Wild Salmon Policy - Strategy 2: Fish Habitat Status Report for the Conuma River Watershed

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LIST OF ACRONYMS / ABBREVIATIONS USED

AUC	**Area Under the Curve**
CU	**Conservation Unit**
CVRD	**Comox Valley Regional District**
CWAP	**Coastal Watershed Assessment Procedure**
DO	**Dissolved Oxygen**
EMNG	**Ministry of Energy, Mines, and Natural Gas**
FISS	**Fisheries Information Summary System**
FPC	**Forest Practices Code**
GIS	**Geographic Information Systems**
IT	**Impairment Temperature**
LRDW	**Land and Resources Data Warehouse**
LWD	**Large Woody Debris**
MAD	**Mean Annual Discharge**
MFLNRO	**Ministry of Forests, Lands, and Natural Resources Operations**
MOE	**Ministry of Environment**
NSWS	**Nootka Sound Watershed Society**
ppt	**Parts per Thousand**
PSCIS	**Provincial Stream Crossing Inventory System (PSCIS)**
PSF	**Pacific Salmon Foundation**
RPF	**Registered Professional Forester**
SIL	**Stream Inspection Log**
TFL	**Tree Farm Licence**
UOTR	**Upper Optimum Temperature Range**
VIHA	**Vancouver Island Health Authority**
WCA	**West Coast Aquatics**
WCVI	**West Coast Vancouver Island**
WFP	**Western Forest Products**
WSC	**Water Survey of Canada**
WSP	**Wild Salmon Policy**

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1.0 INTRODUCTION

Canada's Wild Salmon Policy (WSP) sets out a series of strategies which will serve to incorporate habitat and ecosystem considerations into salmon management, and to establish local processes for collaborative planning throughout British Columbia (Fisheries and Oceans Canada, 2005). Strategy 1 of the WSP involves the identification of salmon Conservation Units (CUs), which are defined in the WSP as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe" (Holtby and Ciruna, 2007). Strategy 2 of the WSP involves the assessment of habitat status, firstly in a synoptic habitat pressure analysis to inform landscape scale pressure indicators such as total land cover alteration, road density, riparian disturbance, etc., and secondly in an analyses of species and life cycle dependent habitats in the watershed. This strategy outlines a process for the identification of factors that are limiting production, high value habitats that require protection, and data gaps that require further monitoring. The assessment of habitat status will continue with the application of a monitoring framework using a selection of indicators and benchmarks, to identify changes in habitat condition over time (Stalberg et al, 2009).

Implementation of the WSP has been initiated throughout several regions along the west coast of Vancouver Island. The selection of high priority watersheds (Tahsis River, Leiner and Perry Rivers, Sucwoa River, Canton Creek, Conuma River and Tsowwin River) requiring habitat status assessments by the Nootka Sound Watershed Society (NSWS) represents the initiation of Strategy 2 of the WSP within Nootka Sound. The outcomes of these assessments is intended to facilitate the planning and prioritization of prescriptive measures to improve salmon habitats and populations, as well as identify data gaps and subsequent monitoring priorities on a watershed by watershed basis.

The following report presents a Strategy 2 habitat status assessment for the Conuma River watershed.

1.1 Objectives

This report is intended to identify the state and quantity of habitat factors that are potentially limiting fish production in the Conuma River, as well as key habitats (by life history stage) that require protection. Specific objectives of this report include:

- The documentation of existing habitat characteristics;
- A comparison to historical habitat characteristics, where information exists;
- Selection of habitat indicators and a comparison of assessed values to known risk benchmarks;
- Identification of data gaps requiring further monitoring; and
- Recommended enhancement activities within the study watersheds which would have both a direct and indirect effect on salmon species within the Conuma River watershed.

In addition to the abovementioned objectives, this work is also intended to feed into a future WSP expert-based risk assessment workshop whereby identified limiting factors will be ranked in order of spatial and temporal risk to fish and fish habitat on a watershed basis. This habitat status assessment of the Conuma River watershed follows the Tahsis River watershed example (deVisser and Wright, 2015), and has been completed concurrently with other high priority Nootka Sound watersheds including Leiner and Perry Rivers, Canton Creek, Tsowwin River and the Sucwoa River.

1.2 Conuma River Watershed

The Conuma River watershed is located approximately 100km west of Campbell River and 22km southeast of the Village of Tahsis on the west coast of Vancouver Island, and is one of the largest rivers draining into Nootka Sound (Figure 1) (Reid and Walsh, 2003). The Conuma River drains from Stevens Peak, and initially flows southeast before turning south and west into Moutcha Bay in Tlupana Inlet (Figure 1). The Conuma River watershed encompasses a drainage area of approximately 123km^2 (including the Leagh Creek and Norgate Creek sub-basins) and provides 7.21km of anadromous fish bearing mainstem and an additional inferred 13.89km of fish-accessible tributary stream length.

1.2.1 Climate, Topography, and Hydrology

The Conuma River watershed is situated primarily within the coastal western hemlock (very wet maritime) biogeoclimatic zone, with portions in the coastal western hemlock and mountain hemlock (moist maritime) and small portions of coastal mountain-heather alpine (undifferentiated and parkland) zones (Horel, 2008). This area has a mild oceanic climate with high humidity, with the majority of its annual precipitation received as rain. Mean annual precipitation recorded at the Conuma River Hatchery between 1989 and 2002 was 3720mm, and mean annual snow was 41.6cm (Horel, 2008). Heavy precipitation events are common between the months of October and April, with the maximum recorded 24-hour rainfall of 244mm and snowfall of 53.2cm (Horel, 2008). These values were recorded at low elevation, and mean annual precipitation likely reaches about 4000mm at higher elevations in the watershed (Horel, 2008).

Conuma River is a 5th order stream flowing from the foot of Stevens Peak, which is the highest point in the watershed at over 1600m (Noseworthy M. E., 2006). The upper valley above the Norgate Creek confluence, 10km upstream of the estuary, trends northwest-southeast and is wide and variable with irregular slopes and steep, nonalluvial, entrenched tributaries (Horel, 2008). Three upland lakes exist in the upper slopes, Leighton Lake (25ha) being the largest. The top of the Conuma mainstem branches into 3 headwater tributaries with some small alpine headwater lakes, flowing down from steep, high alpine terrain with common avalanche tracks and many active natural landslides (Horel, 2008). Natural and pre-code logging induced landslides are common in this upper section (Horel, 2008). The mainstem in the upper valley includes fully, semi, and non-alluvial reaches; alluvial reaches have widened and aggraded where logged on the northeast side of the channel (Horel, 2008). Although logging has resulted in sediment contribution to the Conuma River, that volume of sediment is considered to be less than that of inputs from natural landslides in the upper watershed (Horel, 2008).

Norgate Creek flows west into Conuma River near the mid-point of the Conuma River watershed (Horel, 2008). The v-shaped valley trends east-west with generally steep slopes. The channel within the lower 2.7km is a non-alluvial, entrenched gorge with high energy flows (Horel, 2008). The Norgate mainstem only has a small alluvial reach, and its tributary streams are generally nonalluvial with a few full and semi-alluvial reaches (Horel, 2008).

The mid-valley between 7-10km trends north-south and is comprised of a narrow irregular valley floor with irregular, steep slopes and some old natural slides (Horel, 2008). The mainstem in this section is semi-alluvial to non-alluvial, mostly confined with a small 0.8km alluvial section where the valley floor briefly widens – this reach has further widened and aggraded as a result of riparian logging on the east side (Horel, 2008).

Leagh Creek drains down from a 10ha headwater lake into the Conuma River approximately 1.8km upstream from Moutcha Bay (Horel, 2008). The V-shaped to narrow U-shaped valley has extensive steep slopes with an entrenched steep nonalluvial mainstem and tributary creeks (Horel, 2008). The fan at the outlet of Leagh Creek onto the Conuma valley floor is widened and aggraded as a result of riparian logging (Horel, 2008). Leagh Creek is the primary water supply for the Conuma River Hatchery (Noseworthy M. E., 2006). Of the 13 reaches in Leagh Creek, 10 are stable and non-erodible; two of the remaining are alluvial, aggraded channels impacted by past riparian harvesting, and the remaining reach is partially aggraded with unconfined banks (Noseworthy M. E., 2006). All three of the aforementioned, alluvial reaches are potentially susceptible to increased peak flows, sediment delivery and riparian vegetation removal (Noseworthy M. E., 2006).

The lower 7 km of the Conuma River watershed is characterized by an east-west trending valley with a broad floodplain. The steep north, bedrock slopes contain several natural active slides and steep tributary creeks (non-alluvial) (Horel, 2008). The south slope is mixed moderate to steep slopes with some upland ponds (Horel, 2008). The upper 2.4km of the valley is narrow and irregular with a confined to entrenched mainstem (semi to nonalluvial) – irregular slopes and floodplain provide runout zones along this portion of the mainstem (Horel, 2008). The lower 4.6km of floodplain is a mix of confined and partially confined alluvial mainstem, impacted by channel instability, widening and aggradation from historic riparian logging (Horel, 2008).

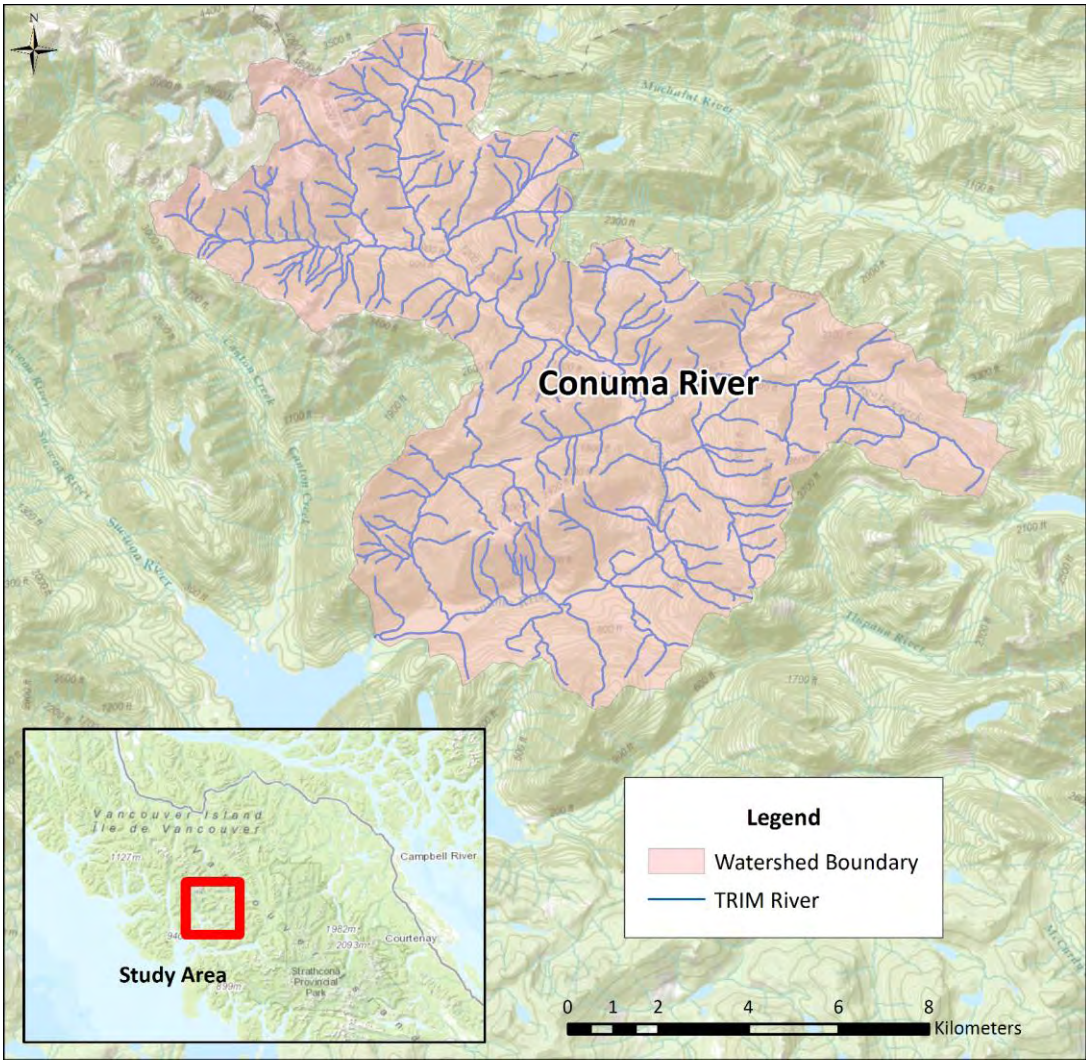

Figure 1. General location of the Conuma River watershed.

1.2.2 Watershed Description

The mainstem contains approximately 7.1km of low-gradient, fish-bearing stream length up to a series of falls and cascades, the first of which is a 5m high falls over bedrock. This first falls is considered the barrier to anadromous fish distribution (Hamilton, 2001 Nootka Sound Watershed Society, pers. comm., 2015). Resident freshwater trout are present upstream of the falls.

Although the 2005 CWAP assessment identified the watershed to be stable (Noseworthy M. E., 2006), an analysis of watershed indicators in 2008 identified the Conuma River watershed to be highly sensitive and highly disturbed, with a high to very high fish capacity (Horel, 2008).

The trend of the watershed was defined as moderately disturbed or improving; however, the Conuma watershed is still of concern due to the alluvial channel instabilities that have resulted from riparian logging. Additionally, the watershed is considered sensitive due to the regional landslide frequency, steep terrain (i.e. approximately 53% of the watershed area has slopes >60%), occurrence of natural landslides, and hillslope connectivity to the mainstem and channel sensitivity (Horel, 2008). Based on watershed sensitivity, trend and fish rank, Horel (2008) selected the Conuma River watershed as one of five priority watersheds for restoration. It was estimated that the condition of the watershed would improve to the next trend category (e.g., improving, may have sites that are still disturbed) in 30 years (Horel, 2008); however, it was noted that there may be potential to accelerate recovery with riparian treatments to encourage conifer growth, subject to a riparian assessment and feasibility study. Sensitive areas identified by Horel (2008) included the alluvial reaches of the mainstem, the floodplain, tributary fans, and the estuary.

A number of mainstem and tributary reaches have been noted as being partially to moderately aggraded, many of which underwent riparian harvesting and, as of 2006, were in the pole sapling state (Noseworthy M. E., 2006). Although riparian recovery is helping to improve channel stability, the aggraded alluvial sections remain susceptible to bank erosion and channel avulsions (Noseworthy M. , 2006). In 2003, the reach near the hatchery (immediately upstream of the delta) appeared to be aggrading, as this is a depositional area for gravels and cobbles (Reid and Walsh, 2003). Additionally, the mainstem near the location of the Conuma side channel had large bars which crested above the top of the stream banks, showing evidence of over-topping and the erosion of sever small side channels – lateral instability above the delta was a concern for the proposed side channel in 2003 (Reid and Walsh, 2003).

For the purpose of analysis in this assessment, the Conuma River was divided into 12 reaches. Reach breaks were adapted from Hamilton, 2001 (Figure 2).

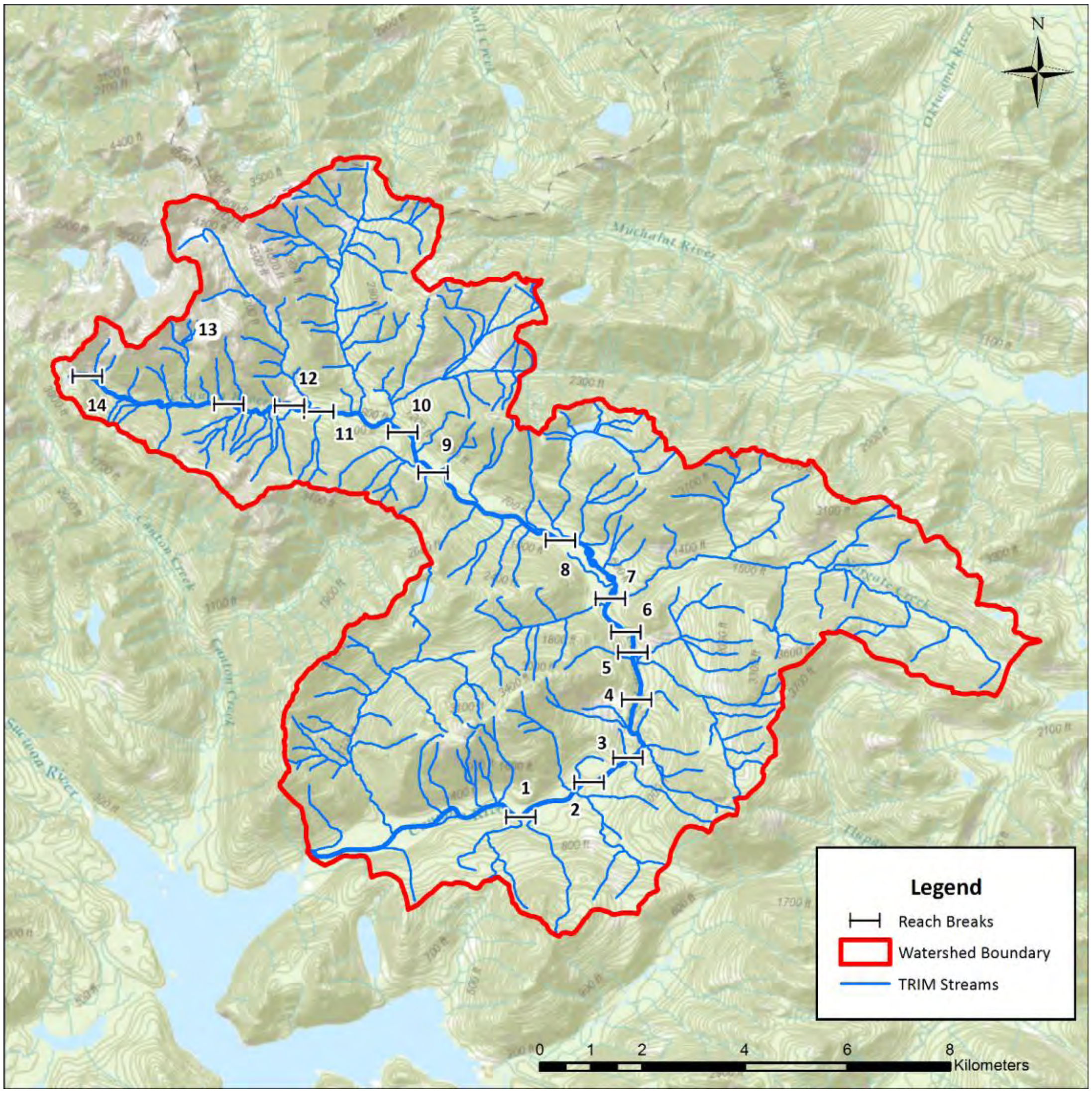

Figure 2. Conuma River reach breaks. Adapted from Hamilton, 2001.

The following table describes the average bankful widths (as determined from 2013 orthophotography) for reaches 1 to 12 of the Conuma River.

Table 1: Reach lengths and average bankful widths for the Conuma River.

Reach Number	Reach Length (km)	Average Bankful Width (m)
1 (CS1 – 9)	4.83	73.5
2 (CS 10 - 12)	1.54	34.9
3 (Canyon below bridge)	1.01	19.5
4 (Canyon to top of falls)	1.51	27.7
5 (Above anadromous barrier)	0.97	32.6
6 (Above anadromous barrier)	0.49	17.7
7 (Above anadromous barrier)	0.91	40.7
8 (Above anadromous barrier)	1.83	66.8
9 (Above anadromous barrier)	3.28	29.0
10 (Above anadromous barrier)	1.14	13.6
11 (Above anadromous barrier)	1.94	19.4
12 (Above anadromous barrier)	0.67	34.1

1.2.3 Watershed History

The Conuma River resides within the traditional territory of the Mowachaht / Muchalaht First Nation, who have remained in this area for thousands of years. The area was first visited by British and Spanish explorers in the 1770s and 1780s, with homesteaders and hand loggers settling in Tahsis Inlet as early as 1882 (Sellars, 1992).

Resource Extraction

The forest land base in the Conuma River watershed is currently licensed for harvest under Tree Farm Licence (TFL) 19 (Horel, 2008). Aerial photographs show vegetation removal along the north side of the lower Conuma River by 1954; however, this was likely associated with installation of the hydro line between Gold River and Tahsis (Photo 1). According to Brown et al (1979), logging commenced in the watershed in 1970 and by 1977 most of the river was readily accessible by road. At this point, the road only extended up to the Norgate Creek confluence. By 1987, clearcuts are visible extending to the river's left edge near the midpoint of the watershed, and the road extends into the upper watershed (Photo 2). Logging progressed into the upper watershed with several clearcuts extending from the left bank up the northeast valley slope by 1996 (Photo 3). Before 1995 riparian harvesting was common practice; 11.2km of Conuma River riparian was logged, 1.9km of Norgate Creek and 0.2km of Leagh Creek, amounting to approximately 57% of the Conuma mainstem riparian (Noseworthy M. E., 2006). A 1999 DEL assessment did not identify any significant impact to channels as a result of riparian removal; only minor impacts on channel stability were identified in the lower reaches (Noseworthy M. E., 2006). This conclusion was not in agreement with Horel (2008), which stated that all of the alluvial reaches of the Conuma River have widened and area at risk of further erosion due to channel aggradation. Harvesting along the lower portion of Leagh Creek Reach 17 during the 1970s has resulted in moderate aggradation (Noseworthy M. E., 2006).

Photo 1. Vegetation removal associated with hydro line construction in the lower Conuma River watershed in 1954.

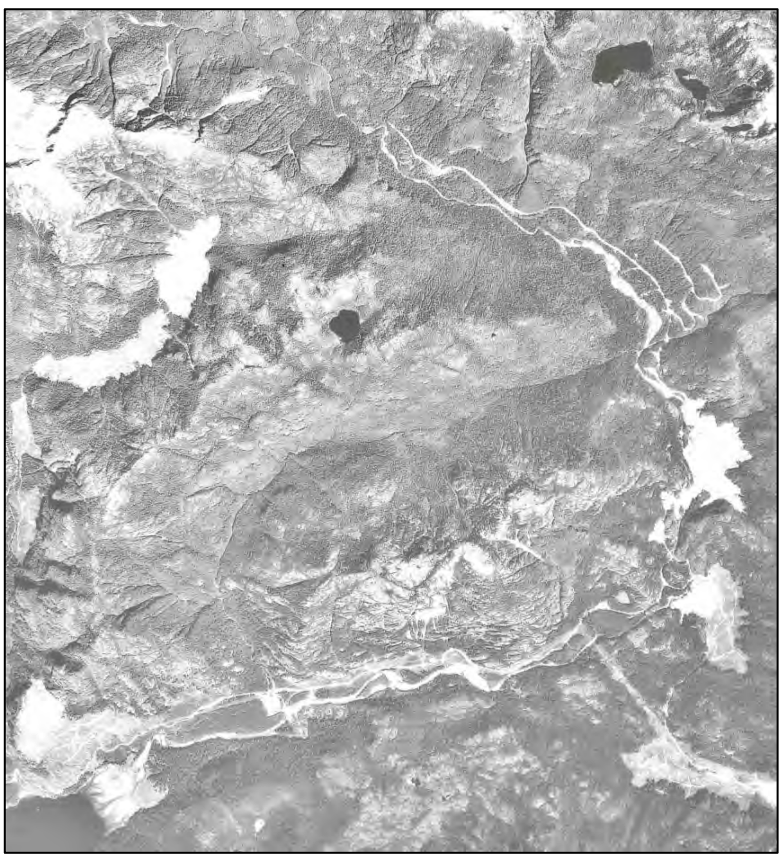

Photo 2. Continued logging activity in the Conuma River watershed in 1987. Note the large mid-watershed clearcuts extending into the riparian zone and the road extension into the upper watershed.

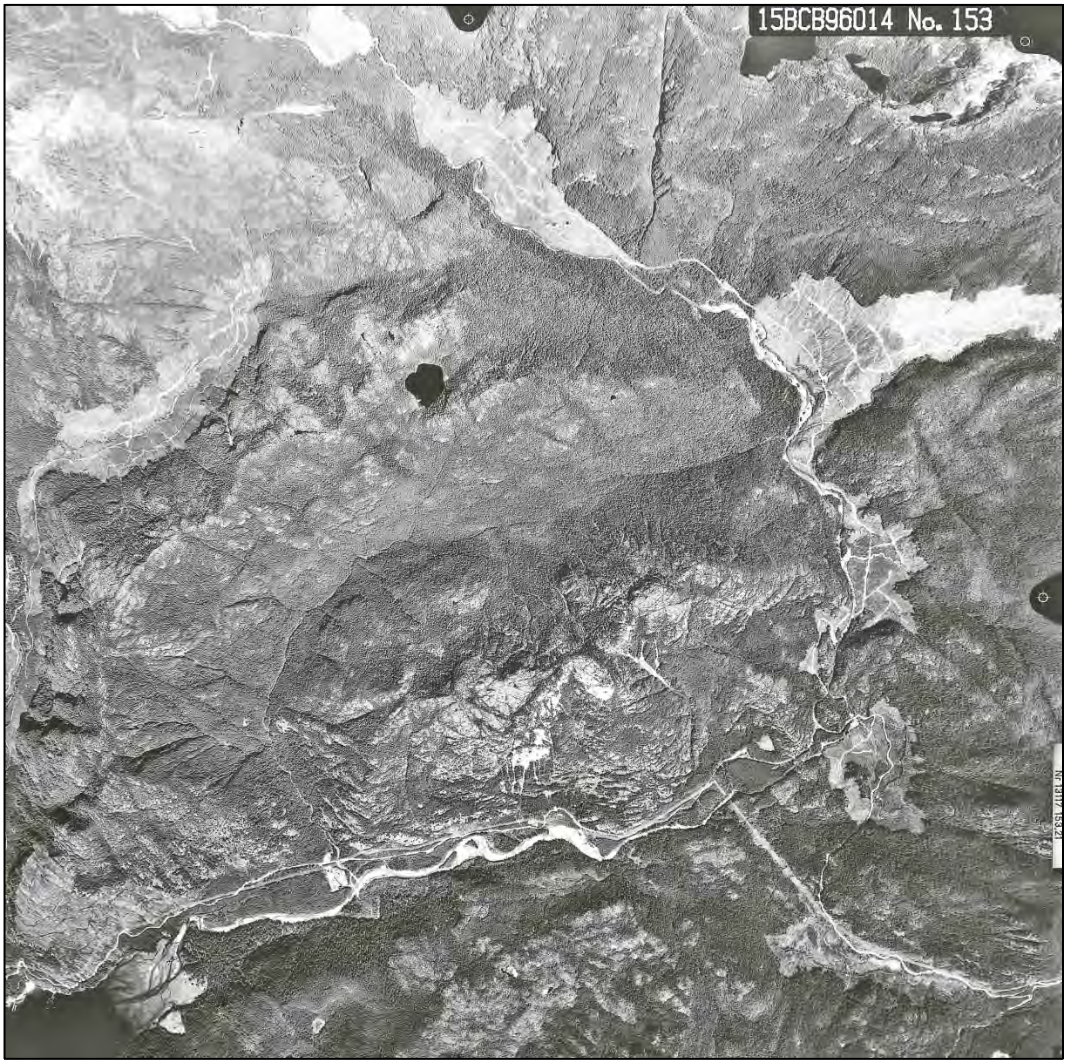

Photo 3. Logging activity extending into the upper watershed by 1996.

