CONNOLLY SIDECHANEL

GROUNDWATER LIMITED SALMONID HABITAT SUITABILITY ASSESSMENT

Prepared for Oyster River Enhancement Society (ORES), Department of Fisheries and Oceans (DFO), & Pacific Salmon Foundation (PSF)

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EXECUTIVE SUMMARY

The Connolly Sidechannel is a 725 m long historical alignment of the mainstem Oyster River that was avulsed during a 1 in 33 year flood event that occurred in 1975 (Miles, 2011); the Patrick and Josephine Connolly Sidechannel was constructed in 2005/2006 along the historical alignment in an attempt to enhance salmonid winter refuge and rearing habitat. In response to challenges associated with the operation and maintenance of the existing channel intake; the present study was undertaken to evaluate potential for the Connolly Sidechannel to support salmonid habitat requirements solely through groundwater inputs.

This report provides a background overview on geological and hydrological characteristics, land-use regime changes, and fish habitat enhancement efforts within the watershed; while the parameters studied in the Connolly Sidechannel salmonid habitat suitability assessment include 1) habitat characterization & suitability rating; 2) seasonal use, juvenile population assessment; 3) water quality monitoring; 4) water-level monitoring – linked to discharge. An assessment of egg incubation was originally a project component but was not undertaken due to low seasonal/unavailable inter-gravel flows lethal to incubating eggs.

A Level 1 Habitat Assessment compares the quantitative values of critical habitat conditions for salmonids within each reach against expected values to evaluate habitat conditions and characterize the quality of each reach as poor, fair, or good. The Level 1 Fish Habitat Assessment is based on methods described in Fish Habitat Assessment Procedures (FHAP) (Johnston & Slaney 1996) and Urban Salmon Habitat Program (USHP) Assessment Procedures (Michalski, Reid, & Stewart 1997) and was employed to better characterize and delineate sidechannel micro-habitat features given the larger channel scale and complexity.

Three seasonal fish enumeration efforts were made in the sidechannel in January, April, and September. Population estimate calculations were made using a modified Zippin Removal/Depletion Summation Method (Zippin 1958) where applicable. In addition, lengths and weights were recorded for salmonid species only.

Water quality measurements were collected at established sampling sites throughout the sidechannel complex using a handmeter and automatic loggers capturing dissolved oxygen and temperature data from Oct. 2013- Sept. 2014. Water level data was also collected from automatic loggers installed in the mainstem Oyster River, the sidechannel intake, and within the Connolly Sidechannel and were statistically correlated using the Pearson Product-Moment Correlation Coefficient.

The results of the above study parameters as they relate to sustaining salmonid habitat requirements can be summarized as follows:

- The FHAP/USHP Level 1 Habitat Assessment results showed that all of the sidechannel reaches received a "*Fair*" rating with the exception of Reach 6 which received "*Poor*". Habitat parameters commonly missing across all assessed reaches include low percent gravel and high percent fine substrates, and lack of crown cover.
- A number of barriers to fish passage exist by way of beaver dams that span the sidechannel in places and effectively limit the ability of juveniles and adult salmonids to enter the sidechannel and access its upper reaches.
- Fish enumeration results showed that there was a pronounced decrease in fish numbers from winter to summer resulting in reduced sample size and potential for habitat isolation. It was noted that mean weights and lengths for coho were similar between January and April catches but fish collected in September averaged heavier and longer.
- Dissolved oxygen (DO) water quality measurements showed observed levels below the instantaneous minimum threshold for juvenile and adult salmonid survival (5 mg/L) at every sidechannel sampling site at

least once during the monitoring period. The numbers of occurrences of levels below the 5 mg/L threshold were fewest at the upstream end of the sidechannel while all other sampling sites showed numerous occurrences below the 5 mg/L minimum. The lowest observed DO levels for supporting aquatic life were in subsurface gravels of Reach 2 which was originally identified as likely having greatest spawning potential.

- Temperature water quality measurements collected by handmeter and by automatic loggers were in general agreement where levels lethal to fish (18 - 19 °C averaged over a 7 day period) began to occur in June and continue through the summer months until returning below threshold levels towards the end of August.
- A comparison between level logger stations in the mainstem Oyster River, at the sidechannel intake, and in the sidechannel proper, and Canada Water Survey (CWS) mainstem hydrograph discharge data showed a strong *positive correlation* where increases and decreases in water levels between the mainstem and the isolated sidechannel were mirrored very closely.
- The mainstem intake screen, which when operating conveys flows into the sidechannel, became dry and exposed from the beginning of August until the end of the study period in mid- September at a mainstem discharge rate between 2.38 – 2.11 m^3/s.
- Sidechannel outflow connectivity with mainstem Oyster River appears to be dependent on multiple factors including the amount of precipitation and groundwater flow contributions. There is no clear, consistent indication from historical CWS mainstem discharge data as to at what point sidechannel connectivity is reliably made. It has been shown that there was no connectivity between the sidechannel and mainstem after May 21, 2014 until the end of data collection on Sept. 17, 2014.

1 INTRODUCTION

The Connolly Sidechannel is a 725 m long historical alignment of the mainstem Oyster River that was avulsed during a 1 in 33 year return flood event in 1975 (Miles, 2011) and in an attempt to enhance winter refuge and rearing habitat, the Patrick and Josephine Connolly Sidechannel was constructed in 2005/2006. This sidechannel was built along the original mainstem alignment that existed before the avulsion in 1975, and was a partnership project between the Connolly family, the Pacific Salmon Foundation, the Oyster River Enhancement Society, the BC Ministry of Transportation, TimberWest, and Fisheries and Oceans Canada (Powley, 2011).

The Connolly Sidechannel is located approximately 1.3 km upstream of the marine shoreline of the Strait of Georgia, and 100 m upstream of the Highway 19A bridge crossing. The Oyster River watershed drains a relatively large area of 362 km^2 (compared to the mean area of 541 watersheds on Eastern Vancouver Island is 66.7 km^2) of eastern Vancouver Island between Courtenay and Campbell River (MOE, 1979). The study area resides in the Coastal western hemlock (very dry maritime eastern variant) CWHxm1 biogeoclimatic zone. This zone is restricted to elevations between sea level and 700 m in areas subject to the rainshadow of Vancouver Island and the Olympic Range, and is characterized by warm, dry summers; and mild, wet winters.[1]

The Oyster River watershed is a productive system supporting populations of anadromous Coho Salmon, Chum Salmon, Pink Salmon, Chinook Salmon, Cutthroat Trout, Dolly Varden, Steelhead and resident Rainbow Trout (Fish Wizard; Gaboury & McCullough, 2002), with the dominant species being Coho.

1.1 PURPOSE

The present study was undertaken based on concerns for the continued stability and function of the existing sidechannel intake in view of adjacent channel head-cutting -reducing mainstem channel bed elevation and potentially altering both localized water-levels and hydraulic conditions favourable for intake function. Although sidechannel intake integrity is of primary concern, there are additional issues related to intake operation and maintenance due to potential clogging of the intake screen with organic materials and algae, and dewatering during late summer low flow periods[2] (as observed during the 2014 monitoring period). Under these circumstances and recognizing the emerging challenges and uncertainties of maintaining suitable channel intake function, both ORES and DFO felt it was important to isolate and assess sidechannel groundwater contribution in support of habitat requirements, suitability and seasonal fisheries use.

1.2 OBJECTIVES

The objectives for this study were to assess key habitat parameters affecting salmonid distribution, survival, and suitability in the Connolly Sidechannel while the intake pipe was shut off and water inputs limited solely to groundwater and surface runoff. Study parameters included a Level 1 Habitat Assessment using FHAP/USHP (Fish Habitat Assessment Procedures/Urban Salmon Habitat Program) methodology; seasonal (late winter/summer) fish enumeration using multi-pass removal sampling protocols; water quality measurements including temperature and dissolved oxygen from handmeter and automated logging instruments; and the collection of surface water level data from the mainstem and at the intake structure for comparison against groundwater measurements

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1 Ministry of Forests and Range. (2009). CWHxm1 - Moist Maritime Coastal Douglas fir Subzone. Biogeoclimatic Ecosystems Classification Program. Research Branch. Retrieved from <http://www.for.gov.bc.ca/rco/research/eco/bec_web/docs/CWHxm1.htm>.

2 Pers. Comm. Lyle Edmunds, ORES Hatchery Manger, indicates that the intake becomes periodically exposed on an annual basis during late summer flow periods.

taken from the sidechannel proper. An assessment of egg incubation was another original project component though was not undertaken due to low seasonal/unavailable flows to enable adult in-migration to the channel, and measured low dissolved oxygen levels and high temperatures associated with inter-gravel flows and lethal to incubating eggs. Sidechannel discharge and water velocities, associated with observed water levels, were not collected as accurate flow measurements could not be obtained due to channel conditions/complexity.

1.3 SCOPE AND LIMITATIONS

The Connolly Sidechannel is located approximately 1.3 km upstream of the marine shoreline of the Strait of Georgia, and 100 m upstream of the Highway 19A bridge crossing. The sidechannel is 725 m long and has an intake pipe located in the mainstem of the Oyster River. The study area described in this report is largely limited to the sidechannel proper from the mainstem intake outlet downstream to its confluence with the Oyster River mainstem; however, a number of measurements were collected from the intake manhole and in the mainstem 60 m downstream from the sidechannel/Oyster River confluence. As previously mentioned the intake pipe was shut off during the assessment period to prevent mainstem flow from entering the channel and allow for groundwater only inputs to characterize the channel.

Any feasibility or future operational considerations with respect to surface water intake alterations is beyond the scope of this assessment and should be evaluated based on the results of this assessment in conjunction with other relevant existing information, and by addressing any additional information gaps on intake related issues potentially identified by this assessment.

2 OVERVIEW – DESCRIPTION OF STUDY AREA

2.1 WATERSHED/CHANNEL DESCRIPTION

The Oyster River is a 5th order stream with a watershed draining a relatively large area (362 km^2) of eastern Vancouver Island between Courtenay and Campbell River (MOE, 1979). The Oyster River watershed is relatively large compared to the 66.7 km^2 mean area of 541 Eastern Vancouver Island watersheds. Mainstem anadromous length is 22.5 km while considerable headwaters increase anadromous length to 46.3 km (Silvestri, 2006). The headwaters of this system drain the slopes of Mount Washington, Mount Albert Edward, Brooks, Strata and Regan Mountains, flowing through mid to lower elevations mixed aged stands of alpine and sub-alpine forests to the confluence of the Oyster River with the Strait of Georgia south of Kuhushan Point (Goodman, 1974). The two primary tributaries to the Oyster River are the Little Oyster River and Woodhus Creek which both connect with the mainstem from the North. The lower reaches of this watershed are characterized by land-use activity that includes agriculture, forestry, and urban development where there is a small rural community of Oyster River close to the mouth of the river. Development directly affecting the channel of the Oyster River includes extensive rip-rap bank armouring in the lower reaches (Section **Error! Reference source not found.**) and linear developments that include the Highway 19A crossing located approximately 60 m downstream of the Connolly Sidechannel outlet.

According to the Rosgen's channel classification[3], based on a continuum of physical variables/characteristics, the Connolly Sidechannel meets most of the criteria of either a type E(6) or F(6) stream (varies by reach) with an overall entrenched, low gradient (< 2%), channel form and reaches that vary between low to high width-depth

[3] http://www.wildlandhydrology.com/assets/rosgen_geomorphic_channel_design.pdf

ratios with silt/cay dominated substrates. Very limited accumulations of spawning gravel remain in the sidechannel except for two locations, immediately downstream of the upstream bridge crossing at DL01 water quality monitoring station, and downstream of the lower beaver dam in Reach 3 (Figure 4). These gravel patches were placed as potential spawning features during the original channel construction. Observations of spawning coho/chum at these isolated gravel patches were made by ORES members in 2009-2010; at which time an image of holding coho adults at the outlet of the intake pipe was taken (Photo 1). Channel habitat characteristics are detailed in Section 4.1.

Photo 1. Holding adult salmon located at the upstream end of Reach 1 at the outlet of the flow intake pipe from mainstem Oyster River. (Oct. 17, 2009) (Source: Father Charles Brandt)

2.2 FISHERIES RESOURCES

The Oyster River watershed is a sizeable productive system supporting populations of anadromous Coho Salmon, Chum Salmon, Pink Salmon, Chinook Salmon, Cutthroat Trout, Dolly Varden, Steelhead and resident Rainbow Trout (Fish Wizard; Gaboury & McCullough, 2002), with the dominant species being Coho based on escapement averages. Salmon mainly use the Oyster River and the Little Oyster River for spawning and rearing, with limited distribution in Woodhus Creek owing to a series of impassable rapids and falls (Fraser et al., 1974). Moreover, there is an impassable falls 20km upstream from the mouth of the main Oyster River with adjacent channel reaches characterized by sections of boulders and canyons (Fraser et al., 1974). Average salmon escapements in the Oyster River from 1990-2003 by species include approximately 300 chinook, 2,900 chum, 4,000 coho, and 31,000 pink salmon (Silvestri, 2007). The ORES hatchery is a Public Involvement Program (PIP) facility with some support from the DFO Salmon Enhancement Program (SEP) with an incubation capacity of 1.5 million eggs that targets stock enhancement of pink, chum, coho, and chinook in the Oyster River.

2.3 GEOLOGY

In general, the Oyster River watershed contains areas of exposed bedrock and glacial deposits with large amounts of fine gravel and cobble. The mainstem of the Oyster River can be characterized by terraces of exposed bedrock, boulders, canyons in the upper reaches, and large amounts of gravel and sediment deposition in the lower reaches ending in an active delta. The bedrock in this region contains limestone, volcanic, conglomerate, sandstone and shale formations (Ronneseth, 1985). The dominant bedrock types in the lower reaches of the Oyster River near the study site are the sandstones, shales and conglomerates of the Nanaimo Group.

Bedrock characterized by the Nanaimo Group has significant aquifer potential owing to its potential for porosity, permeability, and fracturing (Hamblin, 2012). Additionally, there are patches of shale dominated formations around the lower Oyster River that are important because they limit the amount of liquid able to pass between potential aquifer zones in the region.

Close to the mouth of the Oyster River, unconsolidated stream bed material consists of sandstone bedrock that is covered by alluvial sand, gravel, and cobble. The bed material in the middle reaches of the river (including the location of the Connolly Sidechannel) also contains alluvial sand, gravel, and cobble in addition to patches or seams of clay. Finally, the upstream reaches of the Oyster River contain sand, gravel, and cobble over 3-4 meters of clay (Kohut, 1981). The presence of sand, gravel, and cobble in various concentrations throughout the Oyster River imply suitable spawning and rearing habitats exist for the salmon species known to utilize the system. Deposits of unconsolidated sand/gravel are significant in terms of groundwater potential as they affect recharge rate, aquifer storage and transmission properties, and the response of the aquifer to changes in climate, seasonality, withdrawal, and pollution. Groundwater potential should be a key component used to determine the most suitable location and design for sidechannel construction.

The existing sidechannel flow intake screen was constructed to avoid entrainment of larger sediment sizes; however, it was expected during installation that the intake would remain susceptible to clogging and would require maintenance. The location of the intake structure is on the inside of a channel bend (right bank), susceptible to material deposition, with the thalweg on the opposite (left) bank. The latest installation and design was undertaken to address original design limitations, account for potential continuation of channel head-cutting, and in support of moderating associated costs.

2.4 HYDROLOGY

According to data from the Water Survey of Canada and a study done by the BC Conservation Foundation (Gaboury & McCullough, 2002), monthly flows in the Oyster River watershed typically begin to rise in October in response to rainfall, peak in November and December, and decline again in June with the lowest discharges occurring in August and September (Figure 1). Historic flow measurements in the Oyster River just below Woodhus Creek measured a mean annual discharge (MAD) of 14.2 m^3/s (Silvestri, 2007), an average minimum discharge of 3.49 m^3/s in September, and an average maximum discharge of 21.7 m^3/s in November (Miles, 2011). The mean annual precipitation for this region is 1434.5 mm per year[4]. Real-time discharge, mean discharge, and maximum instantaneous discharge (all in m^3/s) data for the period of Sept 15, 2013 – Sept 15, 2014 (encompassing the study period) is presented in Figure 2. In order to show annual expected presence of salmonids in the Oyster River with respect to the flow regime, available real-time hydrometric discharge data (for the period May 1, 2013 to Sept. 15, 2014) is plotted against the historical MAD (14.2 m^3/s) and generalized coho and chum presence in the system during spawning, incubation/rearing, and smolt out-migration life history periods (Figure 3).

Overall, the Oyster River watershed is considered to have reduced natural storage capabilities most likely attributable to key land-use alterations including historic agricultural and forest harvest practices and urban and linear developments within the lower reaches. It is estimated that 90% of the Oyster River watershed below 500 m elevation was clear-cut between 1900-1960 (Decker & Lightly, 2004).

[4] Campbell River Weather Station A - Climate Normals (1981-2010) recorded mean total annual precipitation of 1407.9 mm. <http://climate.weather.gc.ca/climate_normals/results_e.html?stnID=145>

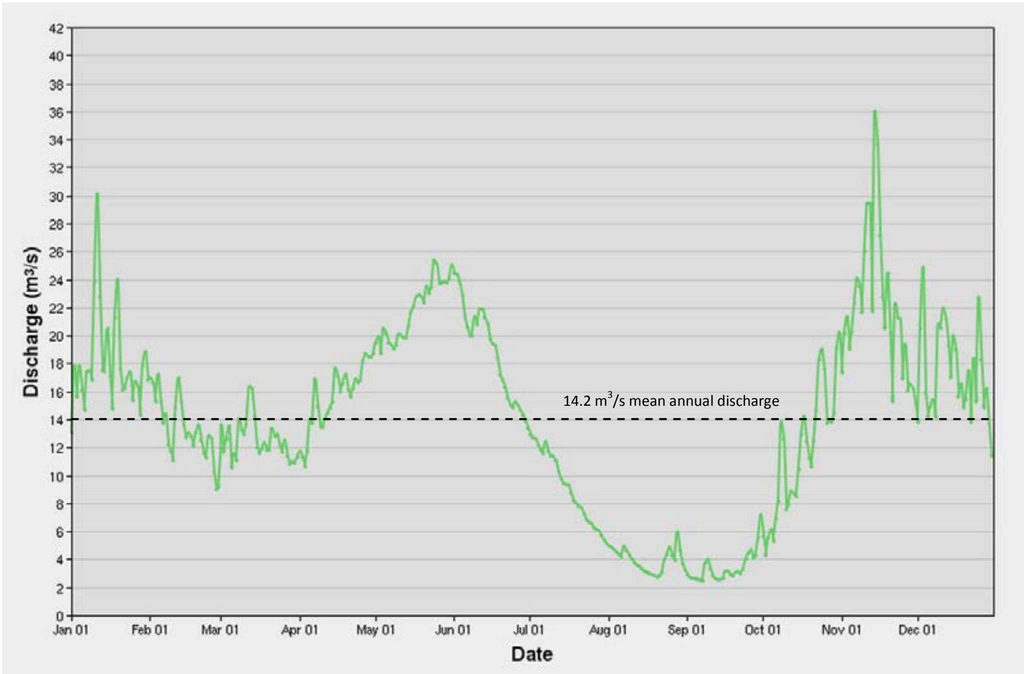

Figure 1. Hydrometric data graph from Canada Water Survey station at Oyster River below Woodhus Creek (08HD011) showing mean daily discharge (m^3/s) statistic corresponding to 39 years of data recorded from January 1973 to December 2011 (shown as daily mean over 12 month period).

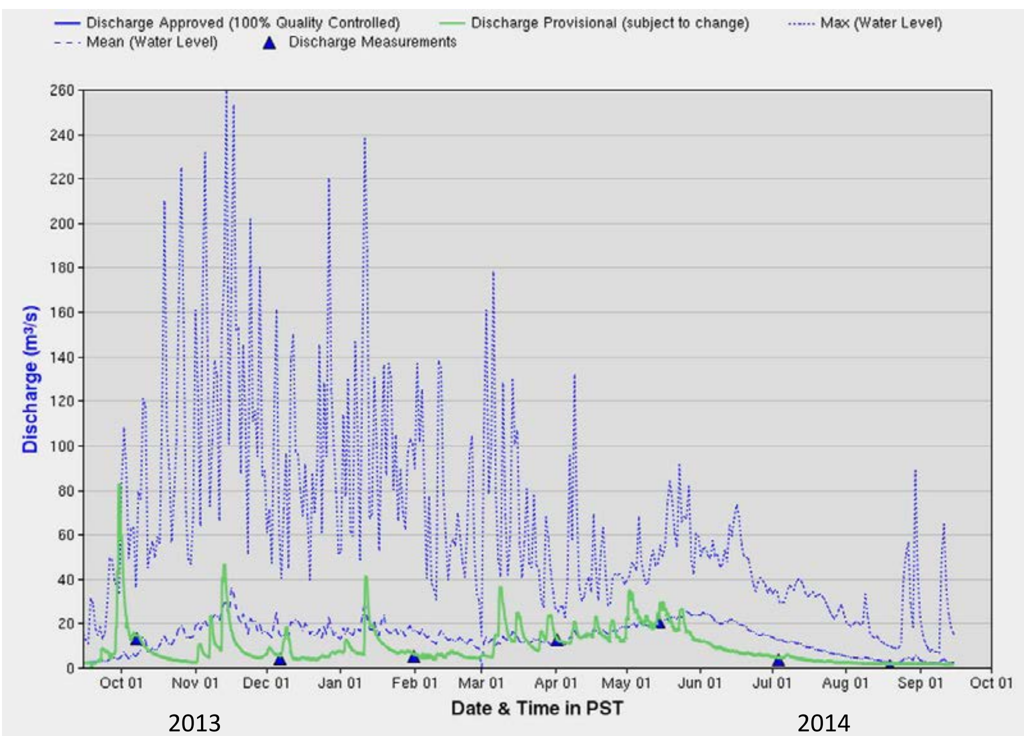

Figure 2. Hydrometric data graph from Canada Water Survey station at Oyster River below Woodhus Creek (08HD011) showing discharge, mean discharge, and maximum instantaneous discharge for the period of Sept. 15, 2013 to Sept. 15, 2014.

