An investigation into the feasibility of modifying derelict dams to improve salmon productivity in the Kloiya River and Rainbow Lake watersheds, British Columbia

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Executive Summary

Skeena Fisheries Commission (SFC), in partnership with the Lax Kw'alaams Fisheries Program conducted a feasibility assessment to determine whether salmon productivity in the Kloiya River and Rainbow Lake watersheds could be improved by modifying a series of derelict dams that were initially installed in the 1950s and 1960s to supply freshwater to the Skeena Cellulose (formerly Columbia Cellulose) pulp mill on Watson Island. The pulp mill has been closed since 2001, and the remaining dam structures have fallen into disrepair while continuing to impound water in two reservoirs, Taylor and Prudhomme Lake immediately upstream of the Kloiya River dam, and Diana and Rainbow Lakes upstream of a second dam on Diana Creek. A third dam, at the outlet of Rainbow Lake prevents water from flowing into the Skeena system through Boneyard Creek.

Our objectives in conducting this study were to determine whether dam infrastructure related to the Columbia/Skeena Cellulose pulp mill have negatively affected salmon populations in the Rainbow Lake and Kloiya River watersheds, and whether modifications to the existing dam system could improve fish passage and fish productivity in either system. The scope of our initial feasibility study included conducting a desktop literature review of historic correspondence, carrying out a preliminary stream habitat assessment survey of affected systems, and circulating a Request for Proposals to carry out a comprehensive hydrological study to assess the feasibility and potential hydrological impacts of modifications to the existing dam system. All of these activities have been completed at this time, and the initial results are contained in this report.

The Kloiya watershed is utilized by six (6) species of Pacific salmon: Pink (*Oncorhynchus gorbuscha*), Chum (*O. keta*), Sockeye (*O. nerka*), Coho (*O. kisutch*), Chinook (*O. tshawytscha*) and Steelhead (*O. mykiss*) salmon which spawn in Kloiya River, Diana Creek, and Prudhomme Creek. While there are insufficient data to determine the effects of the dams installed at Kloiya River and Diana Creek on salmon escapement throughout the system for all species it appears that Sockeye, Coho and Chinook salmon abundances have declined since the 1960s. We found no evidence of historic or contemporary utilization of habitats throughout the Rainbow Lake watershed by anadromous salmon species.

A review of historic correspondence identified reduced water flow as the most likely cause of reduced salmon productivity related to dam infrastructure throughout the Kloiya River system. We identified numerous other effects of the dam structures that have directly or indirectly harmed fish and altered fish habitats, including flooding of spawning areas, particularly for Sockeye salmon by elevated lake levels following dam installation in 1950 and subsequent improvements in 1961. Negative effects to fisheries caused by the dam structures include: poor gravel recruitment in the Kloiya River because of impoundment behind the Kloiya dam; the increased potential for out migrating salmon smolts to become trapped on the intake screens at the stave pipes; and increased recreational fishing pressure as a result of improved access to Kloiya River and the fish ladder.

Because there is no evidence that the Rainbow Lake watershed has ever supported anadromous salmonid populations, it is therefore unlikely that restoring connectivity between Rainbow Lake and the Skeena River by removing the dam at Boneyard Creek would result in any immediate or substantial increases in anadromous fish populations. However, modifications to the Kloiya and Diana Creek dams probably have the potential to improve existing salmon productivity, and restoration activities such as dam modifications or removal, construction of spawning channels and rearing habitat, and modifications to the existing fish ladder may improve anadromous fish passage and fish habitat in the Kloiya River system.

Introduction

Skeena Fisheries Commission (SFC), in partnership with the Lax Kw'alaams Fisheries Program conducted a preliminary feasibility assessment to determine whether salmon productivity in the Kloiya River and Rainbow Lake watersheds could be improved by modifying a series of derelict dams that were initially installed in the 1950s and 1960s to supply freshwater to the Skeena Cellulose (formerly Columbia Cellulose) pulp mill on Watson Island. The pulp mill has been closed since 2001, and the remaining dam structures have fallen into disrepair while continuing to impound water in two reservoirs, Taylor and Prudhomme Lake immediately upstream of the Kloiya River dam, and Diana and Rainbow Lakes upstream of a second dam on Diana Creek. A third dam, at the outlet of Rainbow Lake prevents water from flowing into the Skeena system through Boneyard Creek. Our objectives in conducting this investigation were to determine whether dam infrastructure related to the Columbia/Skeena Cellulose pulp mill has negatively affected salmon populations in the Rainbow Lake and Kloiya River watersheds, and whether modifications to the existing dam structures could improve fish passage and fish productivity in either system. The scope of our initial feasibility study included conducting a desktop literature review of historic correspondence, carrying out a preliminary stream habitat assessment survey of affected systems, and circulating a Request for Proposals to carry out a comprehensive hydrological study to assess the feasibility and potential hydrological impacts of modifications to the dam infrastructure. All of these activities have been completed, and the initial results are contained in this report.

For the literature review, we reviewed historic escapement information and technical reports. We also reviewed archival correspondence obtained from the Department of Fisheries (DFO) North Coast Division. The correspondence archive, which included internal correspondence between DFO officials, and external correspondence between DFO and Columbia Cellulose personnel, provided a rich and valuable perspective on the perceived and real negative effects to fish and fish habitat that were caused by Columbia Cellulose dam infrastructure, in addition to mitigation measures that were implemented to prevent losses to fish productivity in the affected systems. These letters, telegrams, memoranda, and meeting minutes have been compiled and summarized. A summary of the correspondence which we reviewed is available in Appendix 1. Items from the correspondence archive are cited in this report using the format (Author, year of writing (e.g. DFO 2015a)). For example, a letter sent from Fisheries Guardian W.S. Strachan in 1952 would be cited as (Strachan, 1952 (DFO 2015-a)).

We reviewed a number of technical and scientific reports pertaining to fish habitat utilization, including juvenile salmon studies throughout the Kloiya watershed. Historic salmon escapement data, which have been collected in the Kloiya watershed since the early 1920s, comes from two primary sources, both of which were produced by the Department of Fisheries (DFO) North Coast Stock Assessment Division. The first, the North Coast DFO SEDS (Salmon escapement data summary) database, summarizes annual escapement data for all salmon species throughout the North Coast management area. This database, which is updated annually, is referenced in this report as DF0 2015-b. The second, the DFO BC16 archive provides a summary of stream counts and field notes collected in every year that stream walks occurred. The BC16 database is referenced as DFO 2004 (the last year for which BC16 data were compiled). Finally, fish presence, fish observation, and fish sample data for most studies that have been carried out to date in both the Kloiya River and the Rainbow Lake watersheds are summarized in the Fisheries Inventory Summary System (FISS). The FISS database is also continuously updated, and herein referenced as (BC 2015). Additional information was obtained through a series of interviews with technical staff from the federal Department of Fisheries and Oceans (DFO), provincial Ministry of Environment (MoE), and the City of Prince Rupert.

Study system

The adjacent Kloiya River and Rainbow Lake watersheds historically drained in opposite directions. The coastal Kloiya watershed drains through Dennis Arm into Morse Basin southeast of the city of Prince Rupert, and east of the village of Port Edward. The major features of the Kloiya watershed include Diana Lake, at an elevation of 70m which covers approximately 240 hectares, drains into Diana Creek. An impounding dam has been in place near the outlet of Diana Lake since 1961, and the elevation and surface area of the lake vary according to the elevation of impounded water. A steep waterfall composed predominantly of boulders approximately 100 m downstream from the Diana Creek dam forms an impassable barrier for migrating salmon, however there are many high quality spawning areas throughout Diana Creek below the falls. Diana Creek empties into Prudhomme Lake approximately three kilometers downstream of the falls, where it passes under the Highway 16 bridge. Prudhomme Lake covers approximately 168 hectares at an elevation of approximately 27m approximately 1 km upstream of Taylor Lake, which drains into Kloiya River. The first Columbia Cellulose impounding dam, installed in 1950, regulates lake elevation and flow. Downstream from the Kloiya dam, the 2 km Kloiya River empties into Kloiya Bay. Spawning gravels in Kloiya River are restricted to the upper 800 m section below the Kloiya dam. Environment Canada has maintained a staff gauge approximately 500 m

downstream from the Kloiya dam since 1962. After Diana Creek, the second most important tributary to Prudhomme Lake is Prudhomme Creek, which flows into the east end of Prudhomme Lake (Figure 1).

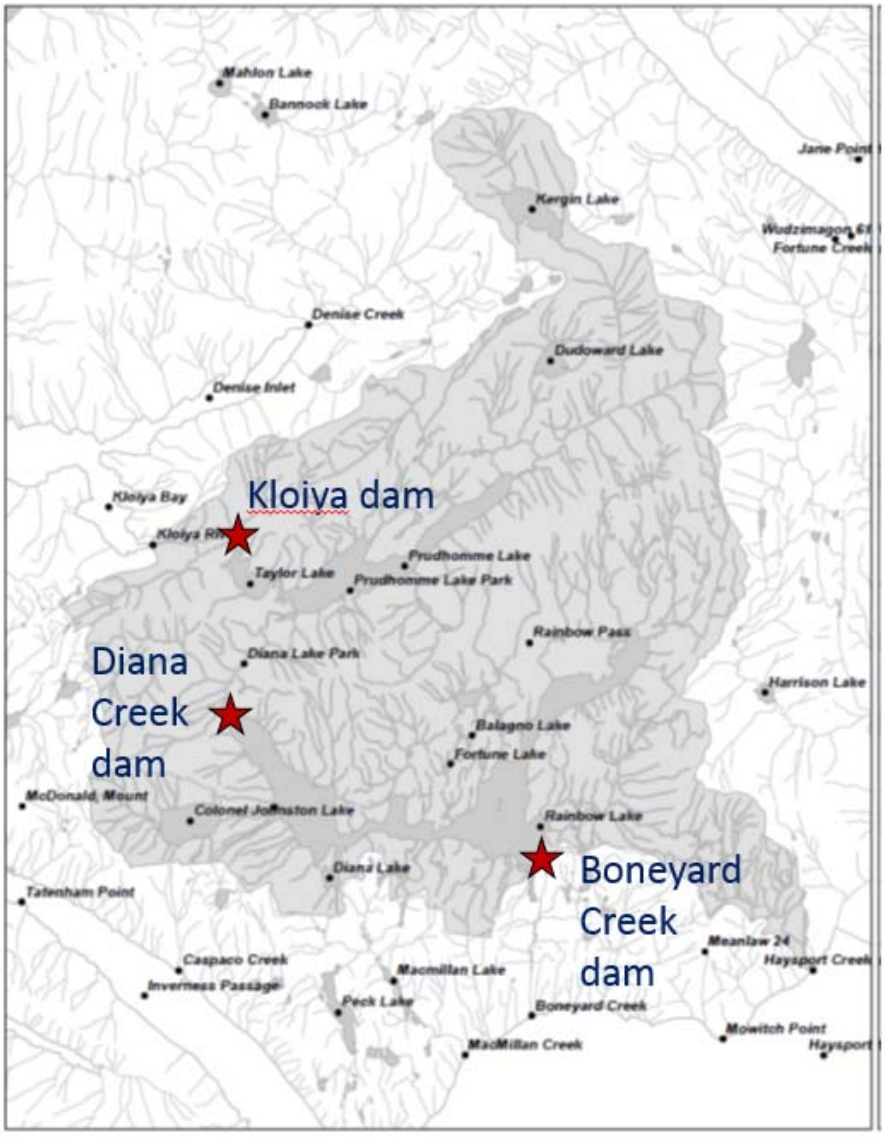


Figure 1: Map showing Kloiya River and Rainbow Lake catchments, showing major tributaries and dams. The dams constructed to support the expansion of water storage facilities for Columbia Cellulose in the early 1960s elevated water levels in Rainbow and Diana Lakes, causing them to join, and for freshwaters from the Rainbow Lake catchment to drain through the Kloiya River system.

Rainbow Lake historically drained through Boneyard Creek into the Skeena River approximately 22 km upstream from Inverness Passage. The terrain surrounding Rainbow Lake is mostly steep-sided, and many first and second, and some third-order creeks drain into Rainbow Lake, which is the most significant water body in this catchment (Figure 1). A bathymetric map produced from data collected during a 1952 survey prior to the installation of the Diana and Boneyard creek dams estimates the surface area to have been just 244 hectares at that time (Figure 2). A second survey 1972 was conducted after the installation of the Diana and Boneyard dams estimates that Rainbow Lake currently covers an area of approximately 389 hectares, with a mean depth of 10 meters and a maximum depth of 30 meters (BC 2015), compared with a maximum depth of 6 meters in 1952. The water levels at the time of the 1972 survey was 26' (8 m) above the benchmark, which was probably installed during the 1952 survey (Figure 2).

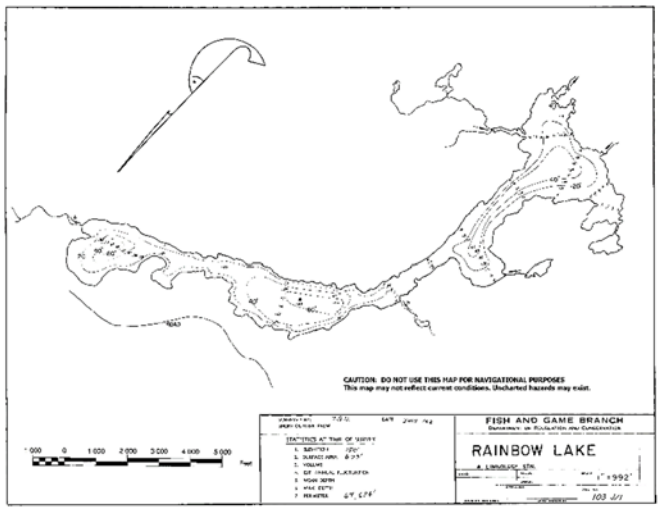


Figure 2: 1955 Bathymetric map showing historic extent of Rainbow Lake

Water storage facilities and dam construction

The British Columbia Water Rights Branch issued Water License #10875 to the Columbia Cellulose Company on November 1, 1947. This original water license allowed a maximum diversion of 60 cubic feet per second to be drawn from Taylor and Prudhomme Lake (Water License Branch 1947, DFO 2015-a)). The construction of the first dam on Kloiya River at the outlet of Taylor Lake began in 1948, with water use at the pulp mill scheduled to start by December 1950. The initial works consisted of the Kloiya River dam and a gravity-fed 60" wood stave pipeline (Water Rights Branch, 1947) (Figure 3). A concrete fishway was built beside the spillway to improve fish passage past the dam. Low water flow was identified as a problem almost immediately after the start of mill operations, which affected both mill operations and anadromous fish passage in Kloiya River. During the 1960s, Columbia Cellulose implemented several measures to increase water storage facilities and the volume of water supplied to the mill, in order to improve the reliability of the water supply during periods of low flows and to improve the quality of pulp produced at the mill (DFO 2015-a).

