Cat Stream Habitat Overview Survey

For:

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Contents

Introduction:

The Regional District of Nanaimo (RDN) Drinking Water & Watershed Protection (DWWP) program works with local stewards, scientists and residents to gain a better understanding of watershed health in the region. Through the RDN Community Watershed Monitoring Network, the DWWP program partners with volunteer groups and the Ministry of Environment to monitor water quality in numerous local streams, including the Cat Stream since 2015. Water sampling has been done by the VIU Fisheries and Aquaculture Program as well as the Island Waters Flyfishers at this site (E290486). In June 2017, the DWWP program organized a training session and stream survey on Cat Stream. The community stewards from area organizations as well as private land owners were invited.

The instream and riparian habitat and water quality data collected in this survey is important as more than a training tool as it will offer a reference characteristics for future comparison. The information would become part of the RDN Community Watershed Monitoring Network and possibly guide restoration, remedial actions and/or further monitoring activities.

The objectives were;

- Survey the stream habitat and physical characteristics of Cat Stream.
- Train and educate community stewards and local property owners.
- Identify Watershed water quality conditions and remediation actions.
- Compare and rank fish habitat conditions and identify restoration actions.

Survey Area and Methods:

We used the Urban Salmon Habitat Program (USHP) methodology[1] developed by a team led by George Reid, Sr. Fisheries Biologist for Ministry of Environment Vancouver Island for our survey of Cat Stream. The habitat objective was to survey all significant reaches in two days with two survey teams. The reach areas were determined by segments of similar development, confinement, riparian width and gradient. The urban setting resulted in generally road crossings as the beginning and end of reach segments. The RDN provided the base map for our reach surveys.

Cat Stream was subdivided into four reaches (Figure 1), in which teams surveyed (at least) ten habitat units (pools or riffles) along the channel. At each point approximately 22 habitat parameters were recorded using the USHP template (Figure 2). The data was collected with tools such as measuring staffs, meter tapes, hip chains and clinometers. It was then recorded on an Apple iPad or iPhone using a custom file (pdf schema) written by D.R. Clough Consulting using a software program (Avenza PDF Map). The stream habitat data, locations and photo points were then exported as KML and CSV files for use on Google Earth and Excel spreadsheet program. The data was summarized and results compared to the Watershed Restoration Program[2] standards for instream and riparian health.

[1] 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.

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

Water Quality was measured at the beginning of each reach (and at any special locations of concern) using an Oxy-Guard instrument collected data on Dissolved Oxygen (DO), Oxygen Saturation (%) and Temperature, the pH was also measured in the field with a LaMotte Wide Range pH kit.

This survey was directed by David Clough, RPBio and Braden Judson Fish Tech.(VIU 2nd year Sciences) of D.R. Clough Consulting in partnership with Julie Pisani of the RDN DWWP. Volunteers from Mid Island Flyfishers Ton Plyntar and Ant Elsdale participated in the survey on both June 6th and 7th, 2017. Environmentally concerned citizens Will Geselbracht, Caitlin Johnston, Antoinette Spoor, Ben Geselbracht and Brunie Brunie were able to commit to the survey on June 6th, 2017. The efforts contributed to this survey by volunteers were essential to its success.

Figure 1.) Cat Stream Survey Reach Areas:

Figure 2.) Survey Data Card

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

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 wetted 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

Assessment Results

This document outlines and analyzes the Fish Habitat, Water Quality and Riparian Quality of the 2017 Cat Stream survey. Many components of habitat are analyzed; these are in the attached Appendices 1-4. The appendices have the detailed measures of the habitat parameters identified in the Figure 2 (above) data card. These appendices list every habitat component (pool and riffle) surveyed and the discrete results at those locations. To provide an overview of the entire reach, a summary table is created and presented in the results below. The summary table compares the habitat, riparian and water quality results to the reference standards established by the USHP methodology[3]. Each parameter of data for the reach is summarized and interpreted with a numeric rating based on the reference. This results in a readily identifiable table of good, fair or poor conditions for the reach and ultimately the watershed.

USHP Ratings and Results

Rating	Result
1	Good
3	Fair
5	Poor

The habitat and riparian results are presented below, the water quality data from the field assessment is attached at the end of results.

Reach 1:

Reach 1 of Cat Stream goes from the box culvert at Fifth Street down to its confluence with the Chase River just below Park Avenue. Over 837m long, the channel is mostly flat in a long ditch and marsh past Robins Park, then it enters a treed steeper segment near the confluence. This lower area of the reach is the most canopied area of the stream. Reach 1 was surveyed by David R. Clough, Julie Pisani, Will Geselbracht, Caitlin Johnston, Antoinette Spoor, Ben Geselbracht and Brunie Brunie on the morning of June 6th, 2017. We met at Robins Park and walked down to the confluence and surveyed back upstream. Our measures started at the pool above the concrete fish-way under Park Avenue. We spent approximately an hour at the beginning of the survey to orient everyone on the survey method. We then proceeded upstream ending the habitat survey just below the footbridge. Above the footbridge we walked upstream into the open areas of the Robins Park along Park Avenue. This reach was surveyed in the lower segment which has steepest gradient in the stream (2-4%). It is made up of a series of short pools and riffles on a bedrock and gravel substrate. The survey took approximately 4 hours.

Instream Fish Habitat R1

Overall, Reach 1 fish habitat is in fair condition (Table 2); however there were Poor scores related with wood cover and spawning substrate. Fish spawning gravels and cobbles were unusable or poorly functioning due to accumulated fine sediments (fines). Urban encroachment

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

and residential properties near the creek also contribute organic materials and sediments into the creek channel. The creek bed has little cover for juvenile fish. Rooted bank undercuts and large boulders are almost completely absent from this reach and would provide valuable instream cover. These sediments appear to be the result of upstream storm water runoff. We also observed garden waste dumped into the wetland edge along Park Avenue which is contributing to fines. There was historic Large Woody Debris (LWD) placement in the lower reach from 15 to 20 years ago. These habitat structures are one of the most positive features about this reach. This wood was well placed and stable, with only minor movement. The structures require some maintenance with new anchor cables before they dislodge (Table 9-1.2)

Debris jams that completely plug the channel in three locations are another concern related to wood instream. These jams are established on large wood cover logs that became plugged with smaller branches, lumber, garbage and sediment (including garden debris and yard waste). Fortunately these debris jams are easily accessible from Park Avenue, are small and could be hand removed (Table 9 -1.3). The material is loose branches, lumber, garbage and silt. The native materials can be removed to above high water and used to create or protect tree seedlings and add to forest coarse woody debris for amphibians.

Table 2) Reach 1 Instream Habitat Summary

Habitat Parameter	Value	Rating	Result
% Pool Area	49	3	Fair
LWD / Bankfull Channel Width	0.6	5	Poor
% Cover in Pools	7	3	Fair
Average % Boulder Cover	1	5	Poor
Average % Fines	28	5	Poor
Average % Gravels	41	N / A	N / A
% of Reach Eroded	9	3	Fair
Obstructions	0	0	Good
% of Reach Altered	0	1	Good
% Wetted Area	80	3	Fair
Total / Average		**28 / 3**	**Fair**

Water quality measures (Table 8) on the day of survey were tolerable to salmonids. The water temperature (17.5^0C) was high for the morning temperature and a reflection of the open exposed heat sink that the ball field wetlands create. Oxygen saturation at 95% was one of the highest measures in the stream, and a reflection of the efficiency of the rocky riffle in the lower reach which had the steepest gradient in the creek.

Riparian Areas R1

The riparian areas (Table 3) of Reach 1 scored well. The crown cover (88%) of the lower reach was high and it was noticeably cooler under the canopy during the hot day. There is an established Park around the lower reach. The upper half of the reach is an open grass-land area following the wetted perimeter of Robins Park ball field that is an in-filled wetland. Encroachment is a concern in this reach, with numerous trails trampling the sensitive plant areas along the stream edge.

