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HABITAT CONDITIONS AND WATER QUALITY FOR SELECTED WATERSHEDS OF HOOD CANAL AND THE EASTERN STRAIT OF JUAN DE FUCA

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Preamble and Acknowledgements

The Washington Department of Ecology (DOE) awarded Point No Point Treaty Council (PNP) a Centennial Clean Water Fund grant in 1992 (Grant No. G9200322). The objectives in the grant were ambitious: augment water quality information, collect stream and riparian habitat data, monitor biophysical parameters to determine trends in habitat conditions, and provide information to watershed management committees. Field data were collected from 1992 to 1994.

Paul Faulds devised the methods, supervised the field crew, drew the maps in the appendices, and entered the data into Excel spreadsheets. He left PNP in 1995. At that time his supervisor, Carol Bernthal, took on the task of writing the report. She converted the data to an Access database, wrote the entire Introduction, most of the Methods, and part of the Results and Discussion. This occurred from 1995 to 1999, as time permitted.

Carol left PNP in February 1999 (for NOAA), and Byron Rot was assigned the task (now April 1999) of finishing the report. By now DOE was rightfully concerned and exerting considerable pressure to finish it up. Byron wrote queries for the Access database, analyzed data, completed the Results and Discussion sections, and edited the document. The draft was distributed for an internal review. Byron left PNP for Jamestown S'Klallam Tribe in July 1999. Compilation of review comments and the final edit fell to Chris Weller's shoulders. Chris has the patience of a saint and great editing skills. Thank you Chris.

When a document travels a journey of this magnitude, there are unsung heroes. Thanks to the following: Our field crew, Mike Jones (still at PNP), Lori DeLorm (now at Jamestown S'Klallam Tribe), and John and Brett DeCoteau. Other heroes include Tom Ostrom for providing invaluable Access advice, coarse analysis of the macroinvertebrate data, creation of macroinvertable tables and figures, and comments. Mike McHenry (Lower Elwha Klallam) for organizing and indentifying the macroinvertebrate samples. Ted Labbe (Port Gamble S'Klallams) for editing and comments.

The true value of the data contained in this report will only be realized if other resource managers, biologists, elected officials, and the public, actively use it. Given the imperiled state of salmon in the region, we believe this report provides a scientific basis for the tough land use decisions that inevitably lie ahead.

We thank DOE for their continued patience during the long development period for this report.

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INTRODUCTION

This report provides a summary of current habitat conditions for Pacific salmon (*Oncorhynchus* spp.) populations and relates those conditions to land management activities and non-point pollution sources for nine streams in seven watersheds in the Hood Canal and Strait of Juan de Fuca Region. The report may be considered in three parts First, there is an overview of watershed characteristics including land use for each of the ten streams. Second, this study's habitat monitoring methods and results are described followed by discussion. The monitoring is of habitat parameters considered critical for spawning, rearing and migration of salmon and steelhead. These parameters include quantity and quality of instream habitat, riparian characteristics, quantity and quality of large woody debris, stream temperature, and spawning gravel quality. The third part of this report is a set of general recommendations for restoration of degraded habitat and future monitoring needs.

A. Background

The Clean Water Act, administered nationally by the Environmental Protection Agency and locally implemented by the Washington State Department of Ecology, specifies that all beneficial uses should be protected and restored to an usable condition. Beneficial uses are defined as desirable uses for given classes of water such as water supplies for domestic, industrial, or agricultural purposes; fish, shellfish, and wildlife habitat; recreation; and navigation. Fish use is further defined to include "salmonid migration, rearing, spawning, and harvesting [and] other fish migration , rearing spawning, and harvesting" (WAC 170-201A-030(1)(b).

Nonpoint pollution, or pollution issuing from a variety of land uses rather than a single source, has been identified as a significant threat to water quality and beneficial uses within the Puget Sound (PSWQA 1994). In 1988, the Department of Ecology initiated a local watershed planning process to correct and prevent impairment of beneficial uses from non-point pollution sources, with guidelines for this process specified in WAC 400-12. Watersheds within the twelve counties bordering the Puget Sound were prioritized for the development of watershed management plans based on threats to beneficial uses. Local watershed management committees composed of local representative interest groups were assembled to evaluate watershed conditions, nonpoint pollution threats, and develop specific action recommendations tailored to the unique conditions of local watersheds.

Information on water quality conditions was provided by county water quality monitoring programs to assist watershed management committees in their deliberations. County monitoring programs typically focus on water chemistry parameters such as dissolved oxygen, turbidity, fecal coliform, etc. to characterize surface and groundwater for public health concerns. Salmonid productivity is clearly linked to physical and biological conditions within stream reaches, and to watershed level processes that can be affected by land use activities. Habitat condition data collected by the Point No Point Treaty Council through this Centennial Clean Water Fund grant is intended to expand upon existing water quality data available to watershed management committees and county governments implementing their monitoring programs.

In addition to providing baseline habitat data to watershed management committees, this data will be useful to tribal and state fishery resource managers as they develop habitat protection and restoration strategies for declining salmon stocks. Of the 32 defined salmon and steelhead stocks in the study watersheds, 21 stocks or 66% are experiencing significant short-term or long-term declines in population size, and an additional two stocks have gone extinct in the last ten years (WDF et al1993 McHenry et al. 1996). Two species within the project area (Hood Canal summer chum, Puget Sound chinook) are listed as threatened by the National Marine Fisheries Service under the Endangered Species Act. Bull trout has also been listed as threatened by the U.S. Fish and Wildlife Service. Washington State fisheries resource management agencies and Western Washington Tribes have determined several stocks of coho and steelhead within the study area to be depressed and the coho of Discovery Bay to be in critical condition (WDF et al. 1993). Declines in native salmon populations have been attributed to a number of factors including habitat loss, over-fishing, negative interactions with hatchery stocks, changes in marine productivity, and predation by animals (Nehlson et al. 1992). While we acknowledge the role of other factors in declining salmon populations, this report focuses on the relationship between habitat quality and salmon productivity in the freshwater ecosystem.

B. Study Objectives

The monitoring objectives for the selected watersheds are:

1. Augment water quality monitoring data collected by other governmental entities.
2. Collect information on the current condition of instream and riparian habitat.
3. Monitor key physical and biological components as a baseline for future comparisons to determine trends in habitat conditions and relationships to land management activities.
4. Provide information to watershed management committees on the condition of freshwater habitat to assist in developing watershed management plans and to determine the effectiveness of recommendations in completed plans.

C. Selection of Streams

Habitat staff for the Point No Point Treaty Council (PNPTC) selected the nine streams for monitoring based on a number of factors. All streams were located within the boundaries of ongoing or recently completed planning areas for non-point pollution watershed management plans initiated by the Department of Ecology and administered by county governments. Each watershed selected supports one or more salmonid stocks identified as at-risk by fisheries resource agencies and habitat conditions were suspected or were known to be degraded by a variety of land use activities. A draft list of streams and monitoring parameters were reviewed by local, state, and federal agencies and led to the final selection of streams and scope of monitoring for this project. The streams are identified and described in the following section.

STUDY-AREA WATERSHED DESCRIPTIONS

The nine streams selected for monitoring are located on the northeastern corner of the Olympic Peninsula in Jefferson and Clallam Counties, and on the east side of the Hood Canal in Kitsap and Mason Counties. An overview of watershed characteristics (geology, geomorphology, hydrology, water quality), land use patterns, salmon and steelhead distribution and stock status drawn from available studies and reports is provided for each study stream. Appendix A contains maps of the study streams.

A. Dungeness River Watershed Planning Area

1. Siebert Creek (WRIA 18.0173)

Siebert Creek is located in the Strait of Juan de Fuca region between the towns of Port Angeles and Sequim. Siebert Creek flows northerly into the Strait of Juan de Fuca and drains an area of 19.5 square miles, with 12.4 miles of mainstem, and 15.95 miles of tributaries (Williams et al. 1975). The stream splits at RM 8.1 into two primary branches known as the East Fork and West. 12.0 miles or 42% of the total stream length in the watershed are accessible to anadromous fish (McHenry 1996).

Watershed topography and geology in the Dungeness River planning area are characterized by three distinct areas: mountains, foothills, and a coastal plain adjoining the Strait of Juan de Fuca. The headwaters of Siebert Creek are in the Olympic National Park at 3,800 feet elevation. Within this area, stream channels are steep and deeply incised through the basalt flows of the Crescent formation and marine sedimentary rocks (Jamestown S'Klallam Tribe (JS'KT) 1994). The stream channel gradient moderates in the foothills as Siebert Creek flows through the Olympic National Forest and private industrial forestland. Geology in this area is dominated by glacial deposits (sands, silts, and clays) associated with Cordilleran ice advances which shaped the Strait of Juan de Fuca, Hood Canal, and Puget Sound (Tabor and Cady 1978). The majority of salmonid habitat is in the mid to lower watershed where the stream channel is deeply incised into the coastal plain and channel gradients are more suitable for anadromous salmon. Siebert Creek emerges through steep coastal bluffs made up of unconsolidated sediments into a small estuary at Green Point. Land use in the lower watershed is dominated by rural development, small scale tree farms, and commercial forest lands.

Siebert Creek is located in the rain shadow of the Olympic Mountains, with precipitation ranging from 18 inches at Sequim to 65 inches in the headwaters in the Olympic National Park (JS'KT 1994). The western slopes of the Olympic Mountains intercept precipitation from winter storms which come predominantly from the west and southwest, causing a distinct declining precipitation gradient from the south and west side to the north and east side of the Olympic Peninsula. Peak flows in Siebert Creek are dominated by winter rains and spring snowmelts (McHenry et al, 1996), with dry summers creating low stream flow conditions typically from July through September. A continuous record stream flow gage, operated by the United States Geological Service (USGS) from 1953-1969, was located on Siebert Creek at Highway 101 (PSCRBT 1991a). Mean annual flow averaged 17 cfs with extreme low flows between 2 and 3 cfs (USGS 1993) and a peak flow of 1,620 cfs recorded in November 1955 (JS'KT 1994).

Siebert Creek is classified as a Class AA waterbody for its entire length. Water quality monitoring conducted by Clallam County in the lower reaches of Siebert Creek indicated low levels of bacteria but elevated turbidity readings during storm events related to sediment inputs from a poorly built logging road in the upper East Fork.

Siebert Creek has supported coho salmon (*Oncorhynchus kisutch)* fall chum salmon (*Oncorhynchus keta)*, winter steelhead (*Oncorhynchus mykiss)*, and cutthroat trout *(Oncorhynchus clarkii)* (Williams et al. 1975, Table 1). Winter steelhead and cutthroat utilize the steeper gradients from RM 4.2 to the mouth. Coho are found up to RM 8.2, their distribution overlapping with chum which historically utilized lower gradient sections (Williams et al. 1975). Coho and chum are both rated as depressed based on variable but generally declining spawning escapements (WDFW and Treaty Tribes 1994). A WDF coho spawner survey index area dating back to 1984 and located in the lower portion of the system was abandoned in 1993 because of low numbers of returning adults (McHenry et al. 1996). Siebert Creek historically supported a small run of fall chum (Williams et al. 1975), but McHenry (1992) determined that chum were probably extirpated from the watershed within the last ten years.

2. McDonald Creek (also known locally as McDonnell Creek), WRIA 18.0160

McDonald Creek is located east of Siebert Creek and west of the Dungeness River. The watershed has a drainage area of 23.0 square miles, with 13.6 miles of mainstem and 17.9 miles of tributaries (Williams et al. 1975). A total of 9.3 miles or 30% of the stream miles are accessible to anadromous fish (McHenry 1996). McDonald Creek is one of the larger independent streams within the Dungeness River Area Watershed.

The geology and geomorphology of McDonald Creek is similar to that described for Siebert Creek. The steep headwaters of McDonald Creek drain the northeastern flank of Blue Mountain in the Olympic National Park, into a moderate gradient stream segment that flows through state and private commercial forestlands. The stream then enters a confined steep wooded ravine until emerging through coastal bluffs into a small estuary. Land use adjacent to the stream corridor and within the watershed is predominantly commercial timber, private woodlots, and rural residential and housing developments (PSCRBT 1993). Conversion from forestland to rural development in the lower watershed is a recent trend and is more prevalent than in neighboring Siebert Creek.

Continuous flow measurements are not available for McDonald Creek but precipitation and stream flow conditions are similar to those described for Siebert Creek. USGS has collected a number of miscellaneous flow measurements; results ranged from less than 1 cfs in late summer and early fall to 20 and 25 cfs in mid and late spring (JS'KT 1994). The Agnew Irrigation District removes water at RM 3.1 and to mitigate for the loss of instream flow, water from the Dungeness River is added to McDonald Creek at RM 5.0 (Williams et al. 1975).

McDonald Creek is a Class AA waterbody. Monitoring completed by Clallam County Water Quality Division from 1989 to 1992 at two locations on McDonald Creek reported compliance with state water quality standards except for parameters as follows. Wilson (1989) reported exceedance of water quality standards for fecal coliform at the Agnew irrigation siphon although subsequent monitoring in 1992 showed bacterial levels were dropping to meet water quality standards. Seasonal high temperatures during low flow conditions, and high turbidity during storm events were also noted at the mouth of McDonald Creek. The Dungeness River watershed characterization (DWMC 1993) reported unfavorable conditions for fish related to channel widening and destabilization of the ravine wall from high sediment loads generated by channelization in the lower watershed associated with residential development.

Coho, late chum, and winter steelhead utilize McDonald Creek up to RM 5.2 where migration is blocked by an impassable falls (Williams et al. 1975). Coho are rated as depressed (Table 1) based on a short-term severe decline in escapement (WDFW and Treaty Tribes 1994). Although late chum have been noted as occurring in McDonald Creek, surveys for late chum are not routinely conducted. WDFW conducts spawning ground surveys for coho in McDonald Creek; this surveys historically have also observed fall chum, but there are no recorded observations of fall chum since 1985 (McHenry 1996). WDFW and Treaty Tribes (1994) rated the fall chum status as unknown, but this salmon run has most likely been extirpated from the basin (McHenry 1996). Winter steelhead is rated as depressed due to a short-term decline in escapement (Table 1).

B. Discovery Bay Watershed Planning Area

1. Salmon Creek, WRIA 17.0245

Salmon Creek is located in Jefferson County at the head of Discovery Bay, a large bay at the eastern end of the Strait of Juan de Fuca. Salmon Creek enters Discovery Bay immediately to the east of Snow Creek, sharing a substantial and ecologically significant estuary. Historically, Snow Creek was a tributary to Salmon Creek, but earlier this century the lower 0.6 miles of Snow Creek was channelized and moved to the eastern side of the valley **(**PSCRBT, 1992). The watershed drainage area is 18.8 square miles. Salmon Creek has 8.7 miles of mainstem and 21.8 miles of tributary streams (Williams et al. 1975). A total of 5.7 miles of mainstem and 6.5 miles of tributary, or 40% of the total stream length of the watershed, is accessible to anadromous fish (McHenry 1996).

The headwaters of Salmon Creek originate on the northern slopes of Mt. Zion at an elevation of 3,400 feet within the Olympic National Forest. Stream gradients in the upper watershed are moderately steep and the valley confined down to RM 4.5. Geology in the upper watershed is dominated by basalt flows and recessional outwash deposited during and shortly after the last retreat of the Fraser Glaciation. Where the stream cuts through glacial outwash, glacial lacustrine deposits, or mudstone and siltstone, are particularly vulnerable to mass wasting and surface erosion (Ricketts et al. 1996). Land use in this section is predominantly public forest land (Olympic National Forest and Washington State Department of Natural Resources), 84% of which is forest 50 years or older (PSCRBT, 1992). Olympic National Forestlands are designated as Late Successional Reserves, Riparian Reserves and Adaptive Management Areas through the Northwest Forest Plan. Road density, mostly associated with forest lands, is 5.0 miles of road per square mile of watershed (Ricketts et al. 1996), well above the recommended threshold of 2.5 miles/square mile (Cederholm et al. 1981, Reid 1981).

Gradients drop dramatically in the middle to lower watershed, and at RM 1.0 Salmon Creek emerges into a wide flat valley. Land use in the lower mile is dominated by small scale agricultural operations while the middle watershed is characterized by private timberlands, divided among several small land owners and one commercial forest land (Pope Resources). Geology is characterized by permeable sands, gravels, and clays that were deposited by meltwater in front of the advancing ice sheet, and more easily eroded sediments deposited from flooding and typical stream depositional processes over the last several thousand years. Material eroded from steeper gradient sections are transported and deposited in low gradient sections, forming an alluvial fan and alluvial valley in the lower watershed.

Hydrology in the Salmon Creek watershed is primarily controlled by rainfall as 93% of the basin area is in the lowland (<800 ft) and rain-dominated precipitation zone (between 800 and 1600 feet (Ricketts et al. 1996), as defined by standard hydrologic assessments conducted for watershed analysis (WFPB 1997). Estimated average annual precipitation in the Salmon Creek watershed is 36 inches (JS'KT 1994). The Washington Department of Wildlife monitored streamflow on Salmon Creek from 1977 to 1982 at RM 1.0. For the period of record, the average annual flow was 8.4 cfs with a low flow of 0.3 cfs (September 1981) and a peak flow of 1,048 cfs (February 1978) (PSCRBT 1992). Hydrologic modeling to predict peak flows for different storm events showed a 100 year peak flow of 1,243 and a 10 year peak flow of 454 (PSCRBT 1992). The estimated 10 year peak flow is 24% higher than those expected under natural conditions of mature forest and no roads (PSCRBT 1992).

Salmon Creek is a Class AA waterbody. Water quality monitoring conducted by Jefferson County in 1989 found fecal coliform counts exceeding water quality standards for Class AA waters in the lower watersheds at the mouth of Salmon Creek, near Uncas Road, and at the junction where a tributary (Houck Creek) enters Salmon Creek (Rubida 1989). In 1994 monitoring conducted by the Jefferson County Conservation District at four sites in the Salmon Creek watershed identified several sites on Salmon Creek and Houck Creek where stream temperatures exceeded water quality standards, including a recorded maximum temperature of 18.5 degrees Celsius in July (Gately 1995). Other water quality issues include sediment loading at twice the estimated background levels, a lack of riparian cover in the lower reaches, actively eroding stream banks, and runoff associated with poor road maintenance on the mainstem in the upper reaches (PSCRBT 1992).

