Campbell River Water Use Plan

Physical Works Terms of Reference

- **JHTWORKS-6 - Salmon River Diversion Juvenile Fish Screen Upgrade**

January 20, 2014

JHTWORKS-6 Salmon River Diversion Juvenile Fish Screen Upgrade Physical Works Terms of Reference

1 Introduction

This Terms of Reference details the physical works improvements to the juvenile fish screen on the Salmon River Diversion.

A cost estimate for the Identification (feasibility design) and Definition (preliminary design) phases, and a tentative schedule for the work are provided. We are currently seeking approval for the Identification and Definition phase funding based on current estimates. As estimates are refined through the project cycle, BC Hydro will resubmit this Terms of Reference as required to seek approval for subsequent required spending.

The planning process for the Campbell River Water Use Plan was initiated in September 1999 and completed in March 2003. This Terms of Reference is submitted in response to the *Order* issued by the Comptroller of Water Rights on November 21,2012. The *Order* states that the BC Hydro shall submit terms of reference to upgrade the fish screen at the Salmon River Diversion to reduce damage to fish and improve its fishing efficiency (as stated in Schedule F).

2 Description of Project

2.1 Location

The Campbell River system is located on central Vancouver Island (refer to the following map for place names). Originating in Strathcona Provincial Park, the Campbell River flows north and then east toward the District of Campbell River, passing through Buttle Lake, Upper Campbell Lake, Lower Campbell Lake and John Hart Lake before flowing into Discovery Passage. The Salmon River located north of the Campbell River flows northeast then north entering Discovery Passage near Sayward. A diversion structure takes Salmon River water, when available, via a canal and channel to Brewster Lake where it flows to Whymper, Gray and Fry lakes and then into Lower Campbell Lake Reservoir. The Quinsam River generally parallels the Campbell River system to the south and naturally joins the Campbell River between the John Hart Dam and Discovery Passage. Diversion structures take Quinsam River water, when available, into Lower Campbell Lake Reservoir.