1.2.4 Previous Restoration Initiatives

Conuma River Hatchery Channel

In order to address a lack of off-channel habitat in the Conuma River, a side channel along the right bank (just downstream of the hatchery) was prescribed to increase the availability of off-channel rearing habitat for all salmonid species in the system (Reid and Walsh, 2003). The construction of the channel was completed in two phases. In 2008, phase 1 construction saw the completion of a 920 meter long ground water channel, with a wetted area of 7,260 m^2. In 2009 the ground water channel was connected to a surface water channel wetted by the Conuma River outflow. The new section of channel is 275 m long for a total channel length of 1,195 m. For phase 1 it was anticipated that the channel would be used by coho and chum salmon. It was projected that the introduced surface flow from the Conuma River hatchery outflow would attract pink and chinook salmon (Norgan et al, 2008). A monitoring program was conducted by Grieg Seafood BC Ltd. and DFO.

2.0 METHODS

Strategy 2 habitat status assessments require the analysis of habitats using the pressure-state indicator model identified in Stalberg et. al. (2009). Within this model, pressure indicators are considered descriptors of landscape-level (and generally man-made) stressors, which can often be evaluated through the spatial analysis of remotely sensed data. State indicators are descriptors of specific habitat conditions, and are typically representative of 'on-the-ground' data collected during field operations. The following table describes the original stream, lake, and estuary pressure and state indicators considered under WSP Strategy 2:

Table 2. Pressure and state indicators identified in Stalberg et. al. (2009).

Habitat Type	Indicator Type	Indicator
Stream	Pressure	Total land cover alterations
Stream	Pressure	Watershed road development
Stream	Pressure	Water extraction
Stream	Pressure	Riparian disturbance
Stream	Pressure	Permitted waste management discharges
Stream	State	Suspended sediment
Stream	State	Water quality
Stream	State	Water temperature: juvenile rearing – stream resident species
Stream	State	Water temperature: migration and spawning – all species
Stream	State	Stream discharge
Stream	Quantity	Accessible stream length, based on barriers
Stream	Quantity	Key spawning areas (length)
Lake	Pressure	Total land cover alteration
Lake	Pressure	Watershed road development
Lake	Pressure	Riparian disturbance
Lake	Pressure	Permitted waste management discharges
Lake	State for sockeye lakes	Coldwater refuge zones
Lake	State for sockeye lakes	Lake productive capacity

Lake	Quantity	Lake shore spawning area (length)
Estuary	Pressure	Marine vessel traffic
Estuary	Pressure	Estuary habitat disturbance
Estuary	Pressure	Permitted waste management discharges
Estuary	State	Estuary chemistry and contaminants
Estuary	State	Estuary dissolved oxygen
Estuary	Quantity	Estuarine habitat area (riparian, sedge, eelgrass, and mudflat)

The selection of applicable indicators for the Conuma River watershed occurred following a comprehensive literature review and spatial data gathering and analyses. In addition to the indicators describe in Table 2, supplemental indicators were evaluated during the data gathering process based on data availability and their perceived importance.

2.1 Literature Review

Literature reviewed as part of the information gathering process included habitat assessments, monitoring initiatives, water use plans, watershed and estuary management plans, and various other technical documents. This information was obtained from the following sources:

- Web sources – FISS, WAVES online library, EcoCAT, J.T. Fyles Ministry of Forests online library, Google search;
- Technical reports received from local experts and stakeholders (i.e. DFO, private consultants, Western Forest Products [WFP], and others);
- Technical reports housed internally by MCW; and
- Preliminary interviews with key knowledgeable persons (i.e. the Tahsis Enhancement Society)

Information from all sources was compiled and entered into a spreadsheet, and was separated by information theme (i.e. fish, habitat, impacts, water quality, etc.). Each document was comprehensively reviewed with important information extracted and synthesized on the spreadsheet. This method allowed for cross-comparison of document results, which was used to identify redundancy across sources and generate consensus on which habitat indicators apply in the system.

2.2 Spatial Data Gathering and Processing

Geographic Information Systems (GIS) data relevant to this project was obtained through the following resources:

- Land and Resources Data Warehouse (LRDW);
- West Coast Aquatics (WCA);
- Western Forest Products Ltd. (WFP);
- GeoBC;
- Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) Fish Passage Investment Program;
- University of British Columbia's Geographic Information Centre;
- Mapster;
- Shapefiles and orthophotographs courtesy of WFP; and
- Existing spatial data previously collected by MCW.

All GIS data processing and mapping was accomplished using ArcGIS Desktop 10.3 with the Spatial and 3D Analyst extensions. Once acquired, data was processed by clipping features to the BC Watershed Atlas 1:20,000 scale watershed boundaries.

2.3 Interviews

In addition to the information compiled during the literature review and spatial data gathering, interviews with the Nootka Sound Watershed Society and other experts in the area were conducted to incorporate local knowledge of the Conuma River. These interviews were conducted during the Nootka Sound Risk Assessment Workshop held in Gold River on May 5 – 7, 2015.

2.4 Selected Stream Habitat Indicators

Upon review of the literature and spatial data gathered, stream habitat indicators were selected based on data availability and indicator suitability. The following sections describe methods used to analyze selected stream habitat indicators against known metrics and benchmarks.

2.4.1 Total Land Cover Alterations

Indicator Type: Pressure

Total land cover alteration captures potential changes in cumulative watershed processes such as peak hydrologic flows and sediment generation that can affect downstream spawning and rearing habitats (Poff et al., 2006 as cited in Stalberg et al., 2009). Alterations can be categorized by agriculture, urbanization, forestry, fire disturbance, mining activity, and road development.

Total land cover alterations in the Conuma River watershed were calculated by analyzing WFP's forest age layer for the entire watershed. This layer categorized all forested areas within a watershed using the following classification scheme: younger than 40 years, 41 to 120 years, and older than 120 years. Forested areas classified as older than 120 years were considered un-altered. Non-forested areas were described as non-productive. For polygons classified as non-productive by WFP, data was overlaid on high resolution 2012 – 2013 orthophotographs to differentiate the type of non-productive land present. These lands were further classified as follows: non-productive (alpine), non-productive (avalanche chute), non-productive (barren surface), non-productive (fresh water), and non-productive (urban). Classification into these non-productive categories was used to determine the area of natural (i.e. unaltered) non-productive land cover versus the area of altered non-productive land cover.

Land cover compositions and distributions were summarized for the entire watershed and analyzed to determine the total land cover alteration risk.

2.4.2 Watershed Road Development

Indicator Type: Pressure

The construction of roads in a watershed has the potential to increase fine sediment deposition into adjacent streams, reduce the aquatic invertebrate diversity, and affect aquatic connectivity, channel bed disturbance, and channel morphology (Tschaplinski, 2010). In addition, road densities are correlated with the extent of land-use within a watershed, and can be an indicator of overall watershed development (Stalberg et al, 2009).

Watershed road development was evaluated by calculating the lineal length of road per square kilometre of watershed. In order to obtain the most accurate representation of the existing road network, GIS layers obtained from the LRDW, WCA, and WFP were compared with 2013 high resolution orthophotographs. Discrepancies between layers were resolved and layers were merged to create one comprehensive road network.

Road development densities were determined by dividing the total length of roads in each watershed by the watershed area. Results were then compared with the following suggested benchmark identified in Stalberg et. al (2009):

<0.4km / km^2 = lower risk
>0.4km / km^2 = higher risk

2.4.3 Water Extraction

Indicator Type: Pressure

The consumptive use of water within a watershed has the potential to impact spawning and rearing habitats through the reduction of instream flows (ESSA Technologies Ltd., 2013). While watershed benchmarks are difficult to define in the absence of detailed climatic and hydrological data, relative risks can be assessed by comparing the total volume of licenced water extraction by watershed.

Water licence information was obtained through the LRDW. Spatial features were clipped within watershed boundaries, and permitted volumes (and licence type) were determined from the water licence attributes.

Watersheds with no licenced water extraction (for consumptive uses) were assigned low risk, while watersheds with any amount of extraction were assigned a moderate risk.

2.4.4 Riparian Disturbance

Indicator Type: Pressure

Riparian disturbance is a commonly used pressure indicator for both streams and lakes (Stalberg et al, 2009). Streamside vegetation provides many critical functions to aquatic habitats, including (but not limited to): temperature regulation, cover, large woody debris (LWD) deposition, nutrient input, and channel stability. While logging practices today are required to manage riparian vegetation adjacent to fish-bearing streams, impacts from historical logging to the stream banks have persisted. In many cases the return of riparian habitats to a proper functioning condition will require intervention through conifer release and bank stabilization practices.

Riparian disturbance in the Conuma River was determined by classifying vegetation within 100m of the high water mark. While a 30m delineation is the commonly referenced width for managing the riparian zone during development within B.C. (e.g., *The Land Development Guidelines for the Protection of Aquatic Habitat* (Fisheries and Oceans Canada & Ministry of Environment, 1992) discussions with the NWSW identified that an understanding of vegetation beyond this 30m width was necessary in order to fully understand impacts to the riparian zone (R. Dunlop, pers. comm.).

Vegetation was classified using 2013 high resolution orthophotographs. All vegetation within a 100m buffer of the high water line was classified using the following categories:

- Mature conifer (i.e. >90% mature coniferous stand);
- Mature mixed (i.e. mixture of mature coniferous and deciduous vegetation);
- Deciduous or regenerating (i.e. >90% deciduous stand and / or a regenerating coniferous stand);
- Early regenerating; and
- Non-productive (i.e. roads and bedrock surfaces).

Once classified, the riparian composition was summarized for the anadromous distribution of the watershed to determine the riparian disturbance pressure for salmonid species.

2.4.5 Permitted Waste Management Discharges

Indicator Type: Pressure

Permitted waste management discharges provide insight into potential pressures on water quality in streams, lakes, and estuaries. Information for the Nootka Sound area was obtained through the BC Ministry of Environment (MOE) permitted waste discharge authorization database (BC MOE Waste Management Website, 2015). A search was conducted for authorizations within the Conuma River watershed. Results were mapped in ArcGIS using the coordinates provided in the database, and all authorization information was retained as fields in the attributes table.

2.4.6 Water Quality

Indicator Type: State

Suggested water quality metrics are the concentrations of contaminants, nutrients, and dissolved oxygen (DO) in stream water. This level of data is typically only available for systems with localized monitoring or research projects (Stalberg et al, 2009). For the Conuma River, water quality data was obtained from the Ministry of Energy and Mines regional geochemical stream survey data. This data was limited to the sampling of uranium, fluoride and pH across six sampling sites and one sampling year (2007).

2.4.7 Water Temperature: Juvenile Rearing and Migration

Indicator Type: State

Water temperature during the incubation, rearing, and migration of salmonid species has a significant impact on the timing of certain life stages (i.e. emergence), and is an important parameter to understand potential exposure to other limiting factors based on timing. No temperature data was available for the Conuma River watershed during the juvenile rearing and migration period and has been identified as a data gap.

2.4.8 Water Temperature: Migration and Spawning

Indicator Type: State

High water temperatures during the summer and fall have the potential to delay or be stressful to migrating salmonids (Sauter et al, 2001). The Upper Optimum Temperature Range (UOTR) and Impairment Temperatures (IT) for all species of salmonids were defined in Stalberg et al (2009) as 15°C and 20°C, respectively.

Stream temperature data was obtained from 2006 to 2013 from DFO's Stream Inspection Logs (SILs). Temperatures during spawner migration in the Conuma River were evaluated for this indicator by determining the maximum temperatures observed by snorkel survey crews each season against the UOTR and IT. Temperatures that remained below these values were considered low risk, temperatures that were at the UOTR or between the UOTR were considered moderate risk, and temperatures at or above the IT were considered high risk.

While a risk assessment of this habitat indicator was possible through SIL temperature data, it should be noted that this data represents only select point samples in time. Continuous temperature loggers during the spawning period are recommended to increase the robustness of this habitat indicator assessment.

2.4.9 Stream Discharge

Indicator Type: State

The carrying capacity of streams and their seasonal suitability for use by different salmonid species and life-stage are directly related to aspects of the annual hydrograph and "mean annual discharge" (MAD). The suggested benchmark for discharge is when the 1 in 2 year 30-day duration summer minimum flow (i.e. July – September) is less than 20% of MAD (Stalberg et al, 2009).

No discharge data was available for the Conuma River and has therefore been identified as a data gap.

2.4.10 Accessible Stream Length

Indicator Type: State

Determination of the accessible stream length (by species) provides an indicator on the relative productive capacity of a watershed, and allows for the analysis of how landscape pressures (i.e. disturbed riparian zones) affect different species and life stages differently. Accessible stream length was determined through the compilation of several sources of information, including the Fisheries Information Summary System (FISS), BC MOE fish passage modelling (MFLNRO Fish Passage Technical Working Group Web Page, 2013), spatial data received from WCA, various technical reports, and interviews with the local experts. Compiled data was digitized as a line feature in ArcGIS to determine the linear length of fish distribution.

2.4.11 Key Spawning Areas (Length)

Indicator Type: State

Quantification of the key spawning areas provides an indicator on the relative productive capacity of a watershed, as well as a baseline to compare future changes in spawning habitat over time. In addition, identification and documentation of these key habitats will provide guidance on critical habitats to protect from future industrial initiatives.

Key spawning areas were identified from the following sources: FISS, various technical reports, and interviews with local experts.

2.5 Additional Stream Indicators

Based on the breadth of data collected during the information gathering process and other known useful stream indicators, the following sections describe the supplemental stream indicators selected for analysis during the habitat status assessment work in Nootka Sound.

2.5.1 Stream Crossing Density

Indicator Type: Pressure

Stream crossings at roads have the potential to impede fish passage through interfering with or blocking access to upstream spawning or rearing habitats (thereby reducing the total amount of habitat salmonid habitat in a watershed (Harper and Quigley, 2000). These crossings have also been known to increase sediment delivery to streams through the provision of direct pathways to aquatic habitats (Brown et al, 2013).

Stream crossing information was obtained from the Provincial Stream Crossing Inventory System (PSCIS). Crossing density was calculated for each watershed by dividing the total number of crossings present in each watershed by the watershed area, and the distribution values across all watersheds were compared to evaluate relative risk. In addition, the number of modelled fish-bearing crossings was determined for each watershed to evaluate the number of crossings potentially affecting fish and fish habitat.

Risks were determined on a comparative basis by ranking both crossing density and the total number of fish-bearing crossings per watershed.

2.5.2 Habitat Composition

Indicator Type: State

Guidelines state that for systems less than 15m wide and with gradients <2% poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Systems with gradients between 2 and 5% experience poor summer and winter rearing conditions with <30% pool habitat area by reach, and systems with gradients >5% experience poor summer and winter rearing conditions with <20% pool habitat area by reach (Johnston & Slaney, 1996). While the Conuma River system is greater than 15m wide, these values still provide a useful indicator of relative habitat condition.

Habitat compositions for the Conuma River were determined by digitizing macrohabitat units from 2013 orthophotographs, where visible in the imagery (note that in some cases, classification was not possible based on canopy cover and / or shadowing). In addition, historical habitat unit composition was determined through GPS data collected in the mid-1990s by M.C. Wright and Associates Ltd. (unpublished data) and digitization of geo-referenced air photos from 1995. All habitats within the bankful widths were classified based on the following categories:

- Riffle;
- Pool;
- Glide;
- Cascade;
- Braided;
- Debris jam;
- Gravel bar;
- Vegetated gravel bar;
- Side channel; and
- Secondary channel.

Habitat units by percent composition were determined by calculating and comparing the respective areas of each habitat unit type in ArcGIS. An assessment of change in habitat unit composition over time was also determined through a comparison of the 2013 and 1995 data.

2.5.3 Channel Stability

Indicator Type: State

Forest harvesting and road building in a watershed have the potential to increase peak flows, increase sediment delivery, alter riparian vegetation, and disturb channel integrity. These alterations can cause morphological changes to a channel, and may result in aggradation or degradation of the streambed. These changes will often affect the stability of stream banks and the conditions of LWD in the system and subsequently impact critical salmonid habitats (i.e. spawning and rearing zones) (Hogan & Ward, 1997).

Channel stability in the Conuma River watershed was evaluated through the comparison of historical air photos (1980 and 1995) and recent orthophotographs (2013). Bankful widths, the location of vegetated and non-vegetated gravel bars, and eroding banks were compared between each time period, and used as an indicator of increasing or decreasing channel stability.

2.5.4 Large Woody Debris

Indicator Type: State

Large woody debris (LWD) affects channel form through the formation and stabilization of pools and gravel bars, and provides valuable habitat in the form of cover for salmonids. In many cases, a reduction in LWD amount and piece size as a result of forest harvesting has been assumed to occur gradually; however, recent studies indicate these changes occur during or shortly after harvest (Bilby and Ward, 1991). Changes in riparian stand composition (i.e. a transition from mature conifers to deciduous) are known to reduce the quality and longevity of LWD in a system as deciduous trees (i.e. alder) break down in river systems faster than mature conifers.

LWD was classified from the 2013 orthophotography where the stream channel was visible in the imagery. In many cases, canopy cover and / or shadows in the upper reaches of the systems prevented classification, and were identified as a data gap. Species differentiation of LWD (i.e. deciduous or coniferous) was not possible from the orthophotographs; however, some assumptions can be made based on classification of the adjacent riparian stand.

Visible LWD was classified using the following categories:

- Functioning (i.e. LWD situated at an angle or perpendicular to the stream bank, with the potential to create scour pools and influence channel form);
- Partially-Functioning (i.e. LWD situated at an angle or perpendicular to the stream bank, but remained only partially wetted and requires higher flows to provide full functionality, or LWD situated parallel to the stream bank);
- Non-Functioning (i.e. LWD situated parallel to the stream bank or situated on gravel bars well above the wetted width); and
- Debris Jam (i.e. a large raft of LWD, typically consisting of 10 pieces of LWD or greater).

LWD habitat condition was determined, at the reach level, using the following diagnostics described in Johnston and Slaney (1996):

- Good = >2 pieces of functional LWD per bankful width;
- Fair = 1 – 2 pieces of functional LWD per bankful width; and
- Poor = <1 piece of functional LWD per bankful width.

2.5.5 Off-Channel Habitats

Off-channel habitats provide valuable rearing and over-wintering habitat for various species of pacific salmon. Chum and coho are most strongly associated with these types of habitats, with chum often observed spawning in groundwater-fed channels or seepage areas, and coho observed spawning in groundwater channels and small surface-fed tributaries (Slaney and Zaldokas, 1997). Coho juveniles utilize refuge areas such as side channels, small tributaries, ponds, and lakes for over-wintering habitat as they provide protection from winter flood events. The productivity of coho in many coastal systems depends on the availability of of good winter refuge (i.e. off-channel) habitat (Diewert, 2007). In addition, off-channel habitats in the lower reaches of the river provide important foraging opportunities for all out-migration salmonids.

Evaluation of off-channel habitat condition in the Sucwoa River watershed was restricted to interviews with local experts, as these habitat types were typically not visible from orthophotography due to canopy cover.

2.6 Selected Estuary Habitat Indicators

Upon review of the literature and spatial data gathered, estuary habitat indicators were selected based on data availability and indicator suitability. The following sections describe methods used to analyze selected estuary habitat indicators against known metrics and benchmarks.

2.6.1 Estuary Habitat Disturbance

Indicator Type: Pressure

Estuaries are extremely important habitats for adult salmon for staging and physiological transition, and are also important to juvenile salmon for rearing, physiological transition, and refugia. Anthropogenic impacts within an estuary and throughout a corresponding watershed can have negative effects on both adult and juvenile salmonids utilizing these habitats. These impacts are compounded considering the added physiological stresses fish experience during the transition from the freshwater to marine environments, and the importance of estuarine habitat for foraging and rearing. Common impacts within estuaries include: 1.) loss of intertidal rearing habitat due to structural development, dredging and filling, and gravel deposition from upstream sediments; 2.) decreases in dissolved oxygen due to input of sewage, agricultural practices, and dredging of anoxic sediments; 3.) creating a toxic condition due to toxic chemical spills and the discharge of chemical waste from industry and mining; and 4.) an increase in suspended solids due to logging activities upstream, agricultural practices, dredging, and input of sewage and industrial waste (Aitkin, 1998).

Relative habitat disturbances in the Conuma River estuary were evaluated through the extent of known historical activities, the presence / absence of existing initiatives in the estuary, and residual impacts identified through literature reviews and orthophoto analyses.

2.6.2 Permitted Waste Management Discharges

Indicator Type: Pressure

Permitted waste management discharges within the estuarine habitat have the potential to impact salmonid through the reduction of water quality (i.e. dissolved oxygen) and an increase in suspended solids (Aitkin, 1998). This indicator was evaluated based on the presence / absence of permitted waste management discharges within the Conuma River estuary.

2.6.3 Estuary Chemistry and Contaminants

Indicator Type: State

An analysis of estuarine chemistry and contaminants (i.e. N, P, N:P, Metals, PAHs and PCBs) can provide an indicator of water quality suitability for aquatic life. Available water quality data was compared with the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, 1999) to determine if any parameters exceeded the thresholds of these guidelines and therefore potentially impacting salmonids utilizing the estuary.

No relevant chemistry or contaminant data for the Conuma River estuary was available, and has therefore been identified as a data gap.

2.6.4 Estuary Dissolved Oxygen

Indicator Type: State

Dissolved oxygen levels and stratification in estuaries have been shown to be important in the freshwater-marine transitions of migrating juvenile and adult salmon (Stalberg et al, 2009). No data was available for the Conuma River estuary; as such, this habitat indicator has been identified as a data gap.

2.6.5 Estuarine Habitat Area

Indicator Type: State

The area of riparian, sedge, eelgrass, and mudflat habitats within an estuary is considered an indicator of the productive capacity of an estuary. An analysis of estuarine habitat changes over time also provides an indicator of habitat improvement or degradation, and may identify critical habitats requiring protection and / or restoration.

Estuarine habitat area for the Conuma River was calculated through the digitization of habitat types from the 2013 orthophotographs. While no historical habitat areas were available for comparison, this data provides a baseline of information from which future changes over time can be compared.

3.0 WILD PACIFIC SALMON OF THE CONUMA RIVER WATERSHED

As one of the larger rivers in this region of the island, the Conuma River is an important producer of anadromous salmon (Reid and Walsh, 2003). Five species of anadromous salmon Chinook (*Oncorhynchus tshawytscha),* Coho (*O. kisutch),* Chum (*O. keta),* Pink (O. gorbuscha) and Sockeye (*O. nerka*) are supported by the Conuma River watershed as well as Atlantic salmon, steelhead (winter) and cutthroat trout. The main species of interest are described in the following sections. In 1978 DFO constructed a fish hatchery on the right floodplain of the river to augment the natural production of chum salmon in support of a commercial fishery. The hatchery also raises coho, chinook, and steelhead to offset incidental commercial fishery catch (Reid and Walsh, 2003).

3.1 Chinook Salmon

3.1.1 Biology, Distribution, and Known Habitats

Chinook typically enter the river and commence spawning in late September. Spawning is usually complete by early to mid-November (Ministry of Environment, 2014). Chinook are known to be distributed up to the falls approximately 7.21km upstream from the upper tide limit at counting station 0 (Figure 3) (Ministry of Environment, 2014). The Conuma Hatchery has been particularly successful in raising Chinook and has increased the return of this species from historic levels of 1,000-3,000 spawning adults to 13,000-25,000 spawning adults – this in turn has led to an increase in local sport fishing (Reid and Walsh, 2003).