This reach could be improved by native planting prescriptions addressing the various impacts: infill shade tolerant in the lower reach; open sun water tolerant along the ball field fill areas (Table 9 -1.4). There was a successful example of planting efforts by stewards are evident with ~4m tall Red Cedar (*Thuja plicata*) saplings established in bunches along the lower reach. The successful efforts need to be complimented with more infill planting of conifers under the mostly deciduous overstory. Reach 1's riparian area is in moderate condition; however much of the vegetation is low-lying shrubbery such as salmon berries and salal. By establishing a conifer-dominated riparian the water quality, bank stability and instream cover can be improved.

Table 3) Reach 1 Riparian Data

Riparian Parameter	Value	Rating	Result
Land Use	20	1	Good
Riparian Slope	32	2	Fair
Bank Stability	48	2	Fair
% Crown Cover	88	1	Good
% of Reach Trail Access	51	5	Poor
Average Vegetation Depth	30	3	Fair
Total Result:		**2**	**Good / Fair**

Reach 2:

The Reach 2 of Cat Stream is approximately 1172m long and goes from 5th street culvert upstream to 3rd St Culvert. This reach has four road culverts. It was surveyed from the 5th Street cement box culvert upstream approximately 235m to the Albert Street access trail. Reach 2 was surveyed by Braden Judson, Ton Plyntar, Ant Elsdale and Antoinette Spoor on the morning of June 6th, 2017. This is a low gradient reach that only drops approximately 3m over the entire survey area. Reach 2 survey area flows through the back of residential properties.

Instream Fish Habitat R2

Overall, Reach 2 fish habitat is in fair condition (Table 4); however there were Poor scores related to LWD, Boulders, Fines Erosion and Wetted Area.

Table 4) Reach 2 Habitat Data:

Habitat Parameter	Value	Rating	Result
% Pool Area	100	1	Good
LWD / Bankfull Channel Width	0	5	Poor
% Cover in Pools	10	3	Fair
Average % Boulder Cover	0	5	Poor
Average % Fines	52	5	Poor
Average % Gravels	17	N / A	N / A
% of Reach Eroded	16	5	Poor
Obstructions	0	0	Good
% of Reach Altered	2	1	Good
% Wetted Area	49	5	Poor
Total Result:		**3**	**Fair**

All of Reach 2 scored poorly with respect to substrate composition as there is very little boulder cover and sediments prevent fish from utilizing gravels for spawning. This is all consistent with the likelihood the channel was dredged as the culverts were installed. Residential banks have been altered with ropes, wood and cement blocks that impair fish passage and accelerate bank erosion. The banks are mostly soft materials that contribute sediments downstream and negatively impact both water and habitat quality. This residential portion of Reach 2 is also lacking in LWD cover. The only instream cover in this reach is the occasional large rock and overhanging vegetation. The addition of anchored LWD along the edge at access sites would provide fish and amphibian habitat diversity. The lack of instream cover in this marsh leaves fish vulnerable to predation as both Raccoon and Heron tracks were present on the creek banks.

On the right bank of the 5th Street culvert the adjacent lot appears to be abandoned. This lot has several fruit trees growing on it; however the stream is very grown in with invasive Himalayan blackberries. The blackberry vines (*Rubus discolor*) dangle into the stream channel and make passage almost impossible. There is also evidence of homeless residency in the riparian area. We observed piles of garbage, feces and drug debris on the creek banks and channel (Table 9-2.1). This area would benefit from signage or fencing. In this area there is also a drain pipe on the right bank that is contributing road runoff. There were several instances of homeowners leaving yard trimmings and compost within several meters of the creek. Most properties also sloped towards the creek and had no fences or materials to prevent direct runoff into the creek. Streamside homeowners informed us during the survey that the creek has become significantly less healthy over the last 5 – 10 years with fewer observations of salmon and crayfish.

Upstream of Pine St, the creek opens into a marshy area that continues until the Albert Street culvert (~340m). It lacks cover. On either side of the channel there is typically 5-10m of tall wetland grasses. The creek here is a long meandering pool with an average width of less than 2.5m and substrate composition being entirely soft sediments and organics. These soft materials are easily eroded and contribute sediments downstream. There is also invasive yellow flag iris populating the creek shoulders that threaten to impair passage and should be removed (Table 9-2.2) Outside of grass, the surrounding vegetation was shrubbery dominated by Black Hawthorne (*Crataegus douglasii*), without any significant trees. This marsh area has low flow

during the summer and is a wide floodplain during the winter. The low gradient pooled water here provides rearing habitat for juvenile fishes, however the instream cover is entirely wetland grasses that load the stream with organic material impairing oxygen levels in summer and having low bank stability characteristics. This reach was influenced by road and lawn runoff; as seen in the sediment accumulation on the creek bed. Several manholes on dead end streets lead right to the creek (i.e Pine, Rosamond). Storm water filtration is recommended (Table 9-item 2.4)

The water quality in this reach is different than reach 1 (Table 8) it is cooler but has lower oxygen levels. Tributary A, which enters from the east rail grade hillside, had quite low oxygen level (6.0 ppm).

