	5.51	7.13	11.57	93	40	0.8	25.98	0.17	0.953	
LeitnerRd	2/21/1994	1:50 PM	7.3	6.93	11.5	86	75	2	High Flow	0.021	0.972	
LeitnerRd	3/21/1994	12:50 PM	7.89	7.1	11.19	100	100	2.6	High Flow	0.4	1.31	
LeitnerRd	10/3/1994	12:35 PM	10.31	7.07	7.78	187	720		10.57	0.073	6.23	
LeitnerRd	11/7/1994	2:50 PM	9.21	7.08	8.65	181	30	0.85	6.38	0.076	5.2	
LeitnerRd	12/20/1994	2:10 PM	8.82	6.65	9.85	82	330	17.5	173.42	0.049	0.93	
LeitnerRd	1/23/1995	1:10 PM	6.35	7.05	11.78	127	45	3	72.05	0.023	2.38	
LeitnerRd	2/22/1995	12:45 PM	9.34	6.83	10.48	89	50	5.05	277.14	0.024	1.74	
LeitnerRd	3/27/1995	2:10 PM	10.35	6.97	11.79	125	1	1.8	83.75	0.026	3.67	
LeitnerRd	8/21/1995	12:00 PM	12.27	7.04	7.98	253	110	3.5	8.96	0.059	10	
LeitnerRd	9/26/1995	10:15 AM	11.13	6.98	7.13	201	35	0.85	6.59	0.074	8.74	
OakDrive	12/22/1993	11:30 AM	3.71	6.82	10.6	101	20	2.9	3.24		0.648	
OakDrive	2/1/1994	9:20 AM	3.34	7.06	10.52	93	25	2.5	6.72	0.03	0.687	
OakDrive	2/21/1994	12:00 PM	6.27	6.82	10.92	78	35	3	High Flow	0.021	0.979	
OakDrive	11/7/1994								Dry			

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite- Nitrate (mg/L)	Ammonia (mg/L)
OldHwy99	9/14/1993	10:10 AM	10.44	7.07	8.82	108	350	3.5	0.13	0.062	0.207	
OldHwy99	10/19/1993	10:30 AM	10.53	6.98	9.27	124	150	2	0.46	0.033	0.169	
OldHwy99	12/22/1993	9:55 AM	2.99	6.72	10.19	111	5	4.2	2.23		0.61	
OldHwy99	2/1/1994	7:45 AM	2.17	7.28	10.4	102	35	5.4	2.99	0.023	0.733	
OldHwy99	2/21/1994	8:30 AM	5	6.91	10.37	89	45	5.3	24.5	0.037	1.07	
OldHwy99	2/21/1994	9:35 AM	5.43	6.68	9.44	76		4.1	49.23			
OldHwy99	3/21/1994	9:00 AM	5.94	6.73	9.54	74		4.8	61.2			
OldHwy99	3/21/1994	11:06 AM	6.22	6.92	10.6	76	195	4.3	High Flow	0.034	0.611	
OldHwy99	10/3/1994						1		Dry			
OldHwy99	10/3/1994								Dry			
OldHwy99	11/7/1994	1:30 PM	6.58	6.57	9.22	89	1	2.4	7.58			
OldHwy99	11/7/1994	2:05 PM	7	6.72	10.04	90	25	1.85	High Flow	0.031	0.452	
OldHwy99	12/20/1994	1:05 PM	8.65	6.5	9.53	66	285	6.5	240.93	0.031	0.9	
OldHwy99	1/23/1995	11:25 AM	4.72	7	12.03	86	10	5.15	31.45	0.02	0.668	
OldHwy99	2/22/1995	11:25 AM	8.16	6.78	10.48	63	20	4.75	145.52	0.022	0.822	
OldHwy99	3/27/1995	10:00 AM	7.22	6.99	11.63	76	1	3.4	37.47	0.024	0.371	
OldMilitaryRd	3/21/1994	8:00 AM	5.5	6.92	10.6	85	560	6.6	35.9	0.048	0.818	