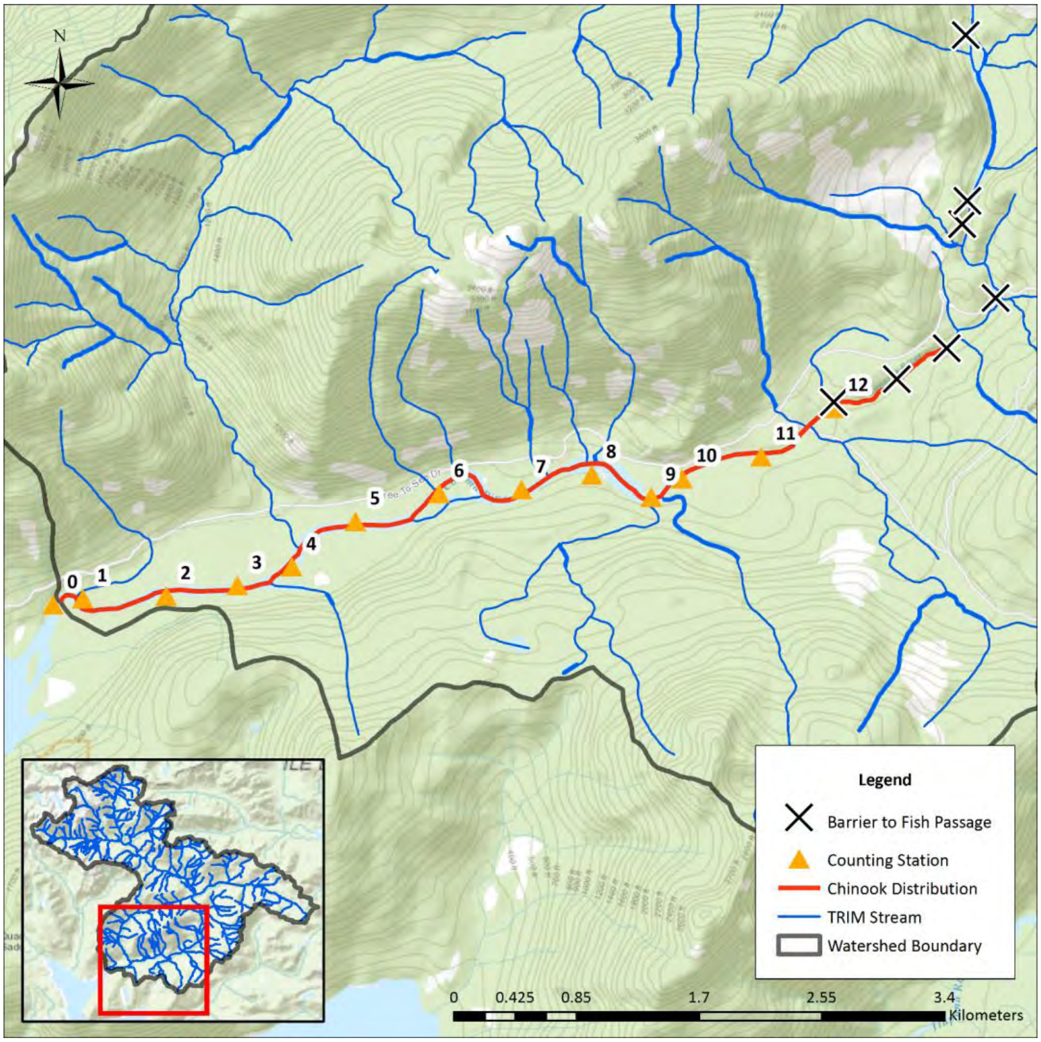

Figure 3. Known chinook distribution in the Conuma River watershed.

Upon entry into the river, a bedrock-controlled stopover pool approximately 100m upstream of the upper tidal limit is utilized by chinook for holding and osmoregulation, and also acts as a broodstock collection location for the hatchery. Important known holding habitats upstream of the stopover pool includes deep water pools adjacent to LWD between counting stations 1 and 2, deep glides along the right bank between counting stations 3 and 4, a bedrock-controlled (and historical broodstock collection) pool at counting station 9, and a pool at counting station 12, at the base of the canyon (Figure 4) (C. Erikson and A. Eden, pers. comm.).

Approximately 60% of the Conuma River chinook population are known to spawn downstream of the hatchery (i.e. counting station 5), despite the presence of suitable spawning habitat (i.e. substrates and flows) upstream of here (A. Eden, pers. comm.). Anecdotal observations indicate the overall spawning grounds to be progressively shifting downstream, possibly due to delayed entry into the river due to lower flows and warmer water temperatures (C. Erikson, pers. comm.).

Spawning activity between counting stations 0 and 1 includes limited spawning at counting station 0 (and the upper limit of tidal influence) and spawning within the glide along the left bank downstream of counting station 1. No spawning activity is typically observed between counting stations 1 and 4. Just downstream of counting station 5, a glide along the right bank is heavily utilized for chinook spawning, as is a glide along the left bank just upstream of counting station 5. Some activity between counting stations 6 and 7 occurs with all glides utilized during higher escapement years. Excellent spawning substrates exist between counting stations 9 and 10, with this location representing the (typical) upper limit of chinook spawning activity (Figure 4) (C. Erikson and A. Eden, pers. comm.).

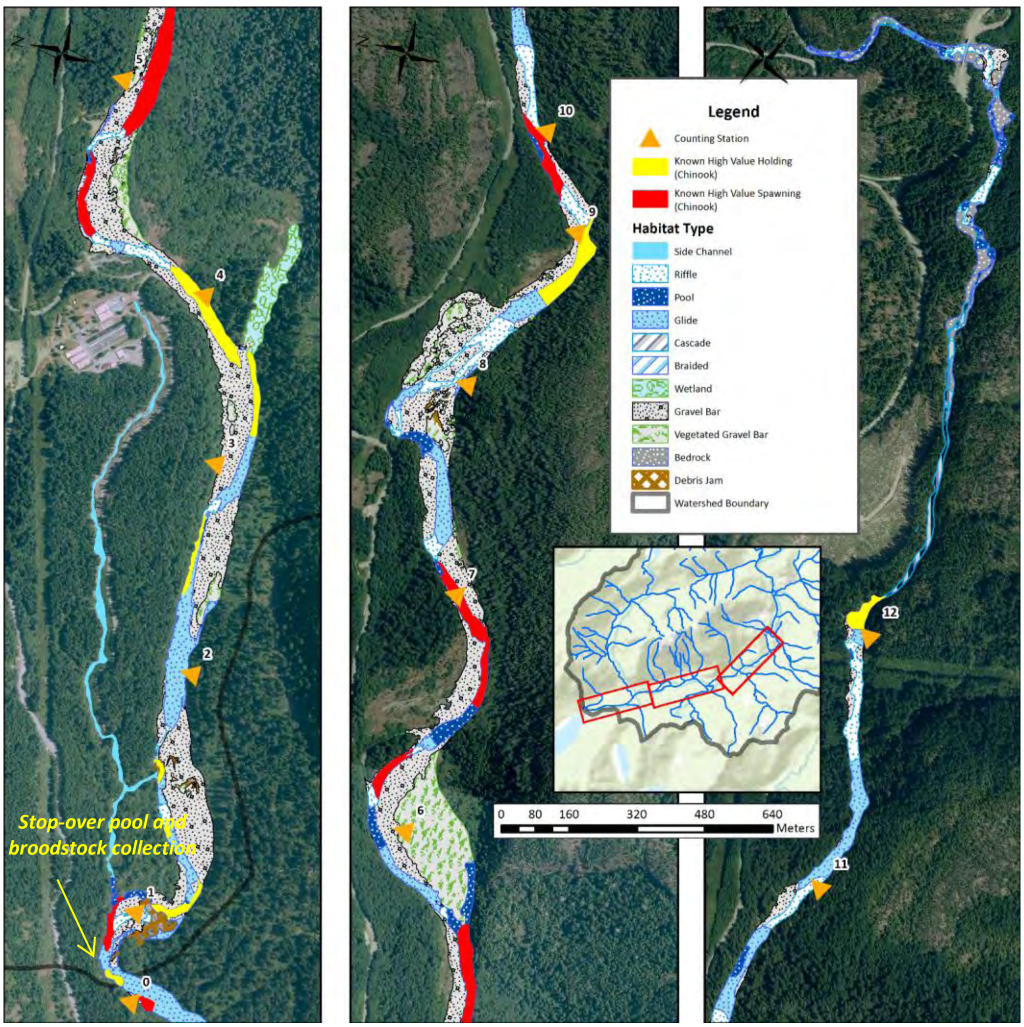

Figure 4. Known high value adult chinook holding and spawning habitat in the Conuma River.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required). Following emergence, Chinook fry typically migrate downstream immediately. Chinook salmon can be separated into ocean-type and stream-type, with ocean-type migrating directly to sea after emergence, and stream-type remaining in the freshwater environment to rear for one or more years. The Chinook in the Conuma River are likely ocean-type as this is the dominant type of Chinook in British Columbia (Diewert, 2007). Downstream migration usually occurs between April and June for ocean-type Chinook (note that the specific migration timing for the Conuma River system is unknown). During downstream migration, fry typically target reduced flows at the river edges (Diewert, 2007).

Known high value juvenile rearing habitat specific to the Conuma River include a debris jam at counting station 1, an off-channel wetland connected to the left bank of the mainstem near counting station 4, and the wetted portion (approximately 100m) of the historic mainstem just downstream of counting station 6 (Figure 5) (C. Erikson and A. Eden, pers. comm.).

Ocean-type Chinook are most dependent upon estuaries to complete their life cycle (Aitkin, 1998). Estuaries are an environmental transition zone that provide opportunities for feeding and growth and refuge from predators. Upon reaching the estuary, juveniles rear in this zone for up to several months, where rapid growth (dependant on food resources available in the estuary) typically occurs (Diewert, 2007). Based on this known life history requirement and local knowledge of chinook rearing in the Conuma River estuary (C. Erikson, pers. comm.), this zone has been classified as high value juvenile rearing habitat (Figure 5).

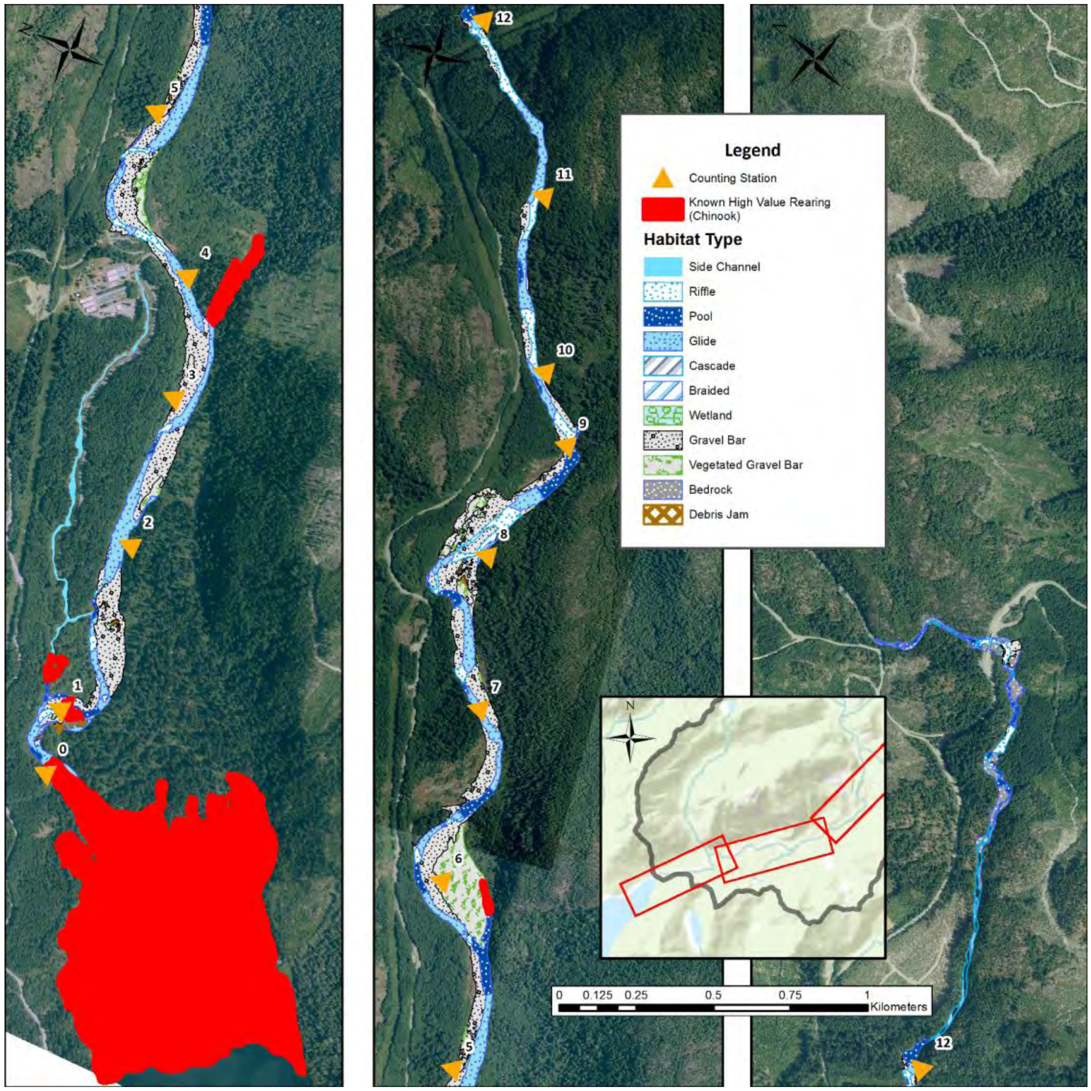

Figure 5. Known high value juvenile chinook rearing habitat in the Conuma River.

3.1.2 Escapement

Prior to construction of the Conuma River hatchery, the Conuma River historically supported Chinook escapements below 3,500 fish. Since construction of the hatchery, escapement numbers have grown to an average of approximately 18,000 fish with a peak of over 62,000 fish in 2013 (Figure 6).

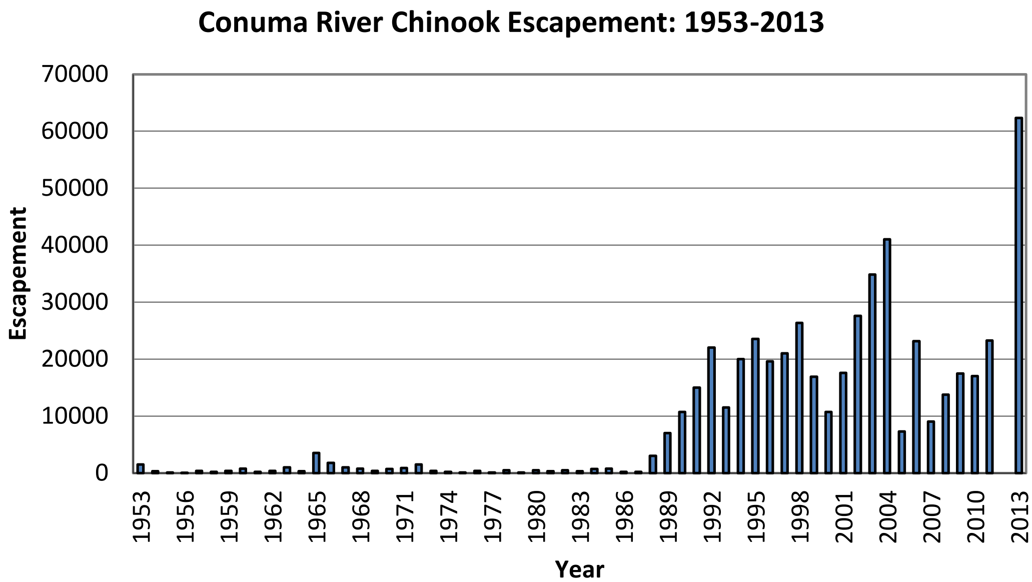

Figure 6. Chinook escapement in the Conuma River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.2 Coho Salmon

3.2.1 Biology, Distribution, and Known Habitats

Coho salmon typically arrive in the Conuma River in early September and begin spawning in late September. The coho run is quite protracted, with the end observed as late as early January (Ministry of Environment, 2014). Distribution has been observed in the mainstem up to the anadromous fish barrier, 7.21km upstream from the upper tide limit at counting station 0. In addition to their mainstem distribution, coho have known access to 2.20km of tributary length including the recently constructed Conuma Hatchery side channel, which provides roughly 1.2km of habitat. There is also 10.54km of inferred tributary access based on modeled tributary gradient. Two tributaries in the system have significant inferred accessible length - one providing approximately 2.3km with a 1ha headwater lake, and another that provides 4.1km of accessible stream length with a 1.6ha headwater wetland. The remaining inferred accessible tributaries provide less than 1km of stream length each. Actual accessible tributary length requires confirmation through local knowledge gathering and field assessment.

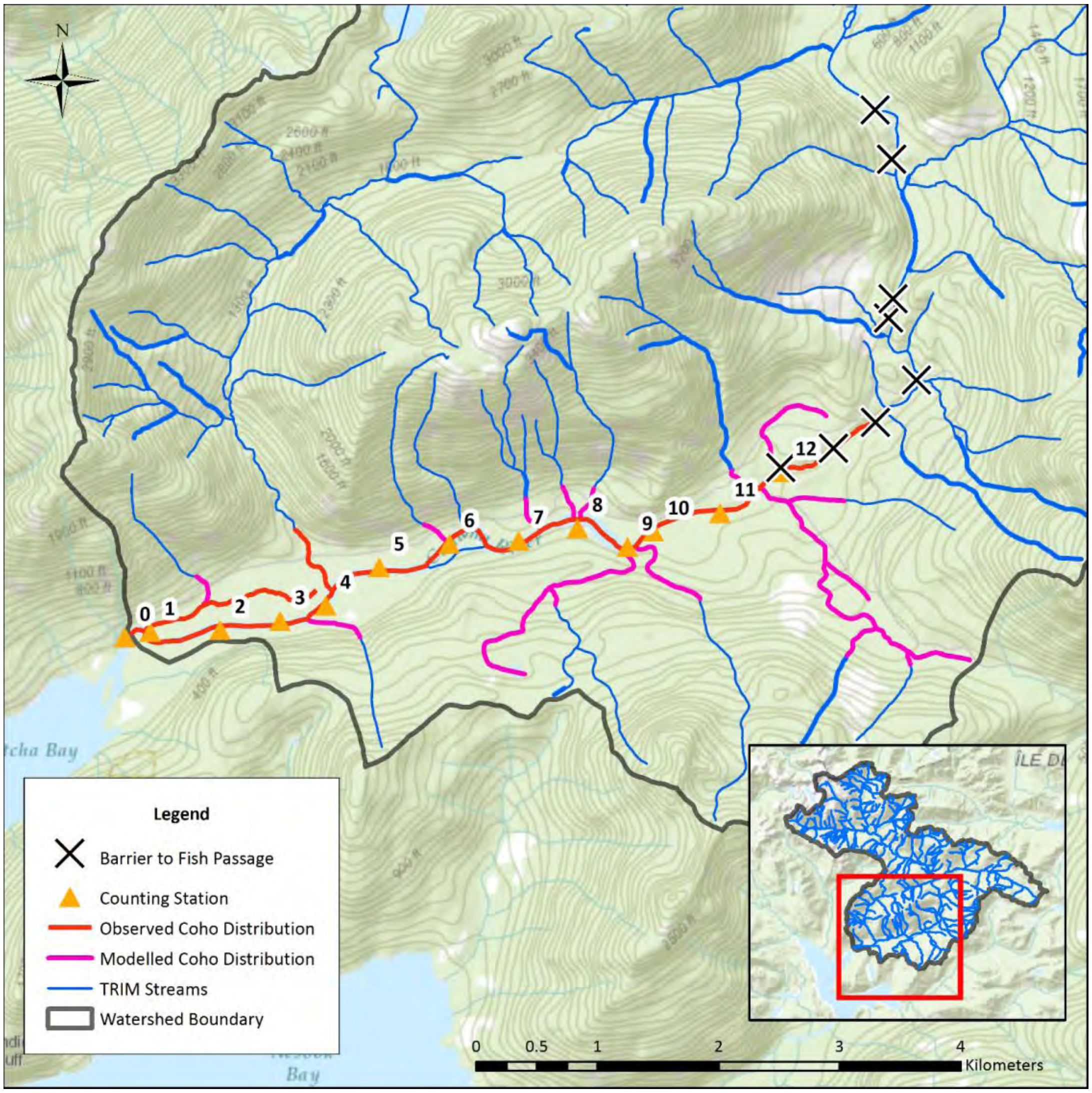

Figure 7. Known coho distribution in the Conuma River watershed.

Upon entry into the river, a bedrock-controlled stopover pool approximately 100m upstream of the upper tidal limit is utilized by coho for holding and osmoregulation. Important known holding habitat upstream of the stopover pool is similar to that of chinook (Section 3.1.1), with the exception of between counting station 3 and 4, where coho are not known to hold. An extremely important pool for coho holding exists between counting stations 6 and 7, and is locally known as "Lazy Hole" (Figure 8) (C. Erikson and A. Eden, pers. comm.).

Coho spawning is typically restricted to above counting station 5. Spawning is observed in the glide upstream of counting station 5, and in higher escapement years, in all glides between counting stations 6 and 7. Other known spawning grounds include the glide between counting stations 9 and 10, and the glide just upstream of counting station 11, which has been identified as extremely high value coho spawning habitat (A. Eden, pers. comm.) (Figure 8). Near counting station 12, coho are known to spawn in a tributary from its confluence upstream to the road crossing with Head Bay FSR. Under low flow years this tributary is known to dry up following spawning which likely results in a loss of eggs (C. Erikson and A. Eden, pers. comm.).

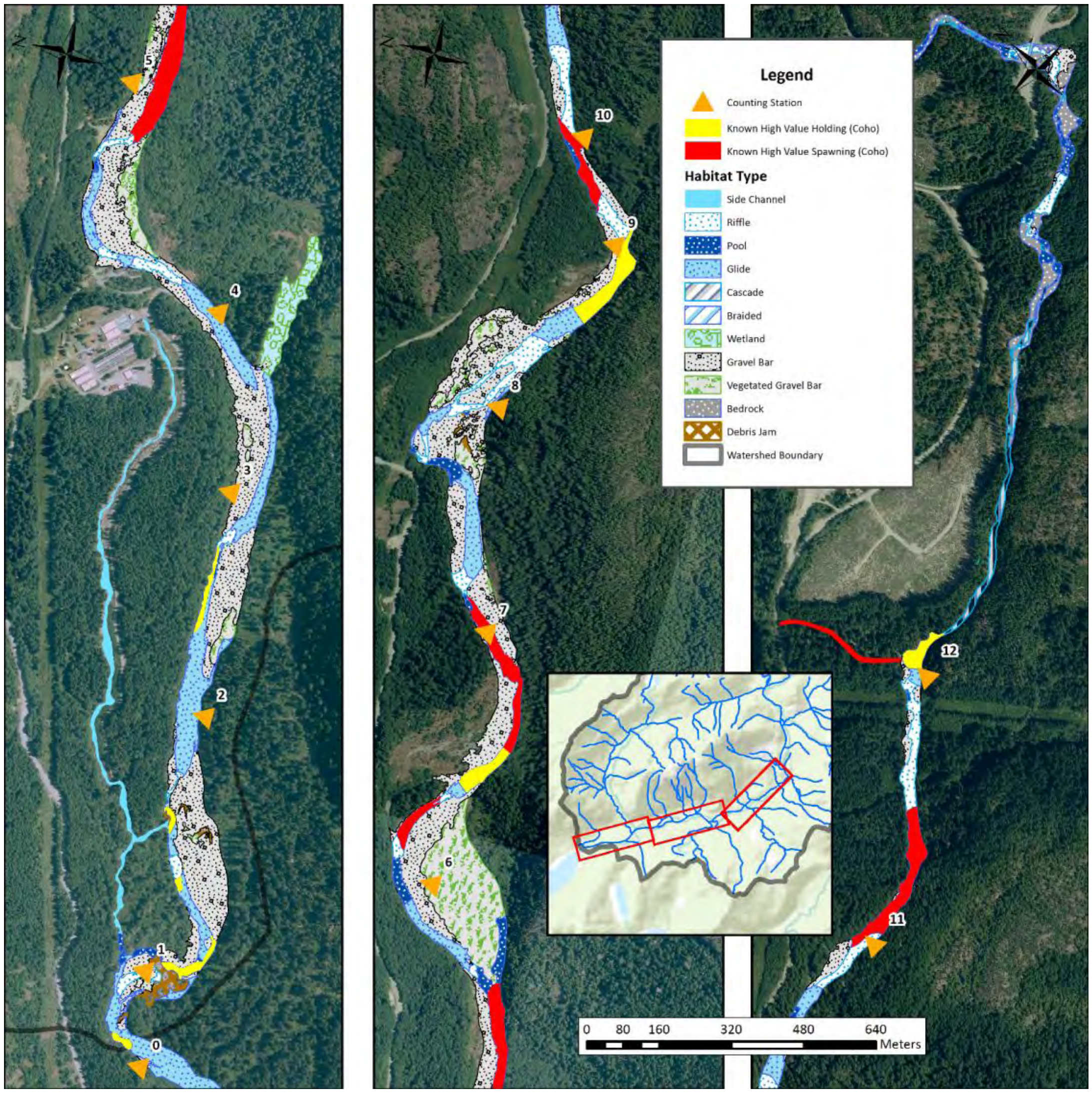

Figure 8. Known high value adult coho holding and spawning habitat in the Conuma River.

Fry emergence is partially dependent on water temperature and can vary from year to year (i.e. the lower the water temperature, the longer the incubation period required), although it typically occurs between March and late June. No studies on fry development and outmigration in the Conuma River were available at the time of writing; however, it is likely that the coho in the Conuma remain in fresh water for one to two years before migrating as smolts (Diewert, 2007)

During early development, pools, backwaters, side channels, and small tributaries are sought out as rearing habitat. By late fall / early winter, fry move into deeper pools or off-channel habitats which provide shelter from winter storm events. The productivity of many coastal systems for coho largely depends on the availability of over-wintering habitat (i.e. off-channel refuge areas) (Diewert, 2007). Known high value juvenile coho rearing habitats in the Conuma River include the Conuma River side channel, a debris jam near counting station 1, the off-channel wetland near counting station 4, the wetted component of the historic mainstem at counting station 6, the anadromous reaches of tributaries to the Conuma, and the estuary (C. Erikson and A. Eden, pers. comm.) (Figure 9).

