Tsolum River Watershed -

Fish Habitat Assessment Report (FHAP)

On behalf of:
Tsolum River Restoration Society

by

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CONTENTS

Figures within Text

Tables within Text

1. INTRODUCTION

The Tsolum River Restoration Society (TRRS) wished to undertake a Fish Habitat Assessment of the Tsolum River Watershed to provide Habitat Restoration Prescriptions, which could guide them on future recovery programs in the watershed. Wayne White and Vincent Hamann Benoit of the TRRS organized the survey. D.R. Clough Consulting was hired to help them in conducting the survey and to analyze the results.

This is a report of the fish habitat survey was conducted in October 2014 with the results and conclusions reported below.

The rationale for conducting this survey was the concern raised by TRRS members over the degradation of the watershed over the years and desiring a baseline of habitat to start from.

The objective of this study included a fish habitat and riparian assessment of the mainstem and all significant salmon bearing tributaries. There were seven streams surveyed reaches were the Tsolum mainstem (T1-T13), Portuguese Creek (T1-3, P5), Dove Creek (D1, D3, D6), Headquarters Creek (H1 & H2), Murex Creek (M1-3), Constitution Creek (C1, C2) and Hell Diver Creek (HD2).

All involved would like to acknowledge the essential support of the grants provided to undertake the survey.

The funders for the Tsolum River Assessment are:

1. Pacific Salmon Foundation – Hungerford Award
2. BC Ministry of Environment – Tsolum Legacy Funds
3. Dick Bradshaw – Private Donor
4. Shell Canada
5. Toronto Dominion Friends of the Environment Fund
6. McLean Foundation

Much of this work was on TimberWest Ltd. private land and the survey team would like to thank them for access, safety planning and information sharing.

2. SURVEY OBJECTIVES

The project objective was to conduct a habitat assessment of the Tsolum River Watershed.

To survey the habitat of the salmon bearing reaches of significant tributaries
Train volunteers and property owners of salmon habitat assessment and monitoring methodology.
Establish monitoring benchmarks at habitat assessment locations
Determine the habitat condition of the watershed
Identify habitat restoration opportunities for the watershed.

3. STUDY AREA AND BACKGROUND INFORMATION

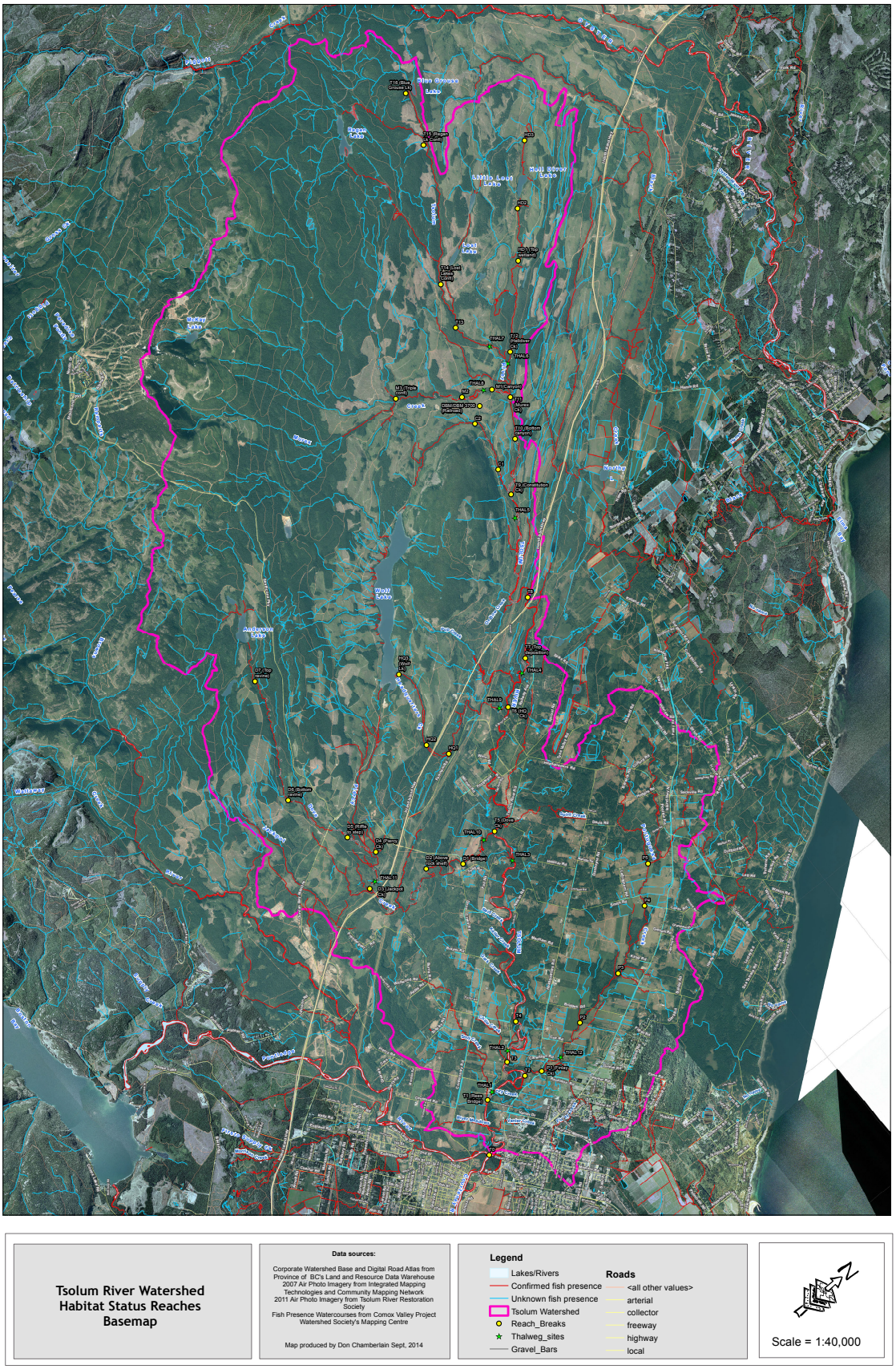
1. Tsolum River Watershed

The Tsolum River (watershed code 920-553200-94100) is the largest tributary of the Courtenay/Puntledge River Watershed. Its mainstem drains the north side of Mount Washington (elev 1585m) while other branches are spread across the low lying approximately 20km wide glacio-marine floodplain from Courtenay to Black Creek. The Tsolum Watershed area is 248 km2 within the 859 km2 area of the Courtenay/Puntledge watershed. The mainstem Tsolum River is approx. 40 km long originating from Mount Washington and joining the Puntledge River to form the Courtenay River which enters the Comox estuary 1.0 km downstream. There are many significant (3rd order or greater) salmon bearing tributaries; Dove, Murex, Headquarters, Hell Diver, Constitution and Portuguese. There are many other smaller stream channels in the watershed which are located on the community stream atlas (Project Watershed SHIM 1999-2005).

Depending on elevation, the watershed is located in variants of the Coastal Western Hemlock (CWH) Biogeoclimatic Zone, (Meidinger and Pojar 1991). The low lying areas where the majority of salmon habitat is found are in CWHxm1; “Very Dry Maritime sub Zone, eastern variant”. Common vegetative species in the CWH xm are Douglas Fir *(Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla),* Western Red Cedar (*Thuja plicata*), with common understory of Salal (*Gaultheria shallon*), Step moss(*Hylocomium splendens*) , Bracken fern (*Pteridium aquilinum*) and Vanilla leaf (*Achlys trifilla*).

The Tsolum Watershed forests have been important resources to humans. The watershed has been home to the people of the Komoks First Nation for thousands of years. The food supply in the watershed was so abundant it was referred to as the ‘land of plenty”. Some forested areas may have been historically cleared by First Nations to tend crops of bulbs and berries through burning of over story trees (Turner & Jones 2000). The European settlers arrived in the 1860’s and the watershed has been logged extensively since then. Forestry continues to be a significant part of the watershed but farmlands now cover a significant portion of the low lying areas. The Tsolum ends in the town of Courtenay at the Puntledge River where the Komoks Band now operate a campground on reserve land between the two waterways.

Figure 1 Tsolum River – Survey Area



2. Fish Habitat and Riparian Assessment Methods

The habitat assessment was conducted using an assessment procedure developed by the Urban Salmonid Habitat Program (USHP). The survey methodology is described in detail in the *Vancouver Island Urban Salmonid Habitat Program (USHP) Assessment and Mapping Procedures Manual*[1]. It was developed the B.C. Ministry of Environment on Vancouver Island to guide watershed stewardship groups on a standard inventory process. The USHP program has been used by stewardship groups all over Vancouver Island allowing for a comparative database of similar streams, which is why it was selected for the Tsolum River. The USHP survey would result in analysis of habitat data using provincial stream habitat standards[2] and a detailed habitat condition comparison between reaches as well as other Vancouver Island Streams.

The survey method collects data on a number of stream parameters including: percentage of in-stream cover, percentage of pool area, number of large woody debris (LWD)/Bankfull channel width, substrate (percentage of fines, gravels, cobbles, boulders, bedrock), percentage of reach eroded and percentage of wetted area throughout the streams length. In-stream cover includes in-stream vegetation, undercut banks, boulders and LWD. Riparian conditions such as plant community type, bank slope and depth were also sampled. The SHIM field data was recorded on field data cards or directly entered on the Trimble GPS during the survey. Figure 2 shows the SHIM Riparian Assessment Field Data Sheet that was printed on waterproof field paper for field use

The USHP survey method collected this information at habitat units identified as pools (areas with residual depth) or riffles (exposed substrates at low flow and no residual depth). Due to the extensive waterway, with over 19km of identified reach segment length, 100% sampling of habitat was not feasible in the timeframe or budget for the current program. Our target was to sample a minimum of 10 habitat units in each reach. The reach habitat units sampled were given a consecutive numbering system starting with Habitat Unit 1 (H1) and walking upstream to H10. The start point in the reach (H1) was marked with an aluminum tag and colored waterproof paper tag with the reach and habitat unit number at eye height on a shrub or tree adjacent the stream. We attempted to place tags at the same side of creek the entire length unless access was difficult. Photo points were taken at the start point and in direction of travel at every habitat unit. The habitat distances were measured with a hip chain, 30 m tape or GPS depending on access and signal strength. Width and depth measures were taken with a marked staff or retractable tape. The data (see Fig. 2) was recorded on waterproof field paper with pre-printed headings in a standard field book using 120x180mm level-level six column paper.

Project Watershed provided two Trimble GPS units, with remote antennae. The units were set up by Don Chamberlain; our GPS/GIS specialist, whom programmed the field data into them, provided a training workshop and downloaded and processed the data. The GPS units were used for locating the start point, recording field data, photo points and mapping the survey area. The units were returned each evening for downloads and recharging to the Project Watershed office in Courtenay.

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[1] Michalski, T, G. Reid & G. Stewart, 2000. Ministry of Environment, Nanaimo B.C.

[2] Johnston, N.T. and P.A. Slaney, 1996. Fish Habitat Assessment Procedures. Watershed Restoration Technical Circular No.8. B.C. Ministry of Environment , Lands and Parks, Ministry of Forests

3. People Involved

Don Chamberlain also produced maps for the watershed, field survey and planning purposes. The data was provided by the past community stream mapping inventories from Project Watershed, Tsolum River Restoration Society and Timber West.

Dave Gooding, P.Eng. (Gooding Hydrology) provided the reach segments based on hydraulic and riparian characteristics. The studies and methodology are described in Gooding (2010) and Gooding & Chambers (2013). For the purpose of this study the reach segments were numbered from the confluence upstream to the headwaters on the mainstem and major channels (see Survey Area). The segments then ground truthed for accuracy and access by Dave Gooding, Jack Minard (TRSS), Wayne White (TRSS), Vincent Hamann Benoit (TRSS) and D.R. Clough on September 17 & 18, 2014.

With the reach segments confirmed, D.R. Clough presented the survey areas to Timber West staff on Sep. 19, 2014. Steve Adams, RFT and Dave Lindsay, RPBio provided road maps, biological data and trim maps. Steve Adams prepared a safety plan and it was distributed by the TRSS.

On Sep. 26, 2014, Dave Gooding reviewed the reach segments and thalweg survey methodology with Vincent Hamann Benoit and Wayne White.

On September 30, 2014, the TRSS organized an orientation, assessment training and safety workshop on the river for the team leaders. The event was organized by Vincent Hamann-Benoit. Field survey methodology was instructed by Don Chamberlain, Vincent Hamann Benoit and Dave Clough.

Volunteer training took place on October 1, 2014 and teams were established. This event was also organised by Vincent Hamann-Benoit.

Field data was collected starting Sep. 30 through to October 17, 2014. During this period water flow went from base low flow for most of the river to flood levels as the last reach segments in the upper watershed were completed (Portuguese Creek and Murex were last). The field data was downloaded daily from the GPS unit and field notes stored in files at the Project Watershed office. The data was processed daily by Don Chamberlain and Vincent Hamann Benoit as well as various crew members whom were available to assist. D. Chamberlain, with the help of Tanner Billie, completed the USHP reach summaries.

Vincent Hamann Benoit was the manager of this project for the TRRS. Vincent organized the field equipment, volunteer schedules, training, data control, and equipment repair as well as data entry. Many others contributed their time to the field surveys and data entry. There were two crews of three for each field day. One to two four reaches were completed for each survey day. The survey training took place in September 30 and field surveys started Sep. 30 Oct 1 and continued until Oct 17.

The Tsolum River Restoration Society was represented by Wayne White, Dave Morwood, Vincent Hamann Benoit and Jack Minard. Jack Minard retired his position in the TRSS after helping establish the framework of the assessment.

Without the volunteers this survey would not have succeeded; the following people slogged through either hot, wet, deep, brushy, buggy and/or slippery conditions for sake of contributing to the health of the watershed. The following people contributed significantly to the assessment; Peter Savin, Michael McNulty, Robert (Bob) Dean, Norm Wiens, Willa Cannon, Jim Messenger, Rod Mackenzie and Laura O'Brien. The Komoks First Nation supported the survey with the skilled help of Cory Frank (Fisheries Guardian), Tanner Billie and Karver Everson, they were there almost every survey day.

Figure 2 Fish Habitat Field Data Table

Stream Name Reach / pg. #	*Fish C.* *R2/pg1*
Habitat Type (P/R)	*P*
Start (m)	*10 m*
End (m)	*20 m*
Wetted Width	*2 m*
Bankfull Width	*3 m*
Average Depth	*0.5 m*
% Bedrock	*20%*
% Boulders	*20%*
% Cobble	*30%*
% Gravel	*20%*
% Fines	*10%*
Instream Cover (type/%)	*C-10%* *B-2%*
% Crown Cover	*60%*
Gradient	*2%*
# LWD	*10*
A/E/O	*E-10m* *A-20m*
Off-Channel Habitat	*L/bank* *20*2m*
Land Use (L/R)	*N/R*
Vegetation (L/R)	*CF/G*
Vegetation Depth (L/R)	*30+/2*
Riparian Slope (%)(L/R)	*10/15*
Stability (L/R)	*M/L*
Livestock Access (L/R)	*20m/0*
Photos	*1,2,3*
Comments	*1,2*

Habitat and Riparian Card Instructions

1. Measure <u>all</u> habitat parameters at the <u>beginning</u> of the reach and <u>every 200 meters</u>. Measure all parameters twice if the reach is less than 200 meters long;
2. Measure riparian parameters (black boxes) <u>every 100 meters</u>;
3. Measure the start, finish & wetted width for <u>pools only</u>; take data for all other shaded boxes along <u>entire stream length</u>.

Abbreviations and Definitions

A/E/O: Altered sites, Erosion sites, Obstructions

Bankfull Width: the horizontal distance from rooted terrestrial vegetation to rooted terrestrial vegetation.

Crown Cover: streamside vegetation at least 1 meter above water surface that provides shade over the habitat unit.

Gradient: slope of the stream, measured with a clinometer

Habitat Type: P=pool or R=riffle

Instream Cover: B=boulder C=undercut banks
LWD=large woody debris O=other
V=instream vegetation (includes algae)

Land Use: C=commercial I=industrial
EX=exposed L=lawns
FC=farms/cattle N=natural
FG=farms/grass R=roads or residential
GC=golf course

Livestock: note the length, in meters, of the site where any type of livestock have access to the stream.