OldMilitaryRd	10/3/1994	3:50 PM	10.18	7.14	7.59	116	670		0.06	0.09	0.062	
OldMilitaryRd	11/7/1994	12:45 PM	7.12	6.83	10.42	90	65	2.9	7.24	0.033	0.454	
OldMilitaryRd	12/20/1994	8:55 AM	8.73	6.58	9.86	65	1100	16	103.25	0.06	0.948	
OldMilitaryRd	1/23/1995	9:50 AM	4.02	6.6	10.15	93	25	8.4	14.81	0.026	0.74	
OldMilitaryRd	2/22/1995	9:40 AM	7.33	6.71	10.01	75	35	7.25	55.6	0.033	0.941	
OldMilitaryRd	3/27/1995	9:20 AM	6.15	6.15	11	85	40	5.9	14.62	0.032	0.417	
OldMilitaryRd	8/21/1995	10:25 AM	13.91	7.09	6.99	117	550	6.5	0.01	0.061	0.189	
OldMilitaryRd	9/26/1995	9:30 AM	13.35	6.92	6.75	97	920	3.5	No flow	0.003	0.096	
OldMilitaryRd	3/26/1996	11:45 AM	8.72	8.1	13.11	111	0	2.6	71.95	0.054	2.85	0.025
OldMilitaryRd	3/26/1996	1:15 PM	9.61	7.4	11.42	108	0	3	73.74	0.052	3	0.043
OldMilitaryRd	3/26/1996	2:15 PM	9.42	7.2	12.07	82	10	2.1	37.36	0.028	0.839	0.016

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	Ammonia (mg/L)
OldMilitaryRd	4/17/1996	1:15 PM	11.23	7.6	11.5	101	30	3	70.63	0.045	1.77	0.031
OldMilitaryRd	4/17/1996	2:30 PM	11.25	7.1	11.16	100	60	3.6	80	0.048	1.65	0.043
OldMilitaryRd	4/17/1996	3:15 PM	11.32	7	12.75	76	1100	6.5	61.3	0.057	0.356	0.034
OldMilitaryRd	8/29/1996	10:50 AM	17.69	7	8.27	91	60	0.8	0	0.012	0.214	0.036
OldMilitaryRd	8/29/1996	11:20 AM	14.67	7.1	9.55	133	20	0.8	No flow	0.071	4	0.028
OldMilitaryRd	8/29/1996	12:15 PM	15.98	7.7	10.02	134	40	1.4	14.45	0.062	3.94	0.014
OldMilitaryRd	9/25/1996	11:20 AM	11.57	7	8.5	87	20	4.1	No flow	0.025	0.005	0.074
OldMilitaryRd	9/25/1996	11:50 AM	10.75	7.2	10.14	135	10	1.6	14.19	0.084	4.34	0.025
OldMilitaryRd	9/25/1996	12:30 PM	10.72	7.8	11.27	136	20	1.4	13.5	0.063	4.26	0.008
OldMilitaryRd	12/16/1996	3:30 PM	6.89	6.8	11.49	72	40	3	134	0.015	0.742	0.067
OldMilitaryRd	12/16/1996	4:30 PM	6.69	7	11.1	75	20	3	147	0.032	1.12	0.015
OldMilitaryRd	12/19/1996	12:00 PM	4.24	7.2	11.84	86	10	1.1	104.67	0.027	1.29	0.005
OldMilitaryRd	1/21/1997	1:00 PM	7.34	7	10.44	72	20	3	199	0.022	0.739	0.018
OldMilitaryRd	1/22/1997	10:25 AM	6.91	6.6	11.18	90	20	4.5	219	0.039	1.94	0.013
OldMilitaryRd	1/22/1997	11:40 AM	7.04	6.9	11.71	91	23	2.2	243.9	0.039	2.03	0.017
OldMilitaryRd	2/19/1997	1:30 PM	7.92	6.6	10.88	70	50	3	196	0.022	0.621	0.005
