Fisheries and Aquatic Habitat Monitoring and Follow-up Program

Site C Clean Energy Project

December 22, 2015

Table of Contents

Appendices

Acronyms

AB	Alberta
CEMP	Construction Environmental Management Plan
DFO	Department of Fisheries and Oceans
EAC	Environmental Assessment Certificate
EAO	BC Environmental Assessment Office
EIS	Environmental Impact Statement
FAHMFP	Fisheries and Aquatic Habitat Monitoring and Follow-up Program
FLNR	BC Ministry of Forests, Lands and Natural Resource Operations
LAA	Local Assessment Area
MOE	BC Ministry of Environment
QEP	Qualified Environmental Professional

Revision History

Version	Date	Comments
draft	October 23, 2015	
draft	Dec 15, 2015	Address agency and FN comments

1.0 Fisheries and Aquatic Habitat Monitoring and Follow-up Program

This Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP) has been developed in accordance with the Condition 7 of the Environmental Assessment Certificate (EAC).

The Conditions in the EAC contemplate three plans and programs that relate to fish and fish habitat. These are summarized below to provide context for the FAHMFP.

1) **Fisheries and Aquatic Habitat Management Plan:** Fisheries and Aquatic Habitat Management Plan (submitted to the CEA Agency and BCEAO in June 2015) in accordance with EAC Condition 4 and federal Decision Statement Condition 8 includes standard mitigation measures (e.g., erosion and sediment control measures) described in the CEMP and project-specific mitigation measures (e.g. reservoir shoreline habitat enhancement works and capping of dam site material relocation site with fish habitat features).
2) **Fisheries and Aquatic Habitat Monitoring and Follow-up Program:** The FAHMFP is a requirement of EAC condition 7 and is described below.
3) **Fish Passage Management Plan:** The Fish Passage Management Plan included in the EIS (Volume 2 Appendix Q) describes the approach to manage fish passage. Following EAC condition 6, a Fish Passage Management Plan, which will include updates since submission of the EIS, will be prepared by QEPs and submitted prior to Project activities that may affect upstream fish passage. The EIS (Volume 2 Section 12) identified the river diversion phase of construction as the first Project activity that is expected to affect upstream fish passage. The planned monitoring for fish movement and fish passage is described in this FAHMFP.

Condition 7 of the EAC requires development and implementation of a FAHMFP that provides for:[1] a) monitoring fish and fish habitat during construction and operation of the Site C Clean Energy Project (the Project), and b) an outline for a procedure to evaluate and implement future mitigation and compensation options during operation of the Project. The types of monitoring and the outline of procedures for evaluation and implementation required by Condition 7 of the EAC are provided for in this FAHMFP. The monitoring will provide information that can be used to assess the effectiveness of the mitigation measures described in Fisheries and Aquatic Habitat Management Plan.

The types of monitoring required by Condition 7 are provided for in this FAHMFP through a Fisheries and Aquatic Habitat Monitoring Program (Monitoring Plan) which consists of 18 spatially and logistically distinct monitoring programs. Those 18 monitoring programs are also provided for in the Fisheries and Aquatic Habitat Management Plan. That plan was submitted to the CEA Agency and BCEAO in June 2015 in accordance with EAC Condition 4 and federal Decision Statement Condition 8.

An outline of the procedure to evaluate and implement future mitigation and compensation options during operation of the Project is provided in Section 5 of this FAHFMP. As described further, below, the information collected from the Monitoring Plan provided for in this FAHMFP will be taken into account in the evaluation and implementation of future mitigation and compensation options.

[1] The requirements under Condition 7 of the EAC are listed in Section 3 of this FAHMFP

2.0 Background

On October 14, 2014, the Minister of Environment of Canada issued a Decision Statement confirming that, while the Project has the potential to result in some significant adverse effects including significant effects on fish and fish habitat, the Federal Cabinet has concluded that those effects are justified in the circumstances. The Decision Statement was re-issued on November 25, 2014. The Decision Statement sets out the conditions under which the Project can proceed.

Further, the Provincial Ministers of Environment and of Forests, Lands and Natural Resource Operations for British Columbia decided that the Project is in the public interest and that the benefits provided by the Project outweigh the risks of significant adverse environmental, social and heritage effects[2]. The Ministers have issued an Environmental Assessment Certificate setting conditions under which the Project can proceed.

See Appendix S for additional background including 1) Site C Clean Energy Project, 2) Project Benefits, 3) Environmental Assessment Process, 4) Environmental Assessment Findings, 5) Environmental Assessment Conclusion, 6) Fish and Fish Habitat Valued Component, 7) Consultation 8) Fish and Fish Habitat Baseline Conditions, and 9) Potential Effects of the Project on Fish and Fish Habitat.

3.0 Objective and Scope

The objective and scope of the Fisheries and Aquatic Habitat Monitoring and Follow-up Program (FAHMFP) is to set out the monitoring and procedures that will be implemented as required by Condition 7 of the EAC.

The monitoring and procedures provided for in this FAHMFP and the requirements of Condition 7 are described in the table 1 below.

Table 1. EAC fish and fish habitat requirements and FAHMFP reference.

EAC Condition	Requirement	Plan Reference
FISH AND FISH HABITAT		
7	The EAC Holder must develop a Fisheries and Aquatic Habitat Monitoring and Follow-up Program to assess the effectiveness of measures to mitigate Project effects on healthy fish populations in the Peace River and tributaries, and, if recommended by a QEP or FLNR, to assess the need to adjust those measures to adequately mitigate the Project's effects.	
	The Fisheries and Aquatic Habitat Monitoring and Follow-up Program must be developed by	This requirement is addressed in Section 9.0 of this FAHMFP, Qualified

[2] Available at: http://www.newsroom.gov.bc.ca/2014/10/site-c-project-granted-environmental-assessment-approval.html

EAC Condition	Requirement	Plan Reference
	a QEP.	Professionals.
	The program must include monitoring during construction for at least the following:	
	• Effectiveness of standard mitigation measures for reducing sedimentation and fish stranding in the construction headpond and proximal reach of the river downstream of the dam.	These requirements are addressed in Mon-3 Peace River Physical Habitat Monitoring Program and Mon-12 Site C Fish Stranding Monitoring Program which are included as Appendices C and M, respectively to this FAHMFP
	• Accuracy of predictions about physical changes to habitat in the reservoir area during the development and operation of the construction headpond during the diversion stage of the Project.	This requirement is addressed in Mon-3 Peace River Physical Habitat Monitoring Program, which is included as Appendix C to this FAHMFP.
	• Documenting, at an appropriate scale, spatial and temporal changes occurring in physical environmental conditions resulting from headpond hydrology, and in localized areas in relation to the effects of construction activities and mitigation procedures.	This requirement is addressed in Mon-3 Peace River Physical Habitat Monitoring Program which is included as Appendix C to this FAHMFP.
	• Effectiveness of mitigation measures for management of predicted effects of sediment and fish stranding, and provide information required to adjust the mitigation program to reduce unforeseen adverse effects, as required.	These requirements are addressed in Mon-3 Peace River Physical Habitat Monitoring Mon-12 and Site C Fish Stranding Monitoring included as Appendices C and M to this FAHMFP.
	• Total dissolved gas.	This requirement is addressed in Mon-11 Site C Total Dissolved Gas Monitoring Program, which is included as Appendix L to this FAHMFP.
	• Fish habitat areas where periodic exposure of side channel and mainstream margins occurs as a result of water fluctuations.	This requirement is addressed in Mon-12 Site C Fish Stranding Monitoring Program, which is included as Appendix M to this FAHMFP.
	The Fisheries and Aquatic Habitat Monitoring and Follow-up Program must include monitoring during operations for a period of twenty years for at least the following:	
	• Continued effectiveness of environmental protection measures undertaken during construction to mitigate effects on fish and fish habitat.	This requirement will be met through implementation of the Site C Fisheries and Aquatic Habitat Monitoring Program as described in FAHMFP Section 6 and the supporting monitoring plans, which are

EAC Condition	Requirement	Plan Reference
		included as Appendices A - Q of this FAHMFP.
	• Total dissolved gas.	This requirement is addressed in Mon-11 Site C Total Dissolved Gas Monitoring Program, which is included as Appendix L to this FAHMFP.
	• Meeting monitoring commitments as per the Fish Passage Management Plan.	This requirement is addressed in: 1) Mon-13 Site C Fishway Effectiveness Monitoring, 2) Mon-14 Site C Trap and Haul Fish Release Location Monitoring Program; 3) and MON-15 Site C Small Fish Species Translocation Monitoring Program These monitoring plans are included as Appendices N – P to this FAHMFP.
	• Implement on-site monitoring of fish habitat areas in the side channel and mainstream margins, resulting from water fluctuations.	These requirements are addressed in Mon-3 Peace River Physical Habitat Monitoring and Mon-12 Site C Fish Stranding Monitoring, which are included as Appendices C and M to this FAHMFP.
	• Fish and fish habitat productivity, for reservoir, reservoir tributaries, and for downstream Peace River.	This requirement is addressed in: 1) Mon-1a Site C Reservoir Fish Community Monitoring Program 2) Mon-1b Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program 3) Mon-2 Peace River Fish Community Monitoring Program 4) Mon-3 Peace River Physical Habitat Monitoring Program 5) Mon-4 Site C Reservoir Riparian Vegetation Monitoring Program 6) Mon-5 Peace River Riparian Vegetation Monitoring Program 7) Mon-6 Site C Reservoir Fish Food Organisms Monitoring Program 8) Mon-7 Peace River Fish Food Organisms Monitoring Program 9) Mon-8 Site C Reservoir Water and Sediment Quality Monitoring Program 10) Mon-9 Peace River Water and Sediment Quality Monitoring Program The monitoring plans are included as Appendices A – J to this FAHMFP.
	The Fisheries and Aquatic Habitat Monitoring	This requirement is addressed in Section

EAC Condition	Requirement	Plan Reference
	and Follow-up Program must outline a procedure for evaluating future mitigation and compensation options after reservoir development and follow-up monitoring, as well as procedures for how compensation options that are technically and economically feasible will be implemented.	7.0 of this FAHMFP, Framework to Implement Future Compensation Actions.
	The Fisheries and Aquatic Habitat Monitoring and Follow-up Program reporting must occur at least annually during construction and operations beginning 180 days following commencement of construction and operations phases, or in accordance with the applicable Fisheries Act authorization(s).	This requirement is addressed in Section 8.0 of this FAHMFP, Implementation and Reporting.
	The EAC Holder must provide the draft Fisheries and Aquatic Habitat Monitoring and Follow-up Program to FLNR, MOE and Aboriginal Groups for review within 90 days following the commencement of the construction and operations phases.	
	The EAC Holder must file this final Fisheries and Aquatic Habitat Monitoring and Follow-up Program with EAO, FLN, MOE and Aboriginal Groups within 150 days following the commencement of the construction and operations phases.	
	The EAC Holder must develop, implement and adhere to the final Fisheries and Aquatic Habitat Monitoring and Follow-up Program, and any amendments, to the satisfaction of EAO.	

4.0 Fisheries and Aquatic Habitat Monitoring

The following sections provide an overview of the Monitoring Plan and the general layout, which is organized into 18 spatially and logistically distinct monitoring programs. The specifics of each of the 18 monitoring programs are discussed within the programs themselves which are included as Appendices A - R, and provide further rationale for the proposed monitoring tasks through a series of Fisheries Management Questions, hypotheses, and tasks used to address these hypotheses. An indicator-specific summary of the Monitoring Plan is presented to allow orientation to a particular key indicator such as Bull Trout or Mountain Whitefish.

The framework of a plan (Monitoring Plan) for monitoring of physical habitat, lower trophic levels, fish abundance, and community composition during construction and operations, as required by Condition 7, is described below.

The framework has been developed in consideration of baseline data as well as provincial and federal objectives for the area. Many of the baseline studies conducted for the environmental assessment of the Project were developed with future monitoring in mind such that the sample sites and methodologies could be repeated to monitor potential changes to fish and fish habitat during construction and operation of the Project.

This framework for monitoring is expressed as a series of questions (see Table 2).

Note that a procedure for the evaluation and implementation of future mitigation and compensation options is described in the section of this Plan which follows.

Table 2. Framework for Site C Fisheries and Aquatic Habitat Monitoring.

Questions about the Fisheries and Aquatic Habitat Monitoring Program	Where are the answers?	
What are federal and provincial objectives for the Peace River?	BC Government 2009; BC Government 2011; Fisheries Act Requirements	
What are the potential changes due to Site C?	Baseline data collection; EIS predictions; Conceptual models of fish species indicators	Fish Species Indicator Summaries
Where/how will we monitor for these changes and evaluate the effectiveness of Project mitigation measures?	Monitoring Programs (Fisheries Management Questions, Hypotheses)	
How well can we detect changes? What are possible causes of observed changes (both Site C and others)?	Power Analysis (Ma et al. 2014) ; Diagnostic Tool (Compass and ESSA 2015)	
What can be done to mitigate for and/or offset effects of the Project?	Fish Passage Management Plan; Fisheries and Aquatic Habitat Management Plan; Tributary Mitigation Opportunities Evaluation Program; Harvest Management	
How will decisions on future mitigation actions as well as revisions to the Monitoring Plan be made with input?	FAHMFP Section 7.0, Framework to Implement Future Compensation Actions	

The following sections explain the rationale used in developing the Monitoring Plan, the structure of the Monitoring Plan, the tools used to refine the Monitoring Plan (Power Analysis and Diagnostic Tool), and concise summaries of how the monitoring programs that comprise the Monitoring Plan relate to key fish species indicators.

The flow of information used in developing the Monitoring Plan is described in Figure 1. The Peace River area affected by the Project (Site C Local Assessment Area; LAA) was characterized using baseline monitoring information. This baseline information helped inform provincial objectives, which are reported in BC Government (2009) and BC Government (2011; Figure 2). The EIS defines the Site C impact pathways and predictions about indicator status and trends taking into account First Nations input and associated traditional ecological knowledge received during the EIS development and consultation process.

The Monitoring Plan has been designed to monitor certain changes to fish and fish habitat that may result from the Project, as required by EAC Condition 7. The Monitoring Plan includes a

series of Questions and Hypotheses that reflect uncertainties in EIS predictions. When designing the Monitoring Plan, statistical power analyses were used to refine sampling plans and to assess the likelihood of addressing program-specific Fisheries Management Questions. Logic models (which are called Diagnostic Tools) were used to determine if the Monitoring Plan was likely to detect possible causes of observed changes, and whether those causes are an effect of the Project or some other source.

A weight-of-evidence approach will be used to assess observations from the Monitoring Plan in recognition that a single line of evidence is not sufficient to make decisions. Observations from different tasks within the Monitoring Plan will be synthesized using Diagnostic Tools, annual workshops, and synthesis reviews. The synthesis reviews are generally scheduled every 5 years over the monitoring period or at the end of major stages of the Project's development.

Figure 1. Foundation of the fisheries and aquatic habitat monitoring program (Monitoring Plan)

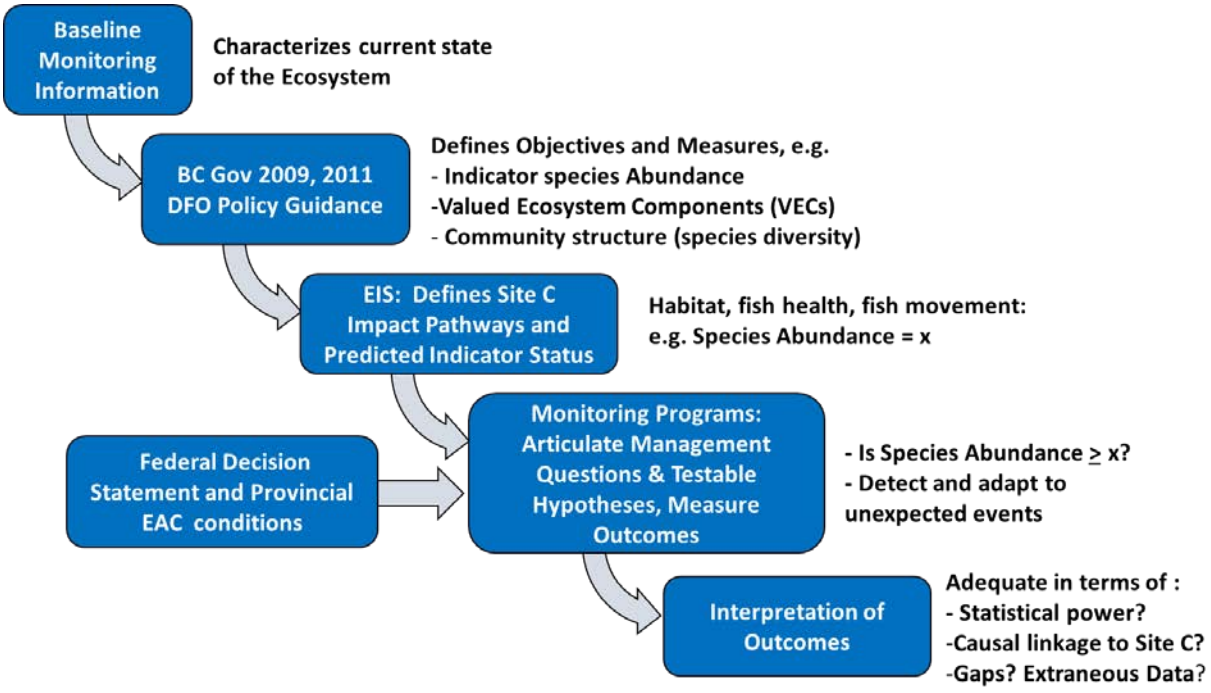
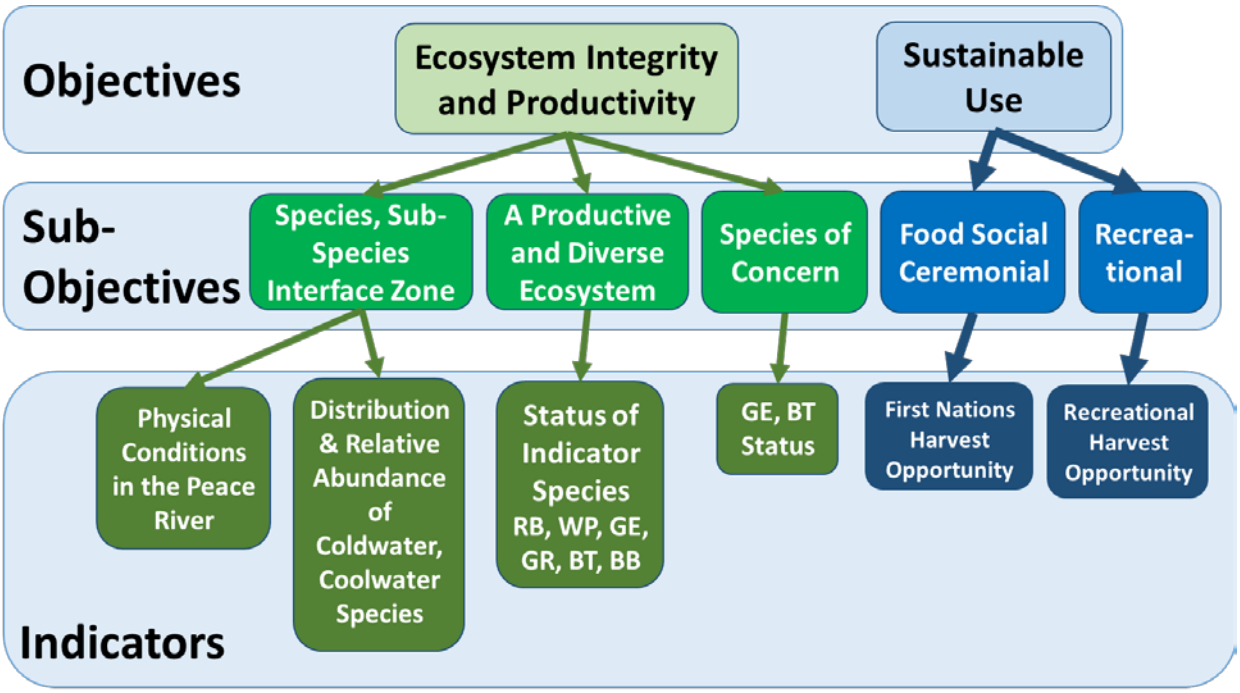


Figure 2. Summary of Provincial Objectives Hierarchy (based on BC Government 2009). RB = Rainbow Trout, WP = Walleye, GE = Goldeye, GR = Arctic Grayling, BT = Bull Trout, BB = Burbot, LT = Lake Trout



The following principles have been used in the development of the Monitoring Plan:

1. All monitoring will be in service of clearly defined Fisheries Management Questions.
2. Decisions will recognize and consider multiple objectives within constraints.
3. Decisions will recognize the inherent limitations of the best available information.
4. An adaptive approach will be taken to monitoring and mitigation.
5. The Monitoring Plan will strive for transparency and accountability.

These principles are expected to also apply during implementation of the Plan.

Principle 1: All monitoring will be in service of clearly defined Fisheries Management Questions.

A large volume of data will be collected over the period of monitoring. Data collection will be prioritized according to how valuable the data are for answering the key Fisheries Management Questions and evaluating future mitigation and compensation options and in implementing those measures.

Principle 2: Decisions will recognize and consider multiple objectives within constraints.

Choices regarding study selection and specification during development and implementation will involve consideration of constraints and potential impacts across a range of objectives.

Constraints could be legal or logistical. Objectives will consider a balance of financial resources, human resources, and monitoring that avoids further impacts. The magnitude of investments in monitoring will reflect both the management value of the information, and the risks of not acquiring the information.

Principle 3: Decisions will recognize the inherent limitations of the best available information.

Monitoring decisions, such as study selection and specification, can only be based on information that either currently exists or that can be collected within a reasonable timeline for the Project. Indicators will have sufficiently low spatial and temporal variability to provide useful results as quantified by a statistical power analysis. Analyses under the Monitoring Plan will take into account multiple lines of evidence that will be evaluated and weighed by appropriate professional judgment (i.e., a weight-of-evidence approach). Such an approach increases the likelihood of obtaining valuable information for making management decisions by hedging against the lack of clarity from a given component of information.

Multiple lines of evidence may include the following:

- Local empirical data
- Benchmark data from other locations
- Inferences from other sources
- Experimental information
- Theoretical models

Principle 4: An adaptive approach will be taken to monitoring and mitigation.

Monitoring designs will adopt an adaptive approach to implementation. This principle of adaptation covers a spectrum from minor field-based program adjustments to major, larger scale contingent initiatives. Any revisions to the monitoring will need to be balanced with the interest in a consistent sampling approach through time.

The monitoring programs will need to be adjusted based on initial empirical results. While the need to make these localized field adjustments may be predictable in some cases (e.g., determining the appropriate attraction flow for collecting fish at the fish passage facility), it may be less obvious in other cases. Individual monitoring programs will be evaluated and budgeted in consideration of the likely need and ability to be adapted over their lifecycles.

For some Site C monitoring initiatives, threshold triggers are proposed that will guide activities if observed outcomes are either above or below the threshold. In some cases, this is done primarily as a means of prioritizing resources. In others, it is a logical necessity (e.g., habitat mitigation Project X should only be implemented if Species Y is ultimately found in the reservoir and is likely to benefit from that project). Project specifications will include provisions for adjustments based on experience and empirical evidence.

The use of contingent monitoring will reflect the value of obtaining this information. For example, if catch rates of Goldeye under the Peace River Fish Community Monitoring (Mon-2) during the initial years of construction suggest that the mid-August to late September sampling period will not yield sufficient catch data for this species, contingent monitoring focused on Goldeye during the spring will be implemented at key tributary confluences where catch rates are expected to be higher.

Principle 5: The Monitoring Plan will strive for transparency and accountability.

Information on the status of monitoring will be made available to government agencies, Aboriginal groups[3], and the public in a timely way.

4.1 Overview of Fisheries and Aquatic Habitat Monitoring Programs

The 18 monitoring programs that comprise the Monitoring Plan included as Appendices A - Q and summarized in Table 3 are designed to address different Fisheries Management Questions and impact hypotheses. Individual monitoring programs are comprised of one or more data collection tasks (Task 2, described below), and span different spatial strata within the Site C LAA (Figure 3). Figure 4 provides an overview of major features of the spatial layout of the Site C LAA including the upper and lower boundaries (Peace Canyon Dam and Many Islands Area, Alberta respectively) and major tributaries. The programs are organized in space and time such that the section of Peace River that transitions to the Site C Reservoir is monitored under the programs titled 'Peace River' prior to reservoir filling, and programs titled 'Site C Reservoir' following reservoir filling.

Table 3. Individual monitoring programs which address specific Fisheries Management Questions within the Monitoring Plan.

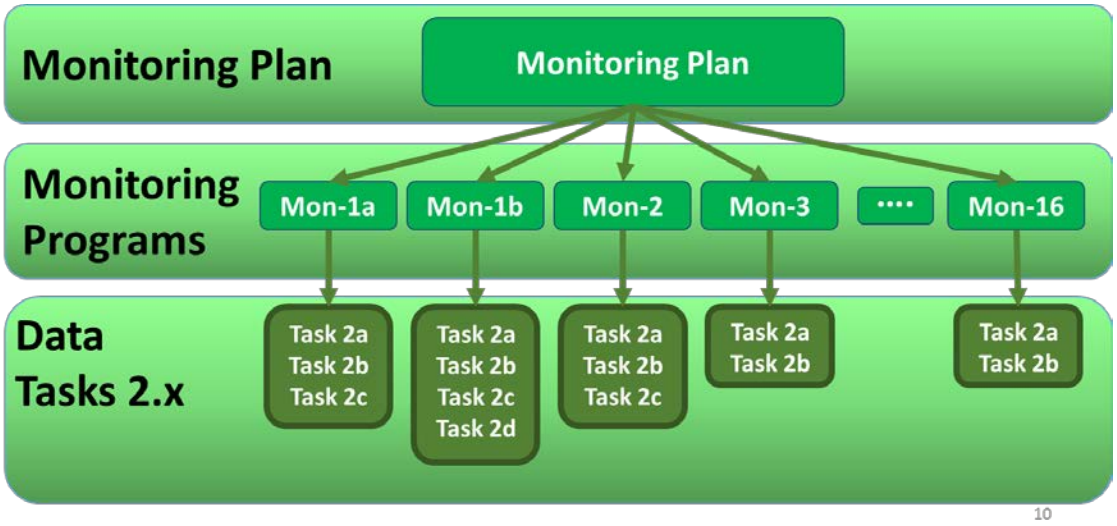
Monitoring Program ID	FAHMFP Appendix	Monitoring Program Name and Description
Mon-1a	**A**	**Site C Reservoir Fish Community Monitoring Program** Monitor the effects of river to reservoir transformation on the fish community in Site C Reservoir and associated tributaries.
Mon-1b	**B**	**Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program** Monitor fish populations in Peace River and Site C reservoir that migrate to tributaries to determine effects of the Project and the effectiveness of mitigation measures for fish and fish habitat.
Mon-2	**C**	**Peace River Fish Community Monitoring Program** Monitor fish populations in the Peace River to determine effects of the Project and the effectiveness of mitigation measures for fish and fish habitat.
Mon-3	**D**	**Peace River Physical Habitat Monitoring Program** Monitor the effects of the Project on physical habitat.
Mon-4	**E**	**Site C Reservoir Riparian Vegetation Monitoring Program** Monitor the effectiveness of planned riparian planting adjacent to Site C Reservoir.
Mon-5	**F**	**Peace River Riparian Vegetation Monitoring Program** Monitor how the construction and operation of the Project affects the quality and quantity (species composition, biological productivity, spatial area) of riparian vegetation along the Peace

[3] "Aboriginal groups" as defined in the Environmental Assessment Certificate and federal Decision Statement: Blueberry River First Nations, Dene Tha' First Nation, Doig River First Nation, Duncan's First Nation, Fort Nelson First Nation, Halfway River First Nation, Horse Lake First Nation, Kelly Lake Métis Settlement Society, McLeod Lake Indian Band, Métis Nation British Columbia, Prophet River First Nation, Saulteau First Nations, and West Moberly First Nations.

Monitoring Program ID	FAHMFP Appendix	Monitoring Program Name and Description
		River downstream of Site C.
Mon-6	**G**	**Site C Reservoir Fish Food Organisms Monitoring Program** Monitor the effects of Site C Reservoir formation on the production of fish food organisms.
Mon-7	**H**	**Peace River Fish Food Organisms Monitoring Program** Monitor the effects of Project construction and operations on the biomass of invertebrates and the availability of fish food organisms downstream of Site C.
Mon-8	**I**	**Site C Reservoir Water and Sediment Quality Monitoring Program** Monitor the effects of reservoir formation on water and sediment quality.
Mon-9	**J**	**Peace River Water and Sediment Quality Monitoring Program** Monitor the effects of the Project on water and sediment quality downstream of Site C.
Mon-10	**K**	**Site C Fish Entrainment Monitoring Program** Monitor entrainment rates and survival rates of entrained fish during the operation of Site C.
Mon-11	**L**	**Site C TDG Monitoring Program** Monitor Total Dissolved Gas (TDG) supersaturation and potential effects to downstream fish populations resulting from Gas Bubble Disease (GBD) during Site C Project construction and operation.
Mon-12	**M**	**Site C Fish Stranding Monitoring Program** Monitor Project construction and operation effects associated with flow fluctuations and fish stranding on the Peace River fish community.
Mon-13	**N**	**Site C Fishway Effectiveness Monitoring Program** Monitor the performance of the temporary and permanent fishways at the Project.
Mon-14	**O**	**Site C Trap and Haul Fish Release Location Monitoring Program** Monitor the movements following release of fish collected at Site C fishways and transported and released several upstream release locations.
Mon-15	**P**	**Site C Small Fish Species Translocation Monitoring Program** Monitor small fish species populations in the Peace River to determine effects of the project on genetic structure, movement, and genetic exchange.
Mon-16	**Q**	**Site C Reservoir Constructed Shallow Water Habitat Areas Sediment and Vegetation Monitoring Program** Monitor the suitability of benthic substrates in constructed shallow water habitats of Site C Reservoir for aquatic plants and monitor the natural colonization of aquatic plants in these habitats.
Mon-17	**R**	**Peace River Water Level Fluctuation Monitoring Program** Investigate the effects of water level fluctuations on the catchability of Peace River fish and the biomass and production of periphyton,

Monitoring Program ID	FAHMFP Appendix	Monitoring Program Name and Description
		downstream of Site C.

Figure 3: Monitoring Plan structure including only the data collection tasks



Each of the 18 monitoring programs follows a similar layout, which includes three main elements:

- Rationale
    - Background
    - Fisheries Management Questions
    - Management Hypotheses
    - Key Mitigation and Offsetting Questions Affected
- Monitoring Program Proposal
    - Objective and Scope
    - Approach
    - Tasks (e.g., a particular project, project management, reporting)
    - Interpretation of Monitoring Program Results
    - Schedule
- References

The **Rationale** section provides the background for the monitoring program based on findings presented in the EIS. Fisheries Management Questions are provided, along with Hypotheses to address the Fisheries Management Questions. These Fisheries Management Questions are then related back to mitigation and offsetting decisions that would be informed by results of the monitoring program.

The **Monitoring Program Proposal** section provides an overview of the objective and scope of the monitoring program, the approach to the monitoring program including baseline data that have been collected, the proposed tasks, and schedule. Monitoring programs include a standard set of Tasks (Table 4), of which Tasks 2 and 3 typically represent the majority of the effort.

Table 4. Standardized list of tasks within each monitoring program.

Task Number	Task Name	Description
1	Project Coordination	This task contains all efforts by the contractor to coordinate the project and communicate with BC Hydro.
2	Data Collection	This task includes all data collection by all contractors involved in the program. It can be divided into several sub-tasks to distinguish data collected for different purposes or collected by different contractors.
3	Data Analysis	This task describes the analyses required for data collected in Task 2 and for addressing the Fisheries Management Questions and testing the hypotheses. Data Analysis is divided into the same sub-tasks detailed in Task 2, as required.
4	Reporting	This task describes any reporting requirements associated with Tasks 2 and 3.
5	Data Management	This task describes data management requirements for delivery to BC Hydro.
6	Annual Workshop	This task provides for the contractor to attend a 1-day workshop each year where results from the different monitoring programs are presented and discussed relative to the objectives of each program and how these inform the management decisions.
7	Synthesis Review	This task provides for an approximate 5 year synthesis of all data collection tasks within the monitoring program and, if applicable, related tasks from other monitoring programs.

4.2 Analyses Supporting Development of the Monitoring Plan

The following analyses were undertaken to support development of the Monitoring Plan.

4.2.1 Power Analysis

Statistical power analyses were conducted on six Key Performance Measures (Ma et al. 2014) that were identified as priorities to assess in the Monitoring Plan. Power analyses supported the design of specific Monitoring Programs, as listed in parentheses (following numbering in Table 3).

Bull Trout redd counts in Halfway River tributaries (Mon 1-b);

Kokanee biomass in Site C Reservoir (Mon-1a);

Mountain Whitefish abundance and biomass in the Peace River downstream of the Project (Mon-2);

Bull Trout movement and entrainment rates through the Project (Mon-10);

Species diversity in the Peace River downstream of the Project (Mon-2); and

Goldeye and Walleye abundance in the Peace River downstream of the Project (Mon-2).

These six measures were selected based on key measures identified in the EIS, local management objectives, and traditional use.

Power analyses were done using either analytical or simulation methods. Effect sizes were based on either EIS predictions or biologically meaningful thresholds (e.g., Kokanee biomass necessary to sustain a Bull Trout population). Where possible, baseline data from the Peace River basin were used to estimate process and sampling error. In some cases, sampling error was estimated using data from other systems. Results were framed in the context of the Monitoring Plan. The findings of the power analyses are discussed in the fish species indicator summaries presented below.

4.2.2 Diagnostic Tools

The Diagnostic Tool refers to a tracking table that links outcomes for specific species indicators with the alternative impact pathways that are consistent with that outcome, monitoring information, tasks, and potential management actions. Diagnostic Tools are designed to understand impact pathways that might cause observed changes in aquatic habitat, and how those pathways are monitored in the Site C Aquatic Monitoring Plan. This tool serves two main purposes: (1) in planning, providing a sufficiency review of the Monitoring Plan and the associated tasks, and (2) once monitoring data are available, a tool to synthesize results from different monitoring programs and diagnose causes of observed changes.

Diagnostic Tools have been developed for a subset of the Valued Environmental Components and indicators identified in BC Government (2011). These indicators were selected because some of the key uncertainties associated with predictions in the Effects Assessment related to these indicators. The list includes three of the seven indicator species from BC Government (2011); the first two items represent values associated with fish species diversity and ecosystem productivity:

1. Fish community in Site C Reservoir and the Peace River downstream of the Project;
2. Planktivorous fish (i.e., Kokanee) in Site C Reservoir;
3. Bull Trout in Site C Reservoir and the Peace River downstream of the Project;
4. Goldeye in the Peace River downstream of the Project; and
5. Walleye in the Peace River downstream of the Project.

The findings and framework used for developing the Diagnostic Tools are discussed in the indicator summaries below.

4.3 Indicator Summaries

This section provides summaries that orient the monitoring programs around fish species indicators outlined in BC Government (2011). The species-specific summaries in this section are helpful to understand the design of the overall Monitoring Program, which is generally organized by type of information collected and by location, rather than all of the information collected for one species across all locations. For the example of Bull Trout, the summary provides a summary of all Bull Trout information collected across 29 tasks under eleven monitoring programs in the Peace River, Site C Reservoir and tributaries, and the summary describes how the information will be used to determine potential causes of observed results. Each summary starts with a brief description of the biology and ecology of the species, and highlights key uncertainties outlined in the EIS. These summaries should not be viewed as exhaustive descriptions of species biology/ecology or of monitoring programs. For an in-depth description of the biology/ecology of each species, refer to the EIS and detailed monitoring

plans included as Appendix A - Q. The findings of the power analysis and Diagnostic Tool (where performed) are in each species summary. After the species summaries, a summary focused on the entire fish community which presents values that are not covered in the species summaries. Monitoring program tasks are linked to specific uncertainties and hypotheses. Tasks are referred to using a short-hand notation of Mon-__, T__, where 'Mon' represents the specific monitoring program being referenced, and 'T' represents the Task within that specific monitoring program. The specific monitoring tasks associated with each indicator are presented in Table 5. Within this table, tasks are distinguished as directly informing the status of an indicator, indirectly informing the status of an indicator, or not informing the status of an indicator.

N

Many Islands Area

Proposed Site C Dam

Peace Canyon Dam

Fort St. John

Taylor

Hudson's Hope

Dawson Creek

BRITISH COLUMBIA

ALBERTA

BLUEBERRY HILL

Peace River

Clear River

Pine River

Moberly River

Kiskatinaw River

Pouce Coupe River

Halfway River

Cache Creek

Farrell Creek

Maurice Creek

Lynx Creek

Beatton River

Alces River

Wilder Creek

Tea Creek

Charlie Lake

Worsley

Cleardale

Moberly Lake Provincial Park

Charlie Lake Provincial Park

Beatton River Provincial Park

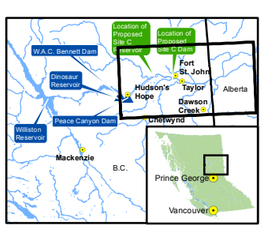
Peace River Provincial Park

Legend

- City/District Municipality
- Proposed/Existing Dam
- Provincial Border
- Highway
- Existing Railway

1:500,000

0 20 km



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Topographic background: Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.
3. Other data provided by BC Hydro.

BC hydro

SITE C CLEAN ENERGY PROJECT

Figure 4
Aquatics Study Area Overview

Date	June 16, 2015	DWG NO	1016-C14-B5137	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification

N:\Bur-Graphics\Projects\2013\1492\13-1492-0066\GIS\Mapping\MXD\Fish\Aquatic_Study_Area\1016_C14_B5137_Aquatic_Study_Area_Overview.mxd

Table 5. Site C monitoring programs and associated data collection tasks identified with monitoring of select indicators in provincial objectives (BC Government 2011). Tasks are categorized as directly informing the status of an indicator (✓), indirectly informing the status of an indicator (○); and not informing the status of an indicator (blank). The colour-coding of rows represents the geographical location of sampling for the monitoring program. Green is Reservoir, Blue is the Peace River, Purple is both the Reservoir and Peace River, Red is at the Site C dam, and Orange is Peace River and Reservoir Tributaries. An asterisk represents monitoring programs where monitoring will occur in the Peace River upstream of Site C with the Site C Construction Headpond during the Construction Phase but limited to the Peace River downstream of the Site C dam during the Operations Phase.

Monitoring Plan	Task Number	Task Title	Bull Trout	Kokanee	Mountain Whitefish	Goldeye	Walleye	Fish Community Status
1a - Site C Reservoir Fish Community Monitoring Program	2a	Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey	✓	✓	✓			✓
	2b	Site C Reservoir Summer Profundal Index Netting (SPIN) Survey	○	○				✓
	2c	Site C Reservoir Creel Survey	✓	✓	○		○	✓
1b - Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program	2a	Peace River Arctic Grayling and Bull Trout Movement Assessment	✓					○
	2b	Peace River Bull Trout Spawning Assessment	✓					○
	2c	Site C Reservoir Tributaries Fish Population Indexing Survey	○	✓				✓
	2d	Site C Acoustic Telemetry Array System	✓		✓			
2 - Peace River Fish Community Monitoring Program	2a	Peace River Large Fish Indexing Survey	✓	○	✓	✓	✓	✓
	2b	Peace River Fish Composition and Abundance Survey	✓	○	✓		○	✓
	2c	Peace River Creel Survey	✓		✓	✓	✓	✓
	2d	Offset Effectiveness Monitoring Program	○	○	○	○	○	○
	2e	Arctic Grayling Status Assessment (Halfway and Beatton Rivers)						✓
3 - Peace River Physical Habitat Monitoring Program	2a	Channel Morphology						○
	2b	Substrate size						○
	2b	Offset Effectiveness Monitoring Program						○
4 - Site C Reservoir Riparian Vegetation Monitoring Program	2a	Vegetation Survey and Bank Stability Assessment						○
5 - Peace River Riparian Vegetation Monitoring Program	2a	Aerial Imagery Interpretation						○
	2b	Vegetation Surveys / Ground Truthing						
6 - Site C Reservoir Fish Food Organisms Monitoring Program	2a	Biomass and Availability of Fish Food Organisms	○	○				○
	2b	Ecosystem Attributes	○	○				○
7 - Peace River Fish Food Organisms Monitoring Program	2a	Biomass and Availability of Fish Food Organisms	○	○	○	○	○	○
	2b	Ecosystem Attributes	○	○	○	○	○	○
8 - Site C Reservoir Water and Sediment Quality Monitoring Program	2a	General Water and Sediment Quality Monitoring	○	○				○
	2b	Temperature Monitoring	○	○				○
	2c	Turbidity Monitoring	○	○				○
9 - Peace River Water and Sediment Quality Monitoring Program	2a	General Water and Sediment Quality Monitoring	○	○	○	○	○	○
	2b	Temperature Monitoring	○	○	○	○	○	○
	2c	Turbidity Monitoring	○	○	○	○	○	○
10 - Site C Fish Entrainment Monitoring Program	2a	Williston Peace Reach Kokanee Spawner Survey	○	✓				✓
	2b	Monitoring of Entrainment Rates	✓					✓
	2c	Monitoring Survival Rates of Entrained Fish	○	✓	✓			✓
11 - Site C TDG Monitoring Program	2a	TDG Monitoring	○	○	○	○	○	✓
	2b	TDG Effects on Fish	✓	○	✓	✓	✓	✓
12 - Site C Fish Stranding Monitoring Program	2a	Identification of Monitoring Sites						
	2b	Monitoring Stranding Sites						✓
13 - Site C Fishway Effectiveness Monitoring Program	2a	Site C Tailrace and Fishway Telemetry Assessment	✓		✓			
	2b	Attraction Efficiency and Entrance Accessibility Assessment	✓		✓			
	2c	Contingent Radio Telemetry Surveys in Site C Tailrace	✓		✓			
14 - Site C Trap and Haul Fish Release Location Monitoring Program	2a	Data Collection - Monitor tagged fish	✓		✓			
15 - Site C Small Fish Species Translocation Monitoring Program	2a	Data Collection - Tissue Sample Collection for Genetic Analysis						✓
16 - Site C Reservoir Constructed Shallow Water Habitat	2a	Substrate Monitoring						○

Monitoring Plan	Task Number	Task Title	Bull Trout	Kokanee	Mountain Whitefish	Goldeye	Walleye	Fish Community Status
Areas Sediment and Vegetation Monitoring Program	2b	Aquatic Plant Monitoring						○
17 – Peace River Water Level Fluctuation Monitoring Program	2a	Supplementary Sampling of Benthos and Periphyton	○		○	○	○	○
	2b	Supplementary Sampling of Small Fish	○		○	○	○	○
	2c	Supplementary Sampling of Large Fish	○		○	○	○	○
	2d	Supplementary Sampling of Fish	○		○	○	○	○

4.3.1 Bull Trout Summary

Bull Trout were selected as an indicator species to monitor the environmental sustainability and ecological integrity of key values by the Province for the following reasons:

- "high value target for anglers
- relatively well studied within [Lower Peace River Watershed] and elsewhere
- representative of cold-water fauna, highly migratory, noteworthy headwater populations, not tolerant of high turbidity, global level conservation concerns, top predator
- Bull Trout are representative of Pacific origins" [4]

Bull Trout have a complex life-history. They are long lived; repeat spawners that often do not reach sexual maturity until age-5 (McPhail 2007). Bull Trout generally occupy cold-water habitats in remote locations and typically naturally occur at low densities when compared to other salmonids, such as Mountain Whitefish.