Summer chum, coho, winter steelhead, and cutthroat trout are known to utilize Salmon Creek. Occasional plantings of hatchery chinook occurred in the mid-1970's, but low stream flows in fall appear to limit any natural production. Coho and winter steelhead utilize available habitat in the mainstem up to RM 3.0 where gradients become too steep; tributaries with sufficient stream flow are also utilized. Chum spawning occurs up to RM 1.5, with the highest concentration of spawning occurring in the lower two-thirds of a mile of Salmon Creek (Ricketts et al. 1996). In 1992, a summer chum supplementation program was initiated to increase returns to support a recolonization project on Chimacum Creek. Resident cutthroat is present in steeper gradient reaches to approximately 1,600 feet in elevation (Ricketts et al. 1996).

Table 1 summarizes stock status for Salmon Creek. Summer chum and coho are both rated as critical based on a short-term severe decline in escapement. Winter steelhead is rated as depressed based on a short-term severe decline in wild populations. Cutthroat trout status is unknown.

C. Quilcene/Dabob Watershed Planning Area

1. Little Quilcene River, WRIA 17.0076; Howe Creek, WRIA 17.0090, and Ripley Creek WRIA 17.0089.

The Little Quilcene River and two of its largest tributaries (Howe and Ripley Creek) are discussed collectively because of similarities in watershed characteristics and a common outlet in Quilcene Bay. The Little Quilcene River drains into Quilcene Bay north of the Big Quilcene River in eastern Jefferson County. Howe Creek has a drainage area of 5.5 square miles, and flows southerly for 3.4 miles before joining the Little Quilcene River at RM 5.2. Ripley Creekhas 3.5 miles of mainstem and joins the Little Quilcene River at RM 4.35. The Little Quilcene River has a drainage area of approximately 30 square miles, with 12 miles of mainstem and 29 miles of tributaries.

The Little Quilcene River headwaters begin above 4400 feet elevation on the north slopes of Mt. Townsend. Stream channel gradient is steep and confined until RM 6.6 where it begins to moderate, meandering the last three miles in a low gradient, unconfined valley near the town of

Quilcene. The upper watershed is located within the Olympic National Forest and historically was managed primarily for timber, with high harvest rates noted by Williams et al. (1975). The mid and lower watershed also contains private and state timberlands. A dam diverts water at RM 7.1 for the City of Port Townsend and Port Townsend Paper Mill (JS'KT 1994). The City of Port Townsend holds a water right of 9.6 cfs that is directed to the Lords Lake reservoir. Pasture land and rural development and the eastern edge of the small city of Quilcene are dominant landuse in the lower watershed.

Howe and Ripley Creek are characterized by headwaters originating at elevations less than 1500 feet and watersheds draining the low foothills surrounding Quilcene Bay. The upper portions of these watersheds are generally confined but with gradients less than 6%. Land use is primarily private non-commercial forestland and rural development. Stream gradients drop to less than 2 % in unconfined valleys dominated by agricultural and rural development in the lower reaches of these streams. In contrast to the Little Quilcene River, these smaller streams are located within sand and gravel deposits left by the retreating continental glaciers and tend to be more erosive. All streams in the Little Quilcene River watershed terminate in the northwestern corner of Quilcene Bay estuary. Quilcene Bay provides important rearing habitat for outmigrating salmonid smolts and holding areas for returning adults to wait until stream flows are adequate to migrate upstream.

Stream hydrology in this watershed is differentiated into two distinct source types, snowmelt in higher elevation headwater areas (Little Quilcene River) and wetland/groundwater discharge in low elevation streams (Howe and Ripley Creek). In each case, stream flows are significantly affected, but to a lesser degree than in the Dungeness River watershed, by the rain shadow effect of the Olympic Mountains, and in the case of Little Quilcene River, water withdrawals during critical summer low flow periods. Average annual precipitation is 49 inches, the majority of which falls during the winter months (JS'KT 1994). All streams within the planning area experience natural low flow conditions in summer. Over a seven year period of record, average stream flow at RM 1.8 on the Little Quilcene River was 53.9 cfs, with minimum flows ranging from 5 to 13 cfs (Lichatowich 1993).

All streams in this region are classified as Class AA waterbodies. Water quality concerns within the Little Quilcene River watershed include historic high bacterial contamination in upper Quilcene Bay (Welch and Banks 1987). Quilcene and Dabob Bay is listed as an impaired water body under Section 303(d) of the Clean Water Act because water quality standards have been exceeded for fecal coliform (DOE 1994).

Coho and resident cutthroat trout utilize mainstem areas in Howe and Ripley Creeks throughout their entire length. Rearing is limited by summer low flow as upper segments tend to go dry although several wetlands in Howe Creek contain good rearing habitat. Coho utilize the Little Quilcene River up to RM 6.6 where a steep cascade limits upstream anadromous migration (Williams et al. 1975). Summer chum primarily spawn below RM 1.8 while late chum are found from RM 0.5 to RM 3.0. Native runs of winter steelhead occur in the watershed and there have been failed attempts to plant hatchery chinook.

The status of salmon stocks in this watershed are summarized in Table 1. Coho are depressed in all streams due to short-term severe declines in adult escapement. In the Little Quilcene River, the status of summer chum is critical, winter steelhead is unknown, and late chum is healthy.

2. Big Quilcene River, WRIA 17.012

The Big Quilcene River is located in eastern Jefferson County north of the Dosewallips River and south of the Little Quilcene River. With a drainage area of 68 square miles, the Big Quilcene River is the largest stream system within the Quilcene-Dabob Watershedshed Planning Area. The Big Quilcene River has a mainstem length of 18.9 miles and 81.9 miles of tributaries (Williams et al. 1975). Primary tributaries include Tunnel, Townsend, and Penny Creek.

The watershed is made up of three primary geomorphic areas: highly confined, extremely steep gradient (upper watershed), confined moderate gradient (mid watershed), and unconfined low gradient (lower watershed). Headwaters of mainstem and tributary streams originate between 5,000 and 6,000 feet in the Buckhorn Wilderness Area (Olympic National Forest) and Olympic National Park, flowing steeply in an easterly direction. Most of the upper watershed is designated as Late Successional Reserve under the Federal Forest Plan. Townsend Creek joins the mainstem at RM 11.0. The high percentage of extremely steep gradient stream miles is due to high-energy downcutting of streams into the resistant basalt flows of the Crescent Formation. The upper watershed ends at RM 9.4 where Tunnel Creek enters the Big Quilcene River.

Below Tunnel Creek, the Big Quilcene River flows southeast through a steep gorge, with a sharp bend to the north at RM 6.1. During glacial times, it is believed that the Big Quilcene River continued south, exiting at the current location of Spencer Creek, but with upthrust of the surrounding mountains and resistant rock, the river was trapped in it's present location. Land ownership in the mid-watershed is primarily federal and state forest.

Geology in the lower watershed is characterized by Cordilleran glacial drift overlying bedrock, with visible examples of bedded glacial lake and outwash deposits where the river is downcutting through this unit. At RM 4.8, stream gradient begins to moderate and the valley floor widens. Below RM 1.0, the mainstem meanders across an alluvial fan built by sediment deposition from steep upstream reaches. Penny Creek with 4.3 miles of low gradient habitat, enters the mainstem at RM 2.8, flowing southerly along an uplift zone (Grimstad and Carson 1981). The Quilcene National Fish Hatchery (QNFH) is located at the confluence of the mainstem and Penny Creek (RM 2.8). Channel migration and bank cutting is common between RM 3.5 and RM 1.0. The lower two miles of the Big Quilcene River is subject to frequent flooding caused by stream channel aggradation, constriction of the historic floodplain, and straightening and channelization along the mainstem. The lower one mile of river was diked around the 1880's for agricultural development. Scattered rural developments, private and state forestlands, and the town of Quilcene (RM 1.0) dominate land use in the lower watershed.

Precipitation varies from 75 inches per year in the headwaters to 50 inches per year in the town of Quilcene, with an overall average of 63 inches per year (JS'KT 1994). No long term gauging of flows is available, but data from a period in the early 1970's showed a 12 -month mean flow of 215 cfs downstream of Penny Creek (JS'KT 1994). Estimated summer low flow is 20 cfs or less near the mouth of the river (Willams et al. 1975).

Instream flows are reduced by several water diversions. The City of Port Townsend has a water right of 30 cfs for domestic and municipal water, diverting surface water from the Big Quilcene River at a diversion dam at RM 9.4. This is a consumptive use and diverted out of the basin. Water is also diverted by the QNFH from Penny Creek (25 cfs water right) for hatchery operations, with augmentation from the Big Quilcene River (15 cfs, plus 25 cfs with minimum flow criteria) when demand exceeds the available water right from Penny Creek (Mayte et al.

1994). During low flow periods, the channel can be dewatered for about 800 yds on the Big Quilcene between the hatchery intake and outlet.

The Big Quilcene River is classified as a Class AA water. Identified water quality concerns include seasonally elevated turbidity, elevated bacteria in Quilcene Bay, diminished instream flows, and impaired habitat conditions. The Big Quilcene River was placed on the 303(d) impaired water body list in 1996 due to the impaired stream flows and degraded habitat conditions. The Olympic National Forest and Washington State Department of Natural Resources completed a watershed analysis in 1994. The lower Quilcene River has been the focus of habitat restoration activities since 1995.

The Big Quilcene River supports runs of coho, summer chum, fall chum, winter steelhead, sea-run and resident cutthroat trout. Coho, fall chum, and summer chum utilize the mainstem river up to RM 2.8 where a fish weir at QNFH prevents upstream migration from June to January. Historically coho occurred up to a falls at RM 4.8 and presumably much of the 4.3 miles of Penny Creek. Salmon access to Penny Creek is blocked by the QNFH. Coho and chum are prevented from migrating above the QNFH weir, due to concerns about potential contamination of hatchery water supplies by introduced fish pathogens. The weir also blocks much of the migrating sea-run cutthroat. The QNFH release hatchery coho fry above the weir to rear. Winter steelhead due to their later migration timing, utilize the mainstem and tributaries above the QNFH weir up to RM 7.4 where a 20 foot falls blocks upstream passage (Mayte et al. 1994). Residential cutthroat trout occur in all accessible reaches in the upper watershed.

Status of salmon stocks in the Big Quilcene River is summarized in Table 1. Coho is rated as depressed, winter steelhead and cutthroat trout are unknown, summer chum is critical. Fall chum, a stock made up of hatchery releases and wild runs, is rated as healthy.

D. Lower Hood Canal Watershed Planning Area

1. Dewatto River, WRIA 15.0420

The Dewatto River is located on the southeast shore of Hood Canal north of Belfair in Mason County. The Dewatto River drains 18.4 square miles, flowing in a southeasterly direction into Hood Canal. The mainstem is 8.7 miles in length, with 21.5 miles of tributary habitat. Important tributaries for salmonid production include White Creek, entering the Dewatto River at RM 0.4, Shoe Creek at RM 2.3, and several unnamed tributaries in the upper watershed (Williams et al. 1975).

In contrast to watersheds described in previous sections, almost the entire length of the Dewatto River and a considerable amount of tributaries are accessible to salmonids because of the low gradient of the stream network. The headwater of the Dewatto River originates between 300 and 400 feet in elevation. The channel gradient of the mainstem throughout its entire length is generally less than 3%. The river is unconfined in a relatively wide valley with numerous wetlands and beaver ponds surrounded by rolling hills. Most tributaries are short in length, initiating from wetlands, lakes, or areas of groundwater discharge. Tributary headwaters begin on a flat plain flowing into steep, confined ravines to join the main river valley. The watershed is predominantly rural in nature, with small tree farms, commercial forestlands, several small-scale agricultural farms and scattered rural development. While the area still retains a rural character, there has been an increasing pattern of development in the Lower Hood Canal.

Watershed topography is the result of periods of glaciation in which the Puget Lobe of the continental ice sheet covered the entire Hood Canal. The predominantly gentle slopes of the watershed are remnants of a Pleistocene glacial drift plain formed by deposits of till, recessional outwash and advance outwash sediments (PSCRBT 1991b). The mainstem Dewatto River follows a broad glacial outwash channel, with the headwaters originating in naturally erosive till and outwash sand and gravel units. The stream channel erodes and transports this material to lower gradient downstream sections, providing substrate for spawning as well as creating a delta and estuary at the mouth of the river from finer grained sediments. Tributaries originate on a flat glacial till plain composed of compacted gravels overlaying more erosive sand layers. Streams flowing across this material actively downcut to form steep ravines. The large number of wetlands, lakes, and ponds are caused by an impermeable hardpan layer underlying glacial sands and gravels in topographical depressions. Beavers have also been historically important in creating ponds and wetlands critical for salmonid rearing.

Due to the low elevation of the watershed, stream hydrography in the Dewatto River is controlled almost exclusively by rainfall with half of the annual precipitation falling during the November to January time period (PSCRBT 1991b). Wetlands, ponds, and lakes play an important role in controlling peak flows in winter as well as augmenting stream flow during summer months with limited rainfall. Based on records for a stream gage located at RM 1.8 and operated from 1947 to 1975, the mean annual flow was 70.6 cfs, with 9.0 cfs as the lowest recorded flow and a peak flow of 2160 cfs (Williams et al. 1975).

The Dewatto River and all tributaries are classified as Class AA waters. Limited water quality data is available for the Dewatto River. The Lower Hood Canal Watershed Characterization Report did note that sediment and bacteria pollutants entering the stream were related to animals accessing the river on several farms in the mid section of the watershed (PSCRBT 1991b).

The Dewatto River supports runs of coho, late chum, and chinook, winter steelhead, and cutthroat trout. Coho are reported to utilize the entire mainstem length and accessible tributary habitat in Shoe, White, Windship and unnamed tributaries with gradients less than 12%. Williams et al. (1975) reported two distinctly timed runs of fall chum, but WDFW and Treaty Tribes (1994) only reports one run. A small naturally producing run of summer and fall chinook occurs in the mainstem. Hatchery plants of chinook have also occurred over the years but production is limited by available productive habitat (WDFW and Treaty Tribes 1994). Winter steelhead and cutthroat trout utilize the upper reaches of the watershed. Summer chum had utilized the lower two miles of the mainstem but became extinct in the 1980s.

The Dewatto River is reported to have some of the most productive habitat in western Washington (PSCRBT 1991b) yet a review of stock status reveals a mixed situation for salmon productivity. Two stocks are rated as healthy (chinook and fall chum), two are depressed (coho and winter steelhead), and one is extinct (summer chum) (WDFW and Treaty Tribes 1994). Chinook found in individual watersheds are grouped together as one stock for all of Hood Canal, but WDFW and Treaty Tribes (1994) notes that a healthy rating is based on substantial escapement returns only in the Skokomish River; the Dewatto River chinook stock is noted as having low escapement levels.

2. Tahuya River, WRIA 15.0 446

The Tahuya River watershed is located on the southeastern shore of the Hood Canal, south of the Dewatto River and southwest of the town of Belfair. The largest watershed in the Lower Hood Canal watershed planning area with 21.1 miles of mainstem and 43.8 miles of tributaries, the

Tahuya River is an important watershed for salmonid production. Major tributaries to the Tahuya River include Tin Mine at RM 20.4, Gold Creek at RM 19.5, and the Little Tahuya at RM 7.4. The watershed area spans two counties; the headwaters are located in Kitsap County with the majority of the watershed drainage in Mason County.

Tin Mine Creek and the mainstem originate at the base of Green Mountain. Stream gradients remains steep until entering Tahuya Lake at RM 19.9; below the lake stream gradient is less than 5% with many stream reaches having channel gradients of less than 1%. Gold Creek joins the Tahuya River at RM 19.5. The Tahuya State Forest, managed by the Washington State Department of Natural Resources, makes up a substantial portion of the upper watershed. Numerous short tributaries enter the mainstem along its entire length, most originating in wetlands, lakes and ponds occupying topographic depressions on the glacial till plain, and then flowing down confined ravines. Several of these lakes (Panther, Tahuya, Erdman, Howell, Collins, Bennettsen, Blaksmith) historically and currently provide important potential rearing habitats, but introduction of non-native fish species such as large mouth bass and bluegill and screening of several lake outlets has reduced the suitability of these habitats.

The mainstem occupies a wide, open valley and the channel meanders extensively within this area from RM 14 to the mouth. Large beaver ponds and wetlands are common, especially in the lower four miles of the mainstem and from RM 12.0 to RM 21.0. Wetlands and ponds created by beaver dams represent a dynamic and changing component of the stream system, and provide excellent rearing habitat especially for coho. A large enclosed bay and estuary provide important transitional areas for outmigrating smolts, and holding areas for returning adults as they wait for suitable streamflows to migrate upstream. Small-scale timberlands, rural development and hobby farms are dominant land uses in the lower watershed.

USGS flow data is available for two locations (upper and lower watershed) on the Tahuya River from 1945 to 1956. At the upper location near the outlet of Panther Lake, mean annual flow was 22.3 cfs, with a low flow recording of 0.1 cfs and a peak flow of 504 cfs. At the lower location (approximately RM 2.8), the mean annual flow was 69.4 cfs, with a low flow of 0 cfs and a peak flow of 1,210 cfs.

Limited water quality monitoring has been completed for the Tahuya River but available data indicates generally good water quality with the exception of localized areas of high fecal coliform related to improper farming practices. Attempts to control channel meandering and floodplain enroachment by rural development have also degraded available habitat (M. Ereth, personal communication).