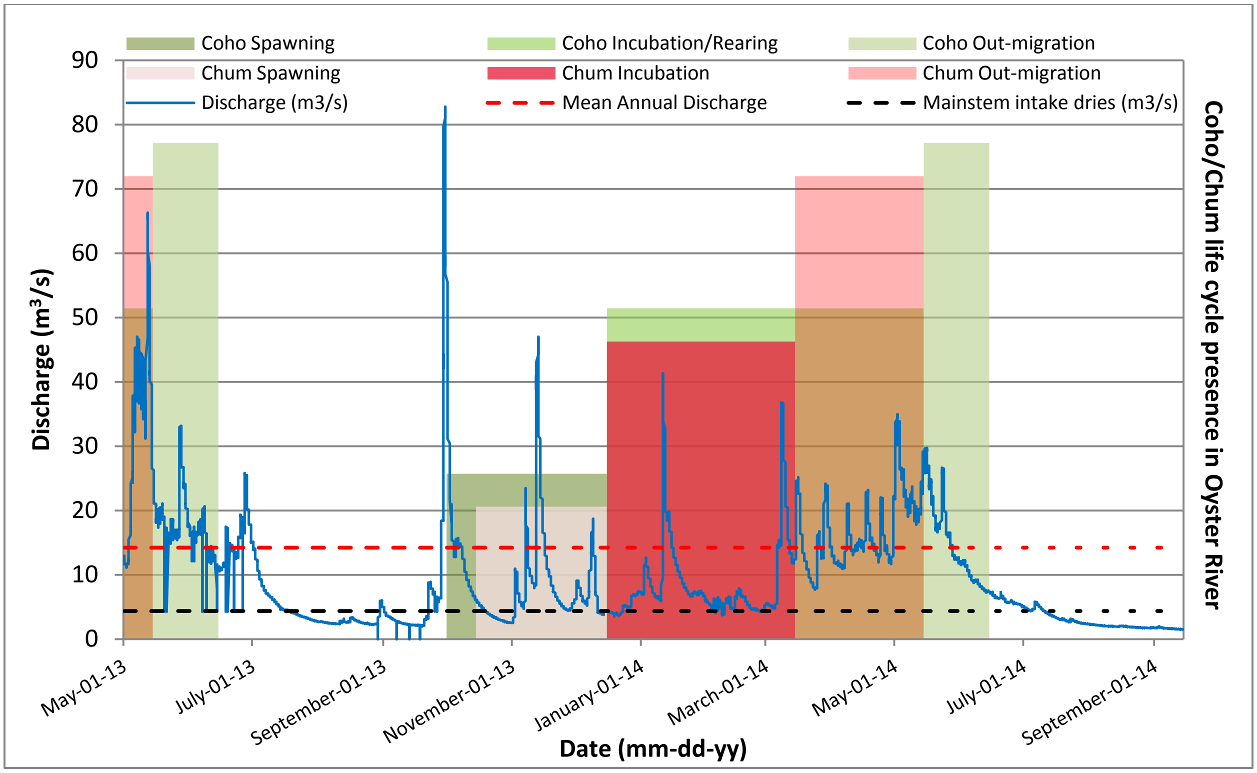

Figure 3. Oyster River hydrometric discharge data (from May 1, 2013 – Sept. 15, 2014) compared against the historical mean annual discharge (14.2 m^3/s) and coho/chum life history timing in the system.

2.5 LAND USE

For the purposes of this study land use changes are defined as anthropomorphic modifications to the Oyster River watershed affecting its natural hydrologic and nutrient cycles. These modifications include *Logging* (Section **Error! Reference source not found.**), *Water Withdrawal and Discharge* (Section 2.5.2), and *Rip-rap Flood Protection* of residential properties and the Highway 19A crossing near the Connolly Sidechannel (Section **Error! Reference source not found.**). Other modifications worth consideration are *Watershed Restoration Projects* that have been implemented in an attempt to enhance fish habitat (Section 2.6) in addition to background on the Connolly Sidechannel (Section 2.7).

2.5.1 Forestry

While the Oyster River watershed has undergone relatively limited impacts from urban development, forestry remains the dominant land use activity throughout the watershed. Island Timberlands Limited Partnership and TimberWest Forest Corporation both own and/or have logging rights to a large portion of the upper and middle areas of the watershed (Silvestri, 2007). It is estimated that 90% of the Oyster River watershed below 500 m elevation was clear-cut between 1900-1960 (Decker & Lightly, 2004). Much of the old growth from the mainstem and tributaries has been logged and some second-growth stands remain eligible for harvesting.

This loss of conifer recruitment capable of supplying large woody debris (LWD) structures in the stream channel has impacted summer and winter fish rearing habitat in the Oyster River (Gaboury & McCullough, 2002). Historical clear cutting and logging road development has also lead to rapid overland flow, slope instability, and sediment loading in the watershed; however, as the riparian forest is allowed to mature it is expected to restore watershed processes to a more natural state (Decker & Lightly, 2004).

2.5.2 Water Withdrawal and Discharge

The Oyster River watershed is an important source for drinking water for the community of Oyster River and for irrigation for the surrounding farmland (Nagpal, 1981). Irrigation licenses account for approximately 53% of the total water extracted from the Oyster River watershed which includes the UBC Research Farms, Dalcor Holdings Ltd., and several small scale farming operations (Nagpal, 1990). Industrial uses (resort) and domestic water licenses account for the remaining 47% of the total water consumption from the Oyster River watershed (Nagpal, 1990). The combined total amount of water withdrawal from the Oyster River watershed is estimated at 0.096 m^3/s or approximately 0.7% of the mean annual discharge of 14.2 m^3/s.

In terms of waste water discharge, while several companies hold licenses for mineral extraction (coal) within the Oyster River watershed, the mining activities in this area are currently limited to the exploration level. That being said, the only commercial activity producing waste water is a small area of Mount Washington Resort that has a permit to discharge treated effluent into Piggott Creek, a tributary to the Oyster River subject to tertiary treatment including membrane bioreactor filtration prior to release to the creek.

2.6 RESTORATION PROJECTS

There have been numerous habitat enhancement and restoration projects completed along the Oyster River that have involved human modification of the watershed. These projects were primarily spearheaded by the Oyster River Enhancement Society (ORES), a non-profit organization driven by community volunteers. Given the flashy nature of this system and the lack of off-channel habitat, a lot of the major projects have involved developing and enhancing salmonid productivity. Past projects include the development of the Raven Sidechannel (2.5km), Rippingale Channel Complex (3km), Sidechannel #1 and #2, Arthur Mayse Sidechannel (0.6km), and past efforts made on the Connolly Sidechannel (ORES[5]; Silvestri, 2007). Other important projects involved the construction of the Woodhus Creek fish-ladder that opened up available fish habitat in the upper reaches of Woodhus Creek, and establishing a hatchery facility that incubates up to 1.5 million salmon eggs annually (ORES[5]).

2.7 BACKGROUND ON THE CONNOLLY SIDECHANNEL

2.7.1 Mainstem Avulsion - 1975

Based on satellite imagery and a report prepared by M. Miles and Associates (2011), it was determined that in 1975 a 1 in 33 year flood event in the Oyster River caused an avulsion which redirected the river down a straighter route just upstream from the Coastal Island HWY (HWY 19a). After this event, the river along this reach continued to erode the new channel, which eventually became the mainstem of the Oyster River, and left the old channel isolated and dry. This newly formed segment of the Oyster River is fairly straight, with a shorter length and steeper gradient in comparison to the channel prior to the flood in 1975.

2.7.2 Rip-rap Flood Protection and Altered Dynamics in the Mainstem

[5] http://www.oysterriverenhancement.org/

As a result of the steeper gradient and shorter length in this new reach of the Oyster River, sediment began to deposit and the banks were eroding at an increased rate while the river attempted to find equilibrium. The left side cut bank along the newly formed reach was armoured with rip rap shortly after the 1975 flood to prevent the river from encroaching further onto private property (Miles, 2011). More recently, in the past five years, the banks downstream of this reach surrounding the HWY have also been armoured with rip rap to protect the bridge abutments on the HWY 19a bridge (Photo 2). This narrowing of the stream channel with rip-rap further restricted the flow in this reach which resulted in higher velocities and a greater potential for gravel movement including head-cutting and deposition along the right bank. Given the relatively recent nature of these dynamics it is unlikely that the reach adjacent to the Connolly Sidechannel has achieved equilibrium; the result being an increase in both frequency and duration where the sidechannel intake structure will be unable to draw water from the mainstem (Miles, 2011) (Photo 30).

Photo 2. View south (towards the right bank) of the Highway 19A bridge crossing showing rip-rap armouring at the base of bridge abutments that have caused channel narrowing approximately 60 m downstream of the Connolly Sidechannel. (Sept. 25, 2013) (Source: Doug Swift)

2.7.3 Original Sidechannel Restoration in 2005

The avulsion that occurred along this reach of the Oyster River in 1975 cut off viable winter habitat for salmonids. In an attempt to enhance winter refuge and rearing habitat, the Patrick and Josephine Connolly Sidechannel was proposed and constructed in 2005/2006. This sidechannel was built along the old channel bed that existed before the avulsion in 1975, and was a partnership project between the Connolly family, the Pacific Salmon Foundation, the Oyster River Enhancement Society, the BC Ministry of Transportation, TimberWest, and Fisheries and Oceans Canada (Powley, 2011).

The original construction of the Connolly Sidechannel involved access to the mainstem of the Oyster River at the end of the channel, but with no intake at the head of the channel. The original plan did not include a mainstem intake as the channel was expected to be fed by groundwater. However, observations made during the construction of the channel in 2005 indicated that groundwater levels were lower than expected. According to Miles (2010) “there was very little in the way of sub-surface investigations to support the concept [that the channel could be sustained by groundwater] prior to construction”.

2.7.4 Construction of an Intake in 2006

After the observations made during construction in 2005, an intake was constructed in 2006 to divert some water from the Oyster River into the Connolly Sidechannel (Powley, 2011). This intake was built in the most practical location, which unfortunately imposed maintenance issues as it was located on the inside of a meander bend, and opposite the channel thalweg, an area of sediment deposition. In order to access the thalweg near the opposite bank, a pipe was extended across the river with limited protection on top.

2.7.5 Intake failure and rebuilding from 2009-2011

High flow events during the winter of 2009/2010 caused damage to manmade structures in numerous rivers between Campbell River and Courtenay, and the intake pipe for the Connolly Sidechannel was no exception (Powley, 2011). The pipe was ripped off of its attachment point at the manhole and was carried a short distance downstream. Once the flows reduced in August 2010, the old pipe was removed from its resting place and portion of the pipe was temporarily reconnected to the manhole to maintain water levels in the Connolly Sidechannel over the winter of 2010. Since the pipe was shortened and now lay in an area of sediment deposition, a wire mesh screen was installed at the new intake in an attempt to prevent sediment and debris from blocking intake flows.

Over the winter of 2010/2011, the temporary intake screen became clogged by gravel accumulation, and as DFO funding became available that winter, a new intake was built similar to the previous version but with a finer stainless steel wedge wire mesh screen in 2011 (Powley, 2011). Although the intake screen design was intended to reduce potential for clogging it was understood that the need for regular maintenance would continue owing to the modified intake location, for protection purposes, in an area prone to deposition. In addition to intake concerns, continual sidechannel site location challenges include a limited elevation drop from the flow intake outlet to the downstream mainstem confluence (head differential), lack of initial or sufficient groundwater study/testing to determine whether the sidechannel could be supported by ground water alone, and apparent mainstem head-cutting causing the sidechannel outlet to become seasonally disconnected at lower mainstem flows.

3 STUDY METHODS

3.1 LEVEL 1 HABITAT ASSESSMENT

Habitat Assessment sampling was completed during the early spring period (April 14, 2014) following an abnormally dry winter and previous fall/summer of 2013. The flow intake from the Oyster River mainstem was closed during the period leading up to, and at the time of assessment, to help the channel stabilize under groundwater flows and to reveal potential habitat deficiencies under low flow conditions. Undertaking the habitat assessment enabled characterization of sidechannel micro-habitats/features to better support evaluation and interpretation of channel function, suitability, and fisheries use.

Field methodology for the Level 1 Assessment was adapted from the WRP Technical Circular No. 8 – Fish Habitat Assessment Procedures (FHAP) by Johnston and Slaney (1996) and the Urban Salmon Habitat Program (USHP) Assessment Procedures for Vancouver Island Manual (Michalski, Reid, & Stewart 1997). Complete sampling of the sidechannel system was undertaken to better characterize the sidechannel environment and infer overall habitat characteristics for each reach as per methods described in Johnston and Slaney (1996). Representative photos of sample sites were taken from established photo posts and significant habitat features were recorded.

The Assessment was completed in stages prescribed by Michalski, Reid, & Stewart (1997) and is described as follows:

1. Field Assessment: Field collection of stream habitat data. Field data collection was done using FHAP methods described in Johnston and Slaney (1996).
    a. The field assessment was undertaken with support from volunteers from ORES volunteers.
2. Habitat Data Entry: A standardized Excel spreadsheet supplied by Tracy Michalski, Ministry of Forests Lands and Natural Resource Operations (MFLNRO), and USHP methods descried in Michalski (1997) were used to input collected field data.

Raw data sheets including reach characteristics and chainages are available in Appendix A – Habitat Assessment Raw Data. Specific methods for *Data Collection* and *Data Processing* are described below.

3.1.1 Data Collection

Field data was collected and transcribed according to methods described in Johnston and Slaney (1996). Reach breaks were determined wherever a significant change in channel characteristics, or beaver dam, channel confluence, or man-made break such as a bridge crossing was encountered (Figure 4). Multiple reaches were established within the sidechannel to help characterize and preserve details of the micro-habitats in the system as opposed to treating the entire sidechannel as a single reach or habitat type. It should be noted that, although it is generally a key factor in determining habitat quality and suitability, flow velocity measurements are not part of the FHAP/USHP methods and were not undertaken as part of this assessment.

Representative photographs were taken of each reach with upstream and downstream views of most Habitat Units. Additional photographs have been taken since the beginning of the project coinciding with water quality measurement effort from established photo-posts and may be used as comparison against varying flow conditions in the same locations.

Locations for photographs, reach breaks, habitat unit breaks, obstructions, off-channel habitat, and other points of interest were recorded using a handheld tape and a Garmin GPSmap 60cx with an expected accuracy of ±3 m. Relevant points and linework are shown graphically in maps produced using a desktop GIS platform (Figure 4). A surveyed site plan showing existing condition during the assessment period including elevations of channel features, intake structure and outlet channel, beaver dams, bridge crossings, and spawning gravel locations is adapted from DFO (Figure 5).

Reach habitat ratings are based on the conditions observed during the time of sampling only (April 14, 2014) and are associated with the time of year and as defined under groundwater flow conditions.

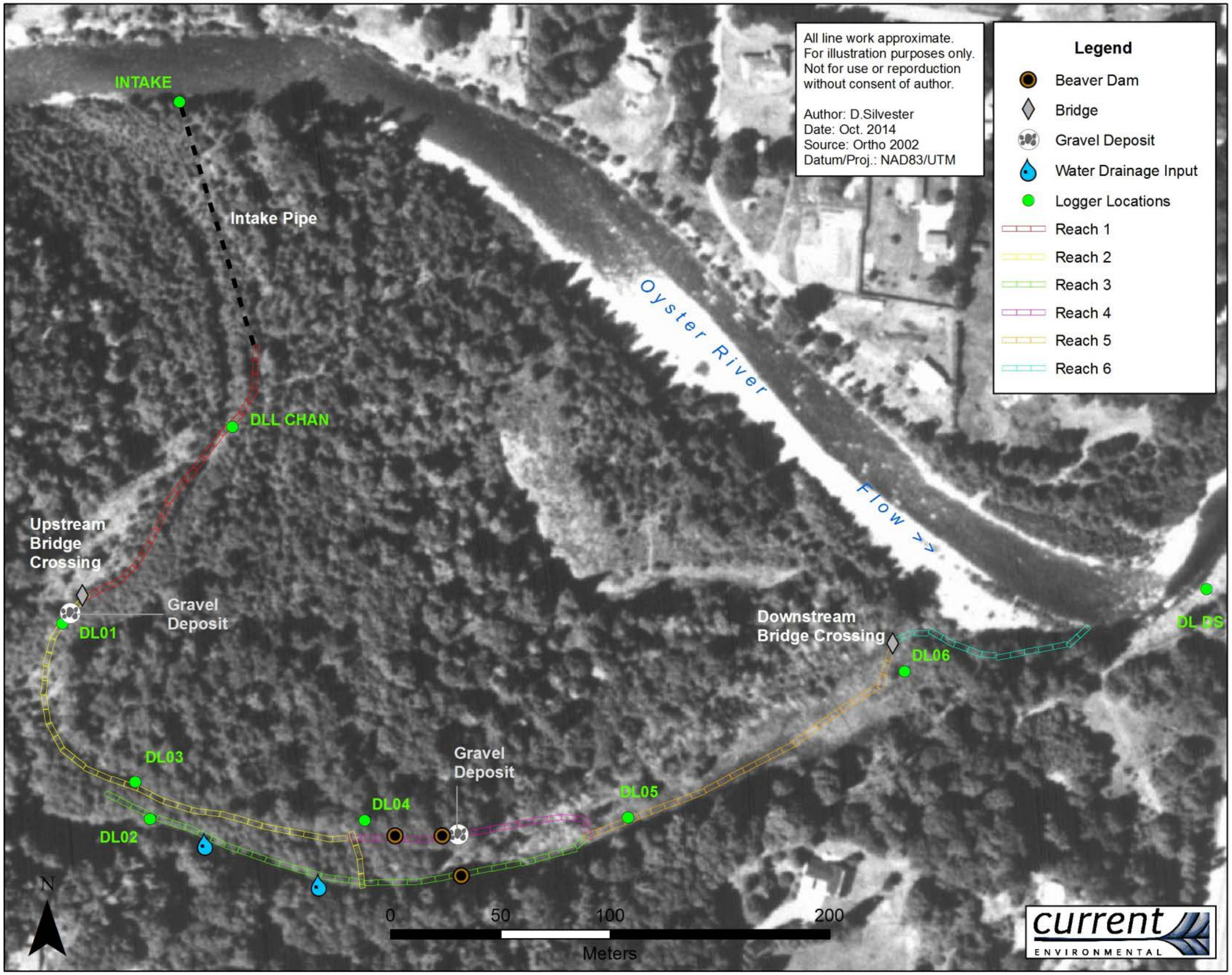

Figure 4. Site map of Connolly Sidechannel showing reaches, reach breaks, and obstructions referred to in the Level 1 Habitat Assessment and the locations of automatic data logger and handmeter sampling locations described in water level and water quality.

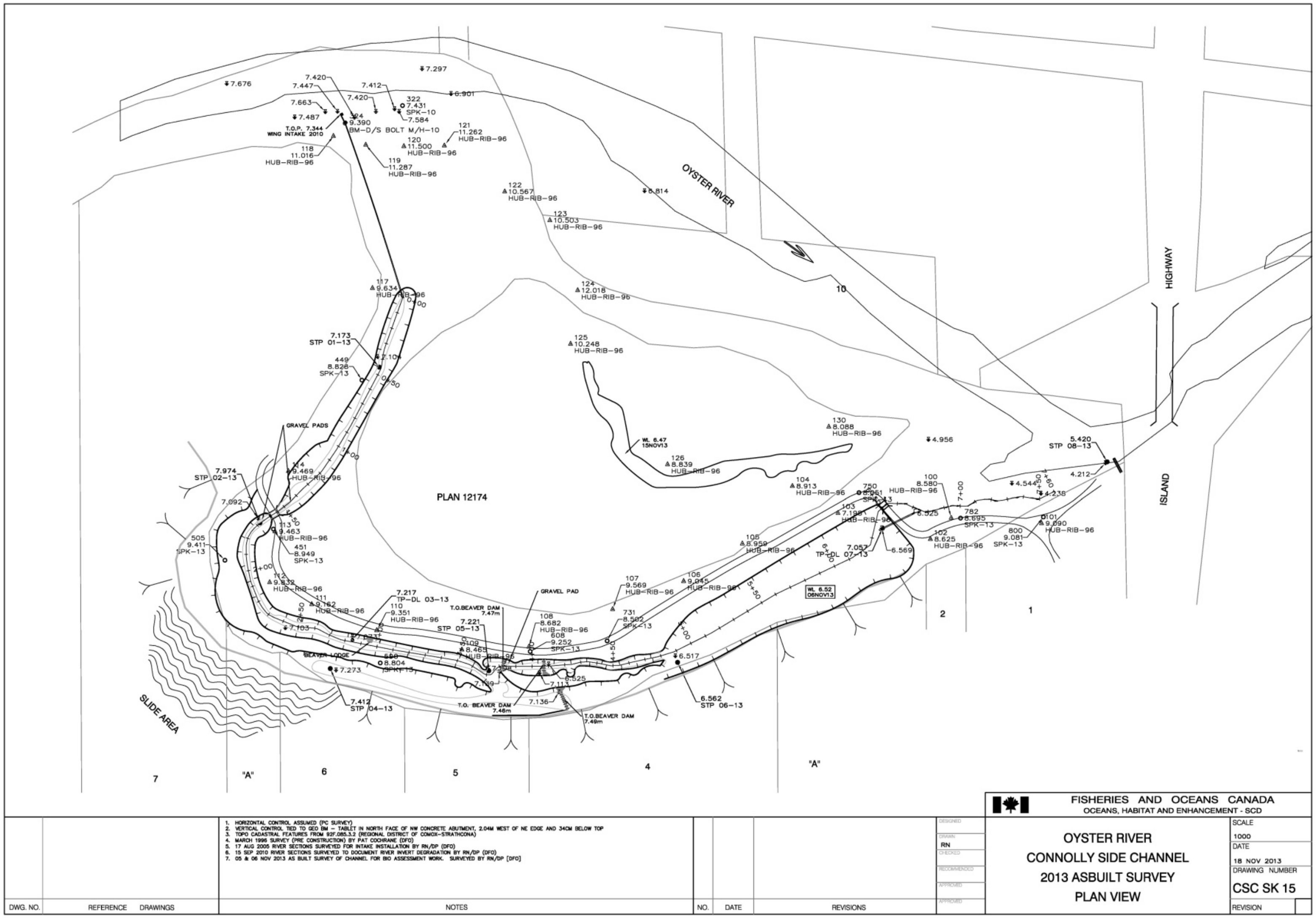

Figure 5. Surveyed site plan of Connolly Sidechannel showing existing condition during the assessment period including elevations of channel features, intake structure and outlet channel, beaver dams, bridge crossings, and spawning gravel locations. (Adapted from DFO; Nov. 18, 2013)

3.1.2 Data Processing

Raw field data (Appendix A – Habitat Assessment Raw Data) was input into a Microsoft Excel spreadsheet produced by the USHP and retrieved from the online Ministry of Environment Ecological Reports Catalogue[6]. The USHP spreadsheet automatically generates ratings for the habitat parameters to help identify habitat limitations in the sidechannel. The rating scale is as follows: 1 = Good; 3 = Fair; 5 = Poor. The ratings for each parameter are totaled to produce an overall rating for the reach with a separate rating scale: <10 = Good; 10-22 = Fair; >22 = Poor. The following table shows the criteria used in rating habitat parameters:

Table 1. Habitat Parameter Ratings for the Comparison of Assessment Data to Habitat Diagnostics.