Bull Trout in the Peace River present distinctive sampling challenges for assessing population status. The EIS notes the following:

> "Complex migratory patterns are common in bull trout (McPhail 2007). The current Halfway/Peace population follows a fluvial life-history where sub-adult and adult fish inhabit different parts of the same river system...[Therefore] Following reservoir construction, part of the population would be expected to follow an adfluvial life-history, where adults reside in a lake or reservoir but spawning and sub-adult rearing takes place in tributary streams"[5].

Migration past Site C is part of the life history of a component of this population and the EIS "*highlighted bull trout as being the priority species for detailed evaluation of fish passage technologies, since there is high certainty that fish passage could serve to meet management objectives*"[6].

The monitoring program for Bull Trout is based on clear management objectives (Government of BC 2011), which are reiterated in the EIS as follows:

> "conservation objectives and performance measures concerning: abundance, species distribution, population structure, size and age distribution"[7] measured in terms of "adult abundance (upstream and downstream of Site C), mean age, [percent] with access to spawning habitat, and connectivity to upstream (spawning areas)"[8].

Additional performance measures include "*Bull Trout (passage) mortality (adults and juveniles)*" and "*total bull trout angler days*"[9]. In addition to the performance measures identified in the EIS, the Monitoring Plan provides supplementary information that will be used in diagnosing the cause of any change in status that is observed under the monitoring plan described in the EIS.

Key uncertainties for Bull Trout include the following:

[4] BC Government 2011, Section 3.2, Table 1, p 22
[5] EIS, Volume 2, Appendix Q, Part 3, Section 2.5.1, pp. 17,18
[6] EIS, Volume 2, Appendix Q, Part 2, Section 2.1.2, p. 20
[7] EIS, Appendix Q2, Section 2.1.2, p17
[8] EIS, Appendix Q2, Section 2.1.2.1, p21
[9] EIS, Appendix Q2, Section 2.1.2.5, p24

1. whether Bull Trout will continue to move into Site C Reservoir and downstream past the Project;
2. whether entrainment through Site C will reduce Bull Trout abundance in Site C Reservoir;
3. whether Bull Trout can be effectively moved upstream from downstream of the dam;
4. whether there will be sufficient prey in Site C Reservoir to maintain high condition Bull Trout;
5. whether Bull Trout will be the top predator in Site C Reservoir (vs. Lake Trout); and
6. whether Bull Trout harvest rates can be sustained.

The effect of a change in the proportion of Bull Trout that move past Site C on spawner abundance in the Halfway River watershed was explored in the EIS[10]. It was predicted that Bull Trout spawner abundance will vary by less than 10% among different fish passage mitigation alternatives. Ecosystem simulations of the potential effects of Site C[11] explored a range of possible changes in the biomass of Bull Trout both upstream and downstream of the Project, building on various lines of evidence, including observations from other reservoirs and the results of more detailed single species models in the EIS[12].

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to Bull Trout biology (Table 5) to determine that the appropriate information was planned to be collected under the Site C Aquatic Monitoring Plan (Ma et al. 2014; Compass and ESSA 2015). Three distinct habitats were identified: 1) tributaries; 2) reservoir; and 3) Peace River. Overall, eleven monitoring programs and 29 tasks are relevant to Bull Trout.

The Monitoring Plan addresses the key uncertainties with Bull Trout, which focus on movement and survival, while monitoring the Site C LAA for status and trends in Bull Trout abundance, as follows:

The uncertainty in Bull Trout movement into and past the Site C Reservoir will be addressed by:

- the Site C Acoustic Telemetry Array System (Mon-1b, T2d), and from fish tagged in the reservoir (Mon-1a, T2a) and its tributaries (Mon-1b, T2a),
- the Peace River Large Fish Indexing Survey (Mon-2, T2a), and
- as part of the Fishway Effectiveness Monitoring (Mon-13, T2a).

Uncertainty in entrainment rates and survival are addressed in:

- the Site C Fish Entrainment Monitoring Program (Mon-10),

The ability of Bull Trout to move back upstream past the dam will be monitored in:

- the Site C Fishway Effectiveness Monitoring Program (Mon-13) and
- the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

The uncertainty around Bull Trout prey availability in the reservoir will be linked to Kokanee abundance (see Section 6.4.2). Lake Trout could be a main competitor to Bull Trout in Site C

[10] EIS, Volume 2, Appendix Q3
[11] EIS, Volume 2, Appendix P3
[12] EIS, Volume 2, Appendix Q3

Reservoir. Summer Profundal Index Netting surveys (Mon-1a, T2b) will estimate Lake Trout abundance entering the Site C Reservoir from upstream of the Site C LAA and also will measure Bull Trout (and Lake Trout) size and age. The sustainability of Bull Trout harvest will be monitored in the Site C Reservoir Creel Survey (Mon-1a, T2c) and the Peace River Creel Survey (Mon-2, T2c).

Status and trends will be monitored using annual redd counts (Mon-1b, T2b), supplemented by fish resistivity counters, a PIT tag detection array system, and telemetry array systems (Mon-1b). Based on available data, trends in abundance of Bull Trout spawners will require 11 to 18 years of redd counts to detect a 10% per year decline in redd abundance with 80% certainty due to the high year-to-year natural variability in spawner abundance (Ma et al. 2014). Resistivity counters and array systems will provide a cost-effective means of ground-truthing spawner count data (Mon-1b, T2a, T2d), and the telemetry data will be central to understanding Bull Trout movement. During select monitoring years, small fish boat electroshocking will provide a means of capturing and tagging subadult Bull Trout prior to these fish exiting the Halfway River system. In the Site C Reservoir, the relative abundance of Bull Trout will be assessed under the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey (Mon-1a, T2a) and Summer Profundal Index Netting (Mon-1a, T2b). Mon-6 and Mon-8 will measure primary productivity and environmental conditions in the reservoir, which will provide insight when interpreting Bull Trout data in the reservoir. The relative abundance of Bull Trout downstream of Site C Dam in the Peace River will be monitored in the Peace River Large Fish Indexing Survey (Mon-2, T2a) and the Peace River Fish Composition and Abundance Survey (Mon-2, T2b). Mon-7 and Mon-9 will measure primary productivity and environmental conditions downstream of the dam, which will provide insight when interpreting Bull Trout data downstream of the dam. In both Site C Reservoir and the Peace River, monitoring environmental parameters will help diagnose causes of declines should declines be detected. Results also can be applied to the Diagnostic Tool.

Bull Trout abundance (e.g., total number in the system, spawners, non-spawners and sub-adults) will be estimated from models[13]. The model is intended to integrate collected data including redd counts, PIT tag detectors, and the acoustic telemetry data both upstream and downstream of the Site C Dam to produce these estimates.

4.3.2 Kokanee Summary

Kokanee are a focus of the Monitoring Plan because they are expected to be a major component of the reservoir ecosystem and a key item in the diet of the indicator species of Bull Trout.

Kokanee are a pelagic freshwater species that is widely distributed throughout BC (McPhail 2007). Kokanee colonize lacustrine habitats of many large lakes within BC and have been introduced into numerous small lakes throughout the province. Kokanee spawn in both streams and lakes during the fall and are generally sexually mature by age-3 or age-4, depending on the population and productivity of the system (Sebastian et al. 2009). In the Peace River system, Kokanee occur naturally in some of the headwater lakes, and supplemental stocking has been conducted in Williston Reservoir (Langston and Murphy 2008) where they successfully reproduce (Langston and Zemlak 1998; Sebastian et al. 2009). Kokanee are considered the dominant pelagic species in Williston Reservoir (Sebastian et al. 2009).

[13] EIS Volume 2, Appendix Q3, Sections 2.5, 3.1, and 4.1.

Ecosystem modeling in support of the EIS predicts that Kokanee abundance will increase following the creation of the Site C Reservoir, mostly as a result of entrainment from upstream reservoirs:

> "Results indicated about a 3-fold increase in the total biomass of three groups of fish in the proposed Site C reservoir relative to what currently exists in the Peace River….. The changes in overall biomass were driven most strongly by a substantial increase in group 3 planktivorous fish species (kokanee and lake whitefish) over both the early stage and long term"[14].
>
> "The model predicts the development of a kokanee population in the Site C reservoir with two sources of recruitment. Most adult kokanee in the Site C reservoir would enter the reservoir via entrainment from Williston Reservoir as younger fish. A much smaller proportion of adult kokanee would be the progeny of adult kokanee that spawn in tributaries to the Site C reservoir. "[15]

The EIS predicts that Kokanee will be an important prey source for piscivores in Site C Reservoir:

"Estimated post development biomasses of bull trout, burbot, and northern pike are predicated on the assumption that these species would be able to switch the portion of their diet that currently is based on mountain whitefish and Arctic grayling (species expected to decrease) over to kokanee or suckers (expected to increase)"[16]. Key uncertainties for Kokanee include the following:

1. sources of recruitment (i.e., recruitment through entrainment from Williston Reservoir or from newly established recruitment sources in Site C Reservoir tributaries);
2. whether there will be any negative interactions with Lake Trout; and
3. whether entrainment rates at the Project are high (Compass and ESSA 2015).

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to Kokanee biology (Compass and ESSA 2015). Nine monitoring programs and 20 associated tasks are relevant to Kokanee Fisheries Management Questions (Table 5).

Status and trends in Kokanee are monitored in the Site C Reservoir Fish Community Monitoring Program (Mon-1a). The Site C Reservoir Hydroacoustic, Trawl and Gillnet Survey (Mon-1a, T2a) will provide an estimate of abundance of Kokanee in the reservoir. This information will be supplemented by the Site C Reservoir Creel Survey (Mon-1a, T2c). Based on the power analysis, the proposed monitoring will be sufficient to detect predicted large magnitude increases associated with achieving EIS predicted outcomes in the near term (10 years post construction) after 5 years of post-operations sampling (should such increases occur within that time period), and more subtle changes associated with achieving EIS predicted outcomes in the longer term (30 years post construction) should be detectable after 12 years of monitoring. Shortfalls greater than 35% compared to EIS predictions can be detected (Ma et al. 2014). If Kokanee abundance does not trend upwards based on results from the Site C Reservoir Hydroacoustic, Trawl and Gillnet Survey (Mon-1a, T2a), contingent monitoring is planned to determine if there is natural recruitment from Site C LAA tributaries (Site C Reservoir Tributaries

[14] EIS, Volume 2, Appendix P3, Executive Summary, p. *v*
[15] EIS, Volume 2, Appendix Q3, Executive Summary, p. 2
[16] EIS, Volume 2, Appendix P3, Section 6.6.1, p. 60

Fish Population Indexing Survey; Mon-1b, T2c). Environmental conditions in the Site C reservoir, including primary productivity, will be monitored by Mon-6 and Mon-8, which will provide insight when interpreting Kokanee data. Monitoring environmental parameters will help diagnose causes of declines, should a decline be detected, and can be applied to the Diagnostic Tool.

The Monitoring Plan addresses the key uncertainties for Kokanee while monitoring status and trends to compare against EIS predictions. The uncertainty around the source of recruitment of Kokanee is addressed by monitoring of recruitment from upstream of the Site C LAA in the Williston Peace Reach Kokanee Spawner Survey (Mon-10, T2a), and contingent monitoring of potential natural recruitment within the Site C reservoir tributaries (Mon-1b, T2c). The uncertainty around losses to entrainment is addressed in the Site C Fish Entrainment Monitoring Program, which will estimate Kokanee entrainment rate and entrainment survival (Mon-10, T2b and T2c respectively). Lake Trout abundance, size and age within the Site C reservoir will be estimated using Summer Profundal Index Netting (Mon-1a, T2b).

4.3.3 Mountain Whitefish

Mountain Whitefish were selected as an indicator species to monitor the environmental sustainability and ecological integrity of key values by the Province for the following reasons:

- "relatively well-studied within the [Lower Peace River watershed] and elsewhere
- representative of cold-water fauna, not tolerant of turbidity
- this is an important insectivore prey species for piscivorous fish
- representative of Pacific origins"[17]

Mountain Whitefish are a western North America species that are distributed on both sides of the Rocky Mountains from the Mackenzie River to Utah and California (McPhail 2007). Their BC distribution includes the lower Peace River and Liard River drainages, but they are missing from low relief areas in northeastern BC, such as the Hay River drainage. Mountain Whitefish are yellow-listed in BC (considered not at risk). They are often the most abundant fish species in small streams and large rivers, but are also common lakes and reservoirs. Mountain Whitefish feed on a variety of small food items including zooplankton, aquatic insects and other invertebrates but rarely eat other fish. Mountain Whitefish usually spawn in flowing water and typically migrate to suitable spawning areas in tributaries of lakes and rivers but some mainstem spawning occurs even in the large rivers such as the Peace. There is no spawning site preparation and spawning usually occurs at night over gravel substrate in the fall or early winter when temperatures drop below 10 C. Newly hatched fry disperse into low velocity areas at the margins of streams. Most fish are mature by age-6 and males mature about a year younger than females. Mountain Whitefish generally spawn every year but few live beyond age 12. Mountain Whitefish can make regular movements between feeding, overwintering and spawning areas separated by as much as 100 km.

Mountain Whitefish are widespread and abundant in the mainstem Peace and are

> "the dominant species in the LAA. In 2011 within the Peace River, there were an estimated 275,500 large-sized mountain whitefish (70,400 kg) upstream of the proposed Site C Dam site and an estimated 86,000 large-sized mountain whitefish (29,000 kg) downstream of

[17] BC Government 2011, Section 3.2, Table 1, p 22

> the proposed Site C Dam site. Longnose sucker replaces mountain whitefish as the dominant large-fish species downstream of the Beatton River confluence."[18]

Migration behavior of Mountain Whitefish in the Peace River is diverse:

> "some mountain whitefish complete all life history actives within a 1 or 2 km section of the Peace River, while other mountain whitefish migrate more than 80 km in order to access tributary spawning habitats in the Pine River, Moberly River, and Halfway River."[19]

The EIS predicts a loss of distinct groups of Mountain Whitefish that spawn in the Peace River mainstem or tributaries located upstream of the Project:

> "Existing fish populations that rely on Peace River mainstem habitats to sustain these populations would be negatively affected. Species that are expected to be adversely affected include: …. mountain whitefish. Distinct groups of fish from those species that are expected to be most negatively affected include: …. Peace River mainstem spawning mountain whitefish."[20]

Below the Project,

> "The downstream model (a quantitative ecosystem model used to analyze changes to aquatic productivity) suggests a 1.2 to 1.4-fold increase in the total biomass of fish in the three groups of fish. This increase in total biomass is composed of a 45% to 80% decrease in the biomass of group 1 fish (burbot, lake trout, rainbow trout, walleye, northern pike), counteracted by a 1.8 to 1.9-fold increase in the biomass of group 2 fish (Arctic grayling, mountain whitefish, bull trout). The increase in group 2 fish is due primarily to a doubling of mountain whitefish, which are assumed to benefit from increased water clarity downstream of the Site C Dam."[21]

Uncertainties in Mountain Whitefish abundance are associated with to the anticipated positive response to improvements in water clarity below the Site C Dam and the anticipated negative response to the conversion to reservoir habitat above Site C.[22]

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to Mountain Whitefish biology to evaluate the proposed Site C Aquatic Monitoring Plan (Compass and ESSA 2015). Nine monitoring programs and 18 associated tasks are relevant to Mountain Whitefish monitoring questions (Table 5).

The Monitoring Plan addresses the key uncertainties for Mountain Whitefish by monitoring abundance both upstream and downstream of Site C. Upstream of the Project, Mountain Whitefish are not expected in great abundance but will be monitored in the upper reaches of the reservoir under the Site C Reservoir Fish Community Monitoring Program (Mon-1a, T2a, T2c). Downstream of the Project (and before the dam is operational, the entire Site C LAA), Mountain Whitefish abundance will be monitored under the Peace River Fish Community Monitoring Program (Mon-2, T2a, T2b, T2c). The power analyses suggest that up to 17 years are required to detect a trend in Mountain Whitefish abundance based on the large year-to-year natural

[18] EIS, Volume 2, Section 12.3.2.7, p28.
[19] EIS, Volume 2, Section 12.3.2.3, p26.
[20] EIS, Volume 2, Section 12.6, p81
[21] EIS, Volume 2, Appendix P3, Section 6.6.2, p62
[22] EIS Volume 2, Appendix P3, Table 6D

variability (Ma et al. 2014). Mountain Whitefish movement and survival will be monitored below the dam (Mon-13) using dual-mode (acoustic and radio) telemetry tags (attached as part of Mon-2). Environmental conditions in the Peace River downstream of Site C will be monitored under Mon-7 and Mon-9. Monitoring environmental parameters will help diagnose causes of declines, should declines be detected, and can be applied to the Diagnostic Tool.

4.3.4 Goldeye Summary

Goldeye were selected as an indicator species to monitor the environmental sustainability and ecological integrity of key values by the Province for the following reasons:

- "not well studied within the [Lower Peace River Watershed] and elsewhere
- representative of cool-water fauna, tolerant of turbidity, and highly migratory
- representative of Great Plains origins"[23]

Goldeye are endemic to North America, occurring in Canada from western Ontario to the Rocky Mountains and north to Great Slave Lake, with an isolated pocket of distribution directly south of James Bay in Ontario and Quebec (McPhail 2007). Goldeye are a blue-listed species (i.e., a species of special concern) in British Columbia, and classified as "secure" in Alberta[24]. They can be found in a variety of habitats including warm, silty/turbid, slow-moving waters of large rivers, quiet shallow lakes, ponds, marshes, and muddy shallows of large lakes. Goldeye are adapted to low light and turbid water conditions and are essentially nocturnal. They are mainly surface feeders, consuming aquatic insects, snails, small fish, and any other edible organisms they encounter. Goldeye can exhibit both riverine and adfluvial life history types. Goldeye reach maturity at approximately age-6 to age-7 and spawn annually in the spring. Young-of-the-year Goldeye are found in rivers in areas of large eddies as well as shallow areas with limited water movement. Juvenile and adult Goldeye may move upstream during summer feeding periods and then return to overwintering areas in the late fall.

With respect to the Project, the most important characteristic of Peace River Goldeye is their migratory behavior, which is described in the following summaries from the EIS:

> "Goldeye is a migratory species that can travel long distances from wintering habitats downstream to spawning and feeding habitats to as far upstream as the Moberly River. The goldeye population spawns in the Peace River and in several tributaries, primarily in Alberta. "[25]
>
> "Radio-tagged goldeye moved long distances and the total range of movement encompassed approximately 700 km of river from Vermillion Chutes to the Pine River confluence in British Columbia. Although the majority of goldeye were highly migratory, not all fish moved past the Dunvegan site during annual migrations. A portion of the sample population remained downstream (of Dunvegan). Peak upstream migrations were most likely to occur between May and July. Downstream (migrations) were most likely to occur between August and October when fish returned to wintering habitats.
>
> Radio-tagged goldeye frequented confluence areas of several tributaries, generally were not recorded moving upstream into the tributary. Exceptions include upstream migrations by goldeye into the Smoky River near the Town of Peace River, Alberta, as well as the Clear River and Beatton River near the B.C./Alberta boundary. The presence of goldeye in

[23] BC Government 2011, Section 3.2, Table 1, p 22
[24] EIS, Section 12, Table 12.5
[25] EIS, Volume 2, Section 12.3.2.3, pp. 12-25

> (Peace River) tributaries during the spawning period suggested that tributaries may be used for spawning by goldeye. "[26]

The EIS predicts changes to Goldeye abundance downstream of the Project. Goldeye abundance is expected to decrease because

> "Spawning migration is cued by temperature. Lower temperatures, less turbid water, and flow fluctuations will make conditions less preferable for goldeye."[27]

The life history of Goldeye implies that if they do decline, key uncertainties include the following:

1. whether changes to conditions within the Site C LAA result in changes in Goldeye survival and migration into the Site C LAA; and
2. whether changing conditions outside the Site C LAA downstream from Many Islands due to factors not related to the Project will result in changes in Goldeye survival and migration into the Site C LAA (Compass and ESSA 2015).

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to Goldeye biology to evaluate the proposed Site C Aquatic Monitoring Plan (Compass and ESSA 2015). Four monitoring programs and 9 associated tasks are relevant to Goldeye monitoring questions (Table 5).

The Monitoring Plan addresses the key uncertainties for Goldeye within the Site C LAA, while providing information on status and trends if a decline in Goldeye were to occur. Within the Site C LAA, the Peace River Fish Community Monitoring Program (Mon-2) Large Fish Indexing Survey (Task 2a) will sample the Peace River to Many Islands, AB, thereby sampling the Goldeye migratory range within the Site C LAA. Currently, the power to detect a change in Goldeye abundance is limited by the small number of years of baseline sampling (3 years of survey data) (Ma et al. 2014). This will provide a means of monitoring Goldeye relative abundance within the Site C LAA, supplemented by creel survey information (Mon-2, T2c). Environmental conditions will be monitored by Mon-7 and Mon-9. Monitoring environmental parameters will help diagnose causes of declines, should a decline be detected.

The Large Fish Indexing Program (Mon-2, T2a) occurs during the late summer period (i.e., mid-August to mid-September). This time period was selected for several reasons, including maintaining compatibility with historical datasets, increasing sampling efficiency by sampling when turbidity is low, and reducing potential impacts to Bull Trout by sampling when spawners are not present in the Peace River mainstem (i.e., when they are spawning in select tributaries). Goldeye generally migrate into the Site C LAA during the spring as water turbidity increases. These individuals migrate downstream out of the Site C LAA over the summer as water turbidity decreases. The proposed time period for Mon-2, T2a is near the end of the Goldeye migratory period.

If poor catch data from Construction Year 1 and 2 suggest that the Peace River Large Fish Indexing Survey will not yield sufficient data to monitor Goldeye populations in the Site C LAA, a dedicated contingent monitoring task will be implemented to monitor Goldeye. The contingent assessment will consist of boat electroshocking in the spring (i.e., mid-May to early June) near

[26] EIS, Volume 2, Appendix O, Section 6.1.1.4, pp. 132
[27] EIS, Volume 2, Appendix P3, Table 6D.2

the confluences of major Peace River tributaries in Sections 7 and 8[28], most notably the Beatton, Kiskatinaw, Alces, Pouce Coupe, and Clear rivers.

As part of the continued collection of baseline data, microchemistry analysis will be performed on stored fin rays or otoliths to determine the proportion of Goldeye originating from outside the Site C LAA (Mon-2, T2a). Baseline microchemistry analysis suggested that very few of the 25 Goldeye sampled originated from within the Site C LAA[29]. If Goldeye abundance declines, contingent microchemistry analysis would occur during the operations phase to determine if the proportion of Goldeye originating from outside of the Site C LAA changes

4.3.5 Walleye Summary

Walleye were selected as an indicator species to monitor the environmental sustainability and ecological integrity of key values in the Peace River by the Province for the following reasons:

- "high value target for anglers
- relatively well studied within [Lower Peace River Watershed] and elsewhere
- representative of cool/coldwater fauna, tolerant of turbidity, highly migratory
- representative of Great Plains origins"[30].

Walleye are endemic and widely distributed in North America (McPhail 2007, Hartman 2009). Their native distribution in BC includes the lower Peace River, Liard River, and Hay River drainages. Walleye have been introduced into many western states in the Unites States, and as a result have also moved into southern BC through the Columbia River drainage. Walleye are yellow-listed in BC (considered not at risk). Walleye are common in turbid lakes and reservoirs, but can also be found in large rivers with deep, turbid water. Walleye are predators that feed on small fish and other organisms such as amphipods, crayfish, insects, and worms. Cannibalism is also considered a part of Walleye feeding behaviour and may affect population structure. These fish spend most of their time in dark, deep water, protecting their sensitive eyes from daylight, and usually feed in shallow water at dawn and dusk. Walleye are highly migratory and can exhibit riverine, adfluvial, or lacustrine life history types. They are broadcast spawners, with spawning occurring each spring over shallow rocky areas of rivers or windswept shallows in lakes. Newly hatched fry disperse into the upper levels of open water; by the latter part of the summer, young-of-the-year have moved into deeper water and associate with the bottom. Male Walleye mature at age-2 to age-4 and females at age-3 to age-6. Once mature, Walleye generally spawn every year. Mature Walleye will migrate either upstream or downstream from their over-wintering areas to spawning locations, while additional migratory movements may occur post-spawning to summer foraging areas.

A key characteristic of Peace River Walleye is that they engage in annual migrations, which are described in the following summary from the EIS:

> "Walleye undertake post-spawning feeding movements in the Peace River from spawning areas in the Beatton River, Clear River, and Pouce Coupe River to as far upstream as the Halfway River, a distance of 100 km. Some of these walleye enter and move upstream into larger tributaries such as the Pine River, Moberly River, and Halfway River.[31] "

[28] EIS, Volume 2, Appendix O
[29] EIS, Volume 2, Appendix O
[30] BC Government 2011, Section 3.2, Table 1, p 22
[31] EIS, Volume 2, Section 12.3.2.3, p. 26

Walleye juveniles appear to migrate to the mainstream Peace River as age-0 and age-1 fish at lengths ranging from 50-200 mm:

> "All young walleye (Age 0 and 1) were recorded in Section 7 and Section 8 (Figure 6.4.9) Age 0 fish were recorded at and immediately downstream of the Beatton River confluence in Section 7 and immediately downstream of the Pouce Coupe River confluence in Section 8. Young walleye were also recorded in main channel and side channel areas away from tributary confluences."[32]

Most walleye appear to overwinter in the Peace River, within the LAA, downstream of Site C:

> "Most walleye that moved up the Beatton River in spring were fish that over-wintered (October-April) within the vicinity of the Beatton River mouth"[33]

Baseline microchemistry analysis suggests that most of the 40 Walleye sampled within the Site C LAA were recruited from tributaries to the Peace River within the Site C LAA:

> "The major source of recruitment for walleye collected from the Peace River is the Beatton River watershed. Sources from this system included the mainstem Beatton River, several of its tributaries (Milligan River, Blueberry Creek, and Fish Creek), and Charlie Lake. Peace River walleye also recruited from the Pine River watershed (mainstem Pine River and Murray River), as well as from tributaries in Alberta that included the Pouce Coupe River and Smoky River in Alberta. A portion of the sample whose source could be identified also recruited from the Peace River.[34] "

Downstream of Site C, Walleye (and other coolwater species) are expected to decrease in abundance:

> "Walleye .... populations would remain downstream of the Pine River due to the regulated flow regime, cooler summer water temperatures, and the reduced sediment load during freshet. ....Walleye may not reside in the Peace River between the Site C Dam and the Pine River confluence, but still might forage upstream of the Pine when conditions are favorable. .....The extent of the change on all (coolwater) fish populations downstream of the Pine River would be based primarily on the degree to which Pine River and other tributary inputs (i.e., Beatton River, Kiskatinaw River, Clear River, and Pouce Coupe River) would attenuate the flow and thermal and ice regime as a result of the operations of the Project. "[35]

Upstream of Site C, the future status of Walleye is not clear:

> "It is uncertain whether walleye would reside in the reservoir. Walleye regularly occur in the Site C reservoir section of the Peace River. Walleye would be upstream of the dam and generating station construction zone at the time of scheduled closure of the Peace River in Year 4 of construction. The resulting construction headpond would allow walleye to remain upstream until creation of the Site C reservoir. If sufficient numbers of walleye are present at the time of reservoir formation, a population could become established. Walleye is a species that can exploit reservoir habitats, and there would be abundant food resources. In addition, historical spawning and rearing habitats traditionally utilized

[32] EIS, Volume 2, App. O, Section 6.4.1.1, p. 158
[33] EIS, Volume 2, App. O, Section 6.1.1.2, p. 129
[34] EIS, Volume 2, App. O, Section 6.4.2, p. 172
[35] EIS, Volume 2, Section 12.4.2, p. 46

> by the Peace River walleye population (i.e., Halfway River system) would be available. „[36]

The key uncertainty regarding Walleye is their population structure within and outside of the Site C LAA (Compass and ESSA 2015). Walleye population structure would need to be clarified to determine drivers of change (i.e., are changes related to the Project?). The population structure of Walleye in the Peace River within the Site C LAA will be determined using microchemistry analysis. If the core Walleye population is found to be outside the Site C LAA, then factors affecting Walleye survival or their ability to migrate upstream from outside the Site C LAA may be independent of Site C impacts.

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to Walleye biology to evaluate the currently proposed Site C Aquatic Monitoring Plan (Compass and ESSA 2015). Five monitoring programs and 11 associated tasks are relevant to Walleye monitoring questions (Table 5).

The Monitoring Plan addresses the key uncertainties for Walleye within the Site C LAA, while providing information on status and trends. Within the Site C LAA, the Peace River Fish Community Monitoring Program (Mon-2) Large Fish Indexing Survey (Task 2a) will sample the Peace River to Many Islands, AB, thereby sampling the Walleye migratory range within the Site C LAA. Baseline data for Walleye are limited; therefore, power analysis results are limited (Ma et al. 2014). The proposed monitoring will provide a measure of trends in relative abundance in the downstream reach of the Peace River within the Site C LAA, which will be supplemented by creel survey information (Mon-2, T2c). Environmental conditions will be monitored by Mon-7 and Mon-9. Monitoring environmental parameters will help diagnose causes of declines, should declines be detected, and can be applied to the Diagnostic Tool. Monitoring of adult habitat outside of the Site C LAA will be indirect and limited. The areas outside of the Site C LAA include both the upper reaches of the tributaries downstream of the Site C dam that feed into the Peace River, and the Peace River below Many Islands, AB. There are no plans to monitor the upper reaches of the Beatton River. Mon-2, T2b includes telemetry tagging/tracking to determine the proportion of Walleye that spawn outside the Site C LAA. As part of the continued collection of baseline data, microchemistry analysis will be performed on stored fin rays or otoliths to determine the proportion of Walleye that originate outside the Site C LAA (Mon-2, T2a). Baseline microchemistry analyses suggest that the major source of recruitment were from tributaries to the Peace River within the Site C LAA[37]. If Walleye abundance declines, contingent analysis could occur during the operations of Site C to determine if the proportion of Walleye originating from outside of the Site C LAA changes.

4.3.6 Fish Community Status Summary

Monitoring the fish community status focuses on high level objectives that are additional to the status of indicator species. These objectives are stated in BC Government (2009, Table 3, p11):

1. Ecosystem Integrity and Productivity:
   a. Zoogeography of fish fauna;
   b. Productive capacity of the native fish community; and
   c. Structure and function of aquatic community.
2. Sustainable Use:

[36] EIS, Volume 2, Section 12.4.1, p. 41
[37] EIS, Volume 2, Appendix O

a. Sustain an adequate fisheries resource to support First Nations' traditional uses and treaty rights; and
b. Optimize recreational angling opportunities, participation and local benefits.

Site C Reservoir represents a change in ecosystem characteristics that will affect the values associated with fish communities directly and indirectly:

> "The Project may destroy fish habitat by placing a permanent physical structure on that habitat, or the Project may alter fish habitat by changing the physical or chemical characteristics of that habitat in such a way as to make it unusable by fish. Destruction or alteration of important habitats may be critical to the sustainability of a species population."
>
> "The Project may affect fish health and survival. It may cause direct mortality of fish or indirect mortality of fish by changing system productivity, food resource type and abundance, and environmental conditions on which fish depend (e.g., water temperature)."
>
> "The Project may affect fish movement by physically blocking upstream and downstream migration of fish or by causing water velocities that exceed the swimming capabilities of fish, which results in hindered or blocked upstream migration of fish. Blocked or hindered fish movement has consequences to the species population. Fish may not be able to access important habitats in a timely manner or not at all (e.g., spawning habitats). Blocked fish movement may result in genetic fragmentation of the population. "[38]

Each effect is associated with indicators that are integrated into the monitoring plan:

> "Change in fish habitat: Quality and quantity of fish habitats, habitat availability, water depth, velocity, water temperature, sedimentation, water quality, ice regime, aquatic productivity, and food resources, competition for food and habitat."
>
> "Change in fish health and survival: Species diversity; fish population distribution, fish population relative abundance, fish population biomass, sedimentation, stranding, fish entrainment, total dissolved gas. "
>
> "Change in fish movement: Fish species population, movement patterns and general life history parameters (i.e., access to habitats), swim speeds, entrainment."[39]

The Monitoring Plan will assess aquatic ecosystem status at the community level by linking the desired outcomes of species diversity, fish abundance and sustainable harvest to changes in physical habitat using the weight of evidence for alternative impact pathways or hypotheses. Impact pathways are defined in terms of hypotheses that are based on a state-of-science understanding of ecosystem structure and processes, and expected changes due to the Project. Changes in physical habitat are predicted in the EIS and will be evaluated by monitoring programs under the Monitoring Plan. The monitoring programs also will collect data on intermediate indicators, including fish food availability, that affect stated management objectives directly. Future conditions in the Peace River and Site C Reservoir will be compared with conditions that are predicted and documented in the EIS[40].

Monitoring Summary

Monitoring programs and associated tasks were assessed in terms of their relevance to fish community objectives to evaluate the currently proposed Monitoring Plan (Compass and ESSA

[38] EIS Volume 2, Section 12.1.2, p4
[39] EIS Volume 2, Section 12.1.4, p5, Table 12.4
[40] EIS, Volume 2, Appendix P3

2015). Fifteen monitoring programs and 28 associated tasks are relevant to fish community objectives monitoring questions (Table 5). Monitoring programs and associated tasks were organized according to their relevance to various impact pathways, which are in turn linked to fish community objectives. Tasks within monitoring programs will measure indicators of physical and chemical habitat, primary and secondary production (zooplankton, insects), as well as indicators of fish diversity and abundance (Table 5).

The Monitoring Plan assesses status and trends in the fish community through direct monitoring of fish species and environmental attributes of the Site C LAA. Direct measures of fish abundance and diversity in the Peace River will include information from the Peace River Large Fish Indexing Survey (Mon-2, T2a), the Peace River Fish Composition and Abundance Survey (Mon-2, T2b) and the Peace River Creel Survey (Mon-2, T2c). The Halfway and Beatton riverArctic Grayling atatus assessment will provide supplemental information on fish status in the respective systems. A task to Monitor Stranding Sites (Mon-12, T2b) will provide information on juvenile fish status and mortality, helping to refine downstream channel mitigation actions to reduce stranding. Data on Entrainment Rates (Mon-10, T2b) will provide estimates of the biomass subsidy transferred to the Peace River from Site C Reservoir. Genetic diversity of select fish species will be monitored by tasks associated with Data Collection and Analysis under the Small Fish Species Translocation Monitoring Program (Mon-15, T2a, T2b) in order to provide information on the effects of the Project on meta-population structure.

In the Site C Reservoir, the Monitoring Plan focuses on fish abundance rather than diversity. Indicators of abundance will be monitored under the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey (Mon-1a, T2a) and the Site C Reservoir Creel Survey (Mon-1a, T2c). Trends in biomass subsidies from upstream reservoirs will be assessed under the Williston Peace Reach Kokanee Spawner Survey (Mon-10, T2a). Summer Profundal Index Netting (SPIN; Mon-1a, T2b) will provide abundance data for large piscivores.

Creel surveys (Mon-1a, T2c; Mon-2, T2c) in the Peace River and Site C Reservoir will measure recreational angler response to ecosystem changes and collect data on the size, age, and species of fish harvested in the Site C LAA. Specific monitoring of Aboriginal groups' harvesting activities is not proposed; however, any information provided by First Nation on harvest as well as the creel surveys (Mon-1a, T2c and Mon-2, T2c) will collect opportunistic data that will help document total harvest.

Physical habitat and water quality data will be collected from both the Peace River and Site C Reservoir. The primary task that will collect data on fish habitat downstream of the project is Measurement of Ecosystem Attributes (Mon-7, T2b). These data will be supplemented by more specialized data on select aspects of the physical environment including: Cross section surveys (Mon-3, T2c), Grain Size Sampling (Mon-3, T2b), Aerial Photo Interpretation (Mon-5, T2a), Water and Sediment Quality (Mon-8, T2a), and Water Temperature data (Mon-8, T2b).

In the Site C Reservoir, the Measurement of Ecosystem Attributes task (Mon-6, T2b) will collect most of the physical data on fish habitat. This task will be supplemented by a riparian vegetation assessment (Aerial Photo Interpretation and GPS Mapping in Mon-4, T2a, and Vegetation Transect Surveys in Mon-4, T2b) that will quantify shoreline erosion management using riparian vegetation. Additional specific data concerning fish habitat in the reservoir include Water Quality and Sediment Quality (Mon-8, T2a), and Water Temperature Monitoring (Mon-8, T2b).

Information on the standing crop and production of aquatic insects and zooplankton will be monitored under twin tasks on Biomass and Availability of Fish Food Organisms in the Peace River (Mon-7, T2a) and Site C Reservoir (Mon-6, T2a). Fish stomach contents will be used to

link these data to upper trophic levels. Algal biomass and factors affecting primary production also will be collected under these tasks.

5.0 Procedure to Evaluate and Implement Future Compensation Actions

This section has been developed in accordance with:

- EAC Condition 7: “The Fisheries and Aquatic Habitat Monitoring and Follow-up Program must outline a procedure for evaluating future mitigation and compensation options after reservoir development and follow-up monitoring, as well as procedures for how compensation options that are technically and economically feasible will be implemented.”

The Site C Project will continue to involve decisions on the form and intensity of monitoring to determine the effects of the Project and effectiveness of mitigation measures, adjustments to these mitigation measures if required, and the most appropriate types of measures to offset residual impacts which cannot be mitigated. Such decisions on monitoring, mitigation and offsetting need to be made in an integrated and collaborative manner. Mitigation measures and monitoring plans are described in the FAHMP and FAHMFP, respectively, but all involve uncertainty and will need to be iteratively revised over the next several decades based on the response of the aquatic ecosystem and what is learned.

A number of large-scale fish habitat enhancements that are expected to benefit fish populations are described in this offset plan. The effectiveness of other enhancement options is uncertain as their potential benefit depends on the response of the fish community to the Project. Monitoring results can inform the appropriate compensation actions to implement over time as the aquatic ecosystem transitions and species-specific information is collected. This adaptive approach supports offset decisions made on the basis of empirical information.

Measures will be implemented after the reservoir is established. A strategic and adaptive approach to implementation that is coordinated with directed assessment and monitoring is proposed. The Tributary Mitigation Opportunities Evaluation Program is an example of this approach, with the objective of the program is to identify enhancement opportunities (e.g., spawning gravel quality, rearing habitat, overwintering habitat) for stream dependent indicator species including Artic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Walleye, and Rainbow Trout. Such an approach is also consistent with BC Hydro’s broader practices, experience and success in implementing fish habitat compensation programs. The approach will build upon environmental management processes and principles employed at existing facilities operated by BC Hydro. These approaches have proven effective in managing fish and fish habitat, supporting regulatory compliance, and promoting stakeholder and Aboriginal group input in decision making. The approach will provide long term flexibility and responsiveness to implement additional mitigation in the reservoir, tributaries and the Peace River.

It is expected that input on monitoring and compensation actions will be obtained through monitoring advisory and technical committees that meet at least annually to review monitoring program results presented by those implementing the programs. Participation would include regulatory agencies including DFO, MOE, FLNR, and Aboriginal groups.

5.1 Tributary Mitigation Opportunities Evaluation

Habitat enhancement opportunities in tributaries have been identified as a potential option that would benefit fish populations. However, decisions on the form and design of these options will benefit from further information on watershed conditions. The Tributary Mitigation Opportunities Evaluation Program (included as Appendix S) was developed as a directed assessment to confirm scope and approach for compensatory actions. The program objective is to identify enhancement opportunities (e.g. spawning gravel quality, rearing habitat, overwintering habitat) for stream dependent indicator species including Artic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Walleye, and Rainbow Trout in tributaries to the Site C Reservoir and the Beatton River. Watershed Status Evaluation Protocol Tier 1 and Tier 2 assessments will be completed within candidate tributary watersheds involving a mitigation opportunity assessment before completing more formal watershed basin assessments. A list of potential project opportunities will be developed focused on areas where impacts are expected to be greatest.

6.0 Implementation and Reporting

This section has been developed in accordance with:

- EAC Condition 7: “The Fisheries and Aquatic Habitat Monitoring and Follow-up Program reporting must occur at least annually during construction and operations beginning 180 days following commencement of construction and operations phases, or in accordance with the applicable Fisheries Act authorization(s).”