LWD: deadwood >10cm in diameter and >2m. long and stable in the <u>wetted</u> channel

Obstructions: BD=beaver dam
CV=culvert X=log jam
D=dam EBB=other
F=falls

Off-Channel: includes ponds and lateral channels; note the bank side,[1] channel length and width

Riparian Slope: the slope of the bank above the high water mark to the far end of the riparian vegetation or break in slope; include distance if on floodplain

Stability: H=high; M=medium; L=low

Vegetation: Br=broadleaf forest Mix=mixed
Con=coniferous forest Sh=shrub
Gr=grasses

Wetted Width: the width of the water surface measured at right angles to the direction of flow

[1] NOTE: Bank side is determined when facing downstream

measure along stream length; note start and end for pools only

measure every 100 meters

4. Fish Population Sampling

Fish populations were not sampled during the time of the assessment but fish presence was assumed and in many areas; observed. The fish presence for the survey areas was generally known as salmon accessible. These portions of the Tsolum Watershed are home to Pink, Coho, Chum, Chinook, Steelhead and Cutthroat. During the survey, the fall rains arrived and raised flows allowing first spawners to enter. We observed Pink Salmon actively spawning in early October in all the main tributaries. We observed them in the Tsolum Mainstem to above Murex Creek (T11), in Dove Creek to the D5 reach top end. In Headquarters Creek we watched them swim over the hatchery concrete weirs and past our reach survey (HQ1). Many of the upper reaches were dry at the start of our survey were wetted and flowing at the end of our survey. We did observe two barriers; one at Helldiver and another at the bottom of M3 that may not be recorded. These may be anadromous barriers and need to be confirmed.

5. Habitat Data Ranking

The habitat and riparian field data was entered in the USHP spreadsheet program. Both the physical habitat and the riparian parameters are scored using the ranking system outlined in the USHP manual (Michalski et al. 2000). The spreadsheet program automatically extracts data for a number of habitat parameters measured and enters these values into a separate summary table called the Sum and Ratings Table. The program also assigns numeric values to habitat parameters in this table. This ranking procedure assigns a number of one (good), three (fair), or five (poor) to each habitat and riparian characteristic. This allows a numeric summary and comparison of characteristics. The fish habitat parameter data in the Sum and Ratings Table is then compared to the biostandards for healthy streams (Johnston and Slaney 1996). Data sheets for the Reach Segments, as well as the Sum and Ratings Table are provided in Appendix 2.

6. Reach Segments

There were seven streams surveyed. The reaches were the Tsolum mainstem (T1-T13), Portuguese Creek (T1-3, P5), Dove Creek (D1, D3, D6), Headquarters Creek (H1 & H2), Murex Creek (M1-3), Constitution Creek (C1,C2) and Hell Diver Creek (HD1/2).

4. RESULTS

The survey was conducted from September 30 to October 24, 2015. During that period, the river went from base low flow to freshet levels by the end of the survey. We usually had two crews work each day, with one or two reaches surveyed by the crew each day, followed by data downloads and gear preparation at the office in AM and PM. There were a dozen people involved in the survey. No one got hurt, everyone got at least a bit wet. We surveyed from Tsolum River mainstem (T1) upstream and completed most of the mainstem to the V.I. Highway. We then did Dove Creek and Headquarters Creek. The last reaches surveyed were all in upper segments after the rains came at Dove, Tsolum, Helldiver and lastly Portuguese Creek on a very wet day.

1. Tsolum Mainstem Assessment Results – Reach 1-6

The Tsolum mainstem survey covered the approximately 29 km of anadromous habitat in Segments T1to 13. This habitat assessment was the most difficult to undertake as many of the upper locations were isolated with old or no roads available, and the segments were long. The survey data is broken into two segments Reaches 1-6 and reaches 7-13.

T1 Fish Habitat Assessment

This reach begins at the confluence of the Puntledge River (0+000 m) extending upstream at the Rees Bridge on Dove Creek Road at 2,080m. The T1 survey of 10 habitat units covered 957m or almost half of the reach (46%). The survey was conducted on October 1, 2014 and was at base low flow.

The survey segment of T1 had six pools and four riffles for 10 habitat units over a 957 m distance (USHP Reach T1 Data Sheet – Appendix 2). The segment was low gradient and was dominated by long pools and short riffles. The wetted width was less than half the channel width and indicated the swings in wetted area and volume occurring in this reach. The pool area (15,898m^2) comprised 97% of the wetted area at low flow. There was surprisingly good cover (14%) in the pools due to a relatively high amount of LWD. The LWD was made of large logs that had fallen in or were washed down from upstream. The wood cover lacked stability and permanence, with indications it could wash away in a large flood event. The riparian depth (avg. 35m) along the banks varied from 10 to 50m, and the thin areas had the most bank erosion. Bank erosion was found on 11% of the survey area. Bank erosion was most significant in the lower area of the reach near the Hydro Line crossing. Here the left bank was treeless in spots with a 2-3m vertical cut in soft non-rooted soils. At this site the river was cutting into the bank behind rock armour. Further downstream adjacent the extensively armoured right bank along the Komoks Campsite was a large (3.5m height, 7.5m width, 75m length) aggraded sediment bar that had filled the mid section of the channel. This deposition has filled the old river mainstem and the flood waters are eroding the weak left bank. The result is loss of the thin remaining riparian area and more sediment.

Table 1 Reach 1 Habitat Summary Card

Channel Width (m)		39.2	Wetted Width (m)	17.02	Stream Gradient (%)	0.4
Water Temperature (C)		17	Estimated Flow (lpm)	2000	Fish Access	Y
Survey Date	Oct. 1/14		Est Flow Stage (%)	10	Flow regime	P
Substrate	0% Boulder, 3% Cobble, 45% Gravel, 52% Fines					
Canopy	48% Doug. fir,Red cedar, big leaf maple					
In-stream Cover	0% Boulder, 14% LWD, 0% Vegetation					

This reach scored poorly in the following categories including: % boulder and vegetation cover, % fines, erosion, wetted area and off channel habitat.

There are no fish migration barriers in this reach. An interesting alteration in the stream channel is the remnants an abandoned fish trap once operated by Fisheries and Oceans. The wood timber and pile structure crosses the stream channel. Recently a section of the timber was cut to ensure low flow salmon passage (pers. Comm Peter Savin). This wooden structure now appears to create localized scour depth and cover greatly benefitting fish habitat. It does not appear to be creating any erosion concerns on either bank.

Table 2 Tsolum Mainstem Reach 1 Habitat Data Summary and Ratings

Habitat Parameter	T1	Result	Ratings
% Pool Area	98	Good	1
Large Woody Debris/Bankfull Channel Width	1.23	Fair	3
% Cover in Pools	14	Fair	3
Average% Boulder Cover	0	Poor	5
Average % Fines	52	Poor	5
% of Reach Eroded	11	Poor	5
Obstructions	0		0
% of Reach Altered	24	Poor	5
% Wetted Area	43	Poor	5
% Crown Cover	48	Fair	3
Totals			**35**

The stream substrates were comprised of high amounts of gravel (45%) but the material appeared to be mobile in floods due to the changing sediment bars observed each year. During the survey we observed spawning Chinook and Pink Salmon in this reach. Chum salmon are also common spawners in this reach but not observed only due to our lack of inspection after the rains came.

The highest fish habitat concerns are the erosion on river left bank below the hydro line. There is high value fish habitat in this reach due to the large deep pools. They likely receive displaced fry from upstream drying reaches and tributaries. Increasing bank stability and cover through riparian planting is recommended in along with bank stabilization.

R1 Riparian Assessment

A summary of the riparian aspects of Reach 1 from the habitat survey is presented below.

Riparian Vegetation Type: This reach consisted of a second growth forest along its banks primarily of Douglas fir with Red Cedar, Big Leaf Maple, Sitka Spruce and Grand Fir. No old growth was observed, the stream was historically logged to its banks. The understory vegetation varied with site conditions but consisted mainly of Salmon Berry and Red Osier Dogwood. No significant non-native species were observed. The entire riparian area is low lying and in the Tsolum floodplain as there is historic and recent evidence of debris in the forests.

Vegetation Depth: Reach 1 had a right bank average plant depth of 35 m to farm pasture boundary and a left bank depth of 34m to a walking trail and farm pasture. The pasture areas do come within 5m in some locations (due to recent bank erosion). There are two polygons of older and larger trees (Douglas Fir/ Red Cedar/Sitka Spruce) in Reach 1; one at the top river left bank in the park next to the bridge, and the other downstream on the right bank in the Komoks Campsite.

Land Use: Characteristics of the riparian zone within the average of 35 m on either side are all natural regenerating forest. The land immediately adjacent the riparian is almost entirely farm pasture for dairy production. There is no industrial or residential development adjacent Reach 1.

Bank Slopes: This reach has low (20%) riparian bank slopes throughout. There were no landslide areas. The banks at the rivers edge were sharp cut with recent and historic losses of trees.

Bank Stability: The bank stability was an average of moderately low throughout the reach. The left bank was poorer due to the sediment bar and erosion at the hydro line. On the right bank near the old fish trap a large tree had fallen in due to undermining and lack of protection. There were no large tree root complexes armouring the bank and creating fish cover as there would have been in its historic state prior to logging.

Access: There is a trail system off Dove Creek Road on the left bank that follows down the creek at 10 m back from the bank. It has only one large access near the fish trap. The Dove Creek Road crosses at the Rees Bridge. There is a parking spot here and is often the location of illegal dumping.

Restoration Opportunities; T1

- Reach 1 was found to have a relatively wide riparian zone with second growth regenerating in many areas. There are incomplete regenerating areas throughout. Some recent bank erosion has made the riparian thinner; these sites require bank protection but must be complimented with plantings. Riparian restoration plans are recommended for various sites. The forested areas are deficient in understory Red Cedar. The cedar should be planted in areas protected from deer browse. The more open areas require deciduous plantings such as Willow, Red Osier Dogwood (Cuttings or pots) and Red Alder to establish the ground for later succession crops of conifers.

- The channel is eroding along the river left bank and requires protection on the Farm reach below the Hydro Line crossing. The banks require an assessment and detailed prescriptions.

2. Tsolum Mainstem Assessment Results – Reach T2

This reach begins at the Rees Bridge on Dove Creek Road and goes upstream approximately 1300 m. The river has a braid in the upper end that cuts around a treed island. One branch cuts down from Portuguese Creek travelling over 650m on river left bank alongside Headquarters Road. The other braid cuts down on river right bank from Portuguese Creek through a treed island for approximately 440m and joins the left channel. Currently the river right channel is the main channel. A thalweg depth survey was done from just below the bridge upstream through the reach.

T2 Fish Habitat Assessment

The FHAP segment of T2 started just above the Rees Bridge and went upstream 660m to end just below the braid. The survey was done Sep. 30/15 during low flow. Five pools and riffles were measured. This segment was low gradient and dominated by long pools and short riffles. The wetted area of this reach is better than reach T1 as it is slightly more confined and narrower. Possibly the deepest (2m+) pool in the river is here at a favorite roadside swimming hole (T2H5). It must also offer a significant fish rearing volume – coho fry were observed readily in this pool.

Table 3 Reach T2 Habitat Summary Card

Channel Width (m)	37.6	Wetted Width (m)	21.26	Stream Gradient (%)	0.5
Water Temperature (C)	17	Estimated Flow (lpm)	2000	Fish Access	Y
Survey Date Sep. 30/14		Est Flow Stage (%)	10	Flow Regime	P
Substrate	1% Boulder, 8% Cobble, 65% Gravel, 28% Fines				
Canopy	49% Doug. fir,Red cedar, big leaf maple				
In-stream Cover	1% Boulder, 9% LWD, 5% Vegetation				

The pool area (10,743m^2) comprised 75% of the wetted area. This survey was at low flow. There was good cover (15%) in the pools due to a relatively high amount of LWD (24 counted). The LWD was made of large logs that had fallen in or were washed down from upstream. The wood cover lacked stability and permanence, with indications it could wash away in a large flood event.

The over wide channel shows the effects of past flooding and erosion but in this reach, things have stabilized and there was only one 10m long erosion site recorded. Note that there was Rip Rap placed on the left bank in front of a residence.

There are no fish migration barriers in this reach. There are large gravel bars between the deep pools that may impair adult passage at low flow. Table 4 summarizes the habitat assessment ratings. This reach scored poorly in the following categories including: % boulder cover, % fines, erosion, wetted area and off channel habitat.

Table 4 Tsolum Mainstem Reach 2 Habitat Data Summary and Ratings

Habitat Parameter	T2	Result	Ratings
% Pool Area	76.6	Good	1
Large Woody Debris/Bankfull Channel Width	1.4	Fair	3
% Cover in Pools	15	Fair	3
Average% Boulder Cover	1	Poor	5
Average % Fines	27.5	Poor	5
% of Reach Eroded	64.5	Poor	1
Obstructions	0	Good	0
% of Reach Altered	4.5	Poor	1
% Wetted Area	56.6	Poor	5
% Crown Cover	49.5	Fair	3
Totals			27

Spawning Habitat: This area was observed to be spawned by salmon. The habitat characteristics indicate it has low egg survival. The reach has a meandering thalweg in the lower area of large gravel deposits. Spawning areas appear to be washed out or buried each winter. Further upstream the pool tailout locations are more consistent but there appears to be a regular exchange of gravel through the sites that would result in death of disturbed eggs..

Rearing Habitat: The deep pools of this reach are collectors for fry escaping drying habitats upstream (i.e. Portuguese Creek) . These pools have cover along the edges to protect the fry from predation, but there is nothing across or projecting into the water as it all has been swept away. The best cover characteristic is the depth of the pools (up to 2.0m). Inserting cover into these pools would assist summer survival greatly but could very likely be washed away in winter.

R2 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir with Red Cedar, Big Leaf Maple, Sitka Spruce and Grand Fir. No old growth was observed, the stream was historically logged to its banks. The understory vegetation consisted mainly of Salmon Berry and Red Osier Dogwood. No significant non-native species were observed. The riparian area has evidence of flooding.

Vegetation Depth: The riparian depth (24/30m) along the banks was fairly good. The forest was more consistent on banks with less gaps. The right bank riparian area is along a 30m wide road edge and the tall mixed forest of maple, Fir and Cottonwood shade the south aspect

Land Use: Characteristics of the riparian zone on either side are all natural regenerating forest. There are some residential river front lots mostly on the left bank that have removed the trees to gain a view of the river. Unfortunately the tree removal has necessitated the owners armour their frontages with RipRap in order to prevent bank erosion.

Bank Slopes: This reach has low (10-15%) riparian bank slopes throughout. As noted above, the riparian area is in floodplain for most of the length.

Bank Stability: The bank stability was high throughout the reach. The left bank was poorer due to the disturbances by people. At the rivers edge the banks are sharp cut from historic erosion. There are recent and historic losses of trees that have undermined and tipped in.

Access: It follows Dove Creek Road on the right bank allowing small swimming hole foot trails. The residential areas on the left bank are more intrusive with the cleared beaches. An awareness program about the importance of native vegetation to protect banks would help. Unfortunately these houses were built before the Riparian Area regulation which would have identified a no disturbance for 30m to the river.

Restoration Opportunities: **T2**

- The spawning areas in this reach need better anchoring and reduced sediment from upstream. Instream structures in this reach could be swept away or cause erosion. Monitoring the sites with thalweg (this is a site that was surveyed in 2015) and cross section surveys are needed first to determine aggrading and degrading characteristics.
- There is a rip rap wall on the left bank that lacks any riparian vegetation. The property owner should be approached about planting as it would also stabilize the bank.
- The river right bank just upstream of the FHAP area is eroded and should be inspected for stabilization (It offers soils that would likely support willow/red osier cuttings).

3. Tsolum Mainstem Assessment Results – Reach T3

This reach begins at the confluence of Portuguese Creek and goes upstream approximately 900m. This reach is one big meander of the river that cuts through farms and forest. Access is off Dove Creek Road on river right bank.

T3 Fish Habitat Assessment

The FHAP was done Oct. 10, 2015, during moderately low flow, the water was up 10 cm over riffle crests due to rains. The FHAP segment started 200m above the Portuguese Creek confluence. Four riffles and six pools were surveyed over 588m length of the 900m reach

This meander segment cuts into the right bank against Dove Creek Road and there was extensive riprap protection and bank erosion in this reach. The pools in this reach are scoured by winter currents to over 1.0m deep. The same energy scouring the pools is also eroding the banks and delivering a high amount of sediment to the reach. Less than half the channel area is wetted (46%) in low flow. Pink Salmon spawners were observed in the reach.