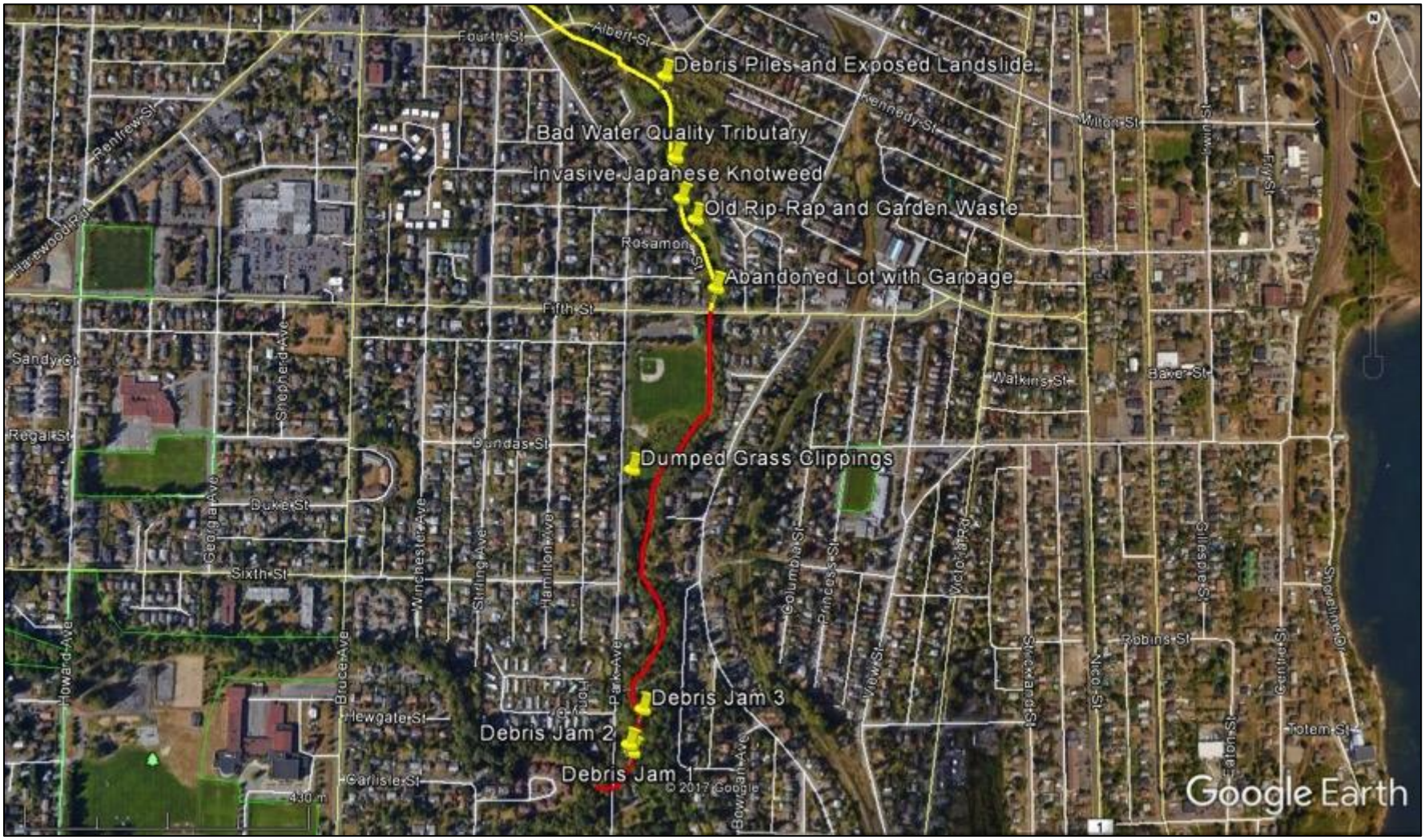
Riparian Areas R2

The riparian area (Table 5) was historically logged and tree regeneration is opportunistic between houses and narrow reserve areas that are not flooded. The confined lower portion has fair (62%) crown cover; however composition is early succession trees such as Bigleaf Maples (*Acer* macrophyllum) and Red Alders (*Alnus rubra*). There is an opportunity to work with homeowners on a planting project to enhance the riparian quality (Table 9-2.3). Some trees could be used as LWD structures as this entire reach is lacking in fish habitat. The wetland areas would benefit from perimeter plantings of taller hydrophytic plants such as Red Osier Dogwood or Red Cedar (where away from properties). At the end of an un-named alley (north of Rosamond Street) there is a large (10x50x12ft) Japanese Knotweed (*Fallopia japonica*). This plant species is highly invasive and is recommended to be removed (Table 9 -2.2). Clearing and removal of some of the blackberries would benefit stream passage and riparian succession. The overall riparian quality scored fair, however in the marshy portion of Reach 2 is poor quality. Planting is recommended in this reach over the grasses for water quality, instream cover and bank stability.

Table 5) Reach2 Riparian Data:

Riparian Parameter	Value	Rating	Result
Land Use	60	3	Fair
Riparian Slope	24	1	Good
Bank Stability	84	4	Poor / Fair
% Crown Cover	62	3	Fair
% Reach Trail Access	0	0	Good
Average Vegetation Depth	14	5	Poor
Total Result:		**3**	**Fair**

Figure 3.) Reach 1 and 2 Issue Locations



Reach 3:

Reach 3 is approximately 1015m in length, from the 3rd Street culvert upstream to above Wakesiah Avenue where an open water wetland begins alongside the Nanaimo Ice Center. This reach was surveyed in two locations by the teams as it was anticipated to be diversely altered. D.R. Clough and volunteers began their survey above the 3rd Street to Howard Avenue. Braden Judson and volunteers began their survey via the 600 Block of Beaconsfield Road ending at Wakesiah Avenue. This reach was found to be the most altered, from many years of residential development and urban encroachment. Despite the impacts of urbanization and poor water quality (Table 8) both survey crews observed juvenile fish all the way into Reach 4.

Instream Fish Habitat

Reach 3 fish habitat scored an average of fair, but with concerns focused around substrate composition, alterations and instream cover. The channel had been dredged in a ditch-like channel in most areas, with some natural features developed despite the alteration. In both sections surveyed, there appeared to be many sedimented riffles or shallow glides where the opportunity to make up for deficient spawning gravel and aeration boulders could be easily established (Table 9 - 3.1) This reach is lacking in instream cover. There are nearly no boulders within the channel to provide cover. Similar to lower reaches, installing LWD and Boulder complexes would increase fish capacity.

Table 6) Reach 3 Habitat Data

Habitat Parameter	Value	Rating	Result
% Pool Area	79	1	Good
LWD / Bankfull Channel Width	0.1	5	Poor
% Cover in Pools	3	5	Poor
Average % Boulder Cover	0	5	Poor
Average % Fines	63	5	Poor
Average % Gravels	22	N / A	N / A
% of Reach Eroded	35	5	Poor
Obstructions	1	1	Good
% Reach Altered	25	5	Poor
% Wetted Area	72	3	Fair
	Total Result:	**4**	**Fair / Poor**

The substrate in this reach was mostly fines and gravels that were stained black from organic input. Sediment loading in this reach was much more extreme than downstream areas. In some locations the sediments were 30 cm deep and littered with organic material. The water is stained and visibility rarely exceeded 10cm. Flow was slower the higher up we surveyed and aquatic vegetation such as Skunk Cabbage (*Lysichiton americanum*) and Horsetail (*Equisetum sp.*) dominated the creek banks. Along the west side of Beaconsfield Road is a large (10m x 10m) pool with a 30 cm deep layer of organic sediments. H_2S gas is released into the water when penetrated. This large pool offers high value fish habitat but would require removing the sediments. Machinery access to this pool is good adjacent the 682 Beaconsfield Road driveway (Table 9- 3.1). Downstream of this pool, two cement culverts drain off Beaconsfield Road and are likely a contributing factor to the local turbidity issue. There is a storm water treatment

opportunity with a rain garden capturing this drainage in the public grassy area near the pond (Table 9-3.3). This site is across from Fairview Elementary offering an education and partnership opportunity for such a project (Table 9-3.4). At the end of Beaconsfield Road there is a footpath that connects to Wakesiah Road culvert. This footpath runs parallel to the creek, which is nearly impassable due to overgrown Himalayan Blackberries and steep, muddy banks (Table 9-3.2). At the downstream side of the Wakesiah Culvert there is a large pool that contains several large boulders. These boulders provide shade and cover for trout, crayfish and aquatic insects. As this pool is roadside, the creek-bed has accumulated a thick layer of sediments from untreated road runoff. The lack of overhead cover in this exposed pool resulted in being very warm. Surveyors observed several small schools of trout fry that were unfortunately accompanied by three mature, invasive bullfrogs.

The water quality (Table 8) in this reach was significantly affected by localized conditions; oxygen was poor (5.9 ppm) at the sedimented runoff at Beaconsfield pool, but higher (7.3-8.1 ppm) at either end of the reach further away from active storm drains. Cat Stream lacks adequate base flow to dilute the toxins entering the stream; the only option is for these inputs to be treated. Thus we highly recommend storm water treatment in this reach (Table 9 item 3.3).

Riparian Areas

Most of this reach's riparian area consists of residential properties, yet scored fair (Table 7). The crown cover (85%) is good but there were still many areas of less than 50% canopy in which to replant; such as the wetland area above 3rd St. Other areas need biodiversity, just above the Sikh Temple , the canopy is all deciduous and needs conifer underplanting (Table 9-3.5). Planting locations are easily accessible and would not only improve habitat quality, but cool the water as well. The upper reach 3 (off Beaconsfield Road) had more substantial riparian vegetation with many mature Red Alder, Maple, and Douglas Fir (*Pseudotsuga menziesii*) trees. Despite the mature vegetation the riparian zone was thin and the trees were being choked out by invasive English Ivy (*Hedera helixa*), Bamboo (*Bambusoidea sp.*) and Daphne (*Daphne laureola*) (Table 9 -3.6). In some places the roots of Willow Trees (*Salix spp.*) were constricting the creek channel.