A proposed implementation schedule for the Monitoring Plan and the Tributary Mitigation Opportunities Evaluation Program in accordance with EAC conditions is included as Figure 5. The Monitoring Plan will be implemented as a phased approach to match three discrete time periods associated with the Project. These include:

- Construction period following start of in-river construction (eight years)
- The reservoir transformation period following reservoir filling (15 years)
- The reservoir post transformation period (15 years)

BC Hydro will provide reports on the implementation of the Fisheries and Aquatic Monitoring and Follow-up Program to the EAO annually by Mar 1 of the year following data collection. This timing is in accordance with the Fisheries Act authorization for Site Preparation. Monitoring is schedule to begin in spring 2016 and the first report will be submitted by March 1, 2017. These reports will include a summary and analysis of plan implementation.

Annual reports will also include a description of any amendments as described in Section 2.4.

7.0 Qualified Professionals

Table 6 lists the qualified individuals who prepared the FAHMFP.

Table 6. Qualified Professionals

Qualified Individual	Expertise
Dave Hunter, B.Sc., R.P.Bio	Fisheries
Brent Mossop, MRM, R.P.Bio	Fisheries
Dustin Ford, B.Sc., R.P.Bio	Fisheries
Eric Parkinson, M.Sc.	Fisheries
Michael McArthur, M.Sc., R.P.Bio	Fisheries
Don McCubbing, M.Sc., R.P.Bio	Fisheries

8.0 Revisions to the Plan

The FAHMFP provides information on monitoring and follow-up measures that will be implemented and adapted through Project construction and operations. The principle of adaptation covers a spectrum from minor field-based program adjustments to major, larger scale contingent initiatives. Any revisions to the monitoring will need to be balanced with the interest in a consistent sampling approach through time.

Further information will become available as monitoring and follow-up program implementation progresses. Further input may also be received from contractors, Aboriginal groups, the public, and regulatory agencies that need to be taken into account in the implementation of monitoring and follow-up programs.

As described in Section 5.0, proposed revisions to the plan and associated monitoring programs will be considered by monitoring advisory and technical committees.

9.0 References

AMEC, Earth & Environmental and LGL Ltd. 2010b. Analysis and Assessment of the Ministry of Environment's Peace River Bull Trout and Arctic Grayling Radio Telemetry Database 1996 to 1999. Report prepared for BC Hydro.

B.C. Government. 2009. Ministry of Environment Fish and Wildlife Interim Objectives for Site C Project Area. 42 p.

B.C. Government. 2011. *DRAFT Fish, Wildlife and Ecosystem resources and Objectives for the Lower Peace River Watershed – Site C Project Area*. 25 p. + appendices.

Beauchamp, D.A. et al. 1994. Summer Habitat Use by Littoral-Zone Fishes in Lake Tahoe and the Effects of Shoreline Structures. *North American Journal of Fisheries Management*. **14**:2, 385-394.

Bolding, B. et al. 2004. Use of Artificial Structure to Enhance Angler Benefits in Lakes, Ponds, and Reservoirs: A Literature Review, *Reviews in Fisheries Science*, **12**:1, 75-96.

British Columbia Ministry of Environment (BCMOE). 2007. *Freshwater fisheries program plan. Province of British Columbia Ministry of Environment*. Available at: www.env.gov.bc.ca/esd/documents/ff_program_plan.pdf. Accessed: April 14, 2012.

British Columbia Ministry of Environment (BCMOE). 2009. *Conservation Framework, Conservation Priorities for Species and Ecosystems Primer*. Available at: http://www.env.gov.bc.ca/conservationframework/documents/CF_Primer.pdf Accessed: December 15, 2012.

British Columbia Government (B.C. Government). 2011. *Draft Fish, Wildlife and Ecosystem resources and Objectives for the Lower Peace River Watershed – Site C Project Area*.
Fisheries and Oceans Canada (DFO). 2013a. Fisheries Protection Policy Statement. October, 2013. Online: http://www.dfo-mpo.gc.ca/habitat/cg2/pol/index-eng.html

Compass and ESSA. 2015. *Site C Monitoring Program Diagnostic Tool (In preparation)*. Prepared for BC Hydro by Compass Resource Management and ESSA Technologies Ltd.

Euchner, T. 2011. *Site C Clean Energy Project Fisheries Studies: 2010 Upper Halfway River Watershed Bell Trout Spawning Survey*. Prepared by Ted Euchner, Diversified Environmental Services and Mainstream Aquatics Ltd for BC Hydro. 22 p. + appendices.

Fisheries and Oceans Canada (DFO). 2013a. Science Advice to Support Development of a Fisheries Protection Policy for Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/063.

Fisheries and Oceans Canada (DFO). 2013b. Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting. November, 2013. Online: http://www.dfo-mpo.gc.ca/pnw-ppe/offsetting-guide-compensation/offsetting-guide-compensation-eng.pdf

Hartman, G.F. 2009. A biological synopsis of walleye (Sander vitreus). *Canadian Manuscript Report of Fisheries and Aquatic Sciences* 2888: v + 48 p.

Hassemer, P.F. and B. E. Rieman, B.E. 1981. Observations of Deep-Spawning Kokanee on Artificially Created Spawning Habitat*. North American Journal of Fisheries Management*. **1**:2,173-176.

Langston, A. R. and E. B. Murphy. 2008. The History of Fish Introductions (to 2005) in the Peace/Williston Fish and Wildlife Compensation Program Area. *Peace/ Williston Fish and Wildlife Compensation Program Report* No. 325. 59p

Ma, B.O., E. Parkinson, E. Olson, D.C. Pickard, B. Connors, C. Schwarz, and D. Marmorek. 2014. Site C Monitoring Plan Power Analysis. Final report. Prepared for BC Hydro by ESSA Technologies Ltd. 74 p. + appendices.

Mainstream Aquatics Ltd. 2013. Site C Fisheries Studies – 2011 Moberly River and Halfway River Summer Fish Inventory. Report No. 11006F: 51 p. + appendices.

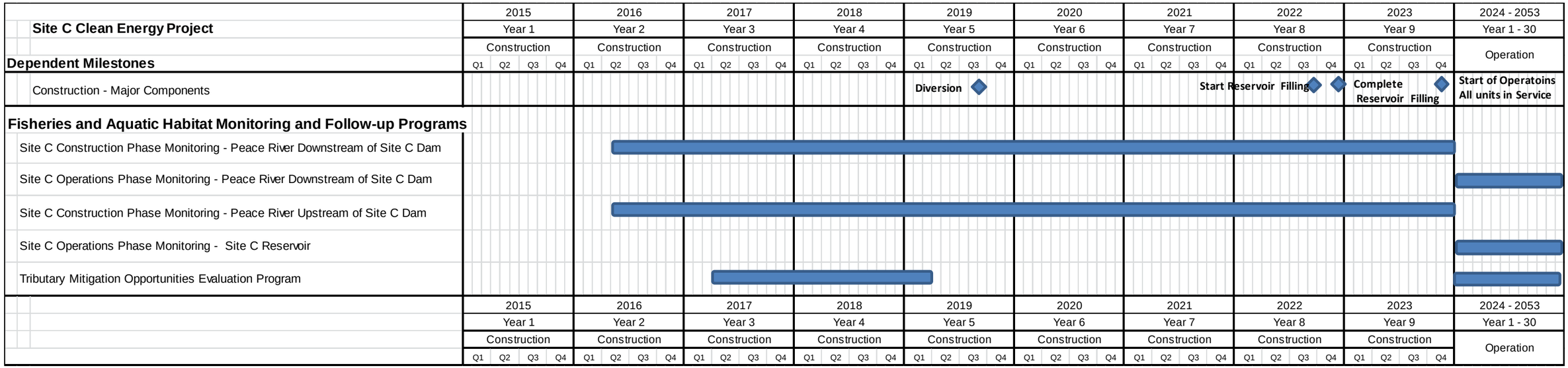
McPhail, J. D. 2007. *The freshwater fishes of British Columbia*. University of Alberta Press. 620 p.

Randall, R.G., Bradford, M.J., Clarke, K.D., and Rice, J.C. 2013. A science-based interpretation of ongoing productivity of commercial, recreational or Aboriginal fisheries. DFO Can. Sci. Res. Doc. 2012/112 iv + 26p.

Sebastian, D., G. Andrusak, G. Scholten and A. Langston. 2009. An index of fish distribution and abundance in Peace Arm of Williston Reservoir based on hydroacoustic and gillnet surveys, Study Period: July 15 – August 2, 2008. *Peace Project Water Use Plan*, Williston Fish Index, GMSMON #13.

Waters, D.A. et al. 1991. How Depth and Interstice Size of Artificial Structures Influence Fish Attraction. *North American Journal of Fisheries Management*. **11**:3 319-329.

Figure 5. Fish and Aquatic Habitat Monitoring and Follow-up Program - implementation schedule.



Appendix A

Mon-1a Site C Reservoir Fish Community Monitoring Program

SITE C RESERVOIR FISH COMMUNITY MONITORING PROGRAM

SUMMARY

ID	Site C Mon-1a – Site C Reservoir Fish Community Monitoring Program
Description	This monitoring program will investigate the effects of river to reservoir transformation on the fish community in Site C Reservoir.
Key Project components / locations	Reservoir Filling and Operation / Baseline sites.
Monitoring Category	Effectiveness and Validation Monitoring
Closely related studies	• Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-2 – Peace River Fish Community Monitoring Program
Schedule	Annually through operation (Operation Years 1 to 30)

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, regulatory agencies, and stakeholders. Section 12.1.2 of the Site C Environmental Impact Statement (EIS) states that the Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement. Physical fish habitat may be destroyed by placing a permanent physical structure on that habitat. The Project also may change the physical, chemical, or biological characteristics of habitat in such a way as to make it unusable by fish. Fish health and survival may be affected through direct mortality (e.g., entrainment mortality), or through indirect mortality, such as altering the system's productivity, food resource type or abundance, or other environmental conditions on which fish depend (e.g., water temperature). Fish movement may be affected by physically blocking the migration of fish, or by generating water velocities that exceed the swimming capabilities of fish.

Fish habitat in the Peace River upstream of the dam site and the use of that habitat by fish is expected to change with the construction and operation of the Project. Potential changes in abundance for each fish species in Site C Reservoir is expected to depend on various factors, including the ability of each species to move and recruit from other sources, rates of predation, and the yield of zooplankton and benthic invertebrates that supply food for fish.

The EIS makes both qualitative[3] and quantitative[4] predictions of fish production[5]. These predictions and conclusions can be tested at various levels of aggregation (i.e., individual fish species, groups of fish species, harvestable fish species[6], and all fish species).

The Site C Reservoir Fish Community Monitoring Program (this Program) has a broad scope that comprises multiple tasks that begin when the reservoir is filled (commencing in Operation Year 1). The operations period includes an ecological conditions transformation period during Operation Year 1 to 15 and a post-transformation period during Operation Year 15 to Year 30. The EIS makes predictions about fish and fish habitat over the short term (i.e., Operation Year 10) and the longer term (i.e., Operation Year 30)[4]. For the purposes of this Program, these predictions correspond to the reservoir transformation and the reservoir post-transformation periods, respectively.

FISHERIES MANAGEMENT QUESTIONS

The overarching Fisheries Management Question (management question) for this Program reflects that the construction and operation of the Project will affect fish in different ways:

1. How does the Project affect fish in Site C Reservoir during the short term (10 years after Project operations begin) and longer term (30 years after Project operations begin)?

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 12, pp. 39-41, 94-95
[4] EIS, Volume 2, Appendix P3
[5] Summarized in EIS, Volume 2, Section 12.4.2.1 and Section 12.6
[6] Harvestable fish species include Arctic Grayling, Bull Trout, Burbot, Kokanee, Lake Trout, Lake Whitefish, Mountain Whitefish, Northern Pike, Rainbow Trout, and Walleye. Total fish biomass includes all harvestable fish species as well as Northern Pikeminnow, suckers, and small fish.

MANAGEMENT HYPOTHESES

This Program focuses on monitoring fish biomass, species distribution, community composition, and population structure within the reservoir, and assessing whether any changes observed in these metrics are related to the construction or operation of the Project. For fish biomass, the 'Most Likely' estimate was used as the reference point to compare observations against. The more detailed hypotheses presented below are framed using specific EIS predictions.

The EIS presents an ecosystem model that makes specific predictions of fish biomass in Site C Reservoir. These predictions take into account changes to primary and secondary productivity, and physical, chemical, and geomorphic processes as a result of Site C construction and operations (Figure 1).

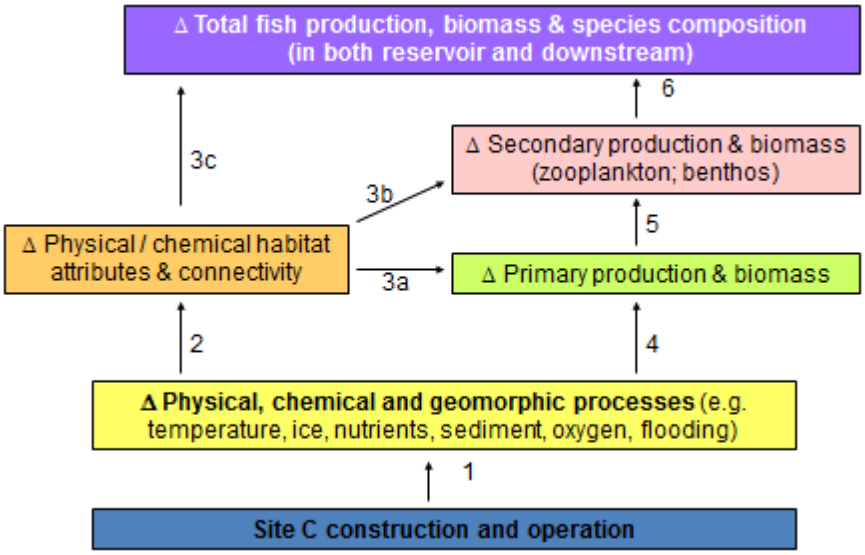


Figure 1: Conceptual model of impact pathways used to develop the EIS ecosystem model[7].

Fish biomass predictions are grouped into total fish biomass, harvestable fish biomass, and species-specific fish biomass predictions. Values for the predictions are shown in Table 1.

[7] EIS, Volume 2, Appendix P3, 3 p.

Table 1: Short and longer term predictions of fish biomass (t) for pre-project (Peace River from Peace Canyon Dam to the dam site) and post-project (Site C Reservoir) conditions. Fish biomass is presented for the "Most Likely" scenario (plus a minimum to maximum range)[4].

			SHORT TERM (IN 10 YRS)		LONGER TERM (> 30 YRS)	
Group	Species Name	Current (Pre-Project) biomass (river) (t)	Post-project biomass (Reservoir) (t)		Post-project biomass (Reservoir) (t)	
			Most Likely	Range (min - max)	Most Likely	Range (min - max)
1	Walleye	0.15	0	0 - 0	0	0 - 0
1	Lake Trout	0	0.03	0.01 - 0.04	0.04	0.01 - 0.06
1	Rainbow Trout	1.64	1.93	1.29 - 2.58	1.93	1.34 - 2.58
1	Northern Pike	0.09	0.23	0.12 - 0.46	0.46	0.12 - 0.93
1	Burbot	0.01	0.05	0.02 - 0.1	0.1	0.05 - 0.1
	Group 1 Subtotal	1.89	2.24	1.44 - 3.18	2.53	1.52 - 3.67
2	Bull Trout	2.97	3.07	1.35 - 4.37	5.52	1.76 - 6.96
2	Arctic Grayling	1.28	0	0 - 0.1	0	0 - 0.1
2	Mountain Whitefish	11.07	0.79	0.16 - 1.58	0.79	0.17 - 1.58
	Group 2 Subtotal	15.32	3.87	1.51 - 6.05	6.31	1.92 - 8.64
3	Kokanee	0.08	11.2	3.36 - 14.56	22.4	6.72 - 29.13
3	Lake Whitefish	0	0.53	0.34 - 0.93	0.11	0.02 - 0.43
	Group 3 Subtotal	0.08	11.73	3.7 - 15.49	22.51	6.74 - 29.55
	Total Harvestable Fish Biomass	17.29	17.84	6.64 - 24.72	31.35	10.19 - 41.85
4	Suckers	8.19	25.23	10.09 - 50.46	25.24	11.11 - 50.46
4	Small Fish	0.38	1.23	0.49 - 2.46	1.23	0.53 - 2.46
4	Northern Pikeminnow	0.49	0.12	0.04 - 0.2	0.12	0.04 - 0.2
	Group 4 Subtotal	9.06	26.58	10.63 - 53.13	26.59	11.68 - 53.13
	Total Fish Biomass	26.35	44.42	17.27 - 77.85	57.94	21.87 - 94.98

Where,

H_1:Post-Project total fish biomass in Site C Reservoir will be greater than pre-Project conditions (current = 26.35 t; at 10 years = 44.42 t; >30 years = 57.94 t).

H_2:Post-Project harvestable fish biomass in Site C Reservoir will be greater than pre-Project conditions (current = 17.29 t; at 10 years = 17.84 t; >30 years = 31.35 t).

In particular, six fish species in Site C Reservoir (Arctic Grayling, Bull Trout, Kokanee, Lake Whitefish, Mountain Whitefish, and Rainbow Trout) are estimated to make up 95% of the predicted upstream total harvestable fish biomass in the short term (at 10 years) and 98% in the longer term (>30 years).

H_3:Post-Project biomass of each fish species in Site C Reservoir will be consistent with biomass estimates in the EIS (see Table 1).

The EIS also predicts an overall change to fish community composition in the reservoir when compared to current conditions:

H_4:Changes in post-Project fish community composition in Site C Reservoir will be consistent with EIS predictions.[8]

Specific uncertainties in the changes to fish community composition in Site C Reservoir are represented in the three hypotheses below:

Kokanee, Lake Whitefish, and Peamouth are expected to occupy the pelagic planktivore niche within the reservoir, and there is uncertainty as to whether Lake Whitefish or Kokanee will become dominant. Based on data from Williston Reservoir, the EIS predicts that over the longer term, Kokanee will become the dominant pelagic planktivore.[9]

H_5:Kokanee will represent the largest proportion of pelagic planktivore biomass in Site C Reservoir in the long term.

Bull Trout are expected to be the dominant pelagic piscivore in Site C Reservoir; however, Lake Trout may compete for the same niche[10].

H_6: Bull Trout will represent the largest proportion of pelagic piscivore biomass in Site C Reservoir in the short and long term.

Key uncertainties identified for Arctic Grayling are their ability to overwinter in the Moberly River, reproduce in the Peace River below the Project, and the response of downstream migrants from the Moberly River to reservoir habitat[11]. Arctic Grayling are expected to avoid the reservoir based on known habitat preferences. To evaluate these uncertainties and related assumptions, the following hypotheses are proposed for Arctic Grayling in Site C Reservoir:

H_7: Post-Project biomass for Arctic Grayling in Site C Reservoir will be less than 0.1 t in the short and long term.

The expected changes to fish community composition and biomass are also expected to lead to corresponding changes in angler harvest:

H_8: Post-Project biomass of fish harvested in Site C Reservoir will be greater than pre-Project levels (current = 0.15 t; at 10 years of operations = 0.30 t; >30 years of operations = 0.39 t).[12]

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish abundance and distribution in Site C Reservoir, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[13] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[14]) and the Federal Decision Statement[15].

MONITORING PROGRAM PROPOSAL

[8] EIS, Volume 2, Appendix P3, Table 6B.1
[9] EIS, Volume 2, Appendix Q3, 65 pp.
[10] EIS, Volume 2, Appendix Q3, 61 pp.
[11] EIS, Volume 2, Appendix Q3, 2 pp.
[12] EIS, Volume 2, Appendix P3, Figure 6.3
[13] EIS, Volume 2, Section 12
[14] EAC, Condition #7, Pages 8 to 9
[15] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

OBJECTIVE AND SCOPE

The objective of this Program is to collect data necessary to validate predictions and address uncertainties identified in the EIS regarding the Project's effects on fish in Site C Reservoir and to assess the effectiveness of fish and fish habitat mitigation measures. This information will be used to guide future management actions.

The spatial scope of this Program is limited to the portion of the Peace River situated between the outlet of Peace Canyon Dam and the Site C dam (i.e., the Site C Reservoir). Peace River tributaries with confluences within Site C Reservoir will not be monitored under this Program; these tributaries will be monitored under the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b).

The temporal scope of this Program is limited to Operation Years 1 to 30; however, not all tasks (see below) occur during each study year. Monitoring of fish populations in the Peace River between Peace Canyon Dam and Site C prior to reservoir formation (i.e., during Construction Years 1 to 9) is included in the Peace River Fish Community Monitoring Program (Mon-2).

APPROACH

This Program builds on information collected during baseline studies (e.g., Robichaud et al. 2010, Mainstream and Gazey 2013) that characterized fish populations in the Peace River. The Site C Reservoir fish community will be monitored using a variety of techniques employed to study fish population in other BC Hydro reservoirs (e.g., Bray et al. 2013) including hydroacoustic, trawl, and gillnetting surveys to monitor pelagic fish species, profundal gill netting surveys to monitor pelagic piscivores, and creel surveys to monitor angling pressure.

Where practical, data from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be collected from the same locations sampled under this Program to maximize the utility of the data for analyses across different ecological components (e.g., fish relative abundance vs. fish food abundance). In addition, data will be spatially and methodologically consistent with data collected during baseline studies and WLR studies when feasible.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey
    - Task 2b – Site C Reservoir Summer Profundal Index Netting (SPIN) Survey
    - Task 2c – Site C Reservoir Creel Survey
- Task 3 – Data Analysis
    - Task 3a – Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey
    - Task 3b – Site C Reservoir Summer Profundal Index Netting (SPIN) Survey
    - Task 3c – Site C Reservoir Creel Survey
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace

River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Table 2: Overview of field work to be conducted under the Site C Reservoir Fish Community Monitoring Program.

Task Number	Task Description	Method(s) / Technology	Species Covered	Performance Measure(s)	Schedule Construction (Years 1 - 9)	Schedule Operations (Years 1 - 30)
T2a	Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey	Hydroacoustic, trawl, and gillnet; gillnetting will be used in littoral areas where trawling is not feasible	Primary pelagic fish	Fish species composition, spatial distribution, size, age, and abundance.	n/a	Annually from Operation Year 1 to 10; every second year from Operation Year 11 to 30
T2b	Site C Reservoir Summer Profundal Index Netting (SPIN) Survey	Summer Profundal Index Netting (SPIN) Lake Trout movement through Site C Reservoir to potential spawning areas	Lake Trout	Index of Lake Trout abundance	n/a	Operation Year 1 and every 5 years beginning in Operation Year 5
T2c	Site C Reservoir Creel Survey	Creel Survey and cameras at select boat launches	Harvestable fish species	Recreational angler effort and catch, and harvest rates by species.	n/a	Every 5 years between Operations Years 2 and 30.

Task 1. Project coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey. The purpose of the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey is to determine the species composition, spatial distribution, size, age, and abundance of primary pelagic fish in Site C Reservoir.

The design of the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey is based on experience conducting similar programs in other reservoirs. The most notable past BC Hydro reservoir hydroacoustic and trawl surveys include multi-year surveys under the Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring Program (CLBMON-2; Bray et al. 2013; Sebastian and Johner 2011), the Arrow Lakes Reservoir Fertilization Experiment (Sebastian et al. 2007 in Schindler et al. 2007), the Kootenay Lake Fertilization Experiment (Sebastian et al. 2010 in Schindler et al. 2010), the Stave Reservoir Fish Biomass Assessment (SFNMON-3; Stables and Perrin 2012), and surveys in Williston Reservoir (e.g., Sebastian et al. 2003). Hydroacoustic and trawl surveys will be conducted in pelagic areas. These data will be supplemented with gill net surveys in littoral areas of the reservoir where hydroacoustic and trawl surveys are not feasible.

The reliability of abundance estimates generated using hydroacoustic data depends on realistic estimates of habitat area by depth. Estimates of habitat area by depth are especially important for reservoir-based surveys when comparing results from different water levels and, therefore, habitat areas. Bathymetry maps of the reservoir area prior to flooding will be generated using LiDAR data collected by other components of the Site C Fisheries and Aquatic Habitat Monitoring Program coupled with bathymetric data collected during the hydroacoustic surveys in the reservoir. Costs associated with collecting LiDAR data are not covered by this Program, as these funds are accounted for under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Tissue samples will be collected from select Bull Trout, Burbot, Kokanee, Lake Trout, Mountain Whitefish, and Rainbow Trout. Processing of these samples will take place if required (i.e., requested by participants the annual or 5 year synthesis workshops). For planning purposes, up to 15 samples from at least 2 different size-classes will be collected for each species. Stomach content samples will be collected from select fish for analysis under the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6). Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Mon-6 budget; however, time associated with collecting these samples will be covered by Task 2a. For planning purposes, up to 45 samples will be collected each year during Operation Years 1 to 7, 16, and 18.

Task 2a may include collection of select fish for analysis under the Site C Long-term Mercury Monitoring Plan to be developed separately from the Site C Fisheries and Aquatic Habitat Monitoring Program in accordance with Environmental Assessment Condition #60 and the Federal Decision Statement Condition #13. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Site C Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by Task 2a. For planning purposes, up to 100 samples will be collected during each study year.

Additional sampling effort may be required in mitigated shallow water habitat areas of the reservoir and in unmitigated (i.e., control) areas of the reservoir. These data will be provided to the Site C Reservoir Constructed Shallow Water Habitat Areas Monitoring Program (Mon-16) for analysis and interpretation.

Task 2b. Site C Reservoir Summer Profundal Index Netting (SPIN) Survey. The purpose of the Site C Reservoir Summer Profundal Index Netting (SPIN) Survey is to determine the spatial distribution, abundance, size, age, and biomass of Lake Trout in Site C Reservoir. Based on the EIS, Bull Trout or Lake Trout are expected to be the primary pelagic piscivorous fish species in Site C Reservoir.

SPIN is designed specifically for quantitative sampling of Lake Trout populations (Sandstrom and Lester 2009; Hicks 1999; Giroux 2003 cited in Mills et al. 2008) and can be modified to target specific size-classes of fish (e.g., harvestable size) based on the sizes of gill nets employed. Task 2b will focus on Lake Trout larger than approximately 300 mm Fork Length to collect data necessary to test Hypothesis #2.

Methods employed during Task 2b will be based on those described by Sandstrom and Lester (2009), including methods described to reduce sampling mortality. The survey will be conducted in mid to late summer when water temperatures are highest.

Site selection in Task 2b will be based on bathymetry maps generated under Task 2a.

Select Lake Trout encountered during SPIN surveys will be implanted with telemetry tags. The movements of these fish within Site C Reservoir will be recorded by the Site C Acoustic Telemetry Array System (Task 2d of Mon-1b). These movement data will be analyzed under the current task with effort focused on determining potential spawning areas for this species within the reservoir.

Telemetry data will be used by several components of the Site C Fisheries and Aquatic Habitat Monitoring Program. Field crews conducting Task 2b may be required to implant telemetry tags into select target fish encountered during the survey. Telemetry tags, and the equipment required to implant them, will be provided by the program that requires the data from the deployed tag. Time associated with implanting the tags will be covered by Task 2b. For planning purposes, up to 30 tags can be deployed during each study year.

Tissue samples will be collected from select Bull Trout, Burbot, Kokanee, Lake Trout, Mountain Whitefish, and Rainbow Trout. Processing of these samples will take place if and when required by participants in the annual or 5 year synthesis workshops. For planning purposes, up to 15 samples from at least 2 different size-classes will be collected for each species.

Task 2b may include collection of select fish for analysis under the Site C Long-term Mercury Monitoring Plan. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Site C Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by Task 2b. For planning purposes, up to 100 samples will be collected during each study year.

Task 2c. Site C Reservoir Creel Survey. The purpose of the Site C Reservoir Creel Survey is to determine the use of the reservoir for recreational angling in comparison to pre-Project Peace River use. The survey will quantify the timing, duration, location of effort, gear type, and species caught in the reservoir to generate spatial and temporal estimates of recreational angling effort, catch (both retained and released), and harvest rates by species. If possible, First Nations catch and effort also will be estimated.

BC Hydro initiated a creel survey in 2008 with the aim of collecting data to be used as a baseline during future assessments (Robichaud et al. 2010). The creel survey monitored recreational use (particularly fishing activities) on the Peace and Pine rivers and on the lower portions of major Peace River tributaries from the outlet of Peace Canyon Dam downstream to the BC-Alberta border between May 2008 and October 2009. Task 2c will follow similar methodologies to those employed during the baseline creel survey (Robichaud et al. 2010) to ensure comparable results and a compatible long-term dataset; however, methods will be modified as needed to account for differences between riverine and reservoir systems.

Task 2c will be initiated after public access and use restrictions on the reservoir are lifted. For planning purposes, Task 2c commences in Operation Year 2.

From Operation Year 2 to Operation Year 30, cameras to monitor angling (i.e., van Poorten et al. 2015) will be installed and operated during ice-free periods at the Lynx and Cache Creek boat launch sites. Based on concurrent creel survey information, the time-lapse frequency and motion-sensing specifications of the cameras will be adjusted to optimize the information that can be derived from this method of monitoring angling pressure. Data collected from the cameras will be used to estimate angling pressure during non-creel study years.

The study area for Task 2c includes the Peace River from the outlet of Peace Canyon Dam downstream to the Site C dam site including the lower portions of major tributaries (most notably the Halfway and Moberly rivers).

Task 2c may include the collection of tissue samples from select fish from the creel for analysis under the Site C Long-term Mercury Monitoring Plan. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Site C Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by Task 2b. For planning purposes, up to 100 samples will be collected during each study year.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be

incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Analyses for Task 2a will include techniques similar to those employed by Bray et al. (2013), Sebastian and Johner (2011), and Sebastian et al. 2007(in Schlinder et al. 2007; Schlinder et al. 2010). These include estimates of biomass, abundance, and species diversity, which will be compared to the predictions presented in the EIS. Outputs will include standard life history summaries for key species (e.g., length-frequency, age-frequency, length-at-age frequency), and standard catch and effort summaries. Results will be compared to other major reservoir hydroacoustic surveys when appropriate. The key result of Task 2a will be an estimate of pelagic fish populations within Site C Reservoir in terms of population abundance, age, growth, and spatial distribution. Information collected under Task 2a also can be fed into management decision models that assess the density and size structure of Kokanee populations relative to optimal values for harvest fisheries and piscivore food demands.

Analyses for Task 2b will include techniques similar to those employed by Sandstrom and Lester (2009). These include estimates of Bull Trout and Lake Trout densities, biomass, abundance, and spatial distribution. Data collected during Task 2b will be compared to predictions presented in the EIS. Outputs will include standard life history summaries for Bull Trout and Lake Trout (e.g., length-frequency, age-frequency, length-at-age frequency, etc.) and standard catch and effort summaries. The key result of Task 2b will be an estimate of pelagic predatory fish populations within Site C Reservoir in terms of population abundance, age, growth, and spatial distribution.

Analyses for Task 2c will include techniques similar to those employed during baseline studies (Robichaud et al. 2010). These include estimates of angler timing, duration, location of effort, gear type, and species caught in the reservoir. Resulting data will be compared to baseline recreational angling data to evaluate changes in patterns of river/reservoir use by recreational anglers over time. Outputs will include standard life history summaries for each species (e.g., length-frequency, length-weight regression analysis, etc.), angling effort and catch rate estimates, and angler harvest rates. Results of Task 2c will be compared to baseline estimates (Robichaud et al. 2010) and results from other, similar systems (e.g., Arndt and Schwarz 2011).

The interpretation of results from Task 2a as well as other components of the Site C Fisheries and Aquatic Habitat Monitoring Program could be influenced by the degree of effort expended by the sport fishery, as indicated by Task 2c. Variable fishing effort and/or catch rates over time will indicate whether the sport fishery is a confounding variable in estimating population abundances. The significance of this confounding variable will depend on the total catch relative to the total population and any changes to sport fishing regulations that may be implemented to regulate angling harvest.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[16].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. . BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Reservoir Fish Community Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures. Task 7 will be conducted every 5 years to facilitate data and information

[16] Decision Statement, October 14, 2014, Section 18 Record Keeping.

sharing between this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on fish upstream of Site C, and to assess the effectiveness of fish and fish habitat mitigation measures.

To date, results from various BC Hydro WLR studies (BC Hydro 2007) suggest that while it is possible for projects to detect changes in various parameters, linking the reasons for observed changes to a single cause is difficult. As an example, results from BC Hydro's Peace River Fish Index Project (GMSMON-2) have suggested as much as a 2-fold increase in the abundance of Mountain Whitefish over a 1-year period (Mainstream and Gazey 2013). Linking an observed change in Mountain Whitefish abundance to the Project will be difficult when pre-project annual variability is high and likely influenced by variables outside of the influence of the Project (e.g., tributary spawning success). For these reasons, data and results from each survey within this Program (Tasks 2a to 2c) will be interpreted in conjunction with each other, through the exchange of information at annual workshops (Task 6), and through the synthesis review (Task 7). Similarly, overall results from this Program will be interpreted in conjunction with results from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program when drawing overall conclusions.

SCHEDULE

A tentative schedule for this Program is detailed below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop before the next year's field season. The synthesis review (Task 7) will be conducted every 5 years beginning in Operation Year 5.

Task 2a. ***Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey***. Task 2a will be conducted annually between Operation Years 1 and 10 and every two years beginning in Operation Year 12 until Operation Year 30. Field work will be conducted between early July and late September of each study year. Annual reports will be submitted during each study year.

Task 2b. ***Site C Reservoir Summer Profundal Index Netting (SPIN) Survey.*** Task 2b will be conducted during Operation Year 1 and every 5 years beginning in Operation Year 5. Field work will be conducted in August of each study year with annual reports due during each study year. Telemetry tags will be deployed into select Lake Trout encountered during the survey during Operation Years 10, 15, 20, and 25.

Task 2c. ***Site C Reservoir Creel Survey***. Task 2c will commence when reservoir public use and access restrictions are lifted and angling is permitted. For planning purposes, this is scheduled for Operation Year 2. Between Operation Years 2 and 30, Task 2c will be repeated every 5 years. During this time period, Task 2c will be synchronized with the Peace River Creel Survey described in the Peace River Fish Community Monitoring Program (Mon-2) to facilitate data sharing and to recognize cost savings. The Department of Fisheries and Oceans conducts the Survey of Recreational Fishing in Canada every 5 years, with the most recent survey conducted in 2010 (DFO 2012). Task 2c also will be synchronized with this survey to increase the utility of collected data. Field work for Task 2c will be conducted year-round during each study year.

REFERENCES

Arndt, S. and C. Schwarz. 2011. Trends in Angling and Piscivore Condition Following Eleven Years of Nutrient Additions in Arrow Lakes Reservoir (Arrow Lakes Creel Survey 2003-2009). Report prepared for Fish and Wildlife Compensation Program – Columbia Basin. Nelson, BC. 49 p. + appendices.

BC Hydro. 2007. Peace Project Water Use Plan. Revised for Acceptance by the Comptroller of Water Rights. August 2007. 17 p. + 3 app.

Bray, K., D. Sebastian, T. Weir, R. Pieters, S. Harris, D. Brandt, L. Vidmanic. 2013. Kinbasket and Revelstoke reservoirs ecological productivity and Kokanee population monitoring: 2008-2011 synthesis report. CLBMON-2 and CLBMON-3. Report prepared for BC Hydro, Generations, Water License Requirement. 105 p.

Department of Fisheries and Oceans (DFO), 2012. Survey of Recreational Fishing in Canada 2010. Economic Analysis and Statistics Strategic Policy. Resource Management Ecosystems and Fisheries Management. Fisheries and Oceans Canada. Ottawa, Ontario. Catalogue No. Fs42-1/2010E. ISBN 978-1-100-54196-9. DFO/2012-1804. 27 p.

Giroux, P.A. 2003. Assessment of Lake Trout (*Salvelinus namaycush*) stocks and an evaluation of netting and analysis techniques in Chapman, Augier, Pinkut, Taltapin and Doris lakes, BC. BC Min. of Water, Land and Air Protection, Fish & Wildlife Science & Allocation Section, Skeena Region, Smithers, BC. Skeena Report Sk-143.

Hicks, F. 1999. Manual of instructions spring Littoral Index Netting (SLIN). Ontario Min. of Natural Resources, Fish & Wildlife Branch, Peterborough Ont. MNR 51270, Queens Printer for Ontario.

Mainstream Aquatics Ltd. and W.J. Gazey Research. 2013. Peace River fish index project – 2012 studies. Prepared for B.C. Hydro. Report No. 12011: 84 p. + appendices

Mills, K.H., Dyck, M, and Harwood, LA. 2008. Proceedings of the second Lake Trout symposium 2005, Yellowknife, Northwest Territories. Can. Tech. Rep. Fish. Aquat. Sci. 2778: xi + 247 p.

Robichaud, D., M. Mathews, A. Blakley and R. Bocking. 2010. Peace River angling and recreational-use creel survey 2008-2009 Final Report. Prepared for BC Hydro, Vancouver, B.C. 69 p. + 8 appendices

Sandstrom, S. J. and N. Lester. 2009. Summer Profundal Index Netting Protocol; a Lake Trout Assessment Tool. Ontario Ministry of Natural Resources. Peterborough, Ontario. Version 2009.1. 22 p. + appendices.

Schindler, E.U., D. Sebastian, H. Andrusak, L. Vidmanic, S. Harris, G.F. Andrusak, F. Pick, L.M. Ley, P.B. Hamilton, D. Johner, P. Woodruff, M. Bassett, K.I. Ashley. 2010. Kootenay Lake nutrient restoration program, Year 16 (North Arm) and Year 4 (South Arm) 2007. Environmental Stewardship - Fish and Wildlife. Ministry of Environment. Province of British Columbia. Major Funding by Fish and Wildlife Compensation Program - Columbia Basin and Kootenai Tribe of Idaho. 268 p.

Schindler, E.U., L. Vidmanic, D. Sebastian, H. Andrusak, G. Scholten, P. Woodruff, J. Stockner, K. I. Ashley and G. F. Andrusak. 2007. Arrow Lakes Reservoir fertilization experiment, Years 6 and 7 (2004 and 2005) Report. Fisheries Project Report No. RD 121. 2007. Fish and Wildlife Science and Allocation. Ministry of

Environment. Province of British Columbia. Major Funding by Fish and Wildlife Compensation Program - Columbia Basin and Columbia Power Corporation. 342 p.

Sebastian, D.C., G.H. Scholten and P.E. Woodruff. 2003. Williston Reservoir fish assessment: Results of hydroacoustic, trawl and gill net surveys in August 2000. Peace/ Williston Fish and Wildlife Compensation Program Report No. 274. 34 p. + appendices.

Sebastian, D., H. Andrusak, G. Scholten, P. Woodruff. 2007. Response of Arrow Lakes Reservoir Kokanee to experimental fertilization, Years 6 and 7 (2004 and 2005). 47 p.

Sebastian, D., H. Andrusak, D. Johner, and G.F. Andrusak. 2010. Response of Kokanee to nutrient additions in the north arm of Kootenay Lake in 2007. 79 p.

Sebastian , D., and D. Johner. 2011. Kinbasket and Revelstoke Reservoirs Kokanee population monitoring. Progress report Year 3 (2010). Prepared for BC Hydro, Water License Requirements. Study No. CLBMON -2. 34 p.

Stables, T. B., and C. J. Perrin. 2012. Abundance and biomass of fish in Stave Reservoir in September 2011. Report prepared by Limnotek Research and Development Inc. and Shuksan Fisheries Consulting for BC Hydro. 17 p.

Van Poorten, B., T. Carruthers, H. Ward, and D. Varkeyvan. 2015. Imputing recreational angling effort from time-lapse cameras using an hierarchical Bayesian model. http://www.researchgate.net/publication /281480123. Fisheries Research 172 (2015) 265–273.

Appendix B

Mon-1b Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program

SITE C RESERVOIR TRIBUTARIES FISH COMMUNITY AND SPAWNING MONITORING PROGRAM

SUMMARY

ID	Site C Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program
Description	This program will monitor fish populations in the Peace River and Site C reservoir that migrate to tributaries to determine the effects of the Project and the effectiveness of mitigation measures for fish and fish habitat.
Key Project components / locations	Construction and Operation / Select Peace River tributaries between Peace Canyon Dam and the Many Islands area in Alberta
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-2 – Peace River Fish Community Monitoring Program
Schedule	Annually through Construction Years 2 to 9 and Operation Years 1 to 30

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, regulatory agencies, and stakeholders. Section 12.1.2 of the Site C Environmental Impact Statement (EIS) states that the Site C Clean Energy project (the Project), including Project construction, reservoir filling, and operation, could impact fish and fish habitat via three key categories of effects: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement[3].

Sections 12.4.2.1 and 12.4.2.2 of the EIS makes several predictions regarding changes in the fish community upstream and downstream of the Site C dam site, respectively. Predictions upstream and downstream of Site C are summarized in the Site C Reservoir Fish Community Monitoring Program (Mon-1a) and Peace River Fish Community Monitoring Program (Mon-2), respectively. Some species spend portions of their lifecycles in Peace River tributaries and migrate past the Site C location to fulfill their life history requirements; most notably, these include Arctic Grayling and Bull Trout.

The Site C Reservoir Tributaries Fish Community Monitoring Program (this Program) generally focuses on the abundance of select species that inhabit Peace River tributaries for portions of their life cycle. This Program comprises multiple tasks during both Construction Years 2 to 9 and Operation Years 1 to 30. This program is most closely linked to the Site C Reservoir Fish Community Monitoring Program (Mon-1a) and the Peace River Fish Community Monitoring Program (Mon-2) and will provide key supporting information on fish community composition and demographic parameters to these programs. Similarly, information from other monitoring programs will assist interpreting results of this Program.