OldMilitaryRd	2/19/1997	2:50 PM	8.39	6.6	11.93	84	58	3	201.76	0.047	1.72	0.005
OldMilitaryRd	2/19/1997	4:00 PM	8.34	6.5	11.72	85	90	2.3	218.05	0.048	1.76	0.005
OldMilitaryRd	3/17/1997	12:50 PM	8.49	6.4	11.59	67	15	3.5	199	0.015	0.521	0.064
OldMilitaryRd	3/17/1997	3:15 PM	8.78	6.9	12.15	76	35	2.9	280	0.033	1.2	0.028
OldMilitaryRd	3/17/1997	4:00 PM	8.89	6.4	12.21	78	50	4	299	0.031	1.29	0.033
OldMilitaryRd	8/19/1997	11:00 AM	14.57	7.8	10.19	128	60	1.5	15.32	0.05	2.56	0.041
OldMilitaryRd	8/19/1997	1:15 PM	14.15	7.4	10.24	130	5	0.9	24.6	0.058	2.88	0.042
OldMilitaryRd	8/19/1997	1:45 PM	18.61	7.2	10.72	96	20	0.8	No flow	0.012	0.123	0.051
OldMilitaryRd	9/22/1997	11:00 AM	13.85	7.3	7.01	92	10	1.2	No flow	0.008	0.059	0.005
OldMilitaryRd	9/22/1997	12:00 PM	13.17	7.7	10.28	129	55	1.5	14.88	0.078	3.16	0.01
OldMilitaryRd	9/22/1997	1:30 PM	13.37	7.4	9.92	130	15	1.3	26.64	0.092	3.6	0.018
OldMilitaryRd	12/16/1997	1:35 PM	7.93	7.3	10.54	93	100	3.5	75.2	0.059	1.6	0.029

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	Ammonia (mg/L)
OldMilitaryRd	12/16/1997	2:30 PM	8.02	7.1	10.03	84	210	2.9	96.6	0.053	1.21	0.005
OldMilitaryRd	12/17/1997	1:20 PM	7.61	6.9	9.9	70	105	7.1	199.7	0.035	0.61	0.032
OldMilitaryRd	1/20/1998	1:00 PM	7.54	7.4	13.34	85	12	2.8	High flow	0.034	1.65	0.02
OldMilitaryRd	1/20/1998	2:30 PM	7.87	7.4	14.2	87	10	3	High flow	0.029	1.68	0.02
OldMilitaryRd	1/22/1998	11:15 AM	6.71	7.2	10.62	79	5	3	160	0.043	0.86	0.017
OldMilitaryRd	2/18/1998	11:00 AM	8.46	7	10.13	81	15	2.8	75.3	0.033	0.704	0.01
OldMilitaryRd	2/18/1998	3:40 PM	9.16	7.6	11.47	103	15	2.1	101	0.039	1.71	0.005
OldMilitaryRd	2/19/1998	4:15 PM	9.5	7.2	11.36	102	15	2.5	120	0.039	1.98	0.005
OldMilitaryRd	3/25/1998	12:00 PM	11.42	6.8	10.77	75	60	4	106	0.043	0.626	0.081
OldMilitaryRd	3/25/1998	2:30 PM	12.32	7.2	11.59	93	40	3	139.2	0.053	1.14	0.012
OldMilitaryRd	3/25/1998	4:15 PM	12.11	7	11.44	93	30	3.5	13.4	0.05	1.82	0.034
OldMilitaryRd	8/17/1998	10:10 AM	16.6	6.5	3.58	96	70	1.6	0	0.026	0.023	0.056
OldMilitaryRd	8/17/1998	1:20 PM	14.75	7.9	10.58	160	55	2	17.9	0.053	3	0.018
OldMilitaryRd	8/17/1998	2:00 PM	13.34	7.7	9.71	160	10	0.9	23.9	0.073	3.41	0.03
OldMilitaryRd	9/22/1998	2:00 PM	12.86	7.6	10.16	169	20	1	19.1	0.059	3.51	0.005