Figure 3. Section of archival blueprint from 1947 showing original plans for Kloiya dam and pipeline to the then -proposed pulp mill facility on Watson Island.

A 1962 Order from the Water Rights Branch amended the original Water License #18075 to authorize construction of a new dam, pump and pipe on the system (Water Rights Branch, 1962 (DFO 2015-a)). An electric pumping station and a second 48" stave pipe was installed downstream of the spillway in 1961, and a second dam was constructed at the outlet of Diana Lake in 1963 (Figure 4). A third dam was subsequently constructed on Boneyard Creek at the outlet of Rainbow Lake. The dams at the outlets of Diana and Rainbow lakes resulted in elevated water levels for the two lakes, which caused them to join, and for Rainbow Lake, which had previously drained through Boneyard Creek into the Skeena catchment, to drain through Diana Lake into the coastal Kloiya catchment. Conditional Water License #10393, issued in 1992, which replaced Water License 18075 and other water licenses that were subsequently issued for this system, authorized a maximum diversion of 131 cubic feet per second, to be drawn from the Taylor, Prudhomme, and Diana and Rainbow lake reservoirs. The maximum quantity of water storage allowed under Water License 10393, which took precedence on 23 December 1963, was 31,000 acre-feet (38,237,880 m^3) from Diana and Rainbow lakes, and 6,000 acre-feet (7,400,880 m^3) from Prudhomme and Taylor lakes (British Columbia 1992-a, DFO 2015-a). A Permit Authorizing the Occupation of Crown Land, issued in 1992, retroactively authorized 7.8 acres of crown land to be occupied for dam sites, and 1005.76 acres for the flooded areas associated with elevated water levels at Taylor and Prudhomme Lakes (British Columbia 1992-b, DFO 2015-a).

Figure 4. Diana Creek dam at the outlet of Diana Lake, which raised the elevation of the lake to 227'

The Skeena Cellulose (formerly Columbia Cellulose) pulp mill ceased operations in 2000, and its associated infrastructure, including the dams, intake systems, and wood stave pipes, have fallen into disrepair. The water license, which is currently held by the City of Prince Rupert, is currently not being utilized. Because the system will need to be rebuilt prior to any future development of this water resource, there is an opportunity to investigate alternatives for integrating modifications to the system in order to realize future water withdrawals from the Kloiya River and Rainbow Lake watersheds without compromising fish passage or productivity.

The dam at the outlet of Rainbow Lake, which in conjunction with elevated water levels at Diana Lake, altered the hydrology of the Rainbow Lake watershed by causing a reversal in flow from the Skeena to the coastal drainage was not the first dam to be built on Boneyard Creek. Boneyard Creek was first dammed in the 1910s to supply water to a sawmill operation at Shirley Mills, a small homesteading community established near the CN rail crossing at the Boneyard Creek – Skeena River confluence (Blacklund 2012).

Anadromous salmon habitat utilization

Kloiya watershed

The Kloiya watershed is utilized by six (6) species of Pacific salmon: Pink (*Oncorhynchus gorbuscha*), Chum (*O. keta*), Sockeye (*O. nerka*), Coho (*O. kisutch*), Chinook (*O. tshawytscha*) and Steelhead (*O. mykiss*) salmon which spawn in Kloiya River, Diana Creek, and Prudhomme Creek. The different salmon species have different habitat requirements for spawning and rearing, and rear in freshwater as juvenile salmon for varying lengths of time. For example, Pink and Chum salmon and ocean type Chinook salmon migrate to sea immediately following emergence, thus juveniles spend very little time rearing in freshwaters. Sockeye, Coho and Steelhead salmon rear in freshwaters for at least a year after emergence. Juvenile Sockeye salmon rear in Prudhomme Lake and probably Taylor Lake as well, while Coho and Steelhead salmon rear in lentic and lotic habitats throughout the system.

Historic escapement data for fall-spawning semelparous salmon species, which fall under the jurisdiction of the Department of Fisheries and Oceans (DFO) come from two sources: the North Coast DFO SEDS (salmon escapement data storage) database, which summarizes annual escapement data for all salmon species throughout the management area, and the BC16 record, which provides a summary of stream counts and field notes collected in every year that stream walks occurred (DFO SEDS). The BC16 record, and presumably stream enumeration activities for each system, began in 1921 for Kloiya River, 1947 for Diana Creek, and 1971 for Prudhomme Creek (DFO BC16, 2004). All species of salmon were not enumerated in all systems in all years. The earliest available stream estimates were provided in relative rather than absolute numbers. For example, in 1921, an unnamed fisheries guardian observed a “light” spawn of Sockeye salmon, which arrived in Kloiya River in June, and “medium” numbers of Coho and Pink salmon, which first appeared in August (DFO SEDS 1921). Steelhead salmon first appear in the BC16 record in 1924. Interestingly, the BC16 record includes no observations of Chinook salmon during any of the inspections that were conducted during the 1920s (DFO BC16, 2004).

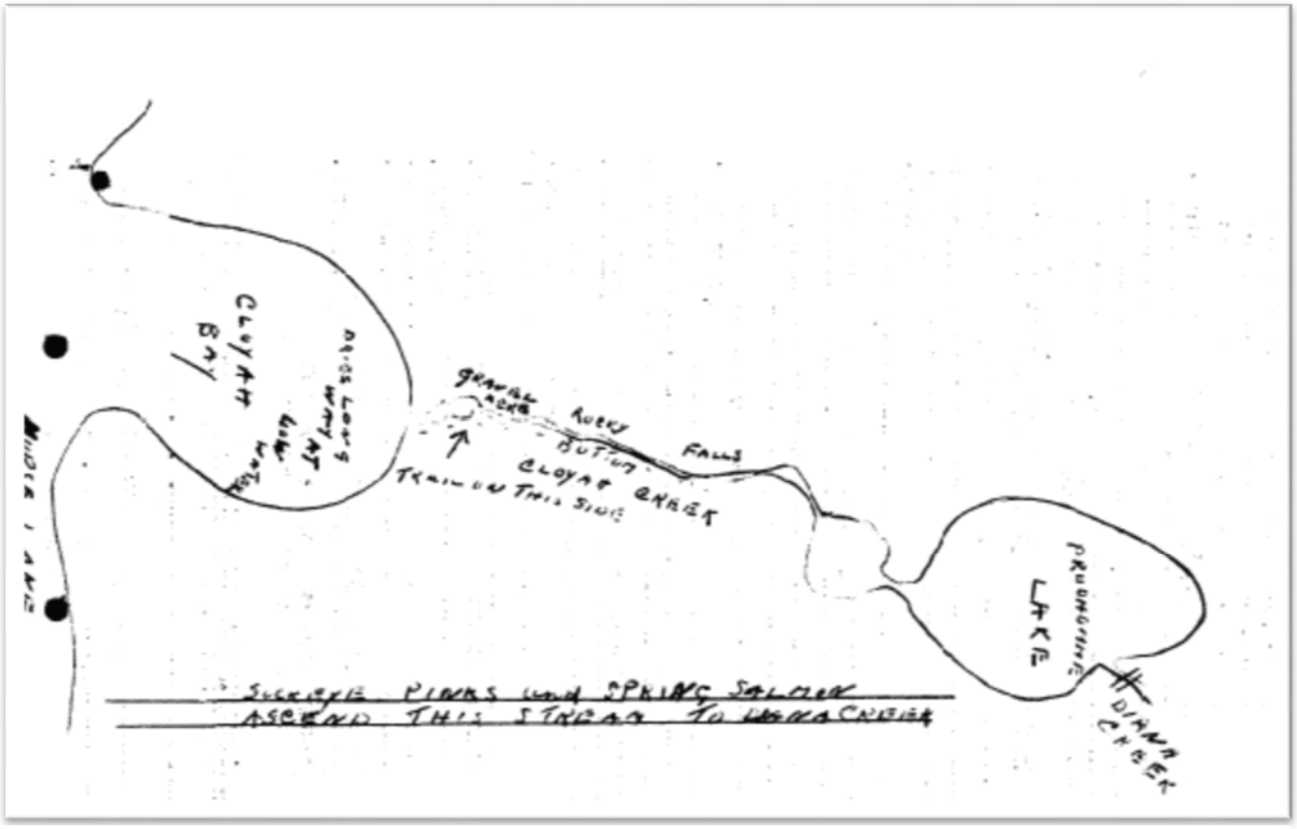


Figure 5. 1948 DFO map drawn by Fisheries Guardian W. Strachan showing spawning area in Cloyah (Kloiya) River. Handwritten text read, "Sockeye, Pinks and Spring salmon ascend this stream to Diana Creek" (DFO (1948))

Escapement estimates for semelparous salmon species in the Kloiya system are based on visual counts of questionable reliability, because the water throughout the system is extremely dark as a result of high levels of tannins (D Wagner (2003), DFO BC16). Furthermore, stream counts for some species are carried out during the fall when high water levels are too high for a reliable estimate. Salmon escapement estimation activities in the Kloiya watershed have been almost entirely carried out by DFO personnel, with some information contributed by the Prince Rupert Salmon Enhancement Society, which collects Broodstock annually in Kloiya River and Diana Creek. Other organizations have at times contributed to stream enumeration, such as Lax Kw'alaams Fisheries program, which partnered with the Department of Fisheries to collect stream inspection data on Kloiya River, Diana Creek, and Prudhomme Creek in 2015.

Pink salmon

Pink salmon spawn throughout the Kloiya watershed in Kloiya River, Prudhomme Creek, and Diana Creek. In 1957, the fisheries inspector observed, "Pink salmon spawned from the mouth of Cloyah

(sic) Creek to fishway" (Figure 5) (DFO (1957) BC16), and escapement records indicate that pink salmon ascend the fishway to spawn in Diana and Prudhomme Creek, sometimes in large numbers. The maximum observed escapement: 25,000 in Kloiya, 400 in Diana Creek, and 250 in Prudhomme Creek (DFO SEDS 2015). While Pink salmon counts have not been recorded in Prudhomme or Diana Creek since 2000, adult Pink salmon spawners have been observed in both systems in recent years. One of the largest recorded Pink salmon escapements to Kloiya River occurred in 2007 which saw an estimated return of 20,000(DFO SEDS 2015). There have been at least two attempts to enhance Kloiya River Pink salmon. In 1995 and 1997 respectively, Oldfield hatchery took 35,000 and 40,000 Pink salmon eggs for broodstock, and in 2010, the Prince Rupert Salmon Enhancement Society took 36,000 pink salmon eggs for broodstock (DFO BC16).

Chum salmon

Chum salmon spawn infrequently in Kloiya Creek and Diana Creek, and there are no historic records of spawning Chum in Prudhomme Creek. Chum salmon appear to have been more abundant in Kloiya River until the 1940s, with relative abundances described as "Heavy" in 1928 and 1930, and "Medium" in 1929 and 1922, 1931, 1932 and 1933. The decadal average for the 1930s after absolute numbers were recorded was 1,000 (DFO SEDS 2015). After the 1930s, Kloiya Chum salmon observations became less frequent, and no Chum salmon were recorded or observed in most years after 1940, with few exceptions. Seven hundred and fifty (750) Chum salmon were observed in the system in 1941, 200 in 1959, 75 in 1961 and 1968, and 400 in 1960. The most recent Chum salmon observation in Kloiya River was 2 individuals which were recorded in 1990. The only Chum salmon observation for Diana Creek is from 1968, when 25 were observed (DFO SEDS 2015).

Chinook salmon

Chinook salmon spawn in Kloiya River and Diana Creek (Figure 5), although no Chinook salmon have been observed in Diana Creek since 1986, when 10 were recorded. The main spawning area for Chinook salmon in the Kloiya watershed is a 300 – 400 yard stretch that begins approximately a ½ mile below the Taylor Lake dam (DFO (1985) BC16). Although Chinook salmon have consistently returned to the Kloiya River since fisheries inspections started in the Kloiya River, abundances declined dramatically during the 1960s, from decadal averages of approximately 450 in the 1950s and 550 in the 1960s to decadal averages of less than 200 in the 1990s and less than 250 in the 2000s. The highest recorded observation of Kloiya River Chinook salmon was 1,500 in 1963 (DFO SEDS 2015).

The Kloiya system produces ocean-type Chinook salmon which enter marine waters immediately after emergence, unlike most Area 4 Chinook salmon populations which are stream-type, meaning that they rear in freshwater for a year before ocean entry. Chinook salmon from the Kloiya system are genetically distinct when compared with other Chinook salmon populations from the north coast of British Columbia. This genetic distance is suggestive of a genetic bottleneck for the Kloiya River Chinook salmon population (I Winther, pers. comm).

Coho salmon

Coho salmon spawn in Kloiya River, Diana Creek, and in Prudhomme Creek. Coho are the only salmon species known to spawn upstream of rapids approximately 1 km upstream of Prudhomme Lake. Coho, which are the last species of salmon to spawn in the fall, are the most difficult to enumerate because high water levels and dark water obscure reliable stream counts. Coho salmon escapement estimates have ranged from 60 to 7,500 for Diana Creek, 10 to 2,000 for Prudhomme Creek, and 30 to 1,500 for Kloiya River. Coho salmon count data have been recorded for 11 of the last 20 years for Diana Creek, 12 of the last 20 years for Prudhomme Creek, and 0 of the last 20 years for Kloiya River, however coho salmon absence/presence has been recorded at Diana Creek in most years since 2008 (DFO SEDS 2015).

Sockeye salmon

Sockeye salmon spawn in Diana Creek between Prudhomme Lake and an impassable falls approximately 2.5 kilometers upstream from the lake, and in Prudhomme Creek approximately 1 km below the rapids. The amount of available spawning habitat decreased in both creeks when the water levels in Prudhomme Lake were elevated after construction of the dam in 1948, and again after improvements were made to the dam in 1961. Diana and Prudhomme Creek Sockeye are early-timed and begin to migrate into the system in early June and July, and spawn in late August and September. Upon emergence, sockeye fry rear for one year in Prudhomme Lake prior to smolting and their seaward migration. Sockeye salmon escapement estimates have ranged from 350 – 10,000 in Diana Creek, and from 150 – 2,500 in Prudhomme Creek (DFO SEDS 2015).

Steelhead salmon

Steelhead salmon fall under the jurisdiction of the province of British Columbia, unlike the remaining salmon species which are managed by the federal Department of Fisheries. Unlike the semelparous salmon species which migrate into the system in the summer and fall, Steelhead salmon migrate into the Kloiya River in the spring, which is typical for coastal Steelhead populations in this

region. Steelhead salmon have historically spawned above and below the Kloiya River dam. The BC Ministry of Environment has operated a resistivity counter at the fishway to enumerate adult Steelhead salmon during their return migration every year since 2006. Most steelhead salmon pass through the resistivity counter between late March and mid-May, with peak timing in the third week of April. Total Steelhead salmon counts for Kloiya River steelhead ranged from 25 – 145 between 2006 and 2011 (Peard, 2011).