FISHERIES MANAGEMENT QUESTIONS

The overarching relevance for this Program reflects that the construction and operation of the Project will affect fish and fish habitat in different ways. Hence, the focus of this Program is guided by the following fisheries management question (management question):

1. How does the Project affect Peace River fish species that use Site C Reservoir tributaries to fulfill portions of their life history over the short (10 years after Project operations begin) and long (30 years after Project operations begin) terms?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring fish biomass, species distribution, community composition, and population structure within the reservoir, and assessing whether any changes observed in these metrics are related to the construction or operation of the Project. For fish biomass, the 'Most Likely' estimate was used as the reference point to compare observations against. The more detailed hypotheses presented below are framed using specific EIS predictions.

Several different life history patterns occur for Bull Trout in the Peace River watershed. As an example, during certain seasons, tributaries of the Halfway River contain both resident Bull Trout and migratory individuals from

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Section 12.1.2, pp. 2-3

the Peace River mainstem. A key uncertainty identified in the EIS[4] relates to the movement of Bull Trout past the Project. Currently, an estimated 34% of all Bull Trout that exit the Halfway River migrate downstream past the Site C dam site[5]. The EIS identifies two potential scenarios that may influence the movements of Bull Trout after the construction of the Project. For Scenario 1, a high abundance of prey fish within Site C Reservoir (most notably Kokanee and Lake Whitefish) will encourage Bull Trout to remain in the reservoir, thereby reducing the number of Bull Trout moving downstream past the Project. Under this scenario, the EIS predicts as little as 5% of the Bull Trout population will migrate past the Project when compared to current estimates[4]. For Scenario 2, factors such as competition with other piscivorous fish species in Site C Reservoir may result in more Bull Trout moving downstream past the Project. Under this scenario, the EIS predicts as much as 34% of the Bull Trout population will migrate past the Project (EIS, Volume 2, Appendix Q3)[4]. Under the latter scenario, the number of spawning Bull Trout in the Halfway River is expected to decline by approximately 20 to 30% when compared to current estimates[4].

H_1: The percentage of subadult Bull Trout that move from the Halfway River downstream past the Project will remain the same as baseline estimates (34% of the population that exits the Halfway River).

H_2: Bull Trout spawner abundance in the Halfway River will decline by 20 to 30% relative to baseline estimates.

Information on subadult Bull Trout moving downstream past the Project and spawner abundance in the Halfway River, in combination information from other programs, will guide management actions for Bull Trout.

The Environmental Assessment identified uncertainties in the response of other fish species that migrate from Site C Reservoir and the Peace River to Site C Reservoir tributaries. These species include Rainbow Trout, Arctic Grayling, and Kokanee.

H_3: Rainbow Trout from Site C Reservoir will continue to spawn and rear in Maurice and Lynx creeks upstream of the Site C Reservoir inundation zone.

Key uncertainties identified for Arctic Grayling include their ability to overwinter in the Moberly River, reproduce in the Peace River downstream of the Project, and the response of downstream migrants from the Moberly River to the reservoir habitat[4]. Based on these uncertainties, hypotheses for Arctic Grayling are the following:

H_4: A self-sustained population of Arctic Grayling will remain in the Moberly River.

H_5: Arctic Grayling from the Moberly River will not move to Site C Reservoir.

H_6: Arctic Grayling from the Moberly River will not be present in the Peace River downstream of the Project.

In the context of these three hypotheses for Arctic Grayling, movement to the reservoir (H_5) acts as diagnostic information to inform observations of abundance in the Moberly River (H_4) and Peace River downstream of the Project (H_6).

Kokanee are predicted to be the primary pelagic fish species in Site C Reservoir[6]. One of the key uncertainties for Kokanee abundance in the reservoir is related to a source of recruitment. Although the main source of Kokanee recruitment is expected to be through entrainment from Williston Reservoir, several tributaries between Peace Canyon Dam and the Project are potential sources of natural recruitment.

[4] EIS, Volume 2, Appendix Q3.
[5] EIS, Volume 2, Appendix Q3, 25 pp.
[6] EIS, Volume 2, Appendix P3.

H_7: Kokanee will spawn in one or more of the following tributaries: Farrell, Lynx, and Maurice creeks, and the Halfway and Moberly rivers.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish movement and abundance in Site C Reservoir tributaries, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[7] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[8]) and the Federal Decision Statement[9].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of the Program is to understand the response of the fish community, test EIS predictions, and address uncertainties identified in the EIS regarding the effects of the construction and operation of the Project on fish and assess the effectiveness of fish and fish habitat mitigation measures within the Peace River. This information will inform management decisions.

The spatial scope of the Program includes major Site C Reservoir tributaries, most notably the Halfway and Moberly rivers, and Farrell, Lynx, and Maurice creeks. Movements of telemetry tagged fish (Tasks 2a and 2d) will be monitored throughout the Peace River watershed, including the above mentioned tributaries, Site C Reservoir, the Peace River downstream of the Project to the Many Islands area in Alberta, and major tributaries downstream of the Project (i.e., the Beatton and Pine rivers). The broad spatial scope of these two tasks accommodates the extended movement ranges of migratory fish species that use Site C Reservoir tributaries to fulfill portions of their lifecycles. As an example, AMEC and LGL (2008c) noted Bull Trout migrating approximately 450 km between the Pine (downstream of Site C) and Halfway (upstream of Site C) rivers. The spatial extent of the Program is consistent with the spatial boundaries for the effects assessment[10], which was guided by physical modelling[11], fisheries studies[12].

The temporal scope of the Program includes Construction Years 2 to 9 and Operation Years 1 to 30; however, not all tasks (see below) occur during each study year.

APPROACH

The Program builds on general sampling approaches developed for baseline studies that characterized fish populations in Peace River tributaries and on which the EIS effects assessment was based. The Peace River fish community that uses Site C Reservoir tributaries will be monitored using a variety of techniques. Data collected during Construction Years 2 to 9 and Operation Years 1 to 30, coupled with existing baseline data will allow the Program to address the Project's management questions.

Where practical, data from other components of BC Hydro's Site C Fisheries and Aquatic Habitat Monitoring Program will be collected from the same locations sampled under the Program to maximize the utility of the data

[7] EIS, Volume 2, Section 12
[8] EAC, Condition #7, Pages 8 to 9
[9] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat
[10] EIS Volume 2 Section 12.1.5
[11] EIS Volume 2, Appendix P2
[12] EIS Volume 2, Appendix O

for analyses across different ecological components (e.g., fish relative abundance vs. fish food abundance). In addition, data will be spatially and methodologically consistent with data collected during baseline studies and WLR studies when feasible.

TASKS

The Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a - Peace River Arctic Grayling and Bull Trout Movement Assessment
    - Task 2b - Peace River Bull Trout Spawning Assessment
    - Task 2c - Site C Reservoir Tributaries Fish Population Indexing Survey
    - Task 2d - Site C Acoustic Telemetry Array System
- Task 3 – Data Analysis
    - Task 3a - Peace River Arctic Grayling and Bull Trout Movement Assessment
    - Task 3b - Peace River Bull Trout Spawning Assessment
    - Task 3c - Site C Reservoir Tributaries Fish Population Indexing Survey
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 1.

Table 1: Overview of field work to be conducted under the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Plan.

Task	Task Name	Performance Measures	Survey Method	Expected Schedule	
				Construction Years 1 to 9	Operation Years 1 to 30
2a	Peace River Arctic Grayling and Bull Trout Movement Assessment	Bull Trout and Arctic Grayling movement through tributaries, Site C Reservoir, and the Peace River downstream of the Project	Radio and acoustic telemetry; Small fish boat electroshocking; microchemistry sampling; microchemistry	Years 5 to 8[a] (River Diversion)	Years 1 to 4; Every 5 years from Years 10 to 30 in 2 year blocks[a]
2b	Peace River Bull Trout Spawning Assessment	Bull Trout spawner abundance	Spawner and redd counts; fish counters (resistivity with cameras); PIT tag detection array	Annually beginning in Year 2 (August and September)	Annually (August and September)

2c	Site C Reservoir Tributaries Fish Population Indexing Survey	Rainbow Trout abundance	Abundance estimates in Maurice and Lynx creeks using a combination of the following: backpack electrofishing, beach seining, hoop netting, box traps	Annually during the fall season starting in Year 2	Years 1 to 5; Every 5 years from Years 10 to 30
		Arctic Grayling abundance	Abundance in the Moberly River using a combination of the following: boat electroshocking, backpack electrofishing, beach seining, hoop netting, box traps	Annually during the fall season starting in Year 2	Years 1 to 5; Every 5 years from Years 10 to 30
		Kokanee spawning	Aerial spawner counts in Farrell, Maurice, and Lynx creeks and the Halfway and Moberly rivers.	n/a	Years 1 to 5; Every 5 years from Years 10 to 30
2d	Site C Acoustic Telemetry Array System	n/a	Acoustic telemetry	Years 5 to 9 during the open water season	Years 1 to 4; Every 5 years from Years 10 to 30 in 2 year blocks

[a] Tags will be deployed in the first and third year of each 4-year assessment block and will be monitored for a 2 year period.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Some tasks under this Program may be requested to collect select fish for analysis under the Site C Long-term Mercury Monitoring Plan to be developed separately from the Site C Fisheries and Aquatic Habitat Monitoring Program in accordance with Environmental Assessment Condition #60 and the Federal Decision Statement Condition #13. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples will be covered under the Site C Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by task that collects the sample. For planning purposes, up to 100 samples can be collected by Tasks 2a to 2c during each study year.

Task 2a. Peace River Arctic Grayling and Bull Trout Movement Assessment.

Purpose: The purpose of the Peace River Arctic Grayling and Bull Trout Movement Assessment is to determine the magnitude, direction, and seasonality of Arctic Grayling and Bull Trout movements within the Peace River, Site C Reservoir, and associated tributaries to help determine the effect the Project may have on these metrics, and to inform various monitoring plans.

Design: Baseline telemetry studies in the Peace River and its tributaries (AMEC & LGL 2008a, 2008b, 2008c, 2009) examined the movements of large-bodied fish. Due to the similarities in objectives between these studies and Task 2a, the study design for Task 2a will be modeled after the former. However, the study design has been

modified to take into account changes to the physical conditions in the study area due to the Project and to accommodate the objectives of other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Telemetry tags employed by Task 2a will be detectible by both acoustic and radio telemetry receivers, such as Lotek Fish & Wildlife Monitoring Systems' R-CART telemetry system (http://www.lotek.com/cart-series-combined-acoustic-radio-tags.htm). Employing Combined Acoustic/Radio Transmitters (CART) will allow fish to be monitored in deep water areas, such as Site C Reservoir, using acoustic technology, and in shallow water areas, such as spawning tributaries, using radio technology. Using both forms of telemetry technology will allow the program to collect data to address the objectives of different monitoring programs at the same time, providing substantial efficiencies (e.g., fewer tags, receivers, surveys, etc.), and reducing the number of fish that need to be captured and implanted with tags.

Fish captured from a variety of locations and over multiple seasons will be implanted with telemetry tags to meet the objectives. Additional information on fish capture for tagging is described in the subsections below.

The temporal design occurs in two year time periods, based on an assumed tag life of approximately two years. Ideally, all telemetry tagged fish will be monitored over two year time periods within each 4 year assessment block. As an example, tags deployed in Construction Year 5 will be monitored in Construction Years 5 and 6 and tags deployed in Construction Year 7 will be monitored in Construction Years 7 and 8.

Telemetry tagged fish will be monitored continuously throughout Site C Reservoir and the Peace River between the Project and the Many Islands area in Alberta by the Site C Acoustic Telemetry Array System (see Task 2d). In addition to this continuous monitoring, ground- or air-based telemetry surveys also will be conducted during key migratory periods for Arctic Grayling and Bull Trout to monitor fish located in tributaries upstream of the range of the Site C Acoustic Telemetry Array System (i.e., the Halfway and Moberly Rivers upstream of the reservoir inundation zone). The ground or air-based telemetry surveys are tentatively scheduled from May to June to monitor Arctic Graying movements and from August to September to monitoring Bull Trout movements as these are the expected migratory periods for these species (AMEC and LGL 2010). However, the timing and duration of these surveys may be altered if results from the Site C Acoustic Telemetry Array System suggest earlier, later, or extended migratory periods for these species.

While information regarding the movements of Arctic Grayling and Bull Trout throughout the study area will be collected, effort will focus on key areas of interest. These areas include (1) Arctic Grayling and Bull Trout movements between tributaries (most notably the Halfway and Moberly rivers) and Site C Reservoir, including tributary embayment areas (i.e., area of tributaries inundated by the reservoir); and (2) Arctic Grayling and Bull Trout movements past the dam site before, during, and after Project construction. Monitoring upstream and downstream movements in these areas correspond to the management hypotheses listed above and will inform management decisions.

Capture of Adult Arctic Grayling: Based on data collected by AMEC and LGL (2008c), most Arctic Grayling present in the Peace River mainstem likely originate from the Moberly River; therefore, all telemetry tags for this movement assessment will be implanted into Arctic Grayling captured in the Moberly River between its confluence and Moberly Lake. Angling is expected to be the primary capture technique. Telemetry tags also will be implanted into Arctic Grayling captured in the Moberly River under Task 2c (see below) if suitable sizes are encountered; however, capture techniques employed by Task 2c generally target smaller individuals (Mainstream 2013). The movements of immature Arctic Grayling will not be monitored under this assessment as the dual-mode tags used by the Site C Acoustic Telemetry Array System (Task 2d) are expected to be too large to implant into immature Arctic Grayling.

Capture of Adult Bull Trout: Due to multiple life history patterns for Bull Trout in the Peace River, these fish will be captured and implanted with telemetry tags from a variety of locations and over multiple seasons. Telemetry tags

will be implanted into Bull Trout captured under the following components of the Site C Fisheries and Aquatic Habitat Monitoring Program:

1. Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b);
    a. Task 2b - Peace River Bull Trout Spawning Assessment;
2. Peace River Fish Community Monitoring Program (Mon-2);
    a. Task 2a - Peace River Large Fish Indexing Survey;
3. Site C Fishway Effectiveness Monitoring Program (Mon-13); and
4. Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

Sample methods, locations, and sample periods for each of the components identified above are described in their respective programs. For planning, costs associated with purchasing telemetry tags and equipment needed to implant them are included under this Program; costs associated with implanting these tags are covered under the programs identified above.

Capture of Immature Bull Trout: The above components of the Site C Fisheries and Aquatic Habitat Monitoring Program generally target larger size-classes of fish. To facilitate monitoring immature Bull Trout, these fish will be captured and tagged using small-fish boat electroshocking in the Halfway River (i.e., prior to these fish migrating out of their natal streams and into the Peace River mainstem). Captured immature Bull Trout will be will be implanted with Passive Integrated Transponder (PIT) tags to provide data on the proportion of Bull Trout that exit the Halfway River and the proportion of Bull Trout that are entrained through the Project. The small-fish boat electroshocking survey will be conducted in July to avoid electroshocking Bull Trout eggs deposited during the previous fall while avoiding adult Bull Trout migrating into the river to spawn. Select immature Bull Trout also will be implanted with telemetry tags to monitor their movements with the Site C Acoustic Telemetry Array System (Task 2d) and during the ground- and air-based telemetry surveys detailed above.

Genetic analysis may be used to characterize the contribution of the Pine River Bull Trout population to the Peace River Bull Trout population; therefore, genetic samples will be collected from select immature Bull Trout encountered during small-fish boat electroshocking surveys. These genetic samples will be catalogued and stored for potential future analysis. For planning purposes, up to 30 genetic samples will be collected under this task during each study year.

Microchemistry: Task 2a includes a microchemistry analysis component designed to investigate the origins of Arctic Grayling and Bull Trout encountered under the various components of the Site C Fisheries and Aquatic Habitat Monitoring Program. Methods will be similar to those employed during Site C baseline studies (Earthtone and Mainstream 2013). Microchemistry will be used to estimate the proportion of each species that were spawned and reared upstream versus downstream of the Project. To ensure the long-term viability of each species, microchemistry analysis will be limited to fin ray samples; however, otoliths will be opportunistically collected from individuals that succumb to sampling. Water samples will be collected in the Peace River and all major tributaries known to have Arctic Grayling and Bull Trout populations. In addition to Task 2a, Arctic Grayling and Bull Trout fin rays also will be collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. Samples collected under these various programs will be provided to Task 2a for analysis and interpretation. For budgeting purposes, microchemistry analyses will be conducted on up to 40 samples during each study year.

Task 2b. Peace River Bull Trout Spawning Assessment. The purpose of the Bull Trout Spawning Assessment is to assess the distribution, and abundance of Bull Trout spawning in known spawning locations in the Halfway River watershed on an annual basis. In addition, information on the relative body size of spawning Bull Trout will be collected in order to determine the abundance of larger spawner that are expected to be migratory, relative to the smaller spawners that are expected to be resident in the Halfway River watershed.

A portion of the Bull Trout population is known to travel upstream and downstream through the Site C location when migrating to and from the Halfway River for spawning purposes (AMEC & LGL 2008a, 2008b, 2008c, 2009). Accurate Bull Trout spawner and redd abundance data will information the evaluating the effectiveness of proposed mitigation measures for moving Bull Trout past the Project.

Task 2b will follow the study designs during baseline sampling (Diversified and Mainstream 2009, 2011; and Euchner 2002), which used a combination of aerial surveys in conjunction with snorkel surveys to monitor Bull Trout spawning in the Halfway River watershed. Collecting these data using consistent methods will ensure data continuity.

To supplement the aerial survey approach, a PIT tag detection array systems paired with fish counters (e.g., resistivity counter and cameras) will be employed following the design used on other river systems (e.g., McCubbing et al. 1999, 2012; McCubbing 2010). These data are expected to provide independent estimates of spawn timing, duration, and spawner abundance, relative to those generated using the aerial and snorkel surveys, as well as provide additional data on the movement patterns of Bull Trout in the Halfway River watershed to supplement Task 2a. In addition, resistivity counters can provide information on fish size.

The PIT tag detection array and resistivity fish counter systems with cameras will be installed in select Halfway River tributaries to monitor Peace River Bull Trout migrating upstream to spawn and to monitor post-spawned and subadult Bull Trout migrating downstream to the Halfway River or Site C Reservoir. Four separate systems are expected to be installed each year downstream of known spawning areas, including Needham Creek, the Chowade River, Cypress Creek, and the upper Halfway River. Pilot testing will confirm feasibility at these systems.

Data collected under Task 2b also will provide post-project data necessary to revise the Bull Trout population model generated as part of the EIS[13]; however, the model will not be updated under this Program. Results of the revised model will be coupled with information garnered under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program to design appropriate passage mitigation strategies.

Task 2b includes a survey using angling techniques in known Bull Trout spawning areas during the Bull Trout spawning season during select study years. The objective of this survey is to capture adult Bull Trout to implant them with telemetry and PIT tags for monitoring under the Task 2a (see above). The movements of these fish will not be monitoring under Task 2b; however, capturing and tagging these fish on behalf of Task 2a while they are in spawning tributaries ensures that this Bull Trout life history pattern is adequately monitored and consistent with methods employed by the Ministry of Environment (Burrow et al. 2001 as cited in AMEC and LGL 2010).

Task 2c. Site C Reservoir Tributaries Fish Population Indexing Survey. The purpose of the Site C Reservoir Tributaries Fish Population Indexing Survey is to monitor tributary fish populations' responses to the Project.

BC Hydro implemented the Baseline Peace River Tributaries Fish Use Assessment in 2008 (Mainstream 2009) and the Moberly and Halfway Rivers Fish Inventory in 2009 (Mainstream 2011) to obtain additional information on fish use and habitat characteristics in some Peace River tributaries. The two programs used a variety of sampling techniques (i.e., boat electroshocking, backpack electrofishing, beach seining, hoop netting, box traps, and kick nets [for egg surveys]) to gather baseline data on the abundance and distribution of fish in Maurice, Lynx, Farrell, Cache, and Wilder creeks, and in the Halfway and Moberly rivers. Task 2c will closely follow the study designs employed during the above two surveys (Mainstream 2009, 2011). However, Task 2c will be modified from baseline study designs to provide absolute measures of fish abundance and distribution (e.g., through depletion-removal or mark-recapture surveys) in representative index sections.

[13] EIS, Volume 2, Appendix Q3.

The spatial scope of Task 2c is limited to representative index sites in tributaries identified as being potential or important sources of recruitment for Peace River fish populations (Mainstream 2012). These include Maurice and Lynx creeks for Rainbow Trout, the Moberly River for Arctic Grayling, and Maurice, Lynx, and Farrell creeks and the Moberly and Halfway rivers for Kokanee (Table 2). To maintain consistency with baseline data (Mainstream 2009), sampling in Maurice and Lynx creeks will be limited to the first approximately 2 km lengths of each creek located immediately upstream of the Peace River. Sampling for Arctic Grayling in the Moberly River will extend from the Peace River or Site C Reservoir, depending of the study year, upstream to Moberly Lake, as Mainstream (2012) indicated that Arctic Grayling use much of the Moberly River and may contribute to reservoir recruitment.

Maurice, Lynx, and Farrell creeks will be monitored for spawning Kokanee using the ground count methodology described by Andrusak and Sebastian (p, 187-189 *in* Andrusak et al. 2000). The Moberly and Halfway rivers will be surveyed by aircraft. If there is a significant discrepancy between Kokanee spawn monitoring data and the results of the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey (Mon-1a, Task 2a), then Kokanee spawning monitoring will be expanded to additional drainages using aerial surveys to guide deployment of additional sampling effort or to more quantitative sampling methods (e.g., fish fences, mortality surveys) if required.

Table 2: Proposed spatial scope of the Site C Reservoir Tributaries Fish Population Indexing Survey (Task 2c) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b).

Species	Monitored Tributaries
Rainbow Trout	Maurice Creek, Lynx Creek
Arctic Grayling	Moberly River
Kokanee[1]	Maurice, Lynx, and Farrell creeks, and the Moberly and Halfway rivers.

[1] Kokanee monitoring will be limited to aerial spawning surveys.

Sampling for Task 2c will be conducted during the fall season only. Conducting surveys in the fall will allow comparisons to data collected by Mainstream (2009, 2011), providing a longer time series of data. In addition, sampling during the fall may allow field crews to capture spring-spawned age-0 fish, providing indices of recruitment for both Arctic Grayling and Rainbow Trout. All Arctic Grayling, Bull Trout, and Rainbow Trout encountered under Task 2c will be implanted with PIT tags.

Task 2c may be requested to collect genetic samples from select fish for analysis under the Site C Small Fish Translocation Monitoring Program (Mon-15). Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Site C Small Fish Translocation Monitoring Program budget; however, time associated with collecting these samples will be covered by Task 2c. For budgeting purposes, up to 100 samples will be collected during each study year.

Task 2d. Site C Acoustic Telemetry Array System. Several components of the Site C Fisheries and Aquatic Habitat Monitoring Program employ the use of telemetry to monitor the movements of fish in the Peace River between Peace Canyon Dam and the Many Islands area in Alberta and in various Peace River tributaries. Task 2d consists of a network of acoustic telemetry receivers positioned at key locations throughout the Site C Local Assessment Area (LAA) that will monitor the movements of all acoustic telemetry tags deployed under the Site C Fisheries and Aquatic Habitat Monitoring Program. Task 2d is designed to address the acoustic telemetry data needs of all components of the Site C Fisheries and Aquatic Habitat Monitoring Program at the same time. This will allow data to be collected consistently (e.g., all monitoring programs will use the same telemetry manufacturer, ensuring compatibility between programs) and efficiently (e.g., all movement data will be stored in the same database, reducing data querying time). Using a single acoustic array system also will reduce the total number of transmitter (i.e., tags) that need to be deployed (e.g., one telemetry-tagged fish can meet the needs of more than one program), reducing impacts to fish associated with capturing, handling, and surgically implanting transmitters. A

summary of the telemetry requirements of each of the above programs by location within the study area is provided in Table 3.

Table 3: Summary of telemetry requirements by species and location for each component of the Site C Fisheries and Aquatic Habitat Monitoring Program.

	Species							Location							Deployed by				
Site C Monitoring Program	Arctic Grayling	Bull Trout	Burbot	Kokanee	Mountain Whitefish	Rainbow Trout	Walleye	Site C Reservoir Tributaries	Inundated Arms of Tributaries	Site C Reservoir	Site C Headpond	Site C Tailrace	Peace River	Peace River Tributaries	Mon-1a	Mon-1b	Mon-2	Mon-13	Mon-14
Mon-1b Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program	x	x						x	x	x	x	x	x	x	x	x	x		x
Mon-10 Site C Entrainment Monitoring Program	x	x	x	x	x	x					x	x						x	x
Mon-11 Site C TDG Monitoring Program	x	x	x	x	x	x						x	x	x	x			x	x
Mon-13 Site C Fishway Effectiveness Monitoring Program	x	x	x	x	x	x						x	x			x	x	x	
Mon-14 Site C Trap and Haul Fish Release Location Monitoring Program	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x

All transmitters deployed under the Site C Fisheries and Aquatic Habitat Monitoring Program will be compatible with receivers deployed under Task 2d. Transmitters also will be capable of both radio and acoustic transmission (e.g., Lotek Wireless Inc.'s CART [Combined Acoustic/Radio Transmitter] series) except when small fish sizes prevent the application of dual mode transmitters. Using dual mode transmitters will allow the movements of fish to be monitored in both deep water (such as Site C Reservoir and the mainstem Peace River) and shallow water (such as spawning tributaries) environments. Additionally, the Site C TDG Monitoring Program (Mon-11) requires depths of habitats used by fish downstream of the Project; therefore, select transmitters will be capable of monitoring fish depths. For each of the monitoring programs transmitters will be deployed by field crews encountering target fish species. This will reduce the number of fish sampled (target and non-target for tagging) in order to meet the tagging requirements by eliminating the need for dedicated capture programs just to deploy transmitters. Components of the Site C Fisheries and Aquatic Habitat Monitoring Program that will be responsible for deploying transmitters are detailed in Table 3.

Task 2d is expected to employ acoustic telemetry receivers comparable to the VEMCO VR2W receivers used by BC Hydro to monitor the movements of White Sturgeon in the Columbia River downstream of Revelstoke Dam (Golder and ONA 2013) and downstream of Hugh L. Keenleyside Dam (BC Hydro 2013) . Telemetry receivers will be positioned at key locations throughout the Site C LAA (Figure 1). For most locations, receivers can be deployed using methods similar to Golder and ONA (2013) and BC Hydro (2013). Briefly, the receiver is attached to a length of heavy-duty rope or stainless steel cable and suspended from a buoy approximately 1 m below the surface of the water and oriented so that the receiver's transducer is pointed towards the bottom of the river. A secondary line extends from the buoy to an anchor that holds the receiver in place. At some locations, it may be necessary to have a second line that attaches the system to shore as a secondary anchor point or to provide an additional means of recovering the receiver if the float or float line fails. Additional security (e.g., protective housings) may be required in areas where safety or vandalism are concerns. Telemetry receivers will be deployed in pairs to allow for the calculation of detection efficiencies (when needed) or direction of movement (when needed). In deep water areas, such as in the Site C Reservoir forebay, receivers should be deployed in a vertical array such that one receiver is located on the bottom of the reservoir positioned so that its transducer is facing towards the surface of the water and one receiver is located near the surface positioned so that its transducer is facing towards the

bottom of the reservoir. Receivers located on the bottom should be installed into a holding system similar to the one presented in Plate 1 to ensure the proper orientation of the receiver.

Effort will be made to reduce loss and damage to receivers due to ice formation. Most receivers will be removed each year prior to ice formation (mid-December[14,15]) and redeployed as soon as possible each spring (early April[14,15]). Receivers situated in the Site C Reservoir forebay and tailrace areas will remain deployed year-round, when possible, to monitor entrainment rates of telemetry tagged Arctic Grayling, Bull Trout, Burbot, and Mountain Whitefish. All transmitters deployed under the Site C Fisheries and Aquatic Habitat Monitoring Program will be preprogrammed to turn off during winter months to conserve battery power and extend the life of the transmitter unless movement data are over the winter are specifically required for a particular species (i.e., Arctic Grayling, Bull Trout, Burbot, and Mountain Whitefish). A general description of the location and quantities of receivers that will be deployed is provided below.

Maurice, Lynx, and Farrell creeks are known spawning locations for Rainbow Trout; therefore, receivers will be deployed in the Peace River approximately 500 m upstream and downstream of each of these confluences to monitor the movements of adult Rainbow Trout in these areas (i.e., 6 receivers in total). These data will be used by this Program (Mon 1b) and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

Information on the movements of fish, particularly Arctic Grayling and Bull Trout, within the lower reaches of the Halfway and Moberly rivers are required by this program, the Site C Reservoir Fish Community Monitoring Program (Mon-1a), the Peace River Fish Community Monitoring Program (Mon-2; prior to river diversion only), and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14). These movements are required during the river diversion phase of construction (i.e., when these areas are still riverine) and operation (i.e., when these areas are inundated). Receivers will be deployed upstream and downstream of each of these confluences to monitor fish movements into the tributaries or inundated areas (depending on study year). Two additional receivers will be deployed approximately 4 and 5 km upstream of their confluences to monitor fish movements within the inundated areas of these tributaries. Two more receivers will be deployed at the upstream ends of each of the inundated tributaries to monitor fish movements between riverine and lacustrine habitats. During construction years, low water levels may limit the effectiveness of acoustic telemetry in these areas. If conditions are unsuitable, these receivers will be removed. Overall, up to six receivers will monitor each of these tributaries (i.e., 12 receivers in total).

The movements of tagged fish in the mainstem upstream of the Project during the river diversion phase of construction and during operation will be monitored using six additional receivers. Two receivers will be deployed near Wilder Creek to monitor movements in the lower portion of the reservoir (during Construction Years 5 to 9, these receivers also will monitor movements upstream and downstream of the Site C Construction Headpond). Two receivers will be deployed near Cache Creek (i.e., upstream of the Construction Headpond) to monitor movements between the Site C Construction Headpond and the Halfway River confluence. Two receivers will be deployed between the Halfway River confluence and the Farrell Creek confluence to monitor fish movements in the Peace River between the Halfway River and Farrell Creek. The general movements of fish within Site C Reservoir will be used by this program, the Site C Reservoir Fish Community Monitoring Program (Mon-1a), the Peace River Fish Community Monitoring Program (Mon-2; during construction years), the Site C Fish Entrainment Monitoring Program (Mon-10), the Site C TDG Monitoring Program (Mon-11), and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

Four receivers will monitor fish movements in the Site C forebay. These receivers will be position to monitor the intake to the diversion tunnels during Construction Years 5 to 9 and positioned to monitor the at the upstream

[14] EIS, Volume 2, Appendix G
[15] EIS, Volume 2, Appendix H

extent of the approach channel during operation years. These data will be used by this program, the Site C Fish Entrainment Monitoring Program (Mon-10), and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

Four receivers will monitor fish movements in Site C Tailrace. These receivers will be position to monitor the fish as they approach the temporary (during construction) and permanent (during operation) fishways and to monitor the movements of fish entrained through the diversion tunnels (during construction), and spillway and generating station (during operation). These data will be used by this program, the Site C Fish Entrainment Monitoring Program (Mon-10), the Site C TDG Monitoring Program (Mon 11), the Site C Fishway Effectiveness Monitoring Program (Mon-13), and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon 14).

Downstream of Site C, the movements of fish within the Pine and Beatton rivers will be monitored. Two receivers will be deployed in each tributary approximately 1 and 2 km upstream from their confluences (i.e., 4 receivers in total). During low flow periods, water levels may be too low in these tributaries to allow adequate acoustic coverage. If conditions are unsuitable, these receivers will be removed. Fish movement data in these tributaries will be used by this program and the Peace River Fish Community Monitoring Program (Mon-2).

The Kiskatinaw and Pouce Coupe rivers contain Walleye populations that may support the Peace River Walleye population; therefore, receivers will be deployed in the Peace River approximately 500 m upstream and downstream of each of these confluences to monitor the movements of adult Walleye in these areas (i.e., 4 receivers in total). These data will be used by the Peace River Fish Community Monitoring Program (Mon-2).

The movements of fish in the Peace River mainstem downstream of the Project will be monitored by eight receivers spread equally between the Project and the Many Islands area in Alberta. This equates to a single receiver approximately every 15 km over a 120 km length of the Peace River. These data will be used by this program, the Peace River Fish Community Monitoring Program (Mon-2), and the Site C TDG Monitoring Program (Mon 11).

Overall, 48 acoustic telemetry receivers are expected to be deployed through the Site C LAA. During deployment, the detection efficiency and range of coverage of each receiver will be assessed and relocated if required. Similarly, receivers will be reassessed if data indicate reduced detection efficiencies relative to other receivers.

All receivers will be downloaded once per month during the open water season. More frequent downloads may be required for some locations for components of the Site C Fisheries and Aquatic Habitat Monitoring Program that require more immediate results. These include the Site C Fish Entrainment Monitoring Program (Mon-10), the Site C TDG Monitoring Program (Mon 11), the Site C Fishway Effectiveness Monitoring Program (Mon-13), and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon 14) during certain times of the year.

All data will be stored in a central database (termed the Site C Acoustic Telemetry Array System Database) developed under this task and be made available remotely to all components of the Site C Fisheries and Aquatic Habitat Monitoring Program. The database will include customizable, user-friendly queries and report that meet the needs of each user. Due to the individual data needs of each component of the Site C Fisheries and Aquatic Habitat Monitoring Program, data will be cleaned and validated by the program that requires the data after the data are queried out of the Site C Acoustic Telemetry Array System Database. The Site C Acoustic Telemetry Array System will be responsible for an initial cleaning of the telemetry data (e.g., removing noise detections); however, detailed QA/QC of the data will be the responsibility of the task that requires the data.

Some components of the Site C Fisheries and Aquatic Habitat Monitoring Program will require movement data in areas that will not be covered by the Site C Acoustic Telemetry Array System (e.g., Task 2a). Monitoring fish movements in these areas (e.g., the Halfway and Moberly rivers upstream of their inundated reaches) will be the

responsibility of the component that requires the data (e.g., Task 2a Peace River Arctic Grayling and Bull Trout Movement Assessment). The Site C Acoustic Telemetry Array System will only monitor fish movements in areas where acoustic telemetry is feasible.

The Site C Fish Entrainment Monitoring Program (Mon 10), the Site C TDG Monitoring Program (Mon-11), and the Site C Fishway Effectiveness Monitoring Program (Mon-13) require more precise movements of fish around the Project (i.e., headpond and tailrace area). Due to acoustic noise associated with the Project, acoustic telemetry may not be a viable option for these areas and radio telemetry may be required. If radio telemetry is required by these programs, it will be the responsibility of the program that requires the data. The Site C Acoustic Telemetry Array System will only monitor fish movements in areas where acoustic telemetry is feasible.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2d are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results. Data analysis will not be required under Task 2d (Site C Acoustic Telemetry Array System). These data will be analyzed under the task or monitoring program that requires the data.

Results from Task 2a will quantify the movements of Arctic Grayling and Bull Trout moving between Peace River tributaries, Site C Reservoir, and downstream of the Project. Analyses will include techniques employed by AMEC & LGL (2008a, 2008b, 2008c, 2009), including summarizing the magnitude, direction, and seasonal variability of movements of tagged fish, with a focus on their movements in the inundated portions of the Moberly and Halfway rivers, movements around and through the dam site, and movements into tributaries. Data will be compared, where appropriate, to data collected by AMEC & LGL (2008a, 2088b, 2008c, 2009) and to predictions presented in the EIS regarding the movements of these species throughout the study area. Information gathered under Task 2a will inform on the design of fish transport plans for the Fish Passage Management Plan.

Analyses for Task 2b will include techniques employed during baseline sampling (Mainstream and Diversified 2009, 2011; Euchner 2002), including (but not be limited to) Bull Trout spawner and redd data summaries (e.g., summarizing spawning, abundance, timing and distribution) and a relative index of Bull Trout spawner abundance and spawn timing. A relative index of subadult Bull Trout abundance and migration timing into Site C Reservoir also will be generated if possible using data collected by the PIT tag detection array systems and resistivity fish counters. Data also will be compared, where appropriate, to historical data (Mainstream and Diversified 2009, 2011; Euchner 2002) and to predictions presented in the EIS regarding Bull Trout spawner abundance. Analyses for Task 2b will be supplemented with Bull Trout movement data collected under Task 2a as needed.

Analyses for Task 2c will include techniques employed by Mainstream (2009, 2011), including percent composition, catch per unit effort, relative abundance estimates, absolute abundance estimates (for common species), length and age distribution, and age-cohort analyses by habitat type for common fish species. Analyses will focus on indices of spawning success for Rainbow Trout (in Maurice and Lynx creeks), Arctic Grayling (in the Moberly River), and Kokanee if there is evidence that this species spawn in these tributaries.

The interpretation of results from Tasks 2a to 2c could be influenced by the degree of effort expended by the sport fishery in Site C Reservoir, as indicated by the Site C Reservoir Creel Survey results (Task 2c) of the Site C Reservoir Fish Community Monitoring Program (Mon-1a). Variable fishing effort and/or catch rates over time will indicate that the sport fishery is a confounding variable in interpreting tributary fish population data. However, the significance of this confounding variable will depend on the extent of the total angler harvest relative to the total population.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[16].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also

[16] Decision Statement, October 14, 2014, Section 18 Record Keeping.

include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

Task 7 will be conducted every 5 years to facilitate data and information sharing between this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of the Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on Peace River fish that employ the use of Site C Reservoir tributaries to fulfill their life histories and to assess the effectiveness of fish and fish habitat mitigation measures.

To date, results from various BC Hydro WLR studies (BC Hydro 2007) suggest that while it is possible for projects to detect changes in various parameters, linking the reasons for observed changes to a single cause is difficult. For this reason, data and results from each task within the Program (Tasks 2a to 2c) will be interpreted in conjunction with each other, through the exchange of information at annual workshops (Task 6), and through the synthesis review (Task 7). Similarly, overall results from the Program will be interpreted in conjunction with results from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program when drawing overall conclusions.

SCHEDULE

A reference schedule for the Program is detailed below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop before the next year's field season. The synthesis review (Task 7) will be conducted every 5 years beginning in Operation Year 5.

Task 2a. Peace River Arctic Grayling and Bull Trout Movement Assessment. Task 2a will be conducted annually between Construction Years 5 and 8 and Operation Years 1 to 4, and in 2 year blocks every 5 years beginning in Operation Year 5 until Operation Year 30. Aerial telemetry surveys will be conducted weekly in May, June, August, and September. Angling surveys for Arctic Grayling will be conducted during tag deployment years. These include Construction Years 5 and 7 and Operation Years 1, 3, 10, 15, 20, and 25. Small-fish boat electroshocking surveys

will be conducted in July of Construction Years 5 and 7 and Operation Years 1, 3, 10, 15, 20, and 25, coinciding with tag deployment years. Annual reports will be submitted during each study year.

Task 2b. Peace River Bull Trout Spawning Assessment. Task 2b will be conducted annually between Constructions Years 2 to 9 and Operation Years 1 and 30. Aerial-based and snorkel-based redd and spawner surveys will be conducted once per week for approximately eight weeks during the Bull Trout spawning season within the Halfway River watershed. Angling surveys for Bull Trout would be conducted during tag deployment years of Task 2a. These include Construction Years 5 and 7 and Operation Years 1, 3, 10, 15, 20, and 25. PIT tag detection array and resistivity fish counter systems will be installed from early August to late September during Construction and Operation Years 1 to 30. While operational, these systems will be monitored weekly. Annual reports will be submitted during each study year.

Task 2c. Site C Reservoir Tributaries Fish Population Indexing Survey. Task 2c will be conducted annually during Construction Years 2 to 9, Operation Years 1 to 5, and every 5 years beginning in Operation Year 10 until Operation Year 30. Field work for Task 2c will be conducted during the fall season. Kokanee spawning surveys will be conducted annually during Operation Years 1 to 5 and every 5 years during Operation Years 10 to 30. Annual reports will be submitted during each study year.

Task 2d. Site C Acoustic Telemetry Array System. Field work for the Site C Acoustic Telemetry Array System will be conducted during the open water season of Construction Years 5 to 9 and Operation Years 1 to 5, 10 to 11, 15 to 16, 20 to 21, 25 to 26, and 29 to 30. The array will be downloaded monthly or as needed by other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. For budgeting purposes, eight downloads per year are assumed.

REFERENCES

AMEC Earth & Environmental and LGL Limited (AMEC & LGL). 2008a. Peace River Fish and Aquatic Investigations, 2005. Peace River and Tributary Summer Fish Distribution, Habitat Assessment and Radio Telemetry Studies 2005. A report prepared for BC Hydro, Vancouver, BC.

AMEC Earth and Environmental and LGL Limited (AMEC & LGL). 2008b. Peace River Fisheries Investigations, 2006. Peace River Tributary Spring Spawning Migration, Tributary Summer Juvenile Rearing and Radio Telemetry Studies 2006. A report prepared for BC Hydro, Vancouver, BC.

AMEC Earth & Environmental and LGL Limited (AMEC & LGL). 2008c. Peace River Fisheries Investigation, 2007. Peace River and Pine River Radio Telemetry Study 2007. A report prepared for BC Hydro, Vancouver, BC.

AMEC Earth & Environmental and LGL Limited (AMEC & LGL). 2009. Peace River Fisheries Investigation. Peace River and Pine River Radio Telemetry Study 2008. A report prepared for BC Hydro, Vancouver, BC.

AMEC Earth & Environmental and LGL Limited 2010a. Peace River Fisheries Investigation - Peace River and Pine River Radio Telemetry Study 2009. Prepared for BC Hydro. 135 p. + appendices

Andrusak, H. and D. Sebastian. 2000. Okanagan Lake Kokanee Biology. Okanagan Lake Action Plan. Chapter 2. Page 183 – 236.

Andrusak, H., D. Sebastian, I. McGregor, S. Matthews, D. Smith, K. Ashley, S. Pollard, G. Scholten, J. Stockner, P. Ward, R. Kirk, D. Lasenby, J. Webster, J. Whall, G. Wilson, H. Yassien. 2000. Okanagan Lake Action Plan Year 4 (1999) Report. Fisheries Project Report No. RD 83. Fisheries Management Branch, Ministry of Agriculture, Food and Fisheries, Province of British Columbia.