Table 5 Reach T3 Habitat Summary Card

Channel Width (m)		36.6	Wetted Width (m)	16.8	Stream Gradient (%)	0.4
Water Temperature (C)		17	Estimated Flow (lpm)	2000	Fish Access	Y
Survey Date	Oct. 10/ 15		Est Flow Stage (%)	10	Flow regime	P
Substrate	4% Boulder, 8% Cobble, 65% Gravel, 28% Fines					
Canopy	46% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Willow					
In-stream Cover	4% Boulder, 0% LWD, 1% undercut , 1% Vegetation, 6% Other					

There was relatively abundant cover (11%) was mostly Rip Rap placed on the right bank and which covered 35% of the survey area. There were only 4 functional LWD pieces in the reach. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 6 Tsolum Mainstem Reach 3 Habitat Data Summary and Ratings

Habitat Parameter	T3	Result	Ratings
% Pool Area	81	Good	1
Large Woody Debris/Bankfull Channel Width	0.2	Poor	1
% Cover in Pools	11	Fair	3
Average% Boulder Cover	4	Poor	5
Average % Fines	26.5	Poor	5
% of Reach Eroded	39	Poor	5
Obstructions	25	Poor	5
% of Reach Altered	36	Poor	5
% Wetted Area	46	Poor	5
% Crown Cover	34	Poor	5
Totals			40

This reach scored poorly in every category but % pool. Most of the Poor attributes are a function of high runoff and erosion.

Spawning Habitat: This area was observed to be spawned by salmon but like the reaches downstream it is unstable. The surveyors noted the high erosion on the right bank that would affect the spawning success.

Rearing Habitat: The deep pools of this reach are collectors for fry escaping drying habitats of the mainstem and tributaries. The highest cover component was rip rap which interstices do not compare to natural root complexes. The best cover characteristic is the depth of the pools (up to 1.5m). Inserting cover into these pools would assist summer survival greatly but could very likely be washed away in winter. There is an off channel area at T3H9 to H10 that is dammed by beavers. This are may be

washed by winter floods but it is well vegetated indicating scour is not high. The area would offer winter flood refuge and feeding opportunities.

R3 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir with Red Cedar, Big Leaf Maple, Sitka Spruce and Grand Fir. No old growth was observed, the stream was historically logged to its banks. The understory vegetation consisted mainly of Willow, pacific Ninebark, Salmon Berry and Red Osier Dogwood. No significant non-native species were observed. The riparian area has evidence of flooding.

Vegetation Depth: The left and right riparian depth (50/37m) along the banks was good. The riparian forest was consistent on banks with less gaps. The left bank is forested to over 100m. The right bank is over 50 m everywhere except alongside Dove Creek Road. Here it is only 5.0 m wide, and eroding.

Land Use: Characteristics of the riparian zone on the left side are native forests and the same on the right side except for approximately 130m of road edge.

Bank Slopes: This reach has low (10%) riparian bank slopes throughout. As noted above, the riparian area is in floodplain for most of the length.

Bank Stability: The bank stability was low throughout the reach. The right bank was observed by the survey crew to be in dire need of repair due to erosion right up to the road edge. There is rip rap along the farm road edge of this bank. The crew noted the bendaway weirs are eroding on the bank side and may require maintenance.

Access: There are no human crossings on this reach and no observed livestock entry areas.

Restoration Opportunities: **T3**

- The spawning areas in this reach need better anchoring and reduced sediment from upstream. Instream structures in this reach could be swept away or cause erosion. Monitoring the sites with thalweg (this is a site that was surveyed in 2015) and cross section surveys are needed first to determine aggrading and degrading characteristics.
- There is erosion under Dove Creek Road on the right bank (T3H9). The river comes at a very steep angle (about 50degrees) against a highly erodible 5m-high silty-loam bank (on top of a base layer of blue clay) located only about 7m away from Dove Cr. Rd. There is active erosion (recently uprooted trees, undermined riprap, etc.), and the integrity of the road might be compromised soon. This area is located just below a large gravel bar, which is obviously the result of upstream changes. This area could be the subject of a combined gravel bar live staking and bank stabilization project, which could redirect and possibly deepen the thalweg, thereby contributing to fish habitat and passage.
- Installation of LWD (ie rootwads & logs tied to rocks) into this reach is risky as it will get battered by flood debris. Opportunistic blowdown anchoring has potential given the riparian zone is regenerating with larger trees. If a large tree with rootwad attached falls in, the opportunity may be there to assist in anchoring it with more ballast.

- There is an off channel area at T3H9 with a beaver dam. It should be further evaluated to determine its winter refuge capability and determine if improvements can be made to access and flood protection.

4. Tsolum Mainstem Assessment Results – Reach T4

This reach begins adjacent Dove Creek Road and goes upstream approximately 1639m. It consists of two wide meanders of the river.

T4 Fish Habitat Assessment

The FHAP was done Oct. 10, 2015, during moderately low flow, the water was up 10 cm over riffle crests due to rains. Four riffles and six pools were surveyed over 672m length of the 1639m reach. This reach has two meander segments, the lower half of the reach was surveyed from just above T3. The pools in this reach are shallower (mean depth 0.57m) compared to the lower reaches. This was the widest Bankfull Channel Width (avg. 48.1m) in the river. The wide gravel bars remaining in the meanders were over 80m wide, indicating the banks had eroded by over 40m compared to lower reaches. This resulted in the least wetted area (28.3%) in the river to this point.

Table 7 Reach T4 Habitat Summary Card

Channel Width (m)	48.1	Wetted Width (m)	13.6	Stream Gradient (%)	0.3
Water Temperature (C)	NA	Estimated Flow (lpm)	2000	Fish Access	Y
Survey Date Oct. 10/ 15		Est Flow Stage (%)	10	Flow Regime	P
Substrate	0% Boulder, 12% Cobble, 60% Gravel, 28% Fines				
Canopy	59.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Willow				
In-stream Cover	0% Boulder, 0% LWD, 0% undercut , 2% Vegetation, 6% Other				

There was poor instream cover (2%). There was only 1 functional LWD piece in the surveyed area of the reach. There are no fish migration barriers in this reach. There was no off channel recorded in the survey area. The USHP ratings table below summarizes some of the habitat qualities.

Table 8 Tsolum Mainstem Reach 4 Habitat Data Summary and Ratings

Habitat Parameter	T4	Result	Ratings
% Pool Area	91.2	Good	1
Large Woody Debris/Bankfull Channel Width	0.1	Poor	5
% Cover in Pools	2.0	Poor	3
Average% Boulder Cover	0.0	Poor	5
Average % Fines	27.5	Poor	5
% of Reach Eroded	2.5	Good	1
Obstructions	0.0	Good	1
% of Reach Altered	0.0	Good	1
% Wetted Area	28.3	Poor	5
% Crown Cover	59.5	Fair	3
Totals			30

Spawning Habitat: This area was observed to be spawned on by salmon but the gravel is unstable and could wash out with floods. There was no boulder or LWD material to stabilize the gravel. Pink Salmon spawners were observed in the reach.

Rearing Habitat: The pools are shallower than lower reaches and this is due to the over-widened channels lacking confined scour depth. There is virtually no cover other than some vegetation in the water. These areas have no rooted banks as the trees have been washed away. This reach had poor instream cover, only fair crown cover and would be poor rearing habitat at any time of the year.

R4 Riparian Assessment

Riparian Vegetation Type: The second growth forest was a mix of Douglas Fir with Red Cedar, Big Leaf Maple, Sitka Spruce and Grand Fir. No old growth was observed, the stream was historically logged to its banks. The understory vegetation consisted mainly of Willow, Pacific Ninebark, Salmon Berry and Red Osier Dogwood. No significant non-native species were observed. There is broom and Blackberry along exposed sections at fence lines. The riparian area has evidence of flooding.

Vegetation Depth: The left and right riparian average depth of 22m was poor for the big river system. There were areas of zero riparian trees against a left bank pasture in the reach above the survey segment.

Land Use: Characteristics of the riparian zone were native forests and farm land. Tree removal adjacent the river banks or in the floodplain appeared to be exasperating the erosion and increasing the meander.

Bank Slopes: This reach has low (10%) riparian bank slopes throughout. As noted above, the riparian area is in floodplain for most of the length.

Bank Stability: The bank stability was rated medium to high in the treed lower survey area. Upstream, airphoto images show the banks have collapsed by up to 40m depth. This is a concern. Stabilizing the gravel that is in the large gravel bars would reduce impacts downstream.

Access: There are no human crossings on this reach and no observed livestock entry areas.

Restoration Opportunities: **T4**

- The bank erosion on the meander corners in the mid and upper reach segment need to be assessed for protection. The meanders are so deep that erosion appears to be self perpetuating. It needs to be determined if it is practical to Install erosion protection along the cut banks.
- The large gravel bars should be stabilized once the bank erosion in the reach is addressed. The site needs closer assessment for prescriptions, but gravel bar staking is likely to be part of the solution. There are several whole trees that show up on aerial photos, if they are still there, they may be anchored and used to protect the banks and bars before they wash away.

5. Tsolum Mainstem Assessment Results – Reach T5

This reach is approximately 6,964m long. It is the longest most consistent reach in the watershed in a relatively confined and protected area. It starts adjacent Burns Road and ends upstream at the Dove Creek confluence.

T5 Fish Habitat Assessment

The FHAP was done Oct. 2, 2015, during low flow. The FHAP segment was 797m long. It was accessed through Godin farm off Nelson Rd. The survey area was in a confined river valley with 20-30m height banks on the river left side and lower banks 3-10m on the right bank. The survey segment captured a long left meander and straight run with five pools and riffles. This survey segment had some of the longest habitats measured in the entire watershed; habitat unit T5H1 was a boulder riffle 286m long, followed in T5H2 by a 104m long pool. In riffle 1, we found no secondary habitats such as edge pools due to the lack of instream wood debris. Pool 1 was similarly deficient in LWD and the best cover the fish would have was depth (1.1m avg). All the other pools were similarly devoid of cover. The stream was flowing at levels just above the lowest summer levels and only 53% of the channel width was wetted.

Table 9 Reach T5 Habitat Summary Card

Channel Width (m)	36.4	Wetted Width (m)	19.35	Stream Gradient (%)	0.5
Water Temperature (C)	na	Estimated Flow (lpm)	2000	Fish Access	Y
Survey Date	Oct. 2/2015	Est Flow Stage (%)	10	Flow Regime	P
Substrate	4% Boulder, 8% Cobble, 65% Gravel, 28% Fines				
Canopy	58.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover	4% Boulder, 0% LWD, 0% undercut , 0% Vegetation, 3% Other				

The instream fish cover was primarily Boulder cover which was not especially good for larger fish. Only three pieces of functional LWD were observed. It was evident that winter floods had moved the material out. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 10 Tsolum Mainstem Reach T5 Habitat Data Summary and Ratings

Habitat Parameter	T5	Result	Ratings
% Pool Area	50.6	Fair	3
Large Woody Debris/Bankfull Channel Width	0.1	Poor	5
% Cover in Pools	6.5	Fair	3
Average% Boulder Cover	4	Poor	5
Average % Fines	24.5	Poor	5
% of Reach Eroded	10	Poor	5
Obstructions	5	Poor	5
% of Reach Altered	0	Good	1
% Wetted Area	53.2	Poor	5
% Crown Cover	58.5	Fair	3
Totals			40

This reach scored poorly in every category but % pool and instream cover. The Poor scores are a function of high runoff and erosion has removed all features from the area. .

Spawning Habitat: This area was observed to be spawned by Pink Salmon. There was less gravel in this survey area and spawning habitat was limited. Not all pool tailouts had suitably sized material; some had only immovable boulders while Pool 1 had a lot of sediment.

Rearing Habitat: The pools of this reach are between 0.75 and 1.1m deep onb average at time of survey. Their crests likely drop 10 – 15 cm lower in mid summer. collectors for fry escaping drying habitats of the mainstem and tributaries. The highest cover component (4%) was boulders. Unfortunately they offer little for adults or winter conditions. Inserting cover into these pools would assist summer survival greatly but could very likely be washed away in winter. There is a large seasonally

flowing and perennially wet floodplain on the left bank. The TRRS volunteers mention it dries and Coho fry are salvaged in summer. It is approximately 300m long and cuts across the left bank meander. There is the possibility the river could break through this sidechannel.

T5 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir with Red Cedar, Big Leaf Maple and Western Hemlock. No old growth was observed, the stream was historically logged to its banks. The understory vegetation consisted mainly of Pacific Ninebark, Salmon Berry and Red Osier Dogwood. No significant non-native species were observed.

Vegetation Depth: The left and right riparian depth (46/43m) along the banks was good. The riparian depth of the entire 6.9 km reach is on average over 30m wide. This results in the widest riparian area segments of the Tsolum Mainstem. The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Characteristics of the riparian zone on the left and right side are native forests with farms and pastures further back. It has virtually no adjacent roadways affecting the riparian area.

Bank Slopes: This reach has a variety of bank slopes at different locations. The steepest bank was at Pool 1 along river left bank with a 30m bank on 50% gradient. The same bank at the top end had only 5% slopes and the river was seasonally overflowing into the floodplain.

Bank Stability: The bank stability was medium to high along all but two cut bars. The reach appears to be improving in bank stability over the years as the trees are growing close to the Bankfull channel.

Access: There are no human crossings on this reach and no observed livestock entry areas.

Restoration Opportunities: Reach T5

- . Development of the left bank sidechannel in the active floodplain area should be reviewed. There is road access to the 300m channel. It has a low entrance and the outlet goes into T5 Pool 1. The work may be preventative to the river changing course and entering which would be disastrous. Protection of the current sidechannel is needed before it blows out. This site offers winter flood refuge which may be possible to improve but due to the river alterations, is especially vulnerable to collapsing.

6. Tsolum Mainstem Assessment Results – Reach T6

This reach is approximately 4375m long. It is a long confined reach from Dove Creek upstream to Headquarters Creek with many forested sections and farm land.

T6 Fish Habitat Assessment

The FHAP was done Oct. 3, 2015, at moderate low flow (there had been one rain elevating the flow above the rocks by 10cm. The channel width dropped by approximately 10m above Dove Creek at 23.8m. The FHAP segment was 387m long and located downstream of the Fitzgerald Road Bridge. The survey area was in a confined river valley. The survey segment captured a left bank meander and long straight run. There were five pools and riffles measured riffles. The longest single habitat unit in this reach was a 138m riffle. The longest pool was 90m long with a 2.5m depth.

Table 11 Reach T6 Habitat Summary Card

Channel Width (m)		23.85	Wetted Width (m)	19.35	Stream Gradient (%)	0.5
Water Temperature (C)		na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 3/2015		Est Flow Stage (%)	15	Flow Regime	P
Substrate	13% Boulder, 35% Cobble, 22% Gravel, 30% Fines					
Canopy	62% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry					
In-stream Cover	7% Boulder, 0% LWD, 0% undercut , 0% Vegetation, 0% Other					

The instream fish cover was primarily Boulder cover as well as some which was not especially good for larger fish. Only three pieces of functional LWD were observed. It was evident that winter floods had moved the material out. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 12 Tsolum Mainstem Reach T6 Habitat Data Summary and Ratings

Habitat Parameter	T6	Result	Ratings
% Pool Area	50.4	Fair	3
Large Woody Debris/Bankfull Channel Width	0.0	Poor	5
% Cover in Pools	7	Fair	3
Average% Boulder Cover	7	Poor	5
Average % Fines	29.5	Poor	5
% of Reach Eroded	10.3	Poor	5
Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	81	Poor	5
% Crown Cover	62	Fair	3
Totals			36

This reach is now stable after likely years of scouring flows. The result is boulder riffles and bare scour pools. The habitat scores reflect the condition of the reach.

Spawning Habitat: The lowest gravel (22%) content in the first six reaches. There appeared to be fwew good places to spawn in this reach due to boulders or fines being the dominant substrates.

Rearing Habitat: The pools of this reach include a very deep (2.5m) scour pool. But offer no cover from predation or flood velocities. There is virtually no off channel refuges due to the confinement.