Trends in abundance: All salmon species

There are insufficient data to determine the effects of the dams installed at Kloiya River and Diana Creek on salmon escapement throughout the system for all species. In recent years, the frequency and quality of DFO stream enumeration activities have been reduced as a result of federal budget cutbacks. Because of the challenging conditions resulting from low water and high flows, the reliability of escapement estimates based on visual counts is low for all salmon species with the exception of Steelhead salmon, which are enumerated by a resistivity counter operated by the provincial Ministry of Environment. There is unfortunately no long-term data series for steelhead escapement to compare modern counts with historic steelhead returns prior to the installation of the Columbia Cellulose dams.

Chum salmon, which appear to have returned to the Kloiya River in relatively high abundances in the 1930s and 1940s, were virtually absent from the system after the 1950s. However, it is possible that the early decline of Chum salmon in the BC16 records after 1941, combined with the first appearance of Chinook salmon in the 1950s, is attributable to species misidentification on the part of the earliest Fisheries Guardians as a result of low water clarity in the system. Conversely, there are no records for Chinook salmon in Kloiya River or Diana Creek prior to 1947 (DFO SEDS 2015), so there is no benchmark by which to compare Chinook salmon returns after the dam installations with historic returns. The largest observed Chinook salmon return to the Kloiya River was 1,500 individuals recorded in 1963, after the Kloiya dam was being installed during construction of the Diana Creek dam (DFO SEDS 2015) (Figure 6).

Sockeye salmon escapement has been recorded at Diana Creek since 1947. The Kloiya River dam was installed in 1949, so there are not enough data from before the dam was built to assess whether it affected salmon returns. Sockeye salmon returns to Diana Lake appear to have declined after the second dam, on Diana Creek, was installed in the early 1960s (Figure 6). Sockeye salmon escapement at Prudhomme Lake appears only to have been recorded since 1971, a decade after the Diana Lake dam was installed, so we cannot compare adult returns to this system before and after the dams were

installed. Likewise, no Coho salmon data are available from before the Kloiya dam, and data collected in the years since has been inconsistent. While Coho escapement estimates are of questionable quality for the entire Kloiya River watershed, there appears to have been a decline in abundance for Coho salmon returns to Diana Creek after 1963 (Figure 6).

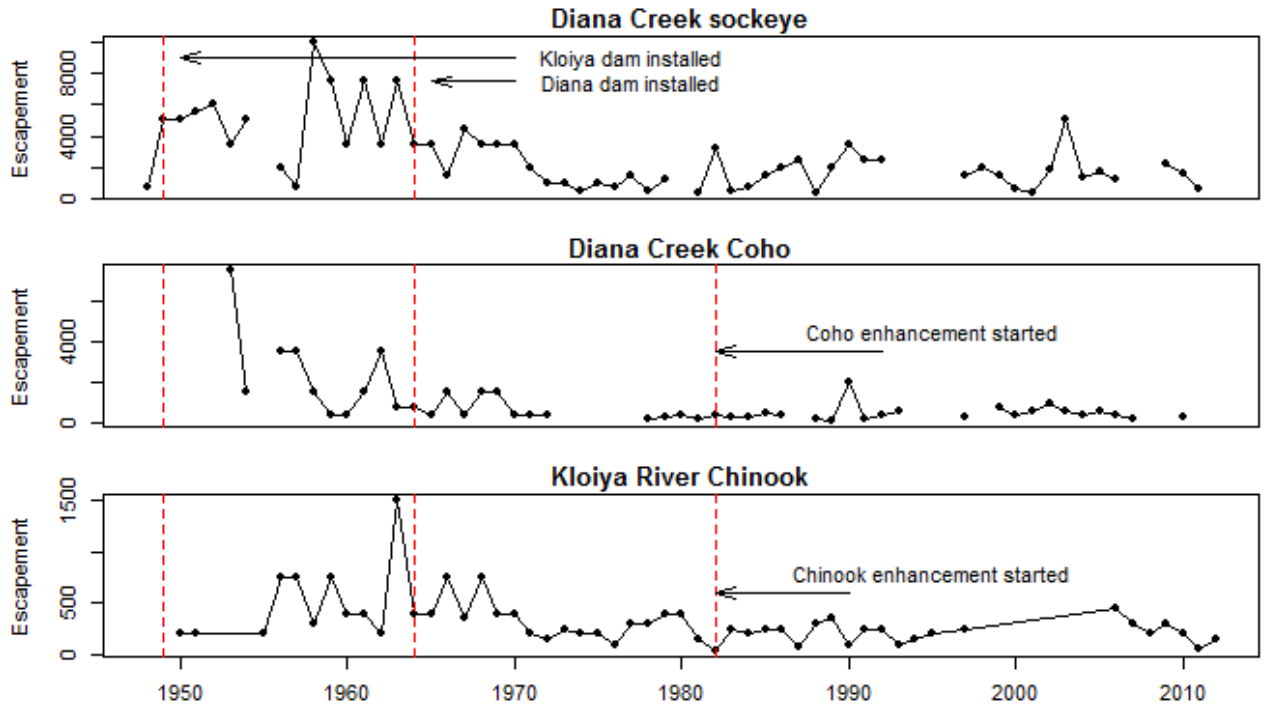


Figure 6: Escapement estimates showing abundance trends for Diana Creek Sockeye, Diana Creek Coho, and Kloiya River Chinook salmon, 1950-2010.

Juvenile salmon and trout

The different species of juvenile salmon and trout rear in different habitats throughout the Kloiya watershed for different lengths of time. Generally, juvenile Pink, Chum and ocean-type Chinook migrate to sea immediately after emergence and thus do not rear in the system for very long. Juvenile Coho, Sockeye, and Steelhead salmon rear for a year or more in freshwater prior to the onset of the downstream migration. Juvenile Coho rear throughout the system, in Prudhomme Creek above and below the rapids, Diana Creek below the falls, in Prudhomme and Taylor lakes, and in Kloiya River below the dam. Juvenile Sockeye salmon rear in Prudhomme (confirmed) and likely Taylor lakes. In addition to the anadromous salmon species, juvenile Cutthroat trout, Dolly Varden, and Brown trout have been captured in the system (British Columbia FISS 2015). While resident O. mykiss (Rainbow trout) have not

been recorded, they cannot be distinguished from anadromous steelhead salmon by morphological characteristics, so we cannot confirm that rainbow trout, the resident form of O. mykiss, do not utilize the Kloiya system.

Numerous studies have been conducted to characterize the distribution and abundance of juvenile salmonids throughout the Kloiya watershed. Of these, the most extensive occurred in 1980, to estimate the rearing capacity of the system to determine its potential for enhancement (Tredger 1981) and in 1998 and 1999, when stream habitat assessments were conducted on Kloiya River, Diana Creek, and Prudhomme Creek as part of a large-scale north coast stream habitat inventory project (Rolston and Proctor 1999). Several less extensive juvenile salmon sampling activities have been carried out by federal and provincial agencies, industry consultants, and other groups since the 1950s. In 2015, Lax Kw'alaams Fisheries program, in partnership with Skeena Fisheries Commission, carried out limited minnow trapping activities in conjunction with stream habitat assessment as part of the present study, and also conducted a hydroacoustic survey on Prudhomme Lake to estimate the abundance of Sockeye fry rearing in the system (Lax Kw'alaams 2015, Appendix 2). Information from most of these surveys are summarized in the provincial Fisheries Inventory Summary System (British Columbia FISS 2015).

Juvenile salmon studies have also been undertaken in the Kloiya watershed to answer specific research questions. A series of studies conducted in 1989 used the Kloiya dam as an experimental platform to explore the effect of changes in streamflow on the microhabitat use and movements of sympatric juvenile Coho salmon and Chinook salmon in a natural stream (Bravender and Shirvell 1989, Bravender and Shirvell 1990, Shirvell 1990). The researchers found that juvenile Coho and Chinook salmon chose similar but not identical microhabitats with a change in stream flow, and that both species remained close to the stream margins. Following an increase in stream flow, Chinook salmon move perpendicularly inshore, while remaining closer to the streambed, and beneath faster currents. On the other hand, Coho moved downstream and parallel to the water's edge when stream flow increased, then moved upstream when the flow decreased. This study concluded that juvenile Coho salmon performance improves with an increase in flow (Shirvell 1990).

Enhancement

Salmon enhancement activities have been conducted in the Kloiya watershed since 1979. The primary goal of the enhancement program was to rrehabilitate spawning stock levels and increase the total run size for Chinook and Coho salmon. A steering committee established in early 1979 coordinated a study to investigate the feasibility of installing streamside incubation boxes downstream from the

Kloiya dam (Community Fisheries Development Center, 1980). Chinook salmon were first captured for broodstock in 1979, and fertilized eggs were reared in streamside incubation boxes that winter. The incubation box program was eventually managed by the Northern Trollers Association, which led egg takes throughout the 1980s (DFO BC16 2004). Eventually, a small on-site hatchery was built in the ground pump house downstream from the Kloiya Dam, where fertilized eggs were incubated and fry were reared in Capilano troughs. The success of the streamside incubation boxes and the on-site hatchery were negatively affected by poor water quality, specifically low pH and low water hardness which prevented a high proportion of salmon eggs from hardening and developing properly (R Dams, pers comm). By 1985, fertilized eggs were incubated and reared in the new Oldfield Creek Hatchery facility in Prince Rupert. The on-site hatchery was vandalized beyond repair in the early 2000s, and has not been utilized as an incubation facility since. The facility is unlikely to be rehabilitated because of water quality and building safety issues (R Dams, pers. comm).

The provincial Ministry of Environment conducted an investigation into the availability of rearing habitat throughout the Kloiya watershed and its potential to benefit from increased enhancement, particularly for Steelhead salmon. For this study, different units (pools, glides and riffles) were sampled throughout Diana Creek, Prudhomme Creek, Kloiya River, and Taylor Lake near the Kloiya Dam (Tredger 1981). The results from this study suggested that the estimated carrying capacity for Kloiya River was 14,000 Steelhead salmon fry, 2,000 Steelhead yearlings, and 8,640 Coho salmon fry. The estimated carrying capacity for Diana Creek, was 7,080 Steelhead fry and 670 Steelhead yearlings, which were restricted by poor edge habitat, and 5,160 Coho salmon fry. The estimated carrying capacity for Prudhomme Creek, was 2,400 Steelhead fry, 4,100 yearlings and 1,800 two year olds. The estimated carrying capacity for Taylor and Prudhomme Lake was 30,000 Steelhead fry and up to 19,000 Steelhead smolts. This study concluded that there was sufficient rearing capacity for introducing more salmonids into Prudhomme Creek and Taylor and Prudhomme Lakes, and that the system as a whole could produce an additional 2,000 Steelhead and 35,000 Coho salmon (Tredger 1981), and supported proceeding with salmon enhancement. However, a synoptic DFO gee-trapping investigation into the availability of suitable Coho rearing habitat found less available habitat in Kloiya River than in Diana Creek, Taylor Lake, Prudhomme Lake, but concluded that that enhancement was not necessary for Coho in this system (Gidora 1981).

Salmon enhancement in the Kloiya watershed has been coordinated out sequentially by several organizations, including the Northern Trollers Association, the Community Chinook Enhancement

Society, Oldfield Creek Hatchery, and most recently, Prince Rupert Salmon Enhancement Society (DFO BC16). The numbers of Chinook and Coho salmon eggs taken for enhancement have been relatively consistent between years, except for years of low returns or high water, when it was difficult to obtain sufficient broodstock. Since 1979, the various groups have incubated an average of 27,000 and a maximum of 45,000 Chinook salmon eggs from Kloiya River, and an average of 30,000 and maximum of 60,000 Coho salmon eggs from Diana Creek. Some of the hatchery reared Coho salmon from Diana Creek were transplanted into nearby Wolfe Creek in 1984 and 1985. There were also several attempts to enhance Pink salmon from the Kloiya River. In 1995 and 1997 35,000 and 40,000 Pink salmon eggs were incubated by the Oldfield Creek Society respectively, and the Prince Rupert Salmon Enhancement Society incubated 36,000 Pink salmon eggs in 2010 (DFO BC16).

Itis not possible to assess whether enhancement for Coho and Chinook salmon in the Kloiya watershed has increased productivity or returns for either species, because the success of enhancement activities in the Kloiya watershed appear never to have been measured by tagging, fin-clipping, or other types of studies. The reliability for escapement estimates for Chinook and Coho salmon throughout the Kloiya watershed is poor, and stream enumeration counts have decreased in frequency since the 1990s, and in some years, the only Coho numbers reported are from counts taken during broodstock collection events. It may be beneficial to review the Kloiya enhancement program to determine whether it is meeting the objectives that were set out by the steering committee in 1979.

Rainbow Lake watershed

We found no evidence of historic or contemporary utilization of habitats throughout the Rainbow Lake watershed by anadromous salmon species. Sampling conducted in Rainbow Lake in 1951, 1952, 1972, 1976, and 1981 observed low species diversity for salmonids, and only Cutthroat trout and Dolly Varden char were captured during all sampling events. The only other fish species recorded were Threespine stickleback and Prickly sculpin (FISS). No adult or juvenile salmon were observed during an October 1988 survey at Boneyard Creek (Rolston and Proctor 1999).

Rainbow Lake appears to support persistent populations of resident Cutthroat trout and Dolly Varden, but we found no records that provided evidence of historic anadromous fish utilization of the system prior or subsequent to the installation of a dam constructed on lower Boneyard Creek to power

the sawmill at Shirley Mills, and therefore cannot confirm whether the absence of anadromous fish in the system was natural or caused by this barrier.

Effects to fish and fish habitat related to dam infrastructure

A review of historic correspondence identified reduced water flow as the most likely cause of reduced salmon productivity related to dam infrastructure throughout the Kloiya River system. We identified numerous other effects of the dam structures that have directly or indirectly harmed fish and altered fish habitats: including flooding of spawning areas (particularly for Sockeye salmon by elevated lake levels following dam installation in 1950 and subsequent improvements in 1961), poor gravel recruitment in Kloiya River because of impoundment behind the Kloiya dam; the increased potential for out migrating salmon smolts to become trapped on the intake screens at the stave pipes; and increased recreational fishing pressure as a result of improved access to Kloiya River and the fish ladder.