Salmonids utilizing the Tahuya River include coho, fall and summer chum, chinook, winter steelhead, and cutthrout trout. Coho are found throughout the entire mainstem to steeper gradient sections on Gold Creek and lower gradient sections of tributaries with adequate stream flows. The upper extent of coho spawning shows variability by year related to streamflow, escapement levels, and the presence of impassable beaver dams (Tabor et al. 1993). Summer chum are now extinct but were found in the lower 2.8 miles. Fall chum are still relatively abundant in the river and extend further upstream with increasing stream flows in November and December. Winter steelhead and cutthroat trout are found in the upper mainstem and all accessible tributaries. Chinook utilize the lower four miles and are limited by stream flow conditions and accessibility during migration (Williams et al. 1975).

Two stocks are rated as healthy (chinook and fall chum), two are depressed (coho and winter steelhead), and one is extinct (summer chum), (Table 1, WDFW and Treaty Tribes 1994).

Summer chum returns have declined precipitously from a peak of 10,714 adults in 1972 to no recorded returns since 1991 (Cook-Tabor 1995). Chinook found in individual watersheds are grouped together as one stock for all of Hood Canal, but WDFW and Treaty Tribes (1994) notes that a healthy rating is based on substantial escapement returns only in the Skokomish River; the Tahuya River chinook stock is noted as having low escapement levels.

Table 1. Status of salmon and steelhead stocks in monitored streams (WDFW and Treaty Tribes 1994).

	Coho	**Chum**		**Chinook**	**Steelhead**	
		Summer	**Fall**		**Summer**	**Winter**
Siebert	Depressed	nm	Unknown/ Extirpated ?	nm	nm	Depressed
McDonald	Depressed	nm	Unknown/ Extirpated ?	nm	nm	Depressed
Salmon	Critical	Critical	nm	nm	nm	Depressed
Howe	Depressed	nm	nm	nm	nm	Unknown
Ripley	Depressed	nm	nm	nm	nm	Unknown
Little Quilcene	Depressed	Critical	Healthy	nm	nm	Unknown
Big Quilcene	Depressed	Critical	Healthy	nm	nm	Unknown
Dewatto	Depressed	Extinct	Healthy	Healthy/depressed	nm	Depressed
Tahuya	Depressed	Extinct	Healthy	Healthy	nm	Depressed

METHODS

Nine streams within four watershed management planning areas located in the Hood Canal and Strait of Juan de Fuca region were monitored from 1992 through 1995. Maps of the study streams are shown in Appendix A. Table 2 identifies the stream, watershed management area, location and types of data collected.

Table 2. Summary of monitored watersheds.

Stream	Watershed Management Area	Location (River Mile)	Types of Data Collected
Siebert	Dungeness	0.0 - 12.0	Habitat, temperature, spawning gravel, macroinvertebrates
McDonald	Dungeness	0.0 - 10.0	Habitat, temperature, spawning gravel,macroinvertebrates
Salmon	Discovery	0.7 - 3.5	Habitat, spawning gravel
Howe	Quilcene/Dabob	0.0 - 2.8	Habitat
Ripley	Quilcene/Dabob	0.0 - 1.5	Habitat
Little Quilcene	Quilcene/Dabob	0.0 - 5.2	Habitat
Big Quilcene	Quilcene/Dabob	0.0 - 2.8	Habitat
Tahuya	Lower Hood Canal	4.1 - 7.4	Habitat, temperature, spawning gravel, macroinvertebrates
Dewatto	Lower Hood Canal	3.0 - 7.7	Habitat, temperature, spawning gravel, macroinvertebrates
Total Miles Surveyed		45.1	

We used four kinds of sampling to characterize habitat conditions in the monitored watersheds: 1) habitat surveys, 2) stream temperature monitoring, 3) sampling spawning gravel composition, and 4) macroinvertebrate surveys. Following are descriptions of the methods and applications of each sampling approach.

A. Habitat Surveys

Habitat surveys were completed in all watersheds at low flow conditions (generally June through September) utilizing monitoring protocols developed by the Timber/Fish/Wildlife (TFW) Ambient Monitoring Program. Maps of the location of the individual streams covered by this project are found in Appendix A. Habitat unit surveys typically started at the stream mouth and proceeded upstream until an impassable barrier to salmonids was found, the stream bankfull width and depth became extremely small, or the stream dried up for 50 meters or more. In some streams (Tahuya, Dewatto, Little Quilcene Rivers) a subset of the total stream length utilized by salmon was surveyed. Survey effort in these watersheds was designed to gather information on segments lacking habitat data.

The TFW Ambient Monitoring methodology consists of a series of modules organized around specific parameters or concerns. The TFW ambient monitoring methodology has undergone a process of refinement since it's inception in 1989 to increase accuracy and replicability of data collection methods. For more thorough descriptions of the TFW Ambient monitoring methods, please refer to the TFW Ambient Monitoring Program Manual for each year (Schuett-Hames et al, 1992, 1993, and 1994). In some cases PNPTC collected additional information to better meet project objectives and provide a higher level of detail. The individual TFW monitoring modules, additions to the standard TFW ambient monitoring protocols, and methods for calculating results are described below.

1. Stream Segment Identification

The streams were divided into segments following criteria of the TFW Ambient Monitoring manual (Schuett-Hames et al, 1992) based on stream gradient, channel confinement and the location of tributary junctions. The segments were initially determined using topographic maps and aerial photographs, then verified in the field. An average segment gradient class (<1%, 1-2%, 2-4, 4-6, 6-17, >17%) and confinement class (unconfined, moderately confined, and tightly confined) were reported for each segment.

2. Reference Point Survey

Permanent reference points were established in the field by placing metal identifier tags on trees every 100 meters within each segment. Bankfull width, depth and canopy closure measurements were collected at each reference point to characterize the reach and results reported as averages for the entire segment. Data regarding habitat units, large woody debris (LWD), and streambank stability as described below were keyed to the reference points.

3 Habitat Unit Survey

Hydraulic and geomorphic characteristics in a stream create a pattern of distinctive features referred to as habitat units. *Pools*, deep and low velocity areas in the summer, are created by a convergence of flow and velocity during floods. In *riffles*, flow and velocity are distributed evenly and relatively shallowly across the channel bed surface. *Pool tailouts* are transitional areas between the downstream end of a pool and the head of a riffle, and *cascades* describe higher gradient drops of swiftly moving water.

Stream discharge was measured at the downstream end of each segment to describe hydraulic conditions at the time of survey and provide reference for future resurveying. Pools, tailouts, riffles, and cascades meeting the minimum size criteria described in the TFW ambient monitoring manual were identified, measured for square meter area, and assigned to the downstream reference point. Lengths were noted for obscured or dry habitat units and walkable wetlands. For surveys conducted in 1993 and 1994 PNPTC identified pools by type to facilitate data sharing with a separate coho salmon assessment project. Pools were typed as scour, plunge, trench, backwater, dammed, or alcove based on the stream classification of Bisson et al. (1982), modified by Nickelson et al. (1992).

Results were reported both for pool and overall habitat unit characteristics. Pool results include surface area by pool type, residual pool depth, pool frequency and the dominant factor responsible for forming pools (pool formation data was not collected in 1992) for each segment. Pool frequency is an indicator of the spacing between pools, taking into account the natural variability based on the bankfull width within a reach. Pool frequency is calculated using the following formula:

Pool Frequency = (L/BW)/P
L= Length of surveyed reach (m)
BW= Average bankfull width for segment (m)
P= Number of pools meeting minimum size and residual pool depth requirements

Results reported for overall habitat unit characteristics included by segment, a calculation of the proportion of pool/riffle/cascade and the percentage of each channel type (primary, secondary, and tertiary). Habitat units were defined as primary (>50% of wetted channel), secondary (<50% of wetted channel) or tertiary (separated by an island).

4. Large Woody Debris (LWD) Survey

Survey information was collected to characterize the abundance, type, and function of LWD and log jams in the monitored streams. The more intensive (Level 2) of the two LWD survey techniques was completed (Schuett-Hames et al. 1994). All logs and rootwads meeting the minimum size criteria (pieces greater than 2 feet in length with a diameter greater than 4.5 inches) were recorded relative to the appropriate channel location zone (Table 3) and the downstream reference point. Diameter at mid-point, length per zone, wood type, stability, and association with pool forming functions were noted for each piece of large woody debris. Angle orientation to the bankfull channel (0, 90, 180 degrees), and decay class (rotten, moderate, and solid) of individual LWD pieces were also noted for surveys conducted in 1993-1994. Jam length, height, width, and lowest channel location zone of influence for log jams meeting minimum size criteria were measured and recorded relative to the downstream reference point (Schuett-Hames et al. 1994).

Table 3. Description of large woody debris channel zones (Schuett-Hames et al. 1994).

Zone	Description
Zone 1	Wetted low flow channel, defined as the area under water at the time of survey done during the low flow period.
Zone 2	Area within the influence of bankfull flow, defined as the being within the perimeter of the bankfull channel and below the elevation of the water at bankfull flow (excluding area defined as Zone 1). Zone 2 includes areas such as gravel bars that are exposed at low flow.
Zone 3	Area within the perimeter of the bankfull channel but above the water line at bankfull flow, including logs extending over the channel but suspended above the elevation of the water at bankfull flow.
Zone 4	Area outside of the bankfull channel perimeter, including the upper banks and riparian areas not directly influenced by bankfull flows.

Large woody debris (LWD) data results reported for each segment included volume, frequency, species composition and decay class percentages, key piece frequency for individual pieces, and frequency of log jams. Large woody debris volume was determined by assuming pieces meeting the minimum length (>2 meters) and diameter (>10 centimeters) form a uniform cylinder. All pieces meeting these criteria within zones 1 through 4 were included. Rootwads were not included. Since logjams were assessed by area only (pieces were not counted), LWD volume in logjams was not included. Volume was calculated using the formula:

$$\text{Volume} = \pi(d/2)^2 * l$$

d = diameter at mid point of log
l = length of log

The total volume per segment was calculated as volume per 100 m channel length. Large woody debris frequency, excluding log jams and rootwads, was calculated by taking the number of LWD pieces in a stream segment, dividing by the length of the segment, and multiplying by the average bankfull channel width. Key pieces are large diameter wood that is stable in the stream reach and capable of retaining other pieces of wood (Table 4).

Table 4. Minimum dimensions to qualify as a key piece (WFPB 1997).

Bankfull Width (m)	Diameter (m)	Length (m)	Volume (m3)
0-5	0.4	8	1.0
6-10	0.55	10	2.5
11-15	0.65	18	6.0
16-20	0.7	24	9.0

Summary data for logjams was reported separately from individual pieces of wood. The volume wood and the number of pieces in logjams was not collected (the field estimates included both air and volume), limiting the analysis to a frequency calculation. Logjam frequency was determined by dividing the number of logjams in a stream segment by the segment's length and multiplying by the average bankfull width for that segment.

5. Substrate

Substrate composition was visually estimated for each habitat type using a modified classification system based on Ralph (1990) and King County Surface Water Management Division (1991, Table 5). The dominant and subdominant substrate by particle size and the percent area covered within each habitat unit were identified. Results were reported as dominant substrate for each segment by taking the highest percentage substrate category greater than 50%; if no single category was greater than 50%, the two highest size categories were identified.

Table 5. Substrate classification system.

Particle Size Category	Particle Size Range (mm)
Silt/Mud	< 0.01
Sand	0.2 - 5
Gravel	5 - 64
Cobble	64-254
Boulder	> 254
Bedrock	Solid piece

6. Streambank Stability

The location, length and width of streambank erosion and mass wasting areas were recorded relative to the downstream reference point and adjacent individual habitat unit(s).

7. Land Use

Predominant land use was noted for the left bank and right bank (facing downstream) of each habitat unit. Land use categories were adopted from the 1989 TFW Ambient Monitoring Manual. Categories included agriculture, livestock/pasture, timber lands, residential, right of way, mining, riparian management zone, wetland, and other. Results were reported as the dominant landuse for each segment by determining the highest percent land use category within each segment; more than one landuse was included if the largest percent category was less than 50 percent.

8. Riparian Characterization

Streamside vegetation within 30 meters of the bank was evaluated on left and right bank (facing downstream) at each habitat unit by species (conifer, deciduous, mixed) and seral stage (grass-forb, shrub-seedling, pole-sapling, young, mature, old growth) using the classification developed by Hall et al. (1992). Results were reported as the dominant vegetation species and class for each segment by determining the highest percent species and seral stage category within each segment; the two highest categories were included if the largest single category was less than 50 percent.

9. Interpretation of Habitat Data

To help interpret the myriad of habitat parameter collected, data was evaluated using indices of resource condition developed for the Washington State Watershed Analysis Methodology (WFPB 1997). Watershed analysis is a method to evaluate the cumulative effects of forestry management on habitat conditions for salmonids and other public resources.

The watershed analysis method defines a suite of habitat parameters and provides a numerical value index for each of these parameters to create ratings of good, fair, and poor conditions (Table 6). While watershed analysis was developed specifically for forestry, the resource condition indices are appropriate and applicable in other land use situations. For the purposes of evaluating the habitat data collected through this project, the resource condition indices were used to generate ratings for each parameter by segment and watershed. A discussion of these ratings and implications for salmon productivity by primary life history stage (migration, spawning, and winter/summer rearing) is given for individual watersheds within each watershed planning area.

Table 6: Habitat quality rating matrix (WFPB 1997, Bjornn and Reiser 1991-for temperature)

Habitat Parameter	**Channel Type**	**Life Phase Influenced**	**Habitat Quality**		
			Poor	**Fair**	**Good**
Percent Pool	<2% grad; <15mwide	Summer/Winter rearing habitat	<40%	40 thru 55%	>55%
	2-5% grad.; < 15m wide	Summer/Winter rearing habitat	<30%	30 thru 40%	>40%
	>5% grad.; < 15 m wide	Summer/Winter rearing habitat	<20%	20 thru 30%	>30%
Pool Frequency	< 2% grad.; <15m wide	Summer/Winter rearing habitat	>4 channel widths per pool	2 - 4 channel widths per pool	<2 channel widths per pool
	2-5% grad; <15m wide	Summer/Winter rearing habitat	>4 channel widths per pool	2 - 4 channel widths per pool	<2 channel widths per pool
	>5% grad; <15m wide	Summer/Winter rearing habitat	>4 channel widths per pool	2 - 4 channel widths per pool	<2 channel widths per pool
LWD Key Piece Frequency	Bank Full Width < 10m	Summer/Winter rearing habitat	<0.15	0.15 thru 0.30	>0.30
	Bank Full Width = 10-20m	Summer/Winter rearing habitat	<0.20	0.20 thru 0.50	0.50
In-channel LWD persistence (species, decay class)	All	Summer/Winter rearing habitat	Deciduous, rotten Unknown, rotten Unknown, moderate Deciduous, moderate	Deciduous, solid Uunknown, solid Conifer, rotten	Conifer, solid Conifer, moderate
LWD Recruitment Potential (species and age class)	All	Summer/Winter rearing habitat	Conifer, young Deciduous, young Mixed, young Deciduous, pole-sapling	Conifer, pole sapling Deciduous, mature Mixed, pole sapling	Mixed, mature Conifer, mature
Percent Canopy Closure	Riparian segment <320 feet*	Summer Rearing	<90%		>91%
	320-680 feet	Summer Rearing	<80%		>81%
	680-1160 feet	Summer Rearing	<70%		>71%
	1160-1640 feet	Summer Rearing	<60%		>61%
Available spawning habitat	All types	Spawning and Incubation	Absent or infrequent (<40% gravel)	41-69 %	Frequent spawnable areas (>70% gravel)
Gravel Quality	All types	Spawning and Incubation	Sand is dominant substrate in some units	Sand is sub-dominant substrate in some units	Sand is never dominant or sub-dominant
Gravel Quality	All types	Spawning and Incubation	> 17% (<0.85mm)	12 - 17% (< 0.85mm)	<12% (<0.85mm)

* Elevation above sea level.

B. Temperature

1. Monitoring

Stream and air temperature was monitored at a total of 19 sites within McDonald, Siebert, Tahuya, and Dewatto River from mid July to late August, 1993 to 1995. Table 7 describes the stream, temperature reach identification code, monitoring dates, site location, type of data collected (air or water), and if a thermal reach characterization (see description in following paragraph) was completed.

Table 7. Stream temperature sampling summary.

Stream	Temperature reach code	Monitoring dates	Location	Data type	Thermal reach characterization
McDonald	M1a	7/30/93-8/29/93	RM 0.1	Water	Yes
McDonald	M1b	8/2/93- 8/30/93	RM 2.0	Water, Air	Yes
McDonald	M2a	7/30/93-8/29/93	RM 4.3	Water, Air	Yes
McDonald	M3a	8/4/93 - 9/1/93	RM 6.5	Water, Air	Yes
McDonald	M5a	8/2/93 - 8/31/93	RM 8.3	Water, Air	Yes
McDonald	M7a	8/2/93 - 8/30/93	RM 9.8	Water, Air	Yes
Siebert	S1	8/3/93 - 8/31/93	RM 0.1	Water	Yes
Siebert	S2	8/4/93 - 8/31/93	RM 1.5	Water, Air	Yes
Siebert	S3`	8/3/93 - 8/31/93	RM 3.1	Water, Air	Yes
Siebert	S4	8/3/93 - 8/31/93	RM 9.4	Water, Air	Yes
Dewatto	D1	8/2/94 - 9/1/94	RM 1.5	Water,Air	Yes
Dewatto	D2	8/5/94 - 8/24/94	RM 2.7	Water, Air	Yes
Dewatto	D3	7/31/95-8/27/95	RM 0.6	Water	No
Dewatto	D4	7/31/95-8/27/95	RM 1.9	Water	No
Little Tahuya	T1	7/18/94-8/2/94	RM 0.1	Water, Air	Yes
Tahuya	T2	7/18/94-8/2/94	RM 5.3	Water, Air	Yes
Tahuya	T3	7/18/94-8/2/94	RM 7.4	Water, Air	Yes
Tahuya	T4	7/31/95-8/27/95	RM 1.0	Water	No
Tahuya	T5	7/31/95-8/27/95	RM 2.3	Water	No

Two types of continuous monitoring thermographs were used; a Unidata logger with external probes to record air and water temperature and a small, submersible Hobo data logger with internal sensors for water temperature only. Data loggers and external probes were calibrated by placing them in an ice water bath to along with a reliable reference thermometer for ten minutes. Any instrument reading +/- 0.5 degrees Celsius from the reference thermometer was discarded. A post season calibration was also conducted to ensure instrument accuracy. All instruments were found to be within the defined range of accuracy throughout the season.