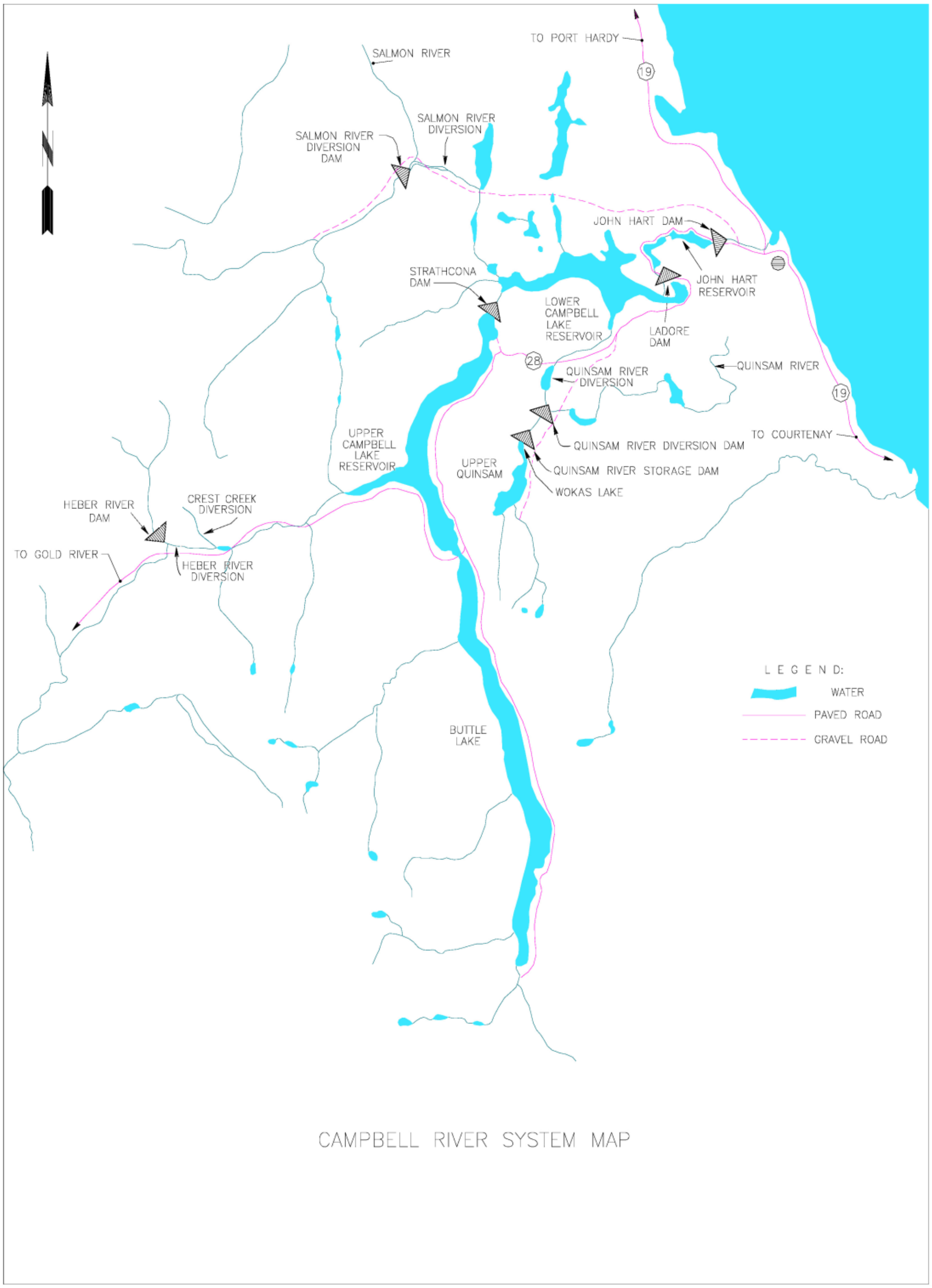


Figure- 1: The Campbell River System

2.2 Existing Works

The existing works comprising the Campbell River project include:

- **Upper Campbell Lake Reservoir**[1]: The reservoir covers 6730 ha, has a gross capacity of 1,036 million m^3, and 860 million m^3 of active storage at full pool. The maximum and minimum operating levels of the reservoir are 220.5 m and 212.0 m above sea level respectively.

- **Strathcona Dam**: The 511 m long and 53 m high earthfill dam is located at the northern end of Upper Campbell Lake Reservoir, and has a crest elevation of 225.6 m above sea level.

- **Strathcona Dam Spillway**: The three vertical lift steel gates have a total discharge capability of 1220 m^3/s when the reservoir is at full pool.

- **Strathcona Generating Station**: The 67.5 MW capacity Strathcona Generating Station is located at the toe of the earthfill dam and contains two vertical shaft Francis turbine generator units. Once water from the reservoir passes through the turbines, the water is discharged from the generating station into the Lower Campbell Lake Reservoir.

- **Lower Campbell Lake Reservoir**: The reservoir covers 3700 ha, has 317 million m^3 gross capacity and has an active storage of 309.5 million m^3 at full pool. The maximum and minimum operating levels of the reservoir are 178.3 m and 174.0 m above sea level respectively.

- **Loveland Saddle Dam**: An earthfill dam that is 80 m long and has a crest elevation of 179.8 m above sea level.

- **Big Slide Saddle Dam**: An earthfill dam that is 15 m long and has a crest elevation of 179.8 m above sea level.

- **Quinsam Storage Dam**: A concrete gravity dam 57 m long with a crest elevation of 368.2 m above sea level. There is a live and usable storage of 12.33 million m^3 at full pool at Wokas Lake.

- **Quinsam Diversion Dam**: A concrete gravity dam 65 m long with a crest elevation of 309.7 m above sea level. At the Quinsam Diversion, water is carried along a 1.7 km long canal from the diversion dam to Gooseneck Lake. Gooseneck Lake in turn drains into Snakehead Lake and Miller Creek and eventually into Lower Campbell Lake Reservoir. The Quinsam Diversion has the capacity to divert 8.5 m^3/s.

