

# Holden Creek Stream Survey - 2016

---

On behalf of  
The Regional District of Nanaimo  
Drinking Water & Watershed Protection

October 2016

Written by D.R. Clough Consulting



## Contents

Introduction .....	4
Objectives .....	4
Methods.....	4
Personnel .....	4
Stream Survey Method .....	4
Fig. 1 USHP Schema for iPad (partial screenshot).....	5
Survey Area .....	6
Fish Data.....	6
Survey Dates .....	6
Fig. 2 Holden Watershed.....	7
Results.....	8
Holden Estuary.....	8
Reach 1.....	9
Reach 1 Habitat Results .....	9
Reach 1 Riparian Results.....	9
Reach 2.....	10
Reach 2 Habitat Results .....	10
Reach 2 Riparian Results.....	10
Reach 3.....	11
Reach 3 Habitat Results .....	11
Reach 3 Riparian Results.....	11
Reach 4.....	12
Reach 4 Habitat Results .....	12
Reach 4 Riparian Results.....	12
Summary & Recommendations for Water Quality & Habitat Improvement .....	13
Conclusions .....	14
Land Owner Interest .....	15

Figure 1 – Photos Holden Creek Reach 1 ..... 16

Figure 2 – Photos Holden Creek Reach 2 ..... 17

Figure 3 – Photos Holden Creek Reach 3 ..... 18

Figure 4 – Photos Holden Creek Reach 4 ..... 19

Appendix 1 – Reach 1 Survey Data ..... 21

Appendix 2 – Reach 2 Survey Data ..... 22

Appendix 3– Reach 3 Survey Data ..... 23

Appendix 4 – Reach 4 Survey Data ..... 24

Appendix 5 – Holden Creek Habitat Ratings Summary..... 25

## Introduction

A key objective of the RDN Drinking Water and Watershed Protection (DWWP) Program is to work with local stewards and residents in gaining a better understanding of the health of their watersheds. To achieve this objective, the RDN Community Watershed Monitoring Network was formed. This program partners with local stewardship groups and the Ministry of Environment to monitor water quality in numerous local streams. Julie Pisani, Program Coordinator, requested we conduct a training session and physical stream assessment with volunteer stewards on Holden Creek, based on community interest and concern for the health of Holden Creek.

## Objectives

- 1.) To train volunteer stewards in stream assessment to understand overall watershed health indicators.
- 2.) To inform and participate with landowners of the stream watershed
- 3.) To identify restoration opportunities in the watershed
- 4.) To create public awareness of the DWWP and Streamkeepers programs in the community.

## Methods

### Personnel

Involved local DWWP volunteer stewards, land owners, staff and instructor/professionals. These people included;

- RDN: Julie Pisani, Chris Midgley
- Land owners contacted/involved: Jessie James and Fonda Munro (West Abbey Farm owner and manager at R2), Andre Grubac (Farm owner at R3), Juan Moreno (Snuneymuxw First Nation Perry Point at R1)
- Stewards: Nanaimo Area Land Trust volunteers including Lindsay Dealy, Hitomi Kimura, Neil Hendrickson, others unnamed.
- Professionals; Dave Clough, RPBio, Brad Remillard RPBio, Braden Judson Fish Tech.

### Stream Survey Method

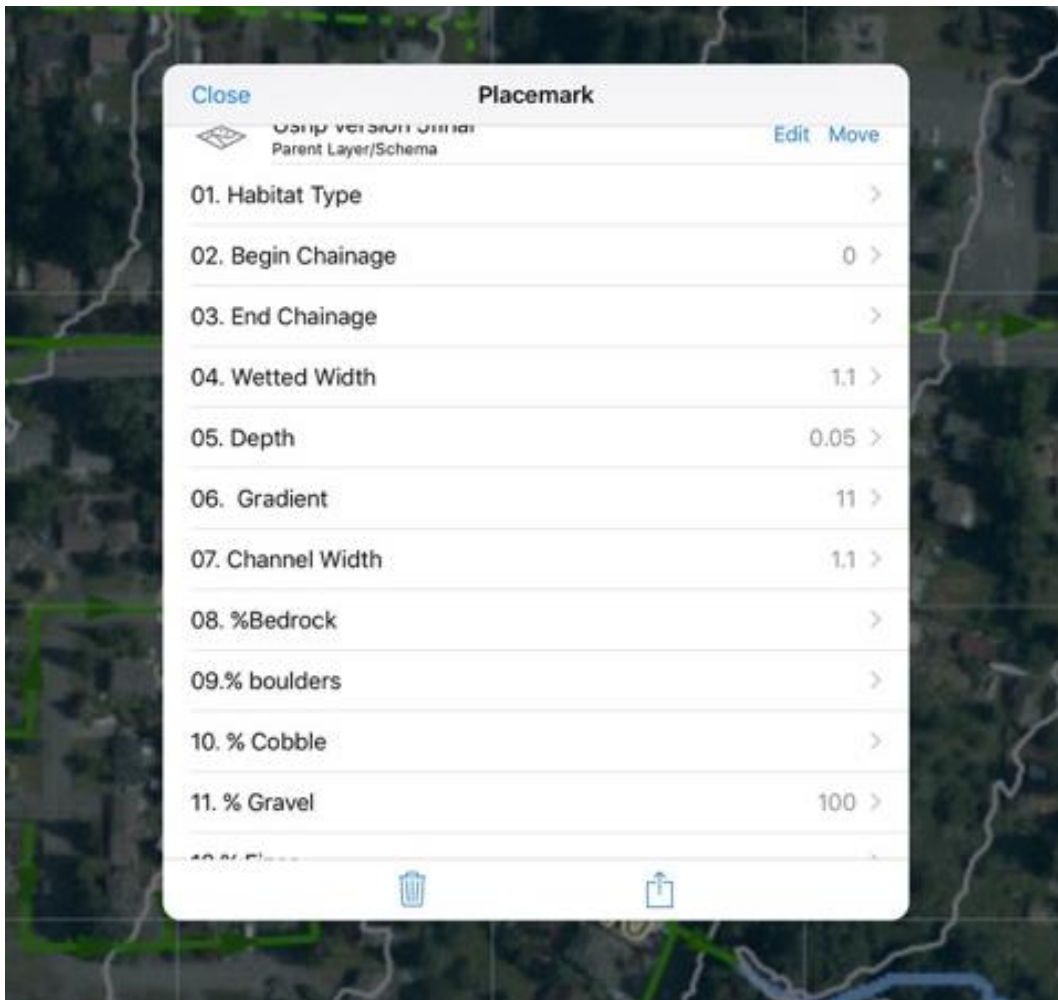
The Urban Salmon Habitat Program (USHP) survey<sup>1</sup> was utilized. This method of survey was initiated in 1997 by the Ministry of Environment in concert with Vancouver Island stewardship groups. The Urban Salmon survey methodology has now been used by the majority of stewardship groups on Vancouver Island and the lower mainland.