T6 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir with Red Cedar, Big Leaf Maple and Western Hemlock. No old growth was observed, the stream was historically logged to its banks. The understory vegetation consisted mainly of Pacific Ninebark, Salmon Berry and Red Osier Dogwood. No significant non-native species were observed.

Vegetation Depth: The left and right riparian depth (14/38m) varied due to farm clearing on left and forest on right. The airphotos indicate that the remaining areas of the reach have even more riparian depth on the left bank. The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Characteristics of the riparian zone on the left and right side are mostly second growth forests which have been logged but the reserve areas appear to be 30 to 50m at least. The farm areas are thinner native forests with farms and pastures further back. It has virtually no adjacent roadways affecting the riparian area.

Bank Slopes: There is a low terrace on 10% slope away from the river, there are river valley walls further back from the river.

Bank Stability: The bank stability was high along the reach segment. No erosion from slides or blowdown was observed.

Access: There are two bridges on Fitzgerald and Farnham Roads. No human crossings or livestock entry areas were observed along the 397m survey area.

Restoration Opportunities: Reach T6

- . Historical impacts removed the LWD cover from this reach. The confinement of the channel limits its restoration potential. Wider channel areas where tractive force is reduced offer areas to add instream habitat but None were noted in the survey area of Reach 6.

7. Tsolum Mainstem Assessment Results – Reach T7

This reach is approximately 1747m long. This reach starts at Headquarters Creek and runs upstream along River Avenue to Reach 8 adjacent Railway Avenue. It is a relatively unconfined meandering reach with many bars. Pup Creek enters the river right bank on this reach.

T7 Fish Habitat Assessment

The FHAP was done Oct. 2, 2015, at moderately low flow where there had been one rain elevating the flow above the rocks by 10cm. FHAP segment was 449m long and represented a 25% sample of the 1747 m reach. The site was accessed from River Avenue. The survey area was in an unconfined river channel with many gravel bars on the inside of the meanders. The survey segment captured a left bank meander. There were five pools and riffles measured riffles, with pools 96% of total wetted area. The longest habitat unit in this reach was a 139m pool. The average depth of the pool was 1.0m. The longest riffle was 25m long.

Table 13 Reach T7 Habitat Summary Card

Channel Width (m)	20.3	Wetted Width (m)	10.39	Stream Gradient (%)	0.85
Water Temperature (C)	na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 3/2015	Est Flow Stage (%)	15	Flow Regime	P
Substrate	0% Boulder, 3% Cobble, 40% Gravel, 58% Fines				
Canopy	55.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover	0% Boulder, 1% LWD, 0% Undercut , 4% Vegetation, 0% Other				

The instream fish cover included some LWD (1%) and instream vegetation (4%). Only four pieces of functional LWD were observed. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 14 Tsolum Mainstem Reach T7 Habitat Data Summary and Ratings

Habitat Parameter	T7	Result	Ratings
% Pool Area	96	Good	1
Large Woody Debris/Bankfull Channel Width	0.18	Poor	5
% Cover in Pools	5	Poor	5
Average% Boulder Cover	0	Poor	5
Average % Fines	58	Poor	5
% of Reach Eroded	13	Poor	5
Obstructions	0	Good	1

% of Reach Altered	0	Good	1
% Wetted Area	51	Poor	5
% Crown Cover	55.5	Fair	3
Totals			36

This reach also had 39.5% gravel in the substrates as a product of the wide meandering bars. There was a wide floodplain along the survey segment that extended into the treed forest. The floodplain had wide routes on river left that over run the banks and saturated the ground resulting in wetland plant species such as Skunk Cabbage as indicators of the flood routes.

Spawning Habitat: There was plenty of gravel and Pink Salmon were spawning on pool tailouts all along the reach. The pool outlet crests had not been scoured down to boulders and were being fully used by salmon spawners. Due to the unconfined nature of this reach, the channel substrates are somewhat protected from flood scour as the floodplains reduce the velocity and intensity.

Rearing Habitat: The pools lack all but vegetation cover. Fortunately the low banks allow the shrubbery to overhang pools and hide fry or adults. The root masses on the banks are re-establishing. .

T7 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir , Red Cedar and a thin bank older red Alder. The regular floodplain results in many understory shrubs including Pacific Ninebark, Salmon Berry and Red Osier Dogwood. No significant non-native species were observed.

Vegetation Depth: The left and right riparian depth (30/30m) was adequate in the survey area, it had been thinned by the residences on either side. Most of the remaining area of the reach is much deeper (50m). The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Land use in the riparian area of this survey segment was native forest and rural residential properties partially cleared.

Bank Slopes: There are low banks on 10% slope. There was evidence of floodplain on the left bank that extended 30-50m. .

Bank Stability: The bank stability was fair with some slumping and erosion on the outsides of meanders. . There were beaver dam holes and human clearing on the banks along the reach segment. The old Red Alder trees are occasionally falling in as they die and tearing out parts of the bank.

Access: There are no crossings on this reach. In the survey segment, there is a trail along the river to a swimming/fishing hole.

Restoration Opportunities: Reach T7

- This reach offers good spawning opportunities compared to other lower areas of the river. It is above and therefore protected from the Dove Creek sediment loads. Protection of the spawning beds is important in this reach.
- Lack of LWD cover in this reach is similar to other reaches, but the placement may be more successful given the low and wide channel. Installation of LWD along these banks appears more likely to succeed but requires further investigation.
- There are many old Red Alders that have fallen and they have left exposed bank areas. The Riparian area in this reach should be assessed for “Alder” management. The leaning Alders may

be cut to lower live limb and the area around under-planted with Red Cedars protected by Alder slash piles from the cut trunk.

8. Tsolum Mainstem Assessment Results – Reach T8

This reach is approximately 1903m long. This reach starts alongside Railway Avenue and ends on the upstream side of Highway 19. It is a relatively confined reach with a forested boundary except the clearings for the Vancouver Island Transmission line and Island Highway.

T8 Fish Habitat Assessment

The FHAP was done Oct. 6, 2015, at moderately low flow where there had been one rain elevating the flow above the rocks by 5-10cm. The FHAP segment was 700.8m long and represented a 36% sample of the 1903 m reach. The site was accessed from Railway Avenue and just below the highway. The survey area was in a confined river channel. The survey segment captured three meanders in the channel. There were five pools and riffles measured. The longest habitat unit in this reach was a 177m Riffle, and the longest Pool was 103m with a mean depth of 0.6m. Average depth of the pool was 1.0m. The wetted area was 73% of the channel, the highest value in all lower reaches.

Table 15 Reach T8 Habitat Summary Card

Channel Width (m)	21.02	Wetted Width (m)	15.35	Stream Gradient (%)	0.65
Water Temperature (C)	na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date Oct. 6/2015		Est Flow Stage (%)	15	Flow Regime	P
Substrate	17% Bedrock, 10% Boulder, 31% Cobble, 28% Gravel, 14% Fines				
Canopy	78.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover	6% Boulder, 1% LWD, 0% Undercut , 2% Vegetation, 0% Other				

The instream fish cover was fair with 9% total, offering fry cover in boulders. Only two pieces of functional LWD were observed in the 700m survey area. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 16 Tsolum Mainstem Reach T8 Habitat Data Summary and Ratings

Habitat Parameter	T8	Result	Ratings
% Pool Area	54.37	Good	1
Large Woody Debris/Bankfull Channel Width	0.06	Poor	5
% Cover in Pools	9	Fair	3
Average% Boulder Cover	6	Poor	5
Average % Fines	13.9	Poor	5
% of Reach Eroded	0	Poor	5
Obstructions	0	Good	1
% of Reach Altered	8	Fair	3
% Wetted Area	73.03	Fair	3
% Crown Cover	78.5	Good	1
Totals			32

This reach also had 27.8% gravel in the substrates. This site was relatively confined with no off channel habitat observed.

Spawning Habitat: The spawning areas were less consistent at every pool tailout due to the bedrock outcropping on the stream bed. As the survey proceeded upstream to the Highway, there was more gravel and spawning opportunities. Overall this reach is not as productive for spawning as T7 below.

Rearing Habitat: The pools lack adult cover, the boulders will hide fry, but several pools were 0.25-0.35m deep, inadequate for survival in summer. The reach lacks flood protection and the lack of LWD is a big loss.

As with T7 the banks have shrubbery overhanging the pools that protects the pools from heat and predators. Property owners have shored up the river left bank with logs in two sites on the survey segment. While likely not intentional, they serve as proof that LWD could be added to this reach and with good anchoring not wash away..

T8 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir, Red Cedar and a thin band of older dying Red Alder. The riparian canopy was 78%, the highest value in the lower Tsolum.

Vegetation Depth: The left and right riparian depth (40.5/43.0m) was quite wide, and included some road and residential clearing. The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Land use in the riparian area of this segment was forestry and rural residential properties partially cleared.

Bank Slopes: There are low banks on 10% slope. There was little evidence of floodplain.

Bank Stability: The bank stability was fair to high, with a couple of locations where residences had shored up banks with logs. The Red Alder trees are over mature and falling in, with no replacement conifers growing behind them. The trees are tearing out parts of the bank as they fall in.

Access: There are no crossings on this reach. There are individual property owner accesses on the left bank. .

Restoration Opportunities: Reach T8

- Lack of LWD cover in this reach is similar to other reaches, but the placement may be successful given the access off Railway Avenue. There appears to be potential anchor trees for short pieces of LWD along the edges of Pools H8 & H10. Small spurs may collect debris and create edge cover if locations allow.
- The aging Red Alder trees are falling in, a riparian prescription is required to determine if it could be pruned and replaced with conifers over time. No doubt some property owners are interested.

9. Tsolum Mainstem Assessment Results – Reach T9

This reach is approximately 3853m long. This reach starts just above Highway 19 and runs upstream through a big meander and then a long straight run beside Wolf Mountain to Constitution Creek.

T9 Fish Habitat Assessment

The FHAP was done Oct. 6, 2015, at moderately low flow where there had been rain elevating the flow above the rocks by 5-10cm. FHAP segment was 765m long and represented a 20% sample of the 3853m reach. The site was accessed from Highway 19. The survey area was in a semi-confined river channel just below a large gravel bar in a meander. The survey segment actually started below the reach in the top of T* and went under the Highway 19 Bridge and then into T9 for the last 5 segments. The

segment had four pools and six riffles. The longest habitat unit in this reach was a 144 m riffle. There were also two pools over 100m long and 0.65 to 1.5m deep.

Table 17 Reach T9 Habitat Summary Card

Channel Width (m)	22.81	Wetted Width (m)	15.36	Stream Gradient (%)	0.65
Water Temperature (C)	na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 6/2015	Est Flow Stage (%)	15	Flow Regime	P
Substrate	7% Bedrock, 10% Boulder, 23% Cobble, 42% Gravel, 20% Fines				
Canopy	54% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover	3% Boulder, 6% LWD, 0% Undercut , 1% Vegetation, 0% Other				

The instream fish cover was better with LWD (6%) and Boulder (3%). There were a dozen pieces of LWD and most were in the H6 pool, where many adult Pink Salmon were hiding as the crew passed through. There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 18 Tsolum Mainstem Reach T9 Habitat Data Summary and Ratings

Habitat Parameter	T7	Result	Ratings
% Pool Area	28.84	Poor	5
Large Woody Debris/Bankfull Channel Width	0.36	Poor	5
% Cover in Pools	9	Poor	5
Average% Boulder Cover	3	Poor	5
Average % Fines	20	Poor	5
% of Reach Eroded	0	Good	1
Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	67.34	Poor	5
% Crown Cover	54	Fair	3
Totals			36

This reach also had 41.5% gravel in the substrates as a product of the meandering bars upstream. There was no offchannel habitat or floodplain noted in the survey. The Highway 19 bridge was over one of the pools.

Spawning Habitat: There were Pink Salmon spawning throughout the reach. This reach was more gravelly that T8 and the salmon preferred it. The spawning habitat in this reach may be improved by adding rock crests using imported rip rap or rearranging large river boulders. If this is possible, it would stabilize the gravel beds and allow increased collection of gravel. There is potential access off the highway.

Rearing Habitat: Some pools have good LWD cover, others have none. Stabilizing the LWD in this reach and adding more along the banks appears to be worth investigating further. There is potential access off the highway or nearby logging roads.

T9 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir , Red Cedar and a thin bank older red Alder. The riparian canopy was 54%, only a fair amount of shade.

Vegetation Depth: The left and right riparian depth (42m) was quite wide. There is active logging in this reach and the depth varied considerably if near a recent cutblock, but there appeared to be no areas cleared adjacent the creek except the Vancouver Island Hydro Line crossing, and included some road and residential clearing. The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Land use in the riparian area of this segment appears to be all forestry and Right of Way clearing for the Hydro Line.

Bank Slopes: There are low banks on 10% slope. There was little evidence of floodplain and no slides observed or expected in the flat terrain.

Bank Stability: The bank stability was medium, with exposed gravel banks at corners and many areas where the Alders have leaned in as the die off. The water washes behind the tree root and results in erosion and loss of confined channels.

Access: The Hydro Line crosses this reach. There is approximately 100m of riparian area cleared on either bank of the river. Hydro does not use this as a service vehicle crossing.

Restoration Opportunities: Reach T9

- The spawning areas of this reach may be improved by riffle crest restoration. Investigate the areas above the Highway and Hydro Line where rock crests may assist in stabilizing the gravel and increase spawning success.
- There were 12 LWD in this survey segment, the most in the area. These pieces may wash out and should be inspected for stabilization with cables or ballast. Also investigate if more LWD could be added to the reach, access appears good in several areas. BD Hydro may be interested in partnering under their easement.
- There are many old Red Alders that have fallen and have left exposed bank areas. The Riparian area in this reach should be assessed for “Alder” management. The leaning Alders may be cut to lower live limb and the area around under-planted with Red Cedars protected by Alder slash piles from the cut trunk. This is forestry land and the property owner may be able to offer advice on thinning, girdling and planting.

10. Tsolum Mainstem Assessment Results – Reach T10

This reach is approximately 1775m long. This reach starts at Constitution Creek and runs upstream in a unconfined and meandering area in forestry lands.

T10 Fish Habitat Assessment

The FHAP was done Oct. 11, 2015, at moderately low flow, there had been rain elevating the flow above the rocks by 5-10cm. the FHAP segment was 706m long and represented a 40% sample of the 1747 m reach. The site was accessed from the Duncan Bay main by walking down or off the DBM 3700 spur and walking up. The survey area was near the top of the reach and ended just below reach T11. It is an unconfined river channel with many gravel deposition bars. There were five pools and riffles measured. The longest habitat unit in this reach was a long (173m) shallow (0.5m) pool. The longest riffle was 65m long.

Table 19 Reach T10 Habitat Summary Card

Channel Width (m)	31.1	Wetted Width (m)	14.75	Stream Gradient (%)	0.5
Water Temperature (C)	na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date Oct.11/2015		Est Flow Stage (%)	15	Flow Regime	P
Substrate	0% Bedrock, 1% Boulder, 26% Cobble, 40% Gravel, 34% Fines				
Canopy	72.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover	0% Boulder, 2% LWD, 2% Undercut , 1% Vegetation, 0% Other				

The instream fish cover included 23 pieces of LWD. This wood was providing cover for fish but aside from a few remnant attached cedar stumps, the wood had recently washed or fell in. There were several recent Red Alder that had fallen out of poorly rooted banks into the channel.

There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 20 Tsolum Mainstem Reach T10 Habitat Data Summary and Ratings

Habitat Parameter	T10	Result	Ratings
% Pool Area	72	Good	1
Large Woody Debris/Bankfull Channel Width	1.01	Fair	3
% Cover in Pools	5	Poor	5
Average% Boulder Cover	0	Poor	5
Average % Fines	33.5	Poor	5
% of Reach Eroded	1	Good	1
Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	47.43	Poor	5
% Crown Cover	72.5	Good	1
Totals			28

This reach also had 39.5% gravel in the substrates as a product of the wide meandering bars. The sediment deposition in this area is influenced from Murex Creek. There were numerous braids and alternate channels running parallel with the main channel. The channel is over wide and unstable with deposition bars pushing the water into the weak riparian zone.

Spawning Habitat: There were some Pink Salmon redds in the vicinity. There is plenty of gravel but many bars are unstable and appear to move about in winter. At low flow the gravel piles are migration barriers to low flow migrating adults.