- **Salmon River Diversion Dam**: A rockfill timber crib dam 89 m long with a crest elevation of 224 m above sea level. The Salmon River Diversion carries water along a canal and then through a flume over Paterson Creek to Brewster Lake, where it

[1] This document uses the common name of Upper Campbell Lake Reservoir. The official name is Upper Campbell Lake and Buttle Lake Reservoir.

flows through Whymper, Gray and Fry lakes and then into the Lower Campbell Lake Reservoir. The Salmon River Diversion has the capacity to divert 42.48 m^3/s. A juvenile fish screen is installed in the diversion canal to screen and redirect out-migrating juvenile and adult fish from the diversion canal back into the Salmon River.

- **Ladore Dam**: The 94.5 m long and 37.5 m high concrete gravity dam is located at the eastern end of the Lower Campbell Lake Reservoir. The crest elevation is 179.5 m above sea level.

- **Ladore Dam Spillway**: The three vertical lift steel gates have a total discharge capability of 1644 m^3/s when the reservoir is at full pool.

- **Ladore Generating Station**: The 54 MW capacity Ladore Generating Station is located at the foot of the dam and contains two vertical shaft Francis turbine generator units. Once water carried by two tunnels from the Lower Campbell Lake Reservoir passes through the turbines, the water is discharged into the John Hart Reservoir.

- **John Hart Reservoir**: The reservoir covers 250 ha, has a gross capacity of 30 million m^3 and an active storage of 3.5 million m^2 at full pool. The normal operating range of the reservoir is between 139.6 m and 139.0 m above sea level.

- **John Hart Dam**: The concrete and earthfill dam 746 m long and 30 m high is located at the eastern end of John Hart Reservoir.

- **John Hart Spillway Sluicegate**: The three-bay spillway sluicegate has a discharge capacity of approximately 1557 m^3/s when the reservoir is at full pool.

- **Power Intake to John Hart Generating Station**: The power intake is located at the east shore of John Hart Reservoir within the John Hart Dam. The power intake consists of three 1767 m long penstocks, with the 1097 m upper portion being 3.7 m diameter woodstave pipeline and the 670 m lower portion being steel pipeline, to the John Hart Generating Station.

- **John Hart Generating Station**: The 126 MW capacity John Hart Generating Station is located on the Campbell River and contains six vertical shaft Francis turbine generator units. Once water from the John Hart Reservoir passes through the turbines, the water is discharged into the Campbell River.

3 Background

The Salmon River Diversion is located near Campbell River on Vancouver Island. A 3 km long, concrete lined canal diverts water from the Salmon River watershed into the lower Campbell River system for generation through BC Hydro's Ladore and John Hart facilities. While maintaining minimum flow requirements along the Salmon River mainstem, the canal can be used to divert up to a maximum allowable 42.5 m^3/s of the Salmon River flow into the lower Campbell River system. Inflows which exceed the maximum canal capacity continue down the Salmon River via overflow spillways at the dam.

The project came on line in 1958 and was not equipped with any upstream fish passage facilities as a barrier existed downstream which prevented the upstream migration of fish before they could reach the location of the diversion dam. This barrier was caused by a construction related landslide in the 1930's. Blasting to remove this barrier was initiated by the BC Ministry of Environment (MoE) in 1977 and stocking of Coho and steelhead in the upstream reaches of the watershed commenced in 1986 (Lydersen et al, 2010).

The upper watershed was estimated to have an average annual carrying capacity of 200-300 steelhead spawners. The Salmon River Coho carrying capacity is expected to between 5,000 to 10,000 Coho spawners with a portion of this population utilizing the upper river (Chilibeck 2010, Burt and Roberts cited therein). The upper Salmon River population is estimated at ~2500 spawners (Shannon Anderson, DFO pers comm). Screening or some other option was required to redirect downstream migrating juveniles around the diversion dam and/or out of the canal during the April to July migration period in order to re-establish a natural run along the Salmon River mainstem. A benefit-cost analysis conducted by MoE in 1983 indicated that this level of fish production warranted an expenditure of $300,000 for the capital cost of a juvenile screening facility which could provide an 80% or greater screening efficiency (Hansen, 2001).