Reduced flow

Insufficient water flow was a persistent problem for both salmon passage and mill operations from the start of operations at Columbia Cellulose, and on several occasions prior to the installation of the Diana Creek dam to increase water storage facilities, the company requested permission to draw down the Prudhomme Lake reservoir below the minimum water level of 88.9' necessary for fish passage through the fishway. The first prolonged dry spell, which occurred during the first summer of mill operations in 1951, exacerbated an existing barrier to salmon migration a few hundred meters downstream, where a large rock in the stream channel split low stream flows. A memorandum from the DFO Regional Engineer to then Regional Supervisor of Fisheries, summarizes the findings of a site visit to investigate this obstruction, where the DFO had found spawning salmon having difficulty ascending the falls due to low water, and makes recommendations to concentrate flow by excavating the main channel.

> "The flow is completely "white" water with no resting pools present...During the low water flow there is very little depth of flow over the rock. The salmon apparently are having difficulty surmounting this obstacle and are falling easy prey to predators. Or else they are jumping at the falls and are forced onto bare rock by the swift water and are stranded". (J. Dyson, 1951)

At the time, water flow in the creek consisted of "flow in the fishladder, seepage from the stoplogs in the spillway sections, flow in the fry bypass pipe, and water from the screen washing trough. The

estimated total flow was 7 to 9 cubic feet per second" (J. Dyson, 1951 (DFO 2015)). At a subsequent meeting, the company agreed to undertake the nightly removal of stop logs upstream of the dam to increase nightly flow and facilitate fish passage. In August 1951, the Department of Fisheries authorized an expenditure of $750 for contract rockworks to clear the obstruction downstream of the fishway, and the work was completed a few weeks later. The effects of the dry conditions on migrating salmon did not escape public notice. On May 1, 1952, the Prince Rupert Rod and Gun Club sent a letter to the then-Minister of Fisheries, Hon. R.W. Mayhew, with the following resolution:

> "WHERAS DURING the summer of the year 1951, thousands of salmon died on the bottom of Cloyah Creek, British Columbia, on account of insufficient water being released from the Columbia Cellulose Company Limited dam…" requests that a fishery officer be stationed at Cloyah creek during salmon spawning season to ensure sufficient flow for salmon to reach spawning grounds." (Prince Rupert Rod and Gun Club, 1951)

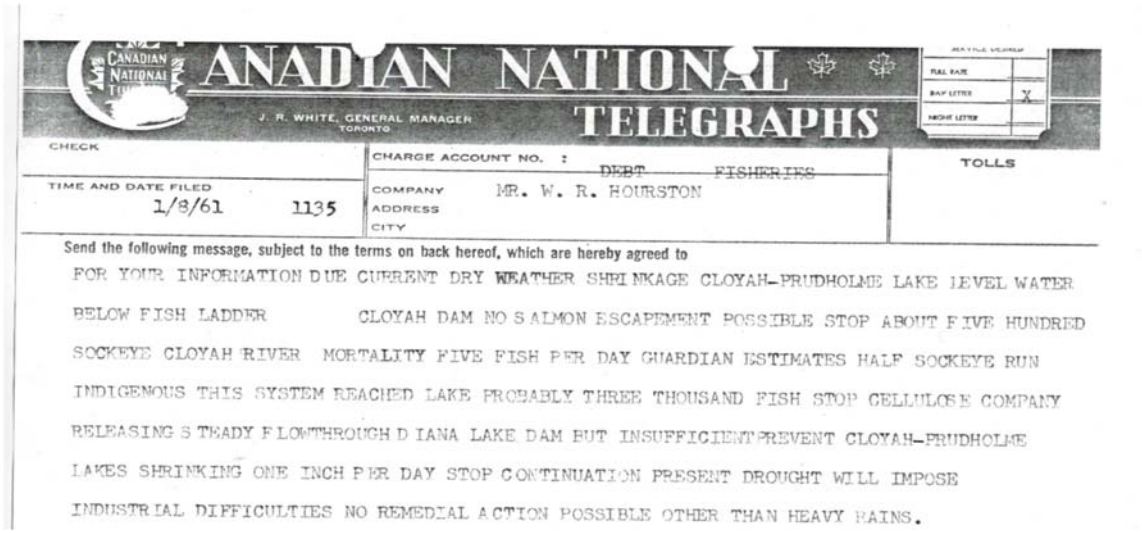
The Minister replied on 7 May 1952, and acknowledged that "some difficulties were experienced in connection with the operation of the fishway and screening device last year, mainly because it was a new operation and had to be adjusted"(DFO 2015). A subsequent departmental investigation into the matter found no basis for the Rod and Gun Club's assertion that "thousands of salmon died on the bottom of Cloyah Creek on account of insufficient water" (DFO 2015).

Periods of drought and insufficient flow occurred regularly until Columbia Cellulose expanded its waterworks in the early 1960s. Following the 1951 crises, droughts threatened salmon passage in 1952, 1956, 1958, and 1960. A July, 1956 letter from the District Supervisor to the Area Director of Fisheries stated,

> "The drought is affecting Sockeye salmon in Kloiya Creek. The level in the lake has dropped to the point where no water is able to pass into the fish ladder. There is a run total of 2000 adult fish. The fish pressed into the river mouth are very weakened. It is being closely observed. The water draining into the fish ladder is warmer and could be lethal." (R.C. Edwards, 1956 (DFO 2015)).

The company was not always cooperative with Department requests to implement fish-friendly measures during construction or operations. In a February 1961 letter to Columbia Cellulose President T.N. Beaupre, Area Director of Fisheries W.R. Hourston advised that he found that "In the view of the Department, the Company's progress toward adopting mutually developed solutions for improving construction practices found to be harmful to fish habitat/threaten the Kloiya River salmon runs" to be rather slow, and requested that the company reply to concerns raised by the Department, and assume

responsibilities defined in the Fisheries Act, which was enclosed. Another drought in that year, prompted the District Supervisor to send a telegram to Mr. Hourston to inform him that low or no flows below Cloyah Dam prevented fish passage of salmon through the dam, with an estimated mortality of 5 fish per day, with half the run left to ascend the fish ladder (Fig 7). Because the drought was also threatening production at the mill, the Company again presented with the Department with a proposal to draw down water below the agreed-upon minimum level, and to rig an electric pumping system to allow fish passage through the fishway. The department reluctantly accepted this proposal, however heavy rains later that year rendered the emergency measure unnecessary (DFO 2015).



CANADIAN NATIONAL TELEGRAPHS

J. R. WHITE, GENERAL MANAGER TORONTO

FULL RATE | DAY LETTER X | NIGHT LETTER

CHECK

TIME AND DATE FILED 1/8/61 1135

CHARGE ACCOUNT NO. : DEBT FISHERIES

COMPANY MR. W. R. HOURSTON

ADDRESS

CITY

TOLLS

Send the following message, subject to the terms on back hereof, which are hereby agreed to

FOR YOUR INFORMATION DUE CURRENT DRY WEATHER SHRINKAGE CLOYAH-PRUDHOLME LAKE LEVEL WATER BELOW FISH LADDER CLOYAH DAM NO SALMON ESCAPEMENT POSSIBLE STOP ABOUT FIVE HUNDRED SOCKEYE CLOYAH RIVER MORTALITY FIVE FISH PER DAY GUARDIAN ESTIMATES HALF SOCKEYE RUN INDIGENOUS THIS SYSTEM REACHED LAKE PROBABLY THREE THOUSAND FISH STOP CELLULOSE COMPANY RELEASING STEADY FLOWTHROUGH DIANA LAKE DAM BUT INSUFFICIENTPREVENT CLOYAH-PRUDHOLME LAKES SHRINKING ONE INCH PER DAY STOP CONTINUATION PRESENT DROUGHT WILL IMPOSE INDUSTRIAL DIFFICULTIES NO REMEDIAL ACTION POSSIBLE OTHER THAN HEAVY RAINS.

Figure 7. 1961 Telegram from District Supervisor R.C. Edwards to Area Director W.R. Hourston advising that low flows had rendered salmon escapement impossible

Columbia Cellulose met with officials from the Department of Fisheries between 1955 and 1960 to discuss expanding their water supply and water storage facilities. During a 1961 meeting between personnel from Columbia Cellulose, and Department of Fisheries and Oceans (DFO) representatives from the Pacific Biological Station and the DFO North Coast office the company's proposal to increase the amount of water taken from Kloiya Dam by 50% by installing a pump into the pipeline below Kloiya dam, and building a second dam at Diana Lake for additional storage was discussed. At the time, the company claimed that it required an increase in water from 20,000 to 30,000 cubic feet per second (cfs) in order to improve the quality of their pulp product. In April 1960, Columbia Cellulose executive notified the DFO of the anticipated improvements to be installed starting in 1961, including a dam to be installed on Diana Creek 100’ downstream from the lake outlet, and a pumping station to be installed downstream from Kloiya dam, which would increase flow by 50%. At the time, the Department

expressed concerns that water flow in Diana Creek would fall below minimum required 15 cfs while the reservoir was filling, but conceded that maintaining higher minimum depth of flow would alleviate the existing problems with fishway (DFO 2015).

While periods of low flow have received considerable attention with respect to salmon mortality, high flows also have the potential to cause salmon mortality particularly during egg incubation. Water levels throughout the system increased substantially after water flow from the Rainbow Lake watershed was reversed to flow through Diana and Kloiya Creeks, leading to concerns about potential scour and streambed movement during periods of high water. High flows and water releases during periods of high water may have contributed to loss of gravel and any fish eggs deposited therein. At this time, the intake at the Kloiya dam is not operation, and the spillway is open (DFO 2015).

Fishway

The only means of salmon migration past the Kloiya River dam is through a concrete fishway that was built beside the Kloiya River dam in 1950 to facilitate fish passage into Taylor Lake. The fishway, consisting of a series of step pools is still utilized by migrating salmon ascending to spawn upstream of Taylor Lake in Diana and Prudhomme Creeks. A 1949 DFO letter from the Chief Supervisor of Fisheries to the Regional Supervisor of Fisheries outlined specifications for the fish ladder proposed to be installed below the Kloiya River dam. These specifications, which were agreed to during a meeting between DFO and Columbia Cellulose engineers, required that the spillway elevation be changed to 90', and the fishway floor at the top exit to be set at 87.25'. A wing wall was built to protect the fish entrance from the flows from the spillway, and a branch connection from the penstock supplied flow to the creek below the fishway (DFO 2015).

The fishway appears to have succeeded in mitigating the migration barrier introduced at the Kloiya dam, and migrating salmon were observed to pass through the fishway when sufficient water flow was available. BC16s from 1953 and 1954 conclude that the fishway was working at the time, and that "Approximately 5,000 Sockeye and 1,500 Coho had ascended the fish ladder and entered Diana Creek" (DFO BC16).

Direct sources of fish mortality associated with the fishway included: salmon jumping over the sides of the fish ladder and drying up on the surrounding rocks, and increased fishing pressure at the fishway itself, discussed below. In 1957, DFO requested that Columbia Cellulose install a grating over the fish ladder to prevent fish from jumping out, people from falling in, and salmon from being poached

from the fish ladder itself. Columbia Cellulose ordered installed such a grating to cover the lower part of the fishway in 1975. A chain link enclosure was subsequently installed around the fish ladder structure in 1961 (DFO 2015).

The Kloiya fishway is still in place, but is in need of repairs to cracks in the original concrete structure (Figure 8), but appears to provide adequate fish passage for Sockeye and Coho salmon. While the historic record for Pink salmon escapement is incomplete, it appears that Pink salmon have spawned above the fishway since its installation; however the most recent recorded Pink salmon escapement in Diana Creek was in 1968. The persistence of salmon populations that spawn upstream of the fish ladder, including Coho and Sockeye salmon in Prudhomme and Diana Creeks, provide evidence that the fishway is operational, however no studies have been conducted to measure what proportion of each species of salmon successfully ascends the fish ladder, and subsequently spawn in a given year. For example, in 2014 and 2015, we observed numerous sockeye salmon leaping towards the spillway rather than the fish ladder during the month of June. While sockeye salmon were subsequently observed in Diana and Prudhomme Creeks in both years, it is not known whether all, or what proportion, of the sockeye salmon that returned to Kloiya Creek ascended the fishway each year.

Figure 8. Kloiya fishway during a period of high flow showing cracks in concrete structure.

Poaching/Fisheries violations

The fish ladder also offered an accessible location for harvesting migrating salmon, which may have contributed to salmon mortality related to dam infrastructure, particularly during periods of low flow which often coincided with the peak migration for Sockeye salmon prior to installation of the grating and chain link fence. In a 1955 letter to the Chief Supervisor of Fisheries, a fisheries officer recommended that Section 25 of the Fisheries Act be amended to read, “No one shall fish in any manner within one hundred yards below or above the fishway at Cloyah Creek dam” (Strachan 1955 (DFO 2015)). An incident report from 1957 described an encounter between Fishery Guardian Collier and several individuals, who he had earlier observed shooting indiscriminately on the trail to the dam, and later found inside of the fishway, having obstructed water flow with a temporary obstruction (Collier 1957 (DFO 2015)). A second incident report filed several months later describes severe gunshot damage to Guardian Collier’s vehicle and tires which were parked at the Kloiya Beach recreational site (Collier 1957 (DFO 2015)).

With improved accessibility resulting from the maintained road and public recreation at the mouth of the creek, Kloiya Creek continued to be an important recreational fishing area following the installation of the grate and chain link barrier. A 1981 memorandum from a fisheries officer noted, "Kloiya Creek is one of two creeks that receives great fishing pressure from the public due to the accessibility and scenic value. We do have some problems on the creek, from June to November, we spend a great deal of time on the system" (Kriegl 1981(DFO 2015)).

Fry trapping/intake screen

A travelling rotating intake screen (Figure 9), which was installed to prevent salmon fry from becoming entrained in the intake pipe, was identified as another potential source of direct fish mortality because of the potential for fry to become trapped on the intake screen because of hydrostatic pressure. On several occasions from the start of mill operations in 1951 until Skeena Cellulose closed in 2001, several different DFO managers raised concerns about the effects of the intake screen to juvenile salmon (DFO 2015).

The intake screen was installed during the initial construction of the Kloiya dam at the recommendation of Department of Fisheries personnel. In 1950, DFO Division Engineer C.H. Clay acknowledged the receipt of plans for revolving (traveling) screen to be installed at the Kloiya dam, and recommended that a fry bypass system be installed to avoid trapping migrating fry on the face of the

screen. Specifications for such a fry bypass and outfall weir were provided in addition to instructions for removing fish from the intake screen. A weir box was added to an existing fry bypass pipe in 1967. A third travelling screen was installed when the larger 78" diameter pipe was installed at the pumping station in 1961. Prior to the construction of the Diana Lake dam and expansion of water storage facilities, DFO personnel raised concerns that the Company's increased water use would likewise increase water velocity at the travelling intake screens, thus rendering them ineffective. The Department recommended either lengthening the proposed screen width or increasing the minimum depth of water flow by maintaining the minimum operating levels at the Taylor Lake reservoir at 90', rather than 87' elevation (DFO 2015).