Habitat Parameter	Ratings (1 - 5) for the Comparison of Assessment Data to Habitat Diagnostics
Overhead cover	< 10/% (Poor) = 5; 10-20% (Fair) = 3; >20 %(Good) = 1
Pools (% area)	< 40% (Poor)= 5; 40 - 55% (Fair) = 3; >55 % (Good) = 1
Large Woody Debris freq (pcs/bfw)	< 1(Poor) = 5; 1 -2 (Fair) = 3; > 2 (Good) = 1
Pool Frequency (# channel widths/pool)	>4 (Poor) = 5; 2-4 (Fair) = 3; <2 (Good) = 1
Percent Cover Instream	0-5% (Poor) = 5; 6-20% (Fair) = 3; > 20 (Good) = 1
Substrate (% gravel)	<20% (Poor) = 5; 20 - 30% (Fair) = 3; >30% (Good) = 1
Substrate (% Fines)	>20 (Poor) = 5; 10-20 (Fair) = 3; < 10 (Good) = 1
Erosion Sites	1 point assigned for each identified site
Number of Obstructions (eg. Dams, perched culverts, bedload);	1 point assigned for each obstruction
Number of Stream Alteration Sites (eg. Riparian removal, channelization, infilling);	1 point assigned for each altered site
% Wetted Area (Wetted Area/Total Area);	<70%(Poor) = 5; 70%-90% (Fair) = 3; >90% (Good) = 1
Dissolved Oxygen (mg/L);	< 4 mg/l (Poor) = 5; 4-6 mg/l (Fair) = 3; >6mg/l (Good) = 1
pH	>8 (Poor) = 5; <5(Poor) = 5; 5-6 (Fair) = 3; 6-8 (Good) = 1

The resulting parameter ratings and overall reach ratings help exemplify where and how each reach may be deficient in habitat features that are known to support and/or improve salmonid productivity. Level 1 Assessment Results are shown in Section 4.1.

3.2 FISH ENUMERATION

A preliminary fish trapping effort was made in the study area using baited minnow traps on January 16, 2014 to introduce ORES members to fish enumeration methods and ensure that the assumptions that would later be tested in statistical analysis could be met (Lockwood & Schneider, 2000). In addition to preparing the site for later study, the preliminary assessment would provide a "snap-shot" of the distribution, relative abundance, and general condition of salmonids utilizing the sidechannel during winter 2014.

Depletion estimate fish capture efforts were made during the periods of March 31-April 3 (late winter/spring) and September 10-12, 2014 (summer low-flow). Minnow traps were baited with roe and deployed at roughly 5-10 m intervals throughout the sidechannel before noon each day and were checked and re-baited within approximately 24 hours. Minnow traps are not expected to capture larger trout because of the size of the trap's entrance

[6] https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=8766

(~ 4 cm Ø); therefore, 5 traps were modified to accommodate the larger specimens as in the preliminary fish capture effort a number of cutthroat trout were observed and caught in modified traps.

Lengths and weights were recorded for salmonid species only. In addition to trapping efforts, visual observations of salmonids were made throughout the assessment process in the majority of reaches. The spatial extent of trapping for each effort is shown in Figure 4 and raw trapping data in Appendix B – Fish Enumeration Raw Data. The captured salmonids were weighed (g) using digital scales (Photo 3) and fork-snout lengths (mm) recorded using smolt boards (Photo 3). Methods differed slightly between the two trapping efforts where three pass and two-pass approaches were used respectively.

The fish population estimate calculations were made using a modified Zippin Removal/Depletion Summation Method (Zippin 1958). A summary of the Zippin method accessed from the Canadian Rivers Institute[7] states "a decrease in catch per unit effort as the population is depleted bears a direct relationship to the extent of the population", and requires a minimum of two sweeps (1958). The statistical formulas used for both the three pass and two pass methods are shown below in Sections 3.2.1 & 3.2.2 with results presented in Section 4.2

According to Lockwood & Schneider (2000) the following assumptions must be met to result in accurate depletion estimates using this method:

1. Emigration and immigration by fish during the sampling period must be negligible;
2. All fish within a specified sample group must be equally vulnerable to capture during a pass;
3. Vulnerability to capture of fish in a specified sample group must remain constant for each pass (e.g., fish do not become more wary of capture);
4. Collection effort and conditions which affect collection efficiency, such as water clarity, must remain constant.


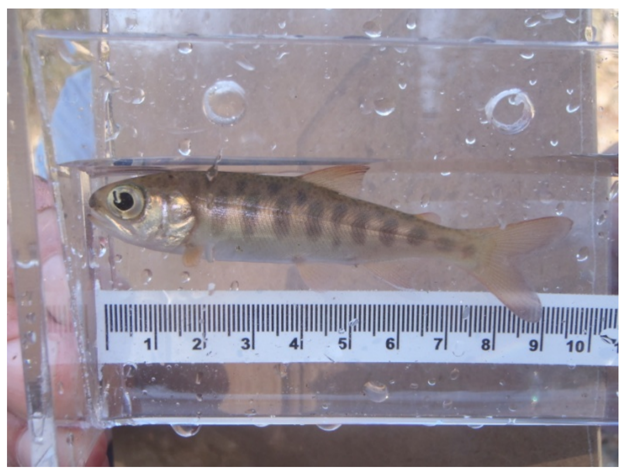

Photo 3 & Photo 4. Oyster River Enhancement Society Volunteers operating a digital scale used to acquire salmonids weights (above left) and a smolt board used to determine lengths (above right). (April 1, 2014)

3.2.1 March-April 2014 Trapping

A three pass depletion estimate was used during March 31 - April 3, 2014 trapping effort (Section 4.2). At the time of sampling, all reaches of the sidechannel were wetted and there was a surface water connection to the mainstem via a 15-20 cm drop over cobble substrates. The fish were trapped throughout the entire sidechannel using 95 minnow traps (5 with widened mouths to allow for trout entry) and were spread at approximately equal

[7] <http://www.unb.ca/research/institutes/cri/_resources/downloads/nbaquaticdatawarehouse/manualanddoc/fishpopstreams.pdf>

intervals throughout the channel (Photo 5). Fish caught on removal day one were transported by bucket to an enclosure area in the upper sidechannel that was isolated from the rest of the channel with two stop-nets (Photo 10). The stop nets were secured to either bank of the channel and a lead-line maintained a seal along the bottom of the channel. Minnow traps were baited with roe from the same source on day 1 & 2 and a second source was used in all traps on day 3.

Photo 5. ORES volunteers placing minnow traps in Connolly Sidechannel during fish enumeration effort (April 1, 2014).

The calculations used in the three pass Zippin method are:

U_1 = number of fish removed on 1st pass
U_2 = number of fish removed on 2nd pass
U_3 = number of fish removed on 3rd pass
M = sum of all removals ($U_1+U_2+U_3$)
C = weighted sum = $(1 \times U_1)+(2 \times U_2)+(3 \times U_3)$
t = number of removal passes
R = ratio of sums
$\hat{p}$ = Estimate of probability of capture during a single trapping
$\hat{N}$ = Population estimate
SE($\hat{N}$) = Standard Error of Population estimate
95% CI = 95% Confidence Interval

$$R = \frac{C - M}{M}$$

$$\hat{p} = 0.996784 + (-0.924031)R + (0.319563)R^2 + (-0.390202)R^3$$

$$\hat{N} = \frac{M}{1-(1-\hat{p})^t}$$

$$SE(\hat{N}) = \sqrt{\frac{\hat{N}(\hat{N}-M)M}{M^2 - \hat{N}(\hat{N}-M)\frac{(t\hat{p})^2}{(1-\hat{p})}}}$$

$$95\%CI = \hat{N} \pm 2(SE[\hat{N}])$$

3.2.2 September 2014 Trapping

A two pass depletion estimate was used during September 10-12, 2014 trapping effort because of lack of flow and reduced wetted area and limited fry observations (Section 4.2). At the time of sampling there was limited wetted area in Reach 4 and Reach 6 was completely dry –there was no surface water connection to the mainstem. The fish were trapped throughout the entire available wetted areas of the sidechannel using 95 minnow traps (5 with widened mouths to allow for trout entry) and were spread at approximately equal intervals throughout the channel. During September 2014 trapping, salmonids caught were removed from the sidechannel system and transported by bucket to be released to the nearby Oyster River mainstem to enhance survival potential.

The calculations used in the two pass multinomial Zippin method are:

$$\hat{N} = \frac{{y_1}^2}{y_1 - y_2} = \frac{43}{1-(1-0.5128)^3} = 48.6$$

$$\hat{p} = \frac{y_1 - y_2}{y_1} = 0.5128$$

$$SE(\hat{N}) = \sqrt{\frac{\hat{N}(\hat{N}-M)M}{M^2 - \hat{N}(\hat{N}-M)\frac{(t\hat{p})^2}{(1-\hat{p})}}}$$

$$95\%CI = \hat{N} \pm 2(SE[\hat{N}])$$

3.3 WATER QUALITY

Handmeter water quality measurements including temperature and dissolved oxygen were taken with an Oxyguard Handy Polaris meter at an approximate weekly frequency from Nov. 6, 2013 to Sept. 17, 2014. Handmeter measurements were taken in the sidechannel at the same locations as deployed Onset Hobo Data loggers. Temperature loggers DL01, DL03, and DL06 were suspended freely in the water column while DL02, DL04, and DL05 were in perforated steel standpipes allowing water to pass through the pipe. DL02 was later moved slightly when water levels fell. In the new location it was suspended freely. The loggers collected water temperature data at one hour intervals from Oct. 17, 2013 - Sept. 12, 2014. The spatial location of logger and handmeter data collection sites is shown in Figure 4. Dissolved oxygen measurements are presented in Figure 6 & Figure 7 and temperature in Figure 8 & Figure 9, raw data is available in Appendix C – Water Quality Data (Dissolved Oxygen & Temperature).

There is one handmeter water quality sampling location in excess of the number of automated logger sampling sites at DL01 where both above and below gravel measurements were collected. The logger DL03 was lost in the sidechannel as its cable corroded and broke, the last recorded reading from this unit was on Feb. 21, 2014. Potential sources of error from temperature logger readings may include skewed levels from solar heating of the logger or standpipe, increasingly shallow water covering them in summer months, and reduced water circulation through pipe perforations with buildup of mud and debris.

3.4 WATER LEVELS

Oyster River mainstem and Connolly Sidechannel water level data was collected from three locations (Figure 4) during the period of Oct. 2013 - Sept. 2014 using submerged level loggers. Loggers used for water level sampling included *Onset Hobo U20 Water Level Logger* (v1.13) in the Oyster River mainstem, approximately 30 m upstream of the Highway 19A bridge crossing and 60 m downstream of the Connolly Sidechannel confluence at the foot of a set of concrete stairs (Photo 6), and a second Hobo U20 in the Connolly Sidechannel itself approximately 40 m downstream of the channel intake pipe outlet (Photo 7); whereas a *Solinst Model 3001 Levelogger* was installed in the sidechannel intake manhole (Photo 8). Atmospheric pressure changes were compensated for by correcting with data from a *Solinst Model 3001 Barologger* located within 30 km of the site – as stipulated by the manufacturer.

For the Hobo U20 Logger deployed downstream of the Oyster/Connolly confluence, 7920 data points were collected at 1 hour intervals between Oct. 17, 2013 and Sept. 12, 2014, the Hobo logger in the upstream end of the Connolly Sidechannel shows 8519 data points collected between Oct. 7 2013 – Sept. 27 2014, and the Solinst logger in the SC intake manhole collected 3914 data points between April 1 2014 – Sept. 11 2014 (Figure 11, Figure 12, & Figure 13).

The depths at which the loggers were installed were determined based on visual estimation of what would likely remain covered by water throughout the year, specifically with respect to low summer flow conditions. The sidechannel logger (“DLL Chan”) was repositioned on Oct. 23, 2013 to a lesser depth of coverage once it was determined that it would likely become inundated with fine sediments that dominate substrates within Reach 1. The elevation change was corrected for in the data presented in Section 3.4.

Photo 6. Upstream view of mainstem Oyster River water level logger (DLL-DS) installed in ABS pipe approximately 60 m downstream of the Connolly Sidechannel outlet. (Oct. 17, 2013)

Photo 7. View downstream of Connolly Sidechannel (Reach 1) showing location of water level logger installed in steel pipe (bottom left of image) approximately 40 m downstream of the intake outlet. (Sept. 10, 2014)

Photo 8. View upstream of the Oyster River mainstem showing the Sidechannel intake manhole where level logger "Intake" was installed. (April 1, 2014)

In order to assess the relationship between observed data sets, the Pearson Product-Moment Correlation Coefficient (r)[8] was applied between all three sets (mainstem, intake, and SC) to confirm that the data is indeed correlated and to reduce concerns over any confounding issues such as the use of different model instruments used to gather data. The results of these comparisons are presented in Section 4.4. According to Microsoft Excel 2007[9] the calculation used in their software to find r is as follows:

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

4 RESULTS

4.1 LEVEL 1 HABITAT ASSESSMENT

A Level 1 Habitat Assessment was undertaken to help define and characterize microhabitats in the Connolly Sidechannel as they may relate to potential salmonid site preferences when compared to abundance and distribution estimates from enumeration effort (Section 4.2).

The entire Connolly Sidechannel system was divided into assessment reaches based on the existence of significant changes in channel characteristics, or presence of beaver dams, channel confluences, or a man-made break such as a bridge crossing (Figure 4). The following is a breakdown of habitat assessment results by reach from a survey using FHAP/USHP methods (Section 3.1).

Overall, according to the results of the Fish Habitat Assessment all of the reaches received a "*Fair*" rating with the exception of Reach 6 which received "*Poor*". Habitat parameters commonly missing across all assessed reaches include low % gravel and high % fine substrates, and lack of % crown cover possibly related to beaver activity and/or poor growing substrates on the banks of the channel.

4.1.1 Reach 1

Reach 1 is the upstream most section of the sidechannel and is characterized by the presence of the mainstem intake pipe outlet (Photo 9) at its upstream end (chainage km 0+000 m) and the first upstream bridge crossing at its downstream end (chainage km 0+160) (Photo 10).

During the period of assessment the mainstem intake at 0+000 m was shut off to demonstrate the groundwater only condition of the sidechannel. In general, potential limiting factors to fish production of the reach includes a very high proportion of deep, organic fine substrates and little to no crown or overhanging vegetation, both resulting in *Poor Ratings*. Riparian vegetation is very limited and has been categorized as grass/shrub dominated by Scotch broom on the right bank, and alder pole sapling mixed with broom on the left bank (Photo 10).

Positive habitat attributes include continuous pool morphology with an average depth of 0.81 m and a maximum depth of 1.04 m, and bankfull widths (bfw) between 6.0 – 8.4 m for a *Good Rating*; the average density of large woody debris (LWD) is 4.7 LWD/bfw resulting in 28% instream within the entire reach for a *Good Rating*. The very

[8] The assumption of normality for Pearson analysis was confirmed with a Probability Plot using MiniTab v17 software.
[9] http://office.microsoft.com/en-ca/excel-help/pearson-function-HP010062528.aspx

downstream end of the reach near the bridge crossing contains an isolated patch of gravel covering an estimated area of 42 m^2 which is not enough to generate a rating beyond *Poor* (Photo 11). The overall rating for the reach is *Fair* (Table 1).

Table 1. Habitat Ratings for Reach 1.

Habitat Parameter	Reach 1	Ratings	
% Pool Area	100.00	1	Good
LWD/BFW	4.70	1	Good
% Cover Instream	32.90	1	Good
Avg % Boulder Cover	0.00	not rated	
Average % Fines	91.11	5	Poor
Average % Gravel	8.89	5	Poor
% Wetted Area	100.00	1	Good
% Crown Cover	0.00	5	Poor
Erosion Sites	0	0	-
Obstructions	0	0	-
Totals		**19**	Fair

Photo 9. View downstream of Reach 1 from the mainstem intake outlet (above left). Note presence of stop nets used during fish enumeration effort to isolate captured fish from the rest of the sidechannel. (Apr. 2, 2014)

Photo 10. View upstream of the "upstream bridge crossing" that defines the reach break between Reach 1 and Reach 2 (above left). (Sept. 10, 2014)

Photo 11. View upstream of Reach 1 from the upstream bridge crossing showing small patch of gravel (foreground) and general reach character including density of LWD (above right). (Sept. 10, 2014)

4.1.2 Reach 2

Reach 2 begins at the first upstream bridge crossing located at the downstream end of Reach 1 (chainage km 0+160) (Photo 12) and extends downstream to its confluence with the relic channel (Reach 3) (chainage km 0+380 m) (Figure 4).

Reach 2 is dominated by pool habitat resulting in part from its low gradient (<1%) and backwatering by a downstream beaver dam in Reach 4. This reach has an average wetted width of 6.50 with relatively steep banks resulting in a 100 % wetted area for a *Good Rating*. The entire reach length is considered a pool and results in a *Good Rating*. The average density of LWD is 4.26 LWD/bfw resulting in 75% instream within the entire reach for a *Good Rating*. Crown cover is non-existent for a *Poor Rating* within a riparian area including a small stand of alder saplings at a distance of approximately 20 m from highwater mark on the right bank and low shrubs including Scotch broom on the left bank (Photo 13).

The primary limiting factors in this reach are related to high % fine substrates, low % gravel substrates, lack of crown cover, and presence of thickets of invasive plant species. A series of two beaver dams located at the upstream end of Reach 4 are acting as a partial obstruction to up- and downstream salmonid migration, and are causing a substantial portion of the lower habitat units of Reach 2 to backwater. The overall habitat rating for Reach 2 is *Fair* (Table 2).

Table 2. Habitat Ratings for Reach 2.

Habitat Parameter	Reach 2	Ratings	
% Pool Area	100.00	1	Good
LWD/BFW	4.26	1	Good
% Cover Instream	86.00	1	Good
Avg % Boulder Cover	0.00	not rated	
Average % Fines	63.33	5	Poor
Average % Gravel	15.00	5	Poor
% Wetted Area	100.00	1	Good
% Crown Cover	0.00	5	Poor
Erosion Sites	0	0	-
Obstructions	0	0	-
Totals		19	Fair

Photo 12. View downstream (above left) of Reach 2 taken from upstream bridge crossing reach break showing typical channel morphology of upstream units. (April 14, 2014)

Photo 13. View upstream (above right) taken from approximate mid channel length of Reach 2 during habitat assessment work showing volunteers ad DFO staff collecting width measurements. (April 14, 2014)

4.1.3 Reach 3

Reach 3 is what is referred to as the "Relic Channel" and runs along the right bank bluff of the Connolly Sidechannel complex (Figure 4). Reach 3 begins at an alcove located adjacent to Reach 2 at approximately 0+250 (Photo 14) and continues downstream to its confluence with the main sidechannel at the downstream end of Reach 4 and upstream end of Reach 5 (chainage km 0+464).

Reach 3 is dominated by pool habitat with shallow average depths (0.37 m) and a low gradient (<1%) (Photo 15) that is backwatered by a downstream beaver dam at km 0+420. This reach has an average wetted width of 10.65 m resulting in a *Good Rating* for wetted area. The average density of LWD is 2.68 LWD/bfw resulting in 15% cover augmented by 32.8 % instream vegetation cover for a total of 47.8 % within the entire reach for a *Good Rating*. Crown cover is the highest in any of the assessed reaches at 50% for a *Good Rating* largely because of its position near the south (right) bluff bank that is forested with maturing mixed coniferous/deciduous tree species while the left bank is largely devoid of canopy species.

The primary limiting factors in this reach are related to high % fine substrates and low % gravel substrates. What isn't captured in the rating of this reach that may have an effect on overall habitat quality is the relatively shallow nature of the reach where during summer months it was observed to dry in many places. The beaver dam located towards the downstream end of Reach 3 is acting as a partial obstruction to up- and downstream salmonid migration and is backwatering a substantial portion of the lower habitat units of Reach 3 (Photo 16). A surface water connection, categorized as a pool under Reach 2 (Photo 17), exists between the relic channel at km 0+380 of the primary channel. The overall rating for Reach 3 is *Fair* (Table 3).

Table 3. Habitat Ratings for Reach 3.

Habitat Parameter	Reach 3	Ratings	
% Pool Area	100.00	1	Good
LWD/BFW	2.68	1	Good
% Cover Instream	47.80	1	Good
Avg % Boulder Cover	2.00	not rated	
Average % Fines	100.00	5	Poor
Average % Gravel	0.00	5	Poor
% Wetted Area	100.00	1	Good
% Crown Cover	50.00	1	Good
Erosion Sites	0	0	-
Obstructions	1	1	-
Totals		16	Fair

Photo 14. View upstream of Reach 3 (above left) showing alcove marking the upstream end of this reach.

Photo 15. View downstream of Reach 3 (above right) taken from approximate mid length of the reach showing wide and shallow wetted area.

Photo 16. Beaver dam with a 1.3 m crest height above streambed (left) that is a significant water level and flow control feature within the sidechannel located towards downstream end of Reach 3. (April 14, 2014)

Photo 17. Downstream view of a pool connecting Reach 3 (right of image) with the upstream end of Reach 2 (left of image at large stump) at km 0+380 of the primary channel. (April 4, 2014)

4.1.4 Reach 4

Reach 4 commences at the confluence of Reach 2 and 3 at chainage km 0+380 (Photo 17) and flows downstream until its confluence with the downstream end of Reach 3 at km 0+464 (Photo 18). Reach 4 contains two beaver dams at km 0+400 (1.1 m height above streambed) and 0+420 (0.95 m height above streambed) (Photo 19). Both dams had been notched out to allow flows and potential fish passage during the assessment period.

Reach 4 is dominated by pool habitat in part from backwatering by the beaver dams in the upper part of the reach and from its low gradient (<1%) in the lower sections. This reach has an average wetted width of 6.20 m with 100% pool coverage for a *Good Rating*. The average density of LWD is 2.62 LWD/bfw resulting in 11% instream cover plus an additional 2% from overhanging and 4 % from instream vegetation for a *Fair Rating*. Crown cover is limited to 20 % for a *Fair Rating* that includes a riparian area colonized by shrubs and some deciduous saplings.

The primary limiting factors in this reach are related to high % fine substrates and low % gravel substrates. The two beaver dams located at the upstream end of Reach 4 are acting as a partial obstruction to up- and downstream salmonid migration. The overall rating for Reach 4 is *Fair* (Table 4).

Table 4. Habitat Ratings for Reach 4.

Habitat Parameter	Reach 4	Ratings	
% Pool Area	100.00	1	Good
LWD/BFW	2.62	1	Good
% Cover Instream	16.90	3	Fair
Avg % Boulder Cover	0.00	not rated	
Average % Fines	96.00	5	Poor
Average % Gravel	4.00	5	Poor
% Wetted Area	100.00	1	Good
% Crown Cover	20.00	3	Fair
Erosion Sites	2	0	-
Obstructions	2	2	-
Totals		21	Fair

Photo 18. Downstream confluence of Reach 3 (foreground) and Reach 4 (left of image) at km 0+464. (April 4, 2014)

Photo 19. Upstream view of upper end of Reach 4 showing two beaver dams at km 0+400 and 0+420 respectively. (April 4, 2014)

4.1.5 Reach 5

Reach 5 begins at the confluence of Reach 3 and 4 at chainage km 0+464 and flows downstream until the bridge crossing (Photo 20) and "beaver baffler" pipe (Photo 21; Photo 22) at km 0+634. Reach 5 had been previously backwatered by a beaver dam under the bridge crossing that had been removed to allow flows to pass unimpeded during the assessment period. In order to help concentrate flows through the open channel under the bridge during the assessment period a plug was installed in the baffler pipe (Photo 23).