BC Hydro. 2007. Peace Project Water Use Plan. Revised for Acceptance by the Comptroller of Water Rights. August 2007. 17 p. + 3 app.

BC Hydro 2013. Columbia River Project Water Use Plan - Lower Columbia River - CLBMON #28 - Lower Columbia River Adult White Sturgeon Monitoring Program: 2009 & 2010 Investigations Data Report. Prepared by BC Hydro Water License Requirements Castlegar, BC. 59 pages.

Burrows, J., T. Euchner, and N. Baccante. 2001. Bull trout movement patterns: Halfway River and Peace River progress. Bull Trout II Conference Proceedings. 153-157.

Diversified Environmental Services and Mainstream Aquatics Ltd. (Diversified and Mainstream). 2011. Upper Halfway River Watershed Bull Trout Spawning Survey 2010. Prepared for BC Hydro. Report No. 10016.

Diversified Environmental Services and Mainstream Aquatics Ltd. (Diversified and Mainstream). 2009. Upper Halfway River Watershed Bull Trout Spawning Survey 2008. Prepared for BC Hydro. Report No. 08008.

Earthtone Environmental R&D and Mainstream Aquatics Ltd. 2013. Site C Fisheries Studies 2012 Elemental Signature Study - Final Report. Prepared for B.C. Hydro Site C Project, Corporate Affairs Report No. 12007F: 163 p. + appendices.

Euchner, T. 2002. Chowade River bull trout aerial and ground redd counts, distribution and density, snorkel survey data summary. Prepared for Ministry of Water, Land and Air Protection, Fort St. John, B.C.

Golder Associates Ltd. and Okanagan Nation Alliance 2013. Middle Columbia River juvenile White Sturgeon monitoring: 2012 investigations. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12-1492-0053: 42 p. + 2 app.

Mainstream Aquatics Ltd. 2009. Site C fisheries studies – Baseline Peace River tributaries fish use assessments in spring and fall 2008. Prepared for B.C. Hydro. Report No. 08008BF: 64 p. + Appendices

Mainstream Aquatics Ltd. 2011. Site C fisheries studies – 2010 Peace River Fish Inventory. Prepared for B.C. Hydro Site C Project, Corporate Affairs Report No. 10005F: 102 p. + plates and appendices.

Mainstream Aquatics Ltd. 2012. Site C Clean Energy Project – Fish and Fish Habitat Technical Data Report. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 12002F: 239 p.

Mainstream Aquatics Ltd. 2013. Site C Fisheries Studies – 2011 Moberly River and Halfway River Summer Fish Inventory. Report No. 11006F: 51 p. + appendices.

McCubbing D.J. 2010. Fish counter enumeration of Steelhead and Rainbow Trout on the Bonaparte River in 2010. Prepared for the Ministry of Forests, Lands and Natural Resource Operations, Fish & Wildlife Branch, Kamloops, BC. By InStream Fisheries Research Inc. 27 p.

McCubbing D.J., B. Ward, and L. Burroughs. 1999. Salmonid escapement enumeration on the Keogh River: a demonstration of a resistivity counter in British Columbia. Fisheries Technical Circular No. 104. 2000. 20 p. + 2 appendices.

McCubbing, D.J., et al. 2012. Cheakamus River Chum Salmon Escapement Monitoring and Mainstem Spawning Groundwater Survey 5 Year Program Review 2007-2011. By InStream Fisheries Research Inc.

Robichaud, D., M. Mathews, A. Blakley and R. Bocking. 2009. Peace River Angling and Recreational-Use Creel Survey 2008-2009. Final Report. Report for BC Hydro.

Wateroffice. 2014. Government of Canada. Real-Time Hydrometric Data for Moberly River near Fort St. John (Station Number 07FB008). Downloaded from http://wateroffice.ec.gc.ca/report/report_e.html?type=realTime&stn= 07FA006 on 12 January 2015.

FRAME 1

Hudson's Hope

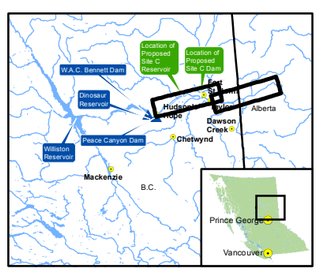
Fort St. John

Taylor

Hudson's Hope

Peace River

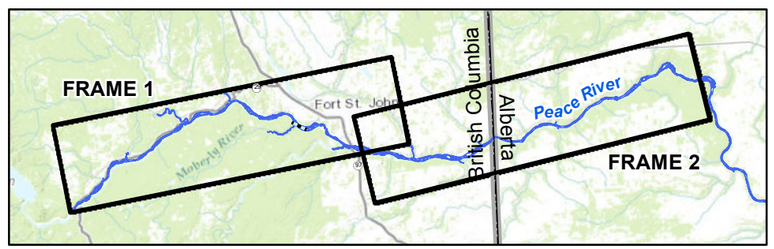
Many Islands Area



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Imagery: Copyright © 20090927 Esri and its licensors. Source:DigitalGlobe WV01. Used under license, all rights reserved.
3. Water features: CanVec © Department of Natural Resources Canada. All rights reserved.
4. Transportation features: CanVec © Department of Natural Resources Canada. All rights reserved.
5. Topographic base: Esri, NRCAN, GeoBase, and the GIS User Community.

Legend

- Site C Project
- Approximate Acoustic Range of Receiver
- Highway
- Local
- Resource/Recreation
- Provincial Border



1:250,000

0 8,000 Meters

SITE C CLEAN ENERGY PROJECT

BC hydro

Golder Associates

Figure 1
Proposed receiver locations for the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b)

Date	Dec. 15, 2015	DWG NO	1016-C14-B5178	R a

Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification.

Y:\burnaby\CAD-GIS\Bur-Graphics\Projects\2013\1492\13-1492-0066\GIS\Mapping\MXD\Fish\Aquatic_Study_Area\1016_C14_B5178_Aoustic_Telemetey_Array.mxd

Appendix C

Mon-2 Peace River Fish Community Monitoring Program

PEACE RIVER FISH COMMUNITY MONITORING PROGRAM

SUMMARY

ID	Site C Mon-2 – Peace River Fish Community Monitoring Program
Description	This program will monitor fish population in the Peace River to determine effects of the Project and the effectiveness of mitigation measures for fish and fish habitat.
Key Project components / locations	Construction and Operation / Peace River between Site C and the Many Islands area in Alberta
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program
Schedule	Annually through Construction Years 1 to 9 and Operation Years 1 to 30

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] is a valued component of the Peace River that is considered important by BC Hydro, Aboriginal groups, the public, the scientific community, and government agencies. The Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement (Site C Environmental Impact Statement [EIS] Section 12.1.2). In the Peace River, physical fish habitat may be lost by the construction of permanent physical infrastructure. The Project also may change the physical, chemical, or biological characteristics of habitat. Fish health and survival may be affected through direct mortality (e.g., entrainment mortality), or through changes to systems productivity, food resource type or abundance, or other environmental conditions on which fish depend (e.g., water temperature). Fish movement will be hindered at the dam site.

The EIS makes both qualitative[3] and quantitative[4] predictions of fish production[5] in the Peace River downstream of the Project. These predictions and conclusions can be tested at various levels of aggregation (i.e., individual fish species, groups of fish species, harvestable fish species[6], and all fish species) and at various spatial and temporal scales.

FISHERIES MANAGEMENT QUESTIONS

The overarching fisheries management question (management question) for the Peace River Fish Community Monitoring Program (this Program) reflects that the construction and operation of the Project can affect fish in different ways:

1. How does the Project affect fish in the Peace River between the Project and the Many Islands area in Alberta during the short (10 years after Project operations begin) and longer (30 years after Project operations begin) term?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring fish abundance and biomass, species distribution, community composition, and population structure, and assessing whether any changes observed in these metrics are related to the construction or operation of the Project. For biomass, the 'Most Likely' biomass estimate was used as the reference point to compare observations against. The more detailed hypotheses presented below are framed using specific EIS predictions.

The EIS presents an ecosystem model that makes specific predictions of fish biomass in Site C Reservoir. These predictions take into account changes to primary and secondary productivity, and physical, chemical, and geomorphic processes as a result of Site C construction and operations (Figure 1).

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 12.4.2.2, p. 48
[4] EIS, Volume 2, Section 12.4.2.2, p. 47
[5] Summarized in EIS, Volume 2, Section 12.4.2.2 and Section 12.6
[6] Harvestable fish species include Arctic Grayling, Bull Trout, Burbot, Kokanee, Lake Trout, Lake Whitefish, Mountain Whitefish, Northern Pike, Rainbow Trout, and Walleye. Total fish biomass includes all harvestable fish species as well as Northern Pikeminnow, suckers, and small fish species.

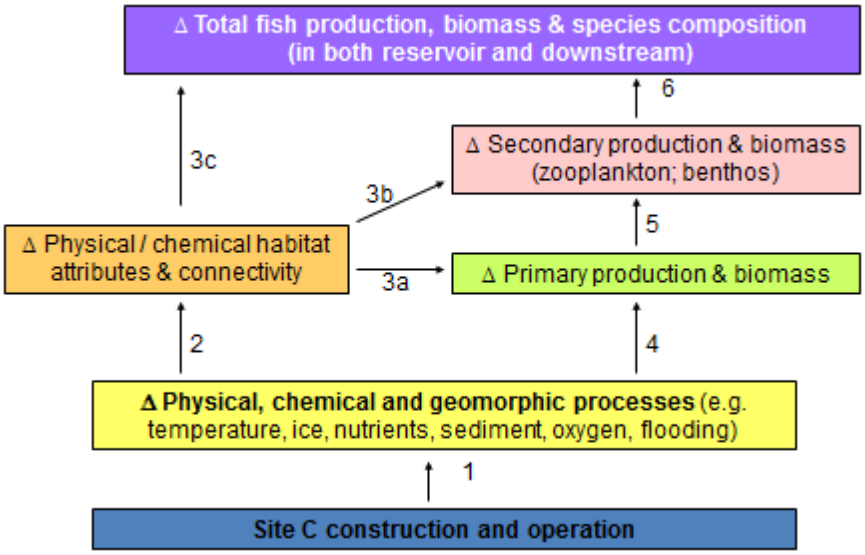


Figure 1: Conceptual model of impact pathways used to develop the EIS ecosystem model[7].

Fish biomass predictions are grouped into total fish biomass, harvestable fish biomass, and species-specific fish biomass predictions. Values for the predictions are shown in Table 1.

[7] EIS, Volume 2, Appendix P3, 3 p.

Table 1: Short and longer term predictions of fish biomass (t) for pre- and post-Project conditions for the Peace River from the Project to Many Islands area, AB. Fish biomass is presented for the "Most Likely" scenario (plus a minimum to maximum range).

			SHORT TERM (IN 10 YRS)			LONGER TERM (> 30 YRS)		
Group	Species Name	Current (Pre-Project) biomass (river) (t)	Post-project biomass (Peace River Downstream of Site C Dam) (t)			Post-project biomass (Peace River Downstream of Site C Dam) (t)		
			Most Likely	Range (min - max)		Most Likely	Range (min - max)	
1	Walleye	3.38	1.69	0.34	- 1.69	1.69	0.34	- 1.69
1	Lake Trout	0	0	0	- 0.01	0	0	- 0.01
1	Rainbow Trout	0.17	0.35	0.17	- 0.35	0.35	0.17	- 0.35
1	Northern Pike	0.74	0.37	0.37	- 0.74	0.37	0.37	- 0.74
1	Burbot	0.1	0.05	0.01	- 0.05	0.05	0.01	- 0.05
	Group 1 Subtotal	4.39	2.46	0.89	2.83	2.46	0.89	2.83
2	Bull Trout	1.49	1.23	1.23	- 2.54	1.23	1.23	- 2.54
2	Arctic Grayling	0.64	0.32	0.06	- 0.64	0.32	0.06	- 0.64
2	Mountain Whitefish	7.38	14.74	14.74	- 14.74	14.74	14.74	- 14.74
	Group 2 Subtotal	9.5	16.29	16.03	17.91	16.29	16.03	17.91
3	Kokanee	0.03	0.01	0	- 0.02	0.03	0.01	- 0.04
3	Lake Whitefish	0	0.01	0	- 0.01	0	0	- 0.01
	Group 3 Subtotal	0.03	0.02	0.01	0.03	0.03	0.01	0.04
	Total Harvestable Fish Biomass	13.93	18.77	16.94	- 20.78	18.78	16.94	- 20.79
4	Suckers	21.74	10.87	10.87	- 10.87	10.87	10.87	- 10.87
4	Small Fish	0.87	0.7	0.43	- 0.87	0.7	0.43	- 0.87
4	Northern Pikeminnow	0.87	0.44	0.26	- 0.52	0.44	0.26	- 0.52
	Group 4 Subtotal	23.49	12.01	11.57	12.27	12.01	11.57	12.27
	Total Fish Biomass	37.42	30.78	28.5	- 33.05	30.79	28.5	- 33.06

Where,

H_1: Post-Project total fish biomass in the Peace River between the Project and the Many Islands area in Alberta will be less than pre-Project conditions (current = 37.42t; at 10 years of operations = 30.78 t; >30 years of operations = 30.79 t).

H_2: Post-Project harvestable fish biomass in the Peace River between the Project and the Many Islands area in Alberta will be greater than pre-Project estimates of harvestable fish biomass (current = 13.93t; at 10 years of operations = 18.77 t; >30 years of operations = 18.78 t).

For harvestable fish biomass (H_2), three fish species (Bull Trout, Mountain Whitefish, and Walleye) represent 88% of the current estimated harvestable fish biomass and are expected to represent 94% of the predicted total harvestable fish biomass over both the short and long term time periods. For total biomass (H_1), suckers (all species combined) will be added to biomass estimates generated to test H_2. These four species combined represent 91% of the current estimated total fish biomass and are expected to represent 93% of the predicted post-Project total biomass for both short and longer-term.

H_3: Post-Project biomass of each fish species in the Peace River between the Project and the Many Islands area in Alberta will be consistent with biomass estimates in the EIS (see Table 1).

H_4: Changes in post-Project fish community composition in the Peace River between the Project and the Many Islands area in Alberta will be consistent with EIS predictions.

Local provincial management objectives include a sustainable use objective to optimize recreational angling opportunities (BC Ministry of Environment 2009). Information from angler creel surveys can provide information on this high-level objective as well as information on fish harvest rates that can inform analysis of changes in the fish community.

H_5: The fish community can support angling effort that is similar to baseline conditions.

Baseline angling effort is summarized in the EIS[8].

Precise estimates of angler effort from creel surveys are challenging to obtain with multi-species fisheries over large areas. Changes in angler behavior and other angling opportunities in the region can also affect trends in angling effort. As a result, information from creel surveys is expected to provide supporting information to be interpreted in the context of other information on the fish community, and general information angling effort.

Another component of this Program is the monitoring of proposed habitat offsets. Monitoring of fish use in these offset areas will be guided by the following hypothesis:

H_6: Indicator fish species will use the Site C offset habitat areas in the Peace River between the Project and the Many Islands area in Alberta for rearing, feeding, and/or spawning as shown in Table 2.

Table 2: Expected fish use of the proposed offsetting locations in the Peace River between the Project and the Many Islands area in Alberta.

	Species				
Location	Arctic Grayling	Bull Trout	Mountain Whitefish	Rainbow Trout	Walleye
River Road Rock Spurs	R[a], F	F	R, F	R, F	
Upper Site 109L	R	F	R, F, S	R, F	F
Side Channel Site 108R	R, F		R, F	R, F	
Lower Site 109L	R	F	R, F, S	R, F	F

[a] R = rearing; F = feeding; and S = habitat suitable for spawning.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish abundance and distribution in the Peace River, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[9] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[10]) and the Federal Decision Statement[11].

MONITORING PROGRAM PROPOSAL

[8] EIS, Volume 3, Section 24.
[9] EIS, Volume 2, Section 12
[10] EAC, Condition #7, Pages 8 to 9
[11] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

OBJECTIVE AND SCOPE

The Program will collect information on all fish species with a focus on monitoring Arctic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Rainbow Trout, and Walleye populations. These species are listed in local provincial management objectives (BC Ministry of Environment 2009, BC Government 2011), identified as species that are of interest to anglers and harvested by Aboriginal groups, and were a focus in the effects assessment. The program will also collect supporting information on fish community composition and demographic parameters.

The objective of the Program is to validate predictions and address uncertainties identified in the EIS regarding the Project's effects on fish in the Peace River and to assess the effectiveness of fish and fish habitat mitigation measures.

The spatial scope of the Program is limited to the portion of the Peace River situated between the Project and the Many Islands area in Alberta. The spatial extent of the Program is consistent with the spatial boundaries for the effects assessment[12], which was guided by physical modelling[13], fisheries studies[14].

The temporal scope of the Program includes Construction Years 1 to 9 and Operation Years 1 to 30; however, not all tasks (see below) occur during each study year.

APPROACH

The Program builds on methods employed during baseline studies (summarized in the EIS[14]) and existing Water License Requirements (WLR) studies (e.g., Mainstream and Gazey 2013) that characterized fish populations in the Peace River and on which the effects assessment was based. The Peace River fish community downstream of the Project will be monitored using a variety of techniques. Data collected during Construction Years 1 to 9 and Operation Years 1 to 30, coupled with existing baseline data will allow the Program to address the Project's management questions.

The monitoring programs have been designed such that, where practical, data will be collected from the same locations sampled under the Program to maximize the utility of the data for analyses across different ecological components (e.g., fish relative abundance vs. fish food abundance). In addition, data will be spatially and methodologically consistent with data collected during baseline studies when feasible.

TASKS

The Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Peace River Large Fish Indexing Survey
    - Task 2b – Peace River Fish Composition and Abundance Survey
    - Task 2c – Peace River Creel Survey
    - Task 2d – Offset Effectiveness Monitoring Program
- Task 3 – Data Analysis
    - Task 3a – Peace River Large Fish Indexing Survey
    - Task 3b – Peace River Fish Composition and Abundance Survey

[12] EIS Volume 2 Section 12.1.5
[13] EIS Volume 2, Appendix P2
[14] EIS Volume 2, Appendix O

    - Task 3c – Peace River Creel Survey
    - Task 3d – Offset Effectiveness Monitoring
    - Task 2e. Arctic Grayling Status Assessment (Halfway and Beatton Rivers)
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 3.

Table 3: Overview of field work to be conducted under the Peace River Fish Community Monitoring Program.

Task Number	Task Description	Method(s) / Technology	Species Covered	Performance Measure(s)	Schedule Construction (Years 1 - 9)	Schedule Operations (Years 1 - 30)
T2a	Peace River Large Fish Indexing Survey	Fish counts using boat electroshocking and implanting telemetry and PIT tags into target species and sizes	Adult life stages of all fish species	Biomass, abundance, and standard life history summaries for each species and species diversity.	Annually	Annually
T2b	Peace River Fish Composition and Abundance Survey	Fish counts using a combination of large and small boat electroshocking, backpack electrofishing, gill netting, and beach seining and implanting telemetry and PIT tags into target species and sizes	All available fish species and life stages, but will specifically target small-bodied fish and the younger age-classes of large-bodied fish	Biomass, abundance, and standard life history summaries for each species and species diversity.	Construction Years 6 and 7	Operation Year 1 and every 5 years beginning in Operation Year 5
T2c	Peace River Creel Survey	Creel Survey and cameras at select boat launches	Harvestable fish species	Recreational angler effort and catch (both retained and released), and harvest rates by species.	Construction Year 6	Every 5 years between Operations Years 2 and 30.
T2d	Offset Effectiveness Monitoring	Fish counts using a combination of large and small boat electroshocking, backpack electrofishing, gill netting, minnow trapping, beach seining, and snorkel surveys	All available fish species and life stages	Catch-per-unit-effort, percent composition, and standard life history summaries for each species.	Construction Years 3 to 5.	
T2e	Arctic Grayling Status Assessment (Halfway and Beatton Rivers)	Backpack electrofishing	Arctic Grayling	Size and age	TBD	TBD

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Some tasks under this Program may be requested to collect select fish for analysis under the Site C Long-term Mercury Monitoring Plan to be developed separately from the Site C Fisheries and Aquatic Habitat Monitoring Program in accordance with Environmental Assessment Condition #60 and the Federal Decision Statement Condition #13. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples will be covered under the Site C Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by task that collects the sample. For planning purposes, up to 100 samples can be collected by Tasks 2a to 2c during each study year.

Task 2a. Peace River Large Fish Indexing Survey. The purpose of the Peace River Large Fish Indexing Survey (Indexing Survey) is to monitor the response of large-bodied fish species[15] in the Peace River to the Project.

BC Hydro's WLR Peace River Fish Index (GMSMON-2), or its predecessor the Peace River Fish Community Indexing Program, has been conducted annually in the Peace River since 2001 (Mainstream and Gazey 2014). Mainstream (2012) delineated the Peace River between Peace Canyon Dam and the Many Islands area in Alberta into 9 different sections. GMSMON-2 includes boat electroshocking-based mark-recapture studies in Sections 1, 3, and 5 of the Peace River and is designed to monitor Arctic Grayling, Bull Trout, and Mountain Whitefish populations by collecting time series data on the abundance, spatial distribution, and biological characteristics of these species.

The Indexing survey will employ a study design consistent with GMSMON-2 to provide a continuous long-term dataset for Sections 1, 3, and 5 of the Peace River. The Indexing survey also will include sampling in Sections 6, 7, and 9 (Mainstream 2012) to provide a dataset that is more coordinated with the objectives of the Program. Sections 6, 7, and 9 were studied under BC Hydro's Peace River Fish Inventory (Mainstream 2010, 2011, 2013a).

Sections 1 and 3 of the Peace River are located upstream of the dam site and will be sampled only during Construction Years 1 to 8. These sections will monitor potential effects of construction including headponding, particularly during the diversion phase of construction (Construction Years 5 to 8).

BC Hydro has proposed habitat offsets as a means of improving fish habitat downstream of the Project to help offset the Project's effects on fish. Established sites (Mainstream and Gazey 2014) situated within these offset areas may need to be relocated or subdivided to ensure data continuity and integrity. In addition, sample sites will be required in offset areas to monitor the effectiveness of these offsets over time. These sites are described under the task Offset Effectiveness Monitoring (Task 2d).

The Indexing Survey will focus on Arctic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Rainbow Trout, and Walleye (BC Government 2011); however, the adult life stages of all large-bodied fish encountered during the Indexing Survey will be analyzed. All captured large-bodied fish greater than 200 mm Fork Length (FL) will be implanted with Passive Integrated Transponder (PIT) tags to monitor future encounters under the Site C Fisheries and Aquatic Habitat Monitoring Program.

[15] EIS, Volume 2, Section 12.3.2.2

Field work for the Indexing Survey is scheduled for the late summer to early fall period (i.e., mid-August to late September). Sampling will be conducted during this time period for several reasons, including ensuring compatibility with historical datasets (Mainstream and Gazey 2014), increasing sampling efficiency by sampling when turbidity is low, and reducing potential sampling effects to Bull Trout by sampling when spawning Bull Trout are not present in the Peace River mainstem (i.e., when they are spawning in select tributaries). Based on data collected by Mainstream (2013a), the mid-August to late September time period proposed for the Indexing Survey field work may occur after most Goldeye and Walleye migrate downstream out of the study area. If catch data from Construction Years 2 and 3 suggest that the mid-August to late September time period will not yield sufficient data to monitor the Peace River Goldeye and Walleye populations (i.e., if less than 20 Goldeye or Walleye are captured during either study year), an additional field program will be implemented beginning in Construction Year 4 that focuses on these species. This contingent assessment will consist of boat electroshocking in the spring (i.e., mid-May to early June) near the confluences of major Peace River tributaries in Sections 7 and 8 (Mainstream 2012) as data indicate high Goldeye and Walleye catch-rates surrounding most tributary confluences in these sections during the spring season (Mainstream 2013).

Due to large number of fish expected to be recorded under the Indexing Survey and the task's large spatial scope, select fish encountered during the task will be provided to other components of the Site C Fisheries and Aquatic Habitat Monitoring Program as needed.

Telemetry tags: Ideally, personnel from the Indexing Survey will be qualified to implant telemetry tags directly for efficiency reasons. Implanting telemetry tags as part of the Indexing Survey supports a substantial cost savings, reduces fish capture and handling times, and may reduce the number of separate provincial fish collection permits required. Telemetry tags, and the equipment required to implant tags, will be provided by the program that requires the data from the deployed tag. Time associated with implanting the tags will be covered by the Indexing Survey. For planning purposes, up to 45 tags can be deployed during each study year.

Stomach content samples: Stomach contents will be collected from select fish for analysis under the Peace River Fish Food Organisms Monitoring Program (Mon-7). Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples will be covered under the Mon-7 budget; however, time associated with collecting these samples will be covered by the Indexing Survey. For planning purposes, up to 90 samples will be collected during both Construction Years 2 and 3 and up to 45 samples will be collected each year during Operation Years 3 to 7 and 15 to 19.

Gas Bubble Disease: Site C has the potential to cause Gas Bubble Disease (GBD) in fish downstream of the Project due to the generation Total Dissolved Gas (TDG) levels related to Project operations. All fish captured as part of the Program will be visually assessed for evidence of GBD, including bubbles in skin tissue (most notably in fins), hemorrhaging, and exophthalmia (bulging eyes). These data will be provided to the Site C TDG Monitoring Program (Mon-11) for interpretation and analysis. The average and maximum sample depths recorded at each site also will be provided with these data.

External Health: Mainstream (2013a) monitored the external health of fish captured by boat electroshocking in the Peace River using a DELT Index (Ohio EPA 1996 cited in Bauman et al. 2000). The DELT Index provides a means of monitoring the frequency and severity of body deformities, tissue erosion, lesions, tumors, cuts, and electroshocking-related damage in fish. The external health of all fish recorded during the Indexing Survey will be monitored using similar methods.

Microchemistry: Under the Indexing Survey, microchemistry will be used to investigate the origins of a subsample of encountered Goldeye and Walleye and to estimate the proportions of each population that were spawned and reared in the study area relative to downstream areas (i.e., downstream of the Many Islands area in Alberta). Methods will be similar to those employed during Site C baseline studies (Earth Tone and Mainstream 2013).

Water samples will be collected from the Peace River and from major tributaries within and downstream of the study area.

Genetics: Under the Indexing Survey, genetic analysis may be used to characterize the contribution of the Pine River Bull Trout population to the Peace River Bull Trout population. Genetic samples will be collected from select Bull Trout, catalogued, and stored for potential future analysis. For planning purposes, up to 30 genetic samples will be collected under this task during each study year.

Task 2b. Peace River Fish Composition and Abundance Survey. The purpose of the Peace River Fish Composition and Abundance Survey is to collect information targeted at small-bodied fish and younger age-classes of large-bodied fish. This information will provide more specific information on recruitment and conditions for early rearing. Data from Task 2b will be used to interpret results from the Indexing Survey and provide a linkage between the Indexing Survey and the Peace River Fish Food Organisms Monitoring Program (Mon-7).

BC Hydro's Peace River Fish Inventory collected baseline information on the fish community in the Peace River from Peace Canyon Dam downstream to the Many Islands area in Alberta (Mainstream 2010, 2011, 2013a). Fish were sampled using several different fish capture techniques in a variety of habitats.

Task 2b will employ field methods and analytical techniques comparable to the Peace River Fish Inventory. Fish collection methods include large fish boat electroshocking, small fish boat electroshocking, backpack electrofishing, gill netting, and beach seining.

Task 2b will specifically target small-bodied fish and the younger age-classes of large-bodied fish. Multiple sample methods will be required to ensure an adequate and thorough inventory. Effort will focus on the portion of the Peace River located between the Project and the Pine River confluence as this area is expected to experience more changes as a result of the Project. BC Hydro also has proposed offset areas in this portion of the Peace River. The Program includes a task dedicated to monitoring the effectiveness of these offsets (see the Offset Effectiveness Monitoring; Task 2d); however, data collected under Task 2b will supplement the Task 2d dataset. Task 2b also includes a limited level of sample effort for the Peace River between the Beatton and Kiskatinaw river confluences.

Sampling under Task 2b will occur during the late August to early October period to correspond with the timing of baseline datasets (i.e., Mainstream 2010, 2011, 2013a), and appropriate sampling conditions in terms of water clarity, water temperature, and discharge. Sampling during this period will also provide a temporal linkage to the Peace River Fish Food Organisms Monitoring Program (Mon-7) and the Peace River Large Fish Indexing Survey (Task 2a), and facilitates the capture of spring-spawned age-0 fish that may be present in the area.

During each study year, genetic samples will be collected from a subsample of each small-fish species encountered during Task 2b and provided to the Site C Small-fish Translocation Monitoring Program (Mon-15) for analysis. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Mon-15 budget; however, time associated with collecting these samples will be covered by Task 2b. For planning purposes, up to 30 samples from each species will be collected during each study year.

Task 2c. Peace River Creel Survey. The purpose of the Peace River Creel Survey is to determine the use of the river for recreational angling. During Project construction, Task 2c will monitor changes in river use associated with construction activities (e.g., the effects of suspended sediment). During Project operation, Task 2c will monitor changes associated with the Project's operations. The survey will quantify the timing, duration, location of effort, gear type, and species caught in the river to generate spatial and temporal estimates of recreational angling effort,

catch (both retained and released), and harvest rates by species. If possible, First Nations catch and effort also will be estimated.

BC Hydro initiated a creel survey in 2008 with the aim of collecting data to be used as a baseline during future assessments (Robichaud et al. 2009). The creel survey monitored recreational use (particularly fishing activities) on the Peace and Pine rivers and on the lower portions of major Peace River tributaries from the outlet of Peace Canyon Dam downstream to the BC-Alberta border between May 2008 and October 2009. Task 2c will follow similar methodologies to those employed during the baseline creel survey (Robichaud et al. 2010) to ensure comparable results and a compatible long-term dataset.

The study area for Task 2c during Construction Years 1 to 9 will include the Peace River from Peace Canyon Dam downstream to the Many Islands area in Alberta and will include the lower portions of major tributaries. During Operation Years 1 to 30, the study area will include the Peace River from the Project downstream to the Many Islands area (including the lower portions of major tributaries). During operation years, the Peace River upstream of the Project will be monitored under the Site C Reservoir Fish Community Monitoring Program (Mon-1a). The 2 surveys may share components, such as overflights, to quantify effort and reduce costs.

Task 2c will focus on annual angler harvest rates for Arctic Grayling, Bull Trout, Mountain Whitefish, Rainbow Trout, Goldeye and Walleye as these species are commonly caught by anglers in the Peace River (Robichaud et al. 2010).

In Construction Year 6, cameras to monitor angler activity (i.e., van Poorten et al. 2015)will be installed and operated during ice-free periods at the Lynx Creek, Halfway River Peace Island Park, Alces River, and the Many Islands boat launch sites. Beginning in Operation Year 2 camera installation and operation will be limited to those boat launch sites downstream of Site C including Peace Island Park, Alces River, and Many Islands Park. Based on concurrent creel survey information, the time-lapse frequency and motion-sensing specifications of the cameras will be adjusted to optimize the information that can be derived from this method of monitoring angling pressure. Data collected from the cameras will be used to estimate angling pressure during non-creel study years.

Task 2c may be requested to collect select fish or fish tissue for analysis under the Site C Long-term Mercury Monitoring Plan where anglers consent to the sample collection. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples are covered under the Site C Project Long-term Mercury Monitoring Plan budget; however, time associated with collecting these samples will be covered by Task 2c. For planning purposes, up to 100 samples will be collected during each study year.

Task 2d. Offset Effectiveness Monitoring. BC Hydro has developed Offsetting Plans as part of various *Fisheries Act* Authorization applications for the Project[16]. Downstream of the Project, these habitat offsets are designed to increase the amount of permanently wetted habitat available to fish, reduce fish stranding risk, and increase the complexity or variability of fish habitat to support various life stage uses by local fish populations. The offsets have been designed to support the ongoing productivity of commercial, recreational, or Aboriginal (CRA) species.

To date, the Offset Plans include 4 offset areas: River Road Rock Spurs, Upper Site 109L, Lower Site 109L, and Side Channel Site 108R.

Based on the design of the offsets and the available background data, there is relatively high confidence (low uncertainty) that the offset measures are likely to be effective[16]. However, uncertainties remain regarding the effectiveness of these offsets in terms of the physical habitat conditions created and fish use of the offset areas. As

[16] BC Hydro 2015. DFO - Application for Authorization. Site Preparation - Site C Clean Energy Project, British Columbia Hydro and Power Authority. February 23, 2015.

a result, the Offsetting Plan includes monitoring of physical conditions, as well as fish use by indicator species and Mountain Whitefish spawning at the offset areas. The monitoring requirements recommended in the *Fisheries Act* Authorization applications will be met and implemented under this Plan. As such, the description below follows from the monitoring sections of the Offsetting Plans. Monitoring of fish use by indicator species and Mountain Whitefish spawning is described below. Monitoring of physical conditions is described in Peace River Physical Habitat Monitoring Program (Mon-3).

The objective of this Offset Effectiveness Monitoring task is to determine the biological effectiveness of the offsets (i.e., to support ongoing productivity) by monitoring fish abundance and community composition at both a site and a reach scale. Reach-scale monitoring is encompassed within the entirety of the Site C Fisheries and Aquatic Habitat Monitoring Program. Task 2d is designed to provide site-scale monitoring of the offsets.

The annual schedule will follow that described in the Offsetting Plans. For planning purposes, this task will be conducted during Construction Years 3 to 5.

Fish use will be monitored at each of the 4 offset areas (i.e., River Road Rock Spurs, Upper Site 109L, Lower Site 109L, and Side Channel Site 108R) during at least one season of each of the 3 monitoring years. Sampling during the late Aug to early Oct period would correspond to the period when most of the baseline data were collected (i.e., Mainstream 2010, 2011, 2013a), allowing for more accurate comparisons (e.g., period corresponding to the long-term fish index monitoring program); sampling conditions are appropriate, in terms of water clarity, water temperature, and discharge; and, the species and life stages that are expected to use the offset sites are expected to be present. Sampling during other periods is difficult and in some cases not possible due to ice and cold weather that limit aquatic sampling in the winter months and high turbidity in the spring and early summer that reduces sampling efficiency. Offset areas also will be sampled during August and September under the Indexing Survey and Task 2b; these data will be provided to Task 2d.

To ensure consistency with baseline data, sample methods employed during baseline studies (Mainstream 2010, 2011, 2013a; Mainstream and Gazey 2014) will be employed under Task 2d. These include beach seining, backpack electrofishing, gill netting, large fish boat electroshocking, minnow trapping, and small fish boat electroshocking. All sites sampled during baseline studies (Mainstream 2010, 2011, 2013a; Mainstream and Gazey 2014) that are located within offset areas will be sampled under Task 2d. In addition, all sites sampled during baselines studies that were located between the offset areas and the CNR railway bridge also will be sampled under Task 2d to provide data from areas that did not include physical works activities. Additional sample sites also will be established as required during the initial study year to ensure adequate spatial coverage of each offset area.

All indicator species fish (i.e., Arctic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Rainbow Trout, and Walleye; BC Government 2011) captured during Task 2d will be scanned for the presence of a PIT tag; untagged indicator species (greater than 200 mm FL) will be implanted with a PIT tag and released. These data will be provided to other components of the Site C Fisheries and Aquatic Habitat Monitoring Program as necessary.

In addition to the techniques employed during baseline studies (Mainstream 2010, 2011, 2013a; Mainstream and Gazey 2014), additional techniques such as snorkel surveys or sonar surveys may also be conducted within offset areas to document fish use of specific habitat features, most notably excavated depressions within Upper Site 109L, Lower Site 109L, and Side Channel Site 108R.

To document the effectiveness of Upper Site 109L and Lower Site 109L at providing potential Mountain Whitefish spawning habitat, assessments of Mountain Whitefish spawning will be conducted within these 2 areas using egg collection mats and methods comparable to Golder (2014). These assessments will be conducted during the first 3 Mountain Whitefish spawning seasons after construction of the offsets are complete. For planning purposes, the spawning assessments are proposed for Construction Years 3 to 5. Information on physical characteristics of these

areas for Mountain Whitefish spawning will be collected under the Peace River Physical Habitat Monitoring Program (Mon-3).

After Year 3 of the monitoring, results will be analyzed and the findings reviewed to determine future monitoring needs. Decisions on future monitoring will take into account physical conditions in the Peace River (i.e., discharge, turbidity) for the 3 year period of monitoring during Project construction, and how changes in physical conditions as well as the response of the fish community during operation of the Project could influence these results.

Task 2e. Arctic Grayling Status Assessment (Halfway and Beatton Rivers). Evaluations of the status of Arctic Grayling within the Halfway and Beatton rivers will involve collection of data on age and size structure for comparison with data from other systems (e.g., Ballard and Shrimpton 2009) as well as for a within-system time trend analysis. This type of data will be used to assess whether the populations are subject to high adult mortality (younger than expected age distribution), poor growth conditions for adults (lower than expected length-at-age, condition, lipid concentration), or poor recruitment conditions (higher than expected lengths of mature adults combined with lower than expected juvenile length-at-age, condition and lipid concentration). It is expected that this information will be collected from a number of electrofishing index sites in these watersheds.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2d are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Analyses for the Indexing Survey will include techniques employed during baseline studies (Mainstream and Gazey 2014), including species percent composition, catch-per-unit-effort, length- and age-frequency histograms, growth rates, survival, age-cohort analysis, and population abundance estimation techniques to discern trends in species populations. Data will be compared, where appropriate, to baseline data and to similar studies conducted in other systems (Golder and Poisson 2014; ONA et al. 2014). Results from the Indexing Survey also will be used to generate estimates of biomass, abundance, and species diversity that will be compared to predictions presented in the EIS. Microchemistry analysis of collected Goldeye and Walleye bony structures will be conducted using methods comparable to those employed by Earth Tone and Mainstream (2013).

Analyses for Task 2b will include techniques employed by Mainstream (2013a), including percent composition, catch-per-unit-effort, relative abundance, length and age distribution, and age-cohort analyses by habitat type for common fish species. When applicable, data will be compared to baseline datasets (Mainstream 2010, 2011, 2013a) to discern trends in species populations. Results from Task 2b will be used to generate estimates of biomass and abundance that will be compared to the predictions presented in the EIS.

Analyses for Task 2c will follow those employed during baseline studies (Robichaud et al. 2010) designed to quantify the timing, duration, location of effort, gear type, and species caught in the river to generate spatial and temporal estimates of recreational angling effort, catch (both retained and released), and harvest rates (i.e., CPUE) by species. Data will be compared, where appropriate, to data collected during baseline studies (Robichaud et al. 2010) and to similar studies conducted in other systems (e.g., Arndt and Schwarz 2011).

The interpretation of results from the Indexing Survey as well as other components of the Site C Fisheries and Aquatic Habitat Monitoring Program could be influenced by the level of fishing effort, as indicated by Task 2c. Variable fishing effort and/or catch rates over time will indicate whether the sport fishery is a confounding variable in estimating population abundances. The significance of this confounding variable will depend on the total catch relative to the total population and any changes to sport fishing regulations that may be implemented to regulate angling harvest.

Analyses for Task 2d will include techniques employed during baseline studies (Mainstream 2013 and Mainstream and Gazey 2014), including percent composition, catch-per-unit-effort, relative abundance, length and age distribution, and age-cohort analyses by habitat type or offset area for common fish species. When applicable, data will be compared to baseline datasets (Mainstream 2010, 2011, 2013a; Mainstream and Gazey 2014) to discern trends in the use of offset areas by fish.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[17].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

[17] Decision Statement, October 14, 2014, Section 18 Record Keeping.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Peace River Fish Community Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures. Task 7 will be conducted every 5 years to facilitate data and information sharing between the Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of the Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on fish downstream of Site C, and to assess the effectiveness of fish and fish habitat mitigation measures.

To date, results from various BC Hydro WLR studies (BC Hydro 2007) suggest that while it is possible for projects to detect changes in various parameters, linking the reasons for observed changes to a single cause is difficult. As an example, results from BC Hydro's Peace River Fish Index Project (GMSMON-2) have suggested as much as a 2-fold increase in the abundance of Mountain Whitefish over a 1-year period (Mainstream and Gazey 2013). Linking an observed change in Mountain Whitefish abundance to the Project will be difficult when pre-project annual variability is high and likely influenced by variables outside of the influence of the Project (e.g., tributary spawning success). For these reasons, data and results from each survey within the Program (Tasks 2a to 2d) will be interpreted in conjunction with each other, through the exchange of information at annual workshops (Task 6), and through the synthesis review (Task 7). Similarly, overall results from the Program will be interpreted in conjunction with results from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program when drawing overall conclusions.

SCHEDULE

A tentative schedule for the Program is detailed below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. The schedule for Task 2e Arctic Grayling Status Assessment (Halfway and Beatton Rivers) will be determined by the responsible contractor. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes

identified during the workshop before the next year's field season. The synthesis review (Task 7) will be conducted every 5 years beginning in Operation Year 5.

Task 2a. Peace River Large Fish Indexing Survey. Task 2a will be conducted annually between Construction Years 1 and 9 and annually between Operation Years 1 to 30. Field work will be conducted between mid-August and late September of each study year. Annual reports will be submitted during each study year.

Task 2b. Peace River Fish Composition and Abundance Survey. Task 2b will be conducted during Construction Years 6 and 7 and once every 5 years during operation beginning in Operation Year 1. Field work will be conducted during the August to October period of each study year. Annual reports will be submitted during each study year.

Task 2c. *Peace River Creel Survey*. Task 2c will be conducted in Construction Year 6 and every 5 years during operation beginning in Operation Year 2. Task 2c will align with the Department of Fisheries and Oceans' Survey of Recreational Fishing in Canada (DFO 2012) and the Site C Reservoir Creel Survey (Task 2c) described in the Site C Reservoir Fish Community Monitoring Program (Mon-1a) to facilitate data sharing and to recognize cost savings. Field work for Task 2c will be conducted year-round during each study year.