Rearing Habitat: The pools lack cover and depth. The accumulated gravel bars dewater in summer to the point they are isolated pools without connected flow. The channel is migrating in several directions and only the historic Cedar root masses offer confinement. These cedar root masses could be the focus of restoration efforts for cover in pools.

T10 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir and Red Cedar. The river edge and floodplain areas is dominated by Red Alder which appears to be poorly understocked with conifer.

Vegetation Depth: The left and right riparian depth was an average of approximately 30m. There were areas where the Alder was experiencing blowdown.

Land Use: Land use in the riparian area of this survey segment was all forestry operations. There was a recent cutblock on the river right side.

Bank Slopes: There are relatively high banks on 25-30% slope. The confinement protects the channel with more shade and less blowdown. There was little meander and no floodplain noted.

Bank Stability: The banks were vegetated to the high water mark. The younger riparian does not have good root strength. In straight runs it holds the banks together, but in meanders, the river breaks out through the trees.

Access: There are no crossings on this reach.

Restoration Opportunities: Reach T10

- This reach is still very active in meandering new routes in the floodplain. The regenerating riparian area is holding the river in confinement except in break out areas. Helping the Riparian area health by under planting with more Conifers and possibly removing/stabilizing leaning Alders should be assessed. .
- There is a lack of stable cover in this reach in pools due to historic logging removing the trees and rooted banks. There remain some old growth Cedar stumps along the stream banks. Locating these stumps (and any other large logs) offer points for establishing instream cover in select pools. The stumps may be made more secure with ballast. If secure they could be anchors for small LWD spurs into adjacent pools. To increase wood cover in pools. This is scalable work to the capability and budget; i.e. hand winching conifer blowdown from adjacent timber edges and pounding in duckbill ground anchors or using machinery and larger material if access is available..

11. Tsolum Mainstem Assessment Results – Reach T11

This reach is approximately 1113m long. This reach starts above T10 Headquarters Creek and runs upstream to the confluence of Murex Creek.

T11 Fish Habitat Assessment

The FHAP was done Oct. 8, 2015, at moderately low flow where there had been some fall rain elevating the base flow above the rocks by 5-10cm. The FHAP segment was 648m long and represented a 58% sample of the 1113 m reach. The site was accessed from the DBM 3700. The survey area is a semi-confined river channel with influence from Murex Creek directly upstream. The lower areas are more confined and further upstream near Murex, the channel is wider and shallower. The survey segment is a long run with little meander. There were five pools and riffles measured. The longest habitat unit in this reach was a 136m pool. The average depth of the pool was only 0.3m. There were many long shallow pools, the riffles were generally shorter with longest at 80m.

Table 21 Reach T11 Habitat Summary Card

Channel Width (m)		19.7	Wetted Width (m)	12.55	Stream Gradient (%)	0.5
Water Temperature (C)		Na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 8/2015		Est Flow Stage (%)	15	Flow Regime	P
Substrate		5% bedrock, 6% Boulder, 22% Cobble, 55% Gravel, 14% Fines				
Canopy		78% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry				
In-stream Cover		4% Boulder, 1% LWD, 0% Undercut , 0% Vegetation, 0% Other				

The instream fish cover included 37 pieces of LWD (1%) and boulders (4%). There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 22 Tsolum Mainstem Reach T11 Habitat Data Summary and Ratings

Habitat Parameter	T11	Result	Ratings
% Pool Area	80.59	Good	1
Large Woody Debris/Bankfull Channel Width	1.14	Fair	3
% Cover in Pools	5	Poor	5
Average% Boulder Cover	4	Poor	5
Average % Fines	55	Poor	5
% of Reach Eroded	0	Good	1
Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	62.8	Poor	5
% Crown Cover	78	Good	1
Totals			28

This reach also had 55% gravel in the substrates as a product of the delivery from Murex Creek. There was a no floodplain noted along the survey segment (it is in a small confined valley with 25-30% sidewalls.

Spawning Habitat: The confined nature of the lower three quarters of this reach (outside Murex influence) has a light layer of gravel anchored against bedrock and boulder outcrops. There had been Pink Salmon spawning in select areas the week before (redds are visible). The sites are relatively low in area but stable. The Murex pile of gravel upstream will seed this site for many years to come.

Rearing Habitat: The entire reach lacks cover. The LWD counted (27) was entirely old large snags, cedar stumps and small Alder blowdown. Most was pinned up against the banks and offered cover only at high water. The material was useful in protecting the banks from further erosion but not hiding fish at low water.

T11 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir , Red Cedar and lots of Red Alder on the stream banks. Areas do not look adequately restocked with conifer understory to succeed the dying Alder. The canopy is dense and well drained, with shoreline shrub line thin but includes Pacific Ninebark, Salmon Berry and Salal. No significant non-native species were observed.

Vegetation Depth: The left and right riparian depth (29.5/15m) was in forestry lands. The forest appears stable with little evidence of blowdown sensitivity in the confined valley. This reach has very high canopy closure (78%) to moderate summer exposure.

Land Use: Land use in the area is forestry.

Bank Slopes: There banks are on 25-30% slope. All were vegetated with no signs of failure. There is no floodplain on this confined reach.

Bank Stability: The bank stability was high throughout the reach. There was evidence of historic sloughs along the channel edges that were now vegetated. There were some bedrock outcrops along the banks.

Access: There are no crossings on this reach.

Restoration Opportunities: Reach T11

- The channel has shallow pools with no cover. The rearing habitat in this reach is poor both for winter flood protection and summer predation protection. There are no easy fixes in this confined energetic reach. Habitat complexing of very large LWD would be expensive and risky. The fish have likely adjusted to the condition and have less utilization of the reach. The reach is relatively short and the areas downstream and upstream of Murex are more stable. There is likely some migration of fry out of this reach at stressful periods.
- Riparian recovery is the long-term objective. Enhancement to regeneration of large structural trees will provide cover, bank protection and instream habitat. The are suffers the same problems as below of lack of Conifer overstory. There appears to be more conifer understory in this reach and a release program to enhance their growth may be investigated.

12. Tsolum Mainstem Assessment Results – Reach T12

This reach is approximately 1240m long. This reach starts at Murex Creek and runs upstream to just above the Duncan Bay Mainline crossing at the outlet of Hell Diver Creek. It is a relatively unconfined and meandering reach with bars.

T12 Fish Habitat Assessment

The FHAP was done Oct. 10, 2015, at moderately low flow where there had been one rain elevating the flow above the rocks by 5-10cm. The FHAP segment was 310m long and represented a 25% sample of the 1240 m reach. The site was accessed from the Duncan Bay Mainline. The survey area is a low gradient, low bank slope area with an unconfined channel. The survey segment was a long run with gentle meanders. There were five pools and riffles measured. The longest habitat unit in this reach was a 98.48m pool and a 48.48m riffle. The average pool depth was 0.48m.

Table 23 Reach T12 Habitat Summary Card

Channel Width (m)	13.56	Wetted Width (m)	7.01	Stream Gradient (%)	0.5
Water Temperature (C)	na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 10/2015	Est Flow Stage (%)	15	Flow Regime	P
Substrate	17% bedrock, 11% Boulder, 5% Cobble, 50% Gravel, 19% Fines				
Canopy	90.5% Doug. Fir, Red Cedar, Alder, Maple, Ninebark, Salmonberry, Salal				
In-stream Cover	1% Boulder, 1% LWD, 0% Undercut , 1% Vegetation, 0% Other				

There was very poor instream cover, with only three LWD (1%) and instream vegetation (4%). There are no fish migration barriers in this reach. The USHP ratings table below summarizes some of the habitat qualities.

Table 24 Tsolum Mainstem Reach T12 Habitat Data Summary and Ratings

Habitat Parameter	T12	Result	Ratings
% Pool Area	90.5	Good	1
Large Woody Debris/Bankfull Channel Width	0.13	Poor	5
% Cover in Pools	2	Poor	5
Average% Boulder Cover	1	Poor	5
Average % Fines	18.5	Poor	5
% of Reach Eroded	0	Good	1

Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	51.7	Poor	5
% Crown Cover	90.5	Good	1
Totals			30

This reach also had 49.5% gravel in the substrates as a product of past depositions. There did not appear to be much new gravel in the site from bank erosion, the channels were moderate to high in stability.

Spawning Habitat: The high gravel content is mostly near the bridge. The spawning habitat is limited as the area is dominated by pools with short tail outs due to the low gradient and lack of structure.

Rearing Habitat: The pools have virtually no cover, and they are shallower (0.5m) than lower reach areas. The overhanging trees offer 90% canopy, the highest found up to this point. This will help keep the water cool in summer but the pools are not very attractive in summer. The winter habitat is better than lower reach T11, the low banks allow some refuge along the edges in lower velocities. It is likely many fry migrate into the HellDiver wetland at the top of this reach for winter refuge and feeding.

T12 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir, Red Cedar and Red Alder. There is a streamside 5m wide thicket of Salmonberry. No significant non-native species were observed.

Vegetation Depth: A left bank Riparian depth of 50m and a right bank depth of 15m (adjacent the road). The forest appears stable with no evidence of blowdown sensitivity.

Land Use: Land use is all forestry in this reach.

Bank Slopes: There are low banks are 8% on the left and 14% on the right bank.

Bank Stability: The bank stability was medium to high with trees to the edge. The Alders are occasionally falling in and opening up exposures.

Access: The Duncan Bay Mainline bridge crosses over the reach top end. No other access was noted.

Restoration Opportunities: Reach T12

- This reach has fair spawning habitat. The long pools and low crests limit their area. Addition of spawning gravel crests (rock weirs) to re-establish dropped river profiles and hold more spawning gravel could be considered in this reach. The best locations would be near the Hell Diver tributary and the Duncan Bay Main. The road site offers machinery/material access opportunities.
- This reach lacks cover in pools. The road location offers the opportunity to import habitat materials. Given the straight run and low banks, placement of Boulders in the pools may be a safe option to start the habitat improvement. Ultimately as the river stabilizes, it needs LWD. Further investigation may reveal some secure places to install LWD such as along old growth stumps.

13. Tsolum Mainstem Assessment Results – Reach T13

This reach is approximately 2048m long. This reach starts just above the Duncan Bay Mainline at Hell Diver Creek and follows the mainstem up to end in a steep sided ravine which may be the end of anadromous access. The reach is entirely in a valley which starts wide and unconfined and as it climbs the valley floor narrows and becomes very confined.

T13 Fish Habitat Assessment

The FHAP was done Oct. 10, 2015, at moderately low flow where one rain elevated flow above the rocks by 5-10cm. The FHAP segment measures were 182m long and represented a 9% sample of the 2048m reach. The site was accessed from the Duncan Bay Mainline. The survey began in an unconfined river channel with many gravel bars that was found more confined upstream. There were five pools and riffles measured. The longest habitat unit in this reach was a 30m Pool followed by a 26m long Riffle. The average depth of the pools was 0.4m.

Table 25 Reach T13 Habitat Summary Card

Channel Width (m)		10.38	Wetted Width (m)	4.66	Stream Gradient (%)	1.2
Water Temperature (C)		na	Estimated Flow (lpm)	Na	Fish Access	Y
Survey Date	Oct. 10/2015		Est Flow Stage (%)	15	Flow Regime	P
Substrate		65 bedrock, 7% Boulder, 50% Cobble, 27% Gravel, 11% Fines				
Canopy		84% Doug. Fir, Red Cedar, Alder, Salmonberry, Devils Club				
In-stream Cover		0% Boulder, 1% LWD, 2% Undercut , 4% Vegetation, 0% Other				

The instream fish cover was poor and included only 2 pieces of LWD and an pverall instream cover of 5%. The lower survey reach was braided with an average channel width of 10.38m , the floodplain in this reach was twice this width. There are no fish migration barriers in this reach but at low flow the fish may not pass over the braids as the riffles were almost dry. The USHP ratings table below summarizes some of the habitat qualities.

Table 26 Tsolum Mainstem Reach T13 Habitat Data Summary and Ratings

Habitat Parameter	T13	Result	Ratings
% Pool Area	63.18	Good	1
Large Woody Debris/Bankfull Channel Width	0.11	Poor	5
% Cover in Pools	6	Poor	5
Average% Boulder Cover	0	Poor	5
Average % Fines	10.5	Poor	5
% of Reach Eroded	30	Poor	5
Obstructions	0	Good	1
% of Reach Altered	0	Good	1
% Wetted Area	44.9	Poor	5
% Crown Cover	84	Good	1
Totals			34

This reach also had 26.5% gravel in the substrates as a product of the bank erosion from braiding. The floodplain had cut recent routes through conifer stands and there were areas where maturing second growth fir are growing, threatening their loss.

Spawning Habitat: There was a mix of stability/instability in this area. Some gravel bars appear to be stable and offer good spawning sites. Other unstable areas risk loss of the site and dewatering. Overall, habitat for spawning is poor here.

Rearing Habitat: The pools lack cover and are increasingly shallow. The braided areas through the conifer forest did not result in any LWD inputs of use as cover as the debris appears to have washed away. This reach is near the end of suitable habitat for salmonids as it increases in gradient in the canyon above on a boulder and bedrock substrate. There are resident fish in the lakes upstream.

T13 Riparian Assessment

Riparian Vegetation Type: The second growth forest was primarily of Douglas Fir , Red Cedar and Red Alder. The floodplain results in many understory shrubs including Salmon Berry and Devils Club. No significant non-native species were observed.

Vegetation Depth: The riparian depth from the outside of the floodplain was 9.6m on the right bank and 31.5m on the left. It would appear that the channel recently flooded to the left bank.

Land Use: The Land use is entirely forestry operations in this reach.

Bank Slopes: There are low banks on 0-5% slope. The floodplain has entered and resulted in wide braids.

Bank Stability: The bank stability was poor with at least 30% of the reach banks eroded due to lack of confinement. The Red Alder located on the Floodplain are helping to stabilize the braiding.

Access: There are no crossings on this reach.

Restoration Opportunities: Reach T13

- The area of braiding on this reach is approximately 200m long. Repairs to the banks to reduce erosion should be assessed. There may be the opportunity to salvage the downed wood and anchor it to the banks to protect them. Machine access may be possible from the right bank cutblock to place local wood along banks.
- Riparian planting along the reserve areas with additional species such as Red cedar

14. Portuguese Creek Assessment Results

Portuguese Creek is anadromous the entire length of the survey area. The mainstem creek is over 12 km long. Farms (Dairy/beef/hay/vegetable/hobby) dominate the land use in the low-lying watershed. There are forested areas above Merville and Coleman Roads. Reaches P1, P2, P3 and P5 were surveyed covering the lower 7.8 km. The creek has seasonal flow with perennial pools. During the survey, the first flush occurred elevating water levels significantly from base low flow.

Fish Habitat Assessment – P1-P5

The Portuguese FHAPs were done from Oct. 1-24, 2015. There was moderate flow during the survey. The creek underwent its first flush rain of the year during the survey.

Table 27 Portuguese Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score
P1	611	329	17.8	0.5	35

P2	1929	124	13.34	0.86	27
P3	1822	159	10.6	0.65	31
P4	2221	0			Na
P5	1214	296	5.9	0.6	35
P6	4087	0			Na

The habitat survey results are summarized below with the full results of the assessment in the Sum and ratings Table (Appendix). The instream fish cover was very good in all reaches and the best attribute of the creek. The crown cover was lacking in most areas, which is due to riparian trees absent along the farm areas. This reach had many erosion observations, which brought into the channel sediments.

Table 28 Portuguese Creek Habitat Data Summary and Ratings

Habitat Parameter	P1	P2	P3	P5
% Pool Area	94.6	89.5	51.4	48.8
LWD/Channel Width	0.6	0.21	0.13	0.30
% Cover in Pools	39	23	16	38
Average% Boulder Cover	1	5	3	4
Average % Fines	29	7	34.5	56
% of Reach Eroded	45	55	46	48
Obstructions	2	0	0	4
% of Reach Altered	0	0	0	0
% Wetted Area	36.4	36.5	76.3	81.9
% Crown Cover	39	56	71	40

Spawning Habitat: The surveyors in October observed spawning Coho and Chum as well as their redds in the riffle areas and pool tail outs. The gravel had been reduced in volume, area and quantity by floods and sedimentation. There remained shallow spawning areas with an underlay of embedded sediments and rock surfaces stained black or brown by the organic material in the water. The fish were challenging the conditions and redds were observed through the reaches. The water during the first flush was clear except where walking had stirred up pool sediments. This indicates the pools are collecting the sediment. The water had a tea colour from tannins, organic inputs and sediment. The cause of sediment observed on most sites was undercut poorly rooted banks falling into the stream.