Preliminary investigations for the juvenile screening facility indicated that the capital expenditure required to install fixed or mechanical screens or louver deflectors would exceed the project's limited budget. However, the project was considered an important part of MoE's fisheries management program and as such warranted continuing the investigations and the acceptance of the risks inherent in an unproven juvenile fish screen design (Chilibeck, 2010). The chosen design was constructed in 1986 and consists of a rigid screen spanning the width of a rectangular section of the canal. The 25 m long screen is hinged at its upstream end and declines downward in a downstream direction at an angle of 6.5 degrees to horizontal. The installed juvenile fish screen is a novel design which is self-cleaning, requires no electricity to operate, and lifts clear of the water when it is not in use. The screen was a state of the art design in many respects.

The performance of the juvenile fish screen has been monitored and documented well by MoE since its first season of use in spring 1987. (Hansen, 2001) BC Hydro has funded the operation of the juvenile screening facility and the monitoring and reporting of the juvenile migration since 1992. BC Hydro manages the operation of the screen in consultation with MoE. The average annual cost for these services is approximately $35,000 to $45,000 per year. Due to dam safety concerns with the diversion dam and canal structure, the Salmon River Diversion was closed and has not operated under normal circumstances since June 2, 2010.

In general, the existing juvenile fish screen system performs well at canal discharges up to approximately 1/3 of the maximum canal capacity but does not perform well under combined higher velocity and increased debris load conditions where the drag forces on the screen tend to pivot the screen such that it either planes or "surfs" in the water column allowing fish to pass under it or its trip mechanism is activated and it lifts clear of the water entirely.

Commencing with the 1996 juvenile migration season, MoE issued an operating protocol which required BC Hydro to “trim” the maximum canal discharge to levels at which the juvenile fish screen was considered to perform adequately. The protocol required that the maximum water depth in the canal measured upstream of the screen be limited to 2.0 m maximum when the screen is in the fishing position. This equates to limiting the maximum canal discharge to 15 m^3/s.

Over the past 20 years, several phases of upgrades and minor design changes have been implemented to improve the juvenile fish screen performance and facilitate screen operation and monitoring. In 1994 significant modifications to the screen, guide vanes, and side seals were completed to reduce impact on fish condition. However, these beneficial changes to the screen material (wedge wire replacing the lower sections of woven wire) also changed the loads and drag forces on the screen and decreased the frequency of “surfing” events. In 1999, the fish bypass flow was increased from 0.15 m^3/s to 0.85 m^3/s and modifications to the bypass entrance and bypass diversion pipe were also implemented to sweep fish more quickly and smoothly from the lower screen to the entrance to the bypass outfall. These modifications were implemented to further improve juvenile fish screen efficiency and fish condition. A physical model study was used to design these modifications.

Recent juvenile fish screen operation experience (2003 to 2006) indicates that the screen continues to perform in compliance with its original structural/mechanical/fish diversion design objectives and that the 1999 upgrades achieved a significant improvement to the condition of the redirected fish. Fish in good condition are observed at all flows including the current maximum canal flow of 15 m^3/s. At 15 m^3/s, the screen does not “surf” under low debris conditions but under high debris conditions “surfing” occurs periodically. The Campbell River Water Use Plan has recommended the implementation of screening during the winter months of November and December when river inflows and debris loads fluctuate frequently during storms and when access to the site is very difficult due to snow. In addition, the juvenile fish screen is also subject to ice loads that may block the screen and/or freeze it in place to the canal at temperatures below 5.5 C. The recommendation was accepted by the Comptroller of Water Rights and the *Order* issued on November 12, 2012 includes specified diversion rates between April 1 and December 31 for when the fish screen is operating effectively. Operation of the existing screen would be very challenging under winter conditions and the procedures for achieving successful winter operation of the screen have not been defined.