OldMilitaryRd	9/22/1998	3:00 PM	14.17	7.9	10.47	168	60	1.1	16.44	0.048	3.29	0.005
OldMilitaryRd	12/28/1998	12:20 PM	7.43	6.9	10.7	65	145	4.9	High flow	0.058	1.24	
OldMilitaryRd	12/28/1998	1:30 PM	7.74	6.6	11.08	56	300	14	High flow	0.074	1.03	
OldMilitaryRd	1/25/1999	11:15 AM	5.23	6.9	12.36	88	30	2.2		0.023	2.28	
OldMilitaryRd	1/26/1999	11:15 AM	6.46	6.9	10.91	75	30	2.5		0.016	1.21	
OldMilitaryRd	2/23/1999	2:15 PM	7.23	7.1	12.05	82	25	3.5		0.023	2.26	
OldMilitaryRd	2/23/1999	3:00 PM	7.27	6.9	11.47	71	35	4		0.025	0.947	
OldMilitaryRd	3/24/1999	10:10 AM	10.44	7.4	10.84	85	8	2.3		0.026	1.02	
OldMilitaryRd	3/24/1999	11:45 AM	10.53	7.5	11.17	108	25	2		0.033	2.58	
OldMilitaryRd	7/28/1999	2:15 PM	17.4	8.1	10.23	177	15	1.4	15.56	0.059	2.67	
OldMilitaryRd	7/28/1999	2:45 PM	18.83	7.7	10.93	100	35	0.7	No flow	0.009	0.487	
OldMilitaryRd	9/20/1999	11:45 AM	14.01	7.8	9.91	183	35	1.4	14.81	0.062	3.02	
OldMilitaryRd	9/21/1999	10:30 AM	15.04	6.9	2.4	104	15	3.4	No flow	0.064	0.03	

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	Ammonia (mg/L)
OldMilitaryRd	12/15/1999	10:30 AM	7.13	6.8	10.35	58	10	3.4	High flow	0.073	0.678	
OldMilitaryRd	12/15/1999	11:00 AM	6.88	7.3	10.3	61	350	4.3	High flow	0.074	0.726	
OldMilitaryRd	1/18/2000	2:30 PM	5.3	7.4	12.03	85	28	1.9		0.033	1.76	
OldMilitaryRd	1/19/2000	10:30 AM	4.6	7.29	10.6	71	20	2.1	161.25	0.027	0.923	
OldMilitaryRd	2/15/2000	11:15 AM	6.81	7.04	10.54	80	35	2.2	84.35	0.03	0.9	
OldMilitaryRd	2/15/2000	1:00 PM	7.04	7.43	11.94	112	5	1.8	98.1	0.048	2.41	
OldMilitaryRd	3/21/2000	1:15 PM	9.78	7.3	11.34	70	25	3.5	142.7	0.032	0.532	
OldMilitaryRd	3/21/2000	2:00 PM	10.45	8	12.43	93	15	2.4	125.3	0.046	1.505	
OldMilitaryRd	7/26/2000	11:15 AM	16.5	7.21	7.05	89	270	0.7		0.018	0.234	
OldMilitaryRd	7/26/2000	11:50 AM	14.79	7.8	10.15	138	30	1.1	19.05	0.052	2.45	
OldMilitaryRd	8/21/2000	11:35 AM	16.18	7.2	5.13	93	15	1.1	No flow	0.015	0.021	
OldMilitaryRd	8/21/2000	12:30 PM	14.36	8	10.92	148	125	1.1	20.27	0.048	2.64	
OldMilitaryRd	12/18/2000	11:30 AM	5.15	7.72	12.8	162	15	2	14.56	0.121	2.86	
OldMilitaryRd	12/18/2000	12:00 PM							No flow			
OldMilitaryRd	1/9/2001	1:20 PM	6.25	6.9	11.94	151	5	1.2	19.15	0.113	2.73	
OldMilitaryRd	1/9/2001	2:10 PM							No flow			