Reach 5 is dominated by pool habitat in part from backwatering by the control elevations of the pipe and bed under the bridge crossing at its downstream end, as well as the low gradient (< 1 %) channel form. This reach has the largest average wetted width at 31.54 m for a *Good Rating*, although depths averaged only 0.69 m. The average density of LWD is 10.38 LWD/bfw resulting in only 6 % instream cover plus an additional 5 % from overhanging and 15 % from instream vegetation for a *Good Rating*. Crown cover is limited to 10 % for a *Poor Rating* where the riparian area on the left bank is colonized by reed-canary grass and shrubs while the right bank is more well vegetated with a mixed coniferous/deciduous forest that is limited in canopy cover because of the larger channel width.

The primary limiting factors in this reach are related to high % fine substrates, low % gravel substrates, and low % canopy cover. The overall rating for Reach 5 is *Fair* (Table 5).

Table 5. Habitat Ratings for Reach 5.

Habitat Parameter	Reach 5	Ratings	
% Pool Area	100.00	1	Good
LWD/BFW	10.38	1	Good
% Cover Instream	26.00	1	Good
Avg % Boulder Cover	0.00	not rated	
Average % Fines	100.00	5	Poor
Average % Gravel	0.00	5	Poor
% Wetted Area	100.00	1	Good
% Crown Cover	10.00	5	Poor
Erosion Sites	2	0	-
Obstructions	0	0	-
Totals		19	Fair

Photo 20. Downstream bridge crossing marking reach break between Reach 5 & Reach 6 (left). Note beaver dam building activity between bridge abutments. (April 4, 2014)

Photo 21. Upstream view of the downstream end of Reach 5 showing the large channel width, instream vegetation, and wetted condition of the channel during habitat assessment effort. Note beaver baffler pipe at left of image. (April 14, 2014)

Photo 22. Beaver baffler pipe intake at low water during fish enumeration effort (above left). (Sept. 10, 2014)

Photo 23. View upstream of the upper habitat units of Reach 6 showing beaver baffler pipe plug used to concentrate flows under bridge crossing. (Nov. 6, 2013)

4.1.6 Reach 6

Reach 6 begins at the outlet of Reach 5 at the downstream bridge crossing at chainage km 0+634 (Photo 20) and flows downstream until the confluence with the Oyster River mainstem at km 0+725 (Photo 24). Reach 6 is seasonally backwatered by the Oyster River during periods of high winter flows; at the time of assessment there were flows from Reach 6 entering the mainstem over an approximate 1 m drop over cobble substrates. Reach 6 was observed to have dried completely during the period of summer drought from June-Sept (Photo 25).

Reach 6 is the only assessed reach to be dominated by glide habitat with a steeper, 2.5 % gradient and no pools for a *Poor Rating*. This reach has the smallest average wetted width at 1.30 m and bankfull width of 2.00 m with average depths of 0.20 m. The average density of LWD is 0.07 LWD/bfw resulting in only 4 % instream cover for a

Poor Rating, plus an additional 2 % from boulders and 85 % from overhanging vegetation for a *Good Rating*. Crown cover is relatively high with an average of 80 % resulting in a *Good Rating* where the riparian area on both banks is colonized by a dense accumulation of younger alder and big leaf maple saplings. This Reach has the highest percentage of gravels at 34 % for a *Good Rating.*

The primary limiting factors in this reach are related to high % fine substrates, low LWD frequency, lack of pools, shallow pool depths, and low % wetted area. The overall rating for Reach 5 is *Poor* (Table 6).

Table 6. Habitat Ratings for Reach 6.

Habitat Parameter	Reach 6	Ratings	
% Pool Area	0.00	5	Poor
LWD/BFW	0.07	5	Poor
% Cover Instream	91.00	1	Good
Avg % Boulder Cover	2.00	not rated	
Average % Fines	32.00	5	Poor
Average % Gravel	34.00	1	Good
% Wetted Area	65.00	5	Poor
% Crown Cover	80.00	1	Good
Erosion Sites	0	0	-
Obstructions	0	0	-
Totals		23	Poor

Photo 24. View downstream of mainstem connection at Connolly Sidechannel outlet of Reach 6 and mainstem Oyster River (above left). (Mar. 21, 2014)

Photo 25. View downstream of mainstem connection at Connolly Sidechannel outlet of Reach 6 and mainstem Oyster River (above right). (Sept. 17, 2014)

Photo 26. View upstream of downstream bridge crossing (above left) that defines the reach break between Reaches 5 & 6 taken from upstream end of Reach 6 showing flow connectivity and beaver dam acting as partial barrier to fish passage. (Apr. 11, 2014)

Photo 27. View upstream of downstream bridge crossing (above right) taken from upstream end of Reach 6 showing dry seasonal conditions and vegetative growth (Sept. 17, 2014)

4.2 FISH ENUMERATION

It is assumed that the minnow trap method effectively captures coho fry and smolts, young trout, and other species such as stickleback, sculpin, and crayfish -and is useful to determine their distribution in the study area. The early spring (April) timing of trapping effort was expected to help characterize the distribution of salmonid fry during their over-wintering life phase, and in late summer (September) their rearing distribution and survival in the groundwater only fed condition of the sidechannel.

Traps were set at approximately equal intervals (5-10 m) and were wetted for approximately 24 hrs. The results showed that there appears to be preferred salmonid presence in the upper reaches, Reach 1 & 2, and to a lesser degree Reach 3, of the assessment area as trapping there produced the highest total amounts by more than a factor of two over Reaches 4-6, and at least one coho during each seasonal effort (Table 7). Preferential usage of the upper reaches may be attributed to reduced flow velocities downstream, migratory restrictions from beaver dams, and decreasing seasonal water quality from winter to summer.

The **one pass** synoptic catch effort in January 2014 showed a total one day catch of 67 coho and 2 cutthroat. Statistical results from using the **three pass** multinomial Zippin method for April 2014 showed a population estimate of 48 coho (± 3) using a 95% confidence interval based on an actual catch of 43. Results of the September 2014 **two pass** Zippin method was 12 coho (± 0.8) based on an actual catch of 12.

Mean weight (g) and length (mm) were calculated for the total catch from each sampling effort (Table 8). Results showed that both weights and lengths were similar between January and April catch efforts with a difference of 0.4 g and 4.9 mm respectively; while the September catch showed a relatively larger mean at 4.7 g and 18.8 mm greater than the nearest numbers from January. It should be noted that the September sample size is quite a bit smaller than both January and April catches which may confound reliable comparisons. Based on weights and lengths of measured coho it is suspected that two, possibly three, age classes are in evidence in the sidechannel and perhaps points to additional evidence of the influence and limitations imposed by reducing seasonal flows under groundwater inputs only.

Since only two cutthroat were caught (300 mm and 125 mm/17.3 g), and the 300 mm individual was too heavy for the scale to provide a weight measurement, their statistics have not been included in Table 8.

Table 7. Total salmonid catch (coho and cutthroat) by reach in Connolly Sidechannel over three sampling efforts. Colour coded text relate to good, fair, and poor habitat ratings from Section 4.1.

Date	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Total
Jan. 2014	17	27	19	1	2	3	***69***
Apr. 2014	4	9	7	11	3	9	***43***
Sept. 2014	10	2	0	0	0	0	***12***
Total	31	38	26	12	5	12	-

Table 8. Mean weights (g) and lengths (mm) of coho caught by date in Connolly Sidechannel.

Date	Mean Weight (g)	Mean Length (mm)	Sample Size
Jan. 2014	7.3	87.5	69
Apr. 2014	6.9	82.6	43
Sept. 2014	12.0	106.3	12

Table 9. Proportion of coho versus three-spined stickleback caught by date in Connolly Sidechannel.

Date	Coho	Stickleback	Ratio
Jan. 2014	69	427	1:6
Apr. 2014	43	4007	1:93
Sept. 2014	12	2086	1:174

A proportionally high number of three-spined stickleback were caught compared to coho throughout all trapping efforts with the ratio being smallest under winter high flow conditions (January) and highest during summer low flows (September) (Table 9). Water quality criteria needed to support salmonids was also observed to decline concurrently with reduced seasonal catch of salmonids (Section 4.3). A high proportion of stickleback to salmonids is a condition commonly used to indicate poor water quality that favours stickleback survival over that of salmonids (Candolin, 2009).

A parasitic growth was observed on the majority of coho caught in trapping effort and according to a presumptive diagnosis by Dave Davies, DFO Community advisor (Pers. Comm. Apr. 3, 2014), it appeared to be *Neascus* sp., belonging to the sub-class Digenea of the phylum Platyhelminthes (flatworm). According to Meyers et al. (2008), most *Neascus* infestations of the skin are non-pathogenic to the host fish.

Mortalities of three-spined stickleback and rough skinned newts (*Taricha granulosa*) were observed in a number of traps (Appendix B – Fish Enumeration Raw Data). It is suspected that the newt mortalities resulted from them being in their terrestrial life-stage and unable to return to the surface for oxygen once trapped. Stickleback mortalities are suspected to have resulted from being relegated to an area of especially poor water quality; nearly all mortalities were found in a few traps within the same general area of Reach 2.

4.3 WATER QUALITY

Measured water quality parameters included dissolved oxygen (mg/L) and temperature (°C) as they relate to salmonid health, and were recorded at established water quality sampling sites throughout the Connolly Sidechannel based on channel characteristics and in relation to potential input sources (Figure 4). Raw water quality data is presented in Appendix C – Water Quality Data (Dissolved Oxygen & Temperature). The following is a brief description of how these parameters affect salmonid health according to limits prescribed by *RISC Guidelines for Interpreting Water Quality Data* (RISC, 1998):

- **Dissolved Oxygen** is essential to respiratory metabolism of most aquatic organisms. It affects the solubility and availability of nutrients, and therefore the productivity of aquatic ecosystems. Levels below an instantaneous minimum of 5 mg/L and 30 day mean of 8 mg/L may be lethal to juvenile and adult salmon, while for buried embryo and alevin stages an instantaneous minimum of 9 mg/L and 11 mg/L for a 30-day mean apply.
- **Temperature** affects the solubility of many chemical compounds and can therefore influence the effect of pollutants on aquatic life. Increased temperatures, in conjunction with reduced oxygen solubility, elevate the metabolic oxygen demand of many species, and in effect cause suffocation. Temperatures averaged over 7 days are lethal in excess of 18-19 °C for adult and juvenile fish, 8-10 °C for spawning, and 13-15 °C for embryo survival.

4.3.1 Dissolved Oxygen

Dissolved oxygen (DO) levels were observed below the instantaneous minimum threshold for salmonid survival (5 mg/L) at every sidechannel sampling site (Figure 4) at least once during the monitoring period (Appendix C – Water Quality Data (Dissolved Oxygen & Temperature); Table 12). In general, DO levels in the sidechannel began to dip below the threshold beginning in May with DL02 (Relic Channel) and DL03, followed by the approximate middle of the sidechannel at DL04 and DL05 by mid-late June, and DL06 the downstream end of the sample site near the outlet pipe by mid-July. The upstream end of the sidechannel nearest the intake outlet didn't fall below the minimum threshold until the end of July through mid-August and then proceeded to increase above the threshold from the end of August until the end of sampling in mid September and may be attributed to the site's location near the head of channel nearest to the point of infiltration of sub-surface flows from the mainstem.

Two sampling sites were established at DL01 ("above gravel" and "below gravel") in a patch of exposed gravel just downstream of the uppermost channel bridge crossing (Photo 28). This site was identified as a key location representing only two areas in the entire sidechannel where earlier observations were made of adult spawning activity. At this location samples were taken at bed level and within a well approximately 30 cm below the gravel's surface. The depth of sub-surface sampling was selected based on a simulation depth for coho redds. As described in Section 1 it was decided that an egg incubation experiment would not be undertaken as part of this assessment based on observed and predicted low dissolved oxygen levels and high temperatures in sidechannel gravels that would be lethal to eggs (Section 4.3), as well as the lack of adult access to this area resulting during low flows and water levels associated with the groundwater only flow regime. The efficacy of this prediction was confirmed by observed subsurface oxygen throughout a generalized egg incubation period for coho from December to May (Sandercock, 1991). During this period, levels were observed below the instantaneous threshold with the exception of increases in late February and mid-April, and all measurements fell below the 30 day mean minimum level (Appendix C – Water Quality Data (Dissolved Oxygen & Temperature).

Photo 28. View downstream of DO/Temp sampling site (DL01) during the summer low water period showing exposed pipe. (Sept 17, 2014)

The total number of observed occurrences of DO levels falling below the 5 mg/L instantaneous minimum threshold for adult/juvenile salmonid survival for all eight sampling sites is shown in Figure 6 by sampling date. This count of occurrences demonstrates a general seasonal trend of DO water quality conditions over the entire sidechannel. In general, the highest number of occurrences below the survival threshold for all sites was highest (> 3) between the beginning of July and end of December[10]. These occurrences are compared against sidechannel water levels measured from level logger station DLL Chan and demonstrates a strong negative correlation (- 0.61) where when water levels drop the occurrence of DO levels below the instantaneous threshold increase, and conversely (Figure 6).

An additional comparison of DO levels between sites (occurrences of levels above and below 5 mg/L) is shown in Figure 7. This comparison shows the general trend of DO levels by site where a number of stations showed more occurrences below the threshold than above (DL01 "below gravel surface" and DL03) while DL02 was the only site that showed equal counts above and below, and the balance of sites were more often above the threshold than below it.

Visual observation of ice on the surface of the channel at water quality sampling locations was made beginning on Nov. 20, 2013 and continued intermittently until Feb. 21, 2014. During this period DO levels were observed to decrease for sites DL03-05 in mid-November and then increase again by mid-January (Table 12; Appendix C).

[10] Note that winter data from Nov-Dec was collected in 2013 and summer in 2014. There is no data for the month of October of either year.

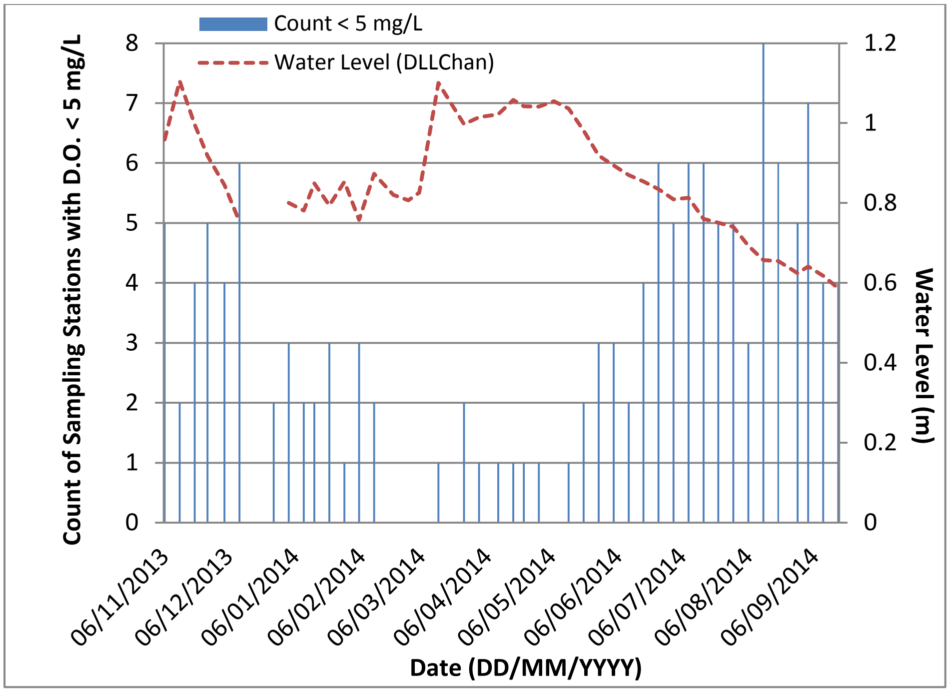

Figure 6. Count (i.e. number of observed occurrences) of sampling stations in Connolly Sidechannel (eight total) with dissolved oxygen (mg/L) concentrations less than the 5 mg/L instantaneous critical limit for salmonids per weekly handmeter sampling effort from Nov 6. 2013 to Sept. 17 2014.

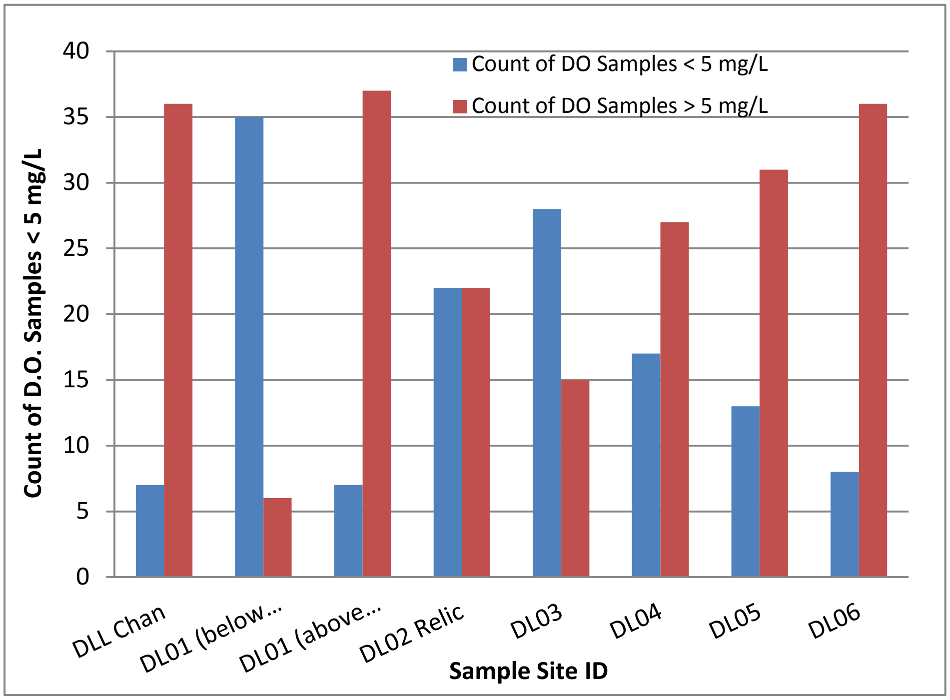

Figure 7. Bar graph showing the count (i.e. number of observed occurrences) of weekly handmeter dissolved oxygen measurements greater and less than the 5 mg/L instantaneous critical limit for salmonids, organized by sampling station from Nov 6. 2013 to Sept. 17 2014.

4.3.2 Temperature

Sidechannel temperature measurements were collected weekly using a handmeter at seven well sites during the period of Nov. 6, 2013 to Sept. 17, 2014 (Figure 8), and concurrently by automated loggers located at well sites collecting measurements at an hourly frequency from Oct. 17 2013 to Sept. 12 2014 (Figure 9). These measurements serve to show the seasonal variations in water temperature and their relationship to levels lethal to fish.

Handmeter data shows that lethal levels (18 - 19 °C averaged over a 7 day period) begin to occur first at DL06 starting mid-June, followed by DL04 and DL03 toward the end of June (Figure 8). The balance of other sites including DL05, DL02, DL01 (above gravel), and DLL Chan exceeded the temperature threshold starting mid-July. DL02 (Relic) exceeded the threshold on only one sampling effort on July 16, 2014. The only site that did not appear to exceed the 18°C limit was DL01 (below gravel). Temperatures for all of the site exceedances returned below threshold levels between Aug. 20 – 29, 2014. Visual observation of ice on the surface of the channel at water quality sampling locations was made beginning on Nov. 20, 2013 and continued intermittently until Feb. 21, 2014

Logger data showed a similar general trend as handmeter data; however, site by site trends varied somewhat. For example, similarly to handmeter data the first measurements above the 18°C level occurred in early to mid-June and included DL06 and DL04; although, unlike handmeter data these exceedances were first observed at DL01. Site DL01 was located at a small patch of gravel immediately downstream of the upstream bridge crossing over the sidechannel, and based on visual observations through the summer months the logger location became completely exposed with receding water levels (Photo 28), the result being that the highest temperatures of any site occurred here including 34.6 °C on August 11. Temperatures at DL01 remained above the 18 °C threshold until Sept. 9, 2014. Mainstem DLL DS was the next most frequent exceedance from the end of June through to the end of August. This was likely influenced in part by low water levels exposing both the standpipe and surrounding riprap to solar heating effects. DL02 only increased beyond the threshold on a few occasions between mid-July and end-August. DL02 was the only site observed not to increase to the threshold reaching its highest point of 16°C on August 1. DL02 was located in Reach 3 (relic channel) that is located near the south bluff bank and remained in the shade throughout the sampling period. These temperature readings were likely influenced in part by nearby surface and groundwater inputs at the base of the embankment along the south bank. The logger DL03 was lost in the sidechannel as its cable corroded and broke, the last recorded reading was on Feb. 21, 2014.

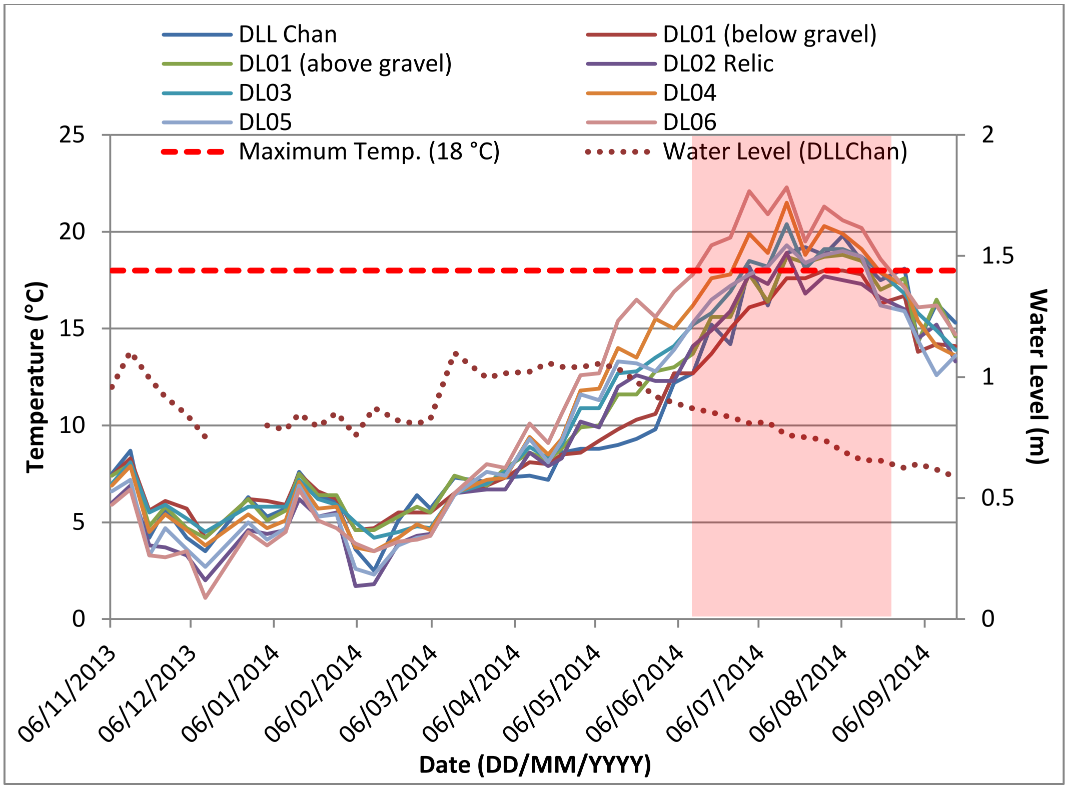

Figure 8. Temperature (°C) measured weekly by handmeter at seven sites throughout the Connolly Sidechannel from Nov 6. 2013 to Sept. 17 2014 with comparison to water levels measured at DLL Chan.