Task 2d. *Offset Effectiveness Monitoring.* Task 2d will be conducted annually over 3 consecutive years after the construction of offset areas is complete. For planning reasons, sampling is currently scheduled for Construction Years 3 to 5. Field work for fish use by indicator species is expected to be conducted during late August to early October, and Mountain Whitefish spawning sampling is expected to occur when spawning is complete in November or December of each study year. Annual reports will be submitted during each study year.

REFERENCES

Arndt, S. and C. Schwarz. 2011. Trends in angling and piscivore condition following eleven years of nutrient additions in Arrow Lakes Reservoir (Arrow lakes Reservoir Creel Survey 2003-2009). Columbia Basin Fish and Wildlife Compensation Program. 49 p. + app.

Bauman, P., V. Cairns, B. Kurey, L. Lambert, I. Smith, R. Thoma. 2000. Lake Erie Lakewide Management Plan (LaMP) Technical Report Series. Fish Tumors or Other Deformities. Technical Report No. 6. January 2000. 30 p. + appendices.

Ballard. S and J.M. Shrimpton. 2009. Summary Report of Arctic Grayling Management and Conservation 2009. A synopsis of the information available on Arctic grayling in the Omineca region of northern British Columbia and identification of additional information needs. Peace/Williston Fish and Wildlife Compensation Program Report No. 337. 66 pp plus appendices.

BC Government. 2011. DRAFT Fish, Wildlife and Ecosystem resources and Objectives for the Lower Peace River Watershed – Site C Project Area. 25 p. + appendices.

BC Ministry of Environment. 2009. DRAFT Ministry of Environment Fish and Wildlife Interim Objectives for Site C Project Area.

BC Hydro. 2007. Peace Project Water Use Plan. Revised for Acceptance by the Comptroller of Water Rights. August 2007. 17 p. + 3 app.

Department of Fisheries and Oceans (DFO), 2012. Survey of Recreational Fishing in Canada 2010. Economic Analysis and Statistics Strategic Policy. Resource Management Ecosystems and Fisheries Management. Fisheries and Oceans Canada. Ottawa, Ontario. Catalogue No. Fs42-1/2010E. ISBN 978-1-100-54196-9. DFO/2012-1804. 27 p.

Earth Tone Environmental R&D and Mainstream Aquatics Ltd. 2013. Site C Fisheries Studies 2012 Elemental Signature Study - Final Report. Prepared for B.C. Hydro Site C Project, Corporate Affairs Report No. 12007F: 163 p. + appendices.

Golder Associates Ltd. 2014. Lower Columbia River Whitefish Life History and Egg Mat Monitoring Program: Year 5 Interpretive Report. Report prepared for BC Hydro, Castlegar, BC Golder Report No. 11-1492-0111F: 102 p. + 5 app.

Golder Associates Ltd. and Poisson Consulting Ltd. 2014. CLBMON-45 Lower Columbia River Fish Population Indexing Surveys – 2013 Investigations. Report prepared for BC Hydro Generations, Water License Requirements, Castlegar, BC. Golder Report No. 1314920102-R-Rev0: 65 p. + 8 app.

Mainstream Aquatics Ltd. 2010. Site C fisheries studies – Peace River Fish Inventory. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 09008AF: 90 p. + plates (Volume 1) and appendices (Volume 2).

Mainstream Aquatics Ltd. 2011. Site C fisheries studies – 2010 Peace River Fish Inventory. Prepared for B.C. Hydro Site C Project, Corporate Affairs Report No. 10005F: 102 p. + plates and appendices.

Mainstream Aquatics Ltd. 2012. Site C Clean Energy Project – Fish and Fish Habitat Technical Data Report. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 12002F: 239 p.

Mainstream Aquatics Ltd. 2013. Site C fisheries studies – 2011 Peace River Fish Inventory. Prepared for B.C. Hydro Site C Project, Corporate Affairs Report No. 11005F: 98 p. + plates and appendices.

Mainstream Aquatics Ltd. and W.J. Gazey Research. 2013. Peace River Fish Index Project - 2012 Studies. Prepared for B.C. Hydro. Report No. 12011: 84 pp. + appendices.

Mainstream Aquatics Ltd. and W.J. Gazey Research. 2014. Peace River Fish Index Project – 2013 Studies (Draft). Prepared for B.C. Hydro. Report No. 13011F: 82 pp. + appendices.

Ohio EPA (Ohio Environmental Protection Agency). 1996. Ohio EPA's Guide to DELT Anomalies. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Okanagan Nation Alliance, Golder Associates Ltd., and Poisson Consulting Ltd. 2014. CLBMON-16 Middle Columbia River Fish Population Indexing Survey. Report prepared for BC Hydro Generation, Water License Requirements, Revelstoke, BC.

Robichaud, D., M. Mathews, A. Blakley and R. Bocking. 2010. Peace River Angling and Recreational-Use Creel Survey 2008-2009. Final Report. Report for BC Hydro.

van Poorten, B., T. Carruthers, H. Ward, and D. Varkeyvan. 2015. Imputing recreational angling effort from time-lapse cameras using an hierarchical Bayesian model. http://www.researchgate.net/publication/281480123. Fisheries Research 172 (2015) 265–273.

Appendix D

Mon-3 Peace River Physical Habitat Monitoring Program

PEACE RIVER PHYSICAL HABITAT MONITORING PROGRAM

SUMMARY

ID	Site C Mon-3 – Peace River Physical Habitat Monitoring Program
Description	During construction, this monitoring program will investigate the effects of construction on physical habitat within the Site C Construction Headpond and within the Peace River downstream of Site C. During operation, this monitoring program will investigate the effects of operation on physical habitat within the Peace River downstream of Site C.
Key Project components / locations	Construction and Operation / Site C Construction Headpond and the Peace River between Site C and the Many Islands area in Alberta
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-2 – Peace River Fish Community Monitoring Program • Mon-7 – Peace River Fish Food Organisms Monitoring Program • Mon-9 – Peace River Water and Sediment Quality Monitoring
Schedule	Construction Years 1 to 9. Operation Years 1 to 30.

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, regulatory agencies, and stakeholders. Section 12.1.2 of the Site C Environmental Impact Statement (EIS) states that the Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and lower trophic biota), changes to fish health and fish survival, and changes to fish movement.

The focus of the Peace River Physical Habitat Monitoring Program (this Program) is to monitor physical habitat within the Site C Construction Headpond (the Peace River from Site C upstream to near the Wilder Creek confluence) during Construction Years 5 to 8 and within the Peace River downstream of the Project to the Many Islands area in Alberta during Construction Years 1 to 9 and during Operation Years 1 to 30.

The Project will shift the point of regulation on the Peace River approximately 85 km downstream of Peace Canyon Dam (PCD). Associated changes to river flows will affect the types and distributions of aquatic habitats available to fish both upstream and downstream of the Project. Downstream of the Project, the daily range of water levels is predicted to increase from 0.5 m to 1.0 m at the Site C tailrace, and from 0.4 m to 0.8 m near Taylor, BC[3]. The Project also will raise water levels within the Site C Construction Headpond, which will influence physical processes driving river geomorphology, such as water velocities and sediment transport capacities.

The EIS acknowledged that there is inherent uncertainty in predicting changes to physical habitat. This program is designed to validate predictions presented in the EIS and builds on recent studies that characterized physical habitat in the Peace River and on which the EIS effects assessment was based. Existing physical habitat was described in the EIS using a combination of methods, including channel morphology, bed surface grain size, and physical habitat mapping. With consideration to existing datasets, the objectives of this Program, and the data needs of other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, up to 50 channel cross-section transects situated between the upstream extent of the Site C Construction Headpond and the Many Islands area in Alberta are available. The locations of each of the proposed transects as well as the justifications for including them in this Program are detailed by Golder (2015) and are summarized in Figure 1 and Table 1.

In 2014, existing bed surface grain size data from the Peace River were evaluated for use as a baseline dataset for monitoring changes to physical habitat during the construction and operation of the Project (Golder 2014). Based on the review, additional baseline bed surface grain size and cross-section profile data were recorded at each available transect located upstream of the Pine River confluence (Golder in prep.). Overall, bed surface grain size data and cross-section profile data were collected at 13 transects located upstream of the Project and within the footprint of the Site C Construction Headpond. These data also were collected at 15 transects located between the Project and the confluence of the Pine River. Data were collected upstream of the Project to provide additional baseline data for the Site C area Construction Headpond prior to the headpond's development. Data were collected between the Project and the Pine River confluence because this area is expected to experience the greatest change to physical habitat due to development of the Project[4].

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 11.4.5.2
[4] EIS, Volume 2, Section 11.8.6, p. 145

FISHERIES MANAGEMENT QUESTIONS

The overarching fisheries management questions (management questions) for this Program reflect that the Project can affect physical habitat in different ways:

- How does the construction of the Project affect physical habitat in the Site C Construction Headpond?
- How does the construction and operation of the Project affect physical habitat in the Peace River between the Project and the Many Islands area in Alberta?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring to address the following hypotheses:

H_1: The Site C Construction Headpond will not affect channel morphology or bed sediment composition within the extent of the headpond.

H_2: The construction and operation of the Project will not affect channel morphology, bed surface grain size composition, or wetted area in the Peace River between the Project and the Many Islands area in Alberta.

Another component of this Program is the monitoring of proposed habitat offsets. Monitoring the physical habitat of these offset areas will be guided by the following hypothesis:

H_3: Site C offset habitat areas in the Peace River maintain their design and purpose over time.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding physical habitat in the Site C Diversion Headpond and the Peace River downstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[5] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[6]) and the Federal Decision Statement[7].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to validate predictions and address uncertainties identified in the EIS regarding the Project's effects on physical habitat in the Site C Construction Headpond and the Peace River between the Project and the Many Islands area in Alberta.

During Construction Years 1 to 9, the spatial scope of this Program is limited to the Site C Construction Headpond and the portion of the Peace River situated between the Project and the Many Islands area in Alberta. During Operation Years 1 to 30, the spatial scope of this Program is limited to the portion of the Peace River situated between the Project and the Many Islands area in Alberta. The spatial extent of this Program was guided by physical modelling[8] and feedback from First Nations, regulatory agencies, and various stakeholders.

[5] EIS, Volume 2, Section 11
[6] EAC, Condition #7, Pages 8 to 9
[7] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat
[8] EIS, Volume 2, Appendix I

The temporal scope of this Program includes Construction Years 1 to 9 and Operation Years 1 to 30; however, not all tasks (see below) occur during each study year.

APPROACH

This Program builds on methods employed during baseline studies[8] and other studies (e.g., Church 2015) that characterized physical habitat in the Peace River and on which the EIS effects assessment was based. Physical habitat in the Site C Construction Headpond and the Peace River downstream of the Project will be monitored using a variety of techniques. Data collected during Construction Years 1 to 9 and Operation Years 1 to 30, coupled with existing datasets will allow the Program to address the Project's management questions.

Changes in physical habitat over time will be assessed using a combination of the following methods:

- Channel cross-section surveys using, LiDAR, aerial photography, river bathymetry, and Real Time Kinetic (RTK) river bank mapping;
- Grain size sampling using the Wolman pebble count method or underwater videography; and
- Mapping of physical habitat features associated with fish habitat.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Channel Morphology
    - Task 2b – Substrate Size
    - Task 2c – Offset Effectiveness Monitoring
- Task 3 – Data Analysis
    - Task 3a – Channel Morphology
    - Task 3b – Substrate Size
    - Task 3c – Offset Effectiveness Monitoring
    - Task 3d – Habitat Mapping
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Channel Morphology. Changes in channel morphology over time will be monitored using a combination of cross-section bathymetry surveys, LiDAR, aerial photography, and/or river bank RTK mapping, depending on the study year. These data will be coupled with bed surface grain size data (collected under Task 2b) and general observations of substrates to generate habitat maps of the study area under Task 3d.

During Construction Year 4, LiDAR and aerial photography surveys will be conducted from the upstream end of the Site C Construction Headpond (i.e., near the Wilder Creek confluence) downstream to the Many Islands area in Alberta and on the lower portions of select Peace River tributaries (most notably the Moberly River). During Operation Years 1, 6, 15, and 25, LiDAR and aerial photography surveys will be conducted from the Project downstream to the Many Islands area in Alberta

To ensure compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, channel cross-section bathymetry surveys will be conducted at transect locations detailed in Golder (2015) and summarized in Table 1 and Figure 1. The spatial distribution of these transects is weighted such that more transects are located in proximity to the Project, where most of the changes in the channel bed are predicted to occur during both construction and operation[9].

During construction years in which LiDAR and aerial photography surveys are conducted (i.e., Construction Year 4), cross-section bathymetry surveys will be conducted in the Site C Construction Headpond and in the Peace River from the Project downstream to the Many Islands area in Alberta. During construction years in which LiDAR and aerial photography surveys are not conducted (i.e., Construction Years 6 and 8), cross-section bathymetry surveys will be conducted in the Site C Construction Headpond and in the Peace River from the Project downstream to the Pine River confluence; cross-section bathymetry surveys will not be conducted between the Pine River confluence and the Many Islands area in Alberta during these study years. During operation years, cross-section bathymetry surveys will not be conducted upstream of the Project. During operation years in which LiDAR and aerial photography surveys are expected to be conducted (i.e., Operation Years 1, 6, 15, and 25), cross-section bathymetry surveys will be conducted from the Project downstream to the Many Islands area in Alberta. During operation years in which LiDAR and aerial photography surveys are not conducted (i.e., Operation Years 3 and 10), cross-section bathymetry surveys will only be conducted from the Project downstream to the Pine River confluence; cross-section bathymetry surveys will not be conducted between the Pine River confluence and the Many Islands area in Alberta during these study years.

During study years in which LiDAR surveys are conducted (i.e., Construction Year 4, and Operation Years 1, 6, 15, and 25) changes in channel morphology will be monitored using a combination of LiDAR and cross-section bathymetry survey data. During study years in which LiDAR surveys are not conducted (i.e., Construction Years 6 and 8, and Operation Years 3 and 10) changes in channel morphology will monitored using a combination of cross-section bathymetry survey data and river bank RTK mapping. LiDAR systems survey only those portions of the river channel situated above the surface of the water; therefore, these surveys should be conducted at low water levels to facilitate surveying a larger portion of the active river channel. Similarly, bathymetry surveys should be conducted at higher water levels to allow the inclusion of more of the river channel in these surveys. Combined these two methods should cover the entire active river channel.

[9] EIS, Volume 2, Section 11.8.6, p. 145

Task 2b. Substrate Size. Bed surface grain size data can be collected to validate EIS predictions regarding operational effects on bed sediment composition, confirm the effectiveness of mitigation in relation to sediment control during construction, and to provide explanatory data to be used by other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Bed surface grain size data can be collected at existing transects (Golder 2015). Bed surface grain sizes will be measured using a combination of the Wolman pebble count method and underwater videography. Underwater videography will be used at each transect situated within the Site C Construction Headpond using methods comparable to Knight Piésold Ltd. (2012) and the Wolman pebble count method will be used at each transect situated downstream of the Project. When the Wolman pebble count method is employed, a minimum of 200 pebbles will be measured at two to three representative locations along each transect using methods similar to those used during baseline studies (summarized in Golder 2014).

Bed surface grain size data will be collected at each transect surveyed for bathymetry (Task 2a). See Task 2a for a description of transect locations surveyed for bathymetry during each study year. Ideally, bed surface grain size data will be collected during periods of low water levels to facilitate collecting data from portions of the river channel that are under water during periods of higher flows.

Task 2c. Offset Effectiveness Monitoring. BC Hydro has developed several different offset plans as part of various *Fisheries Act* Authorization applications related to the Project[10]. Downstream of the Project, these offset plans are designed to increase the amount of permanently wetted habitat available to fish, reduce fish stranding risk, and increase the complexity or variability of fish habitat to support various life stage uses by local fish populations. The offsets have been designed with the intention of supporting the productivity of commercial, recreational, or Aboriginal (CRA) species.

To date, the offset plans include 4 major components: River Road Rock Spurs, Upper Site 109L, Lower Site 109L, and Side Channel Site 108R[10].

BC Hydro notes that uncertainties remain regarding the effectiveness of the above offset components in terms of potential rates of sediment deposition and changes in physical configuration over time. The objective of the Offset Effectiveness Monitoring under this Program is to ensure that the areas maintain their structure and function over time and evaluate the suitability of habitat for fish.

Habitat suitability will be monitored by measuring water depths, water velocities, and substrate sizes over time. A range of potential methods are available to obtain this information, including manual depth / velocity measurements with visual substrate assessments, or with vertical or side-scan sonar, Acoustic Doppler Current Profiler (ADCP), or underwater videography. Survey data will be georeferenced to allow GIS mapping and the calculation of metrics of variation in channel bathymetry that measure habitat for fish. Aquatic vegetation is only expected to be present in Side Channel Site 108R; however, the presence of aquatic vegetation will be visually assessed at all offset areas. .

Monitoring under Task 2c will be conducted during 3 consecutive years after offset construction is completed. For planning reasons, it is assumed that Task 2c will be conducted during Construction Years 3 to 5. After 3 years of monitoring, results will be analyzed and the findings will be reviewed with DFO and provincial representatives to determine future monitoring needs.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be

[10] BC Hydro 2015. DFO - Application for Authorization. Site Preparation - Site C Clean Energy Project, British Columbia Hydro and Power Authority. February 23, 2015.

incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Task 3a. Channel Morphology. Data from LiDAR, aerial photography, cross-section bathymetry surveys, and river bank RTK mapping will be used to create digital elevation charts. The profile of the river bed at each transect will be graphically prepared and used to determine the magnitude of changes to river bed elevation through aggradation and degradation over time.

Task 3b: Substrate Size. Bed surface grain size data will be presented in graphical form and appropriate descriptive statistics (e.g., d_{50}) calculated for each location and summarized for each transect. Data will be analyzed to assess how bed surface grain size differs among transects and over time. River flow and water quality monitoring data will be used when possible to help explain observed patterns in bed surface grain size.

Task 3c: Offset Effectiveness Monitoring. When possible, data collected under Task 2c will be georeferenced to allow GIS mapping and the calculation of metrics of variation in channel bathymetry that measure habitat for fish. Outputs will include areas of habitat enhanced, the type and spatial arrangement of habitats, substrate conditions, depths, and water velocities. Using these data, Weighted Useable Area (WUA) will be calculated for Upper Site 109L and Lower Site 109L for adult and juvenile Rainbow Trout, adult Bull Trout, and Mountain Whitefish. WUAs will be derived from habitat suitability indices (HIS) in the literature, and results will be interpreted in the context of the caveats associated with this approach. Each offset area will be assessed based on whether they are maintaining their structure and function as outlined in BC Hydro's applications[10]. These results will be provided to the Offset Effectiveness Monitoring Program (Task 2d) of the Peace River Fish Community Monitoring Program (Mon-2) for interpretation and identifying linkages between fish habitat and actual fish use.

Task 3d: Physical Habitat Mapping. Software tools, such as those provided by the River Bathymetry Toolkit Program (ESSA 2014), will be used to generate a variety of physical habitat metrics at each transect over a range of Peace River flows. Typical habitat metrics include wetted area, wetted width to depth ratios, gradient, channel sinuosity, and habitat connectivity. Additional metrics of relevance to particular fish species or life stages will also be computed as needed by other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. Estimations of habitat quality and quantity in relation to water velocities are not a part of this Program.

Appropriate data summaries and statistical techniques will be used to assess changes in aquatic habitat metrics over time by comparing baseline data to data collected under this Program.

As detailed above, LiDAR and aerial photography surveys are not proposed during the river diversion phase of Project construction (i.e., Construction Years 5 to 9). In the absence of up-to-date LiDAR and aerial photography data during this time period, physical habitat mapping, and subsequent interpretation, will be based solely on channel morphology and substrate size data collected at each transect during these study years.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and

8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program.

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. Some components of the Site C Fisheries and Aquatic Habitat Monitoring Program included synthesis reviews at regular intervals to integrate data collected under other components of the plan. However, synthesis reviews are not required for this Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of the Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on physical habitat in the Site C Construction Headpond and in the Peace River between the Project and the Many Islands area in Alberta. Results will also be used to assess the effectiveness of offset programs designed to improve fish habitat downstream of the Project.

To date, results from various BC Hydro Water Use Plan (WUP; BC Hydro 2007) projects suggest that while it is possible for projects to detect changes in various parameters, linking the reasons for observed changes to a single

cause is difficult. Physical habitat data collected in the study area over the previous 50 years indicate a dynamic Peace River. Therefore linking an observed change to the Project will be difficult when the river is still stabilizing from previous upstream impoundments and is influenced by variables outside of the influence of the Project (e.g., tributary inputs). For these reasons, data and results from this Program should be interpreted in conjunction with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

SCHEDULE

A tentative schedule for each Task within the Program is detailed below. Work associated with Task 1 (Project Coordination) would be ongoing on an "as needed" basis. Ideally, the annual workshop (Task 6) will be conducted during the late spring to early summer period. This would provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop prior to the next year's field season.

Within each study year, channel morphology data should be collected when water levels are high to allow the inclusion of the majority of the river channel in the cross-sectional profile. However, substrate data should be collected when water levels are low to facilitate the collection of substrate data from locations that are typically underwater at high water levels.

Channel morphology (Task 2a) and substrate size (Task 2b) data were collected in Construction Year 1 in the Site C Construction Headpond area and in the Peace River between the Project and the Pine River confluence (Golder in prep.).

During Construction Year 4, channel morphology and substrate size data will be collected in the Site C Construction Headpond area and in the Peace River between the Project and the Many Islands area in Alberta. During Construction Years 6 and 8, channel morphology and substrate size data will be collected in the Site C Construction Headpond area and in the Peace River between the Project and the Pine River confluence.

During Operation Years 1, 6, 15, and 25, channel morphology and substrate size data will be collected in the Peace River between the Project and the Many Islands area in Alberta. During Operation Years 3 and 10, channel morphology and substrate size data will be collected in the Peace River between the Project and the Pine River confluence.

LiDAR and aerial photography surveys are scheduled for Construction Year 4 and Operation Years 1, 6, 15, and 25.

A thorough review of the data will be conducted during Operation Year 6. Depending on the results of that review, additional surveys may be required during future study years. For budgeting purposes, additional surveys are included in Operation Years 10, 15, and 25.

Offset Effectiveness Monitoring (Task 2c) will be conducted annually over 3 consecutive years after the construction of offset areas is complete. For planning purposes, sampling is currently scheduled for Construction Years 3 to 5. After 3 years of monitoring, results will be analyzed and the findings reviewed with DFO to determine future monitoring needs.

Physical habitat mapping (Task 3d) is scheduled for Construction Years 4, 6, and 8, and for Operation Years 1, 6, 15, and 25. During Construction Years 6 and 8, physical habitat mapping will be based solely on channel morphology and substrate size data collected at each transect; LiDAR and aerial photography surveys are not proposed during these two study years.

REFERENCES

BC Hydro. 2007. Columbia River Projects, Water Use Plan. 41 p. + 1 appendix.

Church, M. 2015. The Regulation of Peace River: A Case Study for River Management. The University of British Columbia. Vancouver, Canada. Wiley Blackwell. 278 pages.

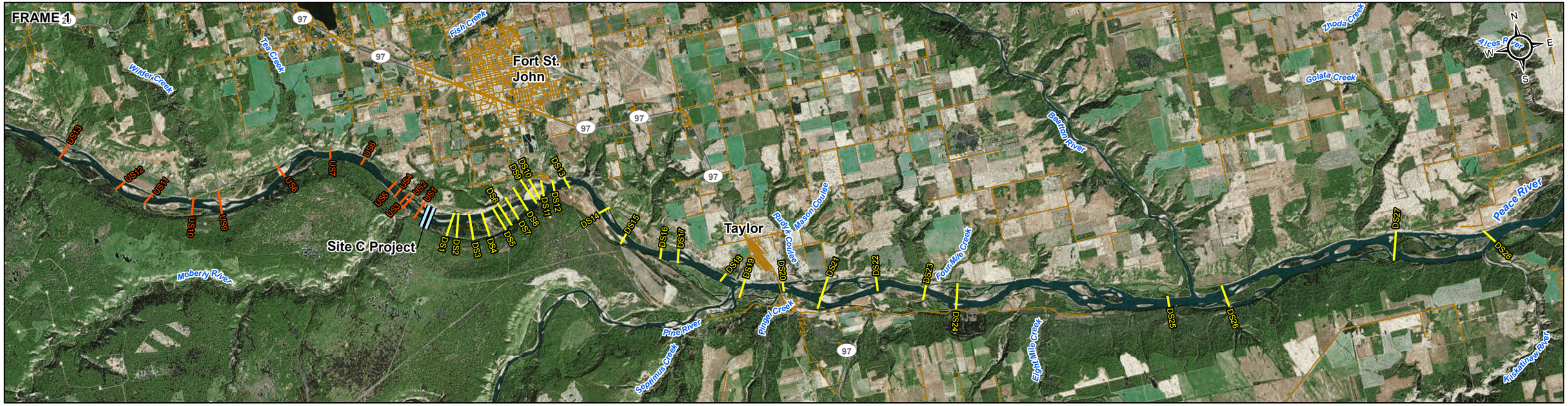
ESSA Technologies Ltd. 2014. River Bathymetry Toolkit (RBT). Downloaded from: http://essa.com/tools/river-bathymetry-toolkit-rbt/.

Golder Associates Ltd. 2014. Site C Physical Habitat Mentoring Program- Review of Sediment Size Data. Prepared for BC Hydro, Vancouver, BC. Technical Memo.

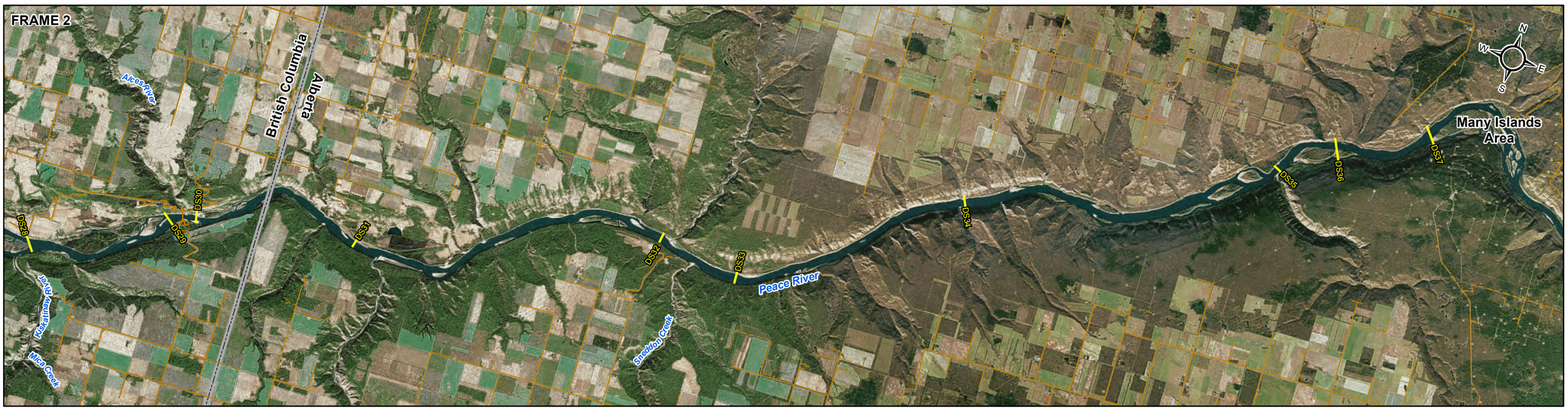
Golder Associates Ltd. 2015. Site C Mon-3 Peace River Physical Habitat Monitoring Proposed Transect Locations. Prepared for BC Hydro, Vancouver, BC. Technical Memo. 4 pages + attachments.

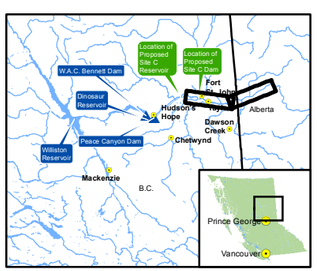
Knight Piésold Ltd. 2012. Site C Clean Energy Project – geomorphology and sediment regime study, 2011 Surficial Bed Material Sampling. Prepared for BC Hydro, Vancouver, BC.

FRAME 1



FRAME 2

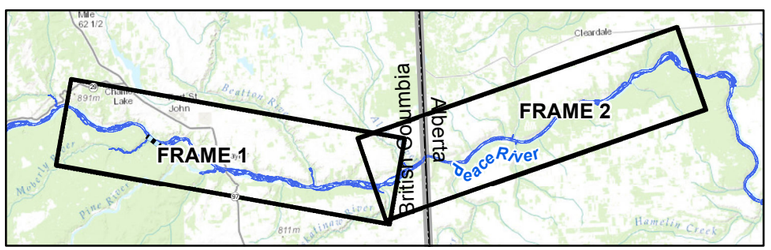




Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Imagery: Copyright © 20090927 Esri and its licensors. Source:DigitalGlobe WV01. Used under license, all rights reserved.
3. Water features: CanVec © Department of Natural Resources Canada. All rights reserved.
4. Transportation features: CanVec © Department of Natural Resources Canada. All rights reserved.
5. Topographic base: Esri, NRCAN, GeoBase, and the GIS User Community.

Legend

- Site C Project
- Upstream Transect
- Downstream Transect
- Highway
- Local
- Resource/Recreation
- Provincial Border



1:175,000

0 5,000 Meters

SITE C CLEAN ENERGY PROJECT

BC hydro | Golder Associates

Figure 1
Proposed Mon-3 Physical Habitat Monitoring Program Transects

Date	June 30, 2015	DWG NO	1016-C14-B5132	R a

Y:\burnaby\CAD-GIS\Bur-Graphics\Projects\2013\1492\13-1492-0066\GIS\Mapping\MXD\Fish\Aquatic_Study_Area\1016_C14_B5132_Aquatic_Study_Sections_V2.mxd

Table 1 Location and association of proposed transects of BC Hydro's Peace River Physical Habitat Monitoring Program (Mon-3) to historical datasets and other monitoring sites within the Site C Fish and Aquatic Environment Monitoring Plan.

Transect Identifier[a]	Left Bank[b]			Right Bank[b]			Comments
	Zone[c]	Easting	Northing	Zone	Easting	Northing	
US13	10V	613952	6235887	10V	613405	6235327	Located near the upstream extent of the Site C Construction Headpond (90th Percentile; Hanna 2015).
US12	10V	616173	6233773	10V	615660	6233502	Located near the upstream extent of the Site C Construction Headpond (90th Percentile; Hanna 2015). At the upstream end of a small side channel.
US11	10V	617346	6233054	10V	616836	6232627	Located immediately upstream of the Wilder Creek confluence.
US10	10V	619122	6232538	10V	618884	6231738	Located immediately downstream of the Wilder Creek confluence.
US9	10V	620268	6232665	10V	620260	6231563	Located near the upstream extent of the Site C Construction Headpond (50th Percentile; Hanna 2015).
US8	10V	623088	6233279	10V	623387	6232711	Located immediately upstream of the Tea Creek confluence and at a historical data site (Church 2010).
US7	10V	625601	6233581	10V	625551	6233188	Located immediately downstream of the Tea Creek confluence.
US6	10V	627148	6232966	10V	626854	6232647	Located at a historical data site (Church 2010).
US5	10V	628331	6231622	10V	627869	6231270	Located at Mon-6 and Mon-8 sample site PR3.
US4	10V	628501	6231310	10V	628086	6230905	Located at a historical data site (Church 2010; KPL 2012).
US3	10V	629005	6230872	10V	628354	6230366	Located at a historical data site (Church 2010).
US2	10V	628846	6231010	10V	628280	6230599	Located immediately upstream of the Moberly River confluence and at a historical data site (KPL 2012).
US1	10V	629461	6230481	10V	628795	6229816	Located immediately downstream of the Moberly River confluence, immediately upstream of the Site C damsite and at a historical data site (KPL 2012).
DS1	10V	630670	6229758	10V	630133	6228783	Located immediately downstream of Site C at a historical data site (KPL 2012), at the proposed Temporary Bridge Crossing, and within Section 5 of Mon-2.
DS2	10V	630856	6229716	10V	630577	6228620	Located at a historical data site (Church 2010), downstream of the proposed Temporary Bridge Crossing, and within Section 5 of Mon-2.
DS3	10V	631314	6229624	10V	631318	6228389	Located at a historical data site (KPL 2012) and within Section 5 of Mon-2.
DS4	10V	631894	6229580	10V	632071	6228420	Located at a historical data site (Church 2010), proposed offset area 108R, and within Section 5 of Mon-2.
DS5	10V	632409	6229718	10V	632843	6228578	Located at a historical data site (KPL 2012), proposed offset areas 108R and 109L Upper, and within Section 5 of Mon-2.
DS6	10V	632669	6229861	10V	633151	6228740	Located at a historical data site (Church 2010), proposed offset areas 108R and 109L Upper, and within Section 5 of Mon-2.
DS7	10V	633063	6230053	10V	633503	6228942	Located at a historical data site (Church 2010), proposed offset area 108R, and within Section 5 of Mon-2.
DS8	10V	633504	6230441	10V	633976	6229267	Located at a historical data site (KPL 2012), proposed offset areas 108R and 109L Lower, and within Section 5 of Mon-2.
DS9	10V	633901	6230725	10V	634432	6229522	Located at a historical data site (KPL 2012), proposed offset area 109L Lower, and within Section 5 of Mon-2.
DS10	10V	634272	6230691	10V	634617	6229672	Located in proposed offset area 109L Lower and within Section 5 of Mon-2.
DS11	10V	634801	6230531	10V	634810	6229795	Located at a historical data site (KPL 2012), proposed offset area 109L Lower, and within Section 5 of Mon-2.
DS12	10V	635315	6230462	10V	635324	6229897	Located at a historical data site (KPL 2012) and within Section 5 of Mon-2.
DS13	10V	635823	6230523	10V	636048	6229939	Located at a historical data site (Church 2010; KPL 2012) and within Section 5 of Mon-2.

…continued.

[a] Transects are sorted upstream to downstream.

[b] As viewed facing downstream.

[c] NAD83.

Table 1 Concluded.

Transect Identifier[a]	Left Bank[b]			Right Bank[b]			Comments
	Zone[c]	Easting	Northing	Zone	Easting	Northing	
DS14	10V	637680	6228779	10V	637153	6228588	Located at a historical data site (Church 2010) and within Section 5 of Mon-2.
DS15	10V	638221	6227477	10V	637861	6227040	Located at a historical data site (Church 2010) and within Section 5 of Mon-2.
DS16	10V	639668	6226526	10V	639517	6226047	Located at a historical data site (KPL 2012) and immediately downstream of the CNR Railway Bridge.
DS17	10V	640442	6226405	10V	640277	6225729	Located at Mon-7 and Mon-9 sample site PD1 and at a historical data site (Church 2010).
DS18	10V	642362	6224867	10V	642029	6224567	Located at a historical data site (KPL 2012) and immediately upstream of the Pine River confluence.
DS19	10V	643194	6224524	10V	642756	6223675	Located immediately downstream of the Pine River confluence and within Section 6 of Mon-2.
DS20	10V	644807	6224091	10V	644809	6223601	Located at a historical data site (Church 2010), immediately downstream of the Highway 97 bridge, and within Section 6 of Mon-2.
DS21	10V	646872	6223891	10V	646171	6222573	Located at a historical data site (Church 2010) and within Section 6 of Mon-2.
DS22	10V	649026	6223532	10V	649014	6222875	Located at a historical data site (Church 2010) and within Section 6 of Mon-2.
DS23	10V	651210	6222776	10V	650966	6222125	Located at a historical data site (Church 2010), immediately upstream of the Four Mile Creek confluence, and within Section 6 of Mon-2.
DS24	10V	652641	6222601	10V	652363	6221437	Located at a historical data site (Church 2010), immediately downstream of the Four Mile Creek confluence, and within Section 6 of Mon-2.
DS25	10V	661945	6220369	10V	661936	6219853	Located at Mon-7 and Mon-9 sample site PD2, immediately upstream of the Beatton River confluence, and with Section 7 of Mon-2.
DS26	10V	664448	6220395	10V	664622	6219398	Located immediately downstream of the Beatton River confluence and within Section 7 of Mon-2.
DS27	10V	672708	6221474	10V	672355	6220144	Located at Mon-7 and Mon-9 sample site PD3, upstream of the Kiskatinaw River confluence, and with Section 7 of Mon-2.
DS28	10V	676600	6220779	10V	677056	6220183	Located immediately downstream of the Kiskatinaw River confluence.
DS29	10V	682133	6223850	10V	682711	6223422	Located immediately upstream of the Alces River confluence.
DS30	10V	683511	6224430	10V	683645	6223850	Located immediately downstream of the Alces River confluence.
DS31	11V	317999	6225195	11V	317864	6224796	Located at Mon-7 and Mon-9 sample site PD4 and immediately upstream of the Pouce Coupe River confluence.
DS32	11V	331457	6228902	11V	331353	6228425	Located immediately upstream of the Clear River confluence.
DS33	11V	335112	6228020	11V	335104	6227449	Located downstream of the Sneddon Creek confluence.
DS34	11V	344245	6233889	11V	344452	6233386	Located between the Sneddon Creek confluence and the Many Islands area.
DS35	11V	357593	6238661	11V	357983	6238442	Located at the upstream end of Section 9 of Mon-2.
DS36	11V	359971	6240553	11V	360361	6239576	Located at the upstream end of Section 9 of Mon-2.
DS37	11V	363863	6242126	11V	364389	6241350	Located at Mon-7 and Mon-9 sample site PD5, immediately upstream of the Many Islands complex, and within Section 9 of Mon-2.

[a] Transects are sorted upstream to downstream.

[b] As viewed facing downstream.

[c] NAD83.

Appendix E

Mon-4 Site C Reservoir Riparian Vegetation Monitoring Program

SITE C RESERVOIR RIPARIAN VEGETATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-4 – Site C Reservoir Riparian Vegetation Monitoring Program
Description	This monitoring program will investigate the effectiveness of planned riparian planting adjacent to Site C Reservoir.
Key Project components / locations	Construction and Operation/Site C Reservoir.
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Mon-5 – Peace River Riparian Vegetation Monitoring Program
Schedule	Operations Years 1, 6, 15, and 25.

RATIONALE

BACKGROUND

The Site C Reservoir Riparian Vegetation Monitoring Program (this Program) will monitor the effectiveness of riparian plantings to provide riparian habitat in the planting area and bank stabilization. As a condition of the Provincial Environmental Assessment Certificate[1] for the Site C Clean Energy Project (the Project), BC Hydro will plant riparian vegetation on an estimated 16 ha of farmland adjacent to Site C Reservoir (described in the Fisheries and Aquatic Habitat Management Plan[2]). This 15 m wide riparian area will provide both riparian habitat and bank stabilization along the reservoir shoreline. The planting area has been identified as non-forested with a slope of less than 25%, suitable for riparian development. The planting proposed includes a mix of balsam poplar, willow, and red-osier dogwood live staked at densities of 4,000 stems/ha.

FISHERIES MANAGEMENT QUESTION

The fisheries management question (management question) that will be answered by this Program is as follows:

1. Is riparian planting along the Site C Reservoir shoreline effective in supporting the functional attributes of a healthy riparian ecosystem?

MANAGEMENT HYPOTHESES

The hypothesis to be tested by this Program is as follows:

H_1: Riparian planting along the shoreline of Site C Reservoir is effective in supporting the functional attributes of a healthy riparian ecosystem (e.g., bank stability, habitat quality, and shading)

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding the effectiveness of riparian plantings along the Site C Reservoir shoreline, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement. In addition, the information will provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[1]) and the Federal Decision Statement[3].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The overarching objective of this Program is to address the management question posed by collecting data necessary to draw inferences and to test the management hypothesis. The objective of this Program is to assess the establishment and effectiveness of riparian planting areas adjacent to Site C Reservoir in supporting the functional attributes of a healthy riparian ecosystem (e.g., bank stability, habitat quality, and shading). The scope

[1] EAC, Condition #4, Page 7
[2] Site C Fisheries and Aquatic Habitat Management Plan, 2015; Section 6.2.3.5, Reservoir Shoreline Riparian Planting
[3] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

of the program is to employ vegetation ground surveys to assess the effectiveness of riparian plantings at select index locations.

The temporal scope of this Program is limited to Operation Years 1 to 25; however, not all Program components are conducted each year.

The spatial scope of the Program is limited to the estimated 16 ha of riparian habitat to be planted.

APPROACH

The Program will document the establishment of riparian vegetation in planting areas adjacent to Site C Reservoir over a 25 year study period through the use of vegetation ground surveys.

TASKS

This Program includes the following tasks:

- Task 1 - Project Coordination
- Task 2 – Data Collection
    - Task 2a - Vegetation Survey and Bank Stability Assessment
- Task 3 - Data Analysis
    - Task 3a - Vegetation Survey and Bank Stability Assessment
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Vegetation Survey and Bank Stability Assessment. Surveys will evaluate the establishment of riparian plantings in the planting area by documenting species composition, survival, and density. Visual assessments of

bank stability in the planting area also will be conducted at this time. Data collected from post-planting surveys will be used to monitor the effectiveness of the reservoir riparian planting mitigation program.

The following activities are proposed:

1. The establishment of permanent benchmarking and geo-referenced vegetation surveys to allow repeated surveys through time at riparian planting locations.
2. The establishment of permanent photo-monitoring points to capture photographic records of site conditions over time, including bank stability and vegetation composition, survival, and density.
3. Assessments of late summer survival of riparian plantings at regular intervals (i.e., Operation Years 1, 6, 15, and 25).
4. Assessments of riparian vegetation species composition, survival, and density over time. This assessment will be based on data collected throughout the monitoring program.
5. Assessments of bank stability (including visual assessments of erosion and scour) and bank protection mechanisms, such as vegetation, roots, woody debris, and bank material.