A February 1961 letter from W.M. Scott, engineering inspector for Columbia Cellulose to R.C. Edwards, DFO District Supervisor of Fisheries informed him that two dead Sockeye fry had been found on the travelling screens in the previous months. Intermittent investigations into perceived fry mortality related to the intake screens continued until 2000. In 1979, W.J. Schouwenberg (Chief, Water Use Unit, Habitat Protection Division) notified Columbia Cellulose that "hundreds of stickleback and much algae and debris impinged on nearly all the submerged screen panels", and made recommendations for improved maintenance of the intake screens. In 1999, a DFO Conservation and Protection officer informed DFO habitat biologist Tom Pendray that the "travelling water screens are killing fish", having observed that 61 of 98 fry caught on April 30 were dead (DFO 2015).

A departmental memorandum from 2000 summarizes an engineering analysis of flow velocities in and around the intake screens for 78-inch diameter water supply pipeline, and found that higher withdrawal rate proposed would exceed allowable limits for approach velocities for a static screen, but not for a travelling self-cleaning intake screen as currently installed, and pointed out that if screens at Kloiya weren't operated on a regular cleaning cycle, that they would behave as static screens. Northern Laboratories conducted a fry mortality study at the dam intake in April 2000 on behalf of DFO and Skeena Cellulose to determine the effects of accumulated debris and the intake screen rotation schedule on fry entrainment and mortality. Their final report concluded that there was no correlation between the amount of accumulated debris and fry mortality, and that fry mortality appeared to be caused by the screen rotation itself, rather than being trapped in accumulated debris, and recommended that the intake screens not be rotated during the night when smolt migration occurs (Northern Laboratories, 2000)

Figure 9. Outside and inside views of the travelling rotating intake screen for the 70” stave pipe at the Kloiya River dam.

Gravel impoundment

Chinook, Coho and Steelhead salmon spawning habitats in Kloiya River downstream of the Kloiya dam have been affected by poor gravel recruitment as a result of sediment accumulation and impoundment upstream of the dam over the past half century. While previous salmon habitat restoration activities in the Kloiya River system included gravel placement in spawning habitats downstream of the dam, much of the new gravel has been washed out as a result of erratic water releases from the dam during periods of high water flow (S. Devcic, pers. comm).

Flooding of spawning areas

Elevated water levels in the Prudhomme Lake reservoir following construction of the Kloiya dam appears to have inundated Coho and Sockeye spawning gravels in the lower sections of Prudhomme and Diana Creeks (Figure 10). An early fisheries guardian observed in 1951 that “since (the) dam was put in at the outlet of Prudhomme lake the water has backed up in Diana Creek for about half a mile” (Strachan, 1951 (DFO 2015)). It is unclear whether the spawning beds were lost, or if it simply became impossible to count spawning salmon in the deep, dark water in the areas flooded by lake water. In 1954, this guardian wrote, “With the installation of the dam and subsequent raise in the level of Prudhomme Lake about ¼ mile of the spawning area on Diana Creek was flooded but there is ample spawning area above this section and below the cascades” (Strachan, 1951 (DFO 2015)), contradicting a 1953 statement from a second fisheries guardian, who found that “the backing up of the lake water has evidently been advantageous and provides a constant satisfactory covering on gravel bars. This stream

may become a prolific source for Coho and Sockeye now that fishway is operating on Cloyah creek inlet to the system." (Sims, 1953 (DFO 2015)). The inundated creek areas may have created habitat for Coho, which have on many occasions been captured in the inundated riparian areas adjacent to Diana Creek (Lax Kw'alaams Fisheries 2015, FISS).

Figure 10. Section of former spawning habitat at Diana Creek inundated by elevated water level at Prudhomme Lake.

Field studies

Skeena Fisheries Commission (SFC), in partnership with Lax Kw'alaams Fisheries (LKF) carried out stream assessment surveys at Kloiya River, Prudhomme Creek, and Diana Creek in March 2015. The main objectives of these preliminary stream habitat assessments were to identify key spawning and rearing habitats in surveyed reaches, and to provide training to Lax Kw'alaams Fisheries personnel in stream assessment protocol. In 2015, Lax Kw'alaams Fisheries also participated in adult salmon escapement surveys at Diana Creek, Prudhomme Creek, and Kloiya River and conducted a hydroacoustic survey to estimate age-0 sockeye fry abundance at Prudhomme Lake. These field activities were intended to support the current study to determine how modifications to the existing Rainbow, Diana, and Taylor lake dams would affect fish habitats in the Rainbow and Kloiya Lake systems. Preliminary results from field sampling indicate that different salmon species utilize different habitats throughout the Kloiya

River watershed at different life history stages. Spawning habitats below the Taylor Lake dam are utilized by Chinook and Pink salmon during the summer and fall, while spawning habitats above Prudhomme Lake (Diana and Prudhomme Creeks) are used by Coho, Sockeye and Pink salmon. Juvenile sockeye salmon rearing habitat appears to be confined to pelagic areas of Prudhomme Lake, while Coho salmon appear to rear in littoral areas in Prudhomme Lake and Taylor Lake in addition to stream habitats in Diana, Prudhomme, and Kloiya Creeks. Preliminary results from the stream habitat assessments, adult stream enumeration, and hydroacoustic surveys are summarized in an interim report, included in Appendix 2.

Conclusions and recommendations

The Kloiya River system is utilized by all six species of Pacific salmon, and a review of historic escapement data indicates that there has been a general decline in salmon returns to the Kloiya watershed since the Columbia Cellulose dams were installed. The available salmon escapement data are generally poor, and there is no evidence to suggest that the coincident declines in salmon returns were caused by the dam infrastructure or associated changes to fish habitat. Whether or not declines in salmon returns to the Kloiya watershed were caused by dam infrastructure, modifications to the Kloiya and Diana Creek dams probably have the potential to improve salmon productivity, and that restoration activities such as dam modifications or removal, construction of spawning channels and rearing habitat, and modifications to the existing fish ladder could improve anadromous fish passage and fish habitat in the Kloiya River system. Improved escapement information for all species of salmon, including an assessment of the success of salmon migration through the fishway, would help us to quantify the potential benefits of any modifications to the dam infrastructure or other restoration activities. There is no evidence that the Rainbow Lake watershed has ever supported anadromous salmonid populations, and it is therefore unlikely that restoring connectivity between Rainbow Lake and the Skeena River by removing the dam at Boneyard Creek would result in any immediate or substantial increases in anadromous fish populations. Further, removing the dam from Boneyard creek could reduce water flow in the Kloiya system, which may reduce spawning and stream rearing habitat for salmon, and reduce accessability to and through the fish ladder for all species of salmon.

Reduced and insufficient water flow, particularly below the Kloiya River dam, is the most likely cause of reduced salmon productivity related to dam infrastructure and water withdrawals from the Prudhomme Lake reservoir. This problem was somewhat rectified after the Diana and Boneyard creek

dams were constructed to divert flow from the Rainbow Lake watershed into the Kloiya watershed (although this introduced additional potential problems related to scour and movement of creek beds). Therefore, any measures implemented to improve fish passage in the Kloiya watershed will not be effective unless adequate flow is maintained, which must be taken into account when designating future industrial water use in this system. Since the Skeena Cellulose pulp mill ceased operations in 2001, there has been at least one inquiry into repurposing the water license to service an independent power project since 2004 (DFO 2015). In that year, a DFO habitat manager recommended that a minimum flow of 20% of the mean annual discharge and additional flows during the salmon spawning season be reserved to support fisheries values, which the Province considered excessive and a possible deterrent to the sale of the water license (Hillier, 2004, (DFO 2015)). More recently, the Port Edward Water and Power Company submitted an application for a new water license to generate electricity from the existing 3 dams (Prince Rupert Daily News, 2014).

The old Skeena/Columbia Cellulose dams and associated infrastructure are now up to 60 years old (Figure 8), and the intake system and stave pipes are no longer operational, and the water license, which is currently held by the City, is not being utilized. Because the system will need to be rebuilt prior to any future development of this water resource, there is an opportunity to investigate alternatives for integrating modifications to the system in order to realize future water withdrawals from the Kloiya River and Rainbow Lake watersheds without compromising fish passage or productivity. We contacted two engineering firms (McElhanney Consulting Services Ltd. and Embark Engineering) to provide quotations and scopes of work to carry out an engineering study to explore the feasibility of several options to improve fish passage and productivity in the Kloiya watershed, including lowering or removal of one or more existing dam structures, improvements to the existing fish ladder, and constructing spawning channels for Chinook and Sockeye salmon. A complete quotation from Embark engineering is provided in Appendix 2. Because the proposed engineering feasibility study met significant opposition form the City of Prince Rupert, second engineering firms did not finalize a quotation.

The biggest obstacle to conducting any further investigation into improving fish habitat throughout the Kloiya watershed is the reluctance of the City of Prince Rupert to authorize such activities as a result of the complex legal landscape surrounding ownership of the facilities. With the exception of the wood stave pipes, which are owned by the District of Port Edward, all Skeena Cellulose infrastructure, including the old mill facilities on Watson Island and the Kloiya, Taylor, and Prudhomme Lake dams are currently owned by the City of Prince Rupert, which also holds the water rights associated

with the old Skeena Cellulose facility. The City, which acquired the property to compensate for non-payment of taxes by the former owner, Sun Wave Forest Products, which was not successful in reopening the facility following its shutdown in 2000. Pending litigation, which has arisen since the City assumed ownership of the Watson Island facility in 2010, has prevented its sale to interested parties, even though a settlement agreement was reached between the City and Sun Wave in 2013. At this time, City administration is not willing to engage with outside groups that have expressed interest in conducing fish passage and habitat assessment at the Kloiya Dam, and has forbidden that any such activities take place (L Brain and R Long, pers. comm).

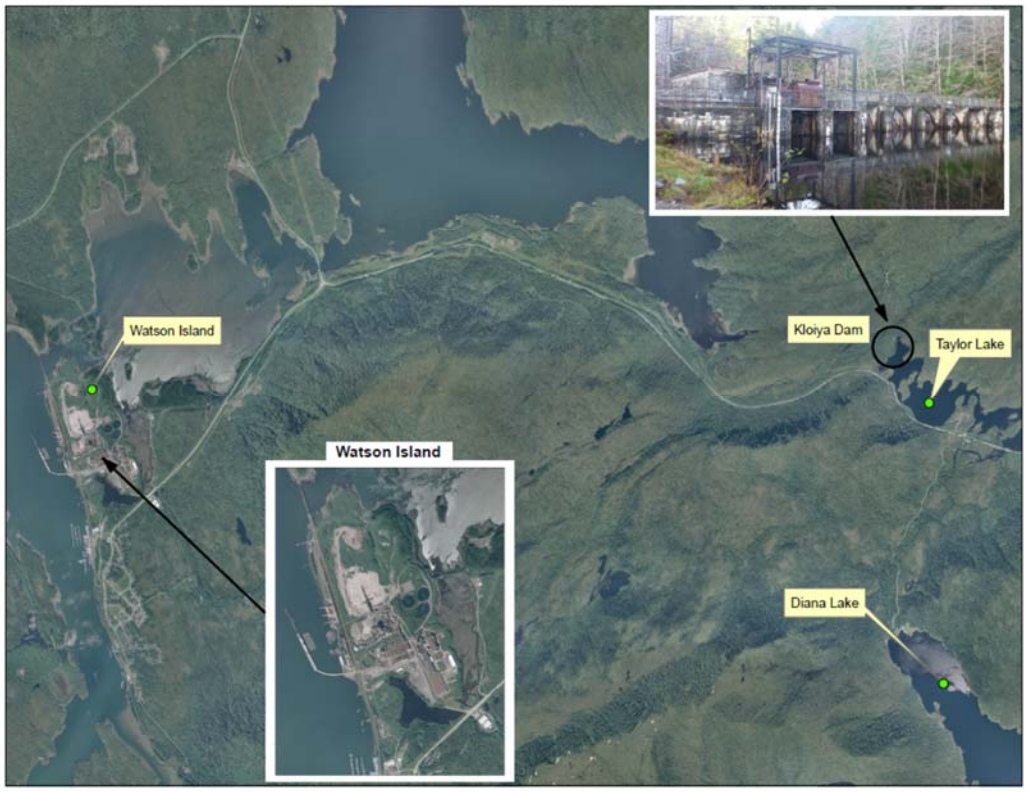


Figure 8. Aerial view of Kloiya River, with inset photographs of Watson Island pulp mill facility and dam at the outlet of Taylor Lake.

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Appendices

Appendix 1. Summary of Department of Fisheries and Oceans (DFO) archival correspondence related to Columbia and Skeena Cellulose waterworks in the Kloiya watershed

Appendix 2. Lax Kw'alaams Kloiya watershed field program interim report, December 2015

Appendix 3. Quotation from Embark Engineering to conduct engineering feasibility assessment of potential fish habitat restoration activities in the Kloiya River system.