---

<sup>1</sup> Michalski, T.A., G.E. Reid, G.E. Stewart, 1997. Urban Salmon Habitat Program ,Assessment And Mapping Procedures for Vancouver Island. Ministry of Environment, Lands and Parks, Fisheries Section. Nanaimo B.C.

The objective was to undertake 10 habitat units or representative segments of each reach of the Watershed within the 2 days of survey. The USHP survey method involves instream and riparian assessments as well as field water quality. There are approximately 20 data items for each habitat unit (pool or riffle) encountered. It is compared to fish habitat assessment standards (Johnston & Slaney 1996<sup>i</sup>) The USHP habitat data was measured using staffs, tapes, chains and clinometers and then entered on an ipad or iphone using a custom file (pdf schema) written by D.R. Clough Consulting. The digital data was recorded using Avenza PDF ©on a GPS enabled PDF reach map provided by the RDN GIS. The data was then downloaded as \*.csv and \*.kml files for use in spreadsheet and location analysis.

**Fig. 1 USHP Schema for iPad (partial screenshot)**



## Survey Area

Holden Creek watershed is approximately 18 square kilometers in area (Fig. 2) . It is in the Regional District of Nanaimo, Electoral Area A, in the community of Cedar. It drains low hills at 60m elevation. It is approximately 9.0 km long from the top of Quennell Lake to the Nanaimo River estuary.

Quennell Lake sits at the top of the watershed and is a complex polygon with many arms. It is bordered by farm pasture land on the west side and rural residential on the east side.

From the upper lake it crosses Yellow Point Road to enter a series of long narrow wetlands and pools over 1.5 km and a drop from 35m to 9m in elevation at Holden Lake. Holden Lake is a 1.5 km long shallow water body surrounded by large private lands that are mostly forested.

Below Holden Lake is the main study area where the mainstem of Holden Creek is easily defined by the pool and riffle complex of stream habitat. The mainstem of Holden Creek is approximately 3.0 km long and was the focus our assessment in June.

## Fish Data

No records of salmon fish access exist for above Holden Lake. Coho and sea-run Cutthroat Trout are known to exist in the mainstem Holden Creek. Resident Cutthroat Trout are found in the lakes. Peamouth Chub are an anomaly minnow species only found in this stream and not in any other Vancouver Island streams<sup>2</sup> (except Kennedy Lake) .