OldMilitaryRd	2/15/2001	12:00 PM	6.87	7.9	12.35	173	10	2.4	16.81	0.091	2.72	
OldMilitaryRd	2/15/2001	12:45 PM	6.85	7.5	11.4	91	20	1.8	10.83	0.012	0.638	
OldMilitaryRd	3/14/2001	10:30 AM	8.01	6.8	10.48	93	10	0.7	16.86	0.013	0.574	
OldMilitaryRd	3/14/2001	11:50 AM	8.43	7.9	12.48	169	15	1.3	16.63	0.094	2.939	
OldMilitaryRd	7/25/2001	11:00 AM	15.19	7.91	9.68	164	35	1.5	18.39	0.055	2.19	
OldMilitaryRd	7/25/2001	2:45 PM							No flow			
OldMilitaryRd	8/27/2001	11:50 AM							Low flow			
OldMilitaryRd	8/27/2001	1:40 PM	16.42	7.75	9.51	174	78	1	13.85	0.063	2.64	
OldMilitaryRd	12/20/2001	12:00 PM	6.68	7.8	9.85	71	10	1.8		0.029	1.01	
OldMilitaryRd	12/20/2001	12:55 PM	6.23	7.5	10.9	79	10	1.9	High flow	0.036	3.25	
OldMilitaryRd	1/23/2002	11:30 AM	5.01	7.4	11.25	112	10	3	113.82	0.036	3.14	
OldMilitaryRd	1/24/2002	10:30 AM	6.36	7.4	10.6	78	20	1.8	No flow	0.033	0.993	

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	Ammonia (mg/L)
OldMilitaryRd	2/26/2002	1:35 PM	6.91	7.6	12.16	95	20	2	164.12	0.03	2.37	
OldMilitaryRd	2/26/2002	2:30 PM	7.3	7.5	11.14	75	5	3		0.031	0.894	
OldMilitaryRd	3/26/2002	2:00 PM	9.27	7.6	12.35	109	5	1.2	124.91	0.024	2.82	
OldMilitaryRd	3/26/2002	3:00 PM	9.04	7.2	11.16	84	0	1.3	High flow	0.027	0.83	
OldMilitaryRd	7/30/2002	1:30 PM	16.68	8	10.92	156	53	1.2	16.56			
JamesRd	9/14/1993	2:15 PM	14.03	8.17	12.18	167	25	0.95	12.73	0.33	4.77	
JamesRd	10/19/1993	2:00 PM	12.18	8.02	10.79	166	15	0.7	6.67	0.36	4.32	
JamesRd	12/22/1993	4:00 PM	4.21	7.81	13.49	130	55	1.5	8.97		3.8	
JamesRd	2/1/1994	4:45 PM	5.35	7.9	12.7	123		0.9	17.42	0.54	2.81	
JamesRd	2/21/1994	3:00 PM	7.48	7.49	11.84	92	5	1.7	34.7	0.44	1.68	
JamesRd	3/21/1994	2:45 PM	8.29	7.93	12.57	89	215	2.5	75.5	0.44	1.18	
JamesRd	10/3/1994	10:15 AM	10.36	7.52	10.11	150	115	0	14	0.051	3.84	
JamesRd	11/7/1994	4:00 PM	7.27	7.68	12.02	143	5	0.6	14.01	0.055	4.46	
JamesRd	12/20/1994	3:45 PM	8.72	6.75	9.81	83	45	9	128	0.59	1.08	
JamesRd	1/23/1995	3:00 PM	6.07	7.42	12.22	114	20	2.2	78.95	0.39	2.34	
JamesRd	2/22/1995	2:25 PM	9.81	7.1	10.95	77	50	5.6	450	0.036	1.48	
JamesRd	3/27/1995	12:45 PM	9.37	8.3	13.31	103	10	1.6	101.23	0.03	2.88	
JamesRd	8/21/1995	2:30 PM	17.22	8.13	9.04	198	30	1.5	13.3	0.064	7.57	