Closer to Howard Avenue there are several instances of garden and lawn debris being deposited within a few meters of the creek. On the right bank (0+047) there is also a storm pipe that was contributing oily water into the creek. At the Howard Avenue intersection there is a sanitary sewer line that crosses the creek bed.

This reach had eroded, steep banks that had been historically armoured with old tires and rock. Most of the riparian of this reach was vegetated residential yards. Many of these yards were un-fenced resulting in lawn materials, yard sediments migrating into the channel during rain events. We also observed dogs playing in the creek from surrounding properties.

Table 7) Reach 3 Riparian Data

Riparian Parameter	Value	Rating	Result
Land Use	166	3	Fair
Riparian Slope	58	1	Good
Bank Stability	234	4	Fair / Poor
% Crown Cover	85	1	Good
% Reach Accessed	13	3	Fair
Average Vegetation Depth	6	5	Poor
Total Result:		**3**	**Fair**

Reach 4 and Upper Tributaries

The Reach 4 was surveyed on Wednesday June 7th by David Clough, Braden Judson, Ton Plyntar and Ant Elsdale. Reach 4 is actually not one channel but at least four that combine together at the Third St. Park trail at the top of reach 3. These altered upper reaches were considered marginal fish habitat due to the poor fish passage at the new trail culvert (it was dry and elevated) as well as poor water quality and quantity. It may offer some winter- feeding if access through the culvert at higher water levels is possible. This reach was made up of dredged wetlands and ditches with elevated fill areas bisecting the natural drainage and water collection of the old large wetland. Alteration of the wetland bowl did not occur recently; at a public meeting about re-zoning, a local streamkeeper noted this area was a popular military practice site for tanks in the 1940's (Pers. Comm. Charles Thirkill). These alterations, low fish use and limited time determined we could not survey using USHP methodology. Therefore it was not scored with respect to habitat quality. The objective of this portion of the survey as to determine the location and quality of water sources that contributes to the Cat Stream.

Water sources were quantified with respect to their water quality (Table 8). We started at the wetland behind the Nanaimo Ice Center and walked upstream, following the identifiable water bodies. The survey determined the location of the headwater waterways around the Nanaimo baseball diamond (Serauxmen Park), Wessex Lane, Addison Road and drainages below the University Crescent. The survey of Reach 4 found four segments with water flow. Our base map (Figure 4) only shows one of the segments (4-1) as a line, but all the segments can be found based on the location pins on the diagram.

Reach 4 Segments:

Segment 4: This segment is the largest, it is approximately 1255 m long, It originates from the VIU storm culvert at Site 12 on Figure 4 and flows north down the campus hill and across 3rd St to enter a wetland area beside the ball fields. Here the channel makes its way through two more culverts under long bands of imported fill in the wetland area. The reach was wet and flowing the entire length and may run year round offering fish habitat if access is possible. The Segment 4 survey began along the footpath that passes through the Third Street Park below the baseball diamonds. Two culverts pass under the walkway and drain tributary waters into the Cat Stream mainstem. The water around these culverts was stagnant and littered with garbage and small woody debris. This entire wetland area is dominated by Black Hawthorne and Himalayan Blackberries. The wetland's water was either standing or subterranean during the survey. Water quality parameters were analyzed at significant points throughout. The wetland substrate was

typical of wetlands and comprised of mostly organic materials. The major concern with this wetland is it going dry, as it would trap and kill any aquatic residents. If this wetland were able to maintain an above-ground water table throughout the year it would serve as valuable fish rearing habitat.

At Segment 4 are DRC sites 11 and 12 (Figure 4) situated below the University Crescent Residence and adjacent to the stadium and running track. Site 12 is suspected to be the VIU Aquaculture runoff and is one of the most significant contributors to downstream flow. At the time of the survey the 1000 corregated metal pipe (CMP) outlet was flowing at approximately 175 lpm. The water being discharged here was good with respect to oxygen and pH parameters and is previously treated by UV radiation to kill any biotic contaminants. Concerns with this discharge surround the nutrient output potentially contributing to downstream wetland eutrophication. Future corrections could potentially include chemically removing nitrogen and phosphorous containing compounds from the aquaculture effluent. Downstream site 11 is visible from Third Street. Water quality here was similar to the source quality; however the substrate here was clouded with organic slime that resembles the bottom of a fish tank. This is potentially a result of nutrient loading from upstream aquaculture activities. There were no benthic invertebrates here that indicate a healthy stream, however numerous juvenile leaches were observed clinging to the rocks.

Segment 4-1: This segment may have been the mainstem before alterations such as the Highway 19 interception ditches and the ball field construction. It is approximately 781 m long from the Third St. Trail culvert west upstream between the ball field and across JinglePot Road to collect Highway 19 ditch drainage. The lower segment of this reach is the yellow line in Figure 4. The upper reach above Jingle Pot/Third St. has no fish access and was ditched, steep, and dry. At Segment 4-1, the Serauxmen Baseball Diamond parking lot has culverts that drain water into the wetland area. The entire parking lot is comprised of loose gravel and fill. During traffic and rain events these materials are easily transported into the wetland and ditches to the channel. Redirecting drainages, adding filtration areas around the parking lot's perimeter would reduce the rate of sediment deposition and wetland filling. Where possible, constructing bio-swales would filter sediments and chemical runoff from the parking lot while maintaining drainage. There are also minor concerns surrounding garbage being dumped here that can be transported to the creek.

Segment 4-2: This segment drains the steep slopes from Malaspina Heights and across Highway 19 Addison Road and into a bowl below the VIU campus, then drains across Third St. at Site 10 on Figure 4 and joins Segment 4 in a wide wetland area beside the Ball Diamond. This segment is approximately 512m long from the start of water flow below the VIU campus to segment 4. Upper areas are ephemeral and dry. The lower reach may have fish access to Third Street, but ends at the culvert under the upper foot trail which is small (30 cm) and has limited habitat above.

Segment 4-3: Another VIU slope drainage that has a series of small pools and ditches connecting to segment 4-2 at Site 10 on Figure 4. It is approximately 210m long. This segment joins above the foot trail and is not fish accessible nor habitable. At the 'DRC Site 10' station there is a 300mm pipe crossing under the walkway. On the high side of the walkway there are

several pools of standing water. The water here drains through a series of culverts to the ditch line along Third Street. As summarized in Table 8, the water quality in these pools was very poor and the water smelled stagnant. This area was also very muddy and likely contributes sediments downstream.

Water Quality Results

Cat Stream is an urban fish-bearing stream located in southern Nanaimo. Its watershed is made up of roadways, residential homes and commercial development. During the survey, the stream was at base flow and water sources were found at storm water pipes leaving the VIU campus, and a series of seeps along the Highway 19 slopes below Malaspina Heights. In winter, street runoff is the dominant water flow influence.

Both ground and rainwater from the highway pass under Jingle Pot Road through several culverts that drain into a large wetland complex. From the walking path that bisects the wetland area, there is an open water wetland down to Wakesiah Avenue. Below Wakesiah the channel is confined between houses and crosses numerous roads to enter the Chase River. Cat Stream flows for approximately 4.5km to its confluence with Chase River beside Park Avenue. In winter, street runoff is the dominant water flow influence.