In the event that rare plants (e.g., federally or provincially listed species) are found during surveys, these data will be provided to the Conservation Data Center (CDC) by the proponent as appropriate. Similarly, noxious weed species, if encountered, will be identified, entered into the Ministry of Forests and Range Invasive Alien Plant Program Application, and forwarded to the BC Hydro study representative. Weed sites also will be explicitly identified to monitor spread of these species over time.

Task 3. Data Analysis. Analyses to be conducted are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate.

Surveys will provide survival and density estimates of riparian plantings and measurements of natural vegetation establishment. Statistical analyses will follow accepted biometric standards such as Gaboury and Wong (1999), Machmer and Steeger (2002), and RISC (2007) for plant density and for continuous variables of vegetation growth (e.g., height and percent cover).

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any

necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[4].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. Some components of the Site C Fisheries and Aquatic Habitat Monitoring Program included synthesis reviews at regular intervals to integrate data collected under other components of the plan. However, synthesis reviews are not required for this Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Appropriate analytical techniques will be used to summarize data and assess the effectiveness of riparian planting along the Site C Reservoir shoreline. Of particular interest is the condition and diversity of riparian vegetation in the planting areas, and whether plantings are contributing to bank stability. Results of this Program will provide supporting data for conditions listed in the Provincial EAC[1] and the Federal Decision Statement[4].

[4] Decision Statement, October 14, 2014, Section 18 Record Keeping.

SCHEDULE

A tentative schedule for each Task within the Program is described below. Work associated with Task 1 (Project Coordination) would be ongoing on an “as needed” basis. The riparian planting could occur as early as Operation Year 1, however, this timing will depend on site conditions. The schedule for this Program is based on the assumption that riparian planting will occur during Operation Year 1, and may be adjusted based on the actual year that planting occurs.

Ideally, the annual workshop (Task 6) will be conducted during the late spring to early summer period. This would provide proponents with enough time to finalize previous year’s reports prior to the workshop while still providing enough time to implement any changes identified during the workshop prior to the next year’s field season.

REFERENCES

Gaboury, M. and R. Wong. 1999. A Framework for Conducting Effectiveness Evaluations of Watershed Restoration Projects. Watershed Restoration Technical Circular No. 12. 33p. + appendices.

Machmer, M. and C. Steeger. 2002. Effectiveness Monitoring Guidelines for Ecosystem Restoration, Final Report. Submitted to Habitat Branch, Ministry of Water, Land and Air Protection, Victoria, BC. Prepared by Pandion Ecological Research Ltd., Nelson, BC.

Resource Information Standards Committee (RISC). 2007. Vegetation Resources Inventory Ground Sampling Procedures, Version 4.7. 218 pp.

Appendix F

Mon-5 Peace River Riparian Vegetation Monitoring Program

PEACE RIVER RIPARIAN VEGETATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-5 - Peace River Riparian Vegetation Monitoring Program
Description	This monitoring program will assess the response of riparian vegetation to the construction and operation of Site C.
Key Project components / locations	River Channelization/ Operation / Peace River downstream of Site C.
Monitoring Category	Effectiveness and Validation Monitoring
Schedule	Construction Year 4, Operations every 2 years for the first ten years and then every 5 years for the next 15 years

RATIONALE

BACKGROUND

The response of the riparian ecosystem in the Peace River to previous developments in the Peace River is described in the Site C Clean Energy Project's (the Project) Environmental Impact Statement (EIS) as follows:

> "Downstream of the W.A.C. Bennett and Peace Canyon Dams, seasonal changes to the surface water regime have altered the structure of riparian vegetation communities (Church et al. 1997). Reduced annual flood flows and increased winter flows have modified the extent and seasonal timing of floodplain inundation. At upper elevations of the river floodplain, colonizing herb and shrub communities have encroached on exposed river bars due to reduced flood flows, and have progressed to early riparian forest stands. At lower floodplain elevations, successional processes have been delayed due to inundation during elevated spring and winter flows. Much farther downstream, where an annual ice cover forms, ice still plays a primary role in regulating vegetation succession by influence on water levels and through scour damage from ice jamming (Uunila 1997)." [1]

There is uncertainty in how succession would progress over time as it is dependent on river flows that in part dependent on upstream flow management.

The Project has the potential to affect riparian vegetation due to localized increases in the magnitude of peak flows, and more frequent high and low flows, from the Project downstream to the Pine River confluence. Changes in the extent of riparian vegetation can relate to fish habitat. In the case of wide, alluvial river systems such as the Peace Riparian, riparian habitat contributions are more limited compared with smaller stream environments. This program will monitor for changes in the extent of riparian vegetation associated changes to fish habitat.

FISHERIES MANAGEMENT QUESTION

The primary fisheries management questions (management questions) to be addressed by the Peace River Riparian Vegetation Monitoring Program (this Program) are as follows:

1. How does the construction and operation of the Project affect riparian vegetation in the Peace River downstream of the Project as it relates to fish habitat?
2. Can the effects of on-going succession from previous hydroelectric facilities upstream, floodplain natural variability, and climate change be identified separately from the effects that may be attributable to Project construction or operation?

The second question resolves around the challenge of assigning cause to any observed changes, given the natural variability and directional changes that are expected to occur with or without the Project.

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypothesis:

[1] EIS, Volume 2, Section 11

H_1: The construction and operation of the Project does not affect riparian vegetation on the Peace River floodplain between the Project and the Pine River as it relates to fish habitat.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding the status of riparian vegetation along the Peace River downstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement. In addition, the information will be used to verify predictions in the EIS and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[2]) and the Federal Decision Statement[3].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to monitor the extent of riparian vegetation in the Peace River downstream of the Project. The scope of the program is to employ vegetation transect surveys at index locations during Project construction and the first 25 years of Project operation.

The spatial scope of this Program is limited to the portion of the Peace River between the Site C dam site and confluence with Pine River.

APPROACH

The general approach will be to use information collected under and provided by the 'Downstream Rare Plant Occurrence and Riparian Vegetation Monitoring' program (described in Appendix D of the Site C Clean Energy Project Vegetation and Wildlife Mitigation and Monitoring Plan) and analyze and interpret the information as it relates to fish and fish habitat.

TASKS

This Program includes the following tasks:

- Task 1 - Project Coordination
- Task 2 – Data Collection
    - Task 2a - Aerial Imagery Interpretation
    - Task 2b - Vegetation Surveys/Ground Truthing
- Task 3 - Data Analysis
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

[2] EAC, Condition #7, Pages 8 to 9
[3] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Aerial Imagery Interpretation. Available aerial imagery will be used to support information from vegetation surveys (Task 2b). Guidelines for photo interpretation are set out in Resource Inventory Committee (RIC) standards for Vegetation Resources Inventories and TEM (RIC 1998, 2002, 2010).

Task 2b. Vegetation Surveys/Ground Truthing. Information from riparian transects will be collected under the Downstream Rare Plant Occurrence and Riparian Vegetation Monitoring program. Vegetation surveys will include descriptions of sites, and soil and vegetation characteristics using provincial standards (BC MOFR and MOE 2010).

Task 3. Data Analysis. Analyses and interpretation will describe the potential implications to fish and fish habitat of observed changes in the extent of riparian vegetation. Quality assurance for aerial photo interpretation and LiDAR analyses will be conducted throughout Task 2a to confirm accuracy and consistency (e.g., RIC 2006).Data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[4].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. Some components of the Site C Fisheries and Aquatic Habitat Monitoring Program included synthesis reviews at regular intervals to integrate data collected under other components of the plan. However, synthesis reviews are not required for this Program.

SCHEDULE

The schedule of surveys is listed in the Downstream Rare Plant Occurrence and Riparian Vegetation Monitoring program, and involves surveys beginning in the year before river diversion (Construction Year 4). During operation,

[4] Decision Statement, October 14, 2014, Section 18 Record Keeping.

surveys will be conducted every 2 years for the first ten years and every 5 years for the next 15 years. Surveys will be conducted between June and September.

REFERENCES

BC MOFR and MOE (British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment). 2010. Field manual for describing terrestrial ecosystems. -- 2nd ed. BCMFR Research Branch and BCMOE Resource Inventory Branch, Victoria, B.C. (Reprint with updates 2015.)

Church, M., J. Xu, A. Moy, and L. Uunila. 1997. Changes in morphology and riparian vegetation following flow regulation, Peace River, 1968 and 1993. Northern River Basins Study, Project Report 102. Alberta Environmental Protection. Edmonton, AB.

RIC (Resources Inventory Committee). 1998. Standard for terrestrial ecosystem mapping in British Columbia. Resources Inventory Committee Terrestrial Ecosystems Task Force, Ecosystems Working Group, Victoria, BC.

RIC (Resource Information Standards Committee). 2002. Vegetation Resources Inventory Photo Interpretation Procedures. Version 2.4. Available at: http://www.for.gov.bc.ca/ric.

RIC (Resource Information Standards Committee). 2006. Standards for Mapping Ecosystems at Risk in British Columbia. An Approach to Mapping Ecosystems at Risk and Other Sensitive Ecosystems. Version 1.0. BC Ministry of Environment, Ecosystems Branch. Available at: http://ilmbwww.gov.bc.ca/risc/.

RIC (Resource Information Standards Committee). 2010. Vegetation Resources Inventory Ground Sampling Procedures, VRI Ground Sampling Procedures. Version 4.9. Available at: http://www.ilmb.gov.bc.ca/risc/index.html

Uunila, L.S. 1997. Effects of river ice on bank morphology and riparian vegetation along Peace River, Clayhurst to Fort Vermilion. Proceedings of the 9th Workshop on River Ice. 24-26.

Appendix G

Mon-6 Site C Reservoir Fish Food Organisms Monitoring Program

SITE C RESERVOIR FISH FOOD ORGANISMS MONITORING PROGRAM

SUMMARY

ID	Site C Mon-6 – Site C Reservoir Fish Food Organisms Monitoring Program
Description	This study will investigate the effects of Site C Reservoir formation on the production of fish food organisms.
Key Project components / locations	Construction and Operation / Baseline sites in Williston and Dinosaur Reservoirs and in the Site C Reach (i.e., the reach of the Peace River to be inundated) maintained through all phases of construction and operation.
Monitoring Category	Effectiveness and Validation Monitoring
Conditionality of Initiation	Reservoir Filling
Closely related studies	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-7 – Peace River Fish Food Organisms Monitoring Program • Mon-8 – Site C Reservoir Water and Sediment Quality Monitoring Program
Schedule	Construction Years 2 and 3 followed by 5-year continuous monitoring blocks beginning Operation Years 3 and 15.

RATIONALE

BACKGROUND

The focus of the Site C Reservoir Fish Food Organisms Monitoring Program (this Program) is to monitor temporal changes in the biomass and production of invertebrate food for fish and underlying processes that support that food production in the Site C Reach (prior to reservoir filling) and Site C Reservoir (after reservoir filling). The Site C Reach is defined as the portion of the Peace River that will be inundated by the Project and includes the Peace River between Peace Canyon Dam (PCD) and the dam site. As described in the Site C Environmental Impact Statement (EIS), fish habitat, and fish use of that habitat, is expected to change in the Site C Reach with the construction of the dam[1].

As described in the EIS, the change from a river to a reservoir in the Site C Reach will result in a loss of 29.6 km^2 of lotic habitat (in the mainstem and the lower reaches of tributaries), a gain of 9.4 km^2 of littoral habitat, and a gain of 83.6 km^2 of pelagic habitat, resulting in a net gain of 63.4 km^2 of aquatic habitat[2]. Given this change in the amount and type of habitat available, fish food organisms upstream of the dam site between years before and after the construction of the Project will change from an assemblage comprised of benthic invertebrates produced in the Site C Reach and zooplankton drifting from Dinosaur Reservoir to one comprised of zooplankton drifting from Dinosaur Reservoir and being produced in pelagic habitats of Site C Reservoir and benthic invertebrates being produced in littoral habitat of Site C Reservoir. During baseline studies[3], the mean annual areal production of benthic invertebrates (mass/m^2/yr) in lotic habitats of the Site C Reach (62 g dry wt/m^2/yr) were shown to be 30 times greater than in pelagic habitat in Dinosaur Reservoir (2.2 g dry wt/m^2/yr). The larger area of pelagic habitat in Site C Reservoir compared to present lotic habitat may offset the difference in production between habitat types, resulting in little change over time after reservoir formation[4]. Over time, invertebrate production and availability of food for fish in Site C Reservoir may also be similar to that in the existing river.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management questions (management questions) to be addressed by this Program are as follows:

1. What is the change in areal biomass and reach-wide biomass of fish food organisms in the Site C Reach between years before and after construction of the Project?
2. What is the change in production of fish food organisms in the Site C Reach between years before and after construction of the Project?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring of changes in biomass and the production of fish food organisms to address the following hypotheses:

H_1: Reach-wide biomass of invertebrates in the Site C Reach will be the same between years before and after reservoir formation.

[1] EIS, Volume 2, Section 12
[2] EIS, Section 12.4.2.1, 12-37
[3] EIS, Volume 2, Appendix P, Part 1
[4] EIS, Section 12.4.2.1, 12-38

H_2: The production of fish food organisms in the Site C Reach will be the same between years before and after reservoir formation.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish food abundance and productivity in Site C Reservoir, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement. In addition, the information will be used to verify predictions in the EIS[5] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[6]) and the Federal Decision Statement[7].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to validate predictions and address uncertainties identified in the EIS regarding the Project's effects on fish food organisms upstream of the dam site.

During construction, the spatial scope of this Program is limited to the portion of the Peace River between PCD and the Site C dam site (i.e., the Site C Reach) with reference sites situated in Dinosaur and Williston reservoirs and the Halfway and Moberly rivers. During operation, the spatial scope of this Program is limited to Site C Reservoir (including inundated portions of the Halfway and Moberly rivers) with reference sites situated in Dinosaur and Williston reservoirs.

The temporal scope of this Program includes Construction Years 1 to 9 and Operation Years 1 to 30; however, not all tasks (see below) occur during each study year.

APPROACH

Areal biomass is expressed in units of mass/m^2 and *reach-wide biomass* is areal biomass multiplied by the total area of habitat available and is expressed in units of mass. Benthic invertebrate food that is potentially available to fish is the food found in a given area of substrate as defined in the EIS[3]. Invertebrate production is expressed as mass·km^{-2}·$year^{-1}$. Whole reach production is defined as mass·$year^{-1}$ and calculated as production multiplied by area of the reach of interest.

In a reservoir, food for fish includes zooplankton and emerging benthic invertebrates that are available in the water column. Fish also can ingest invertebrates from terrestrial sources that land on the water surface. In a river, benthic invertebrates will drift at rates determined by flow, time of day, and benthos density (Kennedy et al. 2014). Drift can also be zooplankton that originates from the upstream Dinosaur Reservoir and it can be fallout of terrestrial invertebrates that land on the water surface.

Changes in biomass and production from all sources (zooplankton plus benthic invertebrates) can be measured in a before after control impact (BACI) design following the approach of Stewart-Oaten et al. (1986). In this approach, the difference in reach-wide biomass or production of fish food organisms between a treatment and a control area

[5] EIS, Volume 2, Section 12
[6] EAC, Condition #7, Pages 8 to 9
[7] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

before the formation of the reservoir will be tested against the difference after the formation of the reservoir. The treatment area will be the Site C Reach and the control area will be Dinosaur Reservoir. For the purposes of establishing timeframes for before and after sampling, the before period will include baseline data collected in 2010 and 2011[3], and 2012[8], and an additional two years of data scheduled to be collected in Construction Years 3 and 4 prior to the formation of the Site C Diversion Headpond in Construction Year 5. The after period begins with the start of Project operation in Operation Year 1. Two assessments will be conducted during the after period. One of these assessments will be conducted within the first 10 years of Project operation. This assessment will monitor changes in areal fish food biomass in pelagic habitats over the near term (i.e., when trophic upsurge associated with the flooding of soils in areas adjacent to the active river channel would be expected). A second assessment will be conducted after Operation Year 15 to monitor changes in areal fish food biomass in pelagic habitats over the long term (i.e., when trophic depression following the initial release of nutrients from flooded soils would be expected). Each of the three assessment periods will include 5 years of monitoring. Years are replicates in this design, which means there will be five replicates in each of the three blocks of years (one before block and two after blocks). Data will be collected at the same locations that were sampled during baseline studies Table 1. During both the before and after periods, areal biomass and production at Sites PR1, PR2, and PR3 (Table 1) will be averaged for the calculation of reach-wide biomass and production in the Site C Reach. An advantage of having a longitudinal series of sample sites from W1 downstream to PR3 is that patterns in invertebrate assemblages, biomass, and production that provides food for fish over the upstream to downstream gradient can be examined to supplement tests of reservoir development on biomass and production metrics. As the river is changed to a reservoir between PCD and Site C, compiled data will support analyses to show the spatial and temporal shift in assemblages, biomass, and production. A particularly valuable analysis to support interpretations of change in fish populations will be comparison of the ontogeny between the established Dinosaur Reservoir and Site C Reservoir using the invertebrate metrics and supporting habitat attributes.

Invertebrate drift rate is a measure of food available to fish in a river (Allan 1978) but it is sensitive to flow, time of day, and benthos densities (Kennedy et al. 2014). This sensitivity makes drift rate measurements highly variable with change in flow, time of day, and benthos density. The objective of this monitor is not to explain drift but it is to provide a reliable index of food being produced for fish. Due to logistics of operating over long distances on the Peace River, it will not be possible to standardize drift sampling to flow and time of day, which will result in variable and potentially unusable data for purposes of this monitor. In addition, drift was not measured for all of the pre-construction years (2010, 2011, 2012) at all sites, making it not usable as an endpoint for the BACI layout. Given that drift is a function of benthos density, it is preferable to measure that density and the related biomass and production that drives food availability for fish.

Table 1. Proposed sample sites for monitoring biomass and the availability of fish food organisms upstream of Site C dam site before and after reservoir formation.

Site Name (Site Code)	Pre-Reservoir Samples	Post-Reservoir Samples	UTM Easting[a]	UTM Northing[a]	Description
Williston (W1)	Pelagic	Pelagic	549540	6209610	Reference reservoir site.
Dinosaur (D1)	Pelagic & Littoral	Pelagic & Littoral	562028	6203491	Reference reservoir site.
Upper Site C Reservoir (PR1)[b]	Lotic	Pelagic & Littoral	566122	6207857	Near the community of Hudson's Hope.
Middle Site C Reservoir (PR2)	Lotic	Pelagic & Littoral	594889	6229426	Upstream of the Halfway River confluence.
Lower Site C Reservoir (PR3)	Lotic	Pelagic & Littoral	628028	6231374	Upstream of the Moberly River confluence.

[8] EIS, Volume 2, Appendix P, Part 1, Appendix A

Halfway River – Downstream (HD)	Lotic	Pelagic & Littoral	596649	6231488	After reservoir creation, this site will monitor water quality in the reservoir embayment created by the inundation of the Halfway River.
Moberly River – Downstream (MD)	Lotic	Pelagic & Littoral	628620	6230146	After reservoir creation, this site will monitor water quality in the reservoir embayment created by the inundation of the Moberly River.

[a] NAD 83, Zone 10.
[b] This site may need to be relocated approximately 3 km downstream after reservoir creation to monitor permanently inundated conditions in Site C Reservoir.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
  - Task 2a - Biomass and Production of Fish Food Organisms
  - Task 2b - Ecosystem Attributes
- Task 3 – Data Analysis
  - Task 3a - Biomass and Production of Fish Food Organisms
  - Task 3b - Ecosystem Attributes
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Table 2: Overview of proposed surveys to be conducted under the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6).

Task	Task Name	Performance Measures	Survey Method	Schedule	
				Construction Years 1 to 9	Operation Years 1 to 30
2a	Biomass and production of Fish Food Organisms	Zooplankton biomass and production Benthic invertebrate biomass and production	Plankton nets Benthic basket samplers Benthic grab samplers Fish stomach contents	Years 3 and 4	Years 3 to 7 Years 15 to 19
2b	Ecosystem Attributes	n/a	n/a	Years 3 and 4	Years 3 to 7 Years 15 to 19

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Biomass and Production of Fish Food Organisms. Zooplankton biomass will be measured from spring to fall (i.e., May to October) at all pelagic sites identified in Table 1. Zooplankton production will be calculated from the biomass measurements as described in the EIS[3]. Benthic invertebrate biomass will be measured once in spring and late summer or fall, with the latter sampling coinciding with the collection of data under the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey (Task 2a of the Site C Reservoir Fish Community Monitoring Program; Mon-1a) and the Peace River Fish Composition and Abundance Survey (Task 2b of the Peace River Fish Community Monitoring Program; Mon-2). The spring and fall data will provide the amount of information needed for calculation of annual production as outlined in the EIS[3]. Within the footprint of Site C Reservoir, benthic invertebrates will be collected from lotic habitats before reservoir inundation and from littoral and profundal habitats after reservoir inundation. Zooplankton will be collected using standard vertical hauls of a plankton net with a mesh size not greater than 153 µm. In lotic habitat, benthic invertebrates will be collected from basket samplers following seven weeks of incubation in the river using methods described in the EIS[3].

In Site C Reservoir, benthic invertebrates will be collected using a grab sampler and using basket samplers as described in the EIS[3]. Using two different methods to sample the benthic invertebrate community will ensure consistency with baseline studies, while providing an opportunity to test grabs of newly submerged soils. In addition to testing the effectiveness of grab and basket sampling methods, the relative contributions of profundal benthic invertebrates to overall benthic biomass can be assessed. These areas will be sampled by collecting samples along depth gradients from shallow littoral to deep benthic habitats at each of the five Site C Reservoir sites (i.e., PR1 to PR3, HD, and MD).

Terrestrial invertebrates are expected to be a small part of the diets of fish in the study area. The availability of terrestrial invertebrates as fish food in the study area will be monitored by enumerating fish stomach contents. Terrestrial invertebrates will not be otherwise measured as part of this Program. During Construction Years 3 and 4, fish stomach contents will be analyzed using samples collected from fish captured during the Peace River Large Fish Indexing Survey (Task 2a of the Peace River Fish Community Monitoring Program; Mon-2). During Operation Years 3 to 7, 16, and 18, fish stomach contents will be analyzed using samples collected from fish captured during the Site C Reservoir Hydroacoustic, Trawl, and Gillnet Survey (Task 2a of the Site C Reservoir Fish Community Monitoring Program; Mon-1a).

Tissue samples will be collected from select zooplankton and benthos samples. Processing of these samples will take place if and when required by participants in the annual or 5 year synthesis workshops. For planning purposes, samples can be collected from each sample location once during each study year. ***Task 2b. Ecosystem Attributes.*** Measurement of habitat attributes and algal biomass that supports invertebrate assemblages within the food webs before and after reservoir formation will be made to assist with the interpretation of the invertebrate data. The following metrics will be measured:

- **Habitat area.** Areas of lotic, littoral, and pelagic habitats in Dinosaur Reservoir and the Site C Reach over time using GIS techniques.
- **Photosynthetically active radiation (PAR) after reservoir formation**. PAR includes wavelengths of light that drive photosynthesis, the energy source for biological production among algae within rivers, lakes, and reservoirs. Attenuation of PAR over a water column is needed to determine the depth of the euphotic zone, the upper layer where the rate of photosynthesis exceeds the rate of respiration and biomass can be

produced. PAR over the water column will be measured monthly in May through October at each sampling site during each year after reservoir formation.

- **Turbidity and suspended solids concentrations.** Changes in PAR that drives autochthonous biological production can be influenced by bank slumping, wind and wave erosion, and other physical changes that introduce particles to the water column. These particles will be monitored using measurement of turbidity and suspended solids concentrations. Both parameters will be measured monthly at each sample site between May and October in all study years both before and after reservoir formation. After reservoir formation, turbidity will be measured over the water profile at each station and suspended solids concentration will be measured in a water sample collected at the water surface and within 2m of the sediment – water interface.
- **Water residence time.** Water residence time of the reservoir (water volume divided by rate of outflow) is needed to determine the potential time available for zooplankton to reproduce and add biomass after reservoir formation.
- **Water temperatures.** Water temperature will be measured at each sample site using an anchored continuous temperature logger.
- **Nutrient concentrations and other water quality measurements.** A suite of nutrient concentrations (soluble reactive phosphorus, total dissolved phosphorus, total phosphorus, total nitrogen, ammonium, nitrate) and other chemical analytes that will be used to assist with interpreting spatial and temporal variation in nutrient concentrations will be monitored to identify changes in nutrient load and assist with the interpretation of trophic upsurge and trophic depression in the reservoir. The analytes other than nutrient concentrations will include pH, alkalinity, dissolved oxygen (DO) concentration, total dissolved solids (TDS) concentration, and specific conductance. These measurements are required to assist with the interpretation of chemical fluxes that influence habitat for fish and fish food organisms in the study area, particularly in relation to chemical fluxes at the sediment (soil) – water interface that influences the quality of overlying water. Before reservoir formation, these metrics will be measured at the river surface at each site and after reservoir formation they will be measured over the water profile (pH, DO concentration, TDS, specific conductance) or at the surface and within 2m of the sediment – water interface (nutrients, alkalinity) at each site. These metrics will be monitored under the Site C Reservoir Water and Sediment Quality Monitoring Program (Mon-8).
- **Trophic state.** Trophic state will be monitored after reservoir formation. It will be defined by Secchi depth, total phosphorus concentration, chlorophyll-*a* concentrations, and total nitrogen concentration at each site. Trophic state can range from oligotrophic (very nutrient deficient and low algal biomass) to eutrophic (high nutrient concentrations that are biologically available and high algal biomass that can, in some cases, impair habitat for fish and other aquatic organisms. These parameters will be measured in situ (Secchi depth) and from monthly water samples that are collected as part of Mon-8. Chlorophyll-*a* concentrations will be determined from monthly water samples collected at several depths over the depth of the euphotic zone at each site.
- **Algal biomass and composition.** Algae provide food for zooplankton and benthic invertebrates. Before formation of the reservoir periphyton biomass and composition will be measured using the accrual technique on artificial substrata using methods that are described in the EIS[3]. After formation of the reservoir phytoplankton biomass and composition will be measured from samples collected over the euphotic zone, again using methods that were used in the EIS[5]

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a and 2b are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Analyses for this Program will be similar to those employed in the EIS[3,8] to ensure compatibility with baseline datasets. A focus of annual data analysis will be the ongoing preparation of data for the eventual BACI analysis and the use of descriptive information to assist with interpretation of spatial and temporal variation in the biomass, zooplankton and benthic invertebrate species composition, and production of invertebrates that are fish food organisms. Over time, an integration of results from this Program and the Site C Reservoir Fish Community Monitoring Program (Mon-1a) will be required to eventually provide an understanding of links between change in hydrological conditions, change in food production for fish, and change in fish biomass and assemblages.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[9].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any

[9] Decision Statement, October 14, 2014, Section 18 Record Keeping.

field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Reservoir Fish Food Organisms Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted upon completion of each 5-year monitoring period. These include Construction Year 4 and Operation Years 7 and 19. The synthesis reports will collate all data collected under the Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on fish food organisms upstream of Site C. If a statistically significant effect on overall biomass and production of invertebrates (zooplankton and benthos) is found from the BACI analyses and from lines of evidence run before the formal BACI statistics , then formation of the reservoir will deemed to have changed the total biomass or production of food for fish upstream of Site C. That or alternative findings will contribute to future decisions on fish population management and monitoring requirements. Conclusions will be supported with multivariate analyses to examine changes in whole assemblages of invertebrates over years and locations, and to identify taxa that are most important in responding to changes in habitat.

SCHEDULE

A tentative schedule for this Program is outlined below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. Ideally, the annual workshop (Task 6) will be conducted during the early spring to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop before the following field season. The synthesis review (Task 7) will be conducted after the completion of each 5-year monitoring block (Construction Year 4 and Operation Years 7 and 19).

During each study year, data will be collected between May and October. Five replicate years will be assigned to each block of analyses. Data collected in Construction Years 3 and 4 will be combined with baseline data collected in 2010 and 2011[3], and 2012[8] to form the first block for analyses. The second five year block will begin during trophic upsurge in Operation Year 3 (near term) and the third five year block will begin during trophic depression in Operation Year 15 (long term). A summary of sampling to be conducted under this Program is detailed in Table 3. Sampling conducted under this Program coincides with sampling proposed under the Peace River Fish Food organisms Monitoring Program (Mon-7).

Table 3. A summary of proposed sampling to be conducted under the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6).

Task	Phase of Assessment	Years
Task 2a - Biomass and Production of Fish Food Organisms	Pre-reservoir	Construction Years 3 and 4[a]
Task 2b - Ecosystem Attributes		
Task 2a - Biomass and Production of Fish Food Organisms	Reservoir term 1 (during potential trophic upsurge)	Operations Years 3 to 7
Task 2b - Ecosystem Attributes		
Task 2a - Biomass and Production of Fish Food Organisms	Reservoir term 2 (during potential trophic depression)	Operation Years 15 to 19[b]
Task 2b - Ecosystem Attributes		

[a] These data will be coupled with baseline data collected in 2010 and 2011[3], and 2012[8] to provide a 5-year block of data.

[b] For planning purposes, these data are scheduled to be collected between Operation Years 15 to 19, but they can be scheduled for any 5-year period after approximately Operation Year 10.

REFERENCES

Allan, J.D. 1978. Trout predation and the size composition of stream drift. Limnology and Oceanography. 23: 1231-1237.

Kennedy, T.A., C.B. Yackulic, W.F. Cross, P.E. Grams, M.D. Yard, and A.J. Copp. 2014. The relation between invertebrate drift and two primary controls, discharge and benthic densities, in a large regulated river. Freshwater Biology. 59: 557-572.

Stewart-Oaten, A., W.W. Murdoch and K.R. Parker. 1986. Environmental impact assessment: "pseudoreplication" in time? Ecology 67(4): 929-940.

Appendix H

Mon-7 Peace River Fish Food Organisms Monitoring Program

PEACE RIVER FISH FOOD ORGANISMS MONITORING PROGRAM

SUMMARY

ID	Site C Mon-7 – Peace River Fish Food Organisms Monitoring Program
Description	This Program will investigate the effects of dam construction and operations on the biomass and production of invertebrates, including fish food organisms, downstream of Site C.
Key Project components / locations	Construction and Operation / Baseline sites in the Peace River and tributaries downstream of Site C.
Monitoring Category	Effectiveness and Validation Monitoring
Conditionality of Initiation	This Program will commence during Project construction to monitor invertebrates and availability of fish food organisms prior to any downstream alteration to the flow regime, water quality, and habitat.
Closely related studies	• Mon-2 – Peace River Fish Community Monitoring Program • Mon-6 – Site C Reservoir Fish Food Organisms Monitoring Program • Mon-8 – Site C Reservoir Water and Sediment Quality Monitoring • Mon-9 – Peace River Water and Sediment Quality Monitoring
Schedule	Construction Years 3 and 4 followed by five-year continuous monitoring blocks beginning Operation Years 3 and 15.

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, regulatory agencies, and stakeholders. Section 12.1.2 of the Site C Environmental Impact Statement (EIS) states that the Site C Clean Energy Project (the Project), including Project construction, reservoir filling, and operation, could affect fish and fish habitat via three key pathways: changes to fish habitat (including nutrient concentrations and production of lower trophic biota that provides food for fish), changes to fish health and fish survival, and changes to fish movement.

The focus of the Peace River Fish Food Organisms Monitoring Program (this Program) is to monitor temporal changes in the biomass and production of invertebrate food for fish and underlying processes that support that food production in the Peace River downstream of the Project during Project construction and operation.

Fish habitat and fish use of that habitat in the Peace River downstream of the Project is expected to change with the construction and operation of the Project. One predicted change that is described in the EIS is a three-fold decline in the biomass of invertebrates available as food for fish immediately downstream of the Project due to the interruption of recruitment from upstream by the formation of Site C Reservoir.[3]

The EIS predicted that habitat area downstream of the Project will not change following the construction of the Project; however, hydrologic changes will occur[4]. Daily cycles of dewatering and inundation due to the Project are expected to cause fluctuations in the area of available habitat along the river. The daily variation in water elevation in the river will have decreasing influence with distance downstream of the Project as tributary inflows contribute flow and variability to the Peace River. With limited storage capacity in Site C Reservoir, seasonal changes in flow releases from the Project will be determined by the amount of water released from Williston Reservoir and passed through Dinosaur Reservoir with variation added from tributary inflows. Flow simulations in the EIS showed that the area of river habitat between the Site C dam site and the Pine River is expected to increase by 5% at low flows and by 14% at high flows when compared to existing conditions. Farther downstream, changes are expected to be less as inflows from tributaries will attenuate the effects of flow control due to the Project.

This Program includes measurements of temporal changes in biomass and production of invertebrates, including those that are food for fish, and underlying processes supporting food production in the Peace River downstream of the Project before and after construction. The study area includes the Peace River from Site C downstream to the Many Islands area in Alberta, a distance of approximately 120 km.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management questions (management questions) to be addressed by this Program are as follows:

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 12.4.2.2, 12-47
[4] EIS, Volume 2, Appendix P, Part 3.

1. What is the change in areal biomass of fish food organisms in the Peace River between years before, during, and after construction of the Project?
2. What is the change in production of fish food organisms in the Peace River between years before, during, and after construction of the Project?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring of changes in biomass and the availability of fish food organisms in the Peace River to address the following hypotheses:

H_1: Reach-wide biomass of invertebrates in the Peace River between the Project and the Many Islands area in Alberta will remain the same over time before, during, and after the construction of the Project.

H_2: The production of fish food organisms in the Peace River between the Project and the Many Islands area in Alberta will remain the same over time before, during, and after the development of the Project.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish food abundance and distribution in Site C Reservoir, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement. In addition, the information will be used to verify predictions in the EIS[5] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[6]) and the Federal Decision Statement[7].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to validate predictions and address uncertainties identified in the EIS regarding the Project's effects on fish food organisms in the Peace River downstream of the dam site by monitoring the reach-wide biomass and production of benthic invertebrates during and after the development of the Project. These data will be used by the Peace River Fish Community Monitoring Program (Mon-2) to assess whether changes in fish food availability influences fish biomass or fish community structure.

The spatial scope of this Program is limited to the portion of the Peace River situated between the Site C dam site and the Many Islands area in Alberta. The spatial scope of this Program was guided by feedback from First Nations, regulatory agencies, and various stakeholders.

The temporal scope of this Program includes Construction Years 3 and 4 and Operation Years 3 to 7 and 15 to 19.

[5] EIS, Volume 2, Section 12
[6] EAC, Condition #7, Pages 8 to 9
[7] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

APPROACH

Areal biomass is expressed in units of mass·m^{-2} and *reach-wide biomass* is areal biomass multiplied by the total area of habitat available and is expressed in units of mass. Benthic invertebrate food that is potentially available to fish is the food found in a given area of substrate as defined in the EIS[5]. Invertebrate production is expressed as mass·km^{-2}·$year^{-1}$. Whole reach production is defined as mass·$year^{-1}$ and calculated as production multiplied by area of the reach of interest. Fish also can ingest invertebrates from terrestrial sources that land on the water surface. In a river, benthic invertebrates will drift at rates determined by flow, time of day, and benthos density (Kennedy et al. 2014). Drift can also be zooplankton that originates from the upstream Dinosaur Reservoir and it can be fallout of terrestrial invertebrates that land on the water surface.

Changes in whole-reach biomass and food availability will be compared among three assessment periods: pre-diversion; early post-construction; and late post-construction. The pre-diversion period includes three years of baseline data collected between 2010 and 2012[8,9] with two years of supplemental data that will be collected during Construction Years 3 and 4 (i.e., during river channelization). The early and late post-construction assessment periods will begin in Operation Years 3 and 15, respectively. Each assessment period will consist of five years of monitoring.

Sampling under this Program will be conducted at the same Peace River sites that were monitored during baseline studies conducted between 2010 and 2012 as well as at two new sites situated between the Kiskatinaw River confluence and the Many Islands area in Alberta (Table 1).

Table 1. Proposed sample sites for monitoring biomass and the availability of fish food organisms in the Peace River downstream of the Site C Clean Energy Project before and after the Project's development.

Site Name (Site Code)	Sample Type	UTM Zone[a]	UTM Easting[a]	UTM Northing[a]	Description
Peace River immediately upstream of Pine River (PD1)	Invertebrate biomass and production	11	640247	6226276	Peace River upstream of the Pine River confluence.
Peace River immediately upstream of the Beatton River (PD2)	Invertebrate biomass and production	11	661946	6220293	Peace River upstream of the Beatton River confluence.
Peace River immediately upstream of the Kiskatinaw River (PD3)	Benthic Drift	11	672509	6220751	Peace River upstream of the Kiskatinaw River confluence.
Peace River immediately upstream of the Pouce Coupe River (PD4)	Benthic Drift	10	317989	6225175	Peace River upstream of the Pouce Coupe River confluence. There are no existing baseline data for this location
Peace River at Many Islands (PD5)	Benthic Drift	10	364653	6242006	Peace River near Many Islands, Alberta. There are no existing baseline data for this location

[b] NAD 83.

During both the before and after periods, areal biomass at Sites PD1 to PD5 (Table 1) will be averaged to estimate reach-wide biomass for the study area. An advantage of having a longitudinal series of sample sites from PD1 downstream to PD5 is that patterns in the availability of fish food organisms over the upstream to downstream gradient can be examined to supplement tests of time effects on areal biomass and the availability of fish food organisms and links between any changes in benthic invertebrate assemblages and habitat attributes.

[8] EIS, Volume 2, Appendix P, Part 1
[9] EIS, Volume 2, Appendix P, Part 1, Appendix A

Significant differences of biomass and production between blocks of time will be interpreted as a temporal change potentially related to Site C. Multivariate analyses will be used to assess links between invertebrate assemblages and habitat attributes to assist with interpreting reasons for differences among assessment periods.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a - Biomass and Production of Fish Food Organisms
    - Task 2b - Ecosystem Attributes
- Task 3 – Data Analysis
    - Task 3a - Biomass and Production of Fish Food Organisms
    - Task 3b - Ecosystem Attributes
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Table 2. Overview of proposed surveys to be conducted under the Peace River Fish Food Organisms Monitoring Program (Mon-7).

Task	Task Name	Performance Measures	Survey Method	Schedule	
				Construction Years 1 to 9	Operation Years 1 to 30
2a	Biomass and Production of Fish Food Organisms	Benthic invertebrate biomass and production	Benthic basket samplers Fish stomach contents	Years 3 and 4	Years 3 to 7 Years 15 to 19
2b	Ecosystem Attributes	n/a	standard methods for physical, chemical, and biological variables	Years 3 and 4	Years 3 to 7 Years 15 to 19

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of

data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Biomass and Availability of Fish Food Organisms. Benthic invertebrate biomass will be measured once in spring and late summer or fall, with the latter sampling coinciding with the collection of data under the Peace River Fish Composition and Abundance Survey (Task 2b of the Peace River Fish Community Monitoring Program; Mon-2). The spring and fall data will provide the minimum amount of information needed for calculation of annual production as outlined in the EIS[8]. Benthic invertebrates will be collected from basket samplers following seven weeks of incubation in the river using methods outlined in the EIS[8].

The availability of terrestrial invertebrates as fish food in the study area will be monitored by enumerating fish stomach contents. Terrestrial invertebrates will not be otherwise measured as part of this Program. During Construction Years 3 and 4, fish stomach contents will be analyzed using samples collected from fish captured during the Peace River Large Fish Indexing Survey (Task 2a of the Peace River Fish Community Monitoring Program; Mon-2).

Tissue samples will be collected from select benthos samples. Processing of these samples will take place if and when required by participants in the annual or 5 year synthesis workshops. For planning purposes, samples can be collected from each sample location once during each study year.

Task 2b. Ecosystem Attributes. Measurements of other aspects of the ecosystem will be made to assist with the interpretation of invertebrate biomass data. These will include the following metrics:

- **Habitat area.** Areas of lotic habitats in the Peace River between Site C and the Many Islands area in Alberta will be quantified over time using GIS techniques.
- **Turbidity and suspended solids concentrations.** Changes in irradiance that drives autochthonous biological production can be influenced by physical changes that introduce particles to the water column. These particles will be monitored using measurement of turbidity and suspended solids concentrations. Both parameters will be measured monthly at each sample site between May and October during study years and also will be monitored at multiple locations downstream of the Project as part of the Site C Construction Monitoring Plan. Where possible, turbidity will be continuously monitored using instrumentation at each of the invertebrate sampling sites.
- **Water temperature.** Water temperature will be measured at each invertebrate sampling site using continuous temperature loggers attached to sampling equipment.
- **Nutrient concentrations and other water quality measurements.** A suite of nutrient concentrations (soluble reactive phosphorus, total dissolved phosphorus, total phosphorus, total nitrogen, ammonium, nitrate) and other chemical analytes that will be used to assist with interpreting spatial and temporal variation in nutrient concentrations will be monitored to identify changes in nutrient transport and assist with the interpretation of biological production in the river. The analytes other than nutrient concentrations will include pH, alkalinity, dissolved oxygen (DO) concentration, total dissolved solids (TDS) concentration, and specific conductance. These measurements are required to assist with the interpretation of chemical fluxes that influence habitat for fish and fish food organisms in the study area. These chemical data will be obtained from the Peace River Water and Sediment Quality Monitoring Program (Mon-9).
- **Algal biomass and composition.** Algae provide food for benthic invertebrates. Periphyton biomass and composition will be measured using the accrual technique on artificial substrata using methods described in the EIS[8].

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a and 2b will be similar to those employed in the EIS[8,9] to ensure compatibility with baseline datasets. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[10].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented.

[10] Decision Statement, October 14, 2014, Section 18 Record Keeping.

For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Peace River Fish Food Organisms Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures. The synthesis review will be conducted upon completion of each five-year monitoring period. These include Construction Year 4 and Operation Years 7 and 19. The synthesis reports will collate all data collected under the Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on fish food organisms downstream of the Project. Results will be interpreted with a focus on linking benthic invertebrate biomass and production metrics with habitat attributes to determine the importance of hydrologic factors associated with development of Site C on those biological metrics. Strong association between Site C related factors and benthic invertebrate biomass and production determined using temporal contrasts and multivariate approaches that focus on biotic – abiotic linking will provide evidence of effects of the Project on production of fish food organisms. Results from the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6) will assist with interpretations.