Potential monitoring sites were first evaluated in the office to identify representative reaches for segments of interest and to establish a representative thermal reach. A thermal reach is a reach that has similar stream and riparian conditions for a sufficient distance to allow the stream temperature to reach equilibrium with those conditions (Schuett-Hames et al, 1994). Potential sites were then evaluated in the field for appropriate sampling sites and for ease of instrument installation and security.

Data loggers recording water temperature were placed in deep pools shaded from direct sunlight to minimize misrepresentative readings. Hobo loggers were placed in a submersible waterproof case and then secured to logs or rootwads at one half of the pool depth near the center of the thalweg. Air temperatures were monitored at the same location with a separate unit. Air and water temperature were averaged every 30 minutes and recorded continuously for the duration the unit was in the stream.

Unidata data loggers were installed in a waterproof box and secured to trees outside of the channel disturbance zone. An external probe running from each concealed recording unit was attached to a tree to record air temperature in the riparian zone. The water temperature probe was submerged in a pool by attaching it to a stake driven into the channel or weighted down with rocks within the pool. Air and water temperature were averaged hourly for the duration of time the unit was in use. All sites were periodically inspected to ensure security and instrument operation.

For sites monitored in 1993 and 1994, a thermal reach was characterized for 600 meters upstream from the location of the thermograph. Using a spherical densiometer, canopy closure was measured every 50 meters to determine the average canopy closure for the thermal reach using TFW ambient monitoring protocols. Dominant land use and riparian condition (seral stage, type) were also noted for the thermal reach.

2. Interpretation of Temperature Data

In order to interpret the temperature data, the following ranges were used to develop a temperature rating. Temperatures were discussed in terms of State AA water quality rating (16.3 ^{0}C) and the maximum preferred temperature for rearing salmonids (14^{0}C, Table 8). The assumption was made that temperature would have the most long-term impacts on rearing juveniles.

Table 8. Optimal temperature (^{0}C) ranges for several salmon life history stages (Bjornn and Reiser 1991).

	Upstream migration	Spawning	Incubation	Rearing
Winter steelhead	n/a	3.9-9.4	n/a	10-13
Chum	8.3-15.6	7.2-12.8	4.4-13.3	12-14
Coho	7.2-15.6	4.4-9.4	4.4-13.3	12-14
Fall chinook	10.6-19.4	5.6-13.9	5.0-14.4	12-14

C. Spawning Gravel Composition

Spawning gravel was evaluated using the riffle crest survey, TFW ambient monitoring method (Schuett-Hames et al, 1994) at selected sites in Salmon, McDonald, Siebert, Tahuya, and Dewatto during low flow conditions in 1993 and 1994. Spawning gravel samples were taken within segments with gradients less than 2% containing usable spawning habitat.

Samples were collected using a McNeil Gravel Sampler at the right bank, center, and left bank of the riffle crest. Where possible a minimum of three samples per riffle crest were taken. The McNeil sampler was inserted into the gravel to a depth of 23 cm, and substrate manually removed. Substrate and water within the sampler were transferred to a labeled bucket and transported to a sediment processing station.

Gravel samples were processed using the volumetric method by washing gravel through a series of graduated sieves to determine particle size distribution based on the volume of material in various size classes. The sieve sizes provide a geometric progression of gravel size categories used to characterize the overall particle-size distribution of the sample. The volume of sediment per sieve is determined through the displacement of water in a flask. Results were reported as percents within the gravel size categories.

D. Macroinvertebrates

Macroinvertebrate surveys were conducted in the vicinity of spawning gravel samples using the Rapid Bioassesment Protocol 1 (RBP1) developed by the Environmental Protection Agency.

Samples were collected in McDonald, Siebert, Tahuya, and Dewatto in 1993 and 1994 during low flow conditions (Appendix G). Three samples were taken at the riffle crest downstream from spawning gravel. A Surber sampler (frame measuring 1 ft^2 with an attached collecting net) was placed on the stream bottom. Sediment to a depth of one finger was disturbed for one minute within the sample frame to dislodge and capture stream macroinvertebrates. Information on sample site characteristics (water velocity, substrate, and riparian zone vegetation) was recorded. Samples were transported to the lab for cleaning, sorted to taxonomic order and family, and relative abundance by order and family was noted. See Appendices H through J for descriptions of sampling sites, listing of macroinvertebrate taxa and description of macroinvertebrate community metrics. Percent dominance of the most common three taxa and community richness within streams are described in the following Results section.

RESULTS

The narrative description and interpretation of the results are organized by watershed planning areas and by salmonid life stage to allow comparisons between watersheds, and to increase the understanding of how habitat conditions affect each salmonid life stage. Habitat survey data collected from 1992 through 1994 are summarized in two separate tables for each watershed planning area with additional data provided in Appendices B through F. Information presented includes segment characteristics, habitat units, large woody debris, riparian zone and substrate characteristics. These parameters have been selected to provide an overall assessment of habitat quantity and quality. Results of macroinvertebrate and temperature assessments are also shown for those streams where sampling was done.

A. Dungeness River Watershed Planning Area

1. Segment Descriptions

Siebert Creek was surveyed from RM 0.0 to RM 8.0 on the mainstem and for 0.3 miles on the West Fork Siebert Creek (Table 2). Segments 1 and 2 were surveyed in 1992, Segment 3 in 1994. Reference points were established for Segment 4 but due to the difficulty of the terrain, habitat data were not collected in this area, although temperature site S4a was located within this reach. Segments 1, 2, and 3 were low gradient (less than 4%), moderately confined areas (Table 9). Segment 4 had a higher gradient than 3, with similar average bankfull widths and depths.

The mainstem of McDonald Creek was surveyed from RM 0.0 to RM 8.9. Segments 1 and 2 were surveyed in 1992, and Segments 3 through 6 in 1993. Reference points were established for Segment 7, but habitat data were not collected; temperature site M7 was located within this reach. Segments 1-3 were lower gradient areas moderately confined within a ravine (Table 9). Channel gradient in Segments 4 and 5 increased, with the stream channel becoming increasingly confined within the constricting ravine. Channel gradient and confinement moderates in Segment 6, but the smaller bankfull width and depth were a reflection of the diminishing drainage area in the upper reaches of McDonald Creek.

Table 9. Summary information by segment for Siebert and McDonald creeks.

Stream	Segment Location by River Mile[1]	Number of Reference Points[2]	Segment Length (m)[3]	Segment Gradient Class	Segment Confinement Class	Segment Average Bankfull Depth (m)	Segment Average Bankfull Width (m)
Siebert 1	0.0 - 3.4	65	6309	1-2%	Moderate	0.4	7.8
2	3.4 - 6.4	51	4972	2-4%	Confined	0.4	7.9
3	6.4 - 8.1	31	3185	1-2%	Moderate	0.3	8.0
4	8.1 - 0.3[4]	7	600	4-8%	Moderate	0.2	6.8
McDonald 1	0.0 - 4.1	71	6536	1-2%	Moderate	0.3	8.2
2	4.1 - 4.9	18	1726	2-4%	Moderate	0.5	9.6
3	4.9 - 6.7	36	3670	2-4%	Moderate	0.4	8.7
4	6.7 - 8.0	21	2076	4-8%	Confined	0.3	8.3
5	8.0 - 8.5	10	1023	4-8%	Confined	0.3	8.0
6	8.5 - 8.9	9	835	2-4%	Moderate	0.2	6.6

[1] Segment locations were based on the Washington State Stream Catalog (Williams et al. 1975) rather than actual river mile measurements.
[2] Reference points are numbered sequentially beginning with "0". This column indicates the total number of reference points.
[3] Segment lengths are actual measurements made in the channel.

[4] West Fork Siebert Creek.

2. Habitat Descriptions

a. Siebert Creek

i. Habitat conditions by segment

Pool habitat was low ranging from 41% in segment 1 to 29% in segments 2 and 3 (Table 10). Segments 1 and 2 contained most of deeper pools, with about half of the pools having a residual depth between 0.5m and 1.0m (Table 10). Segment 3 was mostly shallow pools with residual depths less than 0.5m. Large woody debris formed few pools in segment 3 but most were formed by flow or boulders (Table 10).

The channel was generally a single thread channel with a minor percentage of secondary or side channel habitat (Table 10). Large diameter "key" pieces were observed at low levels in all segments[1]. Logjams were more abundant in Siebert Creek than in the other eight streams. For segment 3, most LWD was above summer low flow conditions (Zone 2), but still within the bankfull width (Appendix C). In segment 1 in-channel wood was generally solid and equally split between conifer and deciduous origin. Segment 2 contained mostly solid conifer LWD. About ½ of LWD in segment 3 was rotten conifer (Appendix A). Data on riparian conditions was not collected in 1992 for Segments 1 and 2. The riparian zone in segment 3 was predominantly a young mixed deciduous and coniferous with a dense canopy (92% canopy closure)

Spawning gravels, as represented by the surface area in low gradient riffles, were scarce in segment 3, with a higher abundance in segment 1 and 2. Segment 1 contained a high percentage of fines (22.7%) in interstitial spaces of available spawning gravels.

[1] The LWD frequency and volume figure must be considered as a minimum level of wood for each segment. Each figure does not include wood found in LWD jams, since the individual pieces in LWD jams were not counted. Most of the results and discussion will focus on log jam and key piece frequency.

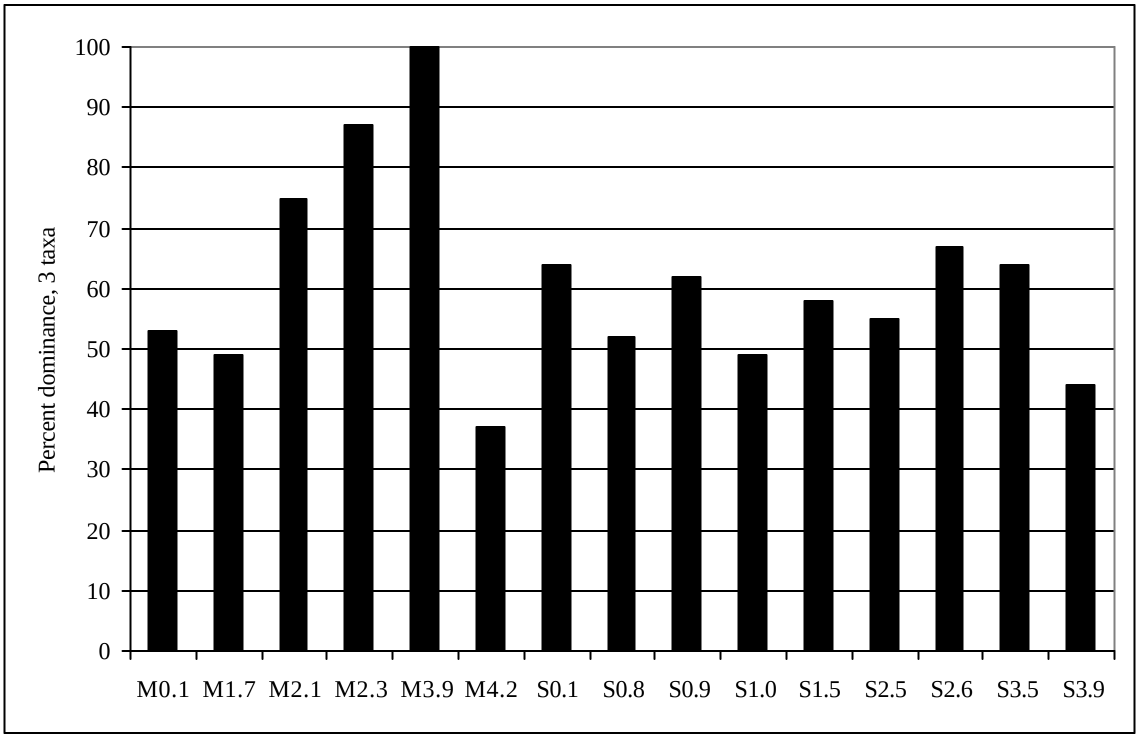
Table 10. Habitat data summary for Siebert and McDonald creeks

Segment	Habitat units					Large Woody Debris			
	Pool/ Riffle/ Cascade Ratio (%)	Habitat Located within Primary, Secondary, and Side Channels (%)	Percentage of pools with a residual depth (<0.49m, 0.5 to 0.99m, >1.0 m)	Pool Frequency (channel width/ pool)	Dominant Pool Forming Factors	LWD Vol. (m^3/100m. Zone 1-4)	LWD Freq. (Pieces per channel width)	Key Piece Freq. (per channel width)	Log Jam Freq. (per channel width)
Siebert 1	41/16/43	91/7/2	40/52/8	3.6	N/A	4.2	0.18	0.04	0.07
2	29/4/66	98/1/1	39/55/6	5.3	N/A	7.1	0.10	0.07	0.04
3	29/40/31	93/5/2	90/10/0	2.7	Boulders Bedform	6.9	0.46	0.05	0.08
McDonald 1	28/45/27	92/5/2	60/37/3	3.5	N/A	5.1	0.49	0.03	0.05
2	36/27/37	93/4/3	47/47/6	2.5	N/A	5.4	0.45	0.03	0.09
3	33/23/44	93/6/1	59/39/2	3.3	Boulders tree roots	5.4	0.51	0.04	0.07
4	33/12/54	95/4/1	72/26/2	2.3	Bedrock Boulders	3.0	0.27	0.02	0.11
5	36/26/38	95/5/0	70/26/4	2.1	Boulders Bedrock	5.1	0.42	0.04	0.11
6	25/24/51	93/4/3	80/18/2	3.0	Boulders LWD	4.8	0.33	0.03	0.08

Segment	Riparian Zone Characteristics			Substrate Characteristics		
	Avg Canopy Closure (%)	Dominant vegetation and seral stage	Dominant Landuse	% Fines <0.85 mm , # samples	Dominant substrate	% Total Substrate in Gravel Size Category
Siebert 1	N/A	Not collected Mature	Woodlot	22.7 n= 24	Gravel	58
2	N/A	Not collected Mature	Timberland	N/A	Gravel	67
3	92	Mixed Young	Timberland	N/A	Boulder/ bedrock	7
McDonald 1	N/A	Not collected	Residential	23.3 n = 18	Gravel	63
2	N/A	Not collected Mature	Residential	N/A	Gravel	55
3	91	Not collected Mature	Timberland	N/A	Gravel	52
4	90	Mixed Young	Timberland	N/A	Bedrock	9
5	92	Mixed/conifer Young	Timberland	N/A	Gravel	49
6	98	Mixed Young	Timberland	N/A	Gravel	76

ii. Macroinvertebrate Population Condition

Macroinvertebrate samples were collected October 4-7, 1994. Fifty seven pecent of all taxa was of the orders Ephemeroptera/Plecoptera/Tricoptera (EPT); that is, mayflies/stoneflies/caddisflies. These three taxa were dominant at all sites. The percent dominance and richness of the EPT are shown by sampling site in Figure 1.



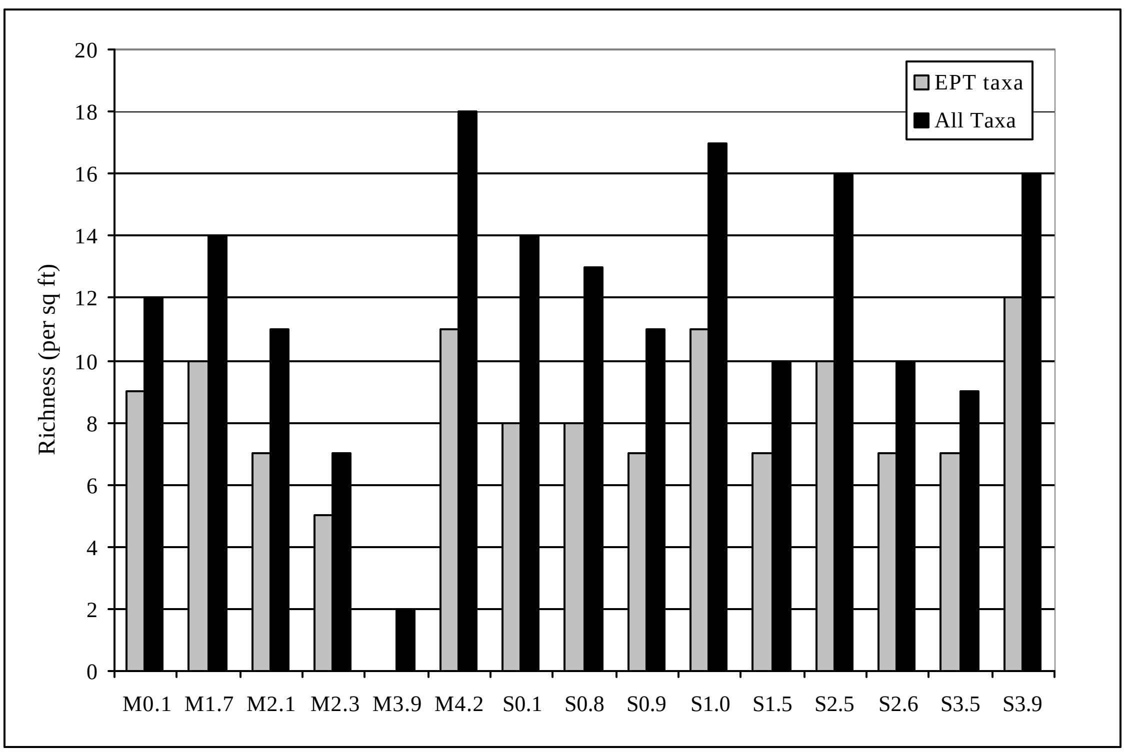


Figure 1. Siebert and McDonald macroinvertebrate community richness (EPT is Ephemeroptera, Plecoptera and Trichoptera) and percent dominance of the three most common taxa. The letter is the Stream Name (e.g., S is Siebert) and the number is the River Mile of the sampling site.

iii. Temperature Conditions by Segment

The temperature probes were installed in Siebert Creek August 3rd and 4th, most likely missing a period of high summer temperatures (see McDonald Creek, site 2a, Appendix F). Only Siebert Creek site 2a, , exceeded AA standards, and this was for just a few hours over two days (Table 11). The preferred rearing temperatures were exceeded for portions of 10-12 days at three of the four sites in Siebert Creek.