## Survey Dates

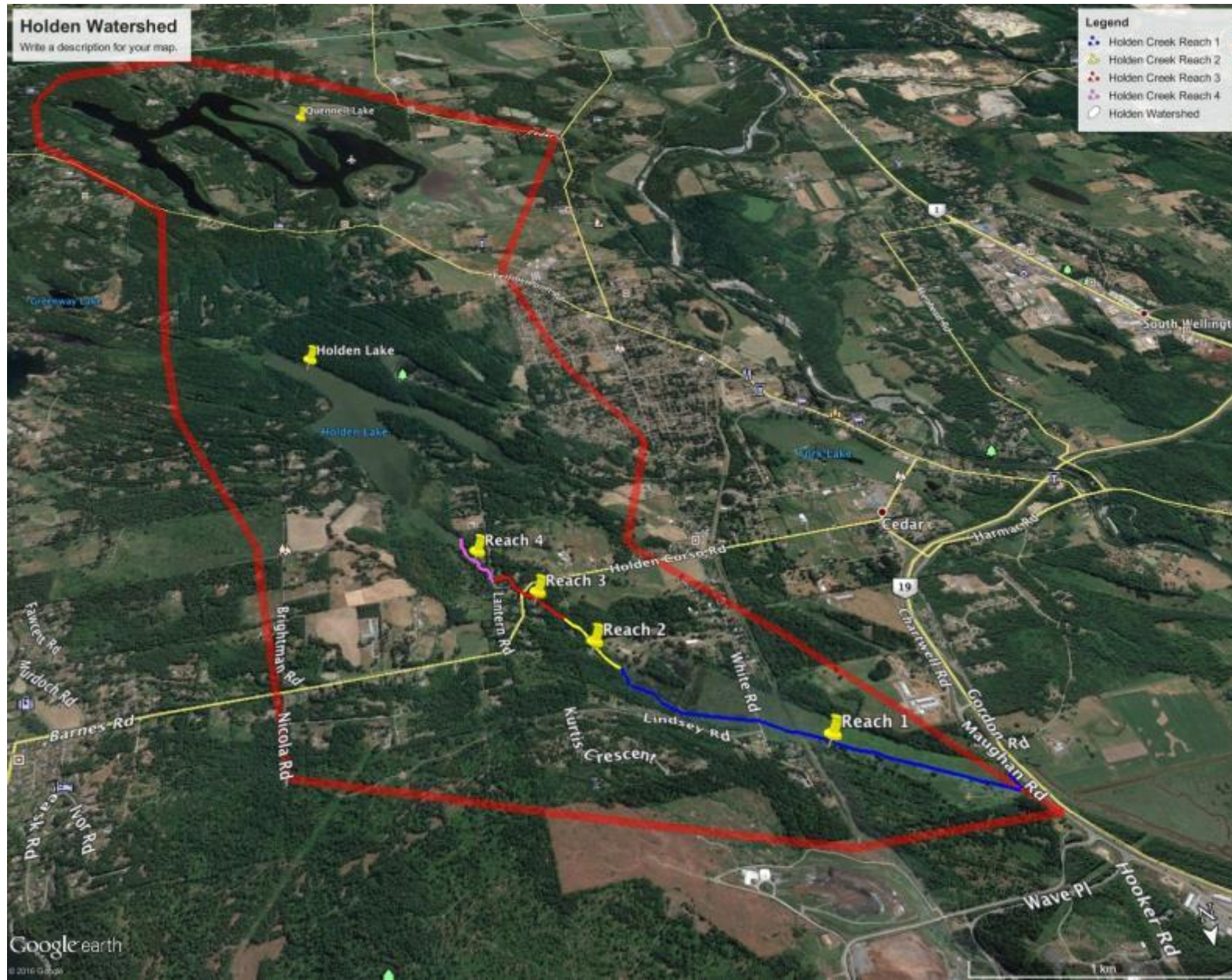
Holden Creek was surveyed on June 2 and 3, 2016. Weather was clear with no precipitation and a mean air temperature of 17C. We met at West Abbey Farms off White Road where farm owner Jessie James provided parking and creek access. We then broke into two groups; on June 2 Brad Remillard led the survey of Reach 2 to the Grubac Farm and Reach 4. Braden Judson led the surveys of Reach 3a below Holden-Corso and Reach 3 above Holden-Corso. On June 3, upper Reach 3 and 4 were completed as well as inspections of habitat in Reach 1 and the upper watershed Reach 5 below Quennell and Holden Lakes.

---

<sup>2</sup> Peamouth Chub are also found in Kennedy Lake on the west coast and are a common Fraser River species.



Fig. 2 Holden Watershed



## Results

The habitat data was summarized for each surveyed reach. As noted in Methods, the survey dates were June 2 and 3, 2016. Reaches 1 -4 from the estuary to Holden Lake were surveyed and reported below. The Urban Salmon Habitat Survey analyzes Fish Habitat, Water Quality and Riparian Parameters.

In the tables presented only 12 important parameters are summarized, rated and scored. Scoring is based on the USHP rating system where;

- Good result scored 1,
- Fair result scored 3
- Poor result scored 5.

The lower the score, the better the habitat. These scores are explained by the references noted in methods. The Appendices 1-4 show the raw data as well as the sums and averages of all the detailed parameters. A summary Table of all the reaches is shown in Appendix 5.

### Holden Estuary

Holden Creek drains into the east side of the Nanaimo River estuary along the Duke Point peninsula. The lower estuary is farmed and ditched. It was not surveyed as it is intertidal habitat not applicable to the survey methodology. The Holden Creek estuary is part of the eastern margin of the Nanaimo River estuary which comprises one of the largest ecological areas of eastern Vancouver Island. All seven species of salmon reside in the Nanaimo River, any of which could enter Holden Creek or be affected by its water quality.



## Reach 1

This reach is approximately 2.0 km long. It goes from Duke Point upstream to the West Abbey Farm. It also passes under a culvert (1.6m diam.) at White Road as well as goes under the Harmac Water line trestles (1.5m culvert). The channel is one long pool at high tide indicating its very low gradient. There is one gravel bar at the lower intertidal reach just upstream of the Duke Point culverts (2x5' gate valves). The reach is a channelized (ditched) route that was historically moved to the east side of the floodplain to accommodate farming on the drained areas. The pastures are now unused and many fence posts are submerged or surrounded by water. It is a low lying unconfined area of widths between 100 and 300m wide. We did not walk the entire reach as it was under water and inaccessible.

### Reach 1 Habitat Results

Habitat Parameter	R1	Ratings	Result
% Pool Area	100	1	Good
Large Woody Debris/Bankfull Channel Width	0	5	Poor
% Cover in Pools	10	3	Fair
Average% Boulder Cover	0	5	Poor
Average % Fines	100	5	Poor
Average % Gravel	0	not rated	
% of Reach Eroded	0	1	Good
Obstructions	0	0	Good
% of Reach Altered	0	5	Poor
% Wetted Area	84	3	Fair
Dissolved Oxygen	3.4	5	Poor
pH	6.7	1	Good
<b>Totals</b>		<b>34</b>	<b>Fair</b>

Reach1 habitat results indicate the effect of ditching and alteration of the channel. There were no habitat structures or spawning gravel. The low gradient reach benefited from no obstructions or recent erosion. Water quality was poor in oxygen likely due to nutrient loading from the flooding. During water quality sampling a broken sewage pipe was discovered near Duke Point. This pipe was immediately repaired by the RDN but it was obvious that it was leaking for quite some time and would have had a negative effect on water quality downstream.