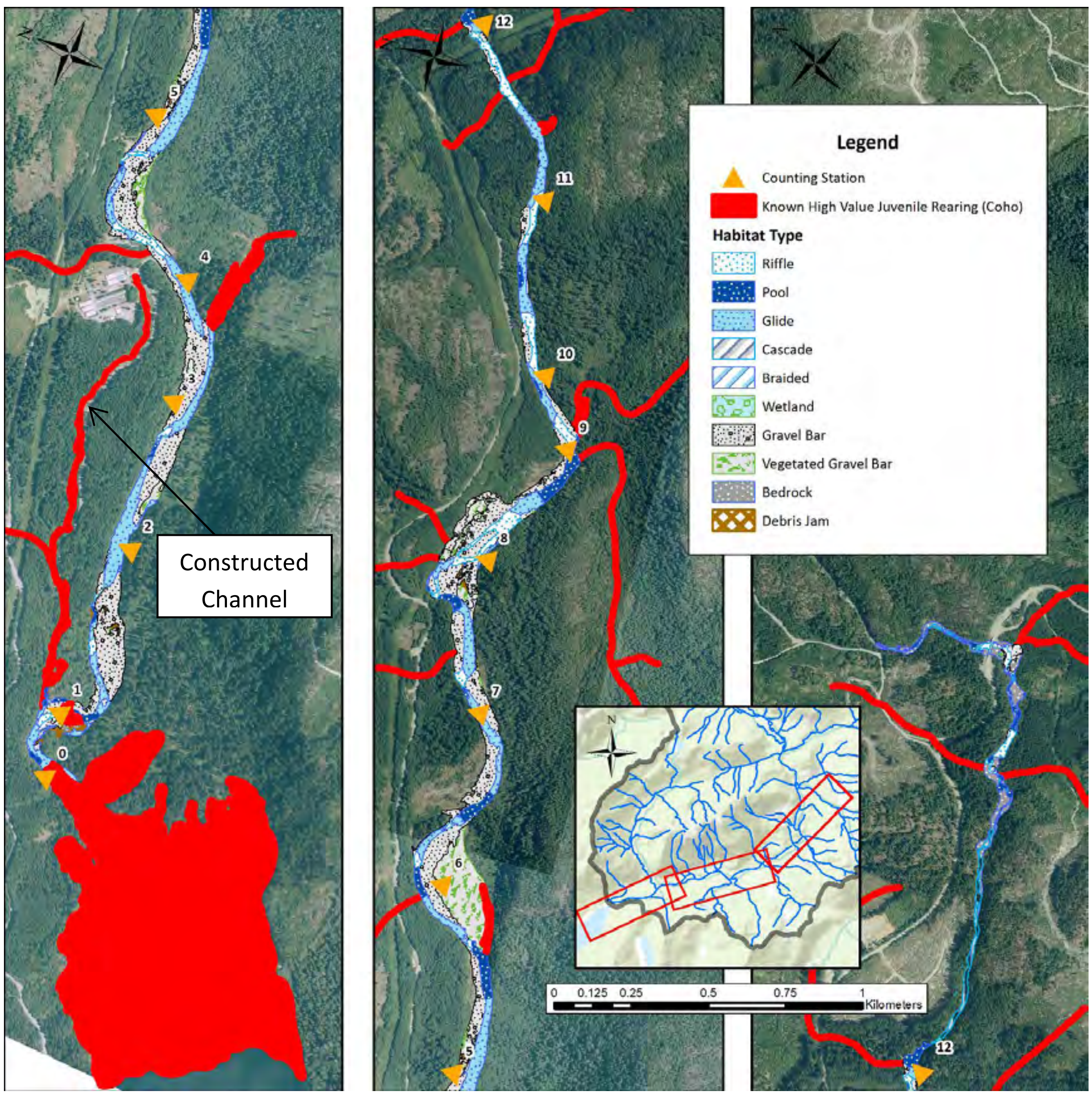

Figure 9. Known and modelled high value juvenile coho rearing habitat in the Conuma River mainstem.

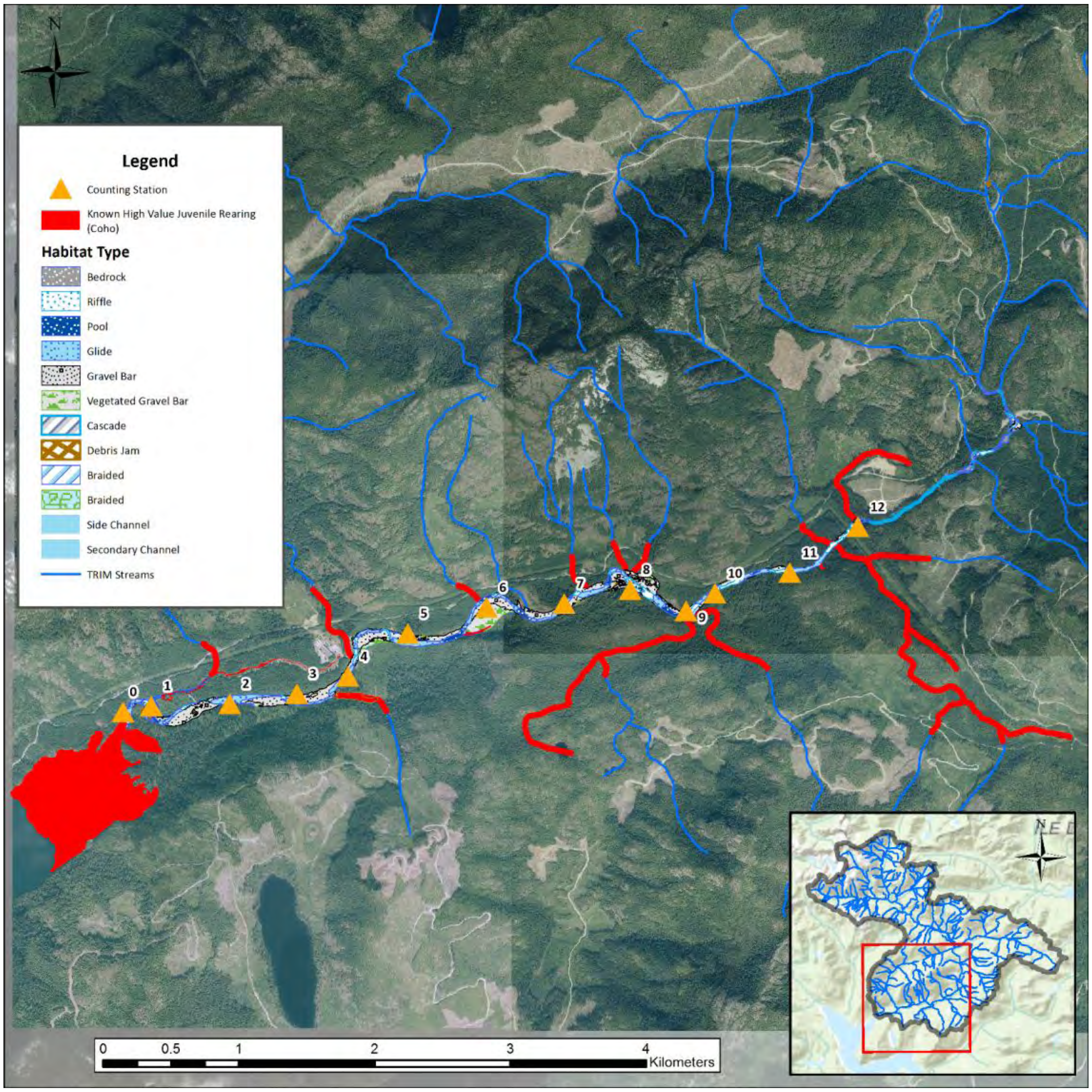

Figure 10. Known and modelled high value juvenile coho rearing habitat in the Conuma River watershed.

Coho fry outplanting in the upper watershed (above the anadromous barrier) has been conducted by Conuma River hatchery staff consistently since the 1980s; however, no studies have been done on the success of this initiative (C. Erikson, pers. comm.).

3.2.2 Escapement

Since 1953, coho populations in the Conuma River have fluctuated between 200 and 5500 fish with an average of 1140. In 1986 numbers increased to an average of 5830 (eight years after the construction of the Conuma Hatchery). During the early to mid-1990s, poor ocean survival resulted in a decrease in the abundance of coho on the WCVI, which was reflected in escapements to the Conuma River within this time frame (1993 and 1994) (Figure 11). Numbers peaked between 2000 and 2002 with more than 10,000 fish per year. Since 2003, the Conuma River has had an average coho escapement of 2980 fish.

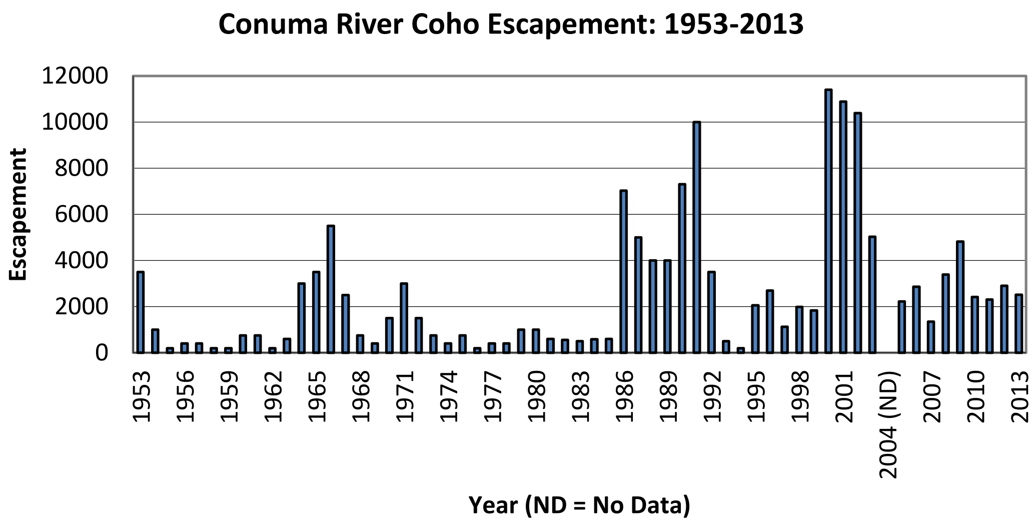

Figure 11. Coho escapement in the Conuma River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.3 Sockeye Salmon

3.3.1 Biology, Distribution, and Known Habitats

Sockeye begin spawning in the Conuma River in mid to late August, and spawning typically ends by mid-October. Distribution has been observed in the mainstem up to the falls approximately 7.21km upstream from the upper tidal extent at counting station 0 (Ministry of Environment, 2014) (Figure 12).

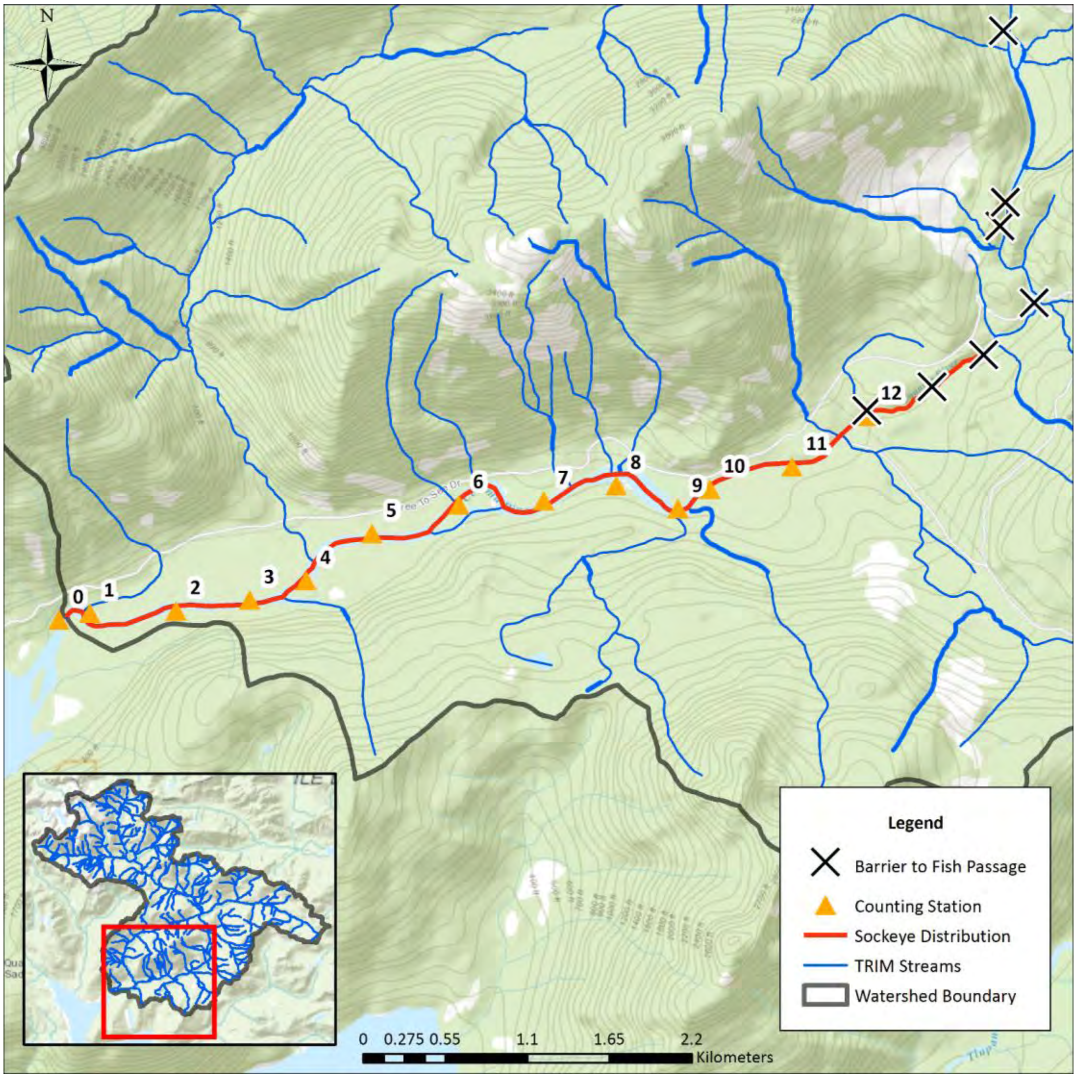

Figure 12. Known sockeye distribution in the Conuma River watershed.

Upon entry into the river, sockeye utilize the bedrock-controlled stopover pool approximately 100m upstream of the upper tidal limit for holding and osmoregulation. Other important known holding habitats upstream of the stopover pool include deep water pools adjacent to LWD between counting stations 1 and 2, a deep glide along the right bank between counting stations 2 and 3, a pool between counting station 5 and 6, a bedrock-controlled (and historical broodstock collection) pool at counting station 9, and a pool at counting station 12 (Figure 13) (C. Erikson and A. Eden, pers. comm.).

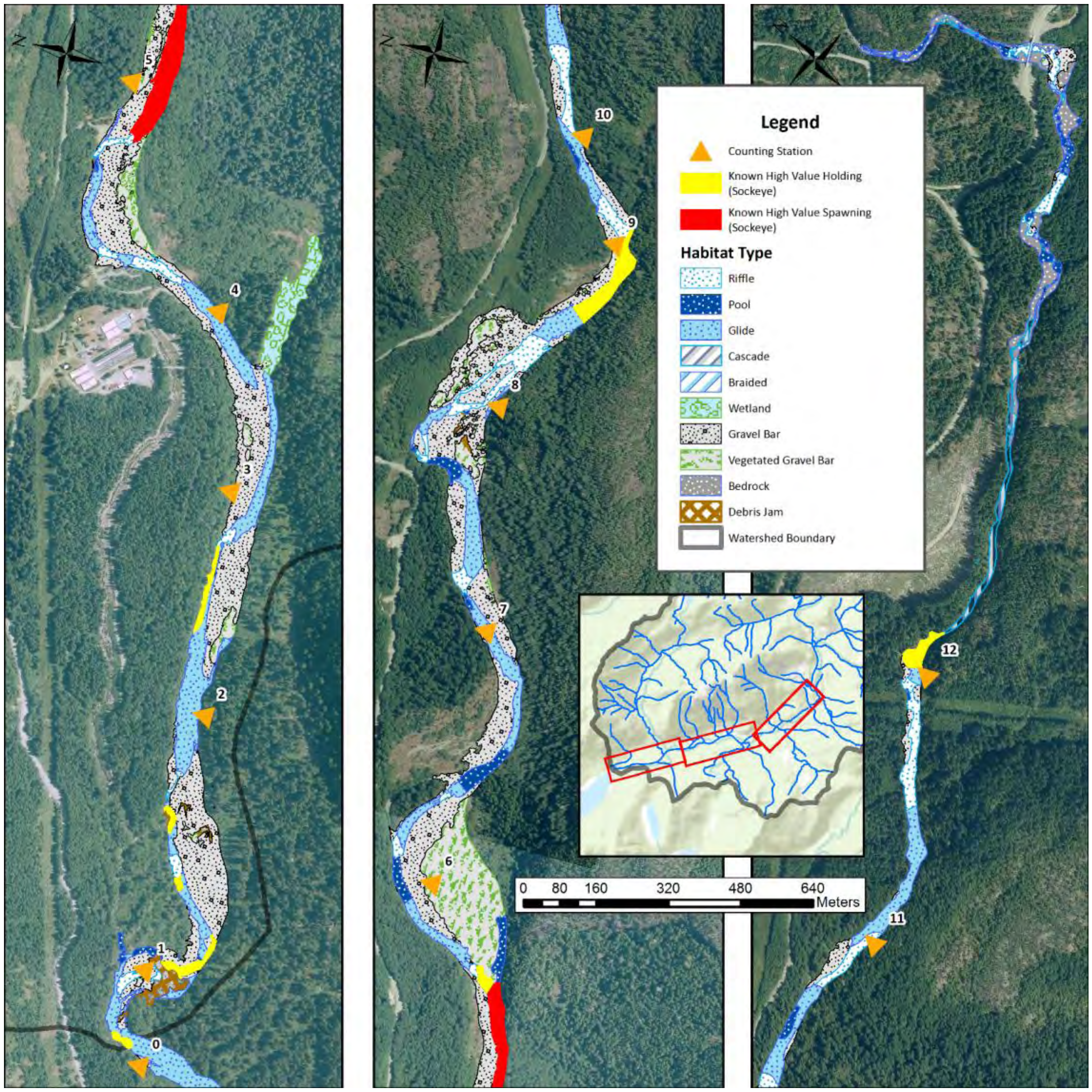

Figure 13. Known high value adult sockeye holding and spawning habitat in the Conuma River.

Sockeye in the Conuma River have a sea-type life history, meaning that following emergence, they spend only a few months rearing in the river before migrating to the estuary, where they typically rear for several months (Aitkin, 1998 and Diewert, 2007). Known high value juvenile sockeye rearing habitats in the Conuma River have been identified as the estuary, the off-channel wetland just downstream of counting station 4, the wetted area of the historic mainstem at counting station 6, and the lower reach of a tributary at counting station 9 (Figure 14).

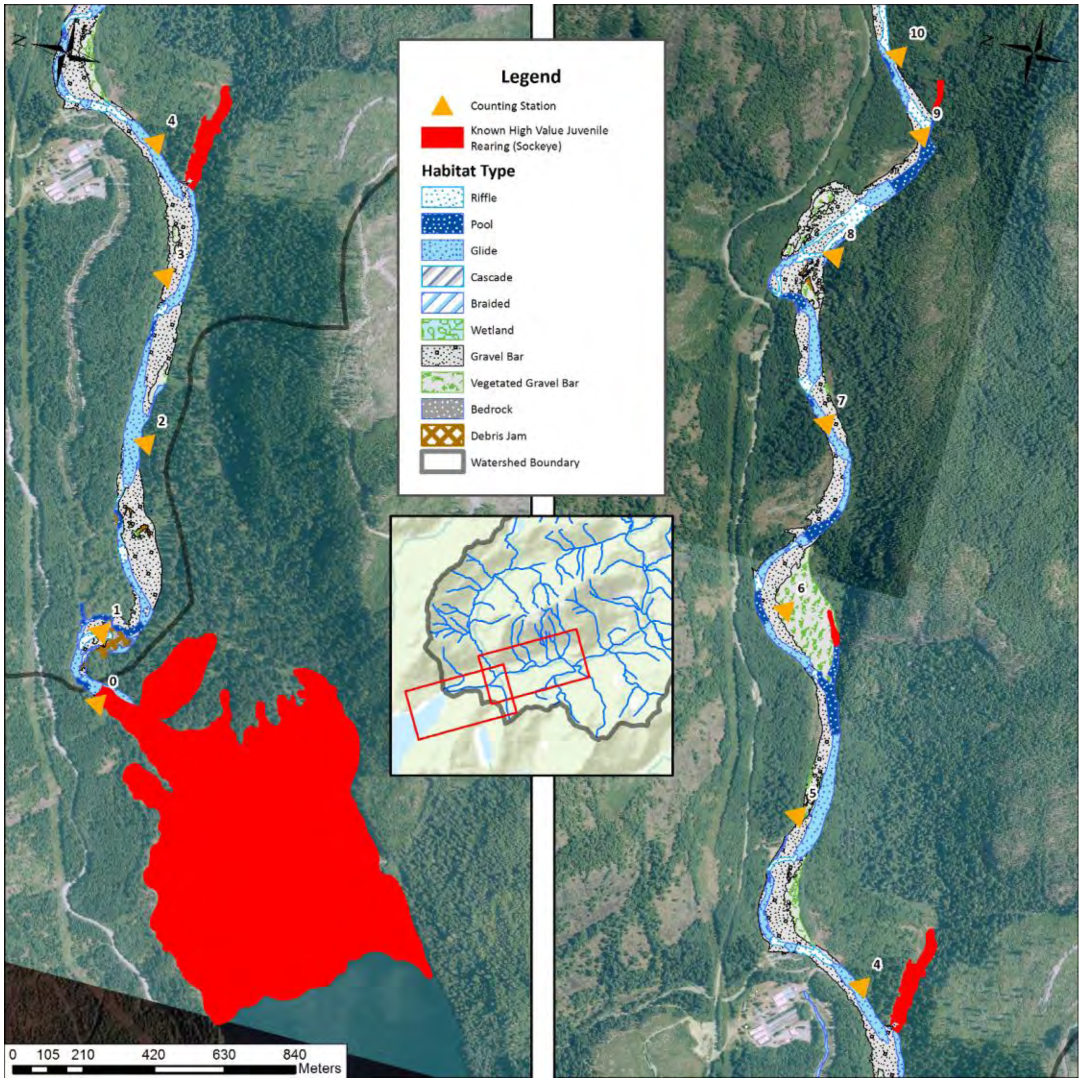

Figure 14. Known high value juvenile sockeye rearing habitat.

3.3.2 Escapement

Little data is available with respect to Conuma sockeye populations prior to 1974. Since 1974, escapements have ranged from 21 – 1,000 fish, with seasons of high and low counts. It is possible that the poor ocean survival noted for coho during the early to mid-1990s also impacted sockeye, as reduced escapement numbers were observed during this period. Between 2003 and 2010, less than 140 fish returned to the Conuma each year, and in 2011 and 2013, 945 and 306 fish returned, respectively (Figure 15).

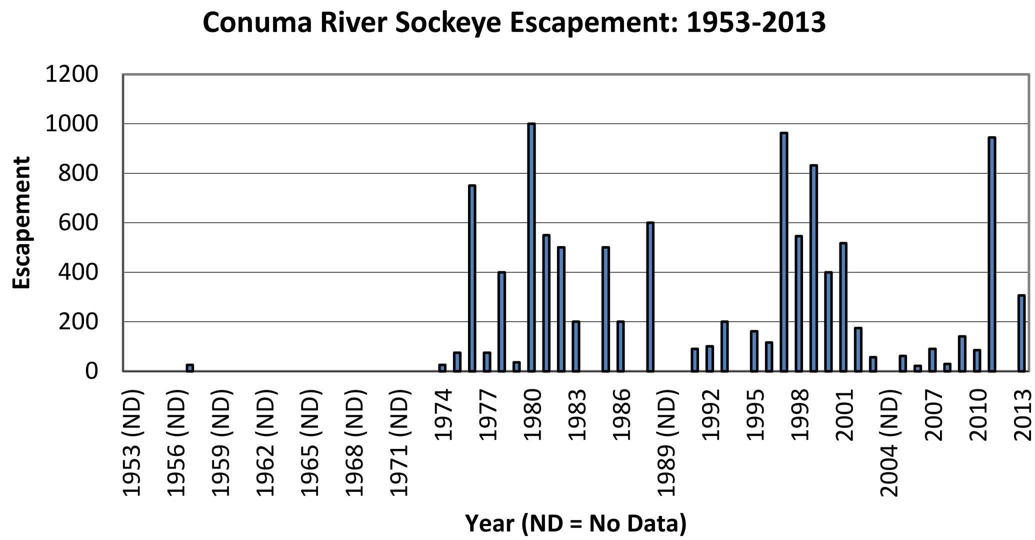

Figure 15. Sockeye escapement in the Conuma River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.4 Chum Salmon

3.4.1 Biology, Distribution, and Known Habitats

Chum begin spawning in the Conuma River in mid-September, and the run is typically complete by the end of November (Ministry of Environment, 2014). Chum distribution in the Conuma River is limited to the lower reaches, up to the canyon located upstream of counting station 12, approximately 6.75km upstream of the upper tide limit at counting station 0 (Figure 16) (Ministry of Environment, 2014).