Appendix 1: Summary of Department of Fisheries (DFO) correspondence reviewed regarding Skeena (formerly Columbia) Cellulose dam infrastructure/effects to fish and fish habitat

Date	Description	To	Title/Agency	From	Agency	Topic
1-Nov-47	**Permit**		**Columbia Cellulose**	**BC Water Rights Branch**		**Water license**
8-Sep-49	Letter	G.S. Reade	Regional supervisor of fisheries, DFO	A.J. Whitmore	DFO	fish ladder
23-Sep-49	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	fish ladder
1-Jan-50	Letter	G.S. Reade	Supervisor of fisheries, DFO	C.H. Clay	DFO	Intake screens
12-May-50	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	Intake screens
15-May-50	Letter	C.H. Klotz, Esq.	Project engineer, Columbia Cellulose	G.S. Reade	DFO	Intake screens
17-May-50	Letter	C.H. Klotz, Esq.	Project engineer, Columbia Cellulose	G.S. Reade	DFO	Intake screens
29-Jun-50	Letter	C.H. Klotz, Esq.	Project engineer, Columbia Cellulose	G.S. Reade	DFO	Intake screens
7-Jul-51	Memo	G.S. Reade	Regional supervisor of fisheries, DFO	J.B. Dyson	DFO	flow, fish passage
25-Jul-51	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	Fish passage
15-Aug-51	Letter		DFO	W.C.R. Jones	ColCel	Fish passage
21-Aug-51	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	Fish passage
21-Aug-51	Letter	W.C.R. Jones	Manager, Columbia Cellulose	G.S. Reade	DFO	Fish passage (falls)
22-Aug-51	telegram	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	Fish passage (falls)
24-Aug-51	Quote	G.S. Reade	Regional supervisor of fisheries, DFO	C.H. Clay	DFO	
27-Aug-51	Quote		Wood and McClay Ltd.	G.S. Reade	DFO	Fish passage (falls)
28-Aug-51	Letter	G.S. Reade	Regional supervisor of fisheries, DFO		Wood and McLay	Fish passage (falls)
28-Aug-51	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.S. Reade	DFO	Fish passage (falls)
28-Aug-51	telegram	G S Reade	Regional supervisor of fisheries, DFO	C.H. Clay	DFO	Flow/fish passage
1-May-52	Letter	Hon. R.W. Mayhew	Minister of Fisheries, DFO	G.A. Rorvik, Secretary	Prince Rupert Rod and Gun Club	Flow
7-May-52	Letter	G.A Rorvik	Prince Rupert Rod and Gun Club	Hon. R.W. Mayhew	DFO	Flow
21-May-52	Memo	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.E. Moore	DFO	Flow/fish passage
28-May-52	Letter	G.E. Moore	Acting supervisor of fisheries, DFO	F. Warne	DFO	Flow
7-Jun-52	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.E. Moore	DFO	Flow/fish passage
16-Jun-52	Letter	G.E. Moore	Area supervisor of fisheries, DFO	A.J. Whitmore	DFO	Flow/fish passage
26-Jun-52	Letter	G.E. Moore	Area supervisor of fisheries, DFO	G.A. Rorvik, Secretary	Prince Rupert Rod and Gun Club	Flow/fish passage
27-Jun-52	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	G.E. Moore	DFO	Flow/fish passage
11-Jul-52	Letter	E T Applewhaite	Member of Parliament	Evelyn C Watson	DFO	Flow/fish passage
25-Jul-52	Letter	G S Reade	Regional supervisor of fisheries, DFO	A.J. Whitmore	DFO	Flow/fish passage
16-Aug-52	Letter	G S Reade	Regional supervisor of fisheries, DFO	WL Hitchcock	DFO	Flow/fish passage
21-Aug-52	Letter	G S Reade	Regional supervisor of fisheries, DFO	WL Hitchcock	DFO	Flow/fish passage
8-Sep-52	Letter	R.C. Edwards	District supervisor of fisheries, DFO	W.R. Hourston	DFO	Diana dam/flow/fish passage/intake
20-Nov-52	Letter	G. S. Reade	Supervisor of fisheries, DFO	F. Warne	DFO	lease granting
28-Nov-52	Letter	A. J. Whitmore	Chief suvervisor of fisheries, DFO	G. S. Reade	DFO	lease granting

Date	Description	To	Title/Agency	From	Agency	Topic
23-Feb-54	Memo	C.H. Clay	Division Engineer, DFO	J.B. Dyson	DFO	Diana dam
4-Oct-55	Letter	A.J. Whitmore	Chief suvervisor of fisheries, DFO	W Strachan	DFO	fisheries violations
17-Jul-56	Letter	A.J. Whitmore	Area Director of fisheries, DFO	R.C. Edwards	DFO	drought conditions to salmon
3-Jul-57	Incident report			Guardian Collier	DFO	fisheries violations
16-Jul-57	Letter	E. Bartlett	Plant engineer, Columbia Cellulose	G.S. Reade	DFO	fish ladder
22-Jul-57	Letter	G.S. Reade	District supervisor DFO	E. Bartlett	Colubmia Cellulose	fish ladder
25-Sep-57	Letter	G.S. Reade	Regional supervisor of fisheries, DFO	EV Armstrong	DFO	fisheries violations
28-Apr-60	Letter	R.C. Edwards	District supervisor, DFO	G.W. Mcleod	Colubmia Cellulose	Flow
2-May-60	Letter	A.J. Whitmore	Area Director of fisheries, DFO	R.C. Edwards	DFO	Flow
2-May-60	Letter	G.W. Mcleod	Plant engineer, Columbia Cellulose	R.C. Edwards	DFO	Flow
25-May-60	Letter	R. C. Edwards	District supervisor, DFO	G. W. McLeod	DFO	water supply to pulp mill
30-May-60	Letter	A. J. Whitmore	Area Director, DFO	R. C. Edwards	DFO	proposed dam
7-Jun-60	Letter	R. C. Edwards	District supervisor, DFO	A. J. Whitmore	DFO	water supply to pulp mill
7-Jun-60	Letter		Columbia Cellulose Co. Ltd.	A.J. Whitmore	DFO	water supply to pulp mill
10-Jun-60	Letter	A.J. Whitmore	Director, DFO	W. D. Stothert	Colubmia Cellulose	water supply to pulp mill
21-Jun-60	Letter	W.D. Stothert	Columbia Cellulose Manager, engineering and Maintenance	C.H. Clay	DFO	Diana dam/flow/fish passage/intake
28-Jul-60	Meeting minutes	(attendees): I. Barclay, W. Stothert (Columbia Cellulose), M. Waldichuk (PBS), O.H. Clay, D. Mackinnon, R. Gordon, K. Jackson (DFO)				Diana dam/flow/fish passage/intake
15-Sep-60	Letter	V.H.B. Giraud	Fishery officer, DFO	R. C. Edwards	DFO	construction of dam
15-Sep-60	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam/flow/fish passage/intake
23-Sep-60	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	Diana dam/flow/fish passage/intake
28-Sep-60	Letter	V.H.B. Giraud	Fishery officer, DFO	R. C. Edwards	DFO	proposed dam
29-Sep-60	Letter	R.C. Edwards	District supervisor, DFO	V.H.B. Giraud	DFO	Diana dam/flow/fish passage/intake
30-Sep-60	Letter	R. C. Edwards	District supervisor, DFO	V.H.B. Giraud	DFO	proposed dam
3-Oct-60	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam/flow/fish passage/intake
9-Nov-60	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam/flow/fish passage/intake
1-Dec-60	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam/flow/fish passage/intake
16-Dec-60	Letter	R. C. Edwards	District supervisor, DFO	V.H.B. Giraud	DFO	construction of dam
5-Jan-61	Letter	I. A. Barclay	Secretary, Columbia Cellulose	W. R. Hourston	DFO	construction of dam
17-Jan-61	Letter	R. C. Edwards	District supervisor, DFO	W. M. Scott	Colubmia Cellulose	travelling screen
20-Jan-61	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam/pumping unit
23-Jan-61	telegram	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam

Date	Description	To	Title/Agency	From	Agency	Topic
27-Jan-61	Letter	R. C. Edwards	District supervisor, DFO	V.H.B. Giraud	DFO	construction of dam
30-Jan-61	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Diana dam
1-Feb-61	Letter	T.N. Beupre	President, Columbia Cellulose Co.	W.R. Hourston	DFO	Diana dam
1-Feb-61	Letter enclosure	R.C. Edwards	Area Director, DFO	W.R. Hourston	DFO	Diana, expansion of water supply
8-Feb-61	Letter	R.C. Edwards	District supervisor, DFO	W.M Scott	Columbia Cellulose	Intake screens
10-Feb-61	Letter	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Intake screens
14-Feb-61	Meeting minutes	In attendance: IA Barclay, WD Stothert (Columbia Cellulose), CH Clay, RE McLaren, K Jackson, RN Gordon, DF				
2-Mar-61	Letter	W.R. Hourston	Area Director of fisheries, DFO	I.A. Barclay	DFO	Diana dam
7-Mar-61	Letter	V.H.B. Giraud	Fishery officer, DFO	R.C. Edwards	DFO	Diana dam
6-Apr-61	Letter	W.D. Stothert	Columbia Cellulose	W.R. Hourston	DFO	Diana dam
6-Apr-61	Letter	R.C. Edwards		W.R. Hourston	DFO	Diana dam
26-Apr-61	Letter	V.H.B. Giraud	Fishery officer, DFO	R.C. Edwards	DFO	Intake screens
1-Jul-61	telegram	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	Diana dam/flows
1-Aug-61	telegram	W.R. Hourston	Area Director, DFO	R.C. Edwards	DFO	Flow
10-Aug-61	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	Flow
10-Aug-61	Letter	G.W. Mcleod	Plant engineer, Columbia Cellulose	W.R. Hourston	DFO	Flow
28-Aug-61	Letter	R.C. Edwards	District supervisor, DFO	N.J. Martinusen	Columbia Cellulose	Flow
28-Aug-61	Handwritten note	unknown		N.J. Martinusen	Columbia Cellulose	flow, fish ladder
23-Sep-61	Letter	W.D. Stothert	Manager, engineering and maintenance, Columbia Cellulose	W.R. Hourston	DFO	Intake screens, fishway, minimum flows
26-Oct-61	Letter	R. C. Edwards	District supervisor, DFO	J. W. Cochrane	DFO	water flow and temp records
31-Oct-61	Letter	R. C. Edwards	District supervisor, DFO	V.H.B. Giraud	DFO	fishway
8-Nov-61	enclosure	W.R. Hourston	Area Director of fisheries, DFO	R.C. Edwards	DFO	flow
17-Nov-61	Letter	W.D. Stothert	Manager, engineering and maintenance, Columbia Cellulose	W.R. Hourston	DFO	Diana dam, flow, stage measurements
17-Nov-61	Letter	R.C. Edwards	District supervisor, DFO	unknown (Letter cut off	DFO	Flow, stage measurements
22-Nov-61	Letter	W.R. Hourston	Area Director of fisheries, DFO	R.C. Edwards	DFO	fish ladder grating
30-Nov-61	Letter	W.R. Hourston	Area Director of fisheries, DFO	W.D. Stothert	Columbia Cellulose	Diana dam
30-Nov-61	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	fish ladder grating
30-Nov-61	Letter	W. D. Stothert	Assistant Mill Manager, Columbia Cellulose	W. R. Hourston	DFO	fishway
4-Dec-61	Letter	W. R. Hourston	Director, DFO	W.D. Stothert	DFO	fishway
8-Dec-61	Letter	V.H.B. Giraud	Fishery officer, DFO	R. C. Edwards	DFO	fishway
18-Dec-61	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	fish ladder
18-Dec-61	Letter	W.D. Stothert	General manager, Columbia Cellulose	W.R. Hourston	DFO	fish ladder gratings
1-Jan-62	Letter	W.R. Hourston	Area Director of fisheries, DFO	R.C. Edwards	DFO	fish ladder
9-Feb-62	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	fish ladder

Date	Description	To	Title/Agency	From	Agency	Topic
9-Feb-62	Letter	R.C. Edwards	District supervisor, DFO	W.R. Hourston	DFO	fish ladder
15-Feb-62	Letter	W.D. Stothert	General manager, Columbia Cellulose	R.C. Edwards	DFO	fish ladder
2-Mar-62	Letter	R.C. Edwards	District supervisor, DFO	G.W. Mcleod	Columbia Cellulose	fish ladder
6-Mar-62	Letter	W.R. Hourston	Area Director of fisheries, DFO	R.C. Edwards	DFO	fish ladder
3-Apr-62	Order		Columbia Cellulose	BC Water Rights Branch		Order
17-May-62	Letter		District supervisor, DFO	G.W. Mcleod	Columbia Cellulose	Kloiya dam
23-May-62	Letter	V.H.B. Giraud	Fishery officer, DFO	R. C. Edwards	DFO	kloiya dam
23-May-62	Letter	G. W. McLeod	Plant engineer, Columbia Cellulose Company Ltd.	R. C. Edwards	DFO	update
5-Nov-62	Letter	R. G. McIndoe	District supervisor, DFO	V.H.B. Giraud	DFO	Expansion in Port Edward
12-Dec-62	Letter	R. G. McIndoe	District supervisor, DFO	V.H.B. Giraud	DFO	causeway construction
19-Dec-62	Letter	W.R. Hourston	Area Director of fisheries, DFO	R.G. McIndoe	DFO	Flow
28-Jan-64	Letter	M. J. R. McLeod	District supervisor, DFO	V.H.B. Giraud	DFO	water rights application
3-Aug-66	Letter	P. D. Murray	District Protection Officer	E. T. Kasmer	DFO	flow rate
9-Aug-66	memo	L. Edgeworth	Chief Engineer	O. Rapp	Columbia Cellulose	discharge flow rate
15-Aug-66	Letter	P. D. Murray	District Protection Officer, DFO	W. R. Hourston	DFO	discharge flow rate
3-Mar-67	Letter	E.T. Kasmer	Fishery officer, DFO	A. Steigleder	Columbia Cellulose	Intake screens
4-Mar-67	Letter		Columbia Cellulose		DFO	Intake screens
5-Mar-67	Letter	A. Steigleder	Columbia Cellulose	E.T. Kasmer	DFO	Intake screens
1-Jul-79	memo	Terry Turnbull		Joan Elezabeth skogan	DFO	kloiya and diana creeks
1-Aug-79	memo	G. Jaltema	District supervisor, DFO	T. Turnbull	DFO	angling restrictions
2-Aug-79	memo			J. E. Skogan	DFO	kloiya creek salmon enhancement
20-Aug-79	memo				DFO	tributary streams
28-Aug-79	Letter	Don Lawseth	salmonid enhancement program	J. E. Skogan	DFO	summer students
27-Sep-79	Letter	Denis Rows	Columbia Cellulose	W.J. Shouwenburg	DFO	Intake screens
12-Oct-79	memo	J. H. Boland	Head Public Involvement, salmonid enhancement program	Don Lawseth	DFO	kloiya and diana creek enhancement
15-Oct-79	Letter	Mr. John Wilson	Canadian Cellulose Co. Ltd.	T. Turnbull	DFO	
20-Nov-79	notes			T. Turnbull	DFO	kloiya creek enhancement meeting
24-Nov-79	Notes			T. Turnbull	DFO	fish and fish habitat studies
8-Apr-81	Report	Gary Logan	DFO Senior biologist, small projects unit	Sam Gidora	DFO	fish and fish habitat studies
29-Apr-81	memo	W. H. McKenzie	Asst. District supervisor-DFO	T. Panko	DFO	Kloiya bay boat ramp
25-May-81	memo	S Kriegl	Fishery officer, DFO	G. Jaltema	DFO	fisheries violations
14-Jul-82	Letter	Lucille Bullen	Northern Trollers Asociations	J H Boland	DFO	enhancement