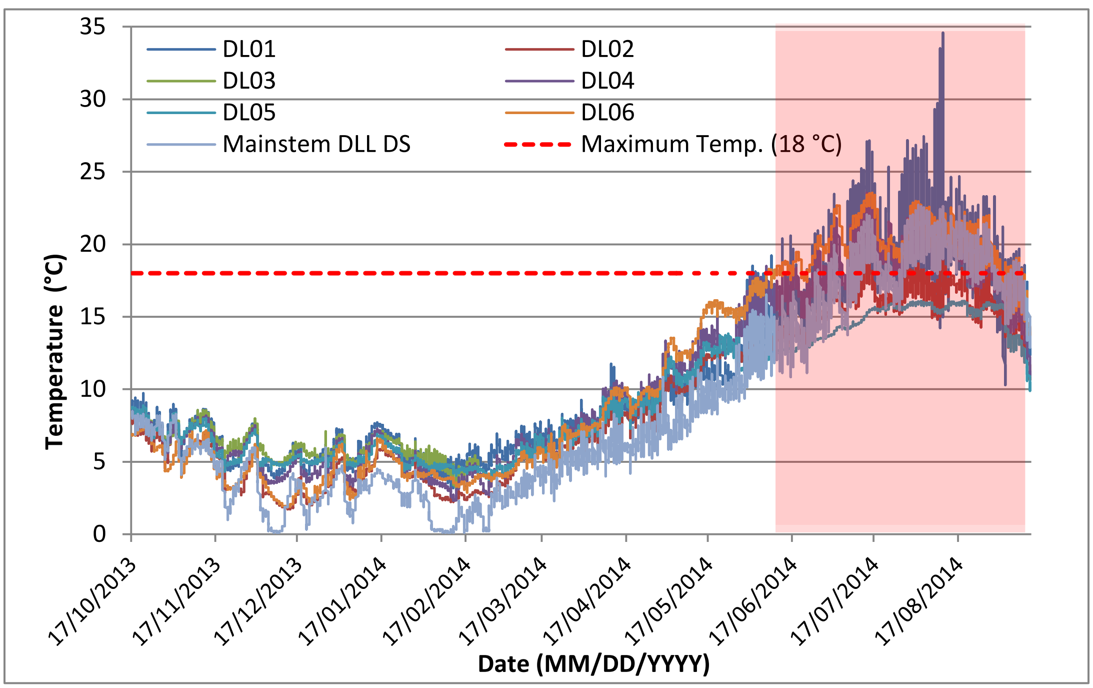

Figure 9. Temperature (°C) measured by automatic loggers at seven sites throughout the Connolly Sidechannel from Oct. 17 2013 to Sept. 12 2014.

Photo 29. View downstream of logger and water quality sampling station DL02 located in Reach 3 (relic channel). This logger was later moved slightly to keep it submerged at lower water levels. (Sept. 10, 2014)

4.4 WATER LEVELS

Water level measurements were collected from Oct. 2013 – Sept. 2014 in the mainstem, sidechannel intake, and sidechannel proper (Figure 4) in order to show how mainstem fluctuations translate to the sidechannel and help determine whether sufficient groundwater levels can be maintained in the sidechannel compared against mainstem levels. Canada Water Survey (CWS) Real-Time Hydrometric Data for Oyster River below Woodhus Creek (08HD011)[14] was acquired for comparison against logger data and known periods of surface water connection between the mainstem and the Sidechannel outlet. A comparison of CWS mainstem discharge versus mainstem logger ("DL DS") is in Figure 10 and a comparison between all three logger data sets is shown graphically in Figure 11. It should be recognized that although the logger levels are all relative to the water's surface at each station, the depth of each sensor is not relative to a common benchmark –as such a comparison of actual water depths is not relevant.

Statistical comparison was accomplished between water level data sets using the Pearson Product-Moment Correlation Coefficient ("Pearson") and was applied between all three sets of logger data [mainstem ("DL DS"), intake ("Intake"), and sidechannel ("DLL Chan")] and Mainstem Oyster River CWS Hydrometric Discharge Data. The statistical comparison serves to confirm whether the data between sampling stations is correlated and to reduce concerns over any confounding issues such as the use of multiple logger types. Data used in the Pearson analysis was limited to the period where all three logger stations were collecting data concurrently (Apr. 3, 2014 – Sept. 11, 2014). The output of Pearson analysis generates a number between 0 – 1 where 0 is no correlation and 1 is perfect correlation. The results of analysis show that a strong correlation (0.7 - 0.9) [11] exists between all sampling sites and CWS discharge data (Table 10).

[11] Dancey, C. & J. Reidy (2004). *Statistics Without Maths for Psychology*. Prentice Hall. London. Pp. 612.

Table 10. Pearson correlation coefficient calculation results showing comparison between three sites.

Mainstem & SC Intake	0.974
Sidechannel & SC Intake	0.926
Sidechannel & Mainstem	0.904
CWS Discharge & Mainstem	0.929
CWS Discharge & SC Intake	0.879
CWS Discharge & Sidechannel	0.843

The Pearson coefficient between CWS Discharge data versus the mainstem logger ("DL DS") shows a strong correlation (0.929). A visual representation of the correlation between these two data sets is shown in Figure 10. The strength of correlation is decreased but remains "strong" between additional CWS Discharge comparisons with the sidechannel intake ("SC intake") (0.879) and sidechannel proper ("DLL Chan") (0.843) respectively.

The coefficient between mainstem logger ("DL DS") and sidechannel intake ("SC intake") data sets shows the strongest correlation of all analyzed data sets (0.974) where increases and decreases in water levels are mirrored very closely. One difference between these two readings appears to be that fluctuations in mainstem readings are more pronounced and may be related to a more "flashy" mainstem condition where the logger site was located near the downstream end of a riffle adjacent to rip-rap bank protection, whereas the SC intake site is located at the upstream end of a riffle within a manhole structure that likely has a small buffering and/or stilling effect on flashy mainstem flows (Figure 12). It should be noted that although intake well readings were collected throughout the study period, the well intake screen dried at a point between observations made on July 30 (discharge of 2.38 m^3/s) and August 6, 2014 (discharge of 2.11 m^3/s; Photo 30), and was not submerged again by the end of the study period in mid-September 2014 (Sept. 15, 2014 discharge of 1.44 m^3/s).

Comparison of SC Intake versus Sidechannel ("DLL Chan") readings show another very close correlation (0.926) where seasonal decreases in water level vary together (Figure 13). The primary difference between these two stations is that during the period of sampling the intake to the Sidechannel was closed, as a result the entirety of flows entering the channel were groundwater derived. The buffering effect of flows is again observed between mainstem versus sidechannel where groundwater fluctuations appear much more moderate than the mainstem (Figure 11).

Photo 30. Mainstem intake screen showing dried condition beginning in August and persisting to the end of the study period in mid-September. (Aug.6, 2014)

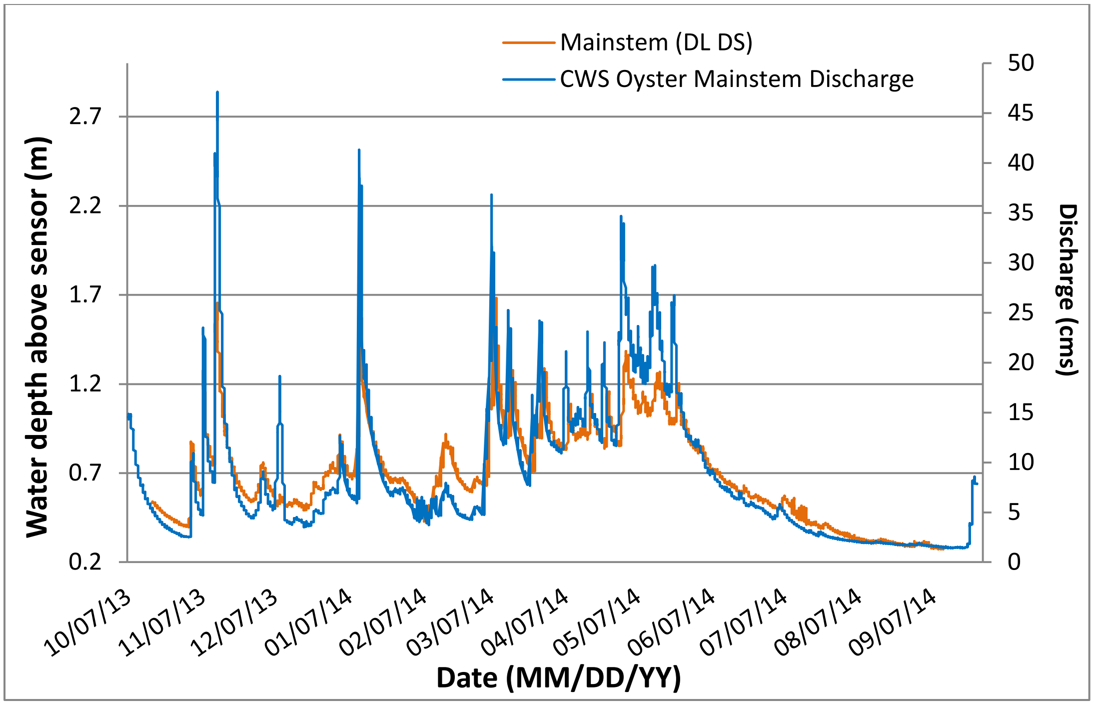

Figure 10. Comparison of Oyster River mainstem discharge (cms) data from CWS Station (08HD011) versus mainstem datalogger installed 60 m downstream of confluence with Connolly SC outlet ("DL DS") from Oct. 7, 2103 – Sept. 12, 2014.

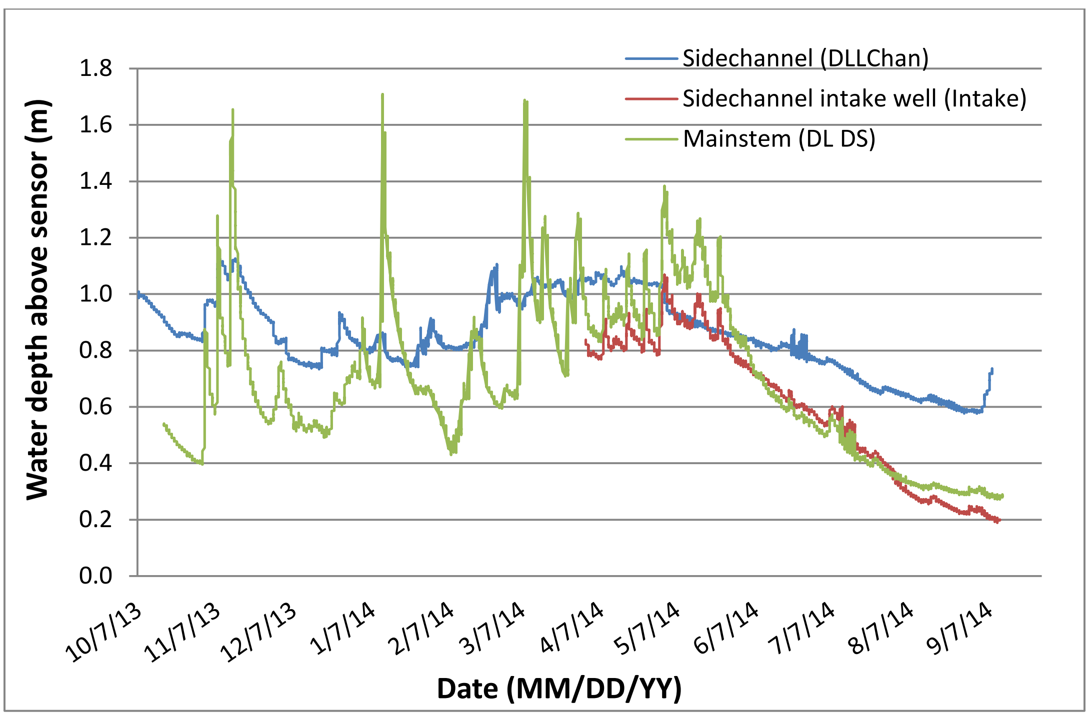

Figure 11. River levels measured as depth of water above logger (m) collected from three locations (1) Oyster River mainstem 60 m downstream of confluence with Connolly SC outlet (green line), (2) Intake to SC in manhole at Oyster River mainstem (red), (3) in Connolly SC near intake outlet during period from Oct. 7 2013 – Sept. 27 2014.

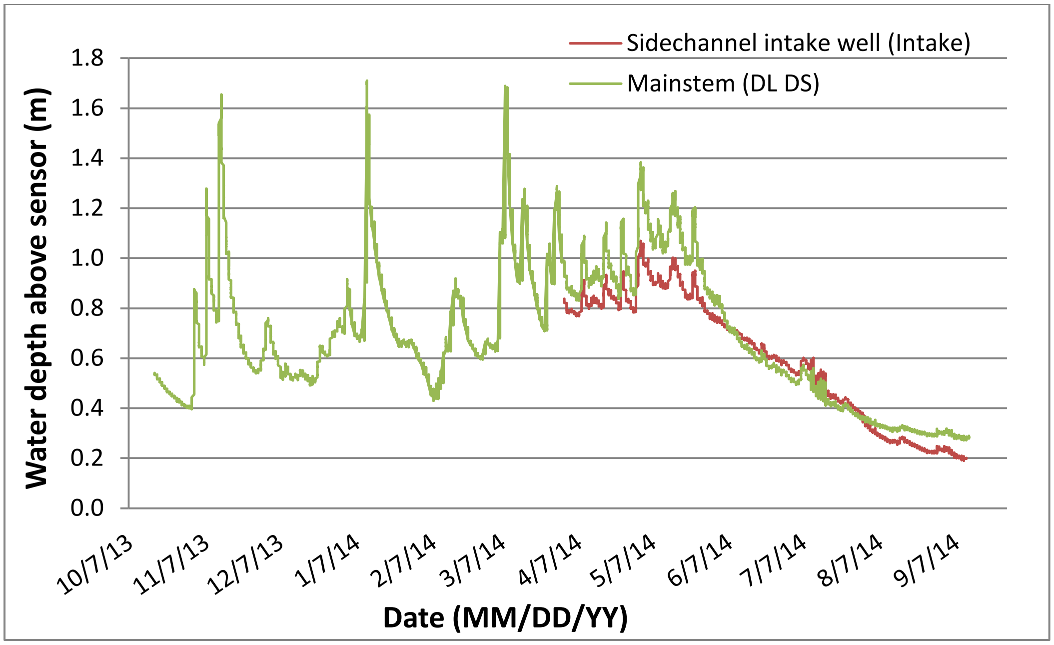

Figure 12. River levels measured as depth of water above logger (m) showing comparison between two mainstem locations (1) Oyster River mainstem 60 m downstream of confluence with Connolly SC outlet (green line), (2) Intake to SC in manhole at Oyster River mainstem (red) during period from Oct. 7 2013 – Sept. 27 2014.

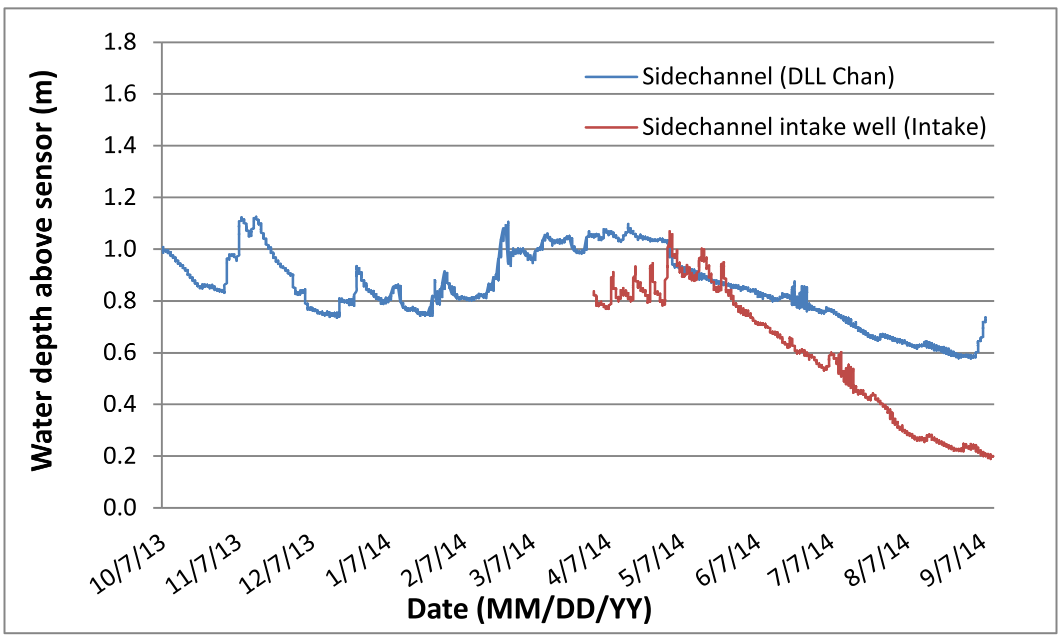

Figure 13. River levels measured as depth of water above logger (m) showing comparison between mainstem vs groundwater condition of the Connolly SC at locations inside manhole intake well (red) and in Connolly SC near intake outlet (blue) during period from during Oct. 7 2013 – Sept. 27 2014.

Visual monitoring of mainstem Oyster River water levels relative to the Sidechannel outlet was done on a weekly basis throughout the sampling period in conjunction with handmeter water quality measurements and photopost monitoring. Roughly weekly outlet flow observations and photos were taken at the confluence between Reach 6 and the Oyster River mainstem (Photo 24 & Photo 25) and at the downstream bridge crossing (reach break between Reach 5 & 6; Photo 26 & Photo 27). Connectivity was visually assessed based on whether it appeared the Sidechannel outflow was wetted sufficiently to support fry passage. A comparison between visually confirmed mainstem/sidechannel connectivity[12] plotted against precipitation (on sampling day and as a total of previous 7 days)[13], and mainstem hydrograph measurements[14] is provided in Figure 14.

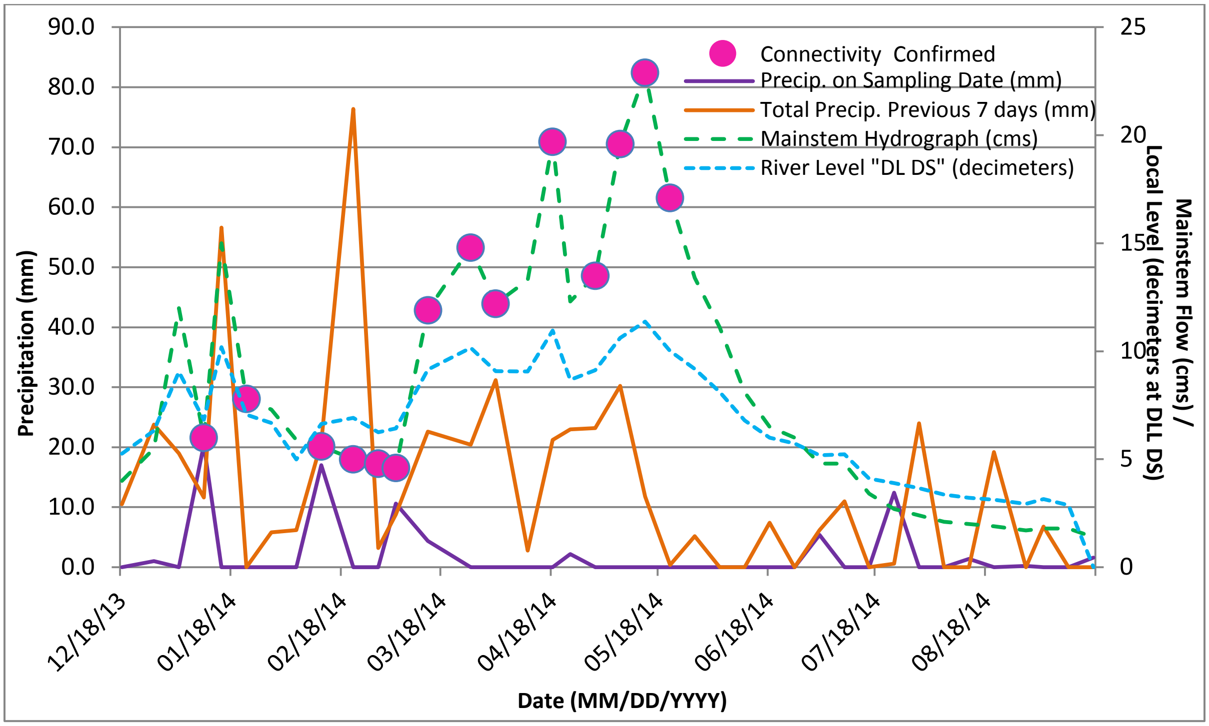

Figure 14. Comparison of visually confirmed mainstem/sidechannel connectivity plotted against precipitation (mm) (on sampling day and as a total of previous 7 days), mainstem hydrograph measurements (cms), and mainstem data logger levels (dm) for the period of Dec. 18 2013 – Sept. 17, 2014.

[12] Sidechannel water velocities, associated with observed water levels, were not collected as accurate flow measurements could not be obtained due to channel conditions/complexity.
[13] Historical Climate Data for Comox Airport A. Accessed from: <http://climate.weather.gc.ca/climateData/dailydata_e.html?StationID=155&Month=10&Day=14&Year=2014&timeframe=2>.
[14] Real-Time Hydrometric Data for OYSTER RIVER BELOW WOODHUS CREEK (08HD011) [BC]. Accessed from < http://wateroffice.ec.gc.ca/>.

5 DISCUSSION

The timing of this study took place from Oct. 2013 - Sept. 2014 and followed an uncharacteristically[15] dry 2013 leading into an even drier 2014[16]. The historical mean annual discharge for the Oyster River is 14.2 m^3/s (1973-2007), whereas, the mean discharge for the period of April 29, 2013 - Sept. 12, 2014 was 13.6 m^3/s. The benefit of undertaking a habitat assessment under drier than normal conditions is that the study parameters used to infer the ability of the sidechannel to support salmonid survival and rearing requirements are more readily exposed. As previously described, the purpose of this study was to assess the groundwater only condition of the sidechannel in order to gain a better understanding of groundwater habitat conditions and seasonal fisheries use, and to help inform future decisions with regard to ongoing operations and maintenance, and possible modification of the mainstem intake. The flow intake from the Oyster River mainstem was closed during the period leading up to, and at the time of assessment, to help reveal potential habitat deficiencies under low flow conditions. The principle assessment parameters used to monitor and assess groundwater conditions in support of fisheries requirements included measurements of water quality and quantity (water-levels linked to gauged discharge), micro-habitat characterization and rating linked to preferred habitat conditions, incubation assessment (abandoned due to site/seasonal conditions), and estimates of seasonal abundance and standing stock.