Table 11. Summary of water temperature survey information for Siebert and McDonald creeks. Water temperature was sampled continuously during the sampling period. Thermographs for each sampling site are located in Appendix G.

Stream sampling site	Sampling dates	Number of days sampled	River Mile (approx.)	Lower elevation (ft)	Canopy closure (%) for 600m above sampling site	Dominant vegetation type and seral stage	Exceed max preferred rearing temperature (14^{o}C), and number of days	Exceed AA water quality (16.3^{0}C) standards, and number of days
Siebert S1a	8/3/93-8/31/93	29	0.1	20	92	Mixed Mature	Yes-10 days	No
Siebert S2a	8/4/93-8/31/93	28	1.6	170	87	Mixed Mature	Yes-12 days	Yes-2 days[1]
Siebert S3a	8/3/93-8/31/93	29	3.1	210	92	Mixed Mature	Yes-10 days	No
Siebert S4a	8/3/93-8/31/93	29	9.4	670	93	Mixed Mature	No	No
McDonald M1a	7/30/93-8/29/93	31	0.1	40	95	Deciduous Mature	Yes-10 days	No
McDonald M1b	8/2/93-8/30/93	29	2.0	160	85	? Young	Yes-24 days	Yes-14 days
McDonald M2a	7/30/93-8/29/93	31	4.3	360	81	? Mature	Yes-9 days	Yes-2 days
McDonald M3a	8/4/93-9/1/93	29	6.5	560	82	Mixed Young	Yes-11 days	Yes-2 days
McDonald M5a	8/2/93-8/31/93	30	8.3	920	91	Mixed Young	Yes-2 days	No
McDonald M7a[2]	8/2/93-8/30/96	29	9.8	1320	97	Mixed Mature	*Yes-29 days*	*Yes-4 days*

[1] Exceedance occurred at beginning of monitoring period and may reflect instrument calibration with water temperature.
[2] This sampling site was located in a step-pool; it is possible it became dewatered. The data are shown here but are not included in the analyses.

iv. Habitat quality ratings

Habitat ratings of Siebert Creek for segments 1 through 3 characterize conditions as ranging from poor to fair (Table 12). The exceptions were for in-channel LWD persistence in segments 1 and 2 and canopy closure in segment 3 where the rating was good. Generally, all segments appear heavily impacted. Potentially, segments 1-3 should have the most productive habitat given the low channel gradient and moderate confinement.

Table 12. Habitat quality ratings for Siebert and McDonald creeks.

Segment Characteristics			Pool Quality		LWD Quality		Riparian Quality		Substrate Quality	
Stream/ Segment	Avg Bankfull Width (m)	Segment Gradient Class	Percent Pool Rating	Pool Frequency Rating	Key Pieces/ channel width Rating	In-channel LWD persistence	LWD Recruitment Potential from Riparian Zone	Canopy Closure Rating	Gravel Quality Rating	Available Spawning Habitat
Siebert 1	7.8	1-2%	Fair	Fair	Poor	Good	N/A	N/A	Poor	Fair
2	7.9	2-4%	Poor	Fair	Poor	Good	N/A	N/A	N/A	Fair
3	8.0	1-2%	Poor	Fair	Poor	Fair-good	Poor	Good	N/A	Poor
McDonald 1	8.3	1-2%	Poor	Fair	Poor	Fair-poor	N/A	N/A	Poor	Fair
2	9.0	1-2%	Poor	Fair	Poor	Good	N/A	N/A	N/A	Fair
3	8.4	2-4%	Fair	Fair	Poor	Good-Fair	N/A	Good	N/A	Fair
4	8.3	4-8%	Good	Fair	Poor	Fair	Poor	Good	N/A	Poor
5	8.0	4-8%	Good	Fair-Good	Poor	Fair	Poor	Good	N/A	Fair
6	6.6	2-4%	Poor	Fair	Poor	Fair	Poor	Good	N/A	Good

b. McDonald Creek

i. Habitat Conditions by Segment

Habitat conditions within segments 1-3 are relatively similar with low pool surface areas (28%, 36%, and 33%), and small average residual pool depths < 0.5m (Table 10). Segment 1 had a lower channel gradient (1-2%) and contained a higher percentage of riffle habitat in contrast with segments 2 and 3 (with a channel gradient of 2-4%). Throughout segment 1-6, the channel was composed of a single thread (primary) channel (Table 10). Logjam frequency was highest in segments 4 and 5. Riparian information was not collected on segment 1. Segments 2 and 3 data indicate a mature riparian forest (Table 10) with good canopy closure on segment 3 (Table 12). The landuse within Segments 1 and 2 was predominantly residential, while segment 3 was commercial timberland. Substrate data in segment 1 to 3 indicated relatively abundant spawning gravel. Segment 1 had a high percentage of fines (23.3%, Table 10).

The lower percent of surface area in pool habitat, decreasing riffle area, and increasing cascade habitat observed in segments 4 and 5 (Table 10) is related to the higher gradient and increased channel confinement (Table 9). Pool characteristics (residual pool depth, pool frequency, pool type) were similar to other segments although side channel habitat types in segments 4 and 5 were absent (Table 10). LWD volume was lower than downstream in segments, indicating the lower retention of wood with increasing stream power created by the higher channel gradient. For segments 4 and 5, 63% and 78% respectively of LWD pieces were not interacting with the channel, and 42% and 33% of LWD pieces were unstable. Rotten conifer LWD was commonly found (Appendix A.) A higher percentage of pools were formed by bedrock and boulders in this segment in comparison to downstream segments with lower channel gradients (Table 10). The riparian forest is a mixture of coniferous and deciduous tree species in a dense young stand, with the surrounding land use in commercial timber land production. Bedrock dominates the substrate type in Segment 4; Segment 5 appears to contain more gravel (49%).

Segment 6 habitat conditions include 25% pool habitat predominantly formed by boulders and LWD. 66% of LWD was rotten conifer, with 33% of LWD volume interactive with the low flow channel (Zone 1 and 2, Appendix B). The riparian corridor was dominated by a fairly dense and young mixed deciduous/conifer stand.

ii. Macroinvertebrate population condition

In segment 1, RM 2.1-3.9 is degraded with low levels of EPT taxa and all taxa in general. This portion of segment 1 is bordered by both residential development and agricultural areas. The substrate of the sample site was cobble dominated and the percentage of fines high (Appendix C). There is an extensive residential development between RM 2.5-3.0 that intrudes at times into the riparian corridor (1997 aerial photo analysis). Below RM 2.0, the channel drops into a forested ravine, physically separated from the agriculture fields and lower density residences.

iii. Temperature conditions by segment

State water AA quality standards on McDonald Creek were exceeded at three of five sites (Table 11, see footnote no.2); however only site M1b, at RM 2.0 (just downstream of a large residential area, see above), substantially exceeded these standards (Table 11). All sites exceeded the preferred temperatures for rearing salmon for varying periods of time (Table 11, Appendix F). Site M5a (segment 5) was confined in a ravine with relatively steep (4-8%) gradients, above extensive residential/agricultural development, and at a relatively higher elevation than the other sites.

B. Discovery Bay Watershed Planning Area

1. Segment description

Salmon Creek was surveyed from RM 0.7 to RM 3.5. Segment 2 was surveyed in 1992, Segments 3, 4, and 5 in 1993. Reference points were established for Segment 4 but due to the difficulty of the terrain, habitat data was not collected in this area. Segment 2 is mostly unconfined with gradients less than 2%, but with some portions moderately confined and having gradients of 2-4%. Segments 3 and 4 are confined with gradients 2-4% and 4-6% respectively (Table 13). Segment 5 is moderately confined to confined with gradients between 1-2% and 2-4%.

Table 13. Summary information by segment for Discovery Bay watershed planning area.

Stream		Segment Location by River Mile	Number of Reference Points	Segment Length (m)	Segment Gradient Class	Segment Confinement Class	Segment Average Bankfull Depth (m)	Segment Average Bankfull Width (m)
Salmon	2	0.2 - 1.3	22	2221	1-2%	Unconfined	0.3	5.2
	3	1.3 - 1.5	4	369	2-4%	Confined	0.4	7.8
	4	1.5 - 2.0	9	800	4-6%	Confined	0.4	6.3
	5	2.0 - 3.8	25	2417	1-2%, 2-4	Moderate and Confined	0.3	4.3

2. Habitat Descriptions

a. Salmon Creek

i. Habitat Conditions by Segment

Segment 2 had relatively infrequent pools (4.6 channel widths/pool) and 39% of surface area in pools (Table 14). Sixty four percent of pools had a residual depth <0.5m, with the rest less than 1m in depth. The channel was a single thread, with relatively low levels of LWD (0.32 pieces/channel width, or CW) and LWD jams (0.04/CW). Large woody debris was 86% conifer, with 82% moderately decayed (Appendix B). The substrate was 75% gravel with 16.1% fines (Table 14).

Segment 3 had higher LWD (1.02 pieces/CW), key piece (0.19 pieces/CW), and log jam (0.15/CW) frequencies (Table 14). Pools were relatively frequent (1.8 CW/pool) but small in area and shallow, with only 36% surface area in pools and 88% pools with a residual depth <0.5m. Boulders and LWD formed most pools. Most LWD was rotten conifer (88%), but 79% of LWD was stable and not mobile (Appendix B). Fifty eight percent of the channel was cascades, which accounted for just 47% of substrate as gravel sized particles (Table 14). The riparian zone was mixed conifer and deciduous, and mature in size.

Like segment 2, segment 5 has few pools with 4.6 CW/pool and 36% pools (Table 14). Most pools were shallow with a residual depth < 0.5m. Large woody debris formed most pools. Large woody debris was also relatively infrequent, generally rotten conifer/unknown (68%), but stable (20% unstable) (Appendix B). Fifty percent of LWD (volume) was located on the floodplain, outside of bankfull width (Appendix C). The riparian zone was mature-deciduous. Eighty five percent of the substrate was gravel (Table 14).

Table 14. Habitat data summary for Salmon Creek

Segment	**Habitat units**					**Large Woody Debris**			
	Pool/Riffle/ Cascade Ratio (%)	Habitat Located within Primary, Secondary, and Side Channels (%)	Percentage of pools with a residual depth (<0.49m, 0.5 to 0.99m, >1.0 m)	Pool Frequency (channel width/ pool)	Dominant pool forming factors	LWD Vol. (m^3/100 m., Zone 1-4)	LWD Freq. (Pieces per channel width)	Key Piece Freq. (per channel width)	Log Jam Freq. (per channel width)
Salmon 2	39/42/19	96/4/0	64/34/2	4.6	DM	7.5	0.32	0.03	0.04
3	36/6/58	90/2/1	88/8/4	1.8	Rocks, boulders	44.6	1.02	0.19	0.15
4	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
5	36/47/17	97/2/1	86/13/1	4.6	Logs	8.8	0.44	0.10	0.00

Segment	**Riparian Zone Characteristics**			**Substrate Characteristics**		
	Average Canopy Closure (%)	Dominant vegetation and seral stage	Dominant Landuse	Percent Fines <0.85 mm and sample size	Dominant substrate	Percent of Total Substrate in Gravel Size Category
Salmon 2	N/A	N/A	Timberland	16.1 n=14	Gravel	75
3	94	Mixed Mature Timber	Timberland	N/A	Gravel	47
4	96	DM	DM*	N/A	DM*	DM*
5	91	Deciduous Mature Timber	Timberland	N/A	Gravel	85

* Data missing. See text.

ii. Habitat quality ratings

The Salmon Creek habitat quality ratings are described in Table 15.

Table 15. Habitat quality ratings for Salmon Creek.

Segment Characteristics			Pool Quality		LWD Quality		Riparian Quality		Substrate Quality	
Stream/ Segment	Avg Bankfull Width (m)	Segment Gradient Class	Percent Pool Rating	Pool Frequency Rating	Key Pieces/ channel width Rating	In-channel LWD persistence	LWD Recruitment Potential from Riparian Zone	Canopy Closure Rating	Gravel Quality Rating	Available Spawning Habitat
Salmon 2	5.2	1-2%	Poor-fair	Poor	Poor	Good	N/A	N/A	Fair	Good
3	7.8	2-4%	Fair	Good	Fair	Fair	Good	Good	N/A	Fair
4	6.3	4-6%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	4.3	1-2%., 2-4%,	Fair-poor	Poor	Poor	Fair-poor	Fair	Good	N/A	Good

C. Quilcene/Dabob Watershed Planning Area

1. Segment Descriptions

The Little Quilcene River was surveyed in 1992 from its mouth to RM 5.2, where Howe Ck enters the Little Quilcene. Channel gradients are mild throughout the surveyed section, gradually rising from <1% in segments 1 and 2, to 2-4% in segment 5 (Table 16). Segment 1 is tidally influenced; the channel width in segment 1 is wide relative to upstream segments due to beaver ponds. The valley is unconfined in segments 1-3 and moderately confined in segments 4 and 5.

Howe Creek, a tributary to the Little Quilcene River, was surveyed in 1993 from its confluence with the Little Quilcene to RM 3.0 (Table 16). In segments 1, Howe Creek rises sharply in a confined ravine from the Little Quilcene, and then the gradient moderates and the valley widens from segment 2 through 6. Segments 3 and 5 are wetlands. Segment 7 is higher gradient and confined.

Ripley Creek, also a tributary to the Little Quilcene was surveyed in 1993 from its confluence to RM 1.6 (Table 16). Habitat data was only collected for segment 1 where the channel was low gradient and the valley unconfined.

The Big Quilcene River was surveyed in 1992 from its mouth to RM 3.4, above the Quilcene National Fish Hatchery (QNFH, at RM 2.8). Segment 1 is tidally influenced and entirely constricted by earthen dikes and riprap that extend upstream through half of segment 2. Both segments have gradients <1.0% with an unconfined valley. In segments 3-5, the channel gradient ranges between 1-2%, with moderate confinement. The QNFH is located in segment 4, which bounds an approximately 800 m portion of the Big Quilcene between the intake (upstream) and the electric fish weir (downstream). Since the channel was mostly de-watered in this segment from QNFH water usage, the habitat data was not collected.

Table 16. Summary information by segment for the Quilcene/Dabob watershed planning area.

Stream	Segment Location by River Mile	Number of Reference Points	Segment Length (m)	Segment Gradient Class	Segment Confinement Class	Segment Average Bankfull Depth (m)	Segment Average Bankfull Width (m)
Howe 1	0-0.4	9	883	6-17%	Confined	0.3	7.1
2	0.4-0.6	3	298	1-2%	Unconfined	0.2	9.3
3	0.6-1.0	Wetland	N/A	<1%	Unconfined	N/A	N/A
4	1.0-1.6	10	989	2-4%	Unconfined	0.3	3.4
5	1.6-1.7	Wetland	N/A	1-2%	Confined	N/A	N/A
6	1.7-2.0	5	408	1-2%	Unconfined	0.3	3.8
7	2.0-2.8	16	1394	4-6%	Confined	0.4	3.8
Ripley 1	0-0.7	12	1129	1-2%	Unconfined	0.3	5.2
2	0.7-1.5	14	1300	4-6%	Moderate	0.3	4.4
Little Quilcene 1	0-0.2	3	283	<1%	Unconfined	0.4	13.1
2	0.2-1.7	22	2091	<1%	Unconfined	0.4	9.7
3	1.7-2.7	14	1391	1-2%	Unconfined	0.5	8.1
4	2.7-4.4	25	2509	1-2%	Moderate	0.4	7.7
5	4.4-5.2	15	1480	2-4%	Moderate	0.4	7.6
Big Quilcene 1	0-0.2	4	400	<1%	Unconfined	0.5	15.0
2	0.2-1.3	14	1369	<1%	Unconfined	0.5	15.8
3	1.3-2.8	28	2768	1-2%	Moderate	0.6	13.8
4	2.8-3.2	QNFH*	800	1-2%	Moderate	N/A	N/A
5	3.2-3.3	2	200	1-2%	Moderate	0.5	11.5

* Quilcene National Fish Hatchery

2. Habitat Descriptions

a. Little Quilcene River

i. Habitat Conditions by Segment

Segment 1 contained several large beaver ponds, accounting for the high percent pools (68%, Table 17). Diking confines the habitat to a single thread channel. Very low levels of LWD were present, 0.4 pieces/CW, with no bgjams or LWD large enough to qualify as key pieces. The dominant substrate was equally sand and gravel (54% and 46%, Appendix F), reflecting the tidal influence.

Segments 2-5 were relatively similar, all with very low levels of LWD (Table 17). Large woody debris in all segments were mostly of deciduous origin, however moderately decayed conifer was present in segments 4 and 5 (40 and 52% respectively, Appendix B). Pools were infrequent and widely spaced (pool frequency 3.9-5.4 CW/pool). Residual pool depths were <1.0 m for segments 1 and 5, with a few pools >1.0 m in segments 2-4. The riparian forest was young in segment 2 and mature in 3-5, with residential as the dominant riparian landuse in segments 2-3, and forested in 4 and 5. Gravel was abundant.

Table 17. Habitat data summary for Howe Cr., Ripley Cr., Little Quilcene R. and Big Quilcene R.