Table 8) Water Quality

Reach	Location	Temp (^{0}C)	pH	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	Turbidity (m)	Time
1	Park Ave culvert above fish-way	17.5	7.3	8.0	94	1	10:20 am
2	5th Street Creek Access	13.6	7.3	7.4	84	1	10:05 am
	Tributary A off Pine Street	11.9	N/A	6.0	66	N/A	11:20 am
3	Mid Reach backyard	16.2	7.5	8.1	83	0.5	1:00 pm
	Beaconsfield pool	17.7	7.3	5.9	72	0.1	2:00 pm
	Wakesiah culvert	17.4	7	7.3	84	0.5	3:00 pm
4	Marsh above Wakesiah	17.3	N/A	3.5	40	N/A	9:30 am
	Marsh outflow	17.8	6.7	8.0	95	N/A	9:45 am
	Wetland walkway off Jingle Pot Rd	15.1	6.5	2.5	29	N/A	10:00 am
	Ballfield stream culvert	14.6	6.3	3.7	41	0.2	10:15 am
	Wetland at ballfield	16.2	6.7	3.9	45	N/A	10:40 am
	Serauxmen parking lot culvert	15.3	7	5.6	66	N/A	10:45 am
	3rd St Trail culvert (Site 10)	15.8	6.7	4.5	54	N/A	11:20 am
	3rd St. Culvert (Site 11)	13.5	6.7	8.1	87	N/A	11:30 am
	Bog below VIU (Site 12)	17.8	6.3	1.3	12	N/A	12:00 pm
	VIU culvert discharge above 3rd St	14.8	6.7	8.6	91	N/A	12:15 pm

Generally water quality was good within the lower reaches of the Cat Stream as oxygen levels were adequate to support populations of fish and other sensitive invertebrates. It is important to note that certain runoff chemicals and toxins may be present but were undetectable using our survey methodology. pH levels seemed normal for an urban, central-Vancouver island creek.

Water quality concerns arise with streamside residential properties leaving lawn clippings in areas in which phosphorous and nitrogen containing compounds can leach into the stream. To prevent excess nutrient leaching homeowners need to properly dispose of their lawn debris or implement a barrier that prevents water running from their lawn into the creek. This was evident along reach 1, 2 and 3.

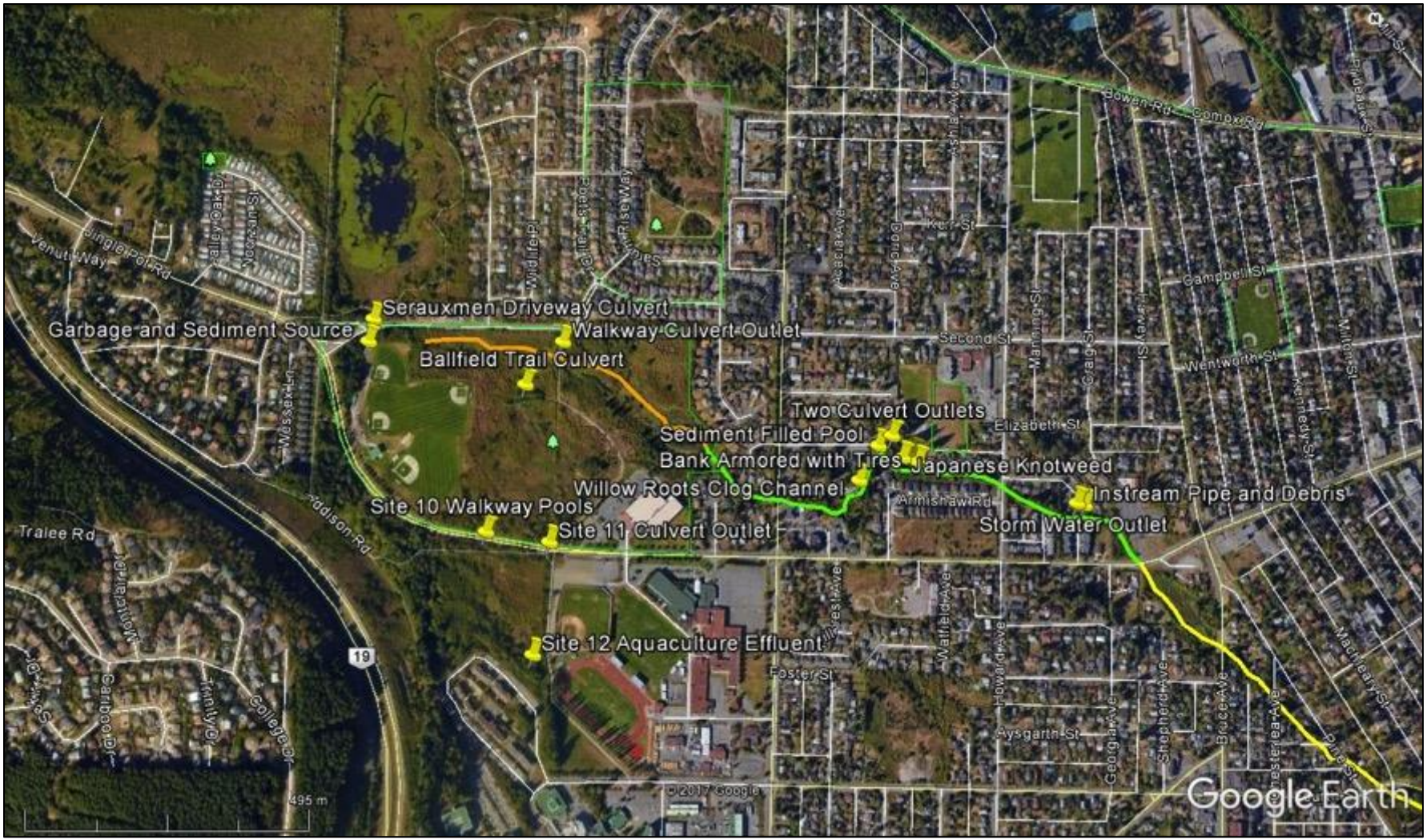
There is an outflow culvert (450 CMP) at the end of Albion Street that forms a tributary into the marshy potion of reach 2. The outflow water had plastic garbage and orange iron residue. The effluent water was 19^0C with 6.0ppm O_2 (68% saturation) at 11:00 am. This culvert contributes hot, low oxygen water that will impair all downstream water quality from this point, as well as contributing unknown toxins and potentially hazardous materials from garbage, road runoff and metal debris.

It is the middle of Reach 3 in which water quality was poorest. The water throughout the Beaconsfield Road area was dystrophic and actively migrating suspended sediments downstream. There are two identified culverts here with unknown impact on water quality, however much of this region is directly clearly affected by roadway runoff.

Many of the streamside properties actively leach nutrients and organics into the creek from compost, lawn clippings, construction and pets. These nutrients can lead to excess algal and plant growth as well as low oxygen levels during the summer months. These nutrient parameters were not measured directly, however streamside garbage, compost and lawn clippings were observed in abundance.

The water quality of Reach 4 drainages experiences slight filtration from the downstream wetland area. However, the water quality of these sources influences the entire creeks health. There are concerns with nutrient loading from the VIU aquaculture effluent that impairs wetland health and function.

Figure 4.) Reach 3 and 4 Issue Locations



Discussion:

The habitat and water quality of the Cat Stream is heavily impacted by roads, residents and urban development. The effects of encroaching urbanization are evident in the lack of significant alterations through housing, roads, culverts leaving little native riparian vegetation and giving considerable sediment loading to the creek bed. There are many residential properties whom have removed, altered or added deleterious materials to migrate into the water. Roads, driveways and parking lots are major sediment sources. We saw this sediment and turbidity in Reach 3 as a significant impact to the water quality and fish health. Our list of activities should prioritize any actions that improve the water quality through sediment reduction or elimination. Table 9 identifies the recommended activities by area, priorities will depend on the resources of those doing the work.