Date	Description	To	Title/Agency	From	Agency	Topic
12-Oct-82	Memo	B. Peters	Biologist	Gary Hoskins	DFO	fish & fish habitat studies
16-Jan-84	Letter	Eric Kremer	Director of Northern operations, DFO canada	R.G. Lightfoot	BC Timber	fish & fish habitat studies
29-Aug-84	memo	Howard Smith	Associate Director Fisheries Research Branch	Cole Shirvell	Research scientist	fish & fish habitat studies
20-Jan-92	Order		Skeena Cellulose	BC Water Management Branch		Water license
20-Jan-92	Permit		Skeena Cellulose	BC Water Management Branch		Permit
12-May-99	Letter	Tom Pendray	DFO habitat	Denis Burnip	DFO CNP	Intake screens
18-May-99	Letter	Fred Lockwood	DFO	Roy Vatcher	Columbia Cellulose	monitoring fish tote in kloiya pumphouse
9-Jun-99	Letter	Fred Lockwood	DFO	Francis Wong	Skeena cellulose	water supply intake for fish hatchery at kloiya dam
29-Oct-99	Letter	Peter Jowett	DFO, fishery officer	John Anderson	Skeena cellulose	Intake screens
28-Jan-00	memo	Uriah Orr	Habitat technician, Habitat & Enhancement Branch, DFO Prince Rupert	Ian Ross	DFO	Intake screens and velocity
28-Jan-05	email	Ivan Winther		Joy Hillier	DFO	independent hydroelectric power on kloiya dam
28-Jan-05	email	Joy Hiller	Habitat management biologist, DFO	Danny Wagner	DFO	independent hydroelectric power on kloiya dam
31-Jan-05	email	Mark Beere	WLAP:EX	Ron Ptolemy	WLAP	independent hydroelectric power on kloiya dam
10-Dec-07	Letter	Brian Peard		Holly Smith	DFO	kloiya river dam operations excerpts
29-Sep-08	email Letter	Pink Li etl.	Sun Wave Forest Products Ltd. ENV: EX, DFO	Normand Bilodeau	DFO	water act order on kloiya river on the 3 dams
4-Jun-09	email & report	Robert Piccini Ltd	ENV:EX	Dean Peard etl.	MoE	engineer report for kloiya dam

Appendix 2

Kloiya watershed field program

Interim report

Charmaine Carr-Harris[1]
Jennifer Gordon[2]
December 2015

[1]Skeena Fisheries Commission [2]Lax Kw'alaams Fisheries Program
Photo: Lax Kw'alaams Fisheries crew conducting stream habitat assessment at Diana Creek, March 2015

Summary

Skeena Fisheries Commission (SFC), in partnership with Lax Kw'alaams Fisheries (LKF) carried out stream assessment surveys at Kloiya River, Prudhomme Creek, and Diana Creek in March 2015. The main objectives of these preliminary stream habitat assessments were to identify key spawning and rearing habitats in surveyed reaches, and to provide training to Lax Kw'alaams Fisheries personnel in stream assessment protocol. We deployed temperature loggers and carried out synoptic fish sampling activities in conjunction with stream habitat assessments at each surveyed stream. The targeted field program, which was carried out during five days in March 2015, provided a snapshot of fish habitat utilization in sampled areas of the Kloiya watershed in late winter. When combined with information from other Lax Kw'alaams fisheries programs carried out in the Kloiya watershed in 2015 (described below), data from the targeted field program contributed to a greater understanding of habitat utilization patterns for different species of salmon at different life history stages, at different times of year.

Lax Kw'alaams Fisheries, in collaboration with the North Coast Fisheries and Oceans Canada Stock Assessment Division, carried out adult salmon escapement surveys at Diana Creek, Prudhomme Creek, and Kloiya River in fall 2015. Lax Kw'alaams Fisheries also conducted a hydroacoustic survey to estimate age-0 sockeye fry abundance at Prudhomme Lake in partnership with Skeena Fisheries Commission. Preliminary results from the stream habitat assessments, adult stream enumeration, and hydroacoustic surveys are contained in this interim report.

Stream Habitat Assessments

Lax Kw'alaams Fisheries conducted preliminary stream habitat assessments at Kloiya Creek, Diana Creek, and Prudhomme Creek in the spring of 2015 (Figure 1). The primary objectives of these preliminary stream habitat assessments were to identify key spawning and rearing habitats in surveyed reaches to assess how modifications to the Taylor, Diana, or Rainbow Lake dams would affect spawning and rearing habitats in these streams. A secondary objective was for Lax Kw'alaams Fisheries personnel to train and become familiar with standard methods of stream habitat assessment. To meet the second objective, Lax Kw'alaams Fisheries team members were accompanied by Kyla Warren, A Skeena Fisheries Commission habitat biologist with extensive previous experience in conducting stream surveys, who directed and supervised the first stream habitat assessment, which was conducted on Diana Creek. The Diana Creek stream habitat assessment was conducted utilizing provincial Resources Information Standards Committee (RISC) protocols.

Figure 1. Lax Kw'alaams Fisheries personnel setting minnow trap during stream assessment survey at Diana Creek, March 11, 2015.

A reconnaissance survey was conducted by Lax Kw'alaams Fisheries personnel at Prudhomme Creek on March 5, 2015. During the reconnaissance survey, a crew of two technicians and one biologist walked the extent of previously identified spawning and rearing habitat to delineate reaches for subsequent surveys. A detailed second survey scheduled on March 15, 2015 was aborted because of a crew injury that occurred at the beginning of the day. However temperature logger was successfully deployed and three minnow traps which were set at the beginning of the aborted second survey, although the minnow traps were retrieved after soak times of less than one hour. Kloiya River was surveyed on March 24, 2015. At the time of the survey, water levels downstream of the Taylor Lake dam were too high to safely or effectively measure stream width and depth. A temperature logger was deployed and minnow traps set during the Kloiya River survey.

Juvenile fish collection

While it was not possible to conduct comprehensive fish sampling throughout the watershed of interest during our five-day field program, fish trapping conducted during stream habitat assessments established fish presence and provided a snapshot of fish communities in sampled habitats throughout the Kloiya watershed. Juvenile fish were captured using minnow traps (G-traps) were set at various locations at Prudhomme Creek, Diana Creek, Kloiya River, and in Taylor Lake in April 2015. Minnow traps were deployed for soak times ranging from one to three hours using dried salmon eggs as bait.

Stream habitat assessments: Preliminary results

We captured fish using minnow traps in all sampled habitats except for the lower reaches of Prudhomme Creek. Fish were present in Kloiya Creek, Taylor Lake, and at several locations throughout Diana Creek, including inundated sections of spawning habitat near Highway 16. Juvenile coho salmon were the most numerous fish species sampled in all habitats. Other fish species captured by minnow traps included juvenile Dolly Varden, threespine stickleback, and a single *Oncorhynchus mykiss*, either anadromous steelhead salmon or resident rainbow trout, which are indistinguishable by morphological characteristics during the juvenile stages (Table 1).

Table 1: Summary of fish species captured by minnow trapping during stream habitats conducted throughout Kloiya River watershed, March 2015.

Location	Date sampled	ntraps	Total soak time (hours)	CO	DV	OM	3ST
Diana Creek - upper bridge/spawning reaches	11-Mar-15	6	15	30	2	1	
Diana Creek - highway crossing	17-Mar-15	2	6	3			
Kloiya River	24-Mar-15	6	3	7			2
Prudhomme Creek: lower reach	15-Mar-15	2	2				
Taylor Lake	17-Mar-15	3	9	27	3		7
Total		**19**	**35**	**67**	**5**	**1**	**9**

CO: Coho salmon, DV: Dolly Varden, OM: Oncorhynchus mykiss (anadromous or resident forms), 3ST: threespine stickleback

Temperature Loggers

Long-term temperature data recorded from Prudhomme, Kloiya and Diana Creeks will allow us to monitor changes in the rearing potential of these creeks with respect to thermal shifts. Lax Kw'alaams deployed a series of Tidbit V2 temperature loggers in Prudhomme, Kloiya and Diana Creeks in the spring/summer of 2015. The temperature loggers, which were cased in a protective housing, were placed in suitable areas of each stream, will collect data for at least one year, and will be monitored periodically to ensure that they remain submerged and functional. We anticipate that data will be retrieved from temperature loggers currently installed throughout the Kloiya River Watershed in August 2016 (Figure 2).

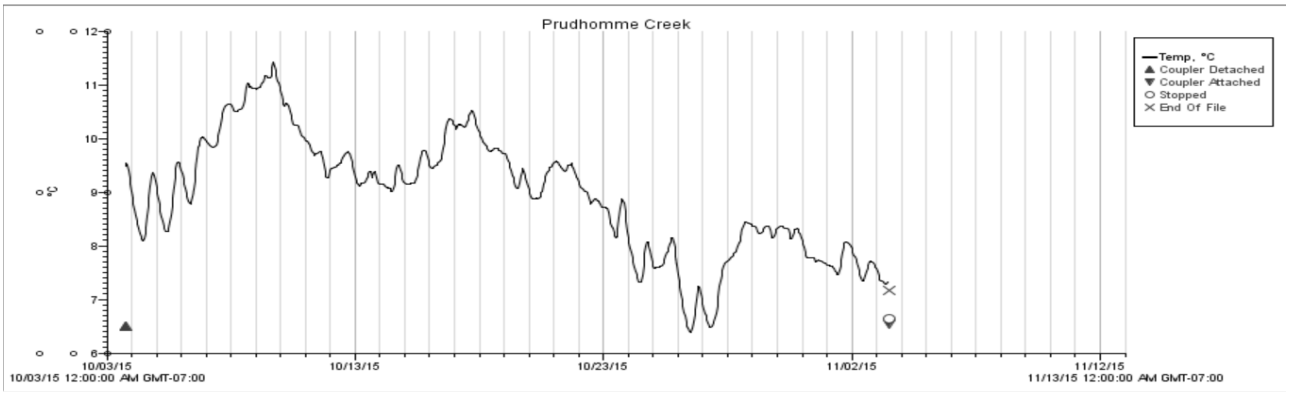

Figure 2: Example output from Tidbit temperature logger deployed at Prudhomme Creek, October 10 – November 11 2015. Following data retrieval, this logger was replaced back into the stream, where it will collect daily temperature data for up to a year.

Figure 3: Spawned-out adult sockeye salmon photographed during creekwalk at Prudhomme Creek, October 3, 2015. Photo credit: Jennifer Gordon.

Adult salmon enumeration

Lax Kw'alaams Fisheries participated in adult salmon enumeration creekwalks in collaboration with the Department of Fisheries and Oceans (DFO) at Kloiya, Diana and Prudhomme Creeks during the fall of 2015. The adult enumeration surveys provided an opportunity to confirm whether spawning salmon were in fact utilizing spawning habitats identified during reconnaissance surveys and stream assessments (Figure 3). Lax Kw'alaams Fisheries personnel were accompanied and trained by experienced DFO creekwalkers. Altogether, Lax Kw'alaams Fisheries participated and/or led three creekwalks at each of Diana Creek, Prudhomme Creek, and Kloiya Creek between September and November 2015. At the time of peak spawning, the maximum number of sockeye salmon, the most abundant fish species observed, were 173 fish at Prudhomme Creek, and 334 fish at Diana Creek. A total of 46 Chinook salmon and numerous pink salmon were observed in Kloiya River in September and October. Coho salmon were observed later in the season in Diana and Prudhomme Creeks. Coho salmon, which appear later in the year than sockeye and pink salmon in most North Coast streams, are often difficult to enumerate by visual escapement estimates when visibility is compromised by high water levels, which may also make streams dangerous to survey. Visual escapement estimates at Prudhomme Creek, Diana Creek, and Kloiya River are also challenging because of high levels of tannins resulting in dark, or tea-coloured waters throughout, which further compromise visibility. As a result the

reliability of visual escapement estimates for Chinook and sockeye salmon in Diana Creek, and for coho salmon throughout the system, are likely to be conservative, while estimates for coho salmon are presence-absence only.

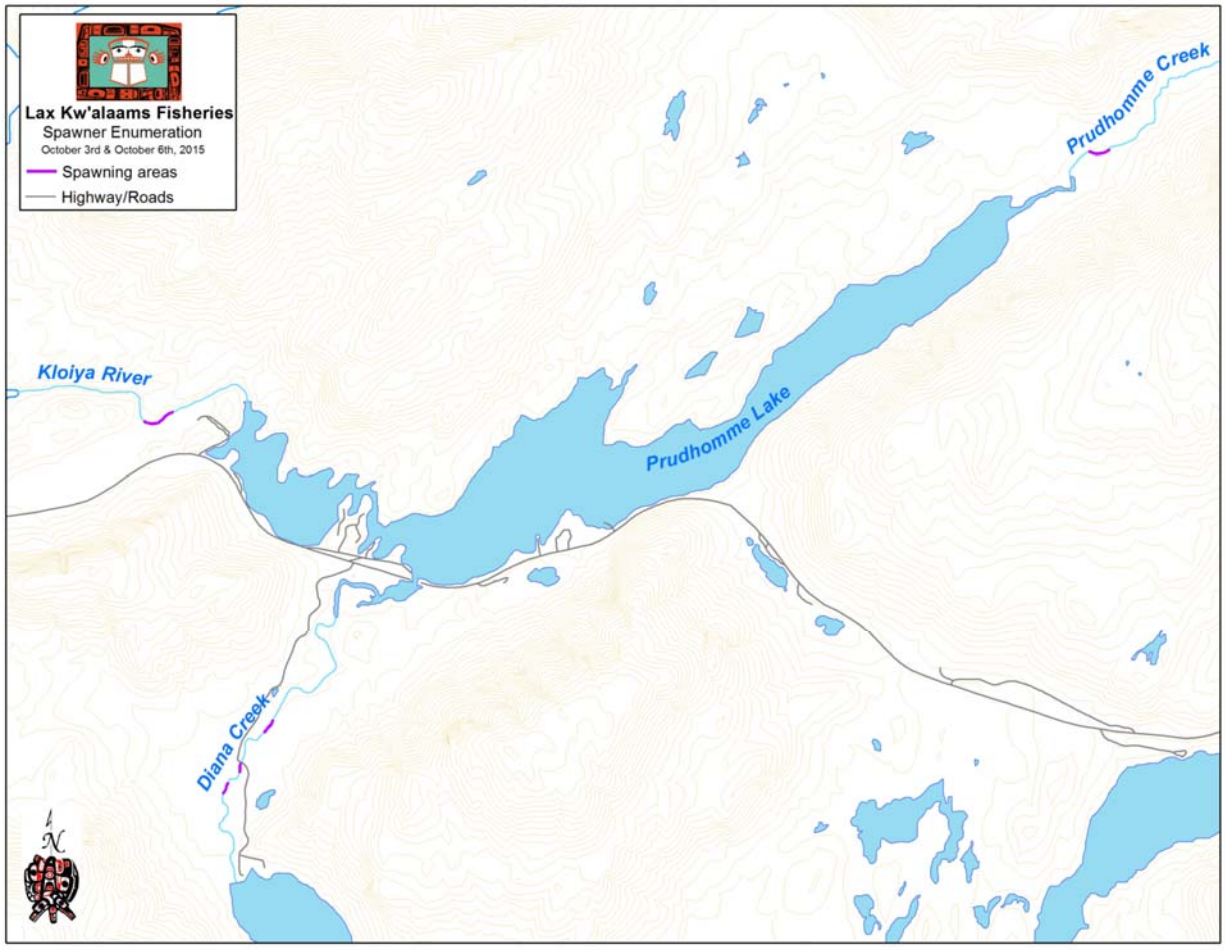

Figure 4. Map showing areas where adult spawning salmon were observed during escapement surveys at Kloiya River, Diana Creek and Prudhomme Lake, September – November 2015. Map created by John Latimer, Lax Kw'alaams Fisheries

Prudhomme Lake hydroacoustic survey

Juvenile sockeye salmon, which occupy pelagic areas of a given lake, are not vulnerable to capture by beach seine or minnow trap. Hydroacoustic surveys, combined with trawl sampling, are considered an effective method for estimating the abundance of juvenile sockeye salmon and competitor limnetic species within a lake. Lax Kw'alaams Fisheries contracted Skeena Fisheries Commission to conduct a hydroacoustic survey at Prudhomme Lake in October 2015. The primary objective of the Prudhomme Lake hydroacoustic survey was to estimate the abundance and biomass of

age-0 sockeye (fry) rearing in the system. Hydroacoustic surveys were conducted using standard methodology. Acoustic data were collected along previously defined transects using a Biosonics DT-X echosounder with a 200 kHz split-beam transducer producing a 6^{o} beam. The downward-pointing transducer was pole-mounted to our inflatable vessel. Hydroacoustic data were collected to an acoustic threshold of -100 dB f as the vessel proceeded along transects at a constant speed.