The FHAP Level 1 Habitat Assessment results based on USHP rating criteria showed that all of the reaches received a "*Fair*" rating with the exception of Reach 6 which received "*Poor*". Habitat parameters commonly lacking across all assessed reaches include: low % gravel and high % fine substrates, and lack of % crown cover possibly related to beaver activity and/or poor growing substrates on the banks of the channel. Reach 6 received the lowest ratings in the study area for lack of % pool area and pool depth, very low large woody debris distribution, high % fine substrates, and low % wetted area. Reach 6, including the confluence with the Oyster River mainstem, was observed to dry during the summer months (June - August). It should be noted that, although it is generally a key factor in determining habitat quality and suitability, flow velocity measurements are not part of the FHAP/USHP methods and were not undertaken as part of this assessment.

Fish enumeration results showed that there was a pronounced decrease in fish numbers from winter to summer. No previous fish population, abundance, or outmigration studies are available for comparison. The one-day preliminary fish catch effort in January showed higher catch numbers of salmonids than the multi-day efforts in April and September combined. Sampled coho densities were much lower than estimated sidechannel fish production biostandards (Table 11). The ability for salmonids to voluntarily enter and depart the channel at the downstream end may have contributed to lower observed numbers later in the sampling window; however, it should be noted that the mainstem connection did not dry entirely until after the April catch effort. Other possible sources for decreased numbers in the channel may be related to predation and/or poor water quality. A parasitic growth (*Neascus spp.*) was observed on the majority of coho caught in trapping effort and may be contributing to decreased fitness in the population. It was also noted that mean weights and lengths for coho were similar for January and April catches; however, fish collected in September averaged heavier and longer. This may be related to a smaller sampling size in September; habitat conditions that favoured larger individual's survival during stressful summer conditions, and/or larger individual's outcompeting smaller individuals for access to food in baited traps. Based on weights and lengths of measured coho it is suspected that two (0+ & 1+), and possibly three

[15] Campbell River Weather Station A - Climate Normals (1981-2010) recorded mean total annual precipitation of 1407.9 mm compared to 994.1 mm in 2013, or 70% of normal levels. <http://climate.weather.gc.ca/climate_normals/results_e.html?stnID=145>

[16] Campbell River Weather Station A - Climate Normals (1981-2010) recorded mean total precipitation from Jan.-Sept. of 820.6 mm, while the same period of months in 2013 was 734.2 mm (89 % of normal), and in 2014 was 659.7 mm (80 % of normal).

(2+), age classes are in evidence in the sidechannel. The distribution of salmonids caught in the sidechannel favoured the upstream three reaches over the downstream three; this may be related to greater groundwater inputs to the upstream reaches.

Dissolved oxygen (DO) water quality measurements showed observed levels below the instantaneous minimum threshold for salmonid survival (5 mg/L) at every sidechannel sampling site at least once during the monitoring period. In general, DO levels in the sidechannel began to fall below the threshold beginning in May and then proceeded to increase above the threshold beginning near the end of sampling in mid-September. Dissolved oxygen water quality exceedances of minimum coho biostandards, according to developmental stage, are shown in Table 11.

It was decided that the egg incubation assessment would be eliminated from the study based on predicted low DO levels and high temperatures in sidechannel gravels that would be lethal to eggs –this prediction was confirmed during the generalized egg incubation period for coho between December to May through documented results of numerous observed subsurface gravel oxygen levels below the instantaneous threshold (9 mg/L) and all measurements during this period falling below the 30 day mean minimum level (11 mg/L). The number of occurrences of levels below the 5 mg/L threshold were fewest at the upstream end of Reach 1 near the intake outlet (DLL Chan), Reach 2 near the upstream bridge crossing (DL01 above gravel) –both of which were also the locations where the highest concentration of salmonids were caught during enumeration effort- followed by Reach 6 near the beaver baffler outlet pipe (DL06). The lowest DO levels for supporting aquatic life was observed in subsurface gravels in Reach 2 near the upstream bridge crossing (DL01 below gravel), and in Reach 2 near the site where stickleback mortalities were observed during September fish enumeration efforts (DL03).

Temperature measurements collected by handmeter and by automatic loggers were in general agreement where levels lethal to fish began to occur in June and continued through the summer months until returning below threshold levels towards the end of August (Table 11). According to handmeter readings, the only site that did not appear to exceed the 18°C limit was DL01 (below gravel) where it is likely that the subsurface character of flows at this location appear to have moderated the temperature increase. Logger readings varied somewhat where DL01 (above gravel) was the first site to exceed the 18°C limit and the last to return below it. It is believed that higher temperatures can be accounted for at DL01 where it was installed on a patch of gravel perched at a higher elevation than other loggers that became uncovered by water earlier and re-covered later. All temperature logger readings may have been affected to different degrees by direct solar heating effects, increasingly shallow water covering them at different rates in summer months, and/or reduced water circulation through pipe perforations that periodically became blocked with buildup of mud and debris.

Table 11. Summary and comparison of coho life history requirements and population densities against observed water quality parameters and expected sidechannel production metrics.

	Species life history requirements			WQ Parameters measured		Sample Date (2014)			Sidechannel Production Metrics **
	Presence Window	Instantaneous minimum*	Maximum Temp. avg. 7 days *	Period Exceeding threshold		January	April	September	
Life Stage	Coho	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	Coho/m²			Coho/m²
Spawners	Oct. - Jan.	5.0	8-10	Exceeded (some sites) Nov-Jan^	Not exceeded	-	-	-	0.068
Eggs/ alevin	Dec. - May	9.0	13-15	Exceeded Dec.- May	Not exceeded	-	-	-	-
Fry	Year round	5.0	18-19	Exceeded May-Sept	Exceeded June - Sept.	0.0063	0.0039	0.0011	1.01
Smolts	May - June	5.0	18-19	Exceeded May-Sept	Exceeded June - Sept.	-	-	-	0.69

* RISC (1998)
** Koning & Keeley (1997)
^ DO threshold for spawners not exceeded at DLL Chan, DL01, DL06 during spawning period.

A comparison between level logger stations in the mainstem downstream of the sidechannel complex, at the sidechannel intake well, and in Reach 1 of the sidechannel showed a strong correlation where increases and decreases in water levels are mirrored very closely. It was noted that fluctuations in mainstem readings are more pronounced and may be related to a more "flashy" mainstem condition, whereas the *intake site* is located at the upstream end of a riffle within a manhole structure that likely has a small buffering and/or stilling effect on flashy mainstem flows. The buffering effect of flows is again observed between mainstem intake versus the sidechannel where groundwater fluctuations appear much more moderate than the mainstem.

The sidechannel intake screen located in the mainstem dried (uncovered) between observations made on July 30 and August 6, 2014 (Photo 30). According to data from the CWS hydrograph in the Oyster River below Woodhus Creek, these dates correspond with average daily discharges of 2.38 m^3/s and 2.11 m^3/s respectively. It is expected that the intake would not become re-wetted until flows once again exceed these discharge levels. The intake screen was not observed to re-cover by the end of the study period where the lowest discharge rate observed during the entire study period was on Sept. 16, 2014 at a discharge of 1.41 m^3/s. The primary implication of these observations is that in future years, should the intake be open and operating under its existing condition, flows into the sidechannel would become groundwater limited at a mainstem discharge rate between 2.38 - 2.11 m^3/s. It is unknown what immediate effect cutting off mainstem flows would be on water quality in the sidechannel; however, should it result in a rapid decrease of dissolved oxygen concentration and increase of temperature it is likely that salmonids rearing in the sidechannel would undergo a period of stress that could affect fitness and survival. In comparison to observations of sidechannel outlet disconnection from the mainstem, discussed below, the period of intake drying occurred later in the season.

Sidechannel outflow connectivity with mainstem Oyster River appears to be dependent on multiple factors including the amount of precipitation, any residual surficial inflows off the rightbank sideslopes, groundwater flow contributions, and possibly to a small degree short-term water level fluctuation from beaver dam building activity. According to the data presented in Figure 14 there appears to be a weak relationship between periods of sustained precipitation (total mm from previous seven days) and confirmed sidechannel connectivity; however, what is not well represented is how fluctuations in mainstem flows represented by hydrograph and level logger data relate to sidechannel connectivity. What is clearly shown in the data set is that there is no connectivity between the sidechannel and mainstem after May 21, 2014 until the end of data collection on Sept. 17, 2014, a considerable period of four months. This extended period of dry and unseasonably warm weather resulted in low river discharge levels, reduced water-levels, and an apparent associated reduction in groundwater flows. Under persistent dry conditions with limited precipitation and runoff inputs, the wetted channel area within the sidechannel continued to decline, reducing localized ambient rearing conditions and restricting accessibility between reaches or potential for access to microhabitats with improved suitability. With degraded channel conditions, the benefits of and preference for off-channel habitats is diminished, and access to mainstem environments with secure flows becomes critical for survival.

It is unknown at what point in the fall/winter that connectivity may be re-established because observations made during this study did not commence until winter 2013/2014, and there is no clear, consistent indication from historical CWS mainstem discharge data regarding what point sidechannel connectivity is reliably made. However, a general timeline of salmonid migration into and out of the sidechannel can be inferred based on visual connectivity observations showing that should rearing or overwintering juveniles enter the sidechannel during periods of fall/winter connectivity (which even from Dec. – Feb. remains inconsistent) their opportunities for egress will be limited to periods of high flow and/or high precipitation through the spring until late May. From the period of late May until fall/winter connectivity is re-established, any stranded juveniles will remain in the sidechannel and subject to seasonal groundwater ambient conditions. Based on the size/length of juvenile salmon sampled during enumeration efforts it appears that many of the survivors could remain in the channel up to an age class of two years (subject to annual or seasonal conditions).

6 CONCLUSIONS

Habitat assessment results, discounting flow discharge/velocities, show that the Connolly Sidechannel may be considered to have an overall *Fair* condition. The results are reflective of conditions influenced by the availability of flow at the time of assessment; as such, the observed cumulative effect of the parameters explored during the assessment should not be considered a primary limiting factor to salmonid productivity, with the exception of a general lack of canopy cover and gravel spawning grade substrates. The outlet channel of Reach 6 was given the only *Poor* rating and would benefit from improved adult passage, where the outlet has become perched due to mainstem down-cutting; increased pool depth and frequency, and higher percent wetted area.

Documentation of habitat parameters associated with groundwater contribution and function of the Connolly Sidechannel indicate that adult migration and spawning activity are unlikely to occur under a groundwater only supported regime. In addition, in a year with higher flows that should support spawning adults entering the sidechannel, and assuming successful navigation of beaver dam obstructions to access limited gravel deposits for spawning, their eggs would not survive to maturity based on observed inhospitable inter-gravel water quality conditions. Additionally, based both on observations and water-level recording data during low precipitation years with reduced seasonal flows, groundwater channel flows alone are unlikely to support adult in-migration, functional spawning depths, or intergravel flows supportive of egg incubation -although adult access and spawning potential could be opportunistic based on annual hydrographic variability (Photo 1).

Years experiencing low-precipitation and water levels, which if 2013-2014 is an indication, may be an increasing trend, and the probability of annual intake screen exposure and cessation of flows into the sidechannel is likely – potentially isolating 'resident' juveniles under unfavourable habitat conditions. As stated in enumeration results, juvenile numbers decline in the sidechannel from January – September, and based on additional information from water quality measurements and observations of parasitic growth on many of the sampled individuals, it appears that rearing suitability is very limited. Under a groundwater only flow regime, results demonstrate that under drier, low-water years dissolved oxygen concentrations can decline below instantaneous minimum thresholds for salmonid survival (5 mg/L) throughout all sidechannel areas at different times of year, though particularly during summer low flow periods. Results of temperature monitoring showed increases above threshold levels beginning in June and continuing through the summer months, returning below threshold levels towards the end of August.

Furthermore, low mainstem water levels in conjunction with mainstem channel down-cutting in recent years has resulted in an elevation difference where the outflow channel is perched above the mainstem in years of lower winter and summer flows, resulting in restrictions to both adult access and later juvenile outmigration. The seasonal cessation of intake flows and outlet disconnection are unfavourable for sustained channel function, and by extension, contribution to system productivity, without further, possibly significant site modifications or intervention.

With decreasing DO levels, reduced seasonal discharge and groundwater inputs, and elevated temperatures – habitat conditions will invariably decline along with restrictions in channel accessibility, essentially inhibiting seasonal juvenile outmigration and restricting localized movements between preferred habitats, isolating or trapping 'resident' salmonids in unfavorable conditions. As conditions further decline leading into and through summer low-flow periods, remaining residents would undoubtedly be exposed to lethal or sub-lethal conditions, thereby reducing fitness and contributing to elevated mortalities (including through predation by trout & other wildlife). Survivability between years under such conditions would be questionable, though highly variable, and most likely predicated on seasonal changes in channel flow and any potential, related improvements in ambient conditions. These results point to the need for assured consistency of flow (defined minimum flows) to enhance physical habitat suitability and to meet salmonid life-stage requirements. Furthermore, documented limitations to availability and security in seasonal groundwater supply emphasize the critical importance of understanding the inter-relationship between channel condition/dynamics to site selection/potential to achieve specific design criteria to secure required target flows.

7 RECOMMENDATIONS

Any feasibility or future operational considerations with respect to surface water intake alterations is beyond the scope of this assessment and should be evaluated based on the results of this assessment in conjunction with other relevant existing information, and consideration of any additional information gaps identified through this assessment.

In the short term, based on the sidechannel habitat suitability parameters documented in this assessment, such as the apparent need for greater or more consistent flows to address intake limitations; perched outlet channel morphology above the mainstem; and limited groundwater contributions; *continued operation of the existing intake would be required to meet minimum habitat suitability requirements in the absence of long-term solutions.*

Furthermore, according to documented groundwater habitat suitability limitations it should be acknowledged that short-term enhancement expectations should reflect the reality of documented fisheries use and channel productivity, reflected in habitat suitability and predicated on annual variations in flow.

In view of site characteristics and groundwater flow limitations; beaver dam and beaver activity management objectives should be clarified as these will likely remain ongoing factors limiting adult and juvenile fish migration and access throughout the sidechannel irrespective of flow regime or site modifications/intervention.

Based on evaluation of the findings of this report, and subject to production expectations of the channel under continued surface flow intake operation; additional assessment would be recommended to account for: a) channel flow monitoring under full intake operation (replicate or similar to groundwater approach), b) identification of any other potential, key information/data gaps and c) to establish a baseline/benchmark for channel productive capacity (potential) and/or assess contribution to system productive output.

Any future considerations around modifications to mainstem surface water intake (or alternatives) for continued/long term security of surface flows should take into account the following: fisheries objectives based on channel habitat suitability limitations, updated assessment of channel reach dynamics, site protection and stability, intake accessibility for operations and maintenance, and provision of required flows and security of/compliance with provincial water license requirements.

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9 APPENDIX A – HABITAT ASSESSMENT RAW DATA

Reach 1

Habitat Information (All Pool and Cross Section Data)

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Pool	7.00	18.00	11.00	6.70	73.70	73.70	100.00	0.68	0.00	6.70	100.00	0	0	0	0	100	0	28	0	5	0	0.00	12	7.31	0	0	0	0	0	0	G/SH	M/PS	-
2	Pool	18.00	30.00	12.00	8.40	100.80	100.80	100.00	0.90	-	8.40	100.00	0	0	0	0	100	0	28	0	5	0	0.00	13	9.10	0	0	0	0	0	0	G/SH	M/PS	-
3	Pool	30.00	40.00	10.00	8.20	82.00	82.00	100.00	0.82	-	8.20	100.00	0	0	0	0	100	0	28	0	5	0	0.00	8	6.56	0	0	0	0	0	0	G/SH	M/PS	-
4	Pool	40.00	60.00	20.00	6.60	132.00	132.00	100.00	0.62	-	6.60	100.00	0	0	0	0	100	0	28	0	5	0	0.00	7	2.31	0	0	0	0	0	0	G/SH	M/PS	-
5	Pool	60.00	80.00	20.00	7.70	154.00	154.00	100.00	1.04	-	7.70	100.00	0	0	0	0	100	0	28	0	5	0	0.00	10	3.85	0	0	0	0	0	0	G/SH	M/PS	-
6	Pool	80.00	100.00	20.00	6.00	120.00	120.00	100.00	0.61	-	6.00	100.00	0	0	0	0	100	0	28	0	5	0	0.00	12	3.60	0	0	0	0	0	0	G/SH	M/PS	-
7	Pool	100.00	120.00	20.00	8.50	170.00	170.00	100.00	0.56	-	8.50	100.00	0	0	0	0	100	0	28	0	5	0	0.00	10	4.25	0	0	0	0	0	0	G/SH	M/PS	-
8	Pool	120.00	145.00	25.00	8.60	215.00	215.00	100.00	0.62	-	8.60	100.00	0	0	0	0	100	0	28	0	5	0	0.00	14	4.82	0	0	0	0	0	0	G/SH	M/PS	-
9	Pool	145.00	160.00	15.00	6.00	90.00	90.00	100.00	0.52	0.01	6.00	100.00	0	0	0	80	20	0	28	0	5	0	0.00	11	4.40	0	0	0	0	0	0	G/SH	M/PS	42 m^2 gravel
	Reach Totals and Averages		160.00	153.00	7.41	1137.50	1185.78	100.00	0.81	0.01	7.41	100.00	0	0	0	9	91	0	28	0	5	0	0.00	97	4.70	0	0	0	0	0	0			

Reach 2

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Pool	5.00	30.00	25.00	6.00	150.00	150.00	100.00	0.40	0.00	6.00	100.00	0	0	20	80	0	2	75	1	3	5	0.00	20	4.80	0	0	0	0	0	0	SH/PS	SH	
2	Pool	30.00	70.00	40.00	6.00	240.00	240.00	100.00	0.73	-	6.00	100.00	0	10	10	0	80	2	75	1	3	5	0.00	23	3.45	0	0	0	0	0	0	SH/PS	SH	
3	Pool	70.00	110.00	40.00	6.00	240.00	240.00	100.00	0.66	-	6.00	100.00	10	0	10	0	80	2	75	1	3	5	0.00	18	2.70	0	0	0	0	0	0	SH/PS	SH	
4	Pool	110.00	160.00	50.00	7.50	375.00	375.00	100.00	0.72	-	7.50	100.00	0	10	0	0	90	2	75	1	3	5	0.00	29	4.35	0	0	0	0	0	0	SH/PS	SH	Beaver lodge at 155 m
5	Pool	160.00	200.00	40.00	7.50	300.00	300.00	100.00	0.99	-	7.50	100.00	50	0	0	0	50	2	75	1	3	5	0.00	30	5.63	0	0	0	0	0	0	SH/PS	SH	
6	Pool	200.00	220.00	20.00	6.00	120.00	120.00	100.00	0.51	0.02	6.00	100.00	0	10	0	10	80	2	75	1	3	5	0.00	21	6.30	0	0	1	21	8	RB	SH/PS	SH	
	Reach Totals and Averages		215.00	215.00	6.50	1425.00	1397.50	100.00	0.67	0.02	6.50	100.00	10	5	7	15	63	2	75	1	3	5	0.00	141	4.26	0	0	1	10	4				

Reach 3

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Pool	15.00	40.00	25.00	9.00	225.00	225.00	100.00	0.26	0.00	9.00	100.00	0	0	0	0	100	0	15	0	3	30	50.00	17	6.12	0	0	0	0	0	0	M/YF	SH/PS	
2	Pool	40.00	90.00	50.00	6.50	325.00	325.00	100.00	0.19	-	6.50	100.00	0	0	0	0	100	0	15	0	3	30	50.00	10	1.30	0	0	0	0	0	0	M/YF	SH/PS	Spring Intake
3	Pool	90.00	140.00	50.00	10.40	520.00	520.00	100.00	0.23	-	10.40	100.00	0	0	0	0	100	0	15	0	3	30	50.00	7	1.46	0	0	0	0	0	0	M/YF	SH/PS	
4	Pool	140.00	152.00	12.00	14.00	168.00	168.00	100.00	0.35	-	14.00	100.00	0	0	0	0	100	0	15	0	3	30	50.00	7	8.17	0	0	0	0	0	0	M/YF	SH/PS	
5	Pool	152.00	180.00	28.00	13.00	364.00	364.00	100.00	0.67	0.09	13.00	100.00	0	0	0	0	100	0	15	0	3	30	50.00	7	3.25	0	0	1	0	0	0	M/YF	SH/PS	Beaver dam at 160 m
6	Pool	180.00	214.00	34.00	11.00	374.00	374.00	100.00	0.52	1.42	11.00	100.00	0	0	0	0	100	0	15	0	3	30	50.00	2	0.65	0	0	0	0	0	0	M/YF	SH/PS	
	Reach Totals and Averages		214.00	199.00	10.65	1976.00	2279.10	100.00	0.37	0.50	10.65	100.00	0	0	0	0	100	0	15	0	3	30	50.00	50	2.68	0	0	1	0					

Reach 4

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Pool	10.00	20.00	10.00	6.50	65.00	65.00	100.00	0.59	0.00	6.50	100.00	0	0	0	10	90	0	11	0	2	4	20.00	10	6.50	0	0	1	0	0	0	SH	SH	Beaver Dam at 2.5 m
2	Pool	20.00	50.00	30.00	7.20	216.00	216.00	100.00	0.66	-	7.20	100.00	0	0	0	0	100	0	11	0	2	4	20.00	7	1.68	0	0	1	0	0	0	SH	SH	Beaver Dam at 13.0 m
3	Pool	50.00	70.00	20.00	4.30	86.00	86.00	100.00	0.76	-	4.30	100.00	0	0	0	10	90	0	11	0	2	4	20.00	10	2.15	0	0	0	0	0	0	SH	SH	
4	Pool	70.00	90.00	20.00	6.00	120.00	120.00	100.00	0.60	-	6.00	100.00	0	0	0	0	100	0	11	0	2	4	20.00	7	2.10	0	0	0	0	0	0	SH	SH	
5	Pool	90.00	100.00	10.00	7.00	70.00	70.00	100.00	0.77	0.62	7.00	100.00	0	0	0	0	100	0	11	0	2	4	20.00	4	2.80	0	0	0	0	0	0	MF	MF	
	Reach Totals and Averages		100.00	90.00	6.20	557.00	620.00	100.00	0.68	0.62	6.20	100.00	0	0	0	4	96	0	11	0	2	4	20.00	38	2.62	0	0	2	0	0	0			