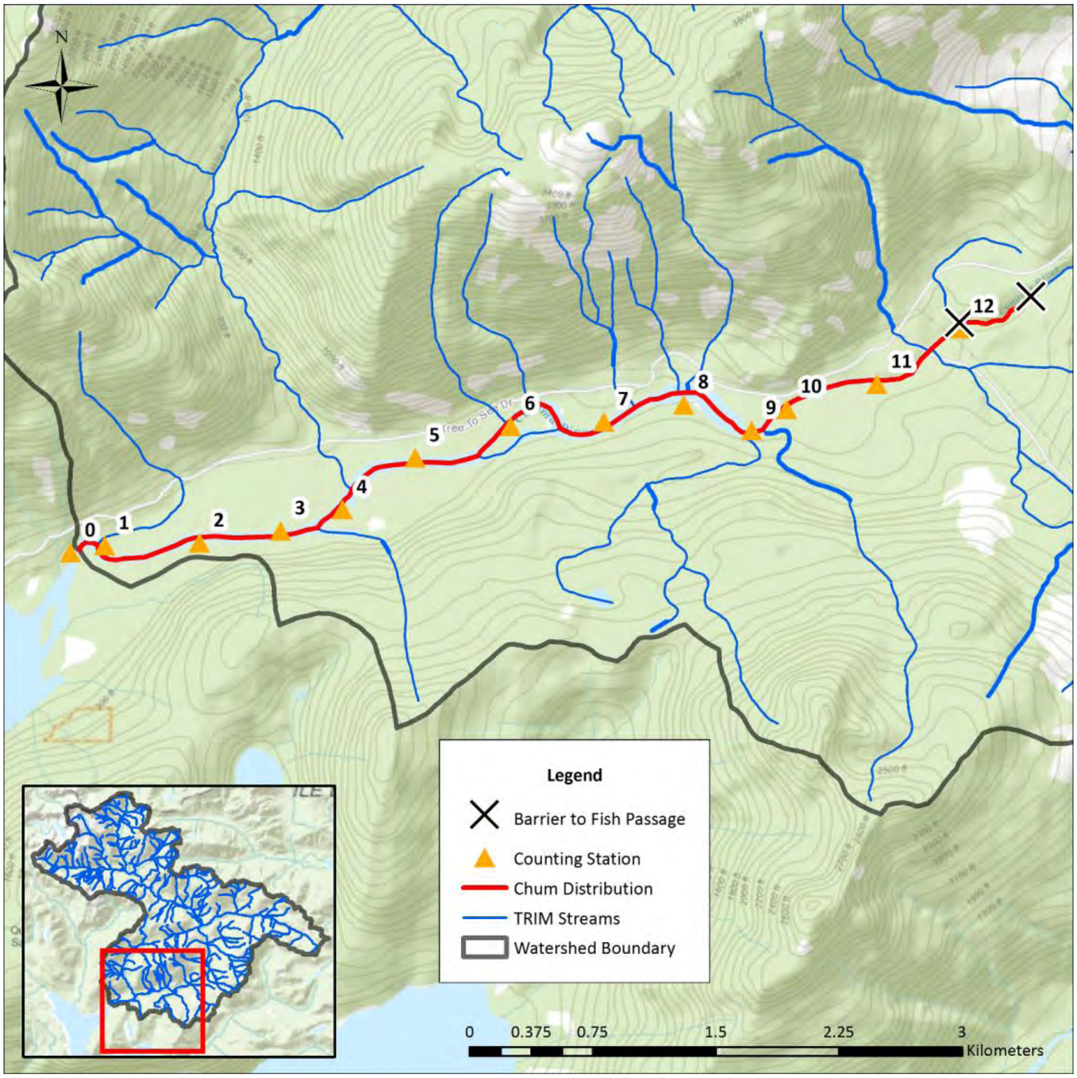

Figure 16. Known chum distribution in the Conuma River watershed.

Known high value chum holding habitats reflect those of chinook (Section 3.1.1), with holding occurring in the stopover pool at counting station 0, and in select pools and deep glides between counting station 1 and 12 (Figure 17). Like chinook, approximately 60% of the population spawns from downstream of the hatchery (i.e. counting station 5) (C. Erikson and A. Eden, pers. comm.), which is not atypical of chum who tend to remain in the lower reaches of coastal river systems (Diewert, 2007). Known high value chum spawning grounds were identified as the glide between counting station 0 and 1, the glide just downstream of counting station 5 (heavy spawning), glides between counting station 5 and 6, and the glide just downstream of counting station 10 (occasional spawning) (A. Eden and C. Erikson, pers. comm.) (Figure 17).

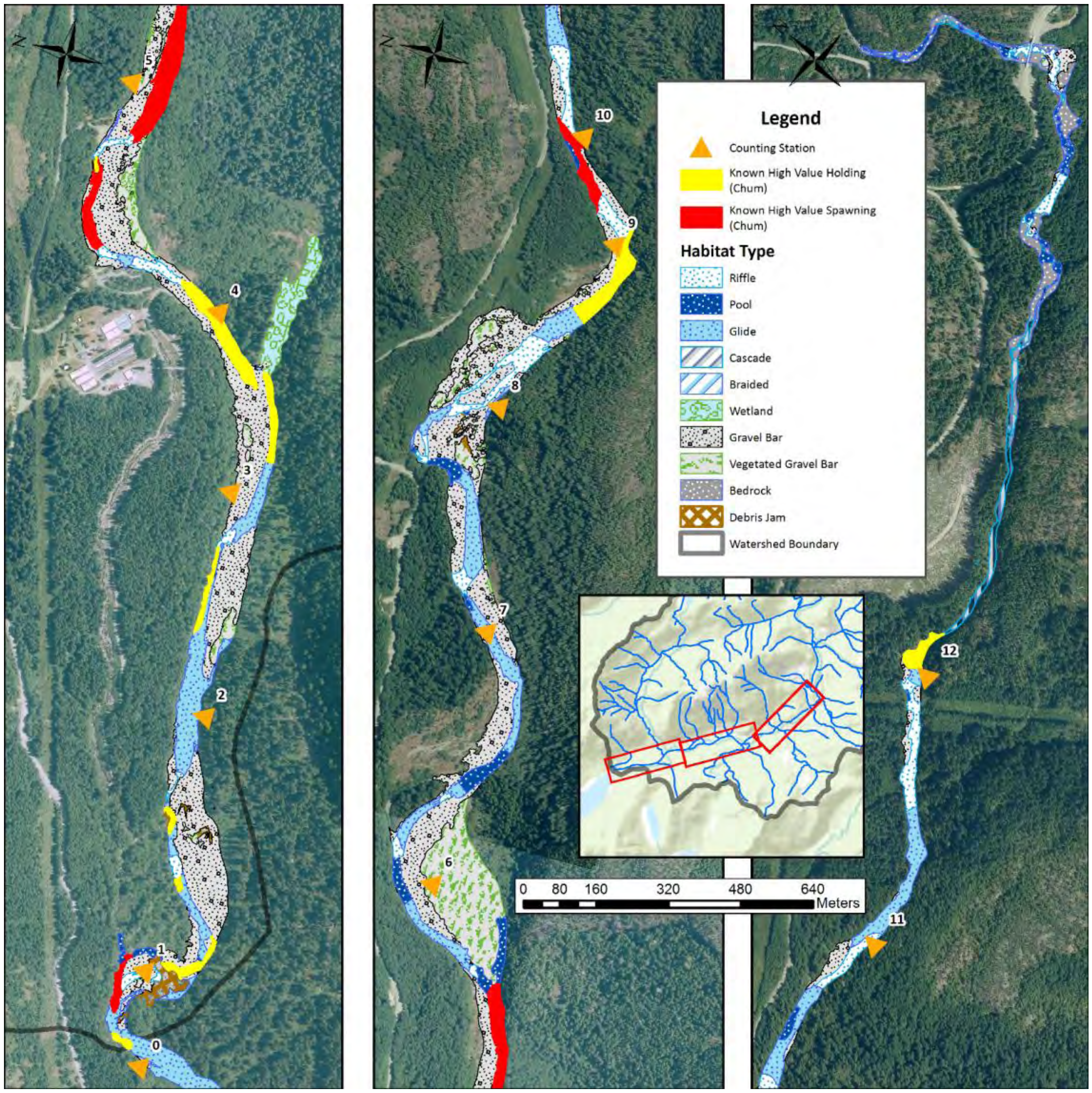

Figure 17. Known high value chum holding and spawning habitat in the Conuma River.

Like other species in the Conuma watershed, the length of time required for egg incubation is partially dependant on water temperature. Upon emergence, fry immediately begin downstream migration to the estuary, typically between the months of March and May (Diewert, 2007). Chum salmon are highly dependent on estuaries for rearing and are known to spend more time in this zone than any of the other species. This period of residence in the estuarine environment appears to be the most critical phase of the life history of chum salmon, and plays a major role in determining the size of the adult return (Diewert, 2007). Given this important life history requirement, the Conuma River estuary has been classified as known high value juvenile rearing habitat (Figure 18).

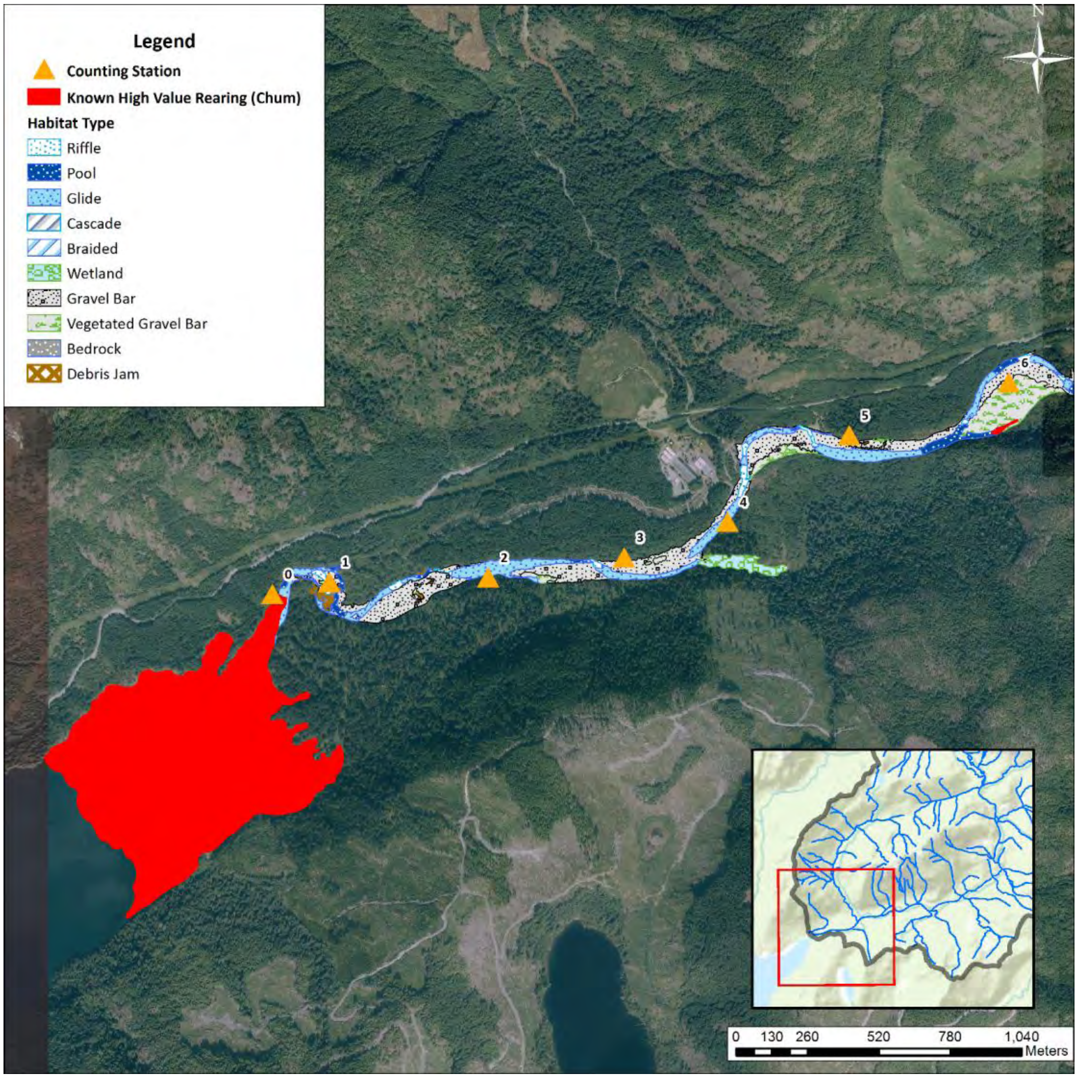

Figure 18. Known juvenile chum rearing habitat in the Conuma River estuary.

3.4.2 Escapement

Yearly chum returns from 1953 to 1979 averaged roughly 6400 fish. Escapement values were much higher between 1980 and 2003 with an average of about 37,000 and a peak of 162,252 in 1998. Since 2003, chum returns have dropped to an average of 7500 and a peak escapement of 16,602 in 2013 (Figure 19). A reduction in the hatchery production of chum coincides with the drop in chum escapement since 2003, but the decline in chum escapement cannot be fully explained by reduced hatchery production

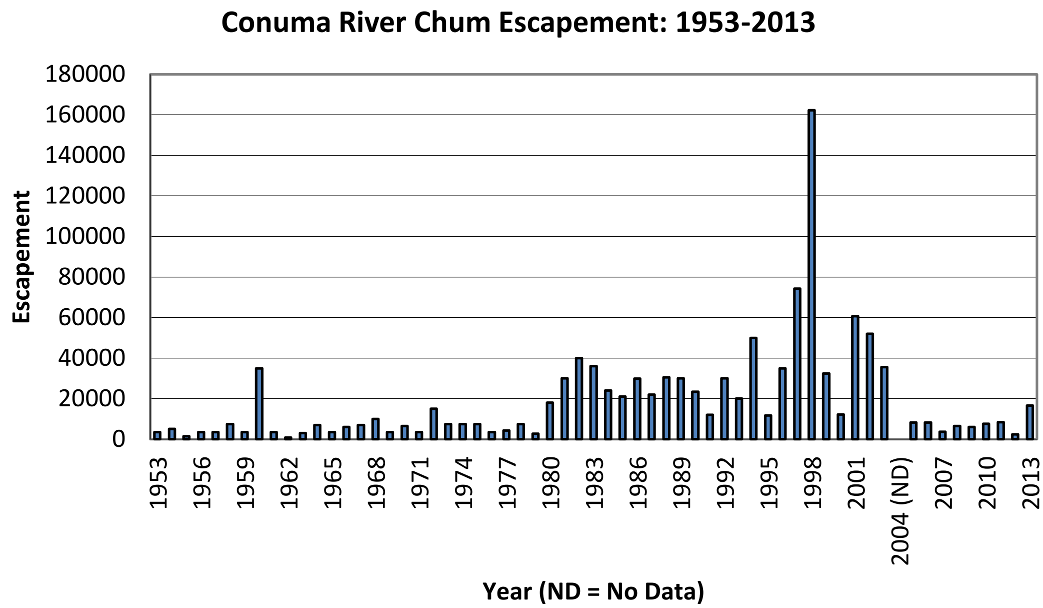

Figure 19. Chum escapement in the Conuma River between 1953 and 2013 (compiled from DFO's NuSEDs database).

3.5 Pink Salmon

Historically, pink salmon returned to Conuma River in late September and completed by mid-October (Ministry of Environment, 2014). However, returns have been virtually non-existent in recent years. This system is no longer considered to support pink salmon with counts in recent years of less than 10 fish (Figure 20). As such, this species is not considered in further discussions of habitat indicators and limiting factors.

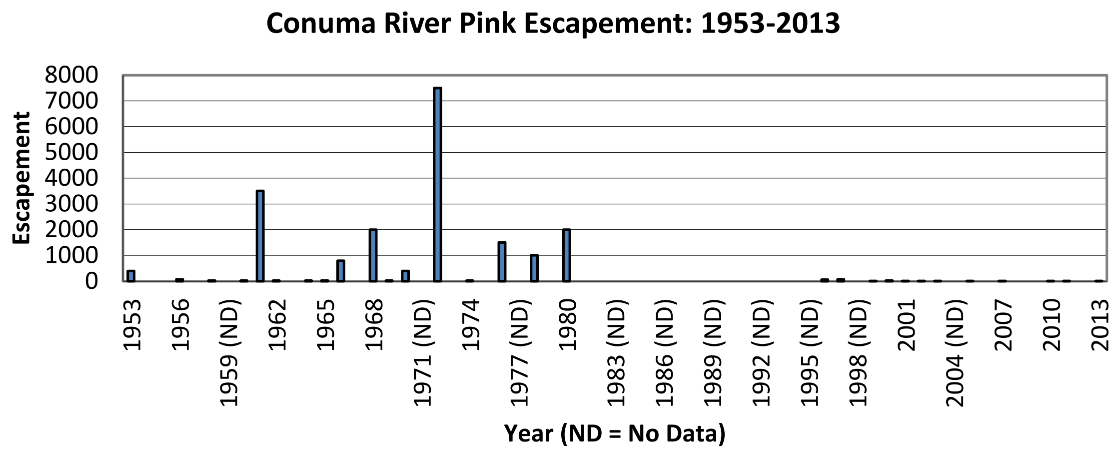

Figure 20. Pink salmon escapement in the Conuma River between 1953 and 2013 (from DFO's NuSEDs database).

4.0 HABITAT INDICATOR ASSESSMENT RESULTS

The following sections present the results of the assessed habitat status indicators in the Conuma River watershed.

4.1 Stream Pressure Indicator: Total Land Cover Alterations

Total land cover alteration within the Conuma River watershed is summarized in Figure 21:

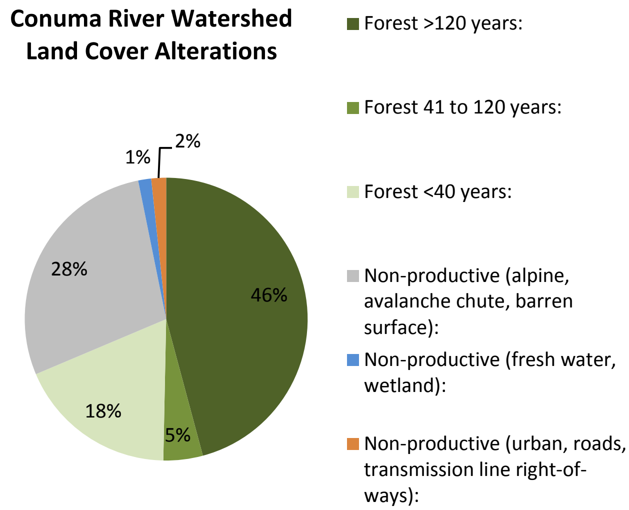

Figure 21. Total land cover alterations for the Conuma River watershed.

Based on Figure 21, approximately 75% of the total area of the Conuma River watershed remains unaltered, with mature forests (i.e. >120 years) comprising 46% of the watershed, and non-productive alpine, avalanche chutes, barren surface, and fresh water areas constituting the remainder. Approximately 2% of the watershed has been altered as roads and transmission line right-of-ways, and approximately 23% of the watershed represents altered forests (i.e. <120 years old). An assessment of the distribution of altered land cover areas demonstrated that while a large component of the watershed remains unaltered, altered areas are situated in areas adjacent to and / or within known salmonid habitats (i.e. riparian zone of the mainstem and the Conuma River estuary) (Figure 22). Considering the proximity of these alterations to known salmonid habitats, the Conuma watershed has been classified as high risk for total land cover alterations.

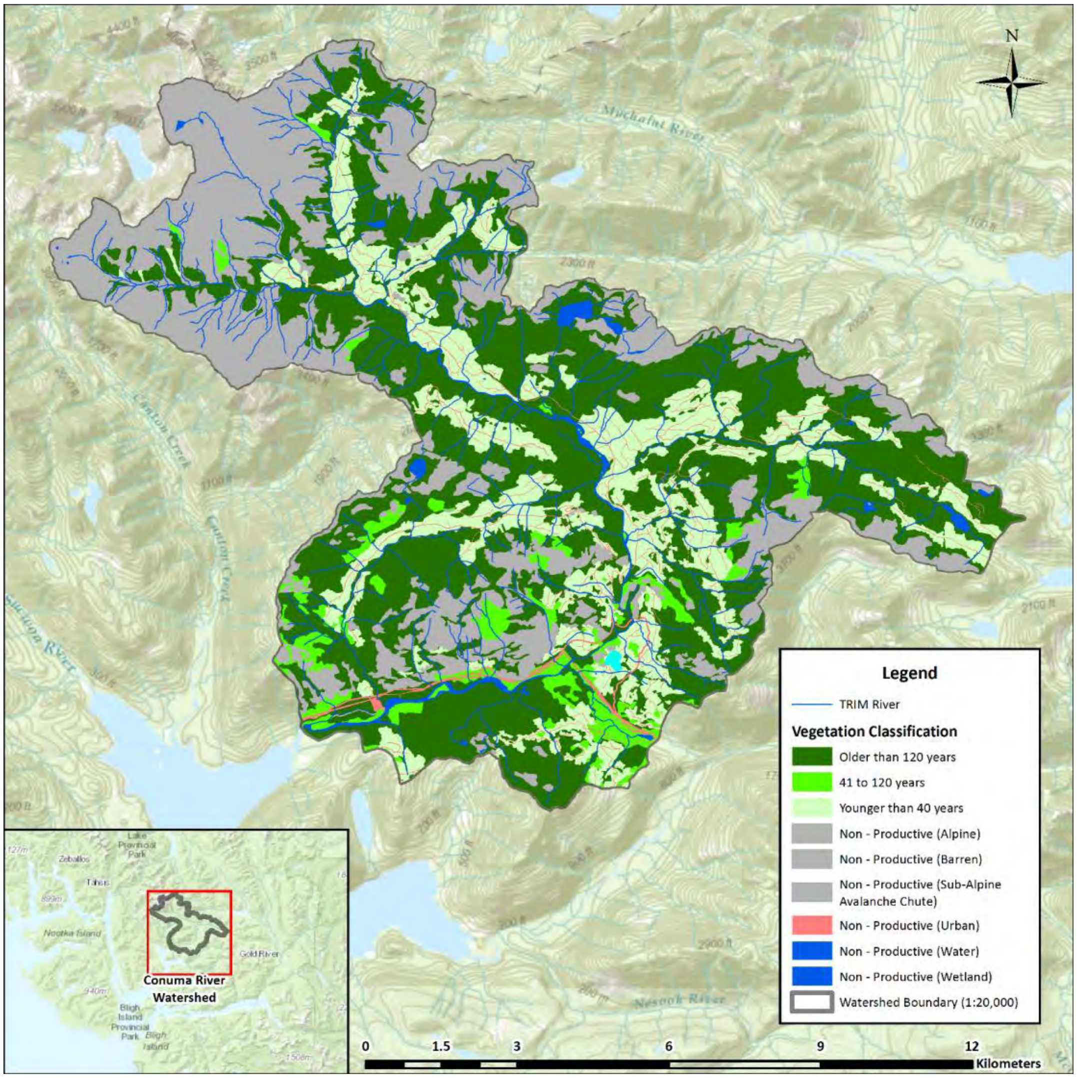

Figure 22. Total land cover alterations in the Conuma River watershed.

4.2 Stream Pressure Indicator: Watershed Road Development

Watershed road development within the Conuma River watershed was calculated at 1.24km/km^2, just above the benchmark of 1.2km/km^2 (Stalberg et al, 2009) (Figure 23). Therefore, the Conuma River watershed is considered high risk for this indicator. The roads layer used in this analysis was confirmed to be an accurate representation of past and recent watershed road development in reference to high quality orthophotos from 2013.

Despite this high road density calculation, it should be noted that simple road density (i.e. total length of road per area of watershed) does not distinguish between roads that are overgrown relative to those that are in active use, roads that have been deactivated or remediated from roads that have not, or roads built before the Forest Practices Code (FPC) from those built under FPC standards (Horel, 2008).

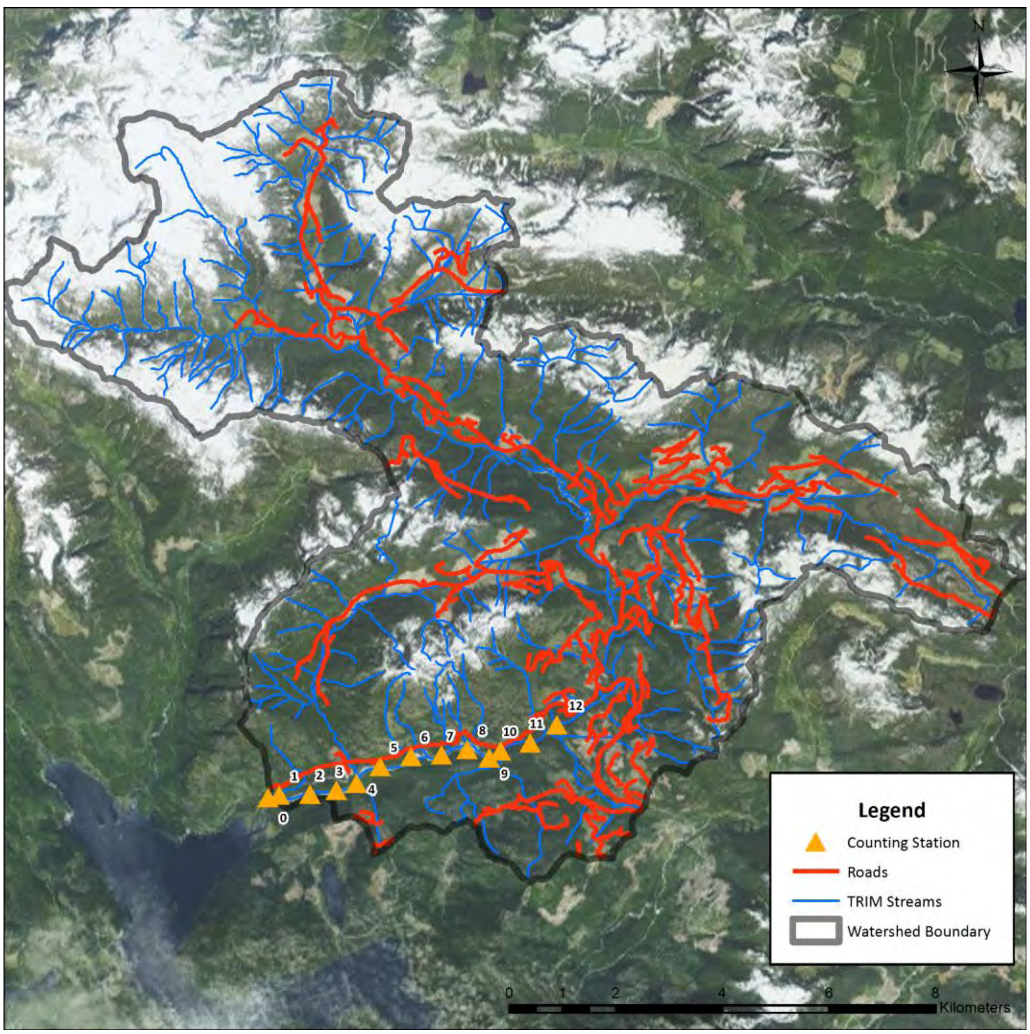

Figure 23. Conuma River watershed road density.