Rearing Habitat: The creek has fair to good pool habitat during the wet seasons. It offers excellent rearing habitat (cover, depth, food) once the channel is above base low flows. The creek can be expected to be colonized by fry from the mainstem Tsolum after the first flush to feed and seek flood refuge. It offers at least eight months of good rearing habitat but in summer pools lack cover and are increasingly shallow. Water quality and quantity in summer are limiting factors. During spring as water levels recede fish will migrate out to the mainstem; with smolts heading to the ocean, and young of year fry headed to the deep pools of the mainstem.

Riparian Assessment – Portuguese Creek

Riparian Vegetation Type: The dominant vegetation in this reach is the shrubbery consisting of Red Osier Dogwood, Salmonberry, Pacific Ninebark and Willow species. There is a thin overstory of Alder, Maple, Douglas Fir and occasional Cedar and Spruce. No significant non-native species were observed.

Vegetation Depth: The riparian depth average was 26m for the creek. Both sides have farm pastures on the backside of the stream. While not optimal, it is adequate if the plant community was improved with select plantings. In each of the four reaches surveyed in Portuguese Creek were sites where trees or shrub plantings will improve the health of the riparian area and reduce erosion and improve shade value locations noted on the reach data sheets.

Land Use: The land around the riparian area is almost entirely farm pastures as well as Headquarters, Smith and Merville Roads.

Bank Slopes: There are mostly low banks of 0-20%.

Bank Stability: The bank stability was fair. There were eroded cutbanks on the meander corners. These sites were often associated with overhanging trees falling in.

Access: There was scarce livestock access into the creek. Reach P1 was the only area noted. There are fences in place but they appear to require maintenance or gates. There were smaller human foot trails throughout.

Restoration Opportunities – Portuguese Creek

- Stabilization of erosion/sediment sources is the highest return in this reach. Ensure the creek is fenced from livestock, then plant along the exposed areas. The cutbank erosion requires protection at the base and stabilization of the upper slope. Including taller trees in planting strategies to alleviate the limited Crown Cover.
- The deep pools in lower reaches offer good rearing but in order to maintain or increase pool depth, the sediment needs to be removed through; passive log scour structures anchored in pools, pool excavation, or a sediment trap near Headquarters Road to collect the sediments before they enter the downstream area.
- There is a beaver dam in P1 and likely in other areas. The P1 dam increases the pool depth benefitting summer fish habitat. It does not appear to be flooding any pasture. Generally Beaver dams overtop or wash out in winter allowing fish access. During the survey the water was not yet overtopping but passing through the .3-.4m height structure. The flood scour line in the channel appeared to be 0.6m so it should overtop. This should be inspected. There are many options for working with Beavers if required to permit fish passage (cages, pipes) and to protect (wire) adjacent plants.

15. Dove Creek Assessment Results

Dove Creek is anadromous the entire length (10,895m) of the survey area D1-D6 (the barrier is just above in the canyon D7). The mainstem Dove Creek is over 20km long and has Anderson Lake in the headwaters below Mt. Washington. Reaches D1, D3 and D6 were surveyed. During late summer the flow is a trickle over riffles with perennial pools.

Fish Habitat Assessment – Dove Creek

The Dove FHAPs were done from Oct. 3 & 6, 2015. Stream flow was at a low level with estimated discharge of 10% of mean flow (approx. 600 lpm). There had been one rain in September that brought levels up briefly but the flow had dropped back to base summer level. This flow was enough to draw in Pink Salmon spawners and they were observed live and dead throughout to the middle of reach D6.

Table 29 Dove Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score
D1	1723	370	18.1	0.7	37
D2	1571	0	Na	na	na
D3	3294	303	10.6	0.65	35
D4	1319	0	Na	na	Na
D5	921	0	Na	na	Na
D6	2067	435	15.2	3.1	31
D7	3691	0	Na	na	Na
D8	6367	0	Na	Na	Na
	20953				

The habitat survey results are summarized below with the full results of the assessment in the Sum and ratings Table (Appendix).

The D1 reach is a confined channel with gentle meanders adjacent large rural properties. It climbed at almost 1% gradient and featured several long (90m) boulder riffles. The pools were much shorter (19-53m) than riffles but were 1.0m deep at base low flow. There were two locations associated with pools (H1, H6) that had bank erosion along the outside of the meander associated with lack of vegetation.

The D3 reach was much lower gradient with long pools, short riffles and approximately 100m of bank erosion (both sides) directly under the Vancouver Island transmission line. The erosion appears to be a product of lack of bank root strength from the trees removed for the power line and sediment deposition from upland and localized erosion. The gravel bars are porous and a fish migration barrier observed with spawning Pink Salmon at low flow. Continuing upstream to the Island Highway, the reach was more confined and stable, lacking in LWD cover.

The characteristics of Reach D4 are visually similar to D3. We accessed D4 off the Parkway down an old road and did a visual inspection of this reach. We found a meandering pool riffle combination in low gradient but with a better riparian area and less erosion. D4 had dozens of Pink Salmon spawning at the time. We did not have time to do a full survey. This area is deficient LWD along the banks. Perseverance Creek enters on the right bank in this reach.

Reach D5 was also not assessed, other than a visual inspection which noted it was steeper than D4 and slightly smaller as it was located above the Piercy Creek entrance on the left bank.

Reach D6 was surveyed from the end of reach D5 upstream 435m under the Duncan Bay Mainline to end just below the beginning of a confined canyon. This reach is boulder dominated riffle with small step pools between longer riffles. The channel has eroded down with roots from remaining tree stumps hanging above the creek bed. There is evidence of past bank and bed erosion along the segment. The remaining material is larger and harder than its native state. There were virtually no fines in the substrate, there was 70% Boulder and Cobble. Spawning sites were limited, but the Pink Salmon were spawning on the limited locations of gravel (all redds were in the lower reach). The riparian canopy in this reach had good coverage (76%) and depth (30m) such that here is the materials to recover some habitat characteristics over time.

Table 30 Dove Creek Habitat Data Summary and Ratings

Habitat Parameter	D1	D3	D6
% Pool Area	38.4	82.96	10.06
LWD/Channel Width	0.15	1.48	0.10
% Cover in Pools	8	8	7
Average% Boulder Cover	6	1	7
Average % Fines	26.5	43.50	3.00
% of Reach Eroded	14	39	10
Obstructions	0	0	0
% of Reach Altered	0	7	5
% Wetted Area	44.03	48.18	45.53
% Crown Cover	68	34.5	76

Spawning Habitat: As noted above, the surveyors saw spawning Pink Salmon in this creek from D1 to D6. It would also serve as Coho and trout habitat. The best spawning areas are in the middle reaches from D2 to D5, where the gradient is flat and lots of gravel. This is where most of the salmon spawners were observed. The impacts of erosion and sedimentation in the D3 reach segment need to be addressed if better spawning habitat is to be attained.

Rearing Habitat: The pools in this creek in the segments of D1 to D5 offer year round rearing. They all lack LWD cover which improves rearing conditions markedly. Addition of cover in association with erosion protection measures is highly recommended.

Riparian Assessment – Dove Creek

Riparian Vegetation Type: The riparian zone is dominated by Douglas Fir with a row of streamside Alder leaning in (and some falling). The areas of disturbance have more Alder, Broadleaf Maple, Cedar, as well as Red Osier Dogwood, Salmonberry and Willow. No significant non-native species were observed.

Vegetation Depth: The riparian depth average was 20 to 30m on either side through the creek. The lower reaches had incursions from property owners (often aiding in bank erosion). The middle reach (D3) vegetation was cut to a thin shrub line at the Hydro line. The upper D6 reach had the widest average riparian (30m).

Land Use: The land around the riparian area is farm pasture in lower reaches (D1/D2) and private land forestry in the upper reaches. The Hydro line and Highway 19 crossing are significant intrusions to the stream.

Bank Slopes: There are mostly low banks of 0-20% with reach D6 having a steep but stable bank (with many areas eroded to hardpan).

Bank Stability: The upland riparian slopes show no evidence of erosion, as they are all low gradient, except D6. The stream bank stability is Fair in Reach D1, poor in Reach D3 and fair in reach D6.

Access: There was no livestock access observed in the creek. The Hydro line has no road across the creek channel and no quad trails.

Restoration Opportunities – Dove Creek

- The D3 reach is a prime candidate for restoration given its easy access for restoration equipment and materials. The hydro line has 100m of erosion on both banks. It is recommended to add LWD such as boulder anchored conifer stumps be placed to protect the channel from erosion and increase fish cover. This may increase scour to provide a low flow thalweg for fish passage.
- The D1 reach has pools with erosion along the outside meander adjacent weakened riparian areas and pasture. The restoration areas have good access for machinery to place material at the toe of the bank (LWD/Boulders) and then pull back the top slope and plant, then fence.

16. Headquarters Creek Assessment Results

Headquarters Creek is anadromous from the Tsolum River up past the Hatchery through to Reach HQ2 at just above the Island Highway (4024m). It drains from Wolf Lake approximately 2.2 km further upstream that has resident trout. Reaches HQ1 and HQ2 were surveyed.

Fish Habitat Assessment – Headquarters Creek

The FHAPs were done from Oct. 3 & 9, 2015. Stream flow was at a moderate level with estimated discharge of 30% of mean flow (approx. 1200 Lpm). There had been one rain in September that brought levels up in the Lake and they were draining back down. The flow was enough to draw in Pink Salmon spawners and they were observed live and dead throughout.

Table 31 Headquarters Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score
HQ1	3303	440	11.99	1.2	25
HQ2	721	335	11.89	4.85	23
HQ3	2228	0	na	na	Na

	6252				

The habitat survey results are summarized below with the full results of the assessment in the Sum and ratings Table (Appendix).

Headquarters Reach HQ1 is 3,303m long from the Tsolum River upstream past the hatchery, under the power lines ending just below Highway 19. The reach is a confined channel with gentle meanders adjacent forestry parcels. It climbed out of the Tsolum valley on to a flat bench just above the hatchery. There are concrete footings and wood weirs across the stream channel. There is no low flow notch and fish are trapped without passage. The survey segment was 440m along this bench from the hatchery upstream to the hydro line clearing. The habitat surveyed was five pools and riffles. The pools varied from 20 to 137m with a mean depth of 0.9m. The riffles were shorter ranging from 7.7 to 61m. The large pool area was deficient in cover. The TRRS (2014) had placed a spawning crest and LWD (9) along the H4/H5 banks to improve habitat. The work was immediately successful, Pink Salmon had completely spawned on the placed gravel on the upstream side of the crest.

Headquarters Reach HQ2 is a steeper upper reach that's heads under Highway 19 to the anadromous barrier. The surveyors observed adult Pink Salmon in this reach despite its habitat limitations. The reach was 335m long and had only one 20m long pool. The remaining nine riffles were 18 to 80m long and broken up by 2-9% gradients. The substrate was over 90% Boulder/cobble, with small patches of gravel and virtually no fine sediments recorded. Instream cover was poor with little LWD. There was no observed bank erosion with boulder edges overhung by shrubbery.

Table 32 Headquarters Creek Habitat Data Summary and Ratings

Habitat Parameter	HQ1	HQ2
% Pool Area	68.13	3.84
LWD/Channel Width	0.44	0.53
% Cover in Pools	7	21
Average% Boulder Cover	2	11
Average % Fines	19.50	0.50
% of Reach Eroded	0	0
Obstructions	0	0
% of Reach Altered	0	0
% Wetted Area	81.23	64.76
% Crown Cover	68.5	85.5

Spawning Habitat: As noted above, the surveyors saw spawning Pink Salmon in this creek in HQ1/2. These sites would also serve Coho and Trout. The best spawning areas are the new gravel additions

placed in 2014. The Pink used them entirely. Augmenting gravel to the sites after this winter is advised as the Coho and floods are likely to push some gravel over the crest.

Rearing Habitat: The HQ1 reach has several deep pools, including a small full spanning beaver dam (with Pinks past it). The pools are year round and offer a large rearing volume. There is a concern of sun exposure on the southeast (Hydro) side.

Riparian Assessment – Headquarters Creek

Riparian Vegetation Type: The riparian zone trees are mostly a mixture of Douglas Fir and Alder. There is more Fir in the lower portions of the segment and more Alder in the top of HQ1 and through HQ2. There are Willow, Red Osier, Ninebark and Salmonberry in the understory.

Vegetation Depth: The riparian depth was an average of 20m in the HQ1 reach. The river right bank was especially thin on the Hydro line side (down to 5m).

The HQ2 reach has 43m depth and as long as riparian shade, currently 85%, is maintained; it will cool the water coming out of Wolf Lake. This is important given the temperature sensitivity of the pools in summer.

Land Use: The land around the riparian area is Forestry, Hydro Line Easement and Highway easement.

Bank Slopes: There are mostly confined vegetated banks on 15-45% slopes.

Bank Stability: The upland riparian slopes show no evidence of erosion and all are vegetated. The HQ1 reach is highly stable. The HQ2 reach has off channel and a log debris jam in the channel. The water routes around the features are old and show no new erosion.

Access: There was no livestock access into the creek. The Hydro line has no road across the creek channel and no quad trails.

Restoration Opportunities – Headquarters Creek

- Fish Habitat restoration at H4 and H5 in HQ1 appears successful with fish hiding under the logs and laying eggs on the gravel. It is important to set up a monitoring program for the habitat restoration structures (i.e. Koning et al 1997). Based on the success, additional work in this reach is recommended.
- At the fishway adjacent the Hatchery in HQ1 are full spanning concrete footings and wood weirs across the stream channel. They block fish passage at low flow. There is no low flow notch and fish are trapped without passage. A notch could be cut into the sills in summer that would ease passage considerably.

17. Constitution Creek Assessment Results

This Creek originates above the Duncan Bay Mainline and drains around the north side of Wolf Mountain and enters the upper Tsolum (T9) downstream of Murex Creek. The stream has four reaches identified as C1-C4. The lower two reaches were surveyed.

Fish Habitat Assessment – Constitution Creek

The FHAP for C1 and C2 was done Oct. 7, 2015. Stream flow was at a low level (15%) with recent rain elevating flow slightly to allow connected flow over Riffles. No adult salmon had yet entered here from the mainstem where Pink Salmon were spawning. No permanent fish barriers were observed.

Table 35 Constitution Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score
C1	798	419	9.46	0.16	27
C2	1597	124.9	7.97	0.5	21
C3	1845	0	na	Na	Na
C4	1581	0	na	Na	Na
	5821				

The habitat survey results are summarized below with the full results of the assessment in the Sum and ratings Table (Appendix).

Constitution Creek Reach C1 starts at the Tsolum and goes upstream to the top of a long wetland. The survey segment captured both stream and wetland features in the 419m survey. The C1 stream segment is a confined channel on 0.5 to 1% gradient. The riffles were 3.5 to 24.5m long. The pools were 13 to 26m long. This segment ended at a beaver dam that floods into the wetland upstream. The wetland segment at habitat unit H10 was 280m long and an average of 30m wide. The entire reach is fish accessible. There is a logging road along the right bank 40 to 100m distant.

Constitution Reach C2 is 1597m long and is a gravel dominated pool/riffle stream segment that ends above the DBM 3700 culvert. The survey segment was 124m long and located just above the C1 wetland. Five pools and riffles were surveyed. The pools were 6.7 to 22.9m long. The riffles were 4.8 to 19.7m long.

Table 36 Constitution Creek Habitat Data Summary and Ratings

Habitat Parameter	C1	C2
% Pool Area	97.5	64.2
LWD/Channel Width	0.4	0.5
% Cover in Pools	10.2	46.5
Average% Boulder Cover	0.0	0.0

Average % Fines	58.0	8.0
% of Reach Eroded	0.0	0.0
Obstructions	0.0	0.0
% of Reach Altered	0.0	0.0
% Wetted Area	54.6	48.3
% Crown Cover	89	76

Spawning Habitat: There were spawning Pink Salmon in the mainstem Tsolum on the day of the survey, but none yet in Constitution Creek as the water flow was too low. The lower reaches of Constitution (C1) had 42% gravel in their substrates. The channel is more likely used by Coho and Trout, with Pinks on wet years. There was plenty of spawning gravel in each pool tail out and riffle. There was less likelihood of the redds washing out in this smaller channel than in the adjacent river mainstem. The gravel bars were better anchored with harder crests and narrower banks. The upper reach (C2) above the wetland is accessible to spawners once heavy fall rains commence. It will wash out the small beaver dam and allow salmon into the next reach. C2 has more gravel, less fines and many places to spawn.