### Reach 1 Riparian Results

Riparian Ratings	R1	Ratings	Result
Land Use	6	3	Fair
Riparian Slope	2	1	Good
Bank Stability	6	3	Fair
% Crown Cover	20	5	Poor
% of Reach Accessed	0	0	Good

Average Vegetation Depth	20	5	Poor
<b>Totals</b>		<b>17</b>	<b>Fair</b>

Reach 1 riparian habitat has been completely altered by historic logging and farming practices. There is a very thin and low shrub cover over the creek for most of this reach.

## Reach 2

Reach 2 is 402 m long from West Abby Farm upstream to the Grubac Farm. The land use is rural, farm and residential. This is the first confined reach of Holden Creek with an established treed riparian area with complex pools and riffles. We surveyed 18 pools and riffles. The average channel width was 5.8 m on a 1.5 % slope.

### Reach 2 Habitat Results

Habitat Parameter	R2	Ratings	Result
% Pool Area	32	5	Poor
Large Woody Debris/Bankfull Channel Width	0.5	5	Poor
% Cover in Pools	21	1	Good
Average% Boulder Cover	30	5	Poor
Average % Fines	37	5	Poor
Average % Gravel	56	not rated	
% of Reach Eroded	8	3	Fair
Obstructions	0	0	Good
% of Reach Altered	1	1	Good
% Wetted Area	68	5	Poor
Dissolved Oxygen	7.8	1	Good
pH	7.0	1	Good
<b>Totals</b>		<b>32</b>	<b>Fair</b>

The habitat results in Reach 2 are much better than Reach 1 in that it has structural features such as large woody debris and instream cover. Water quality reflects the improved habitat structure.

### Reach 2 Riparian Results

Riparian Ratings	R2	Ratings	Result
Land Use	60	2	Good
Riparian Slope	40	1	Good
Bank Stability	82	2	Good
% Crown Cover	72.5	1	Good
% of Reach Accessed	12	3	Fair
Average Vegetation Depth	25	5	Poor
<b>Totals</b>		<b>14</b>	<b>Good</b>

The riparian characteristics of Reach 2 indicate a primarily closed and tall canopy of mixed second growth forest.

### Reach 3

Reach 3 is 461 m long from Grubac Farm upstream past Holden Corso Road culvert to the second Rugg Road culvert. The land use is rural residential with some alterations to the channel by property owners. Seventeen pools and riffles were surveyed over 384 m. The channel width was 7.2 m falling on a 1% slope.

#### Reach 3 Habitat Results

Habitat Parameter	R3	Ratings	Result
% Pool Area	50	3	Fair
Large Woody Debris/Bankfull			Poor
Channel Width	0.2	5	
% Cover in Pools	14	3	Fair
Average% Boulder Cover	0	5	Poor
Average % Fines	48	5	Poor
Average % Gravel	34	not rated	
% of Reach Eroded	5	3	Fair
Obstructions	5	5	Poor
% of Reach Altered	7	3	Fair
% Wetted Area	60	5	Poor
Dissolved Oxygen	5.7	3	Fair
pH	6.5	3	Fair
<b>Totals</b>		<b>43</b>	<b>Poor</b>

The habitat of Reach 3 was in poor condition based on having not enough wood debris for cover, limited boulder cover, several culvert obstructions and limited wetted area. There were high sediments to contaminate the spawning gravel. The water quality was fair with oxygen levels indicative of nutrient loading from organic leachates from adjacent land use (e.g., compost, fertilizer, pastures).

#### Reach 3 Riparian Results

Riparian Ratings	R3	Ratings	Result
Land Use	86	3	Fair
Riparian Slope	40	1	Good
Bank Stability	122	4	Poor
% Crown Cover	52	3	Fair
% of Reach Accessed	0	0	Good
Average Vegetation Depth	11	5	Poor
<b>Totals</b>		<b>15</b>	<b>Fair</b>

The riparian results for Reach 3 indicate a partially cleared forest due to the rural residential developments. The 52 % crown cover requires assistance with additional planting recommended.

## Reach 4

Reach 4 is 379 m long ending at Holden Lake. Land use is a mixture of residential and regenerating natural forest. We surveyed six pools and riffles over 253 m. The channel width was 3.9 m falling on a 0.2 % slope.

### Reach 4 Habitat Results

Habitat Parameter	R4	Ratings	Result
% Pool Area	91	1	Good
Large Woody Debris/Bankfull Channel Width	0.4	5	Poor
% Cover in Pools	21	1	Good
Average% Boulder Cover	0	5	Poor
Average % Fines	30	5	Poor
Average % Gravel	28	not rated	
% of Reach Eroded	1	1	Good
Obstructions	0	0	Good
% of Reach Altered	2	1	Good
% Wetted Area	89	3	Fair
Dissolved Oxygen	5.7	3	Fair
pH	6.5	3	Fair
<b>Totals</b>		<b>28</b>	<b>Fair</b>

Reach 4 habitat results indicated fair water quality which was a concern as there was a visible milky colour indicating some foreign substance was dissolved in the water. There was also a high frequency of fine sediments in the substrate including polluting the spawning gravel. The best part of Reach 4 was its pool habitat and large wetted area.

### Reach 4 Riparian Results

Riparian Ratings	R4	Ratings	Result
Land Use	22	2	Good
Riparian Slope	12	1	Good
Bank Stability	51	4	Poor
% Crown Cover	58	3	Fair
% of Reach Accessed	0	0	Good
Average Vegetation Depth	21	5	Poor
<b>Totals</b>		<b>15</b>	<b>Fair</b>

The riparian results of Reach 4 show a mixed coniferous forest that changes to a shrub dominated canopy near the upper reach by Holden Lake. The lower reach had some bank erosion concerns.