Limnetic fish were sampled using a 2 x 2 m midwater trawl. The trawl net was deployed to a maximum depth of 35 m, towed behind the boat at a constant speed of approximately 1m/s, and retrieved with a portable winch. Large fish were counted and released. Small fish were sorted by species and stored in ethanol, and weighed and measured after at least 30 days of preservation. Temperature and oxygen profiles were taken using a YSI meter with a maximum depth of 30 m. A zooplankton sample was taken using a 150 µm mesh, 30 cm diameter simple conical plankton net.

Prudhomme hydroacoustic survey preliminary results

Acoustic data were successfully captured from ten transects at Prudhomme Lake on the night of October 14-15 2015. These data will be analyzed and an estimate produced in the winter of 2016-2017. While fish targets appeared to be present throughout the lake, our initial observations of substantial acoustic noise throughout the lake from approximately 10-20 m depth (Figure 4) will make these acoustic data more challenging to analyze. The source of noise was confirmed to be *Chaoborous*, or phantom midge larvae, of which large numbers were present in our zooplankton sample.

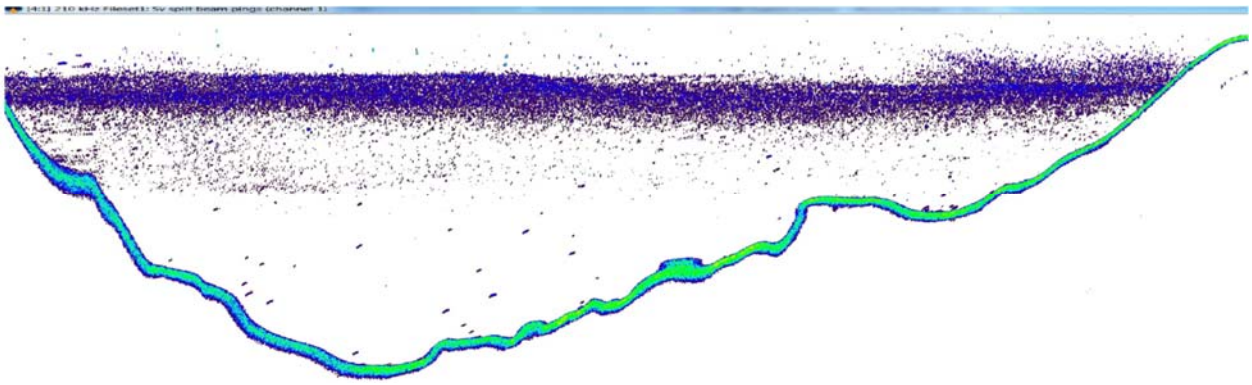

Figure 5. Echogram from first transect of acoustic data recorded at Prudhomme Lake, October 3, 2015 showing individual fish targets with dense chaoborus layer from 10-20 m depth.

We captured 43 juvenile sockeye salmon and 13 threespine stickleback (*Gasterosteus aculeatus*) in 5 trawls with depths ranging from 9 – 20 m and a combined duration of 45 minutes. The mean length and weight for juvenile salmon was 63 ± 16 mm and 2.7 ± 1.8 grams (error term represents ± 2 standard deviations) respectively (Figure 6).

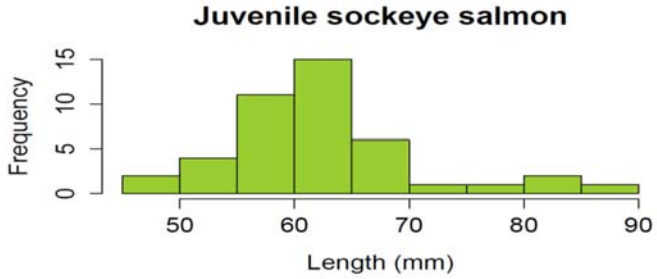

Figure 6. Histogram showing frequency of lengths of sockeye fry captured by midwater trawl, October 19 2015.

Discussion

Field activities, including stream habitat assessments were intended to be one of several components of a detailed study to determine how modifications to the existing Rainbow, Diana, and Taylor lake dams would affect fish habitats in the Rainbow and Kloiya Lake systems. Preliminary results from field sampling indicate that different salmon species utilize different habitats throughout the Kloiya River watershed at different life history stages. Spawning habitats below the Taylor Lake dam are utilized by Chinook and pink salmon during the summer and fall, while spawning habitats above Prudhomme Lake (Diana and Prudhomme Creeks) are used by coho, sockeye and pink salmon. Juvenile sockeye salmon rearing habitat appears to be confined to pelagic areas of Prudhomme Lake, while coho salmon appear to rear in littoral areas in Prudhomme Lake and Taylor Lake in addition to stream habitats in Diana, Prudhomme, and Kloiya Creeks. Interestingly, juvenile coho were captured by minnow traps in littoral habitats near Diana Creek and Taylor Lake where previously forested areas had been inundated by elevated water levels following installation of the Taylor Lake dam, but not in pelagic areas of Prudhomme Lake that were sampled by trawl during hydroacoustic surveys in October 2015.

Appendix 3

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Canada
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Lax Kw'alaams
206 Shashaak Street
Lax Kw'alaams, BC V0V 1H0
Canada
T: 604 839 9872

June 10, 2015

Charmaine Carr-Harris
Skeena Fisheries Commission
3135 Barnes Crescent
Kispiox, BC V0J 1Y4

Dear Ms. Carr-Harris:

RE: KLOIYA DAM RE-PURPOSING
Feasibility Assessment
Our File 13499.001

Embark Engineering Limited (Embark) provides this proposal for assessing the feasibility for re-purposing the Kloiya Dam to enhance the fisheries habitat and use of the Kloiya River and reservoir.

The staff at Embark have a significant portfolio of recent dam projects, including inspections, assessments various design, dam safety reviews and construction oversight. Their hands-on work, a strong understanding of current issues and regulations, and strong working relationships with the provincial and regional dam safety offices has allowed KWL to become a leading company on dam safety. They actively participate in dam associations and conducting project and report debriefing with clients and provincial dam safety officers, and provide thoughtful, leading edge service.

The dam, constructed in the 1950s, was one feature in a complex system which delivered water to a mill on Watson Island. The mill closed down several years ago and the dam has fallen into a state of disrepair through lack of maintenance. The ownership of the dam was also transferred to the City of Prince Rupert.

The dam was constructed to store water on Taylor and Prudomme Lakes; it was subsequently upgraded to store additional water. The facility prevented the natural migration of fish into the upper system but also affected the lower Kloiya River as sediment migration downstream was eliminated. The lack of sediment recruitment altered the fisheries use and available habitat.

There is opportunity to modify the current dam to enhance the fish utilization from the existing structure.

About Embark

Embark Engineering Limited Partnership (Embark) is a First Nation company formed in 2012 by the Lax Kw'alaams Band and Kerr Wood Leidal Associates Ltd. The Lax Kw'alaams Band is one of the largest bands in British Columbia by population. Through its various business interests, the Lax Kw'alaams Band annually generates over $200 million in business activity in the north coast economy. Kerr Wood Leidal Associates Ltd. (KWL) is a well-known and established multidisciplinary engineering firm that has operated in Western Canada since 1975. The two partners, Lax Kw'alaams and KWL, have a long established relationship of working together. Embark provides engineering and management services through KWL, which include planning through to design, construction and commissioning of municipal infrastructure, and resource management. Embark is dedicated to providing excellence in engineering and attentive client service. Our brochure is attached.

A first nation company

Work Program

The approach to this project is based on identifying the competing objectives, considering the outcomes, determining options for consideration and, eventually, preparing drawings sufficient for regulatory approval. In conjunction to this engineering feasibility, Skeena Fisheries Commission is undertaking an assessment to determine the fisheries objectives which would be possible within this system. Our work programs are complimentary and come together in the course of our project. The City of Prince Rupert will also be involved within the objectives discussion. Table 3 outlines the engineering and design effort:

Table 1: Engineering and Design Effort

Task	Description of Task	Identification of Sub-Tasks	Deliverables
1.0 Project Initiation and Management			
1.01	Project Initiation Meeting	• On site meeting in Prince Rupert meeting with Skeena Fisheries Commission representatives to confirm project scope and deliverables • Obtain a Professional Services Agreement (PSA)	• Meeting Notes • PSA
1.02	Site Assessment	• Complete an assessment to review the visual elements of the dam for general condition. • Collect basic physiographic parameters. • Make observations related to potential implications of changes to the dam and surrounding area.	• Inspection Report
1.03	Gather and Review Information	• Discuss current and future objectives and plans with City of Prince Rupert. • Obtain and review pertinent information from Owner, Fisheries and Oceans Canada, Provincial Dam Safety Officer and Skeena Fisheries Commission.	• Reference Listing
1.03	Project Management	• Work Task coordination • Liaison with the Skeena Fisheries Commission and the interested stakeholders. • Completion of invoicing, updating project management plan (PMP)	• Monthly invoicing • PMP
2.0 Opportunity Development			
2.01	Integrate Fisheries Objectives	• Coordination with Skeena Fisheries Commission to understand fisheries objectives and overview with dam conditions, potential upgrades and modifications.	• Meeting notes
2.02	Hydrology Assessment	• Obtain and analyse hydrometric data from Water Survey Canada or other nearby hydrometric stations.	

Task	Description of Task	Identification of Sub-Tasks	Deliverables
		• Determine potential outlet sizes and required fish flows • Determine implications to reservoir volumes	
2.03	Develop Opportunities and cost estimates	• Develop and refine 3 potential opportunities and associated Class D cost estimates	
2.04	Draft Technical Memorandum	• Document the work program and options generated	Draft TM
2.05	Final Technical Memorandum	• Receive comments and incorporate changes from Skeena Fisheries Commission, Fisheries and Oceans Canada, and City of Prince Rupert • Issue	Final TM
3.0 Design Selection			
3.01	Survey of Dam and Channel	• Complete a physical survey of the dam and relevant appurtenances • Complete a topographic survey of downstream areas sufficient for design of any fish habitat enhancements within the channel downstream of the dam.	Reference maps and point coordinates.
3.02	Detail Design Development	• Refine the preferred option • Develop drawings	Drawings suitable for regulatory application.

We plan on subcontracting the surveying task to a local firm with experience in topographic and dam surveys. This meets with our belief to provide as much tasking for the local economy.

Fee Estimate

Attachment C presents our estimated level of effort and fees, including disbursements. Based on the information presently available, our fee estimate for this work is $80,400 plus GST and markup. Our billing will not exceed the approved budget without prior authorization.

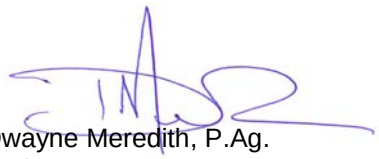
Professional Services Agreement

We value our developing relationship with the Skeena Fisheries Commission. We would be pleased to tailor this proposal further should you require. We are prepared to start work immediately upon agreement of a signed Professional Services Agreement.

Embark appreciates the opportunity to assist with the Kloiya Dam re-purposing. Please contact the undersigned if you have any questions regarding this proposal.

Yours truly,

EMBARK ENGINEERING LIMITED.



Dwayne Meredith, P.Ag.
Project Manager

/dwm

Encl.
Embark Brochure
Experience Summary Table
Fee Estimate

Proprietary and Confidentiality Notice

Copyright Notice

Kloiya Dam Re-Purposing Feasibility

Skeena Fisheries Commission

June 10, 2015

Attachment C: Estimated Level of Effort and Engineering Fees

Task No.	Task Description	KWL Staff Commitment (hours)					KWL	Subconsultant	Totals	
		Project Manager D.Meredith $158	Project Engineer P.Fearon $202	Junior Engineer E.Li $134	Technical Review A.Chantler $247	Project CADD/GIS R.Taylor $114	Expenses Direct	Sub 1 McElhanney LS	Hours	Costs ($)
1	**Project Initiation and Project Management**									
1.01	Project Initiation	8	8				$2,000		16	$4,880
1.02	Site Assessment	10	10		2		$2,000		22	$6,094
1.03	Review Available Information	2	4	8			$150		14	$2,346
1.04	Project Management	34					$500		34	$5,872
	Subtotal	**54**	**22**	**8**	**2**	**0**	**$4,650**	**$0**	**86**	**$19,192**
2	**Opportunity Development**									
2.01	Integrate Fisheries Objectives	5	2				$0		7	$1,194
2.02	Hydrology Assessment		16	40	8		$50		64	$10,568
2.03	Develop Options/ Cost Estimate	10	10	32	4	16	$0		72	$10,700
2.04	Draft Technical Memo	2	4	16			$0		22	$3,268
2.05	Final Technical Memo	2	2				$0		4	$720
	Subtotal	**19**	**34**	**88**	**12**	**16**	**$50**	**$0**	**169**	**$26,450**
3	**Design Selection**									
3.01	Survey of Dam and Channel						$0	$20,000	0	$20,000
3.02	Detailed Design	8	16	45	6	24	$0		99	$14,744
	Subtotal	**8**	**16**	**45**	**6**	**24**	**$0**	**$20,000**	**99**	**$34,744**
	Subtotal (all tasks)	**81**	**72**	**141**	**20**	**40**	**$4,700**	**20000**	**354**	**$80,400**
	SubConsultant Mark Up									
	GST (5%)									**$4,020**
	Total Estimated Budget									**$84,400**

Notes:

File 13499.001

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