Due to dam safety concerns with the diversion structure, the diversion was closed and has not operated between June 2, 2010 and December 23, 2013. The most recent operation that started in December 2013 is limited to a maximum of about 5 m^3/s and is intended to mitigate the impacts of the low inflows experienced from early October 2013. The installation of an upgraded fish screen is now being considered as an integrated component of the dam safety related upgrade to the dam and canal facility.

4 Project Rationale

Juvenile salmonids migrating down the Salmon River can be inadvertently drawn into BC Hydro’s Salmon River Diversion Canal and can end up in the Lower Campbell system rather than continuing their migration down the Salmon River. As discussed in Section 3.0, in 1986, the Ministry of Environment (MoE) constructed a juvenile fish screen facility to redirect these salmonids out of the canal and back into the Salmon River. The operation of the existing juvenile fish screen has been relatively successful and the screen has received several upgrades and minor design modifications over the past 20 years. However, due to the frequency of high debris load conditions in the Salmon River Diversion canal (storm related woody debris and seasonal heavy loading of leaves and catkins) the screen tends to lift or “surf” above the floor of the canal under combined high debris and high flow conditions. To reduce the occurrence of these “surfing” events and the associated downstream passage of fish under the screen, the canal discharge was limited to a maximum of 15 m^3/s when the screen is in “fishing” operation position whereas the maximum canal discharge capacity is 42.5 m^3/s.

The Campbell River Water Use Plan (WUP) Consultative Committee endorsed the continued practice of “trimming” the maximum Salmon River Diversion flow to 15 m^3/s during periods when the screen was in the fishing position in order to maintain acceptable diversion efficiency and fish condition. In addition, the Campbell WUP extended the annual period of screen operation to include all days from April 1 to December 31.

As an option to offset the decreased power generation associated with the extension of the trimming period, the Campbell River WUP Consultative Committee also estimated for up to $2 million (2004 dollars) of funding for physical upgrades to the juvenile fish screen with the intention of increasing screen performance at flows of up to 30 m^3/s. Until such time as physical works are implemented and demonstrated to be effective, canal flows were intended to continue to be trimmed to 15 m^3/s during the period of April 1 to December 31. However, as discussed in Section 3.0, due to dam safety concerns with the diversion structure, the diversion was closed and has not operated normally between June 2, 2010 and December 23, 2013. The diversion structure is currently the subject of a dam safety related upgrade to the dam and canal facility. The installation of an upgraded fish screen is now being considered as an integrated component of the dam safety related upgrade.

BC Hydro, with input from agencies and consultants, proposes to develop a fish screening solution within the overall Salmon Diversion project to ensure the operation of the facility such that it may achieve acceptable diversion rates of fish in good condition at canal flows up to 30 m^3/s.

5 PROJECT OBJECTIVES

There are two main project objectives:

- Obtain agreement from agencies and affected stakeholders on the criteria to be used to determine “acceptable operation” (screening rates of fish, condition of screened fish, operational safety, compliance monitoring requirements) for operation of the Salmon River Fish Screen at canal flows up to 30 m^3/s.

- Identify, design and implement a Salmon River Fish Screen solution integrated with the Salmon River Diversion Upgrade Project to achieve “acceptable operation” of the screen at canal flows up to 30 m^3/s.

6 PROJECT ISSUES

Acceptable Screening Rates

The existing juvenile fish screen was originally designed to achieve an 80% screening rate. Modifications to the screen should theoretically increase its existing performance but with the challenging flow conditions (fluctuating flows, heavy debris load) and challenging operation conditions (remote location, no power) at this site, the proposed juvenile fish screen upgrades are not envisioned to achieve screening rates greater than 80%. Instead, juvenile fish screen upgrades are intended to permit the achievement of 80% screening rates of juvenile fish in good condition at canal flows of up to 30 m^3/s.