## Summary & Recommendations for Water Quality & Habitat Improvement

Reach	Water Quality Impact	Recommended Remedial Action	Comments
1	Broken sewer pipe	Repair broken pipe	This was repaired June 4, 2016.
1	Poor spawning gravel quality due to sedimentation and alterations	Prepare spawning gravel prescription plan for select locations such as Duke Point area and possibly other culvert locations.	This gravel could be used by chum salmon if placed.
1	Poor water temperatures and oxygen.	Plant trees for shade along riparian area.	Seasonal flooded areas will require shrubbery prescriptions and dry areas with conifers.
1	Channelization. This reach was completely ditched and relocated.	Identify the problem with a survey of the channel profile and cross section to determine high or narrow locations as a result of the past alterations.	Improving flow and reducing flooding will be challenging.
1	Flooding resulting in soil loss and nutrient inputs to creek.	As noted above, channel survey needs to be done. The culverts at White Road, Harmac Trestle and Duke Point need to be assessed for their flow characteristics by a PEng.	Engage highways (MOTI) and other partners in these processes to reduce costs and gain permits.
2	Poor water temperatures and oxygen.	Plant trees for shade along riparian area.	Seasonal flooded areas will require shrubbery prescriptions and dry areas with conifers.
2	Limited and sedimented spawning gravels.	Replace gravel and eliminate sediment sources in pool tailout locations noted in the USHP survey	Property owners permission required.
2	Poor instream habitat	Install woody debris and boulder structures to improve cover, bank protection and water quality.	Property owners permission required.
3	Improve shade to reduce water temperatures and improve oxygen.	Under planted conifers in the alder and maple dominated areas.	Property owners permission required as well as a review by a RPF / RPBio.
3	Improve fish passage	Assess the culverts (Holden Corso and Rugg Road) and dams for improvement.	Engage highways (MOTI) and property owners as partners.
4	Improve spawning gravel.	Replace spawning gravel and eliminate sediment sources.	Place gravel below lake outlet.
4	Improve fish habitat.	Add large woody debris for cover.	Property owners permission required.
Holden Lake	Monitor water quality.	Establish a temperature data logger and conduct routine water chemistry.	Work with local schools and property owners.
Quennell Lake	Monitor water quality.	Establish a temperature data logger and conduct routine water chemistry.	Work with local schools and property owners.



## Conclusions

The Holden Creek River habitat survey completed several objectives;

- 1.) We educated and trained stewards in fish habitat assessment as well as gave them an understanding of the value of this habitat.
- 2.) We compiled the first habitat survey of Holden Creek.
- 3.) We identified water quality and fish habitat restoration opportunities.
- 4.) We met many watershed property owners whom also wish to participate in future monitoring or restoration activities by the RDN or local stewards.

The Holden Creek watershed has been altered significantly over the years through forestry, farming and residential uses. The habitat is likely in better condition now than it was 60 years ago when the riparian canopy was a lot younger and development had just occurred. The stream is recovering on its own in many ways. The most significant being the riparian canopy is in fair to good condition in every reach. The easiest and most important restoration activity is repairing the riparian areas. Tree and shrub planting to at least 30 m width is recommended. The lower floodplain areas will always be shrub dominated. There may be some opportunities to reduce the amount of flooding in the lower reaches if the engineering and survey studies recommended in this report identify problem areas such as undersized culverts, sedimented stream channels and debris.

The fish habitat is in relatively poor condition. There are no high quality spawning areas. There are also no deep pools with cover. These two functional limitations are serious but easily addressed by prescriptions for placement of large woody debris and gravel. Reaches 3 and 4 appear in highest need of woody debris and gravel.

Water quality issues were varied in this watershed. The lower reach had been exposed to pollution due to a leaking sewer pipe that was quickly identified by the stewardship program and remedied by the RDN Wastewater department. It is a great example of how simply conducting water quality monitoring, such as the RDN Drinking Water and Watershed Protection monitoring program, can bring about significant change and benefit to a watershed. We have recommended all areas of Holden Creek including the lakes being monitored regularly. This will help protect the existing status and provide direction on restoration problem areas.

Yours Truly,



David R. Clough RPBio

## Land Owner Interest

---

From: Jessie [mailto:pony@shaw.ca]  
Sent: January 13, 2016 2:30 PM  
To: admin@nalt.bc.ca  
Subject: Streamkeepers

I am delighted to hear that Streamkeepers is underway again. I took the course a while ago and found it very worthwhile.

David Clough had approved a restoration job on Holden Creek that runs through my property but it did not materialize. Could this project now be undertaken ?

Thanks,

Jessie James  
West Abbey Farm 250 722 0170  
1462 White Road  
Nanaimo

---

From: Andre Grubac [mailto:algrubac@shaw.ca]  
Sent: Thursday, May 05, 2016 8:18 PM  
To: Pisani, Julie  
Subject: Holden Creek Assessment  
Hi Julie,

I am very interested in taking part in this event for both days. The creek runs through a portion of my property and I hold a water license to remove water for irrigation purposes on my farm. Where will we be staging to start the assessment. Can you tell me how many volunteers you require to proceed with this event. I feel it is very important for the health of the creek, and for the viability of local agriculture that this assessment happens.