Table 9: Cat Stream: Habitat and Water Quality Improvement Opportunities

Reach	Water Quality Impact	Recommended Remedial Action	Comments
1	1.1 Sediment in spawning gravel	Identify sources (road and storm water inputs), remediate (rain gardens, gravel addition, scour structures)	High fish benefits
1	1.2 Loose Wood Cover logs	Historic stream restoration structures require maintenance anchoring. More logs/stumps should be added.	Improve shade and scour sediment from pools
1	1.3 Debris Jam	Hand removal of these 3mx3m debris piles to above high water areas use for riparian	Eliminate erosion and fish passage issues
1	1.4 Planting	Lower reach 1 – infill conifer planting approx. 250 trees Upper reach 1 – wetland edge planting tall deciduous and conifer, approx. 500 plants	Cool the water, reduce erosion and filter runoff.
2	2.1Garbage	Garbage removal in riparian areas	Homeless camp site, include signage, fencing.
2	2.2 Invasives	Invasive Yellow Flag Iris removal in marsh edges below Albert Street Knotweed removal at site near Rosamond Street	Invasives will spread and plug the channel, load nutrients and sediment
2	2.3 Planting	Marsh areas along Pine St. need more overstory plants established (i.e. Red Osier/Cedar)	To improve water quality (oxygen/temperature) and reduce organic loading from grasses.
2	2.4 Storm water runoff affecting turbidity and water chemistry.	Identify all storm water drainage entry locations and determine remediation (sumps, rain gardens, diversion)	Pine St runoff is likely the highest concern

3	3.1 Sedimentation (affecting Oxygen, & Habitat).	Remove sediment accumulation in Beaconsfield pool. Add Boulder and gravel substrates in shallow sites such as above 5th St and Beaconsfield. The small channel could be replenished with 2-4 wheelbarrow loads in each location	The easiest sediment removal site in the reach, could use a vac truck or excavator. Sediment can be hand dug out in spawning gravel sites then place in 4 -6 inches deep with boulders as anchors and aeration.
3	3.2 Erosion and turbidity (general bank erosion)	Along Beaconsfield/Wakesiah school trail area is a high impact site. Work with property owners. shrubbery cuttings would grow and stabilize muddy trail and eroding bank areas.	Willow and Red Osier stakes and taller trees in suitable locations away from homes. Fairview school as a partner
3	3.3. Road runoff Beaconsfield, Wakesiah affecting water quality (Turbidity, sediment, Oxygen)	The drainages require filtration through raingardens/swales. There is public space end of Beaconsfield to work with a filtration gallery. The Wakesiah road runoff could be filtered by cutting the curbs and modifying existing green strip to filter.	Storm Water runoff was directly affecting turbidity in this reach during survey. But many other locations likely negative effect in winter.
3	3.4 Awareness/ partnerships	Work with property owners and schools on restoration. This reach is situated in a highly visible accessible location. Engage Fairview Elementary, Landowners, NDSS, VIU. Streamkeepers..	Highest visibility in this reach for signage, activities, partners.
3	3.5 Shade planting for Temperature & Erosion issues	Shade tree planting in open areas such as lower reach, infill planting of conifers and other native plants everywhere else but especially easy to start in larger public areas or bylaw reserve areas.	There is Fairview Elementary School to partner in efforts. Recommend fall planting schedules over spring.
3	3.6 Invasive Plant removal for protection of shade trees	The Beaconsfield area has Ivy, Daphne and Bamboo to remove and release or replant native shrubbery such as Indian Plum, Red Currant, Red Osier and Pacific Ninebark	Educating the neighbourhood may assist in reducing future problems and gain some assistance in maintenance.
4	4.1 Monitoring	water quality from feeder ditches and culverts, need a monitoring site in the headwater	DWWP
4	4.2 Sediment	.Address sediment source from ball field parking areas into the upper reach through diversion, barriers and filtration.	Ball Field

Monitoring the human impacts on Cat Stream is important in understanding the current trends and assessing the efforts to correct things. Future follow-up assessments should include an area in Reach 3 just below the storm water inputs as well as the headwaters.

The overall riparian habitat on Cat Stream is damaged by historic logging and then removal for housing, roads and recreational areas. Alterations allow invasive species to get started as well. We found one significant infestation of Knotweed in Reach 2 and several smaller occurrences of Ivy, Daphne and Himalayan Blackberry.

As Cat Stream is accessible to the public, especially in Reach 3, there are many opportunities that could be considered from Table 9; planting, rain gardens, sediment removal and spawning gravel. All could be scaled to the size and ability of the interested party.

The Cat Stream is one of the most urbanized streams in the region. It is under tremendous strain from the alterations to its historic state. It likely once had Coho salmon and Cutthroat Trout all the way to the location of the VIU campus in its 4.0 km length. It likely had several more tributaries, the banks were shaded and the substrates clean with year round flow. The wetland areas would have been deep open water wetlands maintained by beavers. There were likely thousands of salmon and trout living in it then.

Cat Stream was developed before streamside protection bylaws were considered. A stream such as Cat Stream needs at least 30m of natural vegetation on its banks to begin to create the hydro-riparian zone necessary to maintain year round water quality. It currently has anywhere from 30m plus in Reach 1 (although this site was all logged) to less than 5m along sections of Reach 2 and 3. This is insufficient and affects the stream in the ways our habitat survey shows. We should stop further damage and begin to restore impacted areas. Efforts should start small and simple; plant trees, educate neighbours about garbage, fertilizers and composts. As things develop, the community can work with the City, RDN, DFO, engineers and biologists and develop more elaborate plans such as rain gardens, sediment removal and instream fish habitat installations of spawning gravel and LWD.

The RDN Drinking Water & Watershed Protection (DWWP) Program is generating essential information that is being used to protect the Cat Stream. This habitat survey and restoration plan is meant to be part of the solution protection of the watershed. It must be in conjunction with water quality data collection in the DWWP Community Watershed Monitoring program. The heavy lifting needs to be done by the trained stewards from this project and other members of the public and landowners if things are to change.

Conclusions

The objective of this document is to provide a baseline understanding of the habitat and water quality of Cat Stream and recommend potential restoration objectives.

The Cat Stream habitat survey completed several objectives;

1.) It educated and trained stewards in fish habitat assessment as well as gave them an understanding of the value of this habitat
2.) It provided a habitat survey that will be useful for monitoring the watershed.
3.) It identified water quality and fish habitat opportunities
4.) It resulted in meeting watershed property owners and initiating the stewardship ideas and water protection concepts.

Submitted by

David R. Clough, RPBio

Photo Page 1) Reach 1 Habitat

Photo 1) Reach 1 Volunteers, Pool 1 above fishway

Photo 2) R1, Pool 4 habitat adjacent to Park Avenue

Photo 3) R1, Pool 5 fish habitat and large woody debris

Photo 4) R1, Riffle 5 boulder complex

Photo Page 2) Reach 1 Restoration Opportunities

Photo 1) Black slime coating streambed substrate

Photo 2) R1, Pool 3 woody debris jam #1

Photo 3) R1, Debris jam #3

Photo 4) R1, Compost dumping along Park Avenue

Photo Page 3) Reach 2 Habitat

Photo 1) R2, Historically armored left bank

Photo 2) Representative site in Reach 2's wetland

Photo 3) R2, Pool 4 full of fry

Photo 4) R2, Riparian vegetation

Photo Page 4) Reach 2 Restoration Opportunities

Photo 1) R2, Exposed slide materials eroding into creek

Photo 2) Pine street culvert effluent contributing poor quality water and sediments

Photo 3) R2, 5th Street culvert garbage and drug debris

Photo 4) Invasive japanese knotweed at the end of unnamed alley way

Photo Page 5) Reach 3 Habitat

Photo 1) R3, Perrennial pool habitat

Photo 2) Reach 3 mature riparian trees

Photo 3) R3, Riffle adjacent to Beaconsfield Driveway

Photo 4) R3, Clean riffle complex behind Gord's House

Photo Page 6) Reach 3 Restoration Opportunities

Photo 1) Sediment accumulation in pool off Beaconsfield Road driveway - needs excavation

Photo 2) R3, Right bank reinforced with old tires

Photo 3) Two culverts draining from Beaconsfield Road

Photo 4) Accumulated sediments, erosion and raccoon tracks

Photo Page 7) Reach 4 Habitat

Photo 1) Wetland drainage under ball field access trail. Stagnant pool at culvert outlet.