Reach 5

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Pool	9.00	30.00	21.00	16.80	352.80	352.80	100.00	0.69	0.00	16.80	100.00	0	0	0	0	100	0	6	0	5	15	10.00	13	10.40	0	0	0	0	0	0	M/YF	SH	
2	Pool	30.00	55.00	25.00	21.00	525.00	525.00	100.00	0.64	-	21.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	6	5.04	0	0	0	0	0	0	M/YF	SH	
3	Pool	55.00	75.00	20.00	23.00	460.00	460.00	100.00	0.65	-	23.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	11	12.65	0	0	0	0	0	0	M/YF	SH	
4	Pool	75.00	100.00	25.00	37.00	925.00	925.00	100.00	0.63	-	37.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	10	14.80	0	0	0	0	0	0	M/YF	SH	
5	Pool	100.00	130.00	30.00	39.00	1170.00	1170.00	100.00	0.64	-	39.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	7	9.10	0	0	0	0	0	0	M/YF	SH	
6	Pool	130.00	157.00	27.00	41.00	1107.00	1107.00	100.00	0.53	-	41.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	3	4.56	0	0	0	0	0	0	M/YF	SH	
7	Pool	157.00	170.00	13.00	43.00	559.00	559.00	100.00	1.01	0.03	43.00	100.00	0	0	0	0	100	0	6	0	5	15	10.00	3	9.92	0	0	1	0	0	0	M/YF	SH	Beaver dam under bridge at 170 m
	Reach Totals and Averages		170.00	161.00	31.54	5098.80	5362.29	100.00	0.69	0.03	31.54	100.00	0	0	0	0	100	0	6	0	5	15	10.00	53	10.38	0	0	1	0					

Reach 6

Unit	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	Substrate Percent Bld	Substrate Percent Cob	Substrate Percent Grv	Substrate Percent Fine	Percent Instream Cover Bold	Percent Instream Cover LWD	Percent Instream Cover Cutbk	Percent Instream Cover OverVg	Percent Instream Cover InVg	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)	Vegetation Type Right	Vegetation Type Left	Comments
1	Glide	5.00	20.00	15.00	2.00	0.00	30.00	0.00	0.34	0.00	3.00	66.67	0	0	60	0	40	2	4	0	85	0	80.00	0	0.00	0	0	0	22	3	LB	D/PS	D/PS	
2	Glide	20.00	35.00	15.00	1.50	0.00	22.50	0.00	0.15	-	2.00	75.00	0	0	80	20	0	2	4	0	85	0	80.00	1	0.13	0	0	0	0	0	0	D/PS	D/PS	
3	Glide	35.00	50.00	15.00	0.90	0.00	13.50	0.00	0.05	-	1.50	60.00	0	0	20	80	0	2	4	0	85	0	80.00	1	0.10	0	0	0	0	0	0	D/PS	D/PS	
4	Glide	50.00	64.00	14.00	1.60	0.00	22.40	0.00	0.14	-	2.50	64.00	0	0	10	10	80	2	4	0	85	0	80.00	1	0.18	0	0	0	0	0	0	D/PS	D/PS	
5	Glide	64.00	91.00	27.00	0.50	0.00	13.50	0.00	0.30	2.50	1.00	50.00	0	0	0	60	40	2	4	0	85	0	80.00	0	0.00	0	0	0	0	0	0	D/PS	D/PS	Subsurface flow through gravel
	Reach Totals and Averages		91.00	86.00	1.30	0.00	118.30	0.00	0.20	2.50	2.00	65.00	0	0	34	34	32	2	4	0	85	0	80.00	3	0.07	0	0	0	24	3				

10 APPENDIX B – FISH ENUMERATION RAW DATA

Prelim Survey (Jan 2014)

Project:	**Connolly Sidechannel**			**Date:**	**16-Jan-14**		**Data collector(s):**		**DFO, Current, ORES**			
	Prelim. Fish Collection			**Time:**	**1000-**		**Wx:**	**Overcast, 6 deg C, Wind calm**				
									Cray or	**Salmonid only**		
Reach	**Trap**	**Time In**	**Time Out**	**Wetted Time**	**CO**	**CT**	**SB**	**SC**	**Salam**	**Length (mm)**	**Weight (g)**	**Comments**
1	T1	1100	1000	2300	1		21			90	8.04	All infected with Neascus unless noted "healthy", age +2
	T2	1100	1000	2300	1		25	1		90	6.74	Sculpin ID to be done fr photo
	T3	1100	1005	2305			3	1				
	Trout 1	1100	1005	2305			2		1			Cray
	T4	1100	1010	2310	1		8			65	3.88	
					1					92	6.75	
					1					90	8.1	
					1					100	10.42	
					1					127	22.5	Age +3 (?)
					1					85	5.93	
					1					65	3.95	
					1					55	2.03	
	T5	1100	1010	2310			17	4				
	T6	1100	1015	2315			2					
	T7	1100	1020	2320			19					
	T8	1100	1025	2325	1		11	2		85	5.69	
					1					70	4.08	
	T9	1100	1030	2330	1		14			120	16.3	
					1					60	2.7	
					1					94	8	
	T10	1100	1036	2336	1		10	2		92	8.45	
					1					74	-	Fish dropped before weighed
2	T11	1120	1040	2320	1		3			92	7.8	
					1					94	7.3	
					1					85	6.2	
	T12	1120	1043	2323			4					
	T13	1120	1045	2325	1		45	1		87	8.48	CO Healthy, lacking parasite, appears "plump"
					1					95	8.82	CO Healthy, lacking parasite, appears "plump"
					1					100	10.02	CO Healthy, lacking parasite, appears "plump"
					1					84	5.1	CO Healthy, lacking parasite
					1					61	2.89	
	Trout 2	1120	1050	2330		1	11			300	-	Too heavy for scale weight measurement
	T14	1120	1050	2330	1		24			88	6.3	
					1					78	5.5	
					1					84	5.6	
					1					80	4.9	
	T15	1120	1055	2335	1		45			-	-	Fish dropped before length/weight measurement
	Trout 3	1120	1055	2335			1					
	T16	1120	1055	2335	1		40			76	4.48	
					1					71	3.28	
					1					106	11.52	CO Healthy, lacking parasite, appears "plump"
					1					104	10.53	
	T17	1120	1055	2335	1		60			90	7.4	
					1					98	9.4	
					1					115	13.5	
					1					94	8.2	
					1					80	5.3	
					1		3.42			70	3.4	
	T18	1120	1055	2335	1		40			88	7.1	
					1					83	5.67	
					1					90	7.38	

3	T19		1125	2300	1		20	0		98	8.15	T19 & T20 - ON EITHER SIDE OF UPPER BVR DAM - CH-LF
					1					90	7.57	
					1					107	11.43	
					1					108	12.4	
					1					106	10.86	
					1					95	8.12	Brownish coloured snout?
					1					70		
	T20		1135		1					81	5.25	
					1					95	8.82	
					1					78	4.3	Spotted-caudal fin
					1					81	5.6	
					1					82	4.81	
					1					87	6.62	
					1					106	10.51	
					1					91	8.08	
					1					91	7.29	
					1					96	9.96	
					1					94	8.3	
					1					89	6.38	
	T21		1150		0		1	0				
	Trout-4		1155		0		4	0				
	T22		1155		0		5	0	1			salamander
	T23		1200		0		25	0				
	T24		1205		0		8	0	1			salamander
	T25		1205		0		18	0				
	T26		1210		0		7	0				
4	T27	1130	1045	2315	0		22	0				
	T28				0		0	0				
	T29				0		60	0				
	T30				0		35	0				
	T31				0		15	0				
	T32				1		45	0		83	5.3	
	T33				0		30	0	2			2 salamanders
	T34				0		10	0				
5	T35	TBD	1220		0		20	0	1			
	T36				0		10	0				
	T37				0		35	0				
	T38				0		45	0				
	T39				0		7	0	1			
	T40				0		50	0				
	T41				0		45	0				
	T42				0		15	0				
	T51				0		45	0				
	T52				0		50	0				
	T53				1		20	0		71	3.8	
					1					90	6.7	
6	T43	TBD	1230		1		6	0		68	3.5	
	T44				0		1	0				
	T45				0		0	0				
	T46				0		0	0				
	T47				0	1	0	0		125	17.3	Cutthroat trout
	T48				1		0	0		70	4.7	
	T49				0		0	0				
	T50				0		0	0				

NOTES

1 Given size categories - would appear we have possibly (3) different age-classess - requires confirmation
2 Many of the coho captured appeared to have a parasite Neascus=??) - should confirm type/implications (see note above)
3 Observation: coho captured lower within the channel/mid-channel area appeared "healthier" - better condition factor
4 Only 2 trout captured (all cuts) though observed more adults within channel - particularly upper to mid channel
5 Water temperraures within channel for Jan. 15/16th ranged between: 6.2 - 7.6 oC
6 All traps baited/set for an 22 - 24 hour period.
7 Channel outflow was "good" with full connection to mainstem - slight cobble drop (@ 15-20 cm) to connect with mainstem flows.
8 During time of trapping (Jan. 15/16) - WSC gauge sdtation discharge ranmged btw approx. 17 - 13 cm - receeding over the two day period. Channel outflow connection was observed on Jan. 10th - when CWS readings were 5 cms.

Enumeration Survey (April 2014)

Project:	Connolly Sidechannel		Date:	01-Apr-14		Data collector(s):		DFO, Current, ORES				
	Fish Collection		Time:	1030		Wx:	Sun, 15 deg C, Wind calm					
								Cray or	Salmonid only			
Reach	Trap	Time In	Time Out	Wetted Time	CO	CT	SB	SC	Salam	Length (mm)	Weight (g)	Comments
1	T1	1045	1040	2355			50					Upst end begins dnst of isolation net at approx. 10 m
	T2	1045	1040	2355			50					
	T3	1045	1040	2355			30					
	T4	1045	1040	2355			40	3				
	T5	1045	1040	2355			50					
	T6	1045	1040	2355	1		40			85	6.0	
	T7	1045	1040	2355			50	1				
	T8	1045	1040	2355			40					
	T9	1045	1040	2355	1		30			65	2.5	
	T10	1045	1040	2355	1		0			55	2.5	
	T11	1045	1040	2355			20	1				
	T12	1045	1040	2355			15		1			Salamander
	T13	1045	1040	2355			15					
	T14	1045	1040	2355			2					
	T15	1045	1040	2355			30					
	Trout 1	1055	1115	2420			0	8				Dnst end at bridge x-ing
2	T16	1055	1125	2430	1		15			100	11.0	Upst end at bridge crossing
	T17	1055	1125	2430			20					
	T18	1055	1125	2430			30					
	T19	1055	1125	2430			20					
	T20	1055	1125	2430			30					
	T21	1055	1125	2430			60	1				
	T22	1055	1125	2430			20					
	T23	1055	1125	2430			20					
	T24	1055	1125	2430	1		20			85	6.6	
	T25	1055	1125	2430			50					
	T26	1055	1125	2430			35	1				
	T27	1055	1125	2430			60					
	T28	1055	1125	2430	1		50		1	102	12.5	
	T29	1055	1125	2430	2		30			35	7.5	
										95	8.1	
	T30	1105	1153	2448			40					
	Trout 2	1130	1125	2395			5	2				
3	T31	1105	1030	2325			30					Backwatered by dnst beaver dam
	T32	1105	1030	2325			20					
	T33	1105	1030	2325			15					
	T34	1105	1030	2325			35					
	T35	1105	1030	2325			30					
	T36	1105	1030	2325			30					
	T37	1105	1030	2325			50					
	T38	1105	1030	2325			40		2			Salamander
	T39	1105	1030	2325			40					
	T40	1105	1030	2325			40		1			Salamander
	T41	1105	1030	2325			45					
	T42	1105	1030	2325			2					
	T43	1105	1030	2325	1		25			83	-	No weight measurement taken
	T44	1105	1030	2325			15					
	T45	1110	1100	2350	1		50			90	7.9	
	T86	1145	1200	2415			20					
	T87	1145	1200	2415			20		2			Salamander
	T88	1145	1200	2415			15		1			Salamander
	T89	1145	1200	2415			20		1			Salamander
	T90	1145	1200	2415			20					
4	T46	1130	1135	2405			15					
	T47	1130	1135	2405			25					
	T48	1130	1135	2405	4		30			93	8.3	
										90	7.3	
										78	5.2	
										75	5.7	
	T49	1130	1135	2405			30					
	T50	1130	1135	2405			4					
	T51	1130	1135	2405	3		30			87	7.0	
										77	4.8	
										72	4.0	
	T52	1130	1135	2405			10					
	T53	1130	1135	2405			4		1			Salamander
	T54	1130	1135	2405			2		1			Salamander
	T55	1130	1135	2405			10					
	T56	1130	1135	2405	1		5			122	17.4	
	T57	1130	1135	2405			15					
	T58	1130	1135	2405			30		1			Salamander
	T59	1130	1135	2405			10		1-1			1 Salamander - 1 Cray
	T60	1130	1135	2405			1					
	Trout 3	1140	1200	2420			6		1			Salamander

5	T61	1145	1115	2330			20					
	T62	1145	1115	2330			7					
	T63	1145	1115	2330			30					
	T64	1145	1115	2330			20					
	T65	1145	1115	2330			25					
	T66	1145	1115	2330	1		5		1	95	8.6	Salamander
	T67	1145	1115	2330			20					
	T68	1145	1115	2330			20		1			Salamander
	T69	1145	1115	2330			5		4			Salamander
	T70	1145	1115	2330	1		20		1	98	11.0	Salamander
	T71	1145	1115	2330			5		6			Salamander (green)
	T72	1145	1115	2330								
	T73	1145	1115	2330			10					
	T74	1145	1115	2330			7		2			Salamander
	T75	1145	1115	2330			3		1			Salamander
	Trout 4	1155	1115	2340			2					
	T79	1205	1200	2355			20					
6	T76	1205	1200	2355			1					
	T77	1205	1200	2355								
	T78	1205	1200	2355	4		2			115	17.9	+2 age
										87	6.4	
										65	4.4	
										71	3.8	
	T80	1205	1200	2355								
	T81	1205	1200	2355								
	T82	1205	1200	2355	1					81	5.7	
	T83	1205	1200	2355								
	T84	1205	1200	2355								
	T85	1205	1200	2355								
	Trout 5	1205	1200	2355								
										Mean		
Total Catch					25	0	1978	17	29	84	7.6	

NOTES

1 No trout captured and none observed in channel.
2 All traps baited/set for an 23 - 24.5 hour period.
3 Channel outflow was "good" with full connection to mainstem - slight cobble drop (@ 15-20 cm) to connect with mainstem flows.

Project:	Connolly Sidechannel			Date:	02-Apr-14		Data collector(s):	DFO, Current, ORES				
	Fish Collection			Time:	1000		Wx:	Sun/cloud, 12 deg C, Wind calm				
									Cray or	Salmonid only		
Reach	Trap	Time In	Time Out	Wetted Time	CO	CT	SB	SC	Salam	Length (mm)	Weight (g)	Comments
1	T1	1040	1010	2355			30					Upst end begins dnst of isolation net at approx. 10 m
	T2	1040	1010	2355			30					
	T3	1040	1010	2355			50					
	T4	1040	1010	2355			30	1				
	T5	1040	1010	2355			20					
	T6	1040	1010	2355			20					
	T7	1040	1010	2355			10		1			Salamander
	T8	1040	1010	2355			20					
	T9	1040	1010	2355			20					
	T10	1040	1030	2355			20					
	T11	1040	1030	2355			2					
	T12	1040	1030	2355			8					
	T13	1040	1030	2355			30					
	T14	1040	1030	2355			3		1			Salamander
	T15	1040	1030	2355			3					
	Trout 1	1115	1035	2320	1		20			70	3.2	Dnst end at bridge x-ing
2	T16	1125	1035	2320			10					Upst end at bridge crossing
	T17	1125	1035	2310			1					
	T18	1125	1035	2310	1		15			85	7.0	
	T19	1125	1035	2310			10					
	T20	1125	1035	2310	1		10			85	7.0	
	T21	1125	1035	2310			20					
	T22	1125	1035	2310			12					
	T23	1125	1035	2310			6					
	T24	1125	1035	2310			20					
	T25	1125	1035	2310			20					
	T26	1125	1100	2335			50					
	T27	1125	1100	2335			40					
	T28	1125	1100	2335			30		1			Salamander
	T29	1125	1100	2335			20					
	T30	1150	1100	2310			10					
	Trout 2	1125	1035	2310			15					
3	T31	1030	1010	2340			12		1			Salamander
	T32	1030	1010	2340			8					
	T33	1030	1010	2340			10					
	T34	1030	1010	2340			6					
	T35	1030	1010	2340			12					
	T36											Trap not returned to water
	T37	1030	1010	2340			25					
	T38	1030	1010	2340			10					
	T39	1030	1010	2340			25					
	T40	1030	1030	2400			6					
	T41	1030	1030	2400			25					
	T42	1030	1030	2400	1		15			114	15.1	
	T43	1030	1030	2400			8					
	T44	1030	1030	2400			15					
	T45	1100	1030	2330			25		1			Salamander
	T86	1200	1100	2300			10					
	T87	1200	1100	2300	1		8					
	T88	1200	1100	2300			12					
	T89	1200	1100	2300			6					
	T90	1200	1100	2300			7					
4	T46	1135	1035	2330			1					
	T47	1135	1035	2330			10					
	T48	1135	1035	2330			5					
	T49	1135	1035	2300			12					
	T50	1135	1035	2300			3		3			3 Crayfish
	T51	1135	1035	2300			8					
	T52	1135	1100	2325			2		1			Salamander
	T53	1135	1100	2325			0					
	T54	1135	1100	2325	1		4	1		100	12.1	
	T55	1135	1100	2325			6		2			Salamander
	T56	1135	1100	2325	2		10		1	75	4.1	Salamander
										70	3.8	
	T57	1135	1100	2325			12					
	T58	1135	1100	2325			15					
	T59	1135	1100	2325			3		1			Crayfish
	T60	1135	1100	2325			5					
	Trout 3	1200	1100	2300			1					

5	T61	1115	1010	2255			1				
	T62	1115	1010	2255			15				
	T63	1115	1010	2255			12				
	T64	1115	1010	2255			3				
	T65	1115	1010	2255			15				
	T66	1115	1010	2255			20				
	T67	1115	1010	2255			20				
	T68	1115	1010	2255			8		1		
	T69	1115	1010	2255			15				
	T70	1115	1030	2315			20				
	T71	1115	1030	2315			15		2		
	T72	1115	1030	2315	1		9		1	82	6.1
	T73	1115	1030	2315			10				
	T74	1115	1030	2315							
	T75	1115	1030	2315					1		
	Trout 4	1115	1030	2315			1				
	T79	1200	1035	2225							
6	T76	1200	1035	2225			1				
	T77	1200	1035	2225							
	T78	1200	1035	2225	3		10			65	4.0
										80	5.1
										60	3.1
	T80	1200	1035	2225			3				
	T81	1200	1035	2225					2		
	T82	1200	1035	2225							
	T83	1200	1035	2225			1				
	T84	1200	1100	2300							
	T85	1200	1100	2300							
	Trout 5	1200	1100	2300			1				
										Mean	
Total Catch					12	0	1127	2	20	81	6.4

NOTES

1 No trout captured and none observed in channel.

2 All traps baited/set for an 23 - 24.5 hour period.

3 Channel outflow was "good" with full connection to mainstem - slight cobble drop (@ 15-20 cm) to connect with mainstem flows.

Project: Connolly Sidechannel Fish Collection | Date: 03-Apr-14 | Time: 830 | Data collector(s): DFO, Current, ORES | Wx: Sun/cloud, 12 deg C, Wind calm

Reach	Trap	Time In	Time Out	Wetted Time	CO	CT	SB	SC	Cray or Salam	Salmonid only Length (mm)	Weight (g)	Comments
1	T1	1010	930	2320			50	1				Upst end begins dnst of isolation net at approx. 10 m
	T2	1010	930	2320			40					
	T3	1010	930	2320			20					
	T4	1010	930	2320			20					
	T5	1010	930	2320			20					
	T6	1010	930	2320			20					
	T7	1010	930	2320			15					
	T8	1010	930	2320			40					
	T9	1010	930	2320			30					
	T10	1030	930	2320			20					
	T11	1030	930	2320			15					
	T12	1030	930	2320			4					
	T13	1030	930	2320			20					
	T14	1030	930	2320			10					
	T15	1030	930	2320			10					
	Trout 1	1035	930	2320			5	3				Dnst end at bridge x-ing
2	T16	1035	950	2315			10					Upst end at bridge crossing
	T17	1035	950	2315			15					
	T18	1035	950	2315			10	1				
	T19	1035	950	2315			10	2				
	T20	1035	950	2315			10					
	T21	1035	950	2315			10					
	T22	1035	950	2315			10					
	T23	1035	950	2315			10					
	T24	1035	950	2315			20					
	T25	1035	950	2315			20					
	T26	1100	950	2315			30					
	T27	1100	950	2315			20					
	T28	1100	950	2315			30					
	T29	1100	950	2315			3					
	T30	1100	950	2315	1		15			90	9.3	
					1					80	5.4	
	Trout 2	1035	950	2315			10		1			Crayfish
3	T31	1010	930	2320			4					
	T32	1010	930	2320			15		3			Salamander
	T33	1010	930	2320			1		1			Salamander
	T34	1010	930	2320			7					
	T35	1010	930	2320			10					
	T36	1010	930	2320			12					Trap not returned to water
	T37	1010	930	2320	1		10			75	4.4	
	T38	1010	930	2320			4					
	T39	1010	930	2320			12					
	T40	1030	930	2320			25					
	T41	1030	930	2300			2					
	T42	1030	930	2300			20					
	T43	1030	930	2300			10					
	T44	1030	930	2300			1		1	85	6.6	Salamander
	T45	1030	930	2300			2		1	95	8.8	Cray
	T86	1100	930	2230	1		6					
	T87	1100	930	2230	1		10					
	T88	1100	930	2230			9					
	T89	1100	930	2230			5		7			Salamander
	T90	1100	930	2230			2					
4	T46	1035	950	2315			3					
	T47	1035	950	2315			5					
	T48	1035	950	2315			3					
	T49	1035	950	2315			3					
	T50	1035	950	2315			1					3 Crayfish
	T51	1035	950	2315			4					
	T52	1100	950	2310								Salamander
	T53	1100	950	2325								
	T54	1100	950	2325			1					
	T55	1100	950	2325			2					Salamander
	T56	1100	950	2325			10					Salamander
	T57	1100	950	2325			10					
	T58	1100	950	2325								
	T59	1100	950	2325			8					Crayfish
	T60	1100	950	2325			1					
	Trout 3	1100	950	2325			2					

5	T61	1010	930	2320			8		1			Crayfish
	T62	1010	930	2320			8					
	T63	1010	930	2320			1					
	T64	1010	930	2320			6					
	T65	1010	930	2320			1					
	T66	1010	930	2320			2					
	T67	1010	930	2320			2		4			Salamander (green)
	T68	1010	930	2320			4					
	T69	1010	930	2320			6		2			Salamander (green)
	T70	1030	930	2300			10					
	T71	1030	930	2300			5					
	T72	1030	930	2300			10					
	T73	1030	930	2300			20					
	T74	1030	930	2300			12		1			Salamander (green)
	T75	1030	930	2300			10					
	T76	1030	930	2300								
	T77	1030	930	2300								
	Trout 4	1030	930	2300			1		2			
	T79	1035	930	2300			1					
6	T76	1035	950	2315	1		2			75	5.7	
	T77	1035	950	2315								
	T78	1035	950	2315								
	T80	1035	950	2315								
	T81	1035	950	2315								
	T82	1035	950	2315								
	T83	1035	950	2315			1					
	T84	1100	950	2310								
	T85	1100	950	2310								
	Trout 5	1100	950	2310								
										Mean		
Total Catch					6	0	902	7	24	83	7	
NOTES												
	1	No trout captured and none observed in channel.										
	2	All traps baited/set for an 22.5 - 23.5 hour period.										
	3	Channel outflow was "good" with full connection to mainstem - slight cobble drop (@ 15-20 cm) to connect with mainstem flows.										