4.3 Stream Pressure Indicator: Water Extraction

The Conuma River watershed presently has two active water licences and one refused water licence application (Figure 24). Both of the active licences are non-consumptive. One is used as a water source for the Conuma Hatchery (Leagh Creek), which is allocated 17,849,376m^3 per year. The second licence is designated for hydroelectric power production, with 444,657,600m^3 per year. These two water licences total 37,517m^3/year/ha, and since they both represent non-consumptive use, this risk factor has been rated as low (Stalberg et al, 2009).

Six wells, located along the Leagh Creek alluvial fan provide water to the Conuma River fish hatchery, supplementing that received from Leagh Creek surface flow . Surface water from Leagh Creek is gravity fed to the hatchery from a low head concrete weir and screened intake in the bedrock controlled portion of the channel upstream of the hatchery. Conuma Hatchery demand ranges from 25L/s in the summer to 600L/s during peak winter demand (Table 3). During summer periods of low water demand, no water is diverted from the creek into the hatchery, reducing the hatchery's impact on the natural stream habitat. During spring periods of high demand, up to 300L/s of surface water are diverted into the hatchery (approximately half of the hatchery's demand – the other 300L/s coming from the 6 wells at a depth of approximately 100ft) (Reid and Walsh, 2003). As with the surface water licences, the well water extraction is a non-consumptive use and is therefore considered a low risk.

Table 3. Flow to Conuma River Hatchery from Leagh Creek and Wells

Month	Wells (L/s)	Leagh Creek (L/s)	Total Water Use (L/s)
January	140	100	240
February	300	90	390
March	300	210	510
April	300	290	590
May	300	70	370
June	25	0	25
July	25	0	25
August	25	0	25
September	140	130	270
October	140	170	310
November	60	40	100
December	140	130	270
		Minimum	**25**
		Maximum	**590**

Source: Fisheries and Oceans, Canada – Conuma River Hatchery

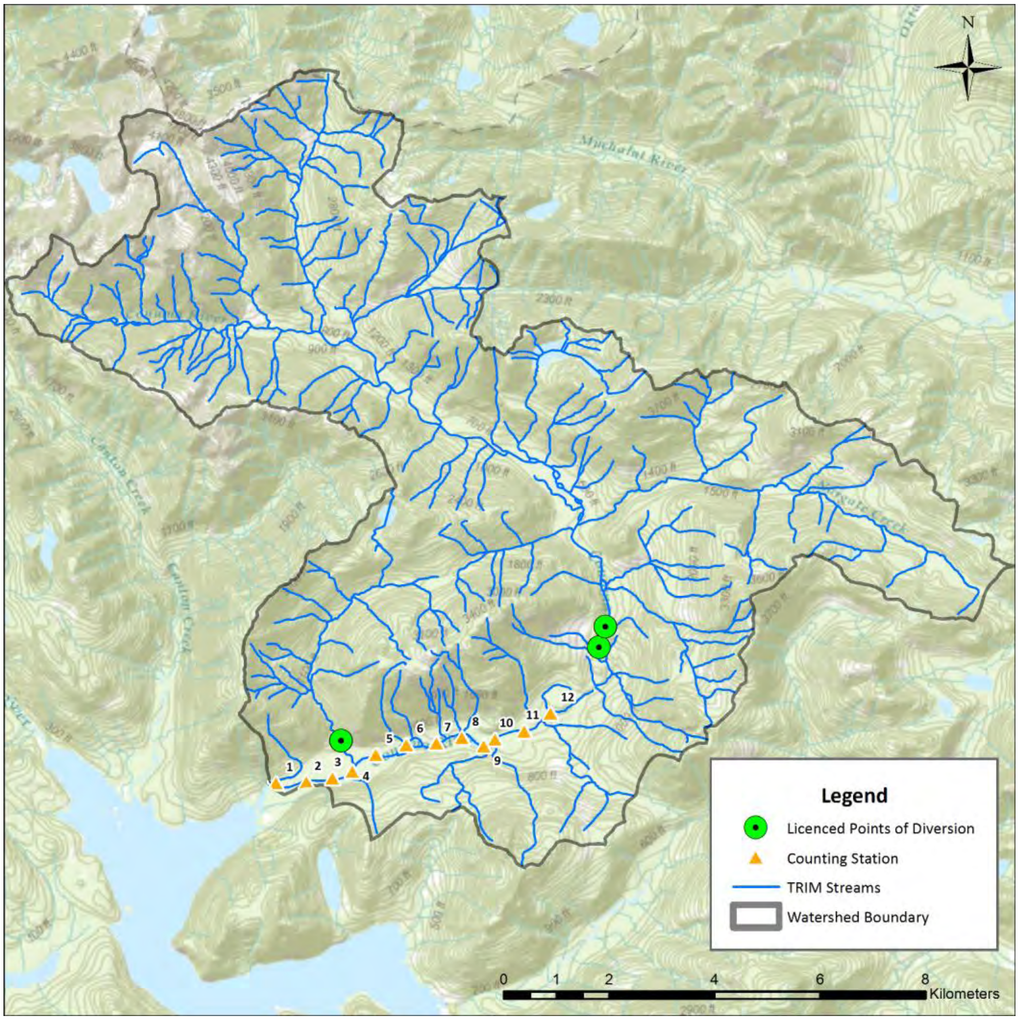

Figure 24. Licenced water points of diversion for the Conuma River watershed.

4.4 Stream Pressure Indicator: Riparian Disturbance

Past disturbances to riparian vegetation in the lower 0-300m elevation band have caused increased sensitivity of channels to high flows, and has increased the potential for surface erosion and delivery of sediment to high fish value reaches. Significant portions of the northeast riparian (left bank) were logged pre-code and reaches 7-10 still exhibit moderately aggraded channels. Much of the sediment input has resulted from natural debris/avalanche chutes upstream, however, some channel widening and aggrading has occurred as a result of historic riparian harvesting (Noseworthy, 2006). An assessment following the November 2006 storm event determined that the past riparian harvesting had not significantly impacted the channel and that with continued growth and recovery, the hazard rating of the watershed is expected to be low with some portions of the mainstem reaches 2, 7, and 10 (and tributaries) having a moderate rating, trending to low

(Noseworthy, 2006). The right floodplain of Conuma River was harvested, but much of it has re-colonized with tall, second growth conifer stands (Reid and Walsh, 2003). Still, there are significant portions of the riparian zone dominated by deciduous, regenerating and early regenerating stands.

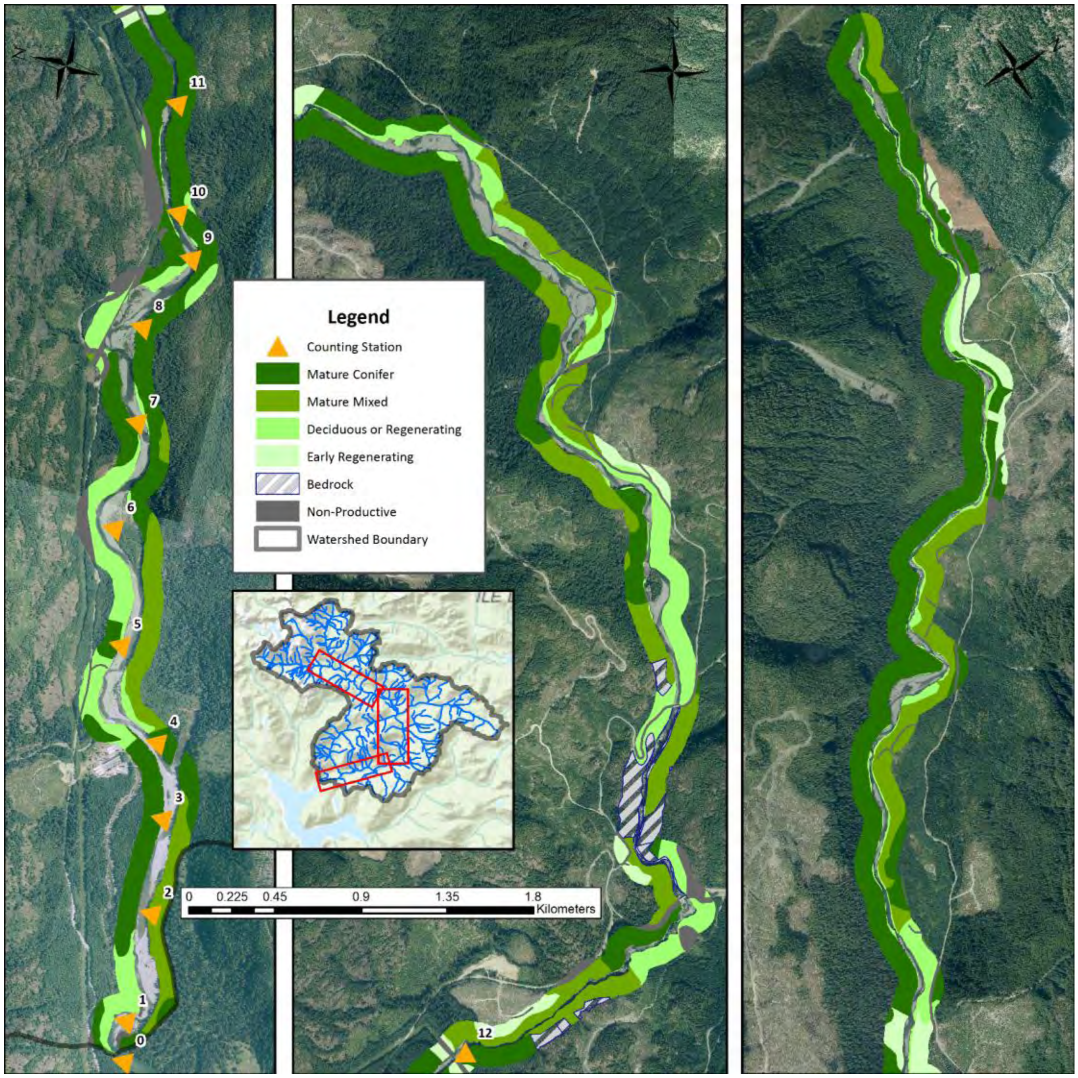

Figure 25. Riparian disturbance in the Conuma River watershed.

Throughout the anadromous reaches, spawning and rearing habitat is affected by a compromised riparian stand. Compared to other watersheds (Leiner River being the exception) assessed in Nootka Sound, Conuma has a significantly higher component of mature conifer (43.71%) and mature mixed (21.13%) riparian forest which, over time, will lead to increased channel stability. The remainder of the riparian forest in the anadromous zone is comprised of 21% deciduous and / or regenerating forest, 3% early regenerating forest, and 11.5% non-productive areas (Figure 26).

Based on the significant component of mature riparian forest in the watershed and the improving riparian trend, riparian disturbances in the Conuma River watershed have been rated as moderate.

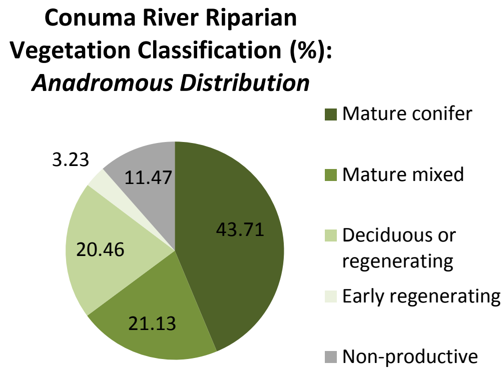

Figure 26. Riparian vegetation composition for the anadromous reach of the Conuma River watershed.

An analysis of riparian condition for tributaries to the Conuma River was not completed. As such, this has been identified as a data gap for coho, considering this species is the heaviest utilizer of tributary habitats.

4.5 Stream Pressure Indicator: Permitted Waste Management Discharges

No permitted waste management discharges were identified in the Conuma River watershed.

4.6 Stream State Indicator: Water Quality

Of the water quality samples collected in 2007 at the 15 regional geochemical stream survey sites located within the Conuma River watershed (Figure 27), all of the results were compliant with the Canadian Water Quality Guidelines for the Protection of Aquatic Life except for pH (BC Ministry of Energy and Mines, 2015). Fluoride levels ranged from 10 to 32µg/L, well below the long-term guideline of 120µg/L (Canadian Council of Ministers of the Environment, 2014). Uranium samples were all below 0.10µg/L, well below the long-term guideline of 15µg/L. Reported pH values ranged from 5.0 to 7.1, with 11 of the sites falling below the minimum long-term guideline of 6.5, and two sites with values below 6.0.

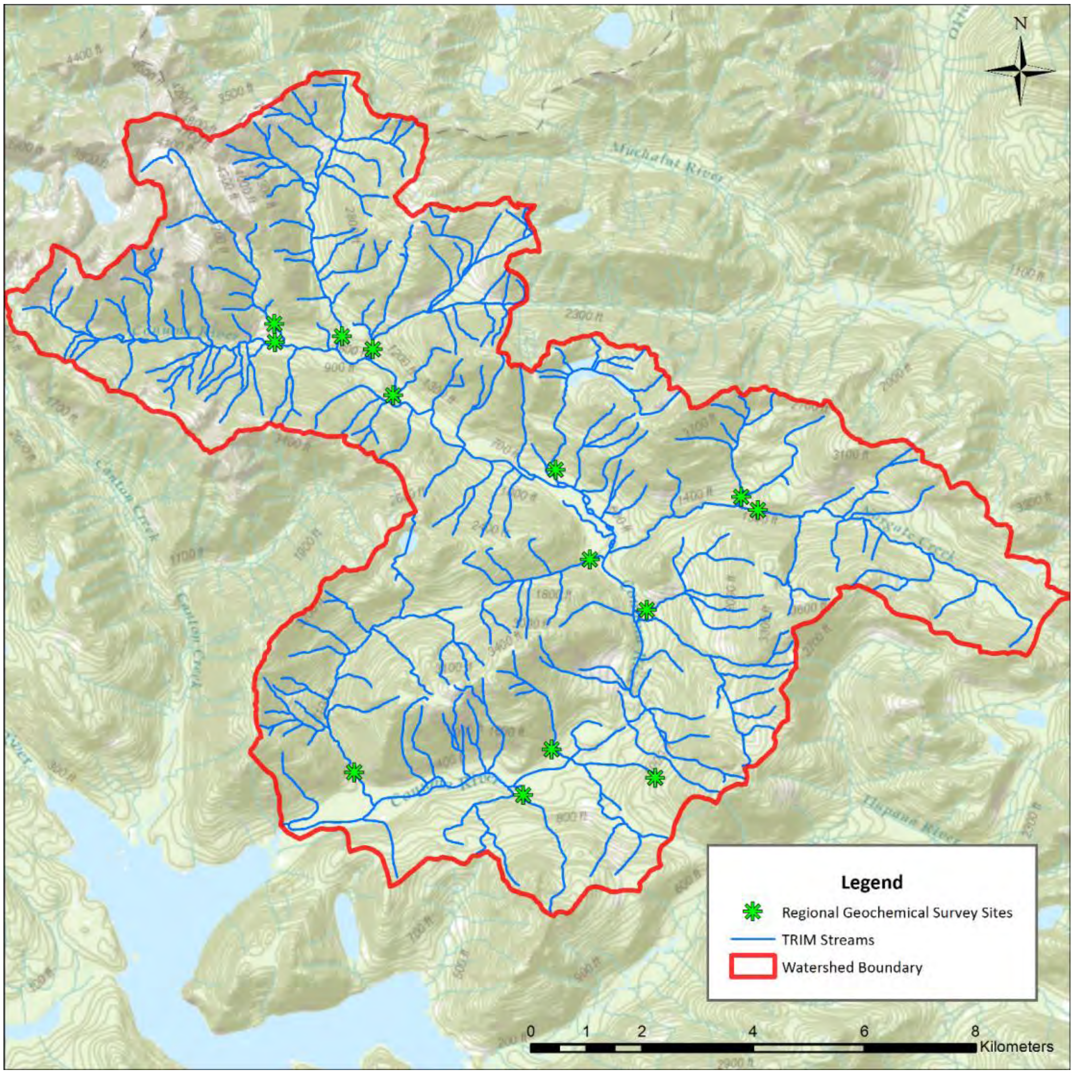

Figure 27. Regional geochemical stream survey locations in the Conuma River watershed.

Note that the available water quality data for the Conuma River watershed was both spatially and temporally limited to the 2007 regional geochemical stream survey at six locations. No dissolved oxygen data was available for either the Conuma River or its tributaries. While no exceedances were identified with the available data, the spatial and temporal distribution of this data, and the number of sampling parameters, were not robust enough to determine any influence water quality may have on fish production in the watershed. As such, the water quality habitat indicator has been identified as a data gap.

4.7 Stream State Indicator: Water Temperature (Migration and Spawning)

Compilation of SIL data collected during the spawning period on the Conuma River demonstrated water temperatures to have remained below the UOTR (between 14°C and 20°C) for all species between 2007 and 2013 (Table 4). As such, this habitat indicator was ranked as low risk.

Note that this indicator was identified as a partial data gap given the limited temporal distribution of these point samples (no water temperature measurements from the mainstem were available for July, and only one was available for August when it would be more likely for the temperature to exceed the UOTR).

Although the Conuma River Hatchery collects water temperature data for Leagh Creek and the well water used for hatchery fish production, these temperatures are not representative of the mainstem. However, the Leagh Creek dataset is valuable as the lower portions of Leagh Creek have been identified as accessible to coho, and the data has been collected daily since April 21, 2010. The water temperature in Leagh Creek exceeded 14°C for 3 days in July of 2010, 4 days in August of 2010, 4 days in August of 2012, 4 days in August of 2013, and 18 days in August of 2014. The maximum water temperature was 14.98°C, measured in August of 2010.

Table 4. Water temperature data from 2007 to 2013 for the Conuma River during adult migration and spawning.

CONUMA RIVER						
Year	***Date***	***Temperature (°C)***	***Species Present***			
			SK	***CO***	***CH***	***CM***
2006	23-Sep	10.5	X	X	X	X
	7-Oct	8	X	X	X	X
	1-Nov	8	X	X	X	X
	14-Nov	8		X	X	X
2007	6-Sep	8	X	X	X	X
	17-Oct	6	X	X	X	X
	26-Oct	7	X	X	X	X
2008	7-Sep	7.5	X	X	X	X
	25-Sep	10	X	X	X	X
	3-Oct	ND	X	X	X	X
	15-Oct	ND	X	X	X	X
	24-Oct	0.5		X	X	X
	19-Nov	ND	X	X		X
2009	9-Sep	ND		X	X	
	13-Sep	ND	X	X	X	X
	25-Sep	ND	X	X	X	X
	2-Oct	ND	X	X	X	X
	14-Oct	ND	X	X	X	X
	22-Oct	8.4	X	X	X	X
	28-Oct	ND	X	X	X	X
	4-Nov	4.1	X	X		X
2010	15-Sep	ND	X	X	X	X
	7-Oct	9	X	X	X	X
	15-Nov	8		X		X
2011	30-Sep	ND	X	X	X	X
	27-Oct	6	X	X	X	X
2012	28-Aug	11.5		X	X	X
	10-Sep	11.5		X	X	
	16-Sep	9.5		X	X	X
	17-Sep	11			X	X
	21-Sep	12		X	X	
	11-Oct	9	X	X	X	X
	17-Oct	9				
2013	6-Sep	11			X	
	27-Sep	11			X	
	11-Oct	10			X	
	26-Oct	9		X	X	X

4.8 Stream State Indicator: Discharge

Discharge data for the Conuma River was unavailable, and has been identified as a data gap.

4.9 Stream State Indicator: Accessible Stream Length

Information on accessible stream length for the Conuma River watershed was limited to the FISS Report and Fish Distribution shapefiles (Ministry of Environment, 2014), and the Preliminary Stream Catalogue that formed the basis of the distribution information provided in the FISS report (Brown et al, 1979). Based on the GIS distribution data presented in Figure 3,

Figure **7**, Figure 12, and Figure 16, Table 5 summarizes accessible stream length by species.

Table 5. Accessible stream length, by species, for the Conuma River watershed.

	Chinook	Coho	Sockeye	Chum
Mainstem	7.21km	7.21km	7.21km	6.75km
Tributary (Inferred)	ND	10.54km[i]	ND	ND
Tributary (Known)	ND	2.20km	ND	ND
Total	8.21km	19.95km	8.21km	6.75km

Note: No data (ND) is available for the accessible length of tributaries for chinook, sockeye and chum, and the accessible tributary length provided for coho is modeled.

Local knowledge and stream surveys may help refine the fish distribution information available for the Conuma River watershed. Particularly the distribution within tributaries is a data gap, and further assessment will be required to determine if accessible stream length is a limiting factor to fish production (i.e. if this length has reduced over time as a result of past forestry impacts).

4.10 Stream State Indicator: Key Spawning Areas (Length)

Key spawning area lengths, by species, were calculated based on the locations presented in Figure 4, Figure 8, Figure 13, and Figure 17.

Table 6. Key spawning area lengths, by species, for the Conuma River.

Chinook	Coho	Sockeye	Chum
4.93km	4.31km	1.20km	3.60km

4.11 Stream State Indicator: Stream Crossing Density

Table 7 summarizes the available stream crossing data for the Conuma River watershed.

Table 7. Stream crossing density (and fish-bearing status) in the Conuma River watershed, as modelled in the PSCIS database.

Stream Crossing Density: CONUMA RIVER	
# of Crossings:	168
# of Fish-Bearing:	79
# of Non-Fish Bearing:	89
Crossing Density:	1.36 / km^2

[i] Tributary accessibility is inferred based on tributary gradient modeling.

Of the modelled stream crossings in the Conuma River watershed, 47% coincide with known and inferred fish habitat (anadromous and freshwater resident). Due to the high density of stream crossings in the watershed, this indicator was assessed as high risk.

4.12 Stream State Indicator: Habitat Composition

An analysis of habitat in the Conuma River watershed indicated the lower reach of this system to be dominated by gravel bars and contain very little pool habitat. From the river mouth up to the pool approximately 390m downstream of counting station 6, there is a lack of pool habitat and the channel is primarily characterized by aggraded sections and glides. Sections with the highest pool frequencies included from 390m downstream to 350m upstream of counting station 6, and the upper 1km below the anadromous barrier. There is also a prominent pool section extending 170m downstream from counting station 9 (see Figure 28).

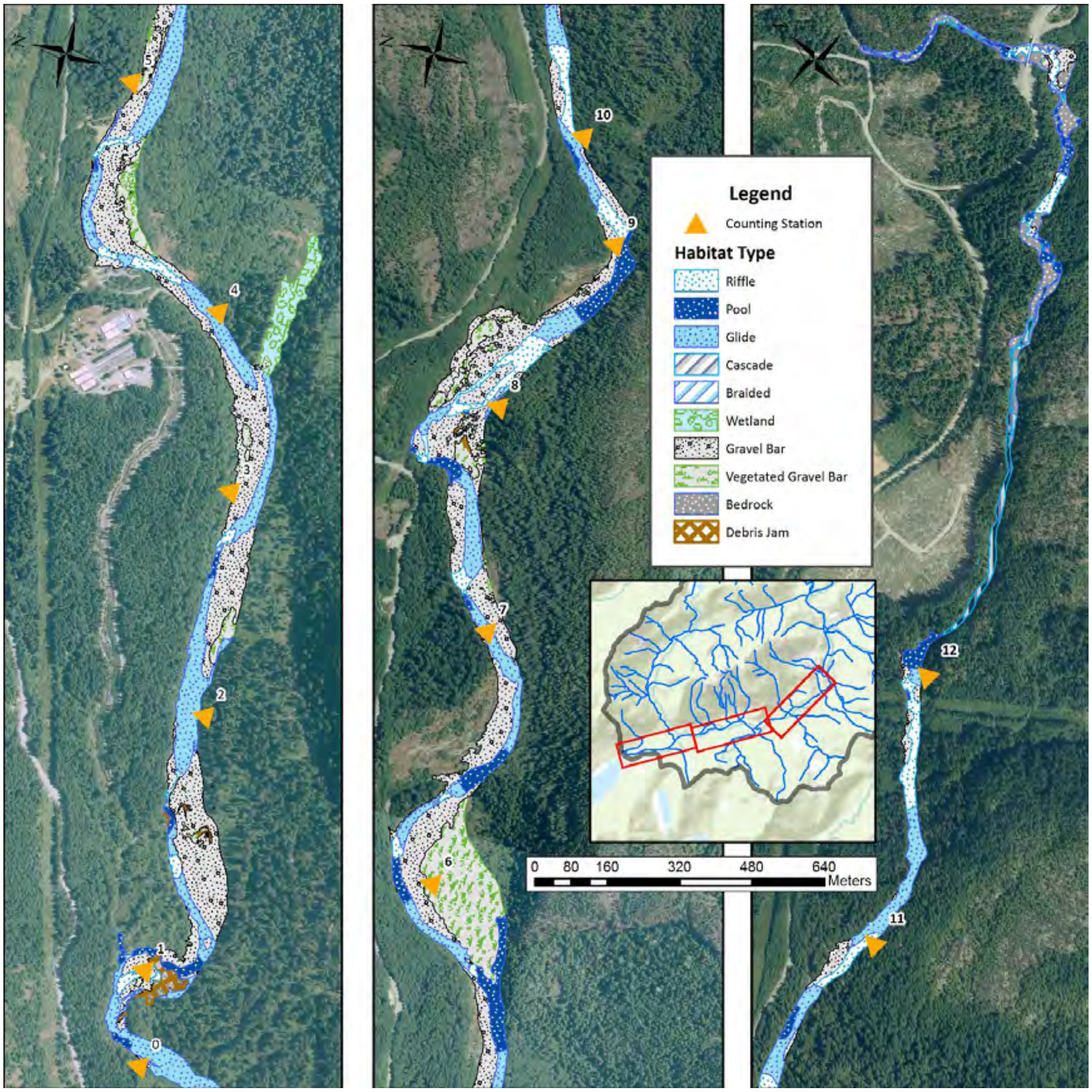

Figure 28. Habitat unit composition (2013) of the Conuma River.