However, better juvenile fish screening efficiency may be achieved by replacing the current screen with other types of newer screening technologies such as the Modular Inclined Screen (MIS) technology (Chilibeck 2010). However, suitability of new screening technologies for the Salmon diversion canal needs to be thoroughly evaluated along with other objectives such as cost, constructability and other values during the identification (feasibility) phase evaluations within the context of the bigger canal upgrade project.

Similarly, agreement from regulators and affected stakeholders as to what criteria will be used to determine “acceptable” operation at 30 m^3/s will be a scope item in the Identification (feasibility) phase of the project.

Winter Operation

The Campbell WUP Consultative Committee has recommended the implementation of juvenile fish screening during the winter months of November and December. This recommendation was accepted by the Comptroller of Water Rights and the *Order* issued on November 12, 2012 includes specified diversion rates between April 1 and December 31 for when the fish screen is operating effectively. As discussed in Section 3.0, during the winter months of November and December, river inflows fluctuate frequently during storms and access to the site is very difficult due to snow and potential ice-up conditions. Operation of the existing screen would be very challenging under these conditions and the procedures for achieving successful winter operation of the screen were not defined. The design and installation of upgrade works to accommodate winter operation were not considered in the $2 million (2004 dollars) estimate provided by the Consultative Committee. The consideration of winter operation will be included in the design of juvenile fish screen upgrades but resolution of winter operation issues related to site access and flashy inflows are outside the scope of this Terms of Reference.

7 Safety and Environment

Safety and Environmental Management Plans will have to be developed for all aspects of the works in accordance with WorkSafe BC and BC Hydro procedures and guidelines. It is important to note that some of the work areas are remote and that appropriate procedures for working in isolation must be followed.

Contractors shall take all reasonable and necessary measures to ensure that any activities undertaken in the performance of the work are conducted in such a way as to minimize any disturbance or damage to the environment. This includes protecting the natural ground surface, vegetation, wetlands, watercourses, wildlife and fish. It also includes minimizing disturbance to neighbours and the general public.

Site specific environmental concerns will be captured in the project Environmental Management Plan (EMP). Contractors shall be responsible for adhering to the requirements of the EMP. For projects that pose a potential environmental risk, an Environmental Representative will need to be assigned. The Environmental Representative maintains the authority to suspend any Contractor's work activities if environmental damage appears to be occurring.

8 Schedule and Scope

The schedule for implementation of this project is integrated with the overall Salmon River Diversion project and referred to as the *Salmon River Canal Refurbishment and Fish Passage Improvements* project. However, funding for the Juvenile Fish Screen component will come from *Ordered Remissible* funds approved under this Terms of Reference.

The objective of the improvements at Salmon River is to explore and implement alternatives to: (i) address Dam Safety Concerns regarding the dam and canal, (ii) improve upstream movement of spawning salmonids past the dam, and (iii) improve capacity of fish entrainment mitigation (to divert out migrating salmonids out of the canal and back into the Salmon River downstream of the dam). BC Hydro's Project Management Practices refine projects into Identification (Feasibility Design), Definition (Preliminary Design), and Implementation (Detail Design and Construction) Phases. The following paragraphs outline the work scope to complete the Identification and Definition phases of the overall project.

Identification Phase (Feasibility Design – July, 2013 to April, 2014)

- Procure the services of Engineering Consulting firm for Feasibility Design.
- Assess the condition of the facility. This will be based on an information review, site investigation, and data collection.
- Develop High-Level User Requirements. This will include criteria from upstream fish passage and preliminary criteria for downstream environment.
- Develop design alternatives and assess those alternatives using a structured decision making process. Evaluation of alternatives for each of the three components (Dam Safety, Upstream Fish Passage, and Downstream Fish Entrainment) will be considered in the context of one facility where all components work seamlessly together
- Prepare a Feasibility Design Report.
- Prepare a Feasibility Level Cost Estimate.
- Develop a Procurement Strategy.
- Prepare and Execute First Nations and Stakeholder Engagement Plans.
- Seek approval and funding to proceed to Definition phase (e.g. Preliminary Design)

- The Identification phase scope specifically related to the Juvenile Fish Screen includes:
  - Researching latest juvenile fish screen technologies for consideration.
  - Development of proposed criteria for acceptance of operation of the juvenile fish screen at 30 m^3/s.