Enumeration Survey (September 2014)

Project:	Connolly Sidechannel		Date:	Sept. 11, 2014		Data collector(s):		DFO, Current, ORES				
	Fish Collection		Time:	1000		Wx:	Sun, 18 deg C, Wind calm					
								Cray or	Salmonid only			
Reach	**Trap**	**Time In**	**Time Out**	**Wetted Time**	**CO**	**CT**	**SB**	**SC**	**Salam**	**Length (mm)**	**Weight (g)**	**Comments**
1	90	1100	1000	2300	2		20		2	100	9.7	
										115	14.2	
	89	1100	1000	2300			20					
	88	1100	1000	2300			5		3			
	87	1100	1000	2300			20		4			
	86	1100	1000	2300			25	1	1			
	85	1100	1000	2300			20		1			
	84	1100	1000	2300	2		15	2	1	120	16.0	Parasites
										95	7.6	Parasites
	Trout 6	1100	1000	2300				1	5			
	83	1100	1000	2300			10		5			
	82	1100	1000	2300	1			1	2	105	11.7	Parasites
	81	1100	1000	2300			15		4			
	80	1100	1000	2300	1					95	7.9	Parasites
	79	1100	1000	2300				5	1			
	78	1100	1000	2300				5				
	77	1100	1000	2300			15					
	76	1100	1000	2300			20					
	75	1100	1000	2300	1		5	1	1	125	17.0	Parasites
	74	1100	1000	2300			20					
	73	1100	1000	2300			30		1			
	72	1100	1000	2300			20		1			
	71	1100	1000	2300	2		5			100	9.6	No parasites
										95	9.6	No parasites
	70	1100	1000	2300			20		7			
	69	1100	1000	2300					1			
	68	1100	1000	2300			20		1			
	67	1100	1000	2300				1	1			
	66	1100	1000	2300			15		1			
	Trout 5	1100	1000	2300			15		1			
	65	1100	1000	2300	1		10			105	10.8	
	64	1100	1000	2300			5					
2	63	1110	1040	2330			10					
	62	1110	1040	2330								
	61	1110	1040	2330			1					
	60	1110	1040	2330								
	59	1110	1040	2330								
	58	1110	1040	2330					3			
	57	1110	1040	2330			30					
	56	1110	1040	2330			2		1			
	55	1110	1040	2330			5					
	54	1110	1040	2330	1		20		3	110	12.6	
	Trout 4	1110	1040	2330			1					
	53	1110	1040	2330			30		1			
	52	1110	1040	2330			50					
	51	1110	1040	2330			15					7 mort. 8 live SB
	50	1110	1040	2330			10					1 mort. Salamander
	49	1110	1040	2330			15		1			
	Trout 3	1110	1040	2330			5					
	48	1110	1040	2330			15					5 mort. 10 live SB
	47	1110	1040	2330			50					

3	46	1200	1130	2330								Traps tampered by racoon (?)
	45	1200	1130	2330			5					
	44	1200	1130	2330			2					
	43	1200	1130	2330			4					
	42	1200	1130	2330								
	41	1200	1130	2330								
	40	1200	1130	2330			8					
	39	1200	1130	2330			20		1			
	38	1200	1130	2330			7					
	37	1200	1130	2330			20					
	36	1200	1130	2330			6					
	35	1200	1130	2330			6					
	34	1200	1130	2330			25					
	33	1200	1130	2330			30					
	32	1200	1130	2330			1		1			
	31	1200	1130	2330			4					
5	30	1130	1135	2405			15					
	29	1130	1135	2405			15					
	28	1130	1135	2405			30					
	27	1130	1135	2405			20					
	26	1130	1135	2405			2		2			
	25	1130	1135	2405			15		2			
	Trout 2	1130	1135	2405								Trap destroyed by bear (?)
	24	1130	1135	2405			20		2			
	23	1130	1135	2405			1		1			Salamander
	22	1130	1135	2405			8					
	21	1130	1135	2405			40					
	20	1130	1135	2405			12		1			
	19	1130	1135	2405			1					
	18	1130	1135	2405			2					
	17	1140	1200	2420			2		1			Salamander
	16	1145	1115	2330								
	15	1145	1115	2330								
	14	1145	1115	2330								
	13	1145	1115	2330			2					
	12	1145	1115	2330			8					
	11	1145	1115	2330			6					
	10	1145	1115	2330					1			Salamander
	9	1145	1115	2330			1		3			Salamander
	8	1145	1115	2330			5		2			Salamander
	7	1145	1115	2330					3			Salamander
	6	1145	1115	2330			60					
	5	1145	1115	2330			25					
	4	1145	1115	2330			30					
	3	1145	1115	2330			50					Mort. SB noted in pool outside trap
	Trout 1	1145	1115	2330			2		5			
	2	1145	1115	2330			20		2			
	1	1155	1115	2340			25		1			Outflow pipe pool (handmeter temp. 13.5 deg. C)
										Mean		
Total Catch					11	0	1164	17	81	106	11.5	
NOTES												
	1	No trout captured and none observed in channel.										
	2	All traps baited/set for an 23 - 24.5 hour period.										
	3	Outflow channel (Reach 6) dry. Relic channel (Reach 4) only shallow isolated pools.										

Project:	Connolly Sidechannel		Date:	Sept. 12, 2014		Data collector(s):	DFO, Current, ORES					
	Fish Collection		Time:	950		Wx:	Sun, 17 deg C, Wind calm					
									Cray or	Salmonid only		
Reach	Trap	Time In	Time Out	Wetted Time	CO	CT	SB	SC	Salam	Length (mm)	Weight (g)	Comments
1	90	955	1000	2405			15	3	1			
	89	955	1000	2405			2	3	1			
	88	955	1000	2405			15		1			
	87	955	1000	2405			15		2			
	86	955	1000	2405			20		2			
	85	955	1000	2405					1			
	84	955	1000	2405			12		1			
	Trout 6	955	1000	2405			1		5			
	83	955	1000	2405			8					
	82	955	1000	2405			20					
	81	955	1000	2405			1		1			
	80	955	1000	2405			18		1			
	79	955	1000	2405			15					
	78	955	1000	2405			8					
	77	955	1000	2405			20					
	76	955	1000	2405			15					
	75	955	1000	2405			2					
	74	955	1000	2405			7		3			
	73	955	1000	2405				1	3			
	72	955	1000	2405			5					
	71	955	1000	2405			3					
	70	955	1000	2405			23		1			
	69	955	1000	2405			3		2			
	68	955	1000	2405								
	67	955	1000	2405			1	1	4			
	66	955	1000	2405			12					
	Trout 5	955	1000	2405			3		1			
	65	955	1000	2405					3			
	64	955	1000	2405			2		1			
2	63	955	1000	2405								
	62	955	1000	2405			1					
	61	955	1000	2405			2					
	60	955	1000	2405								
	59	1050	1015	2325			1					
	58	1050	1015	2325			4					
	57	1050	1015	2325			20		2			
	56	1050	1015	2325			5					
	55	1050	1015	2325			7		1			
	54	1050	1015	2325	1		10			110	17.4	
	Trout 4	1050	1015	2325			10		2			
	53	1050	1015	2325			45					
	52	1050	1015	2325			6					
	51	1050	1015	2325			1					
	50	1050	1015	2325			4					
	49	1050	1015	2325			8					
	Trout 3	1050	1015	2325			12					
	48	1050	1015	2325			40		1			
	47	1050	1015	2325			3					

3	46	1200	1130	2330			2					
	45	1200	1130	2330			10					
	44	1200	1130	2330			12					
	43	1200	1130	2330			3		1			Green salamander
	42	1200	1130	2330			12					
	41	1200	1130	2330			3					
	40	1200	1130	2330			12					
	39	1200	1130	2330			8					
	38	1200	1130	2330			10					
	37	1200	1130	2330			15		1			Green salamander
	36	1200	1130	2330			6					
	35	1200	1130	2330			6		2			
	34	1200	1130	2330			6					
	33	1200	1130	2330			3					
	32	1200	1130	2330								
	31	1200	1130	2330			1					
5	30	1135	1035	2300								
	29	1135	1035	2300			12					
	28	1135	1035	2300			13					
	27	1135	1035	2300			12		1			
	26	1135	1035	2300			12		3			
	25	1135	1035	2300			10					
	Trout 2						6					Trap destroyed by bear (?)
	24	1135	1035	2300			30					
	23	1135	1035	2300			8		1			Yellow salamander
	22	1135	1035	2300			25					
	21	1135	1035	2300			4					
	20	1135	1035	2300			4					
	19	1135	1035	2300			18		1			
	18	1135	1035	2300			4					
	17	1135	1035	2300			2		1			Green salamander
	16	1135	1035	2300								
	15	1135	1035	2300								
	14	1135	1035	2300			3					
	13	1135	1035	2300			10		1			Green salamander
	12	1135	1035	2300			8		1			Green salamander
	11	1135	1035	2300					1			Green salamander
	10	1135	1035	2300			1					
	9	1135	1035	2300								
	8	1135	1035	2300					1			Green salamander
	7	1135	1035	2300			40		1			Green salamander
	6	1135	1035	2300			40					
	5	1135	1035	2300			70					
	4	1135	1035	2300			30					
	3	1135	1035	2300			10					
	Trout 1	1135	1035	2300								
	2	1135	1035	2300			14					
	1	1135	1035	2300			2		1			
										Mean		
Total Catch					1	0	922	8	56	110	17.4	
NOTES												
	1	No trout captured and none observed in channel.										
	2	All traps baited/set for an 23 - 24.5 hour period.										
	3	Outflow channel (Reach 6) dry. Relic channel (Reach 4) only shallow isolated pools.										

11 APPENDIX C – WATER QUALITY DATA (DISSOLVED OXYGEN & TEMPERATURE)

Table 12. Raw Data of Dissolved Oxygen (mg/L) handmeter measurements taken by Oxyguard Handy Polaris at established sampling sites within Connolly Sidechannel from Nov. 6, 2011 – Sept. 17, 2014.

DO (mg/L)								
	DLL Chan	DL01 (below	DL01 (above	DL02 Relic	DL03	DL04	DL05	DL06
06/11/2013	7.1	3.6	6.5	8	3.5	1.9	3.9	4.9
13/11/2013	6.5	1	7.2	4	6.7	6.1	5.9	6
20/11/2013	10	4	7.1	3	2.8	4.5	5.2	5.6
26/11/2013	8	3	7.5	1.5	2.4	3.4	4.2	6.2
04/12/2013	8	1	6.6	7	2.2	2	3.7	5.5
11/12/2013	5.2	1.4	4.4	3	2.2	1.3	3.8	5.3
27/12/2013	7.4	5	6.1	4.3	4.1	5.2	6.2	6.7
03/01/2014	7.8	2	6.9	3.2	1.7	5.1	6	7.1
10/01/2014	7.3	1.4	6.7	5.3	2.3	6	6.4	7.8
15/01/2014	6.3	1.9	6.7	3.7	5.8	6.3	7.2	7.7
22/01/2014	6.8	3.3	6.5	3	3.9	6	6.8	7
29/01/2014	9.6	1.8	6.4	7.8	6.1	6.5	7.4	8.4
05/02/2014	8.7	3.3	7.3	4.6	3.4	6.1	7.4	8.3
12/02/2014	9.8	2.5	6.2	9	3.9	5.9	7.4	8.6
21/02/2014	9	5.8	7.8	8.8	7	8.6	9.2	9.4
28/02/2014	9.6	6.1	7.8	9.1	6.6	8.7	8.7	9.4
05/03/2014	8.3	5.5	8	7.2	7.2	8.5	9.4	9.7
14/03/2014	9.3	4.7	8.6	9.3	8.3	10.5	10	11.1
26/03/2014	9	1.7	8.8	8.1	3.7	8.8	8.7	9.8
02/04/2014	7.7	3.1	8.5	8.8	5.8	9.7	9.3	8.8
11/04/2014	7.5	3	8.6	8.4	5	8.4	9	8.6
18/04/2014	8.4	8	8.1	6.2	4.3	7.2	7.7	8.5
23/04/2014	7.3	4	8	7.7	7.4	8.2	8.9	9.4
30/04/2014	6.8	3	7.8	9.7	6.5	8.7	9.9	10.3
07/05/2014	6.6	8	7.6	7.5	7.4	8.1	8.7	8.5
14/05/2014	6	0	6.4	7.2	5.4	9.3	7.5	9.2
21/05/2014	5.7	1	6.8	4.6	8.1	7.6	8.4	7.7
28/05/2014	5	4	7.1	3	4.3	7.9	7.1	7.7
04/06/2014	7.2	2	6.8	2	4.8	7.3	5.7	7
11/06/2014	4.6	5	7.6	3.2	5.5	6.4	5.5	6.2
18/06/2014	5.3	1	8	3	2.9	5.1	3.6	6.7
25/06/2014	4.1	2	8.1	2.5	4	4.6	2.4	6.6
02/07/2014	5.8	1	7.1	1	3.6	3.9	1.2	5.8
09/07/2014	4.1	1	6.9	1.1	2.7	2.6	1.5	5.4
16/07/2014	4.7	2	6.5	4	3.2	3.9	6	4.4
23/07/2014	6	2	6.7	8	1.3	1.1	1.1	4.4
30/07/2014	4.8	1	3.8	6	2.9	3.6	9	5.3
06/08/2014	5.9	6	3	8	2.7	4.1	7	5.2
13/08/2014	4.8	1	2.4	1	2.3	2.8	2.5	3.7
20/08/2014	4.4	5	2.7	7	2.3	3.9	1.8	2.6
29/08/2014	5.7	4	6.7	7	1.8	3.6	4.7	2.5
03/09/2014	5.3	1.1	2.6	4	1.4	2.2	3.1	3.1
10/09/2014	5.5	1.2	5.3	4	7	2.4	5.4	4.3
17/09/2014	6.5	1.9	2.9	1.1	1.1	5.5	6.5	6.8

Figure 15. Dissolved Oxygen (mg/L) handmeter measurements taken by Oxyguard Handy Polaris at established sampling sites within Connolly Sidechannel from Nov. 6, 2011 – Sept. 17, 2014.

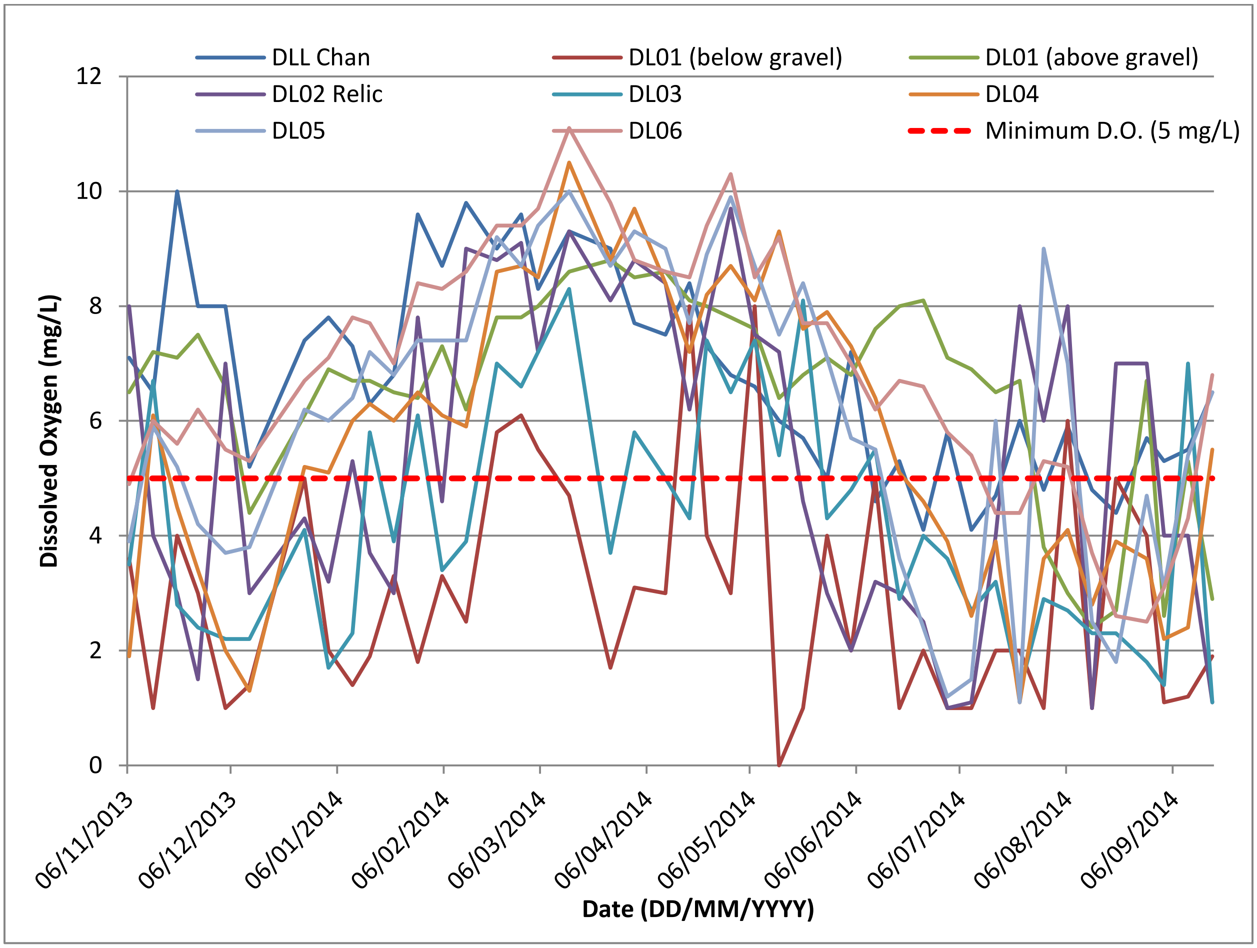

Table 13. Raw Data of Temperature (°C) handmeter measurements taken by Oxyguard Handy Polaris at established sampling sites within Connolly Sidechannel from Nov. 6, 2011 – Sept. 17, 2014.

Temperature								
	DLL Chan	DL01 (below	DL01 (above	DL02 Relic	DL03	DL04	DL05	DL06
06/11/2013	7.5	7.4	7.4	6	7	6.9	6.6	5.9
13/11/2013	8.7	8.3	8	6.9	8.1	7.9	7.2	6.7
20/11/2013	4.2	5.6	4.8	3.8	5.5	4.5	3.3	3.3
26/11/2013	5.7	6.1	5.8	3.7	5.9	5.4	4.7	3.2
04/12/2013	4.2	5.7	4.7	3.3	5.2	4.6	3.6	3.5
11/12/2013	3.5	4.2	4.2	2	4.5	3.8	2.7	1.1
27/12/2013	6.3	6.2	6.2	4.6	5.8	5.4	5	4.5
03/01/2014	5.3	6.1	5.1	4.4	5.8	4.7	4.1	3.8
10/01/2014	5.7	5.9	5.6	4.6	5.8	5.1	4.7	4.5
15/01/2014	7.6	7.5	7.5	6.2	7.2	7.1	6.9	6.7
22/01/2014	6.4	6.6	6.4	5.3	6.2	5.7	5.3	5.1
29/01/2014	6	6.2	6.4	5.5	5.9	5.8	5.4	4.7
05/02/2014	3.6	4.6	4.6	1.7	5	3.7	2.6	3.9
12/02/2014	2.5	4.7	4.6	1.8	4.2	3.5	2.3	3.5
21/02/2014	5.1	5.5	5.3	3.9	4.5	4.2	3.8	4
28/02/2014	6.4	5.5	5.8	4.3	4.8	4.9	4.2	4.1
05/03/2014	5.7	5.5	5.5	4.4	4.7	4.6	4.3	4.3
14/03/2014	7.3	6.5	7.4	6.5	6.5	6.5	6.4	6.5
26/03/2014	7.1	6.9	6.9	6.7	7	7.2	7.6	8
02/04/2014	7.3	7.3	7.8	6.7	7.6	7.3	7.4	7.8
11/04/2014	7.4	8.1	8.6	8.6	8.9	9.4	9.3	10.1
18/04/2014	7.2	8	8.2	7.9	8.3	8.5	8.1	9.1
23/04/2014	8.6	8.5	8.8	8.3	9	9.3	9.2	10.6
30/04/2014	8.8	8.6	9.9	10.2	10.9	11.8	11.6	12.6
07/05/2014	8.8	9.2	10	9.9	10.9	11.9	11.3	12.7
14/05/2014	9	9.8	11.6	12	12.7	14	13.3	15.4
21/05/2014	9.3	10.3	11.6	12.6	12.8	13.5	13.2	16.5
28/05/2014	9.8	10.6	12.8	12.3	13.5	15.5	12.8	15.6
04/06/2014	12.2	12.7	13	12.3	14.1	15	13.9	16.9
11/06/2014	12.7	12.7	13.7	14.1	15.2	16.2	15.3	17.8
18/06/2014	15.2	13.7	15.6	14.9	15.8	17.6	16.5	19.3
25/06/2014	14.2	15	15.6	15.9	16.9	17.8	17.2	19.7
02/07/2014	18.2	16.1	17.8	17.8	18.5	19.9	17.8	22.1
09/07/2014	16.2	16.4	16.4	17.3	18.2	18.9	18.2	20.9
16/07/2014	18.9	17.6	18.7	18.9	20.4	21.5	19.3	22.3
23/07/2014	19.2	17.6	18.4	16.8	18.1	18.8	18.4	19.5
30/07/2014	18.8	18	18.7	17.7	19.1	20.3	18.8	21.3
06/08/2014	19.8	18	18.8	17.5	19.1	19.9	19	20.6
13/08/2014	18.5	17.8	18.5	17.3	18.7	19.1	18.7	20.2
20/08/2014	17.5	16.3	17	16.6	17.9	17.9	16.2	18.6
29/08/2014	18.1	16.7	17.6	16	16.8	17.2	15.9	17.1
03/09/2014	14.3	13.8	14.3	14.5	15.8	15.4	14.4	16.1
10/09/2014	16.3	14.2	16.5	15.2	14.9	14.1	12.6	16.2
17/09/2014	15.3	14.1	14.6	13.3	13.9	13.6	13.6	14.7