All species and life stages in the Conuma River have access to limited pool habitat (approximately 7.41% when gravel bar composition is considered, and 18.25% when gravel bar composition is not considered) (Figure 29). The benchmarks described in Johnston and Slaney (1996) indicate that for systems with an average bankful width less than 15m and with gradients of <2%, poor salmonid habitat condition for summer and winter rearing occurs with <40% pool habitat area by reach. Similar conditions are experienced in systems with gradients between 2% and 5% where <20% pool habitat area is observed. Note that the Conuma River has an average width greater than 15m, and standards are not provided by Johnston and Slaney (1996) for channels wider than 15m. Still, with this limitation in mind, it is clear that there is a lack of pool habitat throughout the anadromous distribution of the watershed. Considering this benchmark, the habitat composition indicator for the Conuma River has been classified as high risk.

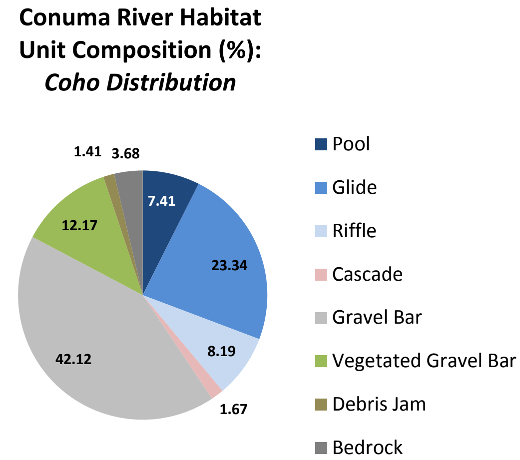

Figure 29. Habitat unit composition in 2013, by species distribution, for the Conuma River.

A comparison of habitat unit composition between 1995 and 2013 (from the upper tidal limit to the anadromous barrier) has demonstrated an increase in pool habitat from 4.37% to 7.41% (Figure 30 and Figure 31). The overall percentage of pool habitat (when not considering gravel bar composition) has increased from 12% in 1995 to 18% in 2013. A positive indication of channel recovery included the decrease in the proportion of gravel bar area of 6%, an increase in vegetated gravel bar area by 3.5%, and overall decrease in gravel bar and vegetated gravel bar by 2%. Glide habitat increased from 16% to 23% and riffle habitat decreased from 20% to 8%, which are also positive indications of channel recovery. Note that inconsistencies may have affected the results of this comparison, particularly the difference between the lower quality 1995 aerial photo and the higher quality 2013 orthophotograph, and that the 1995 habitat units were primarily based on field-collected GPS data while 2013 habitat units were determined entirely through orthophoto interpretation. A field survey of habitat breaks would provide for a more reliable comparison between the 1995 and 2013 habitat compositions.

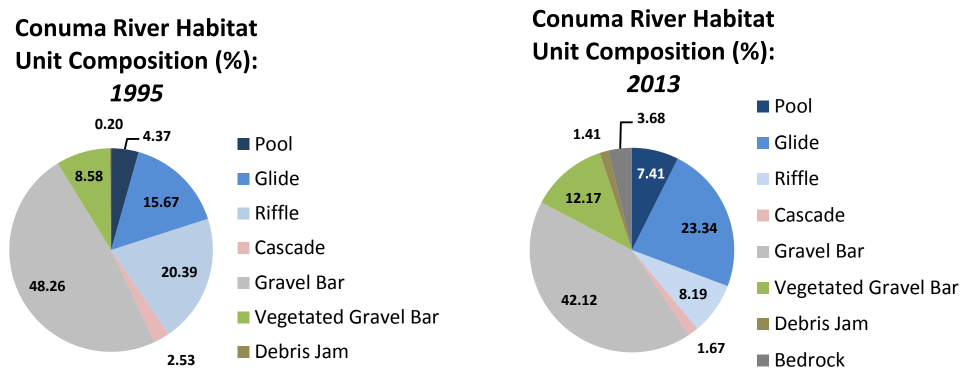

Figure 30. Change in habitat unit composition between 1995 and 2013 in the Conuma River, between the upper tidal limit and the anadromous barrier.

Interviews with local experts indicated that degradation of historical chum and chinook spawning grounds through the infilling of gravels and sand has occurred in recent years. Pool infilling has been observed near the hatchery and confluence with Leagh Creek (a once important holding pool), and it is hypothesized that fish are exhibiting reluctance to move upstream due to a lack of holding pools in the system (Nootka Sound Watershed Society, 2015).

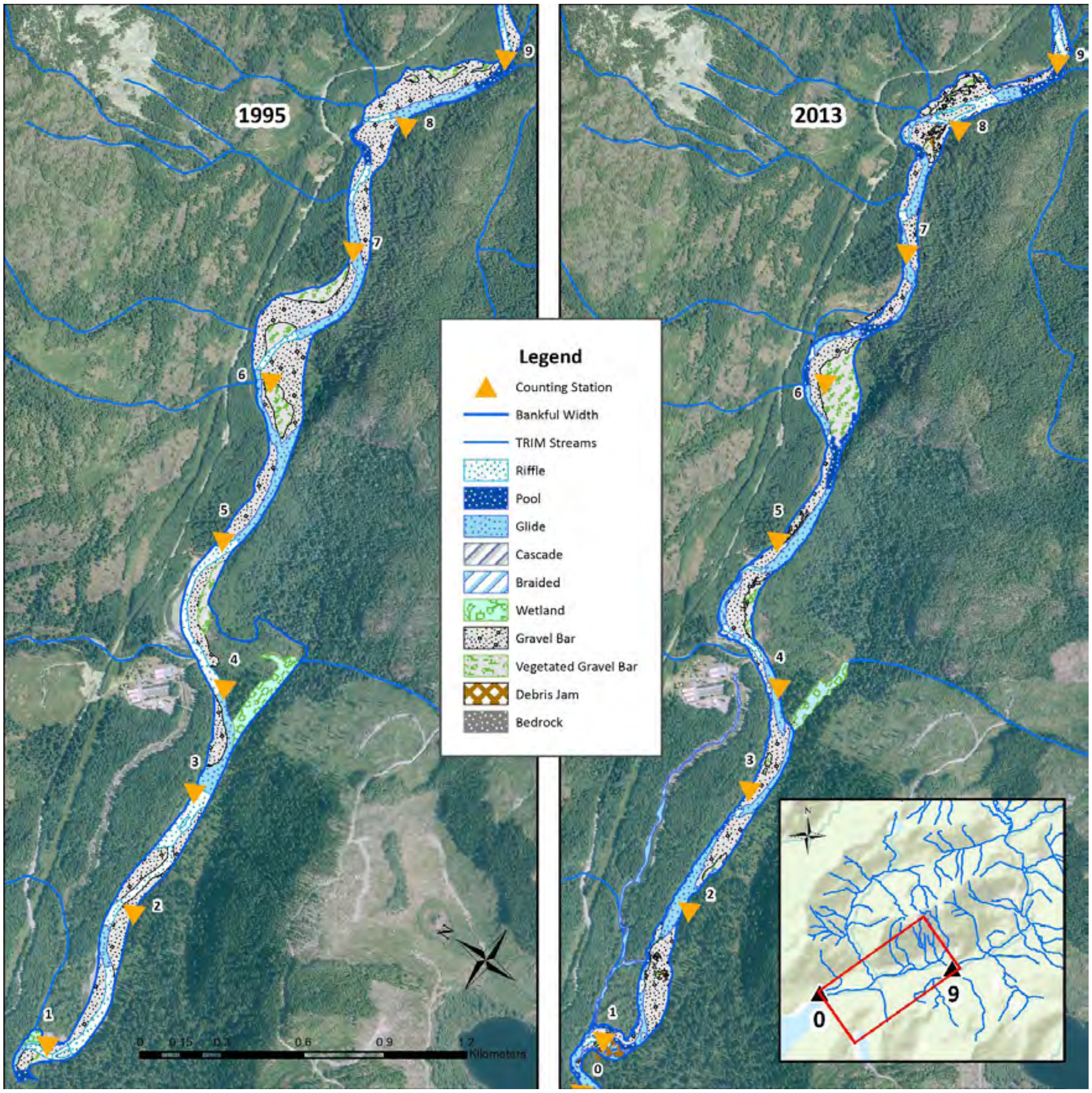

Figure 31. Habitat unit composition comparison between 1995 and 2013 (note gain in pool habitat between counting stations 5 and 9, and reduction in riffles between counting station 1 and 5).

4.13 Stream State Indicator: Channel Stability

A comparison of 1980, 1995, and 2013 imagery between counting stations 1 and 12 demonstrated some significant migration of the channel banks in the lower river over time (Figure 32). Channel widening occurred between 1980 and 1995, between counting stations 8 and 9 and at counting station 6. At counting station 6, the left bank migrated about 140m between 1980 and 1995, and has remained relatively stable since, likely in part due to the mature conifer and mature mixed riparian stand along the left bank. The downstream half of the gravel bar along the left bank at counting station 6 is colonized by deciduous trees, showing potential for recovery, however the upstream half is only sparsely vegetated and appears to experience significant flows during high water events. The right bank at counting station 6 has migrated about 25m towards the road since 1995, and as little as 35m of deciduous riparian forest separated the right bank from the road prism in 2013. Between counting station 6 and 7, the right bank appears to be in the process of revegetation following the migration of the left bank by about 40m since 1980. Still a large proportion of the right side gravel bar has only been colonized by shrubs (likely willow) and there are signs of scouring from high flows.

At counting station 8, the channel width increased from approximately 50m in 1980 to approximately 140m in 1995 and 2013. This section is heavily aggraded with a braided channel, and deciduous trees are dominant along right bank. Some revegetation has occurred on the gravel bars, but the rate of recovery appears to be slow. The right bank extending 270m downstream of counting station 9 has revegetated with deciduous trees, narrowing the channel by up to 55m since 1995, although the upstream end of this vegetated gravel bar is still dominated by shrubs. Interviews with local experts confirmed the channel at this location is highly mobile and changes annually, with sand deposits and reduced substrate quality present throughout this zone (C. Erikson and A. Eden, 2015).

The channel has migrated through the erosion of the right bank between counting stations 4 and 5, just upstream of the hatchery. Interviews with local experts confirmed this erosion to be problematic and possibly posing a threat to the hatchery should the river breach the right bank at this location (Nootka Sound Watershed Society, 2015). Based on the imagery comparision, the right bank had eroded by 30m between 1980 and 1995, and since 1995 the right bank has migrated up to 65m toward the road. As this eroding right bank is bordered by a deciduous riparian stand, the channel is at risk of migrating a further 50m until it reaches the road prism. Interviews with local experts also indicated erosion to be occurring within the lower 150m of Leagh Creek as well (C. Erikson, pers. comm.).

No major changes in the path or width of the channel has occurred upstream of counting station 10, as this section is semi-alluvial and non-alluvial with significant portions of the banks controlled by bedrock.

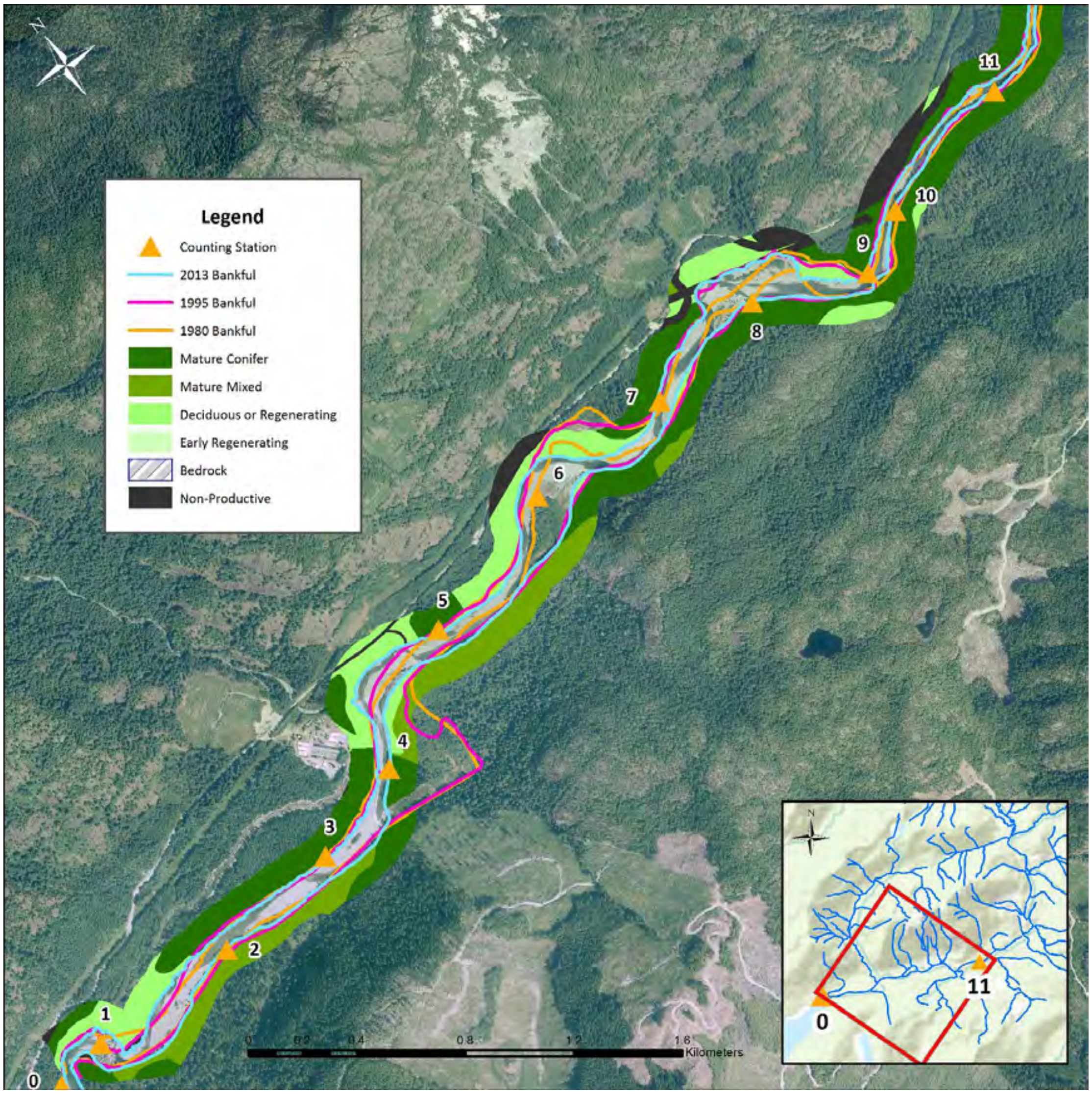

Figure 32. Bankful widths in 1980, 1995, and 2013 of the Conuma River.

Where riparian zones consist of a significant component of deciduous and / or regenerating vegetation, the risk of bank erosion and channel mobility is high (Figure 32). The channel is clearly more stable where the riparian zone is composed of primarily mature conifer forest. Note that a proper study of the Conuma River by a fluvial geomorphologist is recommended to provide a detailed assessment of this indicator.

4.14 Stream State Indicator: Large Woody Debris

LWD was evaluated in the Conuma River to the upstream extent of Reach 12 (Figure 2). The following table summarizes the results of LWD classification by reach:

Table 8. LWD classification in the Conuma River (reaches 1 - 12).

Reach	Pieces of Functioning LWD per Bankful Width	Pieces of Non-Functioning LWD per Bankful Width	Pieces of Partially-Functioning LWD per Bankful Width	Number of Debris Jams	LWD Classification
1 (CS1 – 9)	0.15	0.25	0.19	10	
2 (CS 10 - 12)	0.03	0	0	0	
3 (Canyon below bridge)	0	0	0	0	
4 (Canyon to top of falls)	0	0	0	0	
5 (Above anadromous barrier)	0	0	0	0	
6 (Above anadromous barrier)	0	0.06	0	0	
7 (Above anadromous barrier)	0	0	0.02	0	
8 (Above anadromous barrier)	0.03	0.33	0.01	0	
9 (Above anadromous barrier)	0.03	0.17	0.07	0	
10 (Above anadromous barrier)	0	0.07	0	0	
11 (Above anadromous barrier)	0.21	0	0	0	
12 (Above anadromous barrier)	0	0.3	0	0	

Based on the results presented above, there is a lack of functional LWD in the Conuma River system. Reach 11 demonstrated the highest concentration of functional LWD; however, the number of pieces per bankful width still remained below 1 piece per bankful width. Photo 4 presents an example of functional and non-functional LWD.

Non-functional LWD was present throughout the system, primarily present as wood accumulating on top of gravel bars (Photo 4). There was also a considerable component of this wood that was oriented parallel to the stream bank, and was therefore providing limited function to the system.

Photo 4. Example of functional LWD and non-functional LWD in the Conuma River.

Debris jams were most common throughout reach 1, with the largest jam observed just upstream of counting station 1 (Photo 5). In most cases these jams were providing functional fish habitat.

Photo 5. Debris jam just upstream of counting station 1 on the Conuma River.

The recruitment potential for functional LWD in the Conuma River system is moderate based on its riparian stand classification (i.e. predominantly second growth conifer and mixed stands). Approximately 49% of the riparian forest is greater than 100 years old and likely contributes LWD to the river. However, the amount of functional LWD in the channel was lacking, which suggests that either there is a lack of supply, or the LWD that is being contributed to the river is insufficient in size to prevent it from being flushed out of the system during high flows. A field assessment would be necessary to identify the limiting factors to functional LWD recruitment in this system. Additionally, since approximately 45% of the riparian area includes mixed and deciduous stands, LWD present in the river is likely a mix of deciduous and coniferous. While smaller deciduous LWD still provides some function in the river, larger coniferous LWD is considered more stable, longer lasting, and more influential over stream flow (Poulin et al, 2000).

Based on the lack of functional LWD observed in the Conuma River, this habitat indicator was ranked as high risk.

4.15 Stream State Indicator: Off-Channel Habitats

Interviews with local experts indicated off-channel habitats to be present in the Conuma River, particularly in the lower river and near the confluence with the estuary (C. Erikson, pers. comm.). However, in the absence of ground-truthing the status and connectivity of these areas, off-channel habitats have been identified as a data gap.

4.16 Estuary State Indicator: Estuary Habitat Disturbance

The evaluation of historic and ongoing impacts to the Conuma River estuary was limited to the information that was derived from the available aerial imagery and interviews with local experts. Generally, the Conuma River estuary has remained relatively undisturbed, with the exception of minor gravel deposition from upstream sediment sources. No significant changes in marsh and / or eelgrass habitat have been observed (C. Erikson, pers. comm.). No known log booming grounds have operated in the vicinity of the estuary, and there is a sufficient buffer between the high tide mark and adjacent roads, although past logging did occur up to the edge of the estuary. Further field investigation would be necessary to assess the impacts of past forest harvesting on the Conuma River estuary, such as excessive sedimentation deposition (resulting from erosion from upstream riparian logging). Estuary habitat disturbances has been identified as a data gap. Based on historical and current aerial image interpretation of permanent alterations to the Conuma River estuary, this habitat indicator has been ranked as low risk.

Figure 33. Present-day condition of the Conuma River estuary.

4.17 Estuary State Indicator: Permitted Waste Discharges

There are no permitted waste discharges in the Conuma River estuary. As such, this indicator has been ranked as low risk.

4.18 Estuary State Indicator: Estuary Chemistry and Contaminants

No chemistry or contaminant data was available for the Conuma River estuary. Interviews with local experts indicated no contamination issues are anticipated given the history of the estuary; however, this indicator has been identified as a data gap given the lack of information.

4.19 Estuary State Indicator: Dissolved Oxygen

No dissolved oxygen data for the Conuma River estuary was available. Considering that historical log handing has occurred as close as 100m to the intertidal portion of the estuary, and the known impacts log handling can have on DO levels through wood waste deposition (Picard et al, 2003), some impact to fish habitat can be expected from this indicator. However, based on the absence of information and / or studies, this habitat indicator has been identified as a data gap.

4.20 Estuary State Indicator: Estuarine Habitat Area

Historical and ongoing impacts to the Conuma River estuarine habitat appear to be relatively minimal from the aerial image interpretation. However, the most recent imagery (2013) was captured during a mid tide, and therefore the extent to which habitat types could be differentiated over the portion of the estuary that was under water was limited. Distinct channel features were classified as water, and the majority of the remaining area appeared to be predominantly sand or mud flat, although there may be some salt marsh, eelgrass, and gravel cover within the area of the delta that was included in the sand / mud flat polygons. The accuracy of the habitat classification in the Conuma River estuary could be improved with recent high resolution imagery captured during low tide, and/or a field assessment. The following figure details habitat composition within the estuary (areas shown in hectares):

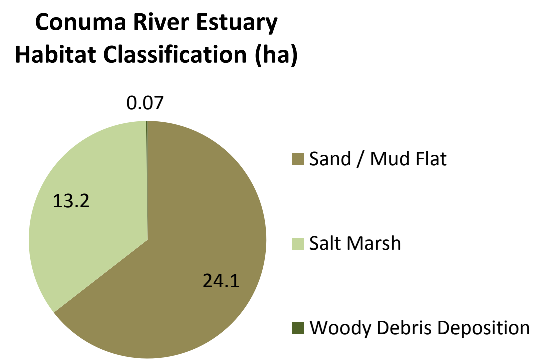

Figure 34. Habitat composition of the Conuma River estuary.

As demonstrated in Figure 34, the intertidal estuarine habitat was classified as predominantly sand or mud flat. While over 13 hectares of salt marsh were identified in this assessment, more may exist that were not visible in the available aerial imagery. Figure 35 shows the distribution of the classified estuarine habitat. It should be noted that no recent data was available pertaining to the subtidal component of the estuary (i.e. eelgrass presence / absence and the extent of historical log handling impacts), and has been identified as a data gap.

Given the known importance of the estuary as a critical rearing and foraging zone for all species of outmigrating salmonids, any historical loss of this habitat represents a loss in salmonid productivity for this watershed. As the majority of the estuary area appears relatively unaltered, this indicator has been ranked as low risk.

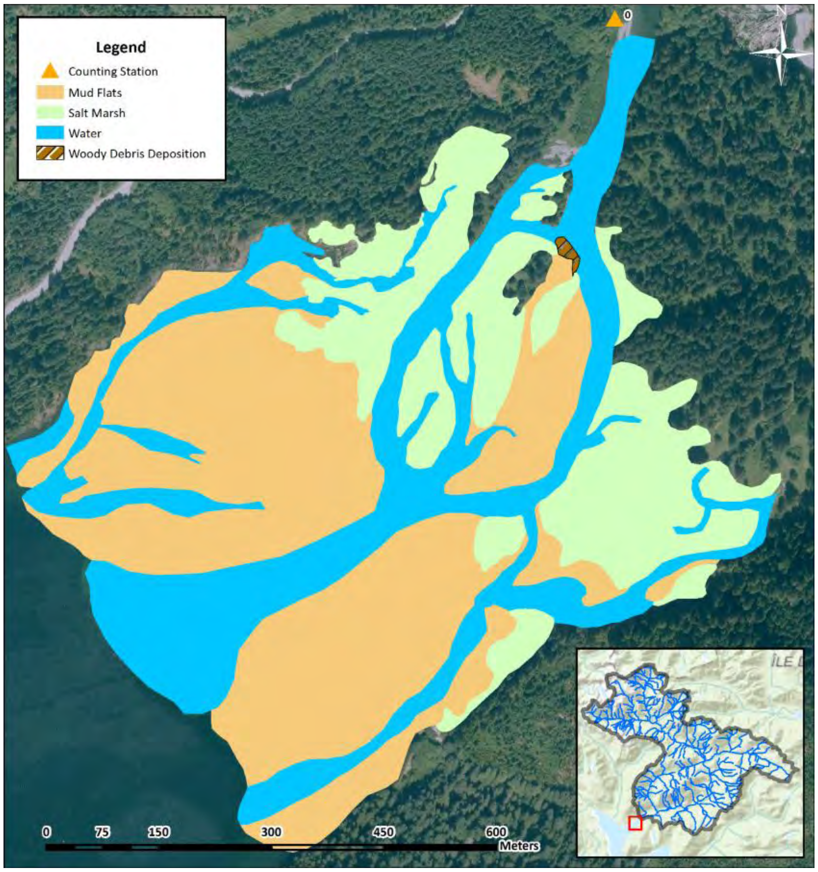

Figure 35. Estuary habitat classification and distribution of the Conuma River estuary.