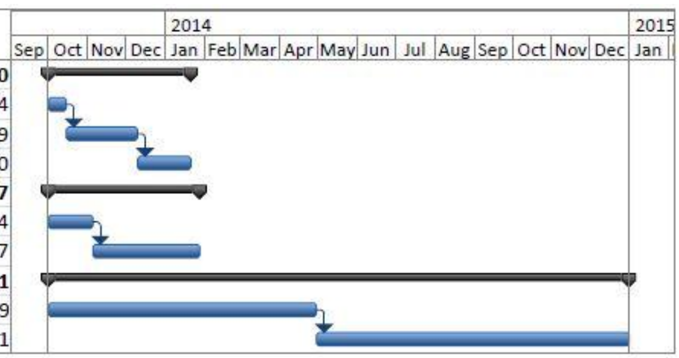
Definition Phase (Preliminary Design – May 2014 to December, 2014)

- Procure the services of an Engineering Consulting firm for Preliminary Design.
- Confirm User Requirements.
- Based on Feasibility Design recommendations develop design to Preliminary Design level.
- Obtain regulatory approvals and permits.
- Confirm Procurement Strategy.
- Prepare a Preliminary Design Level cost estimate.
- Seek approval and funding to proceed to Implementation Phase (Detail Design and Construction).

Given the early stage of the project, the scope described for Definition Phase should be considered preliminary. Furthermore, the staging of the various components of the project will be established once an alternative is selected.

A graphical representation of activities and schedule is provided below:

Task Name	Duration	Start	Finish
Terms of Reference	**80 days**	**Tue 13-10-01**	**Mon 14-01-20**
Develop Draft TOR	10 days	Tue 13-10-01	Mon 13-10-14
Committee Review	40 days	Tue 13-10-15	Mon 13-12-09
Comptroller Review	30 days	Tue 13-12-10	Mon 14-01-20
Fish Entrainment Criteria	**85 days**	**Tue 13-10-01**	**Mon 14-01-27**
Develop Discussion Paper	25 days	Tue 13-10-01	Mon 13-11-04
Agency Review/Acceptance	60 days	Tue 13-11-05	Mon 14-01-27
Project Work Scope	**327 days**	**Tue 13-10-01**	**Wed 14-12-31**
Identification Phase	151 days	Tue 13-10-01	Tue 14-04-29
Definition Phase (EST)	176 days	Wed 14-04-30	Wed 14-12-31



9 Cost Objectives

The estimated cost for completing the Identification phase and Definition phase of the Downstream Fish Entrainment (Juvenile Fish Screen) component of the project is $346,000.

Implementation phase and overall project costs will be developed during Identification and Definition phases so are unavailable at this time.

10 References

Campbell River WUP Consultative Committee Report (WUP CC), 2004. BC Hydro. A report produced for BC hydro Water Use Planning group.

Campbell River System Water Use Plan, November 21, 2012: Revised for Acceptance for the Comptroller of Water Rights. (http://www.bchydro.com/content/dam/hydro/medialib/internet/documents/planning_regulatory/wup/vancouver_island/2012q4/campbell_river_WUP_accept_2012_11_21.pdf)

Chilibeck, B., 2010. Salmon River diversion dam conceptual fish passage option assessment. Northwest hydraulic consults. March, 2010.

Hansen, L. 2001. Additional Salmon River smolt screen modifications and facility improvements report to B.C. Hydro. Letter to Allister McLean of BC Hydro from BC Conservation Federation, March 19, 2001.

Lydersen, H.,Porter A., and Welch, D.W., 2010. Salmon River Fishway Assessment Study. Kintama Research Corp.