Thank you,

Andre Grubac  
Holden Creek Farm  
250-741-7881

---

**Figure 1 – Photos Holden Creek Reach 1**



**R1 - flooding below White Rd to Trestle**



**R1 - Flooded pastures above White Road**



**R1- flooding towards Duke Point/ocean**



**R1 - water quality site near ocean**



**Figure 2 – Photos Holden Creek Reach 2**



**R2 - lack of LWD for cover habitat**



**R2- sedimented spawning gravel sites**



**R2 - Shallow pools**



**R2- June WQ at Pony Farm - oxygen 7.8ppm/Temp. 16.9C**



**Figure 3 – Photos Holden Creek Reach 3**



**R3-Lower riffle in higher gradient**



**R3 - Rugg Rd Culvert 1**



**R3- Pool below Holden Corso Rd**



**R3 - below Rugg Rd Culvert**



**Figure 4 – Photos Holden Creek Reach 4**



**R4 - best riparian canopy in this reach**



**R4- deep pools in this reach**



**R4- short riffles in low gradient reach**



**R4- good winter habitat, marginal oxygen (5.7 ppm)  
high temperatures (16.8C) in summer.**





## Appendix 2 – Reach 2 Survey Data

Stream Name	Holden	Watershed Code	900-687700	Date	June 2 / 16	Reach Name	2.00	Discharge Depth #1	Velocity	Site Length																																									
Water Quality Information																																																			
Disolved Oxygen	1.50	pH	6.50	Total Disolved Solids	72.00	Temp C	16.70	Discharge Depth #2	0.00	Discharge Depth #3	209.00	Chainage at Beginning of Reach	Chainage at End of Reach																																						
Velocity (m/s)	Average Depth (at flow site) <th>Wetted Width (at flow site)</th> <th>Discharge (m3/s)</th> <th colspan="18"></th>		Wetted Width (at flow site)	Discharge (m3/s)																																															
Habitat Information (All Pool and Cross Section Data)																																																			
Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate	Percent Bed	Percent Cob	Percent Grv	Percent Fine	Percent Instream Cover	LWD	Outbk	Cover	Veget	Other	Percent Crown Cover	Large Woody Debris	LWD/bankfull channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Channel Habitat (length)	Channel Habitat (width)	Channel Habitat (bank side)	Land Use	Right	Left	Vegetation Type	Right	Left	Riparian Slope	Right	Left	Stability	Right	Left	Vegetation Depth	Right	Left	Livestock Access	Right	Left	Photos	Comments
Riffle	0.0	5.0		1.6				0.1	4.0	3.8		0.0	5.0	0.0	45.0	50.0								80.0	0.0	0.0	0.0	0.0	0			C	C	Mx	Mx	10	10	Med	Med	30	5	5	5								
Pool	5.0	16.0	11.00	2.70	29.70			0.4	0.0	2.7		0.0	0.0	0.0	30.0	70.0								90.0	0.0	0.0	0.0	0.0	0			C	C	Mx	Mx	10	10	Med	Med	30.00	5.00										
Riffle	16.0	21.0		3.40	0.00			0.1	5.0	3.4		0.0	0.0	0.0	80.0	20.0								90.0	2.0		3.0	0.0	0			C	C	Mx	Mx	10	10	Med	Med	30.00	5.00										
Pool	21.0	28.0	7.00	3.00	21.00			0.2	0.0	4.1		0.0	0.0	0.0	40.0	60.0								80.0	0.0	2.0	0.0	0.0	0			Nat	C	Mx	Mx	5	10	Med	Low	30.00	5.00										
Riffle	29.0	39.0		4.70	0.00			0.2	1.0	6.1		0.0	5.0	5.0	45.0	50.0								70.0	1.0		3.0	3.0	0			Nat	C	Mx	Mx	10	5	Med	Low	30.00	30.00										
Pool	41.0	44.0	3.00	5.00	15.00			0.4	0.0	6.1		0.0	5.0	5.0	30.0	60.0								80.0	0.0		3.0	0.0	0			Nat	Nat	Mx	Mx	10	25	Med	Med	30.00	30.00										
Riffle	57.0	69.0		4.70	0.00			0.1	4.0	5.5		0.0	0.0	0.0	50.0	50.0								90.0	0.0		5.0	0.0	0			Nat	Nat	Mx	Mx	10	25	Med	Med	30.00	30.00										
Pool	69.0	80.0	11.00	6.00	66.00			0.4	0.0	6.2		0.0	0.0	0.0	50.0	50.0								90.0	2.0		3.0	0.0	0			Nat	Nat	Mx	Mx	10	25	Low	Low	30.00	30.00										
Riffle	80.0	83.0		1.60	0.00			0.1	4.0	6.1		0.0	0.0	0.0	80.0	20.0								90.0	0.0		0.0	0.0	0			Nat	Nat	Mx	Mx	10	25	Med	Med	30.00	30.00										
Pool	83.0	89.0	6.00	5.00	30.00			0.4	0.0	6.1		0.0	0.0	0.0	10.0	90.0								80.0	1.0		0.0	0.0	0			Nat	Nat	Sh	Mx	5	25	High	High	30.00	30.00										
Riffle	89.0	101.0		1.90	0.00			0.2	3.0	2.2		0.0	0.0	0.0	100.0	0.0								70.0	1.0		0.0	0.0	0			Nat	Nat	Sh	Mx	5	25	High	High	30.00	30.00										
Pool	101.0	107.0	6.00	4.50	27.00			0.5	0.0	10.5		0.0	0.0	0.0	50.0	50.0								70.0	1.0		0.0	0.0	0			Nat	Nat	Sh	Mx	10	10	High	High	30.00	30.00										
Pool	107.0	117.0	10.00	4.50	45.00			0.6	0.0	10.5		0.0	0.0	0.0	100.0	0.0								70.0	4.0		0.0	0.0	0			Nat	Nat	Mx	Mx	25	25	High	High	30.00	30.00										
Riffle	117.0	153.0		6.00	0.00			0.1	2.0	6.5		0.0	5.0	5.0	60.0	30.0								70.0	2.0		0.0	0.0	0			Nat	Nat	Mx	Mx	25	25	High	High	10.00	30.00										
Pool	153.0	158.0	5.00	4.50	22.50			0.2	0.0	5.9		0.0	0.0	0.0	100.0	0.0								70.0	0.0		0.0	0.0	0			RS	Nat	Mx	Mx	25	25	Med	Med	10.00	30.00										
Riffle	186.0	188.0		4.50	0.00			0.2	2.0	5.2		20.0	0.0	5.0	50.0	25.0								80.0	0.0		0.0	0.0	0			RS	Nat	Mx	Mx	25	60	Med	Med	15.00	30.00										
Pool	188.0	190.0	2.00	3.80	7.60			0.3	0.0	6.6		0.0	5.0	10.0	70.0	15.0								65.0	1.0		0.0	0.0	0			RS	Nat	Mx	Mx	25	60	High	High	15.00	30.00										
Riffle	190.0	209.0		3.40	0.00			0.2	1.0	6.9		20.0	25.0	20.0	15.0	20.0	30.0							60.0	4.0		0.0	0.0	0			RS	Nat	Br	Br	40	40	High	High	7.00	30.00										
Reach Totals and Averages	0.00	209.00	61.00	3.93	263.80	622.07	32.08	0.25	1.44	5.80	67.82	2	3	3	56	37	30	26	22				80	72.50	19	0.53	8	1	0			32	28			18	22	39	43	24.83	24.44	2	2								