Photo 2) Culvert outlet from Serauxmen parking lot

Photo 3) Pool adjacent to Third Street Park walkway

Photo 4) Wetland area behind Nanaimo Ice Center

Photo Page 8) Reach 4 Restoration Opportunities

Photo 1) Culvert outlet below VIU

Photo 2) Serauxmen park drainage channel with accumulated fine sediments

Photo 3) DRC Site 10, stagnant pools with poor water quality and impaired drainage

Photo 4) DRC Site 11, nutrient loading and leeches

Appendix 1) Reach 1 Raw Data Table

Stream Name	Catstream	Watershed Code	920-389300-22700	Date	June 6 2017	Reach Name			
Quality Information						Field Crew	DRC		
Dissolved Oxygen	8 mg/L, 94%	pH	7.30			Temp C	17.50	Chainage at Beginning of Reach	0.00
								Chainage at End of Reach	117.00

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	Bld	Cob	Grv	Fine	Percent Instream Cover Bold	LWD	Cutbk	Veg	Other
Pool	0.00	10.00	10.00	2.10	21.00	21.00		0.20	0.00	3.80		0	5	15	40	40	0	0	5	0	0
Riffle	10.00	13.00		3.20	0.00	9.60		0.10	4.00	3.80		0	5	10	60	25	0	0	0	0	0
Pool	13.00	22.00	9.00	4.50	40.50	40.50		0.30	0.00	5.00		10	25	30	10	15	0	25	0	0	0
Riffle	22.00	35.00		3.40	0.00	44.20		0.10	2.00	3.90		0	10	10	70	10	0	0	0	0	0
Pool	35.00	43.00	8.00	2.80	22.40	22.40		0.35	0.00	3.70		0	0	40	40	20	0	10	0	0	0
Riffle	43.00	45.00		2.10	0.00	4.20		0.10	2.00	2.40		0	0	40	40	20	0	0	0	0	0
Pool	45.00	54.00	9.00	2.30	20.70	20.70		0.00	0.00	3.40		0	5	25	40	30	0	10	0	0	0
Riffle	54.00	79.00		2.70	0.00	67.50		0.10	2.00	3.80		0	5	25	40	30	0	0	0	0	0
Pool	79.00	94.00	15.00	4.30	64.50	64.50		0.30	0.00	4.70		0	0	10	10	80	0	15	0	0	0
Riffle	94.00	117.00		2.30	0.00	52.90		0.20	4.00	2.80		0	5	25	60	10	5	0	0	0	0
Reach Totals and Averages		117.00	51.00	2.97	169.10	347.50	48.66	0.18	1.40	3.73	79.62	1	6	23	41	28	1	6	1	0	0

Habitat Type	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	Land Use Left	Vegetation Type Right	Vegetation Type Left	Riparian Slope Right	Riparian Slope Left	Stability Right	Stability Left	Vegetation Depth Right	Vegetation Depth Left	Livestock Access Right	Livestock Access Left
Pool	95.00	1		0	0	0	0	0	0	Nat	Nat	Mix	Mix	35	45	High	High	30	10	10	10
Riffle	95.00	0		0	0	0	0	0	0	Nat	Nat	Mix	Mix	35	45	High	High	30	10	0	0
Pool	90.00	5		3	0	0	0	0	0	Nat	Nat	Mix	Mix	35	60	High	Med	30	30	0	0
Riffle	90.00	0		0	0	0	0	0	0	Nat	Nat	Mix	Mix	35	60	High	Med	30	30	0	0
Pool	90.00	4		0	0	0	0	0	0	Nat	Nat	Mix	Mix	35	60	Med	Med	10	60	0	0
Riffle	90.00	0		0	0	0	0	0	0	Nat	Nat	Mix	Mix	35	60	Med	Med	10	60	2	2
Pool	85.00	2		2	0	0	0	0	0	Nat	Nat	Mix	Mix	35	5	Med	Med	5	60	0	0
Riffle	75.00	0		0	0	0	0	0	0	Nat	Nat	Mix	Mix	10	15	Med	Med	5	60	0	0
Pool	80.00	6		0	0	0	0	0	0	Nat	Nat	Mix	Mix	10	15	Med	Med	5	60	0	0
Riffle	85.00	0		6	0	0	0	0	0	Nat	Nat	Mix	Mix	10	15	Med	Med	5	60	0	0
Reach Totals and Averages	87.50	18	0.57	9	0	0	0			10	10	40	40	10	22	22	26	16.00	44.00	10	10

Appendix 2) Reach 2 Raw Data Table

Stream Name	Catstream	Watershed Code	920-389300-22700	Date	June 6 2017	Reach Name	2.00		
Water Quality Information					Field Crew		BJJ		
Dissolved Oxygen	7.4 mg/L, 84%	pH	7.30			Temp C	13.60	Chainage at Beginning of Reach	26.00
								Chainage at End of Reach	233.00

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		Vegetation Type		Riparian Slope		Stability		Vegetation Depth		Livestock Access	
												Bed	Bld	Cob	Grv	Fine	Bold	LWD	Cutbk	Veg	Other									Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Riffle	26.00	78.00		1.00	0.00	52.00		0.10	3.00	2.00		0	0	15	35	50	0	0	0	15	0	50.00	0		0	0	0	0	0	0	RS	RS	Mix	Sh	40	55	Med	Low	5	10	0	0
Riffle	78.00	85.00		1.20	0.00	8.40		0.10	2.00	2.10		0	0	10	10	80	0	0	0	15	0	90.00	0		4	0	0	0	0	0	RS	RS	Mix	Mix	25	45	Low	Low	5	10	0	0
Pool	85.00	98.00	13.00	1.50	19.50	19.50		0.25	0.00	2.20		0	20	40	10	30	0	0	0	5	0	90.00	0		13	0	0	0	0	0	RS	RS	Mix	Mix	25	15	High	Low	1	30	0	0
Riffle	98.00	100.00		1.20	0.00	2.40		0.10	1.00	2.00		0	20	40	10	30	0	0	0	5	0	90.00	0		2	0	0	0	0	0	RS	RS	Mix	Mix	25	15	High	Low	1	30	0	0
Pool	100.00	107.00	7.00	2.30	16.10	16.10		0.20	0.00	2.50		0	20	40	10	30	0	0	0	0	0	50.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	25	15	High	Low	1	30	0	0
Riffle	107.00	111.00		1.20	0.00	4.80		0.10	2.00	2.00		0	0	40	35	20	0	0	0	0	0	50.00	0		0	4	0	0	0	0	RS	RS	Mix	Mix	25	15	Low	Med	1	30	0	0
Pool	111.00	120.00	9.00	2.00	18.00	18.00		0.30	0.00	2.70		0	0	40	35	25	0	0	0	0	0	50.00	0		9	0	0	0	0	0	RS	RS	Mix	Mix	25	15	Low	Low	1	30	0	0
Riffle	120.00	124.00		2.30	0.00	9.20		0.10	1.00	2.60		0	0	25	25	50	0	0	0	0	0	50.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	25	15	Low	Low	15	15	0	0
Pool	124.00	227.00	103.00	3.10	319.30	319.30		0.20	0.00	13.00		0	0	0	0	100	0	0	0	10	0	50.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	15	15	Low	Low	15	15	0	0
Riffle	227.00	233.00		0.70	0.00	4.20		0.30	1.00	2.00		0	0	0	0	100	0	0	0	10	0	50.00	0		6	0	0	0	0	0	RS	RS	Mix	Mix	15	15	Low	Low	15	15	0	0
Reach Totals and Averages		267.00	132.00	1.65	372.90	453.90	82.15	0.18	1.00	3.35	49.25	0	6	25	17	52	0	0	0	6	0	62.00	0	0.00	16	2	0	0			30	30			10	14	36	48	6.00	21.50	0	0