Segment	Habitat units					Large Woody Debris			
	Percent Pool Riffle Cascade	Percent Habitat Units within Primary, Secondary, and Tertiary Channel	Percentage of pools with a residual depth (<0.49m, 0.5 to 0.99m, >1.0 m)	Pool Freq. (channel widths/ pool)	Dominant Pool Forming Factors	LWD Vol. (m^3/100 m., Zone 1-4)	LWD Freq. (Pieces per channel width)	Key Piece Freq. (per channel width)	Log Jam Freq. (per channel width)
Howe 1	28/34/38	86/4/10	71/26/3	2.9	Logs, LWD jams	19.5	1.65	0.11	0.15
2	45/55/0	81/9/10	78/22/0	1.7	Logs, debris jams	18.1	2.37	0.22	0.03
3	Wetland	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
4	51/49/0	97/3/0	69/31/0	3.1	Logs, debris jams	8.5	0.61	0.04	0.04
5	Wetland	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
6	40/60/0	97/3/0	85/15/0	4.1	Logs, bank scour	9.6	0.34	0.05	0.01
7	27/29/45	91/10/1	95/5/0	5.5	Logs, rocks	3.3	0.21	0.03	0.04
Ripley 1	50/38/12	98/2/0	90/8/2	3.6	Logs, debris jams	10.6	0.75	0.05	0.11
2	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
Little Quilcene 1	68/29/3 (inc. 51% beaver pond)	100/0/0	50/50/0	5.4	DM*	0.4	0.14	0.00	0.00
2	37/12/51	97/3/0	46/44/0	4.1	DM*	2.7	0.25	0.02	0.02
3	28/12/51	86/8/6	36/59/5	3.9	DM*	4.1	0.22	0.04	0.04
4	23/19/57	95/4/1	37/53/10	4.8	DM*	4.0	0.23	0.03	0.03
5	25/9/66	97/3/0	63/37/0	4.5	DM*	2.7	0.15	0.03	0.06
Big Quilcene 1	0/100/0	100/0/0	0/0/0	0.0	DM*	0.0	0.04	0.00	0.00
2	23/74/3	92/8/0	50/39/11	4.8	DM*	1.3	0.21	0.00	0.00
3	35/16/49	89/3/8	26/54/20	4.0	DM*	2.2	0.22	0.01	0.05
4	Fish hatchery	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
5	53/2/45	93/7/0	40/60/0	3.5	DM*	4.4	0.58	0.00	0.17

Segment	Riparian Zone Characteristics			Substrate Characteristics		
	Average Canopy Closure (%)	Dominant vegetation and seral stage	Dominant Landuse	Percent Fines <0.85 mm and sample size	Dominant substrate	Substrate in Gravel Size Category (%)
Howe 1	95	N/A Mature	Timberland	N/A	Gravel	47
2	80	Mixed Young	Timberland	N/A	Sand	37
3	31	N/A	N/A	N/A	N/A	N/A
4	42	Conifer Young	Timberland	N/A	Gravel	62
5	4	N/A	N/A	N/A	N/A	N/A
6	40	Deciduous Mature	Timberland	N/A	Gravel	93
7	88	Conifer Young	Timberland	N/A	Gravel	95
Ripley 1	87	Mixed Mature	Timberland	N/A	Gravel	47
2	92	DM*	DM*	DM*	DM*	DM*
Little Quilcene 1	N/A	DM* Shrub-Seedling	Wetland	N/A	Sand	46

2	N/A	DM* Young	Residential	N/A	Gravel	73
3	N/A	DM* Mature	Residential	N/A	Gravel	79
4	N/A	DM* Mature	Timberland	N/A	Gravel	85
5	N/A	DM* Mature	Timberland	N/A	Gravel	92
Big Quilcene 1	N/A	DM* Grass/Forb-Pole/Sapling	Agriculture Wetland	N/A	Gravel	100
2	N/A	DM* Mature	Residential	N/A	Gravel	89
3	N/A	DM8 Pole/Sapling	Timberland Agriculture	N/A	Gravel	80
4	DM	DM*	DM*	DM*	DM*	DM*
5	DM	DM8 Young	Timberland	N/A	Gravel	58

* Data missing.

ii. Habitat quality ratings

Ratings for habitat quality of Little Quilcene and the other three streams in the Quilcene/Dabob watershed planning area are shown in Table 18.

Table 18. Habitat quality ratings for Howe Cr., Ripley Cr., L. Quilcene R. and B. Quilcene R.

Segment Characteristics			Pool Quality		LWD Quality		Riparian Quality		Substrate Quality	
Stream/ Segment	Avg Bankfull Width (m)	Segment Gradient Class	Percent Pool Rating	Pool Frequency Rating	Key Pieces/ channel width Rating	In-channel LWD persistence	LWD Recruitment Potential from Riparian Zone	Canopy Closure Rating	Gravel Quality Rating	Available Spawning Habitat
Howe 1	7.1	6-17%	Fair	Fair	Poor	Fair	N/A	Good	N/A	Fair
2	9.3	1-2%	Fair	Good	Fair	Fair-good	Poor	Good	N/A	Poor
3	N/A	<1%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	3.4	2-4%	Good	Fair	Poor	Fair-good	Poor	Poor	N/A	Fair
5	N/A	1-2%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	3.8	1-2%	Fair	Poor	Poor	Poor	Fair	Poor	N/A	Good
7	3.8	4-6%	Fair	Poor	Poor	Poor	Poor	Poor	N/A	Good
Ripley 1	5.2	1-2%	Fair	Fair	Poor	Fair-poor	Good	Poor	N/A	Fair
Little Quil 1	13.1	<1%	Good	Poor	Poor	Good	N/A	N/A	N/A	Fair
2	9.7	<1%	Fair	Poor	Poor	Fair-good	N/A	N/A	N/A	Good
3	8.1	1-2%	Poor	Fair	Poor	Fair	N/A	N/A	N/A	Good
4	7.7	1-2%	Poor	Poor	Poor	Fair-good	N/A	N/A	N/A	Good
5	7.6	2-4%	Poor	Poor	Poor	Fair-good	N/A	N/A	N/A	Good
Big Quil. 1	15.0	<1%	Poor	Poor	Poor	No LWD	N/A	N/A	N/A	Good
2	15.8	<1%	Poor	Poor	Poor	Fair	N/A	N/A	N/A	Good
3	13.8	1-2%	Fair	Poor-fair	Poor	Good	N/A	N/A	N/A	Good
4	N/A	1-2%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	11.5	1-2%	Good	Fair	Poor	Poor	N/A	N/A	N/A	Fair

b. Howe Creek

i. Habitat Conditions by Segment

Segment 1 was steep and the valley confined (Table 16). Relatively abundant LWD pieces and logjams were the dominant pool-forming factor (Table 17). Side channels caused by logjams were common (10%). Eighty one percent of LWD volume was rotten conifer (Appendix B). Pools were moderately frequent given the channel gradient (2.9 CW/pool), but covered just 28% of channel surface area (Table 17). The dominant riparian landuse was forests, which were composed of mature timber.

Segments 2, 4, and 6 (segments 3 and 5 were wetlands) had 40 to 51% of surface area as pools, at a frequency of 1.7 to 4.1 CW/pool (Table 17). The higher frequency of pools in segment 2 resulted from more abundant key pieces (0.22 pieces/CW) and LWD (2.37 pieces/CW). About half of LWD volume was contained between the bankfull channel. Pool residual depth was <0.5 m. Large woody debris was generally rotten for all segments (Appendix B). The riparian forests were young-mixed and conifer for segments 2 and 4, and mature-deciduous for segment 6 (Table 17). The channel substrate was primarily sand in segment 2 (62%), and gravel in segment 4 (62%) and 6 (95%) (Appendix F).

In segment 7, the gradient increased to 4-6% and the valley confined the channel (Table 16). Pools were infrequent, formed by logs and boulders, shallow (95% < 0.5 m), and covered just 27% of the channel surface area (Table 17). Large woody debris was scarce, rotten (70%), and somewhat unstable (37%) (Appendix B). The riparian zone was fully forested, but composed of young conifer. The channel substrate was 95% gravel sized (Appendix F).

ii. Habitat Quality Ratings

The Howe Creek habitat quality ratings are shown in Table 18.

c. Ripley Creek

i. Habitat Conditions by Segment

Pools in Ripley Creek were relatively large (50% of surface area in pools), infrequent (3.6 channel widths/pool), and shallow (90% of pools <0.5m) (Table 17). Large woody debris pieces and jams formed the majority of pools; boulders, bank and bedrock projections, and standing trees formed the remainder. The riparian zone was fully forested and the overstory composed of a mixture of mature deciduous and conifer species. Most LWD was either located on the floodplain or suspended above bankfull (Appendix C). Seventy percent of all LWD (including those on the floodplain and above bankfull) was stable. Rotten LWD accounted for 65% of LWD volume, with much of the remaining LWD as deciduous origin (Appendix B). The channel substrate was 47% gravel and 25% sand (Appendix F).

ii. Habitat Quality Ratings

The Ripley Creek habitat quality ratings are shown in Table 18.

d. Big Quilcene River

i. Habitat Conditions by Segment

In 1992, the Big Quilcene was 100% riffles from the mouth to RM 0.8 (more recently a pool has developed at about RM 0.2). This includes all of segment 1 and a portion of segment 2. Segment 1 is tidally influenced, mostly bordered (outside the dikes) by marsh or agriculture, contains few pieces of LWD, and has 100% gravel substrate.

Segments 2 and 3 are braided with relatively unstable side channels. Pools were infrequent (4.0 and 4.8 CW/pool) and covered just 23 and 35% of channel surface area (Table 17). Segment 2 has few pieces of LWD (0.21 pieces/CW) and no logjams. Segment 3 contains some logjams, but few large, "key piece" sized LWD. The riparian forest is mostly deciduous (field observation) and mature for segment 2, with land use in the lower portion of the segment residential, and forested in the upper portion of the segment. Segment 3 is pole-sized conifer on the right bank, and mostly non-forested agriculture on the left bank. Large woody debris is solid-deciduous in segment 2 and solid-conifer and deciduous in segment 3. Gravel is abundant.

Segment 5 is also braided, with higher levels of LWD (0.58 pieces/CW) and logjams (0.17/CW) than in downstream segments. Large woody debris is small diameter, with none of keypiece size. Pools were abundant (53%), however no pools were greater than 1.0 m in depth (Table 17).

ii. Habitat Rating Quality

The Big Quilcene habitat ratings are shown in Table 18.

D. Lower Hood Canal Watershed Planning Area

1. Segment Descriptions

The Tahuya River habitat was surveyed in 1994 from RM 4.1 to RM 7.. The segment is low gradient (<1.0%) and the valley unconfined (Table 19). The Dewatto River habitat was surveyed in 1994 from RM 3.5 to 7.0. All segments (2-10) had gradients <1.0 % and an unconfined valley. Segments 4, 7, and 9 were wetlands and not surveyed.

Table 19. Summary information by segment for the lower Hood Canal watershed planning unit.

Stream/ Segment	Segment Location by River Mile	Number of Reference Points	Segment Length (m)	Segment Gradient Class	Segment Confinement Class	Segment Average Bankfull Depth (m)	Segment Average Bankfull Width (m)
Tahuya 9	4.1-7.4	67	6788	<1%	Unconfined	0.4	13.0
Dewatto 2	3.0-3.2	3	339	<1%	Unconfined	0.3	11.4
3	3.2-3.5	5	434	<1%	Unconfined	0.5	13.7
4	3.5-4.4	wetland	N/A	<1%	Unconfined	N/A	N/A
5	4.4-5.6	20	2075	<1%	Unconfined	0.5	7.8
6	5.6-6.0	8	770	<1%	Unconfined	0.5	6.4
7	6.0-6.8	wetland	N/A	<1%	Unconfined	N/A	N/A
8	6.8-7.3	12	1157	<1%	Unconfined	0.4	8.7
9	7.3-7.5	wetland	N/A	<1%	Unconfined	N/A	N/A
10	7.5-7.7	4	346	<1%	Unconfined	0.5	7.8

2. Habitat Descriptions

a. Tahuya River

i. Habitat Conditions by Segment

The Tahuya River has relatively frequent pools (2.5 CW/pool), a high percentage of pool habitat (72%), and deep pools (38% of pools with a residual depth >1.0 m) (Table 20). Logjams and individual logs were the most common pool-forming factor, however beaver dams, bank projections, and self-formed pools were also important. The frequency of large diameter LWD (key pieces) was low (0.04 pieces/CW). Ninety one percent of LWD was found within bankfull (zone 1 and 2), and most of the LWD was moderately decayed conifer (39%) and deciduous (38%) (Appendices C and B). Twenty three percent of LWD was unstable. The riparian zone was young and dominated by deciduous species (Table 20). The 39% average canopy closure is mostly attributable to the small deciduous riparian forest and somewhat to the 13.0 m wide channel. Percent fines was a moderate 10.5% and the spawning gravel abundant (79%, Appendix F) where riffles occurred.

Table 20. Habitat data summary for Tahuya and Dewatto River.

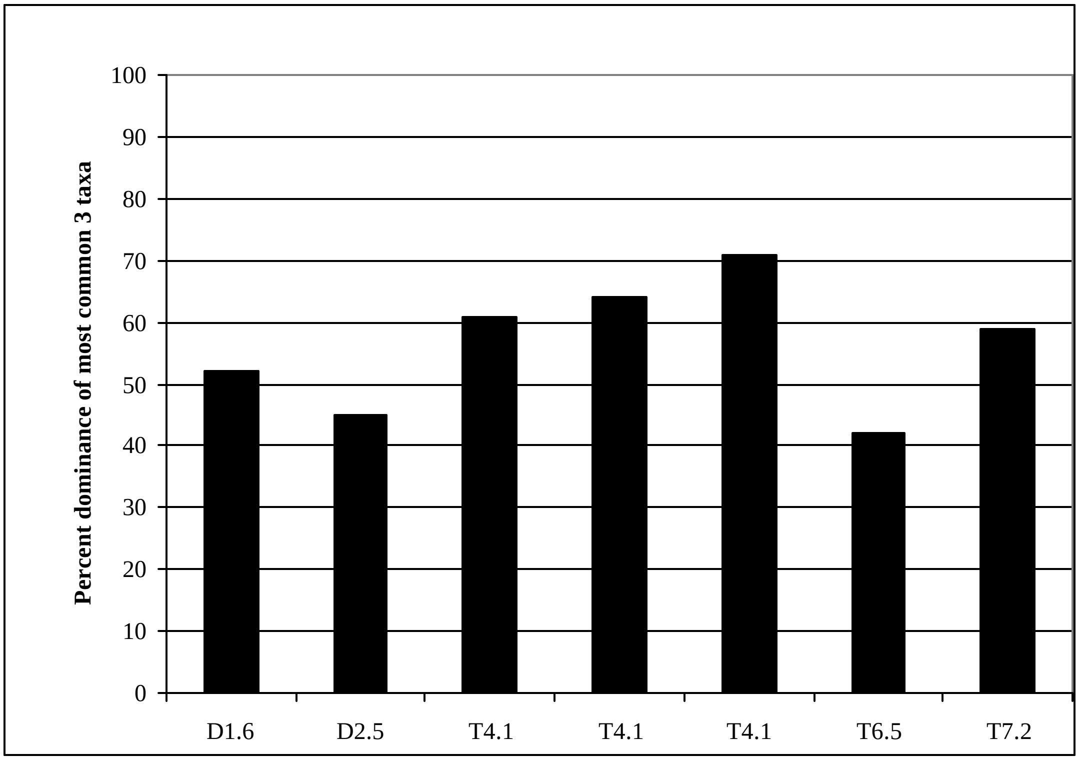
Segment	Habitat units					Large Woody Debris			
	Percent Pool Riffle Cascade	Percent Habitat Units within Primary, Secondary, and Tertiary Channel	Percentage of pools with a residual depth (<0.49m, 0.5 to 0.99m, >1.0 m)	Pool Freq. (channel widths/ pool)	Dominant Pool Forming Factors	LWD Vol. (m^3/100 m., Zone 1-4)	LWD Freq. (Pieces per channel width)	Key Piece Freq. (per channel width)	Log Jam Freq. (per channel width)
Tahuya 9	72/25/3	92/8/0	17/46/38	2.5	Debris jams, Logs, roots	8.7	0.50	0.04	0.04
Dewatto 2	35/55/10	96/4/0	57/29/14	3.7	Roots of standing tree	5.6	0.77	0.00	0.03
3	38/55/7	100/0/0	17/67/14	5.3	Debris jams, roots	8.4	1.27	0.03	0.00
4	Wetland	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
5	82/17/1	92/3/5	33/48/19	2.9	Roots	7.4	0.45	0.08	0.02
6	80/20/0	98/0/2	27/61/12	3.6	Logs, beaver dams	1.2	0.25	0.00	0.01
7	Wetland	DM	DM	DM	DM	DM	DM	DM	DM
8	81/18/1	98/2/0	35/45/20	2.5	Debris jam,logs	15.8	1.06	0.12	0.12
9	Wetland	DM*	DM*	DM*	DM*	DM*	DM*	DM*	DM*
10	77/23/0	90/1/9	57/36/7	2.3	Debris jams, logs	26.3	0.50	0.20	0.14

Segment	**Riparian zone characteristics**			**Substrate characteristics**		
	Average Canopy Closure (%)	Dominant vegetation and seral stage	Dominant Landuse	Percent Fines <0.85 mm and sample size	Dominant substrate	Percent of Total Substrate in Gravel Size Category
Tahuya 9	39	Deciduous Young	Woodlot	10.5 n=13	Gravel	79
Dewatto 2	70	Mixed Young	Woodlot	20.5 n=12	Cobble	15
3	78	Mixed Young	Timber Lands	N/A	Cobble	31
4	DM*	DM*	DM*	DM*	DM*	DM*
5	88	Deciduous Young	Woodlot	N/A	Sand	43
6	40	Deciduous Young	Woodlot	N/A	Gravel	59
7	DM*	DM*	DM*	DM*	DM*	DM*
8	94	Deciduous Young	Timber Lands	N/A	Sand	39
9	DM*	DM*	DM*	DM*	DM*	DM*
10	75	Deciduous Young	Timber Lands	N/A	Sand Gravel	38

* Data missing.

ii. Macroinvertebrate Population Condition

Sixty eight percent of taxa were EPT (Ephemeroptera, Plecoptera and Trichoptera). Fifty nine percent of all taxa were represented by the three most common taxa. The percent dominance and richness of the macroinvertebrate community are shown by sampling site in Fibure 3. The three sampling sites on the Tahuya River at RM 4.1 represented three different sites over a short (100-200 m) distance.