JamesRd	9/26/1995	12:00 PM	14.43	7.62	9.97	159	100	1.45	7.4	0.074	4.7	
CaseRd	9/14/1993	11:30 AM	10.48	6.97	11.02	221	265	0.8	7.37	0.45	8.76	
CaseRd	10/19/1993	11:30 AM	10.69	6.99	9.46	196	225	1.2	9.72	0.54	7.171	
CaseRd	12/22/1993	1:20 PM	7.73	7.02	9.89	189	5	1.8	6.42		5.13	
CaseRd	2/1/1994	12:30 PM	6.69	7.17	11.27	123	15	0.9	21.12	0.42	2.76	
CaseRd	2/21/1994	2:25 PM	7.53	7.01	11.49	103	25	1.6	High Flow	0.31	1.52	
CaseRd	3/21/1994	1:30 PM	9.05	7.39	11.4	115			78.74			
CaseRd	10/3/1994	11:50 AM	10.51	7.04	10.23	144	1		23.7	0.084	4.18	
CaseRd	8/21/1995	12:45 PM	11.73	7.16	9.66	162			27.06			
CaseRd	9/26/1995	1:25 PM	10.89	7.11	9.92	135			19.98			

Table E-1. Water Quality Parameters Collected at Various Locations in Scatter Creek from 1993 to 2002 (Continued)

Location	Date	Time	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)	Fecal Coliform (colonies/ 100 mL)	Turbidity (NTU)	Flow (cfs)	Total Phosphorus (mg/L)	Nitrite- Nitrate (mg/L)	Ammonia (mg/L)
SargentRd	9/14/1993	1:30 PM	12.91	7.53	11.82	161	15	0.85	10.03	0.43	5.39	
SargentRd	10/19/1993	1:00 PM	11.21	7.18	10.05	164	10	1.5	11.77	0.44	5.54	
SargentRd	12/22/1993	3:00 PM	5.43	7.49	12.57	129	5	1.7	11.62		3.74	
SargentRd	2/1/1994	3:11 PM	6.18	7.76	12.66	124	5	1.3	16.7	0.54	3.02	
SargentRd	2/21/1994	4:10 PM	7.43	7.29	11.75	100	20	1.7	45.9	0.42	1.74	
SargentRd	3/21/1994	2:00 PM	8.28	7.35	11.74	88	120	3.4	84	0.44	1.21	
SargentRd	10/3/1994	10:45 AM	10.2	7.22	8.96	150	50		17.27	0.063	4.22	
SargentRd	11/7/1994	4:30 PM	7.89	7.35	10.88	145	5	0.7	15.23	0.067	4.35	
SargentRd	12/20/1994	3:00 PM	8.73	6.66	9.41	79	85	8	160	0.047	1.11	
SargentRd	1/23/1995	2:00 PM	6.43	7.2	12.01	114	13	3.5	81.77	0.037	2.37	
SargentRd	2/22/1995	1:55 PM	9.86	6.99	10.67	78	30	4.8		0.027	1.64	
SargentRd	3/27/1995	1:30 PM	10.22	7.41	12.3	106	1	2.7	107.63	0.032	3.17	
SargentRd	8/21/1995	1:30 PM	15.98	7.48	8.64	198	5	0.5	15.62	0.073	6.53	
SargentRd	9/26/1995	11:05 AM	13.19	7.22	7.92	153	100	1.55	9.96	0.1	5.37	
MAXIMUM			20.3	8.3	14.2	253.0	2015.0	17.5	450.0	0.6	10.0	
MINIMUM			2.2	6.2	2.4	56.0	0.0	0.0	0.0	0.0	0.0	
MEAN			9.5	7.2	10.6	109.2	93.8	3.0	69.3	0.1	2.1	
MEDIAN			8.7	7.1	10.7	94.0	26.5	2.4	26.6	0.0	1.5	

Source: Thurston County Environmental Health Division Database