Appendix 3) Reach 3 Raw Data Table

Stream Name	Catstream	Watershed Code	920-369300-22700	Date	June 6 2016	Reach Name	3.00		
Quality Information					Field Crew		d DRC combined		
Dissolved Oxygen	8.1mg/L 84%	pH	7.30			Temp C	16.20	Chainage at Beginning of Reach	0.00
								Chainage at End of Reach	318.00

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	Bld	Cob	Grv	Fine	Percent Instream Cover Bold	L/VD	Cutbk	Veg	Other	Percent Crown Cover	Large Woody Debris	L/VDbank-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	Land Use Left	Vegetation Type Right	Vegetation Type Left	Riparian Slope Right	Riparian Slope Left	Stability Right	Stability Left	Vegetation Depth Right	Vegetation Depth Left	Livestock Access Right	Livestock Access Left
Pool	95.00	102.00	7.00	1.90	13.30	13.30		0.20	0.00	3.20		0	0	0	15	85	0	0	0	5	0	90.00	0		5	0	0	0	0	0	RS	RS	Sh	Mix	15	15	Med	Med	15	2	0	0
Pool	102.00	108.00	6.00	2.00	12.00	12.00		0.20	0.00	3.20		0	5	20	55	20	0	0	0	0	0	90.00	0		7	0	0	0	0	0	RS	RS	Sh	Mix	25	15	Low	Low	2	2	0	0
Riffle	108.00	124.00		2.40	0.00	38.40		0.10	2.00	3.40		0	0	0	30	70	0	0	0	0	0	75.00	0		16	16	0	0	0	0	RS	RS	Mix	Mix	33	11	Med	Med	8	3	0	0
Pool	124.00	129.00	5.00	2.00	10.00	10.00		0.20	0.00	3.70		0	0	0	30	70	0	10	0	0	0	75.00	3		5	0	0	0	0	0	RS	RS	Mix	Mix	33	11	Med	Med	8	3	0	0
Pool	129.00	136.00	7.00	1.80	12.60	12.60		0.20	0.00	2.80		0	20	0	40	40	0	0	0	0	0	75.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	33	11	Med	Med	8	3	0	0
Riffle	136.00	141.00		0.70	0.00	3.50		0.10	1.00	2.00		0	0	40	25	35	0	0	0	0	0	75.00	0		5	5	0	0	0	0	RS	RS	Mix	Mix	33	11	Med	Med	8	3	0	0
Pool	141.00	146.00	5.00	2.30	11.50	11.50		0.20	0.00	2.60		0	0	40	25	35	0	0	0	0	0	75.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	5	0
Riffle	141.00	143.00		1.20	0.00	2.40		0.10	1.00	1.90		0	10	25	25	40	0	0	0	0	0	75.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Pool	143.00	145.00	2.00	1.80	3.60	3.60		0.20	0.00	2.30		0	10	25	25	40	0	0	0	0	0	75.00	0		0	0	1	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Pool	145.00	153.00	8.00	2.10	16.80	16.80		0.30	0.00	2.30		0	10	25	25	40	0	0	0	0	0	75.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Riffle	153.00	159.00		1.80	0.00	10.80		0.10	1.00	2.30		0	10	25	25	40	0	0	0	5	0	75.00	0		6	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Pool	159.00	169.00	10.00	3.10	31.00	31.00		0.20	0.00	3.40		0	0	0	10	90	0	15	0	0	0	90.00	2		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Riffle	169.00	173.00		1.80	0.00	7.20		0.10	1.00	2.30		0	0	0	10	90	0	5	0	0	0	90.00	1		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	15	3	0	0
Pool	173.00	181.00	8.00	2.50	20.00	20.00		0.40	0.00	2.90		0	0	0	0	100	0	5	0	0	0	90.00	1		0	0	0	0	0	0	RS	RS	Mix	Mix	12	49	Low	Med	8	3	0	0
Riffle	181.00	204.00		1.80	0.00	43.20		0.10	2.00	2.30		0	10	40	10	40	0	0	5	0	0	90.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	8	3	0	0
Pool	204.00	232.00	28.00	2.50	70.00	70.00		0.30	0.00	3.40		0	0	0	0	100	0	0	0	0	0	90.00	0		0	20	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	2	2	0	0
Riffle	232.00	243.00		2.50	0.00	27.50		0.10	2.00	3.10		0	10	40	10	40	0	0	0	0	0	90.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	2	2	0	0
Pool	243.00	271.00	28.00	2.40	67.20	67.20		0.20	0.00	2.90		0	0	0	0	100	0	5	0	0	0	90.00	2		28	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	2	2	0	0
Pool	271.00	287.00	16.00	11.00	176.00	176.00		0.40	0.00	11.00		0	0	0	0	100	0	0	0	0	0	90.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	4	2	0	0
Riffle	278.00	286.00		2.40	0.00	19.20		0.20	1.00	5.20		0	0	0	0	100	0	0	0	0	0	90.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	2	4	0	0
Pool	286.00	312.00	26.00	2.90	75.40	75.40		0.25	0.00	4.10		0	0	0	0	100	0	0	0	0	0	75.00	0		26	0	0	0	0	0	RS	RS	Mix	Mix	12	40	Low	Low	2	4	0	0
Riffle	312.00	318.00		1.80	0.00	10.80		0.20	1.00	2.90		0	0	0	10	90	0	0	0	0	0	90.00	0		0	0	0	0	0	0	RS	RS	Mix	Mix	12	15	Low	Low	25	2	0	0
Reach Totals and Averages		318.00	195.00	2.30	578.80	731.40	79.14	0.19	0.57	3.18	72.44	0	4	11	22	63	0	1	1	1	0	84.82	9	0.09	95	25	1	0			82	84			28	30	120	114	9.25	2.75	3	2

Appendix 4) Summary Data and Results

Stream Name	Catstream		Watershed Code			920-389300-22700	
Habitat Parameter	**1**	**Ratings**	**2**	**Ratings**	**3**	**Ratings**	**Total**
% Pool Area	49	3	82	1	79	1	**8**
Large Woody Debris/Bankfull Channel Width	0.6	5	0.0	5	0.1	5	**18**
% Cover in Pools	7	3	6	3	3	5	**14**
Average% Boulder Cover	1	5	0	5	0	5	**18**
Average % Fines	28	5	52	5	63	5	**30**
Average % Gravel	41	not rated	17	not rated	22	not rated	--
% of Reach Eroded	9	3	16	5	35	5	**28**
Obstructions	0	0	0	0	1	1	**1**
% of Reach Altered	0	1	2	1	25	5	**22**
% Wetted Area	80	3	49	5	72	3	**14**
Totals		**28**		**30**		**35**	**153**

Riparian Ratings							
Reach	**1**	**Ave. Ratings**	**2**	**Ave. Ratings**	**3**	**Ave. Ratings**	**Total**
Land Use	20	1	60	3	166	3	**7**
Riparian Slope	32	2	24	1	58	1	**4**
Bank Stability	48	2	84	4	234	4	**11**
		Ratings		**Ratings**		**Ratings**	--
% Crown Cover	88	1	62	3	85	1	**8**
% of Reach Accessed by Livestock	51	5	0	0	13	3	**8**
Average Vegetation Depth	30	3	14	5	6	5	**16**
Totals		**14**		**16**		**17**	**54**