Rearing Habitat: The wetland in reach C1 is a very important rearing area for fish from the creek and mainstem. The wetland is approximately 280m long and offers a wetted area over 4200m^2. It offers important rearing/refuge habitat from the first high water through winter to early summer.

Riparian Assessment – Constitution Creek

Riparian Vegetation Type: The riparian vegetation in these low lying wetted riparian areas was Red Alder and shrubbery, with Douglas Fir set further back above the moist areas. There was a distinct lack of Cedar in the riparian area except for old burned off stumps and trunks from historic logging.

Vegetation Depth: The riparian depth was an average of 23m and 26m in the C1 and C2 reaches.

Land Use: The land around the riparian area is Forestry.

Bank Slopes: The two lower reaches are flat (0-1%).

Bank Stability: The riparian slopes are flat. The dense and old Alder stands adjacent the creek banks are showing some blowdown and resulting erosion.

Access: There are no trails into the creek, there is one logging road crossing at the fish passable BR 3700 crossing.

Restoration Opportunities – Constitution Creek

- This water way is important off channel habitat to the mainstem. The access into and out of the wetland may need assistance past the beaver dam in C1 at lower flow. An inspection trail could be cut to the site. In the fall to ensure adults/fry are getting over and smolts out in the spring. Monitoring the water quality and fish utilization (Smolt trap/Minnow trap) over the year would help determine the productivity.

- LWD placement would help increase cover and pool depth. This is a smaller stream where energy is lower and structure integrity better. Installation by machine is likely too intrusive as there is no nearby access. Hand anchoring of existing remnant Cedar logs would be a low risk/cost activity.
- Riparian restoration of stream edges is recommended. The stands of Alder are falling into the creek. The riparian area appears understocked in succession conifers. A riparian polygon assessment should be undertaken in the C1 reach. A management plan on trimming the Alder plus underplanting with Cedar and other conifer species would help build root strength along the creek edges.

18. Murex Creek Assessment Results

Murex Creek is anadromous from the Tsolum River up under the Duncan Bay Mainline to Triple Falls at the top of Reach M3, a distance of 4073m.

Fish Habitat Assessment – Murex Creek

The FHAPs were done from Oct. 3 & 9, 2015. Stream flow was at a moderate level with estimated discharge of 30% of mean flow (approx. 1200 lpm). There had been one rain in September that brought levels up in the Lake and they were draining back down. The flow was enough to draw in Pink Salmon spawners and they were observed live and dead throughout.

Table 33 Murex Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score
M1	624	331	23.61	1.5	37
M2	1250	278	20.05	1.5	25
M3	2199	406	20.41	2.3	26
	4073				

The habitat survey results are summarized below with the full results of the assessment in the Sum and ratings Table (Appendix).

Murex Reach M1 is 624m long from the Tsolum River upstream to the Duncan Bay Mainline Bridge. It was surveyed Oct. 7/15 when the discharge was low at approximately 15% of Bankfull discharge. This reach is an unconfined channel with a large sediment deposition filling the channel and influencing the Tsolum downstream. The survey length was from the Tsolum 331m upstream. The habitat surveyed was four pools and six riffles. The pools varied from 12 to 43m with a mean depth of 0.6m. The riffles ranged from 6.8 to 41m. The 27 LWD counted, help make up the 13.5% cover in pools. The surveyors noted many small debris jams each with Pink Salmon Spawners isolated as water flow had dropped.

Murex Reach M2 was surveyed Oct. 7/15 in moderately low flow. The 1250m long reach goes from the Duncan Bay Main upstream to a confined valley at M3. The 278m long survey segment was located mid reach. This area was unconfined. No fish were observed in this reach survey of four pools and six riffles. There is a log debris and sediment pile in the channel that resulted in braids and off channel areas. A debris jam is the product of a new channel forming through a forest of second growth fir on the stream edge. The old river channel is now an off channel. Further upstream the channel is confined from H6-H10. The long gravel reach likely dries in summer.

Reach M3 is 2199m long and entirely in a confined valley of 25-75m width. The survey was done Oct.17, 2015 after a second rain and water was up to 30% of bankfull discharge. The survey segment was 406m long and located just below the triple confluence.. It had five pools from 10-95m long and 0.9m deep. The riffles were 6.9 to 80m long. The entire reach has been observed dry in summer. The substrate was over 65% Boulder/cobble, with patches of gravel and fine sediments. Instream cover was poor with no LWD and 5% boulders. There was no observed bank erosion with bedrock and boulder edges. This survey segment began at a 3.0m ht. bedrock chute in a tight canyon. It may be a salmon barrier. No adults were observed above this feature.

Table 34 Murex Creek Habitat Data Summary and Ratings

Habitat Parameter	M1	M2	M3
% Pool Area	41.2	50.7	47.2
LWD/Channel Width	1.9	10.2	0.0
% Cover in Pools	13.5	19.0	5.5
Average% Boulder Cover	0.0	1.0	4.5
Average % Fines	9.0	4.5	13.5
% of Reach Eroded	0.0	0.0	0.0
Obstructions	10.0	0.0	0.0
% of Reach Altered	0.0	0.0	0.0
% Wetted Area	27.9	30.7	70.2
% Crown Cover	37.5	34	66.5

Spawning Habitat: Pink Salmon were spawning in M1 reach. It had abundant wetted gravel. The spawning sites are poor as they are unprotected from flood disturbance or dewatering. Further up the salmon had not got past the debris in M2. This reach had more stable gravel above but is more likely to be used by Coho later with higher flows. It is doubtful if any salmon get over the falls in upper M3 and it is seasonally dry in the top end and poor habitat. Fry generated in these reaches must outmigrate or risk dying in summer low flow.

Rearing Habitat: The M2 reach is the best of a poor selection of reaches. Murex Creek had no stable deep perennial pools. The large debris jam in M2 appears to have formed several years ago and is not currently a sediment source. The reach is flat with no confinement and offers shallow and seasonal pools. Overall the Murex Creek segments are poor rearing in summer and winter.

Riparian Assessment – Murex Creek

Riparian Vegetation Type: The riparian zone trees are mostly a mixture of Douglas Fir and Alder. There is more Alder in the lower portions of the reach and more Fir in the top. The braids in M1 and M2 are covered with Willow, Red Osier, Ninebark, Devils Club and Salmonberry in the understory.

Vegetation Depth: The riparian depth was an average of 31m and 39m in the M1 and M3 reaches. The M2 reach had only 15m of riparian depth after the creek moved outwards in a braid.

Land Use: The land around the riparian area is Forestry.

Bank Slopes: The two lower reaches are flat (0-10%) while the M3 has 30-45% slopes that are vegetated.

Bank Stability: The upland riparian slopes show no evidence of erosion and all are vegetated. The stream bank edges are beaten up in the M1 and M2 reaches due to sediment filling the channel and pushing the water outwards. The worst of the effect appears to have happened and the banks are not giving up new material.

Access: There was no access into the creek and there is one bridge over the Creek.

Restoration Opportunities – Murex Creek

- Murex Creek is difficult to make confident recommendations for any instream work as the river has been aggrading and braiding. Instream work to anchor the valuable LWD could end in failure if more floods/torrents occur. It is still too early for confidence instream. Avoid work that requires heavy anchoring. Armouring the edges of the channel/floodplain with local debris where opportunities lend themselves safely is a possible option.
- Riparian restoration of the M1 and M2 edges with flood tolerant species of shrub (red Osier/Willow) as well as adding more Cedar trees to build root strength along the creek edges is recommended.

19. Hell Diver Creek Assessment Results

Hell Diver Creek originates from the north side of the Tsolum Watershed and drains down a long flat bench over a bedrock escarpment and into the Tsolum River (T12) above the Murex Creek confluence. This waterway is a series of interconnected waterbodies (wetlands and lakes). A USHP survey of channels was not done, as the wetlands were unapproachable due to their wetted depth. The details of the reaches below was gained from GIS, air photos and a field inspection of the accessible edges of the waterway. The site survey was done on Oct. 15, 2015.

Fish Habitat Assessment – Hell Diver Creek

Hell Diver Reach HD1: This reach enters the Tsolum Mainstem (T12) just above the Duncan Bay Mainline bridge on the river left bank. The reach is approximately 2,756m long (based on GIS). It is entirely a bog wetland with a deep and narrow open water trench meandering down the middle. The wetland varied from 65 to 229m wide and is approximately 30 ha in area. This wetland was visually inspected to confirm the airphotos from access points off the Duncan Bay Mainline. The plant community in the wetland primary species are Hardhack and Sedge spp. This reach is fish accessible with no

barriers observed on the virtually flat gradient from the Tsolum. The winter wetted habitat offers an enormous feeding and refuge area for fish species from the mainstem.

Hell Diver HD2: This reach is GIS mapped from the top of the HD1 wetland upstream to a mapped wetland below Hell Diver Lake. The mapped length is 1,435m. This reach is characterized by narrow wetland sections, the wetted width of the wetland areas was 10 to 50m in these areas. They were too deep to walk in to inspect (1.0m +). The HD2 reach has a potential salmon barrier 1,073 m above Reach 1 and under a logging road bridge. The bedrock falls is a series of 1.0m steps over approximately 8m in height. Confirmation that Coho get above this barrier would indicate they are taking advantage of the best Coho habitat in the watershed (HD3).

Hell Diver HD3: This reach is 1,866m long and includes a lower wetland, Hell Diver Lake and an upper wetland. Hell Diver Lake is estimated to be less than 10m deep given the surrounding gentle taper. The lake is approximately 7ha of open water area plus a wetland band on all sides. Further upstream are wetland characteristics that continue to the reach break at HD4.

Hell Diver HD4: This reach begins as wetland above Hell Diver Lake and it carries on upstream approx.1.0 km to the logging road crossing logging road crossing. At the road it was fed by a 1.8m wide low gradient creek with small pools and gravel riffles. As mapped this reach continues above the wood box culvert at the logging road for approximately 700m. It then divides into small tributaries off hillsides that separate it from the Oyster River drainage. Two other smaller tributaries with fish access potential cross the logging road draining into the HD3 wetland below the road originating from the same gentle slopes.

Table 37 Hell Diver Creek Habitat Survey Area

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Comment
HD1	2756	na	na	0	30 ha wetland
HD2	1435			0	Falls reach
HD3	1866			0	Hell Diver Lake
HD4	1689			1	Headwaters
	7746				

Spawning Habitat: There is little spawning habitat in the mainstem of the Hell Diver Creek. The section below the falls in HD2 has a short gravel area. Upstream there are several gravel-bed seasonal tributaries draining under the perimeter logging road west and south of HD3. HD4 has small streams that offer adequate spawning habitat as well.

Rearing Habitat: This waterway is important off-channel rearing habitat to the Tsolum. Assuring fish access into this waterway would offer fish excellent habitat for at least 8 months of the year. If Coho get over the HD2 barrier to Hell Diver Lake they have year round habitat with food and cover. The entire waterway represents approximately 70ha of wetland habitat. Its rearing potential is unlikely being fully

utilized. The area appears to have been flooded by beaver dams where stream channels once flowed. This waterway is very similar to Black Creek/Northy Lake for fish habitat and likely similar production potential.

Riparian Assessment – Hell Diver Creek

Riparian Vegetation Type: The riparian vegetation was Alder and shrubbery in wetted areas and Douglas Fir set further back above the moist areas. As with other areas, there was a lack of Cedar in the riparian area except for old burned off stumps and trunks from historic logging. The bog wetlands were dominated by Hardhack (Spirea douglassi) and the floor of the wetland had Sphagnum moss and various sedge spp.

Vegetation Depth: The riparian depth was not measured in this survey due to access limitations – many of the sites were forested wetlands currently under water.

Land Use: The land around the riparian area is Forestry.

Bank Slopes: The entire area is low relief.

Bank Stability: The riparian slopes are flat and stable.

Access: This waterway two logging road crossings active, as well as an abandoned one below the lake still in use by off road vehicles.

Restoration Opportunities – Hell Diver Creek

- Inspect the falls at HD2 and determine if fish are getting through, monitor the water quality in the watershed and set fish traps in winter and summer. Improving the fish access at this reach break would open up some of the best coho rearing habitat available in the watershed.

5. DISCUSSION – FISH HABITAT AND RIPARIAN ASSESSMENT

1. Survey Limitations

There are limitations to the survey based on the design and effort discussed below.

SEASONAL TIMING – This USHP inventory was completed during the early fall at base low flow up to first flush of the year (September and October). Normally, the driest time of the year, we were a week or two too late to collect all low flow data. Base low flow is an important component of the fish habitat inventory. The stream flow in the upper reaches declines significantly in summer, to standing pools or completely dry (i.e. Portuguese, Upper Dove and Murex). The survey data on wetted area was taken on the date of survey, but where it was known to be dry it was mentioned. The best summer wetted areas are all in the lower reaches of the Tsolum, most of which were measured first, before the floods hit (Oct. 15), allowing a perspective on how poor water conditions are in summer.

SAMPLING AREA - The survey of 10 habitat units per reach is the recommended sample size used in the Pacific Streamkeepers "Advanced Stream Habitat Survey" . This ensures that a suitable amount of the habitat qualities (10%) in the reach are represented (Johnston and Slaney 1996). The actual sample size per reach varied from 9% to 55%, some reaches such as T1-T3 had more than half the reach surveyed while long reaches such as T4 and T5 were just above or below 10%. In altered settings this is the preferred method as it provides not only overall health but specific knowledge about each habitat unit. High sample rates in altered areas allow the data to also be used for specific monitoring, and restoration objectives.

USHP METHODOLOGY - The USHP survey methodology was first developed in 1996 for Streamkeepers on Vancouver Island. The survey design has stood up very well to the test of time. Its design allowed a group of dedicated but inexperienced people to collect valid scientific data with very little training. It does need some help in data processing and we owe Don Chamberlain who worked through the formulas to correct design or data errors. I would recommend this inventory method again.

DATA COLLECTION - Field data collection was very consistent amongst a large group of people. Credit to Vincent Hamann Benoit organized the data cards, maps, gear and training course. Credit also to the people involved, we had some very informed people whom took to it readily. My only complaint is that some of the photography was more of the people than the habitat behind them. Our photography was all GIS tagged and will be important for photo point monitoring of these reaches in the future.

FISH SURVEYS – No fry density sampling was conducted during this inventory. Adult Pink, Coho and Chinook were observed during the survey. The Pink Salmon moved upstream with water flow increases over the October period of survey and were found to the upper mainstem Tsolum and Reach 5 in Dove Creek. They were also found above the hatchery weirs in Headquarters Creek spawning on the brand new TRRS fish habitat placements (Gravel/LWD). Coho and Trout fry were observed throughout the wetted areas of almost all habitats. Fish sampling is recommended to confirm there is Coho access over barriers on Helldiver Creek just below the lake and wetland complex.

2. Fish Habitat Status – A Comparison

The Tsolum River Watershed is a vast watershed that has been subjected to historic logging impacts that upset many of the important fish habitat features. In reviewing the results of the habitat assessment it was obvious that most of the watershed is recovering from the historic impacts. The state of recovery or degradation can be quickly ascertained by the habitat score for each of the 13 reach segments on the mainstem as well as the 12 more on the tributaries.

The habitat scores for the survey reaches are presented in Table 38 below. The scores are taken from the Ratings Tables that are part of the reach summaries in the USHP program. The scores do not rank every habitat parameter. Only a select group out of approximately 25 parameters is chosen for this comparison by the BC Environment authors. The ten comparative values were;

- % Pool Area,
- LWD/Channel Width
- Cover in Pools,
- Average% Boulder Cover,
- Average % Fines,
- % of Reach Eroded,
- Obstructions
- % of Reach Altered
- % Wetted Area
- % Crown Cover

The scoring for these values was reversed; a low score was best. The values of the ten pools and riffles in each reach were analyzed and averaged. Then compared to biological standards in “Fish Habitat Assessment Procedures” (Johnston & Slaney, 1998).