5.0 SUMMARY OF HABITAT INDICATORS AND DATA GAPS

Based on the results of the habitat status assessment of the Conuma River watershed, it is clear that legacy impacts from forest harvesting continue to persist in this watershed. The Conuma River is considered to be highly sensitive and highly disturbed, in a state of improvement but still of concern with unstable alluvial channels resulting from riparian logging (Horel, 2008). The unstable alluvial channel of the lower Conuma River has prevented the full recovery of the riparian forest from past streamside logging impacts. Degraded riparian zones have resulted in channel instabilities in the lower river, and subsequent sediment inputs have overwhelmed the system and resulted in overall aggradation and loss of pool habitat. Very little functional LWD remains in the system, despite recruitment potential being moderate with a mature canopy dominating approximately 50% of the riparian zone. One positive sign of natural recovery has been the establishment of vegetation on gravel bars, which is expected to encourage rechannelization towards a narrower bankful width and subsequent increase in pool habitat as a result of increased flow velocity, scouring and bedload transport.

Table 9 summarizes the results of ranked assessed habitat indicators and identifies indicator data gaps.

Table 9. Summary of assessed habitat indicators and data gaps.

Indicator	Type	Risk Rating	Data Gaps (Y/N)?	Comments
Total land cover alterations	Stream: Pressure	HIGH	N	Land cover alterations primarily in the form of past forest harvesting.
Habitat composition	Stream: State	HIGH	N	Percent pool area remains below suggested benchmarks described in Johnston and Slaney (1996). Loss of pool habitat between 1995 and 2013 observed.
Large woody debris	Stream: State	HIGH	Y - Partial	Pieces of functional LWD per bankful width remains below suggested benchmarks in Johnston and Slaney (1996) for all assessed reaches. Low functional LWD recruitment potential based on deciduous-dominated riparian zones. Ground truthing of LWD recommended to quantify additional LWD that may not be visible from orthophotographs (i.e. completely submerged LWD in deep pools).
Watershed road development	Stream: Pressure	HIGH	N	Road density was high at 1.24km/km^2.
Stream crossing density	Stream: Pressure	HIGH	Y	Stream crossing density was 1.36 $/km^2$. No data was available on the state of deactivation of historic crossings. Watershed-wide culvert assessment needed to confirm the risk posed to fish by this indicator.
Channel stability	Stream: State	HIGH (specific sections, lower reach) LOW	Y - Partial	Significant channel migration observed in select locations between 1980 and 2013 (Figure 37). In some cases, continued erosion is expected based on lack of stable channel banks and deciduous riparian vegetation in these zones. Ground truthing of these zones is recommended to complement the orthophotography assessment.
Riparian disturbance	Stream: Pressure	MODERATE	Y - partial	In comparison with other watersheds in the Nootka Sound area, a significant component of mature riparian forests exist in the Conuma River (however some areas continue to remain heavily degraded). See Figure 36. **Data gap for riparian classification of tributaries.**
Estuary habitat disturbance	Estuary: State	LOW	Y	Estuary habitat disturbance has been low to negligible based on aerial photo interpretation, local knowledge, and documentation of existing tenures and licences, with no log handling in the vicinity. Additional information would be required to confirm the absence of

Indicator	Type	Risk Rating	Data Gaps (Y/N)?	Comments
				historical log handling in the estuary, gathered from local knowledge, field assessments and/or other sources.
Estuary habitat area	Estuary: State	LOW	Y	Proportion of salt marsh and eelgrass cover was difficult to discern with the available orthophotographs. A field assessment would be necessary to accurately determine the proportion of salt marsh and eelgrass habitat. **Data gap: quantity and quality of productive intertidal and subtidal estuarine habitat (i.e. salt marsh and eelgrass).**
Water extraction	Stream: Pressure	LOW	N	Two non-consumptive licenses exists, and a benchmark was only developed base on consumptive water licences.
Water temperature: Migration and spawning	Stream: State	LOW	Y	No recorded water temperatures during spawn surveys from 2006 – 2014 approached the UOTR for adult salmonids. However, the available data temporally and spatially limited.
Permitted waste management discharges	Estuary: State	LOW	N	No permitted waste discharges were identified in the Conuma River estuary.
Permitted waste management discharges	Stream: State	LOW	N	No waste management discharge permits are associated with the Conuma River watershed.
Water quality	Stream: State	Not ranked – data gap	Y	**No water quality data available for the Conuma River,** apart from the 15 Regional Geochemical Stream Survey (2007) samples, which reported low risk values of uranium and fluoride, as well as 11 pH samples below the minimum long-term guideline of 6.5. Additional data is necessary to rate the water quality risk.
Water temperature: Juvenile rearing and migration	Stream: State	Not ranked – data gap	Y	**No water temperature data available outside of the fall swim survey period.** This metric is important to understand water temperature's influence on emergence timing and potential egg freezing events during winter low flows. Water temperature data was available for Leagh Creek, which is independent of the Conuma River temperature, but may be important for rearing coho.
Stream discharge	Stream: State	Not ranked – data gap	Y	**No discharge data available for the Conuma River.**
Off-Channel Habitats	Stream: State	Not ranked – data gap	Y	Interviews with local experts indicated off-channel habitats to be available to salmonid species in the system; however, **ground-truthing required to confirm status and accessibility of these habitats.**
Estuary chemistry and contaminants	Estuary: State	Not ranked – data gap	Y	**No water quality data (with the exception of historical pH, salinity, and**

Indicator	Type	Risk Rating	Data Gaps (Y/N)?	Comments
				temperature information) available for the Conuma River estuary. Given the absence of evidence of industrial use of this estuary, sediment and water quality issues are likely non-existent.
Estuary dissolved oxygen	Estuary: State	Not ranked – data gap	Y	**No DO data available for the Conuma River estuary.**
Accessible stream length	Stream: State	N/A	Y - partial	Requires temporal comparison of change over time to determine indicator risk. Confirmation of accessible stream length with a focus on stream road crossings is recommended through field mapping of tributary and side channel habitat.
Key spawning areas (length)	Stream: State	N/A	Y - partial	Requires ground truthing of upper and lower limits of spawning zones via GPS to accurately quantify and monitor this indicator.

In addition to the data gaps presented above, an important habitat indicator (beyond the scope of Stalberg et al [2009]) lacking information was identified during the literature review: the quantification of inter-gravel flows and DO levels in known spawning grounds. These parameters were identified as a critical component of egg to fry survival, and must be understood to determine if the infilling of interstitial spaces could be reducing survival.

In many cases data gaps prevented a full assessment of state and pressure indicators. Based on the results of this habitat status assessment, recommendations can be broken down as follows: recommended restoration projects, data gaps to be addressed, and best functioning habitats requiring protection. The following sections discuss these recommendations.

5.1 Recommended Restoration Projects

Given the known impacts of a degraded riparian zone on channel stability in the Conuma River, restoration efforts should be focused on both reclaiming these zones through riparian treatments and conducting appropriate instream works to stabilize actively eroding channel banks.

5.1.1 Riparian Treatments

Riparian restoration is recommended for stands that are currently in an early regenerating, deciduous or regenerating state (Figure 36). Specific areas of concern include the right bank between counting stations 0 and 2, the left and right banks between counting stations 4 and 5, the right bank between counting stations 5 and 7, and the right bank from approximately 200m downstream of counting station 8 up to counting station 9. Note that additional riparian treatment opportunities exist upstream of counting station 6; however, restoration of the lower reach would target more critical habitats for all anadromous species, and would directly address channel instabilities observed in this alluvial section of the channel.

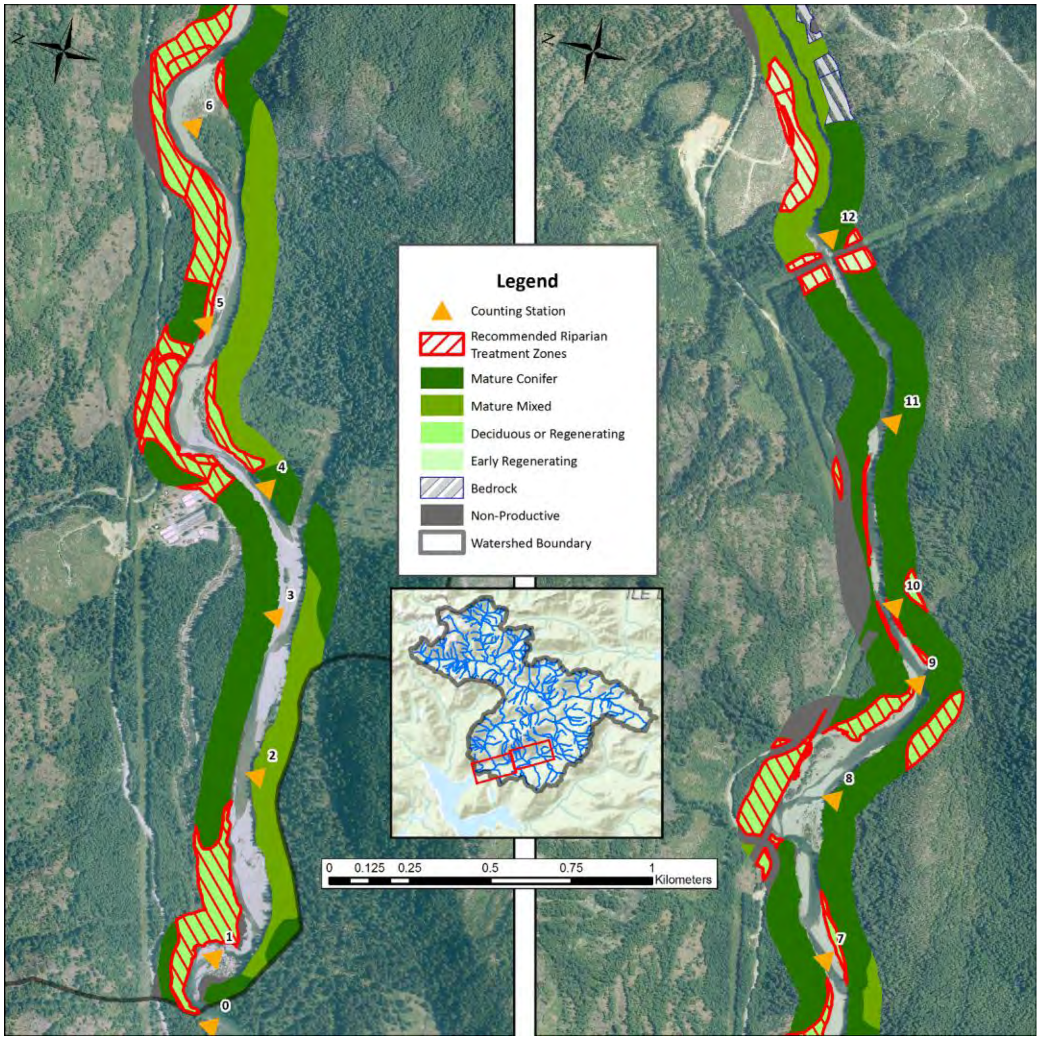

Figure 36. Recommended riparian treatment zones for the Conuma River.

Common riparian treatments utilized in degraded riparian zones that could be applied in the Conuma River include the following (Poulin, 2005):

- Conifer release: treatment removes competing overstory or brush by felling, girdling, or brushing.
- Uniform thin: a thinning treatment that spaces conifer generally uniformly throughout a stand. The treatment maximizes the number of large diameter conifers per unit area.
- Variable thin: allows for wide variability in conifer spacing. Mimics distribution of conifers on moist and wet sites where competition is generally most-severe.
- Planting: planting on best available microsites, implies cluster planting.

It is recommended that a riparian restoration plan is developed and implemented by a Registered Professional Forester (RPF) to address this high risk habitat indicator.

5.1.2 Channel Stabilization

Three locations have been identified as candidates for instream stabilization works along the right bank of the Conuma River (Figure 37). These locations include the right bank between counting stations 4 and 5, the right bank at counting station 6, and the right bank between counting stations 8 and 9. It appears likely that bank erosion will continue in these areas in the absence of bank stabilization efforts.

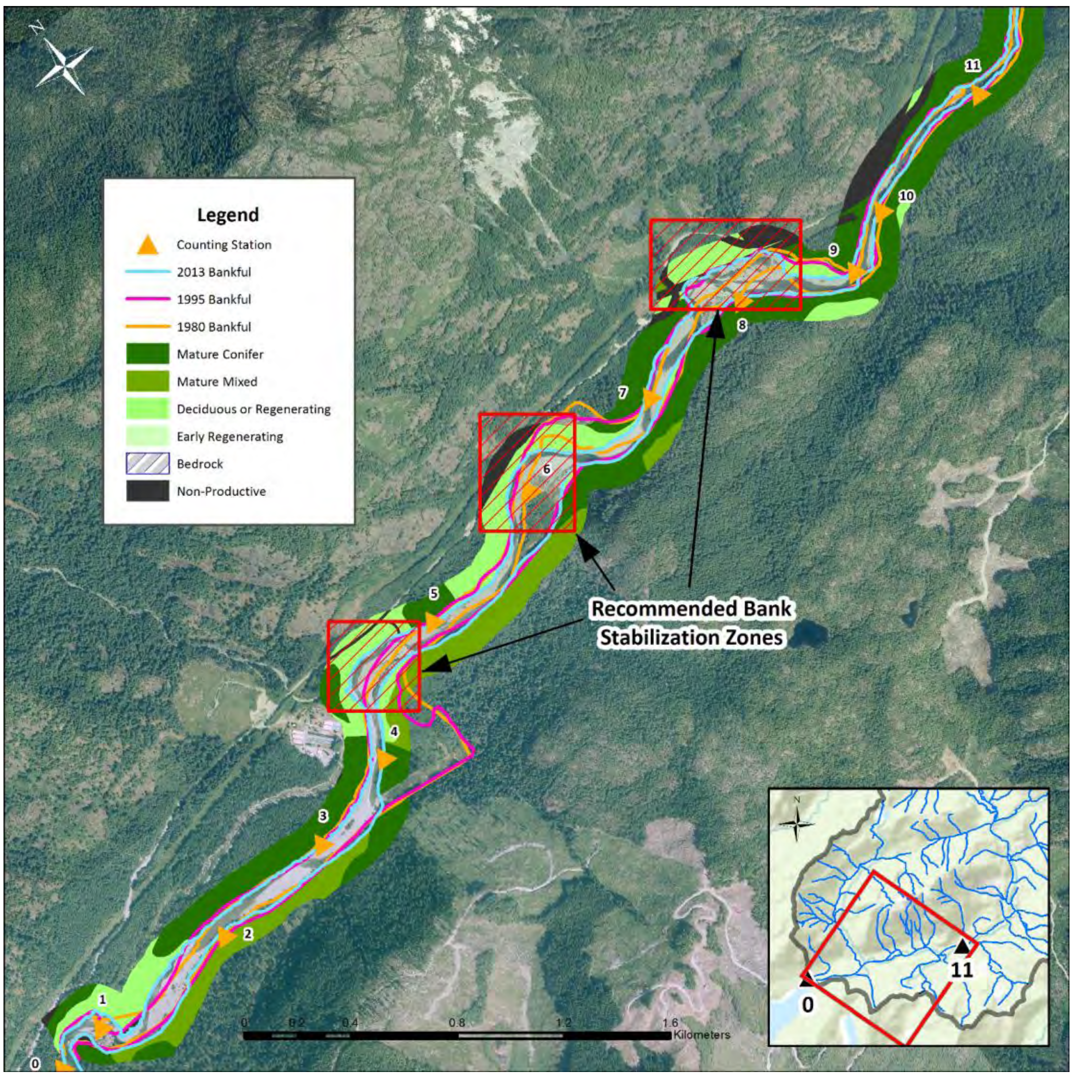

Figure 37. Proposed bank stabilization zones in the Conuma River.

Potential instream methods that could be employed to stabilize the banks identified in Figure 37 include the construction of groynes, debris catchers, and / or the installation of large woody debris revetments. Photo 5, Photo 6, and Figure 38 show examples of both groyne and woody debris revetment installations to protect existing eroding channel banks.

Photo 5. Rock groynes constructed on an eroding left bank in the Phillips River.

Photo 6. Large woody debris revetments installed on an eroding left bank of the Eve River.

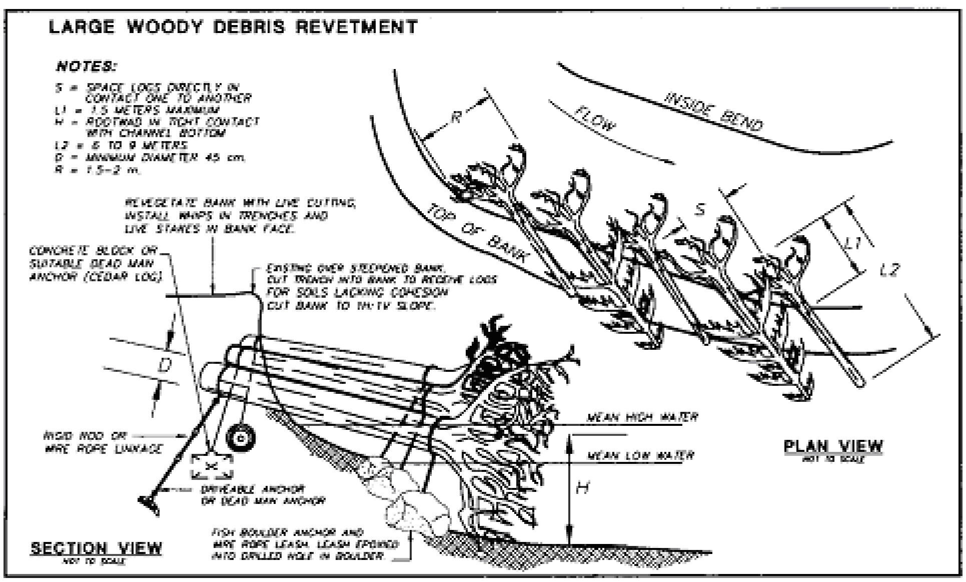

Figure 38. Typical large woody debris revement installation (Slaney & Zaldokas, 1997).

For the sites identified above, it is recommended that a fluvial geomorphologist conduct a field assessment and develop a design to restore the channel stability. Instream methods should be combined with riparian treatments to address both short and long-term channel stability.

5.1.3 Live Gravel Bar Staking

Local experts expressed interest in live staking selected gravel bars as a means of increasing channel stability. Input from a geo-morphologist would be required to identify suitable sites and determine if this would be an appropriate restoration application to address channel instability.

5.2 Data Gaps and Recommended Studies

The following table presents a prioritized list of data gaps identified during this study and recommendations for future initiatives to address these gaps.

Table 10. Data gaps and recommended studies for habitat indicators in the Conuma River.

Data Gap	Priority	Recommendation
Channel stability	High	Ground-truth key eroding bends.
Stream discharge	High	Install a hydrometric station on the Conuma River to measure continuous discharge and temperature.
Water temperature	High	
Water quality	High	Monitor key water quality parameters.
Intergravel flows and DO levels	High	Direct field efforts to collect this intergravel flow and DO data at known spawning grounds. Collect GPS coordinates of upstream and downstream extents of known spawning grounds.
Key spawning areas (length)		
Status of off-channel habitats, including wetlands and tributaries, and accessible stream length of these habitats	High	Direct field efforts to map tributary locations, side channels, and wetlands (within fish-bearing reaches). Classify riparian of these locations based on 2013 orthophotographs. Conduct assessment of all stream crossings in the watershed to identify potential fish passage issues and/or sediment sources.
Stream crossing density	High	
Riparian classification of tributaries	Moderate	
Water quality (instream)	Moderate	Implement water quality monitoring program at several sites distributed throughout the Conuma River.
Large woody debris	Moderate	Ground-truth LWD in the system; incorporate quantification of submerged LWD not visible in the orthophotographs.
Intertidal and subtidal estuarine habitat condition	Moderate	Conduct a detailed intertidal and subtidal habitat study of the estuary, including quantifying and mapping intertidal and subtidal habitat types and impacts. Measure water quality parameters including DO.
Estuary dissolved oxygen	Moderate	
Off-channel habitats	Moderate	Obtain access to WFP's 3D orthophotographs to identify off-channel habitats; conduct field survey to ground-truth these zones.
Estuary chemistry and contaminants	Low	Collect water and sediment chemistry samples.

5.3 Best Functioning Habitats Requiring Protection

The protection of existing known functioning habitats is important to maintain existing fish productivity levels and prevent the loss of these important zones. Figure 39 summarizes all of the known functioning spawning, holding, and juvenile rearing and migration habitat identified during this assessment. All of these habitats have been considered critical and therefore require consideration and protection from future industrial initiatives. Monitoring of these locations on a periodic basis is also recommended to determine if these habitats are improving or degrading over time.

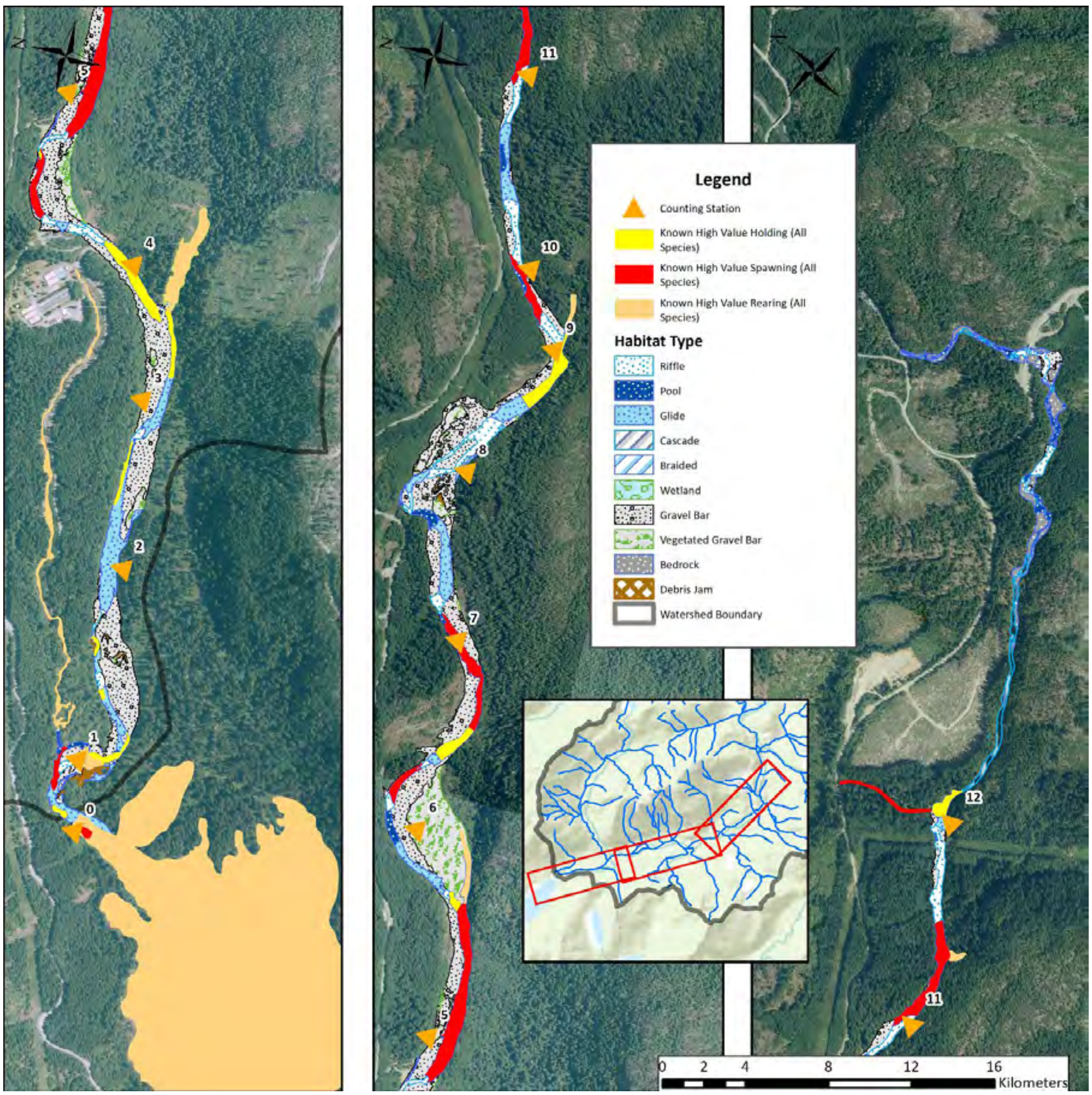

Figure 39. Best functioning (i.e. known high value) habitats in the Conuma River watershed that are recommended for protection. See Figure 10 for full extent of known migration and rearing habitat for coho (tributaries).

6.0 CONCLUSION

The Conuma River watershed remains highly disturbed from historical logging practices removing riparian vegetation to the stream banks. Based on the unstable lower alluvial reach that resulted from historical riparian logging, observable recovery of the Conuma River was estimated to take 30 years (Horel, 2008).

The habitat status assessment for the Conuma River watershed has identified high risk habitat indicators to be high total land cover alterations, riparian disturbances, bank instabilities, negative changes in habitat composition (i.e. loss of pool habitat) due to upstream sediment sources, a lack of functional LWD, road density and stream crossing density. Important data gaps to note include a field assessment of key eroding banks, water quality (both instream and estuarine), continuous discharge and temperature data, intergravel flows and DO in key spawning grounds, quantification of off-channel and wetland habitat condition, and an assessment of road stream crossings to identify potential fish passage issues and sediment sources.

Both riparian and instream restoration opportunities have been provided in response to the results of this assessment. Potential riparian treatment areas have been identified on the right bank between counting stations 0 and 2, the left and right banks between counting stations 4 and 5, the right bank between counting stations 5 and 7, and the right bank from approximately 200m downstream of counting station 8 up to counting station 9 (Figure 36). Candidates for bank stabilization through groyne construction and / or LWD revetment placement included the right bank between counting stations 4 and 5, the right bank at counting station 6, and the right bank between counting stations 8 and 9 (Figure 37).

While high priority restoration initiatives have been identified for this watershed, important data gaps that require further understanding exist as well. Field data collection is necessary to fill the data gaps identified in this report, to obtain a more comprehensive understanding of limiting factors to salmon productivity in the Conuma River watershed.

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APPENDIX 1: CONUMA RIVER WATERSHED MAP ATLAS