### Appendix 3– Reach 3 Survey Data

Stream Name	Holden	Watershed Code	900-687700	Date	June 3 / 2016	Reach Name	3.00	Discharge Depth #1	Velocity	Site Length																																																									
Water Quality Information																																																																			
Disolved Oxygen	7.80	pH	7.00	Total Dissolved Solids	65.00	Temp C	16.90	Chainage at Beginning of Reach	0.00	Discharge Depth #2	Chainage at End of Reach	384.00	Discharge Depth #3		T1																																																				
Velocity (m/s)		Average Depth (at flow site)		Wetted Width (at flow site)		Discharge (m <sup>3</sup> /s)																																																													
Habitat Information (All Pool and Cross Section Data)																																																																			
Habitat Type	Start (chainage at start)	Finish (chainage at end)	Unit Length	Wetted Width	Pool Area	Wetted Reach Area	%Pool Area	Habitat unit Depth (m)	Percent Gradient	Bankfull Width(m)	Average Percent Wetted Area	Substrate Percent				Percent Instream Cover				Percent Crown Cover	Large Woody Debris	LWD/bank-full channel width	Erosion Sites (length)	Altered Stream Sites (length)	Obstructions (number)	Off-Channel Habitat (length)	Off-Channel Habitat (width)	Off-Channel Habitat (bank side)	Land Use Right Left				Vegetation Type		Riparian Slope Right Left		Stability		Vegetation Depth		Livestock Access		Photos	Comments																							
												40	0	20	30	20				50.00	0		0						RS	11	3	1	2	Nat	Mx	Mx	18	1	5	65	Med	Med	10	10																							
R/Fl	0.00	38.00		2.00	0.00			0.05	3.00	4.30		0	20	30	30				5	90.00	0		3	0				Nat	2	1	1	2	Nat	Mx	Mx	54	3	1	32	Med	Med	20	30																								
Pool	38.00	46.00	8.00	3.70	29.60			0.40	0.00	3.70		0	20	30	30				5	90.00	0		3	0				Nat	2	1	1	2	Nat	Mx	Mx	54	3	1	32	Med	Med	20	30																								
R/Fl	46.00	112.00		4.00	0.00			0.05	2.00	8.20		0	10	0	30	60			5	40.00	0		0					RS	11	3	1	2	Nat	Mx	Mx	36	1	1	36	Med	Med	5	30																								
Pool	112.00	119.00	7.00	6.00	42.00			0.20	0.00	7.50		0	20	20	50	10			40	50.00	5		0					RS	11	3	1	2	Nat	Mx	Mx	25	1	1	32	Low	Med	1	30																								
R/Fl	119.00	153.00		4.30	0.00			0.10	3.00	6.50		0	30	20	20	30				40.00	0		0					EX	6	5	1	2	Nat	Mx	Mx	30	1	1	30	Low	Low	15	30																								
Pool	153.00	157.00	4.00	8.00	32.00			0.30	0.00	9.20		0	0	0	30	70			40	50.00	2		0					RS	11	3	1	2	Nat	Mx	Mx	30	1	1	30	Low	Low	15	30																								
R/Fl	157.00	172.00		2.70	0.00			0.20	2.00	10.00		0	10	10	60	20			50	40.00	1		5	0				RS	11	3	3	11	RS	Mx	Mx	30	1	1	30	Med	Med	0	15																								
Pool	172.00	180.00	8.00	3.50	28.00			0.40	0.00	4.50		0	10	10	60	20			40	40.00	0		0					RS	11	3	3	11	RS	Mx	Mx	30	1	1	30	Med	Med	0	15																								
R/Fl	180.00	198.00		5.90	0.00			0.10	2.00	12.00		0	0	20	40	40				40.00	0		0					RS	11	3	3	11	RS	Mx	Mx	30	1	1	30	Med	Med	5	15																								
Pool	198.00	230.00	32.00	6.40	204.80			0.30	0.00	10.50		0	0	20	40	40				40.00	0		0	10				RS	11	3	3	11	RS	Mx	Mx	30	1	1	30	Med	Med	0	15			1.7m x 1.0m																					
Pool	230.00	245.00	15.00	2.80	42.00			0.30	0.00	4.50		0	10	10	40	40			5	100.00	0		3	5				RS	11	3	3	11	RS	Mx	Mx	15	1	1	18	Low	Med	5	5			Old bridge																					
R/Fl	245.00	253.00		4.80	0.00			0.10	1.00	10.90		0	0	0	50	50				60.00	0		5	0				RS	11	3	3	11	RS	Mx	Mx	6	1	1	10	Low	Med	5	10																								
Pool	253.00	298.00	45.00	4.40	198.00			0.50	0.00	7.50		0	0	0	20	80			10	40.00	1		0					Nat	2	1	1	2	Nat	Mx	Mx	10	1	1	18	Med	Med	5	5																								
R/Fl	298.00	307.00		4.70	0.00			0.20	1.00	7.40		0	0	0	10	90				40.00	0		0					RS	11	3	3	11	RS	Mx	Mx	3	1	1	22	Low	Low	1	15																								
Pool	307.00	336.00	29.00	4.40	127.60			0.20	0.00	5.80		0	0	0	10	90			10	40.00	2		0	5				RS	11	3	3	11	RS	Mx	Mx	5	1	1	20	Low	Med	0	20																								
R/Fl	336.00	351.00		1.90	0.00			0.10	5.00	4.00		0	0	20	50	30				5	60.00	0		5	0			RS	11	3	3	11	RS	Mx	Mx	5	1	1	20	Low	Med	10	3																								
Pool	351.00	384.00	33.00	3.50	115.50			0.30	0.00	5.20		0	0	0	10	90				5	60.00	2		0	5			RS	11	3	3	11	RS	Mx	Mx	10	1	1	5	Med	Med	0	10			Two																					
Reach Totals and Averages																					384.00	181.00	4.29	819.50	1648.94	49.70	0.22	1.12	7.16	59.98	2	6	10	34	48	0	30	5	16	51.76	13	0.24	5	7	5	0	49																				