The scores given were; 1=Good, 3 = Fair and 5= Poor.

The results were on comparison of 10 parameters;

Good was 10- 23, Fair was 24-37 , Poor was 38-50.

Table 38 Tsolum River – Fish Habitat Summary.

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
T1	2080	956	39.2	.4	35	Fair
T2	1306	660	37.6	.5	27	Fair
T3	889	588	36.6	.35	40	Poor
T4	1639	672	48.1	.3	36	Fair
T5	6964	797	36.4	.5	40	Poor
T6	4375	387	23.9	.5	36	Fair
T7	1747	449	20.3	.85	36	Fair
T8	1903	700	21.0	.65	32	Fair

T9	3853	765	22.8	.65	36	Fair
T10	1775	706	31.1	.5	28	Fair
T11	1113	649	19.9	.5	28	Fair
T12	1240	310	13.6	.5	30	Fair
T13	2048	182	10.4	1.2	34	Fair
Total (m)	30932			Mean	37	Fair

Portuguese Creek

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
P1	611	329	17.8	0.5	35	Fair
P2	1929	124	13.34	0.86	27	Fair
P3	1822	159	10.6	0.65	31	Fair
P4	2221	0			Na	
P5	1214	296	5.9	0.6	35	Fair
P6	4087	0			Na	
	11884					Fair

Dove Creek

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
D1	1723	370	18.1	0.7	37	Fair
D2	1571	0	Na	na	Na	
D3	3294	303	10.6	0.65	35	Fair
D4	1319	0	Na	na	Na	
D5	921	0	Na	na	Na	
D6	2067	435	15.2	3.1	31	Fair
D7	3691	0	Na	na	Na	
D8	6367	0	Na	Na	Na	
	20953					Fair

Headquarters Creek

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
HQ1	3303	440	11.99	1.2	25	Fair
HQ2	721	335	11.89	4.85	23	Good
HQ3	2228	0	na	na	Na	
	6252					

Murex Creek

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
M1	624	331	23.61	1.5	37	Fair
M2	1250	278	20.05	1.5	28	Fair
M3	2199	406	20.41	2.3	26	Fair
	4073					Fair

Constitution Creek

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
C1	798	419	9.46	0.16	27	Fair
C2	1597	124.9	7.97	0.5	21	Good
C3	1845	0	na	Na	Na	
C4	1581	0	na	Na	Na	
	5821					Fair

Hell Diver Creek (not USHP Surveyed)

Reach	Length (m)	Survey Length (m)	Channel Width (m)	Gradient (%)	Habitat Score	Overall Result
HD1	2756	Na	na	0	Na	
HD2	1435			0	Na	
HD3	1866			0	Na	
HD4	1689			1	Na	
	7746					

The habitat summary scores indicate that the majority of reaches are in Fair condition.

Summary:

Good; C2 & HQ2

Poor: T3 & T5

Fair: All others

The good scores at Constitution Creek C2 and Headquarters Creek Reach 2 are functions of healthy instream cover, low sediment and lack of impacts such as erosion and obstructions. These are both upper reaches where the impacts of sediment deposition are lesser.

The poorest reach scores were both in the mainstem Tsolum with T3 and T5. The erosion issues in T3 were especially a concern. In Reach T5, it was the lack of habitat cover features and pool area.

All the remaining reaches were in the Fair category. These reaches appear for the most part to be improving in habitat characteristics. There were many channels that historically had actively eroding banks and depositing sediment (especially in the tributaries and upper reaches) and the channels were now more stable and with less sediment. The lack of cover is a long term problem as it takes 300 years to grow a sizable Cedar tree to then fall in to contribute to LWD.

The lower Tsolum is the only area where habitat values may continue to degrade. Being at the lowest part of the watershed, reaches T1 to T5, are receiving the sediment and floods of the entire watershed. In addition, these reaches are in areas of highest human impact from farming. They have the thinnest riparian areas and most erosion sites are directly beside the lost vegetation.

6. DISCUSSION – HABITAT RESTORATION OPORTUNITIES

As each reach was analyzed in the results, restoration opportunities were identified at the end of each section. These opportunities are summarized below. A map of the areas was also made using Google Earth place marks to give a spatial context of where the work could occur.

Restoration Opportunities; T1

- Reach 1 was found to have a relatively wide riparian zone with second growth regenerating in many areas. There are incomplete regenerating areas throughout. Some recent bank erosion has made the riparian thinner; these sites require bank protection but must be complimented with plantings. Riparian restoration plans are recommended for various sites. The forested areas are deficient in understory Red Cedar. The cedar should be planted in areas protected from deer browse. The more open areas require deciduous plantings such as Willow, Red Osier Dogwood (Cuttings or pots) and Red Alder to establish the ground for later succession crops of conifers.
- The channel is eroding along the river left bank and requires protection on the Farm reach below the Hydro Line crossing. The banks require an assessment and detailed prescriptions.

Restoration Opportunities: **T2**

- The spawning areas in this reach need better anchoring and reduced sediment from upstream. Instream structures in this reach could be swept away or cause erosion. Monitoring the sites with thalweg (this is a site that was surveyed in 2014) and cross section surveys are needed first to determine aggrading and degrading characteristics.
- There is a rip rap wall on the left bank that lacks any riparian vegetation. The property owner should be approached about planting as it would also stabilize the bank.
- The river right bank just upstream of the FHAP area is eroded and should be inspected for stabilization (It offers soils that would likely support willow/red osier cuttings).

Restoration Opportunities: **T3**

- The spawning areas in this reach need better anchoring and reduced sediment from upstream. Instream structures in this reach could be swept away or cause erosion. Monitoring the sites with thalweg (this is a site that was surveyed in 2015) and cross section surveys are needed first to determine aggrading and degrading characteristics.
- There is erosion under Dove Creek Road on the right bank (T3H9). The river comes at a very steep angle (about 50degrees) against a highly erodible 5m-high silty-loam bank (on top of a base layer of blue clay) located only about 7m away from Dove Cr. Rd. There is active erosion (recently uprooted trees, undermined riprap, etc.), and the integrity of the road might be compromised soon. This area is located just below a large gravel bar, which is obviously the result of upstream changes. This area could be the subject of a combined gravel bar live staking and bank stabilization project, which could redirect and possibly deepen the thalweg, thereby contributing to fish habitat and passage.
- Installation of LWD (ie rootwads & logs tied to rocks) into this reach is risky as it will get battered by flood debris. Opportunistic blowdown anchoring has potential given the riparian zone is regenerating with larger trees. If a large tree with rootwad attached falls in, the opportunity may be there to assist in anchoring it with more ballast.

- There is an off channel area at T3H9 with a beaver dam. It should be further evaluated to determine its winter refuge capability and determine if improvements can be made to access and flood protection

Restoration Opportunities: Reach T5

- . Development of the left bank sidechannel in the active floodplain area should be reviewed. There is road access to the 300m channel. It has a low entrance and the outlet goes into T5 Pool 1. The work may be preventative to the river changing course and entering which would be disastrous. Protection of the current sidechannel is needed before it blows out. This site offers winter flood refuge which may be possible to improve but due to the river alterations, is especially vulnerable to collapsing.

Restoration Opportunities: Reach T6

- . Historical impacts removed the LWD cover from this reach. The confinement of the channel limits its restoration potential. Wider channel areas where tractive force is reduced offer areas to add instream habitat but None were noted in the survey area of Reach 6.

Restoration Opportunities: Reach T7

- This reach offers good spawning opportunities compared to other lower areas of the river. It is above and therefore protected from the Dove Creek sediment loads. Protection of the spawning beds is important in this reach.
- Lack of LWD cover in this reach is similar to other reaches, but the placement may be more successful given the low and wide channel. Installation of LWD along these banks appears more likely to succeed but requires further investigation.
- There are many old Red Alders that have fallen and they have left exposed bank areas. The Riparian area in this reach should be assessed for “Alder” management. The leaning Alders may be cut to lower live limb and the area around under-planted with Red Cedars protected by Alder slash piles from the cut trunk.

Restoration Opportunities: Reach T8

- Lack of LWD cover in this reach is similar to other reaches, but the placement may be successful given the access off Railway Avenue. There appears to be potential anchor trees for short pieces of LWD along the edges of Pools H8 & H10. Small spurs may collect debris and create edge cover if locations allow.
- The aging Red Alder trees are falling in, a riparian prescription is required to determine if it could be pruned and replaced with conifers over time. No doubt some property owners are interested.

Restoration Opportunities: Reach T9

- The spawning areas of this reach may be improved by riffle crest restoration. Investigate the areas above the Highway and Hydro Line where rock crests may assist in stabilizing the gravel and increase spawning success.
- There were 12 LWD in this survey segment, the most in the area. These pieces may wash out and should be inspected for stabilization with cables or ballast. Also investigate if more LWD could be added to the reach, access appears good in several areas. BD Hydro may be interested in partnering under their easement.
- There are many old Red Alders that have fallen and have left exposed bank areas. The Riparian area in this reach should be assessed for "Alder" management. The leaning Alders may be cut to lower live limb and the area around under-planted with Red Cedars protected by Alder slash piles from the cut trunk. This is forestry land and the property owner may be able to offer advice on thinning, girdling and planting.

Restoration Opportunities: Reach T10

- This reach is still very active in meandering new routes in the floodplain. The regenerating riparian area is holding the river in confinement except in break out areas. Helping the Riparian area health by under planting with more Conifers and possibly removing/stabilizing leaning Alders should be assessed. .
- There is a lack of stable cover in this reach in pools due to historic logging removing the trees and rooted banks. There remain some old growth Cedar stumps along the stream banks. Locating these stumps (and any other large logs) offer points for establishing instream cover in select pools. The stumps may be made more secure with ballast. If secure they could be anchors for small LWD spurs into adjacent pools. To increase wood cover in pools. This is scalable work to the capability and budget; i.e. hand winching conifer blowdown from adjacent timber edges and pounding in duckbill ground anchors or using machinery and larger material if access is available

Restoration Opportunities: Reach T11

- The channel has shallow pools with no cover. The rearing habitat in this reach is poor both for winter flood protection and summer predation protection. There are no easy fixes in this confined energetic reach. Habitat complexing of very large LWD would be expensive and risky. The fish have likely adjusted to the condition and have less utilization of the reach. The reach is relatively short and the areas downstream and upstream of Murex are more stable. There is likely some migration of fry out of this reach at stressful periods.
- Riparian recovery is the long term objective. Enhancement to regeneration of large structural trees will provide cover, bank protection and instream habitat. The are suffers the same problems as below of lack of Conifer overstory. There appears to be more conifer understory in this reach and a release program to enhance their growth may be investigated

Restoration Opportunities: Reach T12

- This reach has fair spawning habitat. The long pools and low crests limit their area. Addition of spawning gravel crests (rock weirs) to re-establish dropped river profiles and hold more spawning gravel could be considered in this reach. The best locations would be near the Hell Diver tributary and the Duncan Bay Main. The road site offers machinery/material access opportunities.
- This reach lacks cover in pools. The road location offers the opportunity to import habitat materials. Given the straight run and low banks, placement of Boulders in the pools may be a safe option to start the habitat improvement. Ultimately as the river stabilizes, it needs LWD. Further investigation may reveal some secure places to install LWD such as along old growth stumps.

Restoration Opportunities: Reach T13

- The area of braiding on this reach is approximately 200m long. Repairs to the banks to reduce erosion should be assessed. There may be the opportunity to salvage the downed wood and anchor it to the banks to protect them. Machine access may be possible from the right bank cutblock to place local wood along banks.
- Riparian planting along the reserve areas with additional species such as Red Cedar

Restoration Opportunities – Portuguese Creek

- Stabilization of erosion/sediment sources is the highest return in this reach. Ensure the creek is fenced from livestock, then plant along the exposed areas. The cutbank erosion requires protection at the base and stabilization of the upper slope. Including taller trees in planting strategies to alleviate the limited Crown Cover.
- The deep pools in lower reaches offer good rearing but in order to maintain or increase pool depth, the sediment needs to be removed through; passive log scour structures anchored in pools, pool excavation, or a sediment trap near Headquarters Road to collect the sediments before they enter the downstream area.
- There is a beaver dam in P1 and likely in other areas. The P1 dam increases the pool depth benefitting summer fish habitat. It does not appear to be flooding any pasture. Generally Beaver dams overtop or wash out in winter allowing fish access. During the survey the water was not yet overtopping but passing through the .3-.4m height structure. The flood scour line in the channel appeared to be 0.6m so it should overtop. This should be inspected. There are many options for working with Beavers if required to permit fish passage (cages, pipes) and to protect (wire) adjacent plants.

Restoration Opportunities – Dove Creek

- The D3 reach is a prime candidate for restoration given its easy access for restoration equipment and materials. The hydro line has 100m of erosion on both banks. It is recommended to add LWD such as boulder anchored conifer stumps be placed to protect the channel from erosion and increase fish cover. This may increase scour to provide a low flow thalweg for fish passage.
- The D1 reach has pools with erosion along the outside meander adjacent weakened riparian areas and pasture. The restoration areas have good access for machinery to place material at the toe of the bank (LWD/Boulders) and then pull back the top slope and plant, then fence.

Restoration Opportunities – Headquarters Creek

- Fish Habitat restoration at H4 and H5 in HQ1 appears successful with fish hiding under the logs and laying eggs on the gravel. It is important to set up a monitoring program for the habitat restoration structures (i.e. Koning et al 1997). Based on the success, additional work in this reach is recommended.
- At the Fishway adjacent the Hatchery in HQ1 are full spanning concrete footings and wood weirs across the stream channel. They block fish passage at low flow. There is no low flow notch and fish are trapped without passage. A notch could be cut into the sills in summer that would ease passage considerably.

Restoration Opportunities – Murex Creek

- Murex Creek is difficult to make confident recommendations for any instream work as the river has been aggrading and braiding. Instream work to anchor the valuable LWD could end in failure if more floods/torrents occur. It is still too early for confidence instream. Avoid work that requires heavy anchoring. Armouring the edges of the channel/floodplain with local debris where opportunities lend themselves safely is a possible option.
- Riparian restoration of the M1 and M2 edges with flood tolerant species of shrub (red Osier/Willow) as well as adding more Cedar trees to build root strength along the creek edges is recommended.

Restoration Opportunities – Constitution Creek

- This water way is important off channel habitat to the mainstem. The access into and out of the wetland may need assistance past the beaver dam in C1. An inspection trail could be cut to the site. In the fall to ensure adults/fry are getting over and smolts out in the spring. Monitoring the water quality and fish utilization (Smolt trap/Minnow trap) over the year would help determine the productivity.
- LWD placement would help increase cover and pool depth. This is a smaller stream where energy is lower and structure integrity better. Installation by machine is likely too intrusive as there is no nearby access. Hand anchoring of existing remnant Cedar logs would be a low risk/cost activity.
- Riparian restoration of stream edges is recommended. The stands of Alder are falling into the creek. the riparian area appears understocked in succession conifers. A riparian polygon assessment should be undertaken in the C1 reach. A management plan on trimming the Alder plus underplanting with Cedar and other conifer species would help build root strength along the creek edges.

Restoration Opportunities – Hell Diver Creek

- Inspect the falls at HD2 and determine if fish are getting through, monitor the water quality in the watershed and set fish traps in winter and summer. Improving the fish access at this reach break would open up some of the best coho rearing habitat available in the watershed.

7. CONCLUSIONS

The assessment included recommending activities that can improve fish habitat with the suggested order of priority taken from the habitat items in this report.

The Tsolum River is undergoing the same impacts as many other east coast Vancouver Island watersheds. The 150 years of negative human impacts are recoverable. The Fish Habitat Assessment has broken up the impacts of each segment into easier to address components ranked by their condition. It is entirely possible to see real change in a timeline of 5-10 years. The watershed is mostly in recovery, and a helping hand in simple activities such as riparian planting, monitoring as well as a few directed actions at hotspots such as the erosion issues (T1, T3, D3 & T13) will hasten the recovery. With a long term plan, there will be the need to monitor and adjust. The detailed habitat assessment, mapping and photo points all can be used for reference in the ongoing monitoring of the watershed.

The key ingredient for long term recovery is having the community promoting the recovery plan. With so many people involved in this survey the Tsolum Watershed has lots of promise.

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