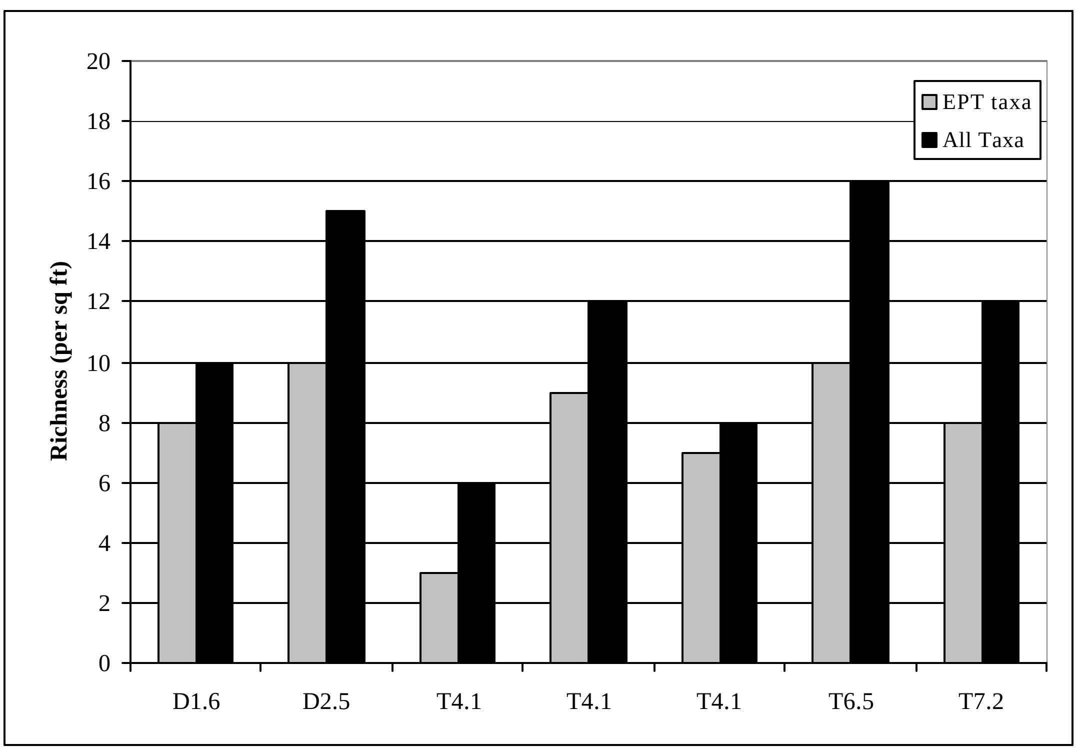


Figure 3. Tahuya and Dewatto River macroinvertebrate community richness (EPT is Ephemeroptera, Plecoptera and Trichoptera) and percent dominance of the three most common

taxa. On the x-axis, the letter is the stream Name and the number is the River Mile of the sampling site.

iii. Temperature Conditions by Segment

The Tahuya River had consistently high temperatures, relative to the other three streams (Table 21). Sites 2a, 3a, and 4a exceeded State standards for about half the days sampled. All sites exceeded the preferred temperature range, and four of the five sites exceeded it on all days sampled (Appendix G).

Table 21: Summary of temperature survey information for Tahuya and Dewatto River. Water temperature was sampled continuously during the sampling period. Thermographs for each sampling site are located in Appendix F.

Stream/ sampling site	Sampling dates	Number of days sampled	River Mile (approx.)	Lower elevation (ft)	Canopy closure (%) for 600m above sampling site	Dominant vegetation type and seral stage	Exceed max preferred rearing temperature (14°C), and number of days	Exceed AA water quality (16.3°C) standards, and number of days
Dewatto D1a	8/2/94-9/1/94	31	1.5	60	59	Mixed Mature	Yes-27 days	Yes-1 day
Dewatto D2a	8/5/94-8/24/94	20	2.5	100	72	Mixed Mature	Yes-20 days	Yes-4 days
Dewatto D3a	7/31/95-8/27/95	29	0.6	20	N/A	N/A	Yes-29 days	Yes-4 days
Dewatto D4a	7/31/95-8/27/95	29	1.9	80	N/A	N/A	Yes-27 days	Yes-4 days
Little Tahuya T1a	7/1/94-8/2/94	33	0.1	?	78	Young Conifer	Yes-10 days	No
Tahuya T2a	7/1/94-8/2/94	33	4.3	120	37	Young Deciduous	Yes-33 days	Yes-15 days
Tahuya T3a	7/18/94-8/2/94	16	5.8	?	50	Young Mixed-Deciduous	Yes-16 days	Yes-16 days
Tahuya T4a	7/31/95-8/27/95	28	1	20	N/A	N/A	Yes-28 days	Yes-14 days
Tahuya T5a	7/31/95-8/27/95	28	2.3	20	N/A	N/A	Yes-28 days	Yes-5 days

iv. Habitat quality rating

Ratings for habitat quality of Tahuya River and the Dewatto River are shown in Table 22.

Table 22. Habitat quality ratings fo the Tahuya and Dewatto rivers.

Segment Characteristics			Pool Quality		LWD Quality		Riparian Quality		Substrate Quality	
Stream/ Segment	Avg Bankfull Width (m)	Segment Gradient Class	Percent Pool Rating	Pool Frequency Rating	Key Pieces/ channel width Rating	In-channel LWD persistence	LWD Recruitment Potential from Riparian Zone	Canopy Closure Rating	Gravel Quality Rating	Available Spawning Habitat
Tahuya 9	13.0	<1%	Good	Fair	Poor	Fair-good	Poor	Poor	Good	Good
Dewatto 2	11.4	<1%	Poor	Fair	Poor	Good	Poor	Poor	Poor	Poor
3	13.7	<1%	Poor	Poor	Poor	Good	Poor	Poor	N/A	Poor
5	7.8	<1%	Good	Fair	Poor	Good	Poor	Poor	N/A	Fair
6	8.7	<1%	Good	Fair	Poor	Poor	Poor	Poor	N/A	Fair

8	6.4	<1%	Good	Fair	Poor	Fair	Poor	Poor	N/A	Poor
10	7.8	<1%	Good	Fair	Fair	Fair	Poor	Poor	N/A	Poor

b. Dewatto River

i. Habitat conditions by segment

Segment 2 and 3 had abundant riffles low percent pools (35 and 38%) in primarily a single thread channel (Table 20). Residual pool depths in segment 2 were shallow for a river of this size (57% < 0.5m), LWD loading low, with no large “key piece” LWD present. In segment 3, pools were less frequent that segment 2 (5.3 CW/pool), but with a greater residual depth (67% of pools 0.5-1.0 m in depth). Individual LWD pieces were present at moderate levels in segment 3 (1.27 pieces/CW), however many pieces were unstable (53%), and no logjams were present. Large woody debris and live trees formed the few pools found in either segment. Large woody debris was mostly moderately decayed conifer (Appendix B). The riparian zone for both segments was young with mixed conifer and deciduous species composition (Table 20). Cobble was the dominant substrate size, and percent fines were high at 20.5% on segment 2.

Segment 5 and 6 had a high percentage of surface area in pools (82 and 80%, Table 20). Sixty-seven and 73% of pools were greater than 0.5 m in depth. The lower 400m of segment 5 was a transitional zone of continuous trench pool from the segment 4 wetland. Pools were formed by live trees in segment 5, and LWD and beaver dams in segment 6. Segment 6 contained a long side channel (>68m), heavily utilized by juvenile salmonids, flowing out of the wetland in segment 7. Large woody debris and key pieces were more frequent in segment 5 than segments 2, 3, and 6. Large woody debris was at very low levels in segment 6. Most LWD was moderately decayed conifer in segment 5 and rotten-unknown or deciduous in segment 6 (Appendix B). Canopy closure was 40% for segment 6(Table 20) reflecting a young, deciduous dominated riparian zone interspersed with wetlands. Beaver ponds were common in segment 6. Segment 5 had a sand/gravel substrate, and segment 6 a gravel/sand substrate.

Like segments 5 and 6, most of the channel surface area in segments 8 and 10 was also pools (81 and 77%, Table 20). Pools were frequent for both segments, and mostly formed by LWD. Segment 10 had relatively extensive side channels, but fewer deep pools (>1.0 m) than all other segments on the Dewatto. Segments 8 and 10 contained moderately abundant levels of LWD, logjams and key pieces. Most LWD pieces were stable (79 and 73%), however most were also rotten conifer (60 and 56%, Appedix B). The canopy was closed for segment 8 (94% closure), and more open in segment 10 (75% closure). Riparian forests were young and deciduous dominated. Sand/gravel was the most common substrate.

ii. Macroinvertebrate population condition

Seventy three percent of taxa were of the EPT (Ephemeropta, Plecoptera and Trichoptera). Forty nine percent of all taxa were represented by the three most common taxa. The percent dominance and richness of the macroinvertebrate community are shown by sampling site in Fibure 3. Note that both sample sites were downstream of the habitat assessment segments.

iii. Temperature Conditions by Segment

The Dewatto River exceeded State AA standards (16.3^{o}C) for portions of only a handful of days (Table 21). However, site D2a exceeded the preferred rearing temperature range of 14^{o}C during the entire sampling period (both night and day). The other sites exceeded the preferred range during most daylight hours (Appendix G).

DISCUSSION

A. Habitat Function and Watershed Dynamics

The ability of salmon populations to survive and reproduce is dependent upon survival at each of the major life history stages (spawning, incubation, rearing, migration in freshwater, and migration and rearing in the marine environment) and the conditions encountered in each of these phases. Habitat conditions vary in time (seasonally, annually) and space (relative position within the watershed) in a dynamic system. Under natural conditions disturbances such as floods, fire, wind storms and landslides provide episodic inputs of wood, water, and sediment; processes critical for maintaining watershed health (Naiman et al, 1992). Salmonids have co-evolved in these conditions, developing life history "strategies" or patterns of utilization, which seek to maximize habitat productivity and minimize the risk of extinction (McHenry et al. 1996b). Strategies unique to each salmon species have also evolved to minimize competition between species.

A variety of habitat features are required for survival at each freshwater stage with some variability based on the particular habitat preference of different species. Sufficient instream flow, adequate holding pools to allow resting and avoidance of predators for upstream passage, and clear passage between areas of concentrated use are required for successful migration between saltwater and freshwater. Spawning success is related to the quantity and quality of riffle habitat with suitable sized substrate, stream temperature, and sufficient stream flow. Summer rearing is largely dependent on the availability and quality of pool habitat, maintenance of stream temperature within a preferred range, and the distribution of a variety of habitat types. Features affecting winter rearing include distribution of large woody debris providing cover; refuge from extreme stream flows provided by certain habitat types such as off-channel areas; and distribution and quality of pool habitat, especially those providing sufficient depth to escape high stream velocities.

Habitat features and processes are hydrologically linked within a watershed in a complex set of interactions. For example, coho production (and to a lesser extent, that of other species) is related to the amount of available pool habitat, with preference for different pool types varying by age class (Bisson and Sedell 1984). Pool quality has been linked to the volume, longevity, and position of large woody debris within a stream channel (Bilby and Ward 1989; Ralph et al. 1993; Grette 1985). Large woody debris volume is in turn dependent on recruitment of wood from the adjacent riparian forest, with the stability and longevity of wood recruited to the channel determined by the species composition of the riparian forest. Grette (1985) found that coniferous large woody debris persists in a stream channel for up to 200 years in comparison with deciduous species that decay much more rapidly. The position of wood within the channel is linked to large-scale processes such as stream hydrology and channel morphology.

Land management activities tend to reduce habitat complexity and simplify channels by directly altering or obliterating habitat (diking, culverts, channelization, construction of impervious surfaces) or on broader scale, altering watershed processes (recruitment of large woody debris, sediment production and transport rates, hydrology, nutrient cycling). Disturbances caused by land management activities occur at a rate and magnitude that can overwhelm the natural resiliency of the system. This in turn reduces the genetic fitness and reproductive success of aquatic organisms by eliminating or reducing certain life history strategies or causing shifts in fish communities (Bisson et al. 1992). For example, one of the most common and persistent impacts to Pacific Northwest streams has been the large scale removal of LWD from stream channels for navigation improvement, to aid water based log transport, and to promote fish passage (Sedell and Luchessa 1982). Long-term studies have shown a concurrent reduction in pool frequency and volume and an associated decline in fish abundance and species diversity (Bisson et al. 1987, Bisson and Sedell 1984, Hartman and Scrivener, 1990).

The degradation and loss of habitat functions and of watershed dynamics negatively impacts salmonids. Following is a discussion of the current habitat conditions and how they affect the salmonid freshwater life history stages within the watersheds of this study's planning areas.

B. Dungeness Watershed Planning Area

1. Siebert Creek

a. Migration Conditions

A culvert at Highway 101 may hinder or prevent upstream movement of adults during low flow periods and downstream movement of juvenile salmonids although the degree of impairment is unknown. The crossing is a box culvert with a fish way and baffles within the culvert; maintenance is key to ensuring favorable conditions for fish passage. The highway was recently expanded to four lanes, the two new east-bound lanes now have a bridge (built 1999), but the culvert remains in the westbound lanes with no immediate plans for removal. This stream crossing also demonstrates processes typically seen with constrictions of the channels and alteration of stream hydrology. During high winter flows the culvert is unable to pass the increased streamflow, causing water to dam up or backwater upstream of the culvert, sediment bedload to be deposited in gravel bars, and aggradation of the main channel. These processes destabilize the reach by causing horizontal instability in the channel and reducing habitat suitability. Downstream of Highway 101, the Old Olympic Highway had a culvert crossing consisting of two parallel culverts with outlet of one of the culverts dropping 15 to 17 feet onto riprap; fish passing through this culvert were subjected to increased mortality (R. Johnson, personal communication). The culvert was replaced with a bridge in 1998.

b. Spawning and Incubation Conditions

Spawning habitat is affected by the relative scarcity of spawning gravels and the diminished quality of areas currently available. Siebert Creek is reported to have experienced a number of road failures in the upper watershed; this factor compounded with bank cutting explains the high levels of fine sediment which are transported and deposited in downstream, lower gradient reaches. The degradation of spawning and incubation habitat is probably partially responsible for the reduction in chum and coho populations in Siebert Creek since chum and coho use low gradient riffles and tailouts for spawning activity.

c. Summer and Winter Rearing Conditions

Low wood volume and logjam frequency in segments 1-2, along with high percentages of cascades result in low abundance and diminished quality of pool habitat. As a result, the quantity of summer rearing habitat and the quality winter rearing conditions for juvenile coho are low, and may favor cutthroat and steelhead (Table 10). McHenry (1992) reported low overall densities of juvenile fish (0.22 fish per m^2), with 82% of the fish observed being riffle-dependent species such as steelhead and cutthroat trout in lower Siebert Creek. Macroinvertebrate communities were diverse, however overall community richness was lower than surveys for the upper Elwha River and Hoh River (McHenry 1991, Munn et al. 1996).

Water temperatures were generally within State AA standards (16.3°C). Water temperatures for segments 1-3 exceeded the preferred temperature range for salmonids for several hours of about 1/3 of the days sampled. Data on riparian composition was not collected for segments 1-2, so its impact on stream temperatures is not known. The lack of wood and resulting shallow residual pool depth could in part account for these temperatures. A pool with relatively shallow depth that is exposed to the sun would maintain a higher average temperature that a deeper pool at the same site.

In segment 3, future LWD recruitment potential is poor. Modeling of LWD levels following timber harvest has shown that recruitment of wood from a second growth forest is usually not significant until 50 to 60 years (Grette 1985), causing a net loss of habitat diversity in this time period. The absence of large diameter "key" pieces or the potential to recruit this wood from the riparian zone causes increased mobility and instability of existing wood, resulting in pieces located outside of the active channel or oriented parallel with the channel margin (Ralph et al. 1993). Habitat complexity, especially the development of channel margin habitat, floodplains and other habitat types important for juvenile fish, is reduced when large woody debris has limited contact with the active channel. McHenry (1992) attributed the lack of wood in Siebert Creek to past management practices that included cedar salvage, riparian logging, and stream cleanout.

Recent trends in land use conversions in lower Siebert Creek and increasing water demands may continue to reduce the most potentially productive portions of the stream and favor shifts toward steelhead and cutthroat populations.