## Appendix 5 – Holden Creek Habitat Ratings Summary

Stream Name	Holden Creek			Watershed Code:	900-687700								
<b>Habitat Parameter</b>	<b>1</b>	<b>Ratings</b>	<b>2</b>	<b>Ratings</b>	<b>3</b>	<b>Ratings</b>	<b>4</b>	<b>Ratings</b>	<b>5</b>	<b>Ratings</b>	<b>6</b>	<b>Ratings</b>	<b>Total</b>
% Pool Area	100.00	1	32.09	5	49.70	3	90.77	1	1	1	1	1	12
Large Woody Debris/Bankfull Channel Width	0.00	5	0.53	5	0.24	5	0.37	5	1	1	1	1	22
% Cover in Pools	10	3	158	1	51	1	58	1	1	1	1	1	8
Average% Boulder Cover	0	5	30	3	0	5	0	5	1	1	1	1	20
Average % Fines	100.00	5	36.67	5	47.65	5	30.00	5	5	5	5	5	30
Average % Gravel	0.00	not rated	55.83	not rated	33.53	not rated	28.33	not rated	not rated	not rated	not rated	not rated	--
% of Reach Eroded	0	1	8	3	5	3	1	1	5	5	5	5	18
Obstructions	0	0	0	0	5	5	0	0	0	0	0	0	5
% of Reach Altered	0	1	1	1	7	3	2	1	5	5	5	5	16
% Wetted Area	84.21	3	67.82	5	59.98	5	88.89	3	1	1	1	1	18
Dissolved Oxygen	3.40	5	1.50	5	7.80	1	5.70	3	1	1	1	1	16
pH	6.70	1	6.50	3	7.00	1	6.50	3	5	5	5	5	18
<b>Totals</b>		<b>30</b>		<b>36</b>		<b>37</b>		<b>28</b>		<b>26</b>		<b>26</b>	<b>183</b>
Off-Channel Habitat as % of Reach		1	0	5	0	5	0	5	1	1	1	1	18
Reach Lengths		not rated	209	not rated	384	not rated	253	not rated	not rated	not rated	not rated	not rated	846
<b>Fish Data</b>													
Reach	<b>1</b>	<b>Ratings</b>	<b>2</b>	<b>Ratings</b>	<b>3</b>	<b>Ratings</b>	<b>4</b>	<b>Ratings</b>	<b>5</b>	<b>Ratings</b>	<b>6</b>	<b>Ratings</b>	<b>Total</b>
Fry Capacity		--	1233	--	2473	--	1316	--	--	--	--	--	5022
Actual Pop.			0.00		0.00		0.00						0
<b>Riparian Ratings</b>													
Reach	<b>1</b>	<b>Ave. Ratings</b>	<b>2</b>	<b>Ave. Ratings</b>	<b>3</b>	<b>Ave. Ratings</b>	<b>4</b>	<b>Ave. Ratings</b>	<b>5</b>	<b>Ave. Ratings</b>	<b>6</b>	<b>Ave. Ratings</b>	<b>Total</b>
Land Use	6	3	60	2	86	3	22	2					9
Riparian Slope	2	1	40	1	40	1	12	1					4
Bank Stability	6	3	82	2	122	4	51	4					13
		<b>Ratings</b>		<b>Ratings</b>		<b>Ratings</b>		<b>Ratings</b>		<b>Ratings</b>		<b>Ratings</b>	<b>--</b>
% Crown Cover	20.00	5	72.50	1	51.76	3	58.33	3	1	1	1	1	14
% of Reach Accessed by Livestock	0	0	12	3	0	0							3
Average Vegetation Depth	20	5	25	5	11	5	21	5	1	1	1	1	22
<b>Totals</b>		<b>17</b>		<b>14</b>		<b>15</b>		<b>15</b>		<b>2</b>		<b>2</b>	<b>65</b>

<sup>i</sup> Johnston, N.T. and P.A. Slaney, 1996, Fish habitat Assessment Procedures, Watershed Restoration Circular No. 8, Ministry of Environment Lands and Parks and Ministry of Forests.