2. McDonald Creek

a. Migration Conditions

Migration habitat in Segments 4 and 5 does not appear to be limited except by the absence of cover.

b. Spawning and Incubation Conditions

Spawning conditions in Segments 1-3 are rated as fair due to their relative abundance of gravel with high levels of fine sediment. Spawning habitats in Segments 4 and 5 appear to be limited by the availability of suitable substrate, with bedrock and boulders comprising the dominant substrate. Spawning habitat in Segment 6 also appears to be more favorable although the ability of fish to utilize this area may be limited by conditions in downstream reaches and flow characteristics.

c. Summer and Winter Rearing Conditions

Summer rearing conditions are limited by a lack of pool habitat in Segments 1 through 3, relatively high summer water temperatures, and the lack of large woody debris and structural diversity. Conditions appear to be worse in Segment 1 where all parameters were rated as poor. Macroinvertebrate community diversity was low between RM 2.1 and 3.9, much lower than upstream and downstream sites and on other rivers (McHenry 1991, Munn et al. 1996). At RM 2.0, stream temperatures may be consistently high enough to cause movement out of the reach and into other areas, thereby decreasing rearing area (Table 11). In Idaho, salmon and trout stayed in their rearing reach even if temperatures reached 24°C as long as daily minimums were 8-12°C. When temperature reached the same maximum, but with 15-16°C daily minimums, they migrated to colder reaches (Bjornn and Reiser 1991). In addition, substantial areas of streambank mass wasting are occurring in Segment 1 below Highway 101 where runoff from homes atop the ravine has been routed onto unstable ravine walls. Attempts to direct the stream away from these areas by using riprap have further disrupted the channel and reduced rearing habitat. Due to the lack of side channel habitats and large woody debris, winter rearing conditions are not favorable in these segments, with the exception of Segment 2, which was rated as fair.

The higher average channel gradient of Segments 4 and 5 diminishes the rearing potential for species such as coho and chum salmon, but represent a higher likelihood of supporting steelhead and cutthroat trout. Steelhead and cutthroat trout are less dependent on pool habitat for summer and winter rearing, instead seeking shelter from winter flows in rock crevice or beneath large substrate material (McMahon and Hartman 1989) and habitats with abundant cover (Grette 1985). Steelhead and cutthroat trout are most often associated with smaller pools for summer rearing.

Rearing conditions for Segments 4 and 5 is rated as good based on availability of pool habitat, but fair based on the pool frequency rating. Due to the low levels of large woody debris and the steeper channel gradient, bedrock and boulders primarily form pools. The large woody debris present tends to be in moderate or rotten condition, with a fairly high percentage (27%) constituting deciduous species (Table10, Appendix B). The low recruitment potential from the riparian zone indicates a situation that will only worsen as the existing wood continues to decay for Segment 5. The role of LWD in sediment storage and stream energy dissipation in smaller streams has been well documented (Bilby 1984, Bisson et al. 1987, Grant et al. 1990). Poor wood stability, and lack of key pieces in these reaches may be a causal factor for the absence and/or shallowness of pools in downstream segments due to increased sediment transport. Habitat conditions in Segment 6 are similar to those described for Segment 3. Wood volume over the long term will decline as the riparian forest will not provide adequate wood.

C. Discovery Bay Watershed Planning Area

1. Salmon Creek

a. Migration Conditions

Washington Department of Fish and Wildlife operated a weir just above the starting point of the habitat survey, at RM 0.25. Originally, upstream migrating adults and smolts migrating downstream were diverted, counted and then passed through. The facility is not currently used for fish counting; however, it is used to collect brood stock for a summer chum supplementation program. Fish passage is not limited by the weir or its operation. Few holding pools (>0.5m in depth) in segments 2 3, or 5 were found for migrating adults, which may lead to increased mortality from predation. Minimal forest cover on segment 2 below Uncas Road, is due to agricultural fields covering a large portion of the riparian zone.

b. Spawning and Incubation Conditions

Spawning and incubating conditions are considered fair in segment 2 with relatively abundant gravel and fine sediment. Studies have shown that elevated levels of fine sediment in spawning gravels causes increased mortality of eggs within a redd (salmon nest) by reducing or eliminating oxygen exchange, allowing accumulation of toxic metabolic by-products, or entombment of emerging fry (Chapman 1988, Everest et al. 1987, Iwamoto et al. 1978). Segment 2 is the primary spawning segment for summer chum. Segment 3 is confined with a higher gradient and abundant cascades. Spawning opportunities are limited with relatively low percentage of gravel and abundant bedrock outcrops. Cutthroat and steelhead most likely favor this segment. Segment 5 has abundant gravel, and is utilized by coho, steelhead and cutthroat.

c. Summer and Winter Rearing Conditions

Historically, disturbances were relatively infrequent in Salmon Creek watershed, although frequent enough to minimize the development of old growth forests. Natural wildfires occurred in 1308 AD, 1508, and 1701, each time creating in the following decade a "pulse" of LWD and sediment input into the channel (Ricketts et al. 1996). Most likely the channel was already rich in large diameter LWD, maintaining good salmon habitat during these periods following a wildfire disturbance. Human induced and natural fire disturbances increased between 1890 and 1940 to 14 events with a large, and most likely logging related, fire occurring in 1924. More importantly, much of the watershed was railroad logged in the 1920's, with logging resuming in the 1980's and 1990's. As a result of human management, the frequency of disturbances rapidly increased over the past century. As of 1996, Salmon Creek watershed had the following forest age class distribution (31% < 20 years, 46% 21-80 years, 18% 81-170 years, and 5% > 170 years, Ricketts et al. 1996). From an ecological perspective (Spies and Franklin 1991), 77% of the watershed was composed of young forests.

Rearing habitat conditions in Salmon Creek reflect the basin management of agriculture and recent forest harvest. The habitat is in poor to fair condition with shallow and infrequent pools in segments 2 and 5. The poor to fair rating for LWD recruitment potential from the riparian zone of segment 2 and 5 (Table 14) indicates that habitat will continue to degrade in future decades. The exception is the relatively short segment 3 (370 m) with its mixed mature conifer-deciduous riparian forest. The portion of the channel comprising segment 2 is mostly agricultural with no riparian forest, or a narrow riparian zone dominated by deciduous species (Bernthal et al. 1999). Segment 5 has mature deciduous species, which over the short-term can provide LWD, but tend to decay rapidly and are generally less stable (Bilby 1984, Grette 1985). Without stream restoration and creation of stable (conifer) LWD jams, the habitat for the next 50 to 100 years is likely to continue to degrade until a mixed species or conifer dominated riparian forest reaches a large average diameter (Grette 1985). This assumes a riparian forest would be planted in the near future along the unforested portions of segment 2. The majority of LWD in segment 5 is already rotten, its persistence considered fair to poor. Both segment 2 and 5 have a high potential for habitat recovery, given the low channel gradient and a channel that is moderately confined to unconfined.

D. Quilcene Bay Watershed Planning Area

1. Little Quilcene River

a. Migration Conditions

No physical barriers are found within the lower 5.2 miles. At one time the water diversion dam at RM 6.6 was a fish passage barrier, but it recently was retrofitted to pass salmon (I. Jablonski, personal communication). The city of Port Townsend draws water from their diversion at RM 6.6, however stream water is not withdrawn during summer low flow periods (Bob Wheeler, Port Townsend Department of Public Works).

b. Spawning and Incubation Conditions

With the exception of the tidally influenced segment 1, the substrate of segments 2 to 5 are mostly gravel and contain adequate spawning habitat (Table 17). Historical landuse information for the Little Quilcene River is sparse. Most low-elevation, mature to old growth forests in Hood Canal were logged between 1880 and 1940 (Amato 1996). In the early 1900's, the Otto Beck Logging Co. harvested cedar stands between the Big and Little Quilcene (what is now the town of Quilcene) and within the riparian zones of each river. By the 1930's, most of the Little Quilcene had been harvested (Amato 1996). A 1932 survey of the watershed noted many logjams (likely composed of logging slash) and six areas of beaver activity (WDF 1932). Starting in 1951 (and for the next 20 years) the Stream Improvement Division of Washington Department of Fisheries removed LWD, beaver dams, and other structures perceived to pose migration barriers (Amato 1996). Williams (1975) noted the channel was stable, except where channelization occurred below RM 0.9. The channel continues to be unstable today below RM 0.9, especially near the river mouth (R. Johnson, personal communication). Segments 2-5 are composed mostly of gravel, with some sand. Large woody debris removal has profoundly and negatively impacted fish habitat and channel stability throughout Hood Canal (Amato 1996, Bernthal et al. 1999). Given the low LWD levels (see below) scour chain studies are now needed to determine if bed instability is a mortality factor.

c. Summer and Winter Rearing Conditions

The Little Quilcene is degraded to a greater extent than other watersheds we surveyed. Pools were infrequent and occupied a lower percentage of the channel than in other watersheds (Tables 10, 14, 17, 20). Williams et al. (1975) described the channel below RM 6.6 as containing few pools. Habitat quality ratings are generally fair to poor (Table 18). As described above, the lower watershed has a long history of riparian forest harvest. LWD recruitment from the riparian forest was not assessed, but from other surveys (Bernthal et al. 1999), the riparian zone below RM 3.0 is dominated by young deciduous or deciduous/conifer forest, which has a poor to fair recruitment potential. Segments 1 to 3 have agriculture or residential landuse within the riparian zone (Table 17). It appears the channel and riparian forest is not recovering from historical logging and more recent land conversion. Given its low gradient and unconfined valley morphology, channel restoration in terms of LWD jam placement should provide short-term improvement, with long term recovery possible through riparian reforestation (where possible) or conversion to conifer dominated forests.

2. Howe Creek

a. Migration Conditions

Segment 1 is relatively steep, and a barrier to chum (Table 16). This segment is not a barrier to coho, steelhead, or cutthroat. No other barriers were found in segments 2-7.

b. Spawning and Incubation Conditions

Spawning grounds suitable for coho were scarce and concentrated to segment 6. Good spawning potential for cutthroat was found in segments 1 and 7. Over the short term, bed stability may be an issue given the rotten condition of LWD for all three segments. Segments 2 and 4 had high levels of sand relative to gravel.

c. Summer and Winter Rearing Conditions

Segment 3 and 5 are wetlands and would provide winter rearing opportunities, especially for coho (Table 16). Overall, Howe Creek had greater abundance of LWD than other watersheds we surveyed. However, key pieces were abundant, which reflects the absence of deep pools >1m (Table 17). LWD recruitment potential for all of the segments is fair to poor. In segments 6 and 7 the stream is dry during summer low flow limiting rearing to downstream segments. Temperature may be an issue in segments 2 and 4. Segment 4 had low canopy closure, and both segments were just downstream of wetlands that potentially contributed to the higher temperatures. In Big Beef Creek watershed, for example, temperature impacts from water warmed in Lake Symington (to >20°C), extended down the Creek for about ½ to 1 mile below the lake (PNPTC 1997 temperature monitoring data).

3. Ripley Creek

a. Migration Conditions

No barriers were found through the survey reaches.

b. Spawning and Incubation Conditions

Spawning conditions were rated as fair with gravel reaches interspersed between bedrock outcrops and cascades. Most LWD was stable, but rotten. The relative impact of bed scour or fines (<0.85mm) is unknown.

c. Summer and Winter Rearing Conditions

Similar to Howe Creek, LWD abundance was markedly greater than in the Little Quilcene. It appears that the WDF Stream Improvement Division did not clear LWD from these two streams as was done on Little Quilcene River. The pattern of low key piece abundance and the lack of deep pools >1m also followed that of Howe Creek. While Ripley Creek has poor to fair habitat conditions in terms of pool and LWD key piece abundance, the likelihood of LWD recruitment in the near term is good with a fully forested mixed/mature riparian zone.

4. Big Quilcene River

a. Migration Conditions

Adult passage is limited in two areas. First is the physical barrier at RM 2.8, second is the fish access problem during summer low flow in the lower river. The latter problem is due to a combination of channel aggradation, past channel manipulation and diking, water withdrawal, and low levels of LWD. The City of Port Townsend withdraws water at RM 9.4. The Quilcene National Fish Hatchery has an electric weir at RM 2.8 which blocks all fish passage between September and January. In addition, the hatchery withdraws river water at about RM 3.4 and returns it to the channel at RM 2.8. The portion of the channel between the water intake and outlet can be de-watered during summer low flow. This was the case during this survey; segment 4 was not assessed for this reason.

b. Spawning and Incubation Conditions

Until the mid 1950's, the Big Quilcene watershed was recovering from several rounds of riparian forest harvest. Below RM 2.8, the riparian zone was intact, the channel a single thread, and pools and LWD abundant (R. Johnson personal communication and 1957 aerial photos analysis). Since the early 1970's, below RM 2.8, the channel has aggraded, widened and become unstable. Forest Service roads failed and introduced a large amount of gravel into the system. A large portion of the riparian forest on the north side of the channel (below RM 2.8) was harvested or lost to the migrating channel. Large woody debris was removed by the Stream Improvement Division and by local landowners (Amato 1996). A dike was built and the channel straightened (in the early 1970's) downstream of the Hwy 101 bridge that caused nearly immediate instability (R. Johnson, personal communication). The dikes below RM 0.8 have been in place for many decades. However, LWD volume is low and LWD large enough to be key piece size are rare (Table 17). All these factors have added to the channel instability downstream of the hatchery. In the Dungeness, bed scour occurred below redd depth when redds were located near dikes indicating some level of impact on salmon egg survival (M. Reed, personal communication). Similar negative effects may be occurring in the Big Quilcene River. Scour chain studies to assess bed instability are being planned. The Big Quilcene Flood Management Plan (Jeffco 1998) calls for channel restoration and dike removal to return the channel and floodplain to a functional and relatively stable state.

c. Summer and Winter Rearing Conditions

Similar to the Little Quilcene, the Big Quilcene has few pools and low levels of LWD (Table 17). Channel manipulations have frequently occurred, many times to the detriment of habitat. In 1957, the WDF Stream Improvement Division diked and isolated several side channels below the hatchery (Amato 1996). In 1970, a small tributary was blocked from channelization activities (WDF 1970). Additional diking and channelization just below the Hwy 101 bridge are described above. Below RM 0.8, the bed has been dredged many times over the years, most recently in 1993. In 1995, a portion of the northern dike was removed, thereby allowing floodwaters and sediment to be distributed across the floodplain. With restoration and dike removal, the potential for channel recovery still exists. About half of the riparian forest below RM 5.0 is mature and mixed conifer/deciduous or conifer dominated (Bernthal et al. 1999).

E. Lower Hood Canal Watershed Planning Area

1. Tahuya River

a. Migration Conditions

No barriers are found between the surveyed segment and the river mouth. See below for a discussion of low flow conditions.

b. Spawning and Incubation Conditions

Percent fines (<0.85mm) were rated as good at 10.5% and spawning gravel was abundant. Rapid growth of retirement homes is occurring along the Tahuya River, and especially its tributaries. A unique feature of Kitsap peninsula watersheds is the large number of mainstem and tributary wetlands. The underlying geology of the Tahuya River downstream of Lake Tahuya is gravel. In the adjacent Seabeck aquifer, the majority of single family wells withdraw water from the same perched aquifer that recharges nearby wetlands and streamflow (PUD 1996). To protect instream flows, the Department of Ecology has closed the Tahuya to further surface water withdrawals between June 15 and October 15. In the Tahuya, a number of small tributaries go dry during summer low flow (Bernthal et al. 1999). A rapid increase in development within the basin is almost certain to occur. If current regulations are not changed regarding single family well exemption and development around wetlands and in the floodplain, there may be profound impacts to fish habitat, instream flow, and channel stability in the future.

c. Summer and Winter Rearing Conditions

In general, most habitat conditions are good or fair to good. Deep pools and percent pools are rated as good. Large woody debris volumes are certainly lower than historical conditions and key piece density is poor (Table 22). Most pools are formed by LWD; habitat conditions and bed stability would benefit with increased volumes of LWD. The WDF Stream Improvement Division in 1955, 1958, and 1962-1970 (Amato 1996) removed logjams throughout the Tahuya River. Other permitted (and nonpermitted) removals of LWD have also occurred (HPA database 1989-1995). Recruitment potential from the riparian forest and water temperature is poor. The channel is aggraded and widened in several areas throughout the survey reach, reducing the shade provided by streamside trees. In addition the riparian forest is young (trees are not at their mature height) and composed of a mixture of conifer and deciduous trees (Table 20). Large woody debris recruitment potential was rated poor, with LWD volumes decreasing over the next 50 years until the forest matures (Table 22). The Tahuya consistently exceeded the preferred rearing salmonid temperature range (Tables 8 and 21). The high temperatures may be the result of upstream land use that, for example, may involve riparian forest clearing and should be further investigated. Salmon seek cold water refugia when exposed to consistently high temperatures or when daily minimum temperatures exceed 15°C, reducing stream productivity and rearing area (Bjornn and Reiser 1991). While the habitat is currently in fair to good condition, habitat conditions will degrade until the riparian forest matures and reaches a functional size. As described above, the habitat will degrade even further unless steps are taken to ensure development does not significantly alter watershed processes.

2. Dewatto River

a. Migration Conditions

No barriers are found between the surveyed segment and the river mouth.

b. Spawning and Incubation Conditions

The same concerns regarding instream flow, described above for the Tahuya, also exist for the Dewatto. The basin is less developed than the Tahuya, but is also vulnerable to impacts from concentrated development. Segment 2 had 20.5% fines in a cobble/gravel substrate, creating poor conditions for incubating salmon. The sediment source is not known, however storage of sand in wetlands at segments 4, 7,and 9 is a possibility, as is logging in the basin. Sand and cobble are the dominant substrate, and with the exception of segment 6, gravel is subdominant. Availability of spawning gravel is fair. Spawning conditions with the cobble/gravel substrate in segments 2 and 3 favor steelhead.

c. Summer and Winter Rearing Conditions

Both summer and winter rearing conditions are good for coho given the extensive wetlands and beaver ponds (winter) in segments 4, 7, and 9, and good in-channel pool habitat (summer). Deep pools are not as common as in the Tahuya, but are greater than in other similar sized watersheds

(McDonald, Siebert, and Little Quilcene). The temperature site at RM 2.5 was consistently above the preferred rearing temperature, which may encourage movement of juvenile salmonids out of the reach to colder water areas. Riparian forest was young and composed of deciduous and mixed/conifer species. Large woody debris recruitment potential is poor. Large woody debris volumes will decrease over the next few decades until the surrounding forest matures enough to contribute LWD of sufficient size to function effectively in the channel. This basin is considered in recovery from past management, and the long-term future could be relatively bright. However, if future development, in this basin and in other areas of Kitsap peninsula, degrades watershed processes over the next few decades, then a reversal of the recovery could occur and the quality of the habitat may diminish.

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