SCHEDULE

A tentative schedule for this Program is detailed below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. Ideally, the annual workshop (Task 6) will be conducted during the late spring to early summer period to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop before the next year's field season. The synthesis review (Task 7) will be conducted after the completion of each five-year monitoring block (Construction Year 4 and Operation Years 7 and 19).

During each study year, data will be collected between May and October. Five replicate years will be assigned to each block of analyses. Data collected in Construction Years 3 and 4 will be combined with baseline data collected in 2010 and 2011[8], and 2012[9] to form the first block for analyses. The second five-year block (near term) will begin during Operation Year 3. The third five-year block will begin during Operation Year 15 (long term). Sampling conducted under this Program coincides with sampling proposed under the Site C Reservoir Fish Food organisms Monitoring Program (Mon-6). A summary of sampling to be conducted under this Program is detailed in Table 3.

Table 3. A summary of proposed sampling to be conducted under the Peace River Fish Food Organisms Monitoring Program (Mon-7).

Task	Phase of Assessment	Years
Task 2a - Biomass and Production of Fish Food Organisms	Pre-diversion	Construction Years 3 and 4[a]
Task 2b - Ecosystem Attributes		
Task 2a - Biomass and Production of Fish Food Organisms	Operations term 1	Operations Years 3 to 7
Task 2b - Ecosystem Attributes		
Task 2a - Biomass and Production of Fish Food Organisms	Operations term 2	Operation Years 15 to 19[b]
Task 2b - Ecosystem Attributes		

[a] These data will be coupled with baseline data collected in 2010 and 2011[8], and 2012[9] to provide a five-year block of data.

[b] For planning purposes, these data are scheduled to be collected between Operation Years 15 to 19, but they can be scheduled for any five-year period after approximately Operation Year 10.

REFERENCES

Kennedy, T.A., C.B. Yackulic, W.F. Cross, P.E. Grams, M.D. Yard, and A.J. Copp. 2014. The relation between invertebrate drift and two primary controls, discharge and benthic densities, in a large regulated river. Freshwater Biology. 59: 557-572.

Appendix I

Mon-8 Site C Reservoir Water and Sediment Quality Monitoring Program

SITE C RESERVIOR WATER AND SEDIMENT QUALITY MONITORING PROGRAM

SUMMARY

ID	Site C Mon-8 – Site C Reservoir Water and Sediment Quality Monitoring Program
Description	This Program will investigate the effects of reservoir formation on water and sediment quality.
Key Project components / locations	Construction and Operation / Baseline sites in Williston and Dinosaur Reservoirs and in the Site C Reach (i.e., the reach of the Peace River to be inundated) maintained through all phases of construction and operation.
Monitoring Category	Effectiveness and Validation Monitoring / Implementation and Compliance Monitoring
Conditionality of Initiation	This Project will be undertaken as a condition of the compliance and will be initiated during construction.
Closely related programs	• Mon-6 – Site C Reservoir Fish Food Organisms Monitoring Program • Mon-9 – Peace River Water and Sediment Quality Monitoring Program
Schedule	Construction Years 2 to 9 and Operation Years 1 to 10

RATIONALE

BACKGROUND

The Site C Reach is defined as the portion of the Peace River that will be inundated by the Site C Clean Energy Project (the Project) and includes the Peace River between Peace Canyon Dam (PCD) and Site C dam site. As described in the Site C Environmental Impact Statement (EIS), fish habitat[1], and fish use of that habitat, is expected to change in the Site C Reach with the construction of the dam[2].

The Site C Reservoir Water and Sediment Quality Monitoring Program (this Program) will collect information to support the interpretation of the Project's effects on water and sediment quality and ultimately on fish and fish habitat upstream of the Site C dam site during both Project construction and operation.

The study area for this Program includes the Site C Reach and those sections of the Halfway and Moberly rivers that will be inundated following reservoir creation (approximately 10 km sections). Reference sites will monitor water flowing into the Site C Reach from Dinosaur and Williston reservoirs.

In the EIS, concentrations of total suspended solids (TSS), dissolved oxygen (DO), and nutrients (orthophosphate, ammonia, and nitrate) were predicted for Dinosaur Reservoir and for the Peace River upstream and downstream of the Site C dam site. The level of uncertainty regarding predictions was considered to be moderate[3]. Data from this Program will be used to evaluate predictions of these water quality parameters. The overall purpose of this Program is to validate predictions and address uncertainties in the EIS regarding the Project's effects on fish and fish habitat in Site C Reservoir and assess the effectiveness of fish and fish habitat mitigation.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management question (management question) to be addressed by this Program is as follows:

- Does the construction and operation of the Project affect fish and fish habitat (as measured through water and sediment quality) in the reservoir and lower sections of reservoir tributaries?

This broad question requires a number of smaller questions to be answered because of the various ways that the Project can affect fish and fish habitat:

1. Is there a change in water or sediment quality in the Site C Reach during the construction of the Project?
2. Is there a change in water or sediment quality in the Site C Reach during the operation of the Project?
3. How effective are proposed mitigation methods in maintaining/protecting water and sediment quality in the Site C Reach?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

H_1: During construction, modeled water quality predictions presented in the EIS are similar to measured water quality in the Site C Reach.

[1] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[2] EIS, Volume 2, Section 12
[3] EIS, Volume 2, Appendix P, Part 2

H_2: During operation, modeled water quality predictions presented in the EIS are similar to measured water quality in the Site C Reach.

H_3: During construction, water and sediment quality for non-modeled parameters remain within background ranges of concentrations, or comply with relevant environmental guidelines[4] in the Site C Reach.

H_4: During operation, water and sediment quality for non-modeled parameters remain within background ranges of concentrations, or comply with relevant environmental guidelines in the Site C Reach.

Two hypotheses related to the effectiveness of mitigation measures for water and sediment quality.

H_5: During construction, mitigation methods employed are effective in maintaining/protecting water and sediment quality in the Site C Reach.

H_6: During operation, mitigation methods employed are effective in maintaining/protecting water and sediment quality in the Site C Reach.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding water and sediment quality in Site C Reservoir, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish habitat in the reservoir. In addition, the information will be used to verify predictions in the EIS[5] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[6]) and the Federal Decision Statement[7].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address the primary management question by collecting data necessary to draw inferences and test the hypotheses. Information on these physical parameters will inform the assessment of changes in lower trophic levels and the fish community.

During construction, the spatial scope of this Program is limited to the portion of the Peace River between PCD and the Site C dam site (i.e., the Site C Reach) with reference sites situated upstream of PCD in Dinosaur and Williston reservoirs, and the Halfway and Moberly rivers. During operation, the spatial scope of this Program is limited to Site C Reservoir (including inundated portions of the Halfway and Moberly rivers), with reference sites situated in Dinosaur and Williston reservoirs.

The temporal scope of this Program encompasses Construction Years 2 to 9 and Operation Years 1 to 10. Construction activities during river channelization have the potential to change water and sediment quality (i.e., turbidity, TSS, and parameters associated with particulate matter). Monitoring will commence during river channelization, focusing on the effects of construction activities on water and sediment quality. After the Project is operational, the Program will focus on changes in the Site C Reach due to reservoir filling and operation.

The scope of this monitoring program does not include specific assessment of water quality in relation to human health or mercury.

[4] As described in the Construction Environmental Management Plan for the Project
[5] EIS, Volume 2, Section 12
[6] EAC, Condition #7, Pages 8 to 9
[7] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

APPROACH

This Program builds on the general approach developed during baseline studies used to characterize water and sediment quality in the proposed reservoir and reservoir tributaries[3] and on which the EIS effects assessment was based[8].

Where practical, different components of the Site C Fisheries and Aquatic Habitat Monitoring Program will monitor parameters at the same sites to maximize the utility of data collected. In addition, monitoring sites will be consistent with those used during baseline studies[3] and other related studies (e.g., Peace Water Licence Requirements), if applicable.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a - General Water and Sediment Quality Monitoring
    - Task 2b - Temperature Monitoring
    - Task 2c - Turbidity Monitoring
- Task 3 – Data Analysis
    - Task 3a - General Water and Sediment Quality Monitoring
    - Task 3b - Temperature Monitoring
    - Task 2c - Turbidity Monitoring
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

[8] EIS, Volume 2, Section 11

Task 2a. General Water and Sediment Quality Monitoring. Water and sediment quality will be monitored in the Peace River between PCD and the Site C dam site and in the lower reaches of the Halfway and Moberly rivers. Two reference sites will be located upstream of the study area in Williston and Dinosaur reservoirs. Samples will be collected from shallow and deep water locations when possible (i.e., in reservoir and tributary embayments). Sediment samples will be collected from the surficial sediments only (i.e., top 5 cm). Locations will generally follow locations sampled during baseline studies[3].

Sampling will occur at water quality sites during each study year; sediment samples are expected to be collected annually year. Data from water quality samples will be used by the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6); therefore, these samples are expected be collected between May and October of each study year to ensure compatibility with that program.

Water quality sampling will focus on measuring parameters that may change in concentration throughout the growing season. Sampling will generally follow the parameters collected during baseline sampling. General water quality sampling includes a mixture of field-based measured parameters (e.g., water conductivity [µS/cm], pH, redox potential [V], and dissolved oxygen [mg/L and percent saturation]), and collection of samples for laboratory analysis of nutrients and general parameters.

Sediments will be collected from depositional areas (i.e., areas of predominantly fine substrates) at sample locations. Samples will be analyzed for particle size, nutrients, and total metals. These samples will be collected during the fall to collate sediment data with data collected under the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-6).

Task 2b. Temperature Monitoring. Continuous measurements of water temperature will be recorded at multiple sites between Williston Reservoir and the Site C dam site before and after Site C Reservoir is created. Sites that are expected to be monitored for water temperature are listed in Table 1. Some of the sites to be monitored for water temperature under this Program are currently being monitored by BC Hydro as a Peace Water Licence (WLR) commitment (under GMSWORKS-2; DES 2013).

In the Site C Reservoir forebay and the Halfway and Moberly rivers embayment areas, up to 10 water temperature loggers will be suspended vertically through the water column to determine thermal stratification (if it occurs), stratification duration, and the strength of temperature gradients.

Table 1. Continuous temperature monitoring sites proposed upstream of Site C.

Site (Site Code)	Existing WLR Site?	Pre-Reservoir Details	Post-Reservoir Details	UTM Easting[a]	UTM Northing[a]	Description
WAC Bennett Dam Forebay (gmsUP1)	Yes	2 Logger	2 Logger	548841	6209022	This site will measure forebay water temperatures.
WAC Bennett Dam Tailrace (gmsDN1)	Yes	2 Loggers	2 Loggers	548881	6207761	This site will measure the temperature of water discharged from Williston Reservoir.
Peace Canyon Dam Forebay (pcnUP1)	Yes	1 Logger	1 Logger	562684	6204075	This site will measure forebay water temperatures.
Peace Canyon Dam Tailrace (pcnDN2)	Yes	2 Loggers	2 Loggers	562803	6204854	This site will measure the temperature of water discharged from Dinosaur Reservoir.
Peace River (or reservoir) at Halfway River Confluence (halfUP1 and halfDN2)	Yes	4 Loggers (2 u/s, 2 d/s)	4 Loggers (paired shallow and deep u/s of confluence)	595165	6230094	This site will measures water temperatures approximately midway between PCD and the Site C dam site.

Halfway River Embayment (HD)	No	None	Up to 10 Loggers	596649	6231488	Vertical array. This site will measure potential stratification (timing and depth of layers) in the Halfway River embayment.
Peace River or reservoir at Moberly River Confluence (mobUP1 and mobDN1)	Yes	4 Loggers (2 u/s, 2 d/s)	None	627158	6232349	This site will measure the influence of the Moberly River on Peace River water temperatures.[b]
Moberly River Embayment (MD)	No	None	Up to 10 Loggers	628620	6230146	Vertical array. This site will measure potential stratification (timing and depth of layers) in the Moberly River embayment.
Site C Forebay (SC FB)	No	None	Up to 10 Loggers	628962	6230288	Vertical array. This site will measure potential stratification (timing and depth of layers) in the Site C Forebay and water temperatures prior to discharge from the reservoir.

[a] UTM, NAD 83, Zone 10. Exact sampling locations may vary following final site selection by the proponent and BC Hydro.
[b] Due to its close proximity to the Site C forebay site, this site will not be necessary after the reservoir is created.

The number and locations of water temperature monitoring sites will change as construction progresses and the reservoir fills. Once Site C Reservoir is filled, some stations will need to be repositioned to allow for representative sampling in the new reservoir. Final site selection will be decided by the proponent with input from BC Hydro and another temperature monitoring program in the watershed (GMSWORKS-2 DES 2013). Data needs from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program also will be considered.

Field methods for water temperature monitoring are expected to follow existing protocols developed under GMSWORKS-2 (DES 2013) to ensure consistency in collection methods and comparability of results. Briefly, temperature sensor/loggers will be checked for calibration, set to record temperature at hourly intervals and placed in a protective steel housing secured to the river bank or anchored to the river bed. Data loggers will be downloaded approximately every three months. If practical and safe, a vertical array of up to 10 loggers will be placed in the Site C forebay and in the Moberly and Halfway river embayments. If possible, these arrays will be attached to built structures such as the dam or bridge piers. These vertical arrays will not be required until Operation Year 1.

Task 2c. Turbidity Monitoring. Turbidity is a measure of the scattering of light in water and is strongly correlated with the concentration of suspended solids. Continuous measurements of turbidity provide good estimates of changes in suspended sediment concentrations over time, without the need to collect and analyze numerous water samples.

Turbidity data are will be collected to support construction monitoring at the dam site. This Program will obtain information from this construction monitoring. For planning, collecting and managing the turbidity and TSS raw data files, screening and checking the raw data, and developing the turbidity to TSS curves will not be completed as part of this Program. This Program will include a summary of turbidity data reviewed and reported under the construction monitoring work. The scope of this Program excludes costs associated with continuous turbidity monitoring (i.e., field work, logger rental and maintenance, data checking, and compilation).

BC Hydro has deployed turbidity loggers at multiple locations in the Peace River to support construction monitoring. The loggers are expected to measure turbidity during the construction (Construction Years 1 to 9) and operation (Operation Years 1 to 10) phases of the project to monitor potential Project impacts on turbidity and suspended sediments. As part of monitoring of Project Construction, water samples will be taken periodically at each turbidity monitoring site and analyzed for TSS concentration to develop a statistical relationship between turbidity and TSS.

As part of the Site C Construction Monitoring Plan, continuous turbidity measurements will be made at the following locations during Construction Years 1 to 9:

- Peace River – Two loggers placed on opposite banks of the Peace River immediately upstream of the Moberly River confluence (PAM-LB and PAM-RB).
    - Peace River – Two loggers placed on opposite banks of the Peace River upstream of the diversion headpond between Cache Creek and the Halfway River (PBH-LB and PBH-RB).

Loggers will be removed each winter if ice damage is a concern. The locations of turbidity monitoring stations during Project operation have not been finalized, but will likely include monitoring at the above two locations.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results. Water and sediment quality samples will be analyzed by a Canadian Association for Laboratory Accreditation Inc. (CALA) certified lab.

Water quality data will be compared to baseline concentrations[9] and water quality data will be analyzed for spatial and temporal trends in relation to guidelines and baseline conditions.

The Peace River Regional District is approved to discharge treated effluent into the Peace River. If a report from that operation is available, it will be reviewed, summarized, and included in annual reports.

Sediment data will be compared to baseline concentrations[9] and to CCME sediment quality guidelines for the protection of aquatic life (CCME 2001). Sediment data will be compared to two different guideline levels: lower interim sediment quality guidelines (ISQG) and higher probable effects level (PEL) guidelines. Sediment data will be analyzed for spatial trends in relation to guidelines and baseline conditions.

Water temperature data will be summarized for each monitoring site using the same methods employed by DES (2013). Tabulated site data will include descriptive statistics, such as mean, median, maximum, and minimum values, calculated both annually and by month or season. Temperature trends over time will be assessed using appropriate trend analysis techniques.

Turbidity data collected by BC Hydro under the Site C Construction Monitoring Plan will be compared to baseline levels (turbidity and TSS) and TSS measurements. Spatial and temporal trends will be identified and provided to other components of the Site C Fisheries and Aquatic Habitat Monitoring Program that may require the data for their analyses.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;

[9] EIS, Volume 2, Appendix E

6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[10].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Reservoir Water and Sediment Quality Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A

[10] Decision Statement, October 14, 2014, Section 18 Record Keeping.

diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted approximately every five years beginning in Construction Year 5 and will align with reviews being conducted under other monitoring programs (e.g., the Peace River Water and Sediment Quality Monitoring Program; Mon-9). The synthesis report will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on water and sediment quality upstream of the Site C dam site. Appropriate quantitative and qualitative analytical techniques will be used to summarize data and assess changes in water and sediment quality, water temperatures, and turbidity over time and in relation to the development of the Project. Other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will use results of this Program as habitat-type explanatory variables.

SCHEDULE

Water quality samples will be collected during the open water period (May to October), coinciding with data collected under the Site C Reservoir Fish Food Organisms Monitoring Program (Mon-8). The concentrations of metals and metalloids in water quality samples will be measured annually. Sediment samples will be collected once during the fall, or as necessary. Water temperatures will be monitored throughout each year if practical and safe.

Water quality, sediment quality, and water temperatures will be monitored annually during Construction Years 2 to 9. During the first 10 years of Site C operations (Operation Years 1 to 10), water quality and water temperatures will be monitored annually. During operations, sediment quality will be monitored in Operation Years 1, 5, and 10.

Synthesis reviews of this Program will be conducted in Construction Year 5, and Operation Years 1, 5, and 10, aligning with synthesis reviews being conducted under other closely related components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

It is assumed that amendments to this Program will occur early in the program in response to site practicalities and information requirements from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

REFERENCES

CCME. 2001. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Introduction. Updated. Canadian Environmental Quality Guidelines, 1999. Winnipeg, MB, Canada.

DES (Diversified Environmental Services). 2013. Peace River baseline TDGP/temperature. Implementation year 4. Peace River Water Use Plan, Reference GMSWORKS-2. Prepared for BC Hydro, June 2013.

Appendix J

Mon-9 Peace River Water and Sediment Quality Monitoring Program

PEACE RIVER WATER AND SEDIMENT QUALITY MONITORING PROGRAM

SUMMARY

ID	Site C Mon-9 – Peace River Water and Sediment Quality Monitoring Program
Description	This Program will investigate the effects of the Project on water and sediment quality in the Peace River downstream of the Project.
Key Project components / locations	Baseline, construction, and operation phases at sites in the Peace River and tributaries downstream of the Project to the Many Islands area in Alberta
Monitoring Category	Effectiveness and Validation Monitoring / Implementation and Compliance Monitoring
Closely related Site C Monitoring Programs	• Mon-7 – Peace River Fish Food Organisms Monitoring Program • Mon-8 – Site C Reservoir Water and Sediment Quality Monitoring Program
Schedule	• Construction Years 2 to 9 and Operation Years 1 to 10

RATIONALE

BACKGROUND

Fish habitat[1] and fish use of that habitat in the Peace River downstream of the Site C Clean Energy Project (the Project) is expected to change with construction of the dam[2]. The lower trophic community structure can be influenced by nutrient availability and water clarity, while fish health can be influenced by a variety of water quality parameters, including total suspended solids (TSS) and metals. The focus of the Peace River Water and Sediment Quality Monitoring Program (this Program) is to collect information to support the interpretation of the Project's effects on water quality and sediment quality in the Peace River downstream of the Project.

The study area for this Program includes the Peace River from the Site C dam site downstream to the Many Islands area in Alberta, a distance of approximately 120 km. For the purposes of this Program, this portion of the Peace River is termed the Downstream Reach.

The Site C Environmental Impact Statement (EIS) predictions of concentrations of TSS, dissolved oxygen (DO), and nutrients (orthophosphate, ammonia, and nitrate) for the Peace River downstream of the Project. The level of uncertainty regarding predictions was considered to be moderate[3]. Data collected as part of this Program will be used to confirm predictions of these water quality parameters, address uncertainties regarding the Project's effects on fish and fish habitat during both project construction (Construction Years 1 to 9) and operation (Operation Years 1 to 30), and assess the effectiveness of fish and fish habitat mitigation.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management question (management question) to be addressed by this Program is as follows:

- Does the construction and operation of the Project affect fish and fish habitat (as measured through water and sediment quality) in the Peace River downstream of the Project?

This broad question requires a number of smaller questions to be answered because of the various ways that the Project can affect fish and fish habitat:

1. Is there a change in water or sediment quality in the Peace River between the Site C dam site and the Many Islands area in Alberta during the construction of the Project?
2. Is there a change in water or sediment quality in the Peace River between the Site C dam site and the Many Islands area in Alberta during the operation of the Project?
3. How effective are proposed mitigation methods in maintaining/protecting water and sediment quality in the Peace River between the Site C dam site and the Many Islands area in Alberta?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

H_1: During construction, modeled water quality predictions presented in the EIS are similar to measured water quality in the Peace River between the Site C dam site and the Many Islands area in Alberta.

[1] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[2] EIS, Volume 2, Section 12
[3] EIS Volume 2 Appendix Part 2.

H_2: During operation, modeled water quality predictions presented in the EIS are similar to measured water quality in the Peace River between the Site C dam site and the Many Islands area in Alberta.

H_3: During construction, water and sediment quality for non-modeled parameters remain within background ranges of concentrations, or comply with relevant environmental guidelines in the Peace River between the Site C dam site and the Many Islands area in Alberta.

H_4: During operation, water and sediment quality for non-modeled parameters remain within background ranges of concentrations, or comply with relevant environmental guidelines in the Peace River between the Site C dam site and the Many Islands area in Alberta.

Two hypotheses related to the effectiveness of mitigation measures for water and sediment quality.

H_5: During construction, mitigation methods employed are effective in maintaining/protecting water and sediment quality in the Peace River between the Site C dam site and the Many Islands area in Alberta.

H_6: During operation, mitigation methods employed are effective in maintaining/protecting water and sediment quality in the Peace River between the Site C dam site and the Many Islands area in Alberta.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding water and sediment quality in the Peace River downstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish habitat in the Peace River. In addition, the information will be used to verify predictions in the EIS[4] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[5]) and the Federal Decision Statement[6].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address the management question by collecting data necessary to draw inferences and test the management hypotheses. The scope of this monitoring program does not include an assessment of water quality in relation to human health or mercury as these metrics are covered under other components of BC Hydro's overall Site C monitoring Program.

During construction, the spatial scope of this Program is limited to the portion of the Peace River between the Site C dam site and the Many Islands area in Alberta (i.e., the Downstream Reach), with reference sites situated in select tributaries.

The temporal scope of this Program encompasses river channelization (Construction Years 1 to 4), river diversion (Construction Years 4 to 9), and Operation Years 1 to 10. Construction activities during river channelization have the potential to impact water and sediment quality (turbidity, TSS, and parameters associated with particulate matter). Monitoring will commence during river channelization, focusing on the effects of construction activities on water and sediment quality. After the Project is operational, the Program will focus on changes in the Peace River due to Project operation.

[4] EIS, Volume 2, Section 12
[5] EAC, Condition #7, Pages 8 to 9
[6] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

APPROACH

This program builds on the general approach developed during baseline studies used to characterize water and sediment quality in the Downstream Reach[7] and on which the EIS effects assessment was based[8].

Where practical, different components of the Site C Fisheries and Aquatic Habitat Monitoring Program will monitor parameters at the same sites to maximize the utility of data collected. In addition, monitoring sites will be consistent with those used during baseline studies[7] and other related studies (e.g., Peace Water Licence Requirements) if applicable.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a - General Water and Sediment Quality Monitoring
    - Task 2b - Temperature Monitoring
    - Task 2c - Turbidity Monitoring
- Task 3 – Data Analysis
    - Task 3a - General Water and Sediment Quality Monitoring
    - Task 3b - Temperature Monitoring
    - Task 2c - Turbidity Monitoring
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

[7] EIS, Volume 2, Appendix P, Part 1.
[8] EIS, Volume 2, Section 11

Task 2a. General Water and Sediment Quality Monitoring. Water and sediment quality will be monitored in the Peace River between the Site C dam site and the Many Islands area in Alberta and in the lower reaches of the Pine, Beatton, Kiskatinaw, and Pouce Coupe rivers. Data from reference sites situated upstream of the Project will be provided by the Site C Reservoir Water and Sediment Quality Monitoring Program (Mon-8). Locations will generally follow those during baseline studies[7],[9] with the addition of a site at Many Islands.

The water and sediment quality sample sites will capture spatial variability within the Downstream Reach and support other components of the Site C Fisheries and Aquatic Habitat Monitoring Program that monitor habitat and biological assemblages in the Downstream Reach.

Water quality samples will be collected during May to October; sediment samples will be collected once during the fall of each study year. Data from water quality samples will be used by the Peace River Fish Food Organisms Monitoring Program (Mon-7); therefore, these samples will be collected monthly between May and October of each study year to ensure compatibility with that program.

Water quality sampling will focus on measuring parameters that may change in concentration throughout the growing season. Parameters will follow those measured during baseline studies. General water quality sampling includes a mixture of field-based measured parameters (e.g., water conductivity [µS/cm], pH, and dissolved oxygen [mg/L and percent saturation]), and collection of samples for laboratory analysis of nutrients and general parameters.

Sediments will be collected from depositional areas (i.e., areas of predominantly fine substrates). Samples will be analyzed for particle size, nutrients, and total metals. These samples will be collected during the fall to collate sediment data with data collected under the Peace River Fish Food Organisms Monitoring Program (Mon-7).

Several provincial and federal surface water quality monitoring stations are located in the Downstream Reach (Table 1). Water quality parameters monitored at these stations include pH, dissolved oxygen, conductivity, nutrients, and biological indicators. When practical, these data will be compared to data collected under this Program.

Table 1. Provincial and federal government surface water quality monitoring stations located in the Downstream Reach.

Station ID	Station Name[a]	Location		Date Range	
		Latitude (°N)	Longitude (°W)	Start Date	End Date
BC EMS Locations (BC MOE 2012)					
400134	Peace River 3.2 km U/S of Fort St. John	56.1922	120.8647	Nov-1971	Oct-2009
400138	Peace River 100 m U/S BCR Rail Bridge	56.1631	120.7547	Nov-1971	Oct-2009
400142	Peace River 6.5 km D/S Alaska Highway	56.1261	120.5722	Nov-1971	Oct-2009
400143	Peace River 6.5 km D/S Alaska Highway	56.1261	120.5725	Nov-1971	Aug-1992
400492	Peace River at Old Fort, 100 m D/S Fort St. John	56.1978	120.8183	May-1974	Oct-2009
410018	Peace River near Old Fort 500 m D/S PE00389	56.1986	120.8133	Oct-1980	Oct-1990
410053	Peace River at Taylor	56.1400	120.6803	Apr-1978	Aug-1991
410054	Peace River at Taylor	56.1394	120.6739	Apr-1978	Oct-2009
Environment Canada Locations (HC 2012)					
E206585	Peace River upstream of the Alces River confluence	56.1261	120.0561	Mar-03[a]	Dec-11

[a] U/S = upstream; D/S = downstream.

Task 2b. Temperature Monitoring. Continuous measurements of water temperature will be recorded at multiple stations between the Site C dam site and the Pouce Coupe river confluence in Alberta. Water temperatures will be

[9] EIS, Volume 2, Appendix P, Part 1, Appendix A.

monitored before, during, and after Project construction. Sites to be monitored for water temperature are listed in Table 2. Some of the sites to be monitored for water temperature under this Program are currently being monitored by BC Hydro under the Peace Water Licence (WLR) program under GMSWORKS-2 (DES 2013). Temperature loggers will be deployed year-round if practical, or at a minimum from May to October, when water quality and sediment sampling is undertaken.

Table 2. Continuous temperature monitoring sites proposed downstream of the Project.

Site (Site Code)	WLR Site?	Baseline Details	Construction and Operation Years Details	UTM Zone[a]	UTM Easting[a]	UTM Northing[a]	Description
Site C Tailrace (SC TR)	No	None	2 Loggers	11V	629484	6229763	This site will measure water temperatures discharged from the Project.
Peace River at Pine River Confluence (PD1 and PD1a)	Yes	4 Loggers (2 u/s, 2 d/s)	4 Loggers (2 u/s, 2 d/s)	11V	642442	6224408	This site will measure water temperatures upstream and downstream of the Pine River confluence.
Pine River (PineR)	No	None	2 Loggers	10V	641197	6223561	This site will measure Pine River mainstem water temperatures.
Beatton River (BeattonR)	No	None	2 Loggers	10V	663054	6221329	This site will measure Beatton River mainstem water temperatures.
Peace River at Pouce Coupe River Confluence (PD4)	No	None	2 Loggers u/s of confluence	10V	317989	6225175	This site will measure water temperature upstream of the Pouce Coupe River confluence.

[a] NAD 83.

Field methods for water temperature monitoring will follow existing protocols developed under GMSWORKS-2 (DES 2013) to ensure consistency in collection methods and comparability of results. Briefly, temperature sensor/loggers will be checked for calibration, set to record temperature at hourly intervals and placed in a protective steel housing secured to the river bank or anchored to the river bed. Data loggers will be downloaded approximately every three months.

Task 2c. Turbidity Monitoring. Construction in or near waterways has the potential to increase concentrations of suspended sediments in the water. Turbidity is a measure of the scattering of light in water and is strongly correlated with the concentration of suspended solids. Continuous measurements of turbidity provide good estimates of changes in suspended sediment concentrations over time, without the need to collect and analyze numerous water samples.

The scope of this Program excludes costs associated with continuous turbidity monitoring (i.e., field work, logger rental and maintenance, data checking, and compilation) as these can provided from data that are already being collected to support construction monitoring. Managing the turbidity and TSS raw data files, screening and checking the raw data, and developing the turbidity to TSS curves will not be completed as part of this Program. This Program will include a summary of turbidity data reviewed and reported under the construction monitoring work.

BC Hydro has deployed turbidity loggers at multiple locations in the Peace River to support construction monitoring. The loggers will measure turbidity during the construction (Construction Years 1 to 9) and operation (Operation Years 1 to 10) phases of the project to monitor potential project impacts on turbidity and suspended sediments. As part of the Site C Construction Monitoring Plan, water samples will be taken periodically at each turbidity monitoring site and analyzed for total suspended solids concentration to develop a statistical relationship between turbidity and total suspended solids concentrations.

Two of the Peace River turbidity monitoring stations included in the Site C Construction Monitoring Plan (PAP-LB and PAP-RB) are located in the Downstream Reach between the Site C dam site and the Pine River confluence. These loggers will be installed each spring and removed each fall to prevent ice damage if necessary. Locations of turbidity monitoring stations during the operational phase of the Project have not been finalized, but will likely include monitoring in the above two locations.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results. Samples will be analyzed by a Canadian Association for Laboratory Accreditation Inc. (CALA) certified lab.

Water quality data will be compared to baseline concentrations[10] and to various environmental guidelines for the protection of aquatic life (e.g., BC MOE 2010, CCME 1999, ESRD 2014). No single source has guidelines for each water quality parameter to be measured under this Program; therefore, guidelines from multiple sources will be considered during analyses. Water quality data also will be analyzed for spatial and temporal trends in relation to guidelines and baseline conditions. The City of Fort St. John and Canfor Corporation are approved to discharge treated effluent into the Peace River within the Downstream Reach. If reports from those operations are available, they will be reviewed, summarized, and included in annual reports.

Sediment data will be compared to baseline concentrations[10] and to CCME sediment quality guidelines for the protection of aquatic life (CCME 2001). Sediment data will be compared to two different guideline levels: lower interim sediment quality guidelines (ISQG) and higher probable effects level (PEL) guidelines. Sediment data also will be analyzed for spatial trends in relation to guidelines and baseline conditions.

Water temperature data will be summarized for each monitoring site using the same methods employed by DES (2013). Tabulated site data will include descriptive statistics, such as mean, median, maximum, and minimum values, calculated both annually and by month or season. Temperature trends over time will be assessed using appropriate trend analysis techniques. Impacts of the Project on downstream water temperatures will be assessed using appropriate "before and after" statistical techniques, taking into account any underlying time trends in water temperature that are independent of the Project. Appropriate statistical techniques will be used to assess the accuracy of EIS predictions regarding the effects of the Project on downstream water temperatures.

Turbidity data collected by BC Hydro under the Site C Construction Monitoring Plan will be compared to baseline levels (turbidity and TSS) as well as TSS measurements. Spatial and temporal trends will be identified and provided to other components of the Site C Fisheries and Aquatic Habitat Monitoring Program as needed.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;

[10] EIS, Volume 2, Appendix E

6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[11].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Peace River Water and Sediment Quality Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A

[11] Decision Statement, October 14, 2014, Section 18 Record Keeping.

diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted approximately every 5 years beginning in Construction Year 5 and will align with reviews being conducted under other monitoring programs (e.g., the Site C Reservoir Water and Sediment Quality Monitoring Program; Mon-8). The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on water and sediment quality downstream of the Project. Appropriate quantitative and qualitative analytical techniques will be used to summarize data and assess changes in water and sediment quality, water temperatures, and turbidity over time and in relation to the development of the Project. Other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, such as the Peace River Fish Community Monitoring Program (Mon-2), will use results of this Program as habitat-type explanatory variables.

SCHEDULE

Water quality samples will be collected during the open water period (May to October), coinciding with data collected under the Peace River Fish Food Organisms Monitoring Program (Mon-7). The concentrations of metals and metalloids in water quality samples will be measured annually. Sediment samples will be collected once per year during the fall, or as necessary. Water temperatures will be monitored throughout each year if practical and safe.

Water quality, sediment quality, and water temperatures will be monitored annually during Construction Years 2 to 9. During the first 10 years of Project operation, water quality and water temperatures will be monitored annually, while sediment quality will be monitored every five years beginning in Operation Year 1.

Synthesis reviews of this Program will be conducted in Construction Year 5, and Operation Years 1, 5, and 10, aligning with synthesis reviews being conducted under other closely related components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

It is assumed that amendments to this Program will occur early in the program in response to site practicalities and information requirements from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. For budgeting purposes, it is assumed that monitoring under this Program will end after Operation Year 10.

REFERENCES

ESRD (Alberta Environment and Sustainable Resource Development). 2014. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Policy Division. Edmonton. 46pp.

BC MOE (British Columbia Ministry of the Environment). 2010. Water Quality Guidelines (Criteria) Reports. January 2010. Available at: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#working..

CCME (Canadian Council of Ministers of the Environment). 1999, with updates to 2014. Canadian Environmental Quality Guidelines. Winnipeg, MB, Canada.

CCME. 2001. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Introduction. Updated. Canadian Environmental Quality Guidelines, 1999. Winnipeg, MB, Canada.

DES (Diversified Environmental Services). 2013. Peace River Baseline TDGP/Temperature - GMSWORKS-2 – Year 4 Monitoring Program – Interim Report January 2012 to December 2012. Prepared for BC Hydro, 24 p. + 6 app.

Health Canada. 2012. Guidelines for Canadian Drinking Water Quality Summary Table. Prepared by the Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health. Ottawa, ON

Appendix K

Mon-10 Site C Fish Entrainment Monitoring Program

SITE C FISH ENTRAINMENT MONITORING PROGRAM

SUMMARY

ID	Site C Mon-10 – Site C Fish Entrainment Monitoring Program
Description	This Program will investigate entrainment rates and survival rates of entrained fish during the operation of the Project.
Key Project components / locations	Operation of flow release structures and power plant
Monitoring Category	Effectiveness and Validation Monitoring
Closely related studies	• Mon-1a - Site C Reservoir Fish Community Monitoring Program • Mon-14 - Site C Trap and Haul Fish Release Location Monitoring Program
Schedule	Construction Year 9 and Operations Years 1 to 10

RATIONALE

BACKGROUND

The Site C Fish Entrainment Monitoring Program (this Program) focusses on downstream fish passage at the Site C Clean Energy Project (the Project), and more specifically, fish entrainment. Fish entrainment occurs when a fish is drawn into a water intake and cannot escape (DFO 2007). For hydroelectric developments, entrainment commonly refers to any downstream movement of fish through the flow release structures of a dam (via spillways or low level outlets) or a power plant (via the turbines).

The change from river to reservoir habitat upstream of Site C is expected to result in changes to fish distribution and relative abundance based on varying fish life history requirements[1]. This Program will monitor rates of entrainment and survival of entrained fish from this newly established fish community.

Fish entrainment at Site C is expected to occur primarily through the generating station because spilling is likely to be infrequent[2]. Entrainment rates for all species present in the Site C Local Assessment Area (LAA) were calculated using a heuristic model of entrainment risk[3]. Entrainment rate is used here as the proportion of the population that is entrained per year. The heuristic model was based on the Entrainment Risk Screening and Evaluation Methodology (BC Hydro 2006); however, the model expanded on this methodology to provide quantitative estimates of entrainment rates measured as the proportion of the population entrained per year. The model is based on species-specific information on fish distribution, habitat preference, movement rates, response to velocity fields, swimming capability, the configuration and operation of the Project, and information on entrainment rates from other hydroelectric facilities. Annual entrainment rates estimated by the model are low (< 10% of the population) for all species except Bull Trout, Kokanee, Lake Whitefish, and Lake Trout[3]. These species are predicted to have higher entrainment rates due to their preference for offshore pelagic habitat. Fish entrained through the generating station and turbines during operations were predicted to have a fish size-dependent survival of greater than 90% for small fish (i.e., 100 mm fork length [FL]) and greater than 60% for large fish (750 mm FL)[4].

The following section describes the target species for this Program and the rationale for their selection:

Arctic Grayling
The Peace River Arctic Grayling population primarily uses the Moberly River for spawning, migration, and rearing. This species is a conservation priority in the Site C LAA and is vulnerable to a decline in abundance.

Bull Trout
Bull Trout are represented in the Site C LAA by a population that uses the Peace River for adult feeding and the Halfway River spawning and early development. Bull Trout are piscivores that are expected to switch their forage from benthic, riverine prey (e.g., Mountain Whitefish) to pelagic fish species that are expected to colonize Site C Reservoir (i.e., Kokanee). Bull Trout are a blue-listed species (a species of special concern) under the provincial Conservation Framework. Their pursuit of prey in pelagic habitats exposes them to entrainment risk.

Kokanee

[1] EIS, Volume 2, Section 12
[2] EIS, Volume 2, Section 11.4
[3] EIS, Volume 2, Appendix Q2
[4] EIS, Volume 2, Appendix Q3

The EIS predicts that Kokanee will be a major component of the pelagic fish community in the reservoir[5]. Understanding entrainment trends for Kokanee is important as it can affect their productivity and age-structure. Kokanee use of pelagic habitat puts them at risk to entrainment.

Fish entrainment survival rates were estimated using a predictive equation developed under the U.S. Department of Energy's Advanced Hydro Turbine System Program (Franke et al. 1997). This program is based on a comprehensive analysis of fish survival rates from multiple hydroelectric projects. Fish survival rates are calculated using turbine characteristics, flow, head, mechanical efficiency, and fish length to estimate the probability that a fish of a given size will come near to, or in contact with, a structural element as it passes through a turbine. Based on data collected at dams located on the Columbia River, the survival rates of fish entrained over the Site C spillway is estimated to be high[6].

Entrainment monitoring is required during the operational phase of the project to confirm the effectiveness of mitigation measures aimed at reducing entrainment effects, as described in the Fish Passage Management Plan, and to validate EIS predictions regarding survival and entrainment rates. The effectiveness of the trap and haul program is not included in the scope of this Program as its effectiveness will be monitored under the Site C Fishway Effectiveness Monitoring Program (Mon-13) and the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14). The information collected during this Program will be used to inform management decisions, particularly if entrainment or entrainment mortality rates at Site C are greater than predicted in the EIS.

FISHERIES MANAGEMENT QUESTION

The primary fisheries management questions (management questions) to be addressed by this Program are as follows:

1. What are the rates of entrainment for Arctic Grayling, Bull Trout, and Kokanee during the operation of the Project?
2. What are the rates of survival for Arctic Grayling, Bull Trout, and Kokanee that are entrained through the Project?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring of entrainment rates and survival at Site C Dam to address the following hypotheses:

H_1: Entrainment rates of Arctic Grayling, Bull Trout, and Kokanee through the Project will be similar to those predicted in the EIS.

H_2: Survival rates of Arctic Grayling, Bull Trout, and Kokanee that are entrained through the Project will be similar to those predicted in the EIS.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish entrainment rates and entrainment survival rates at Site C, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[7] and provide supporting data for conditions listed in the Provincial Environmental

[5] EIS, Volume 2, Section 12.4.4
[6] EIS, Volume 2, Section 12.4.3.3
[7] EIS, Volume 2, Section 12

Assessment Certificate (EAC[8]) and the Federal Decision Statement[9]. Information entrainment and survival rates will inform the assessment of the response of the community to the Project.

The Fish Passage Management Plan[10] describes design features to increase the survival of entrained fish. Information from this Program will provide information on the effectiveness of these measures.

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address the management questions outlined above by collecting data necessary to test the Program's hypotheses. This Program will estimate entrainment rates and survival of target fish species during Site C operations and compare those estimates to EIS predictions. This Program will also assess the effectiveness of entrainment mitigation options outlined in the EIS and provide data to inform the assessment of the response of the fish community to the Project.

The spatial extent of this Program includes the riverine and reservoir habitat areas located upstream and downstream of Site C during operation. Monitoring of entrainment will be focused in the forebay and the tailwater areas of Site C; however, the impacts of entrainment on fish populations farther upstream and downstream will be considered in the assessment. Some monitoring of Williston Reservoir tributaries will also be included in this Program.

This Program will focus on entrainment over the first 10 years of Site C operation (i.e., Operation Years 1 to 10). A pre-study assessment is scheduled for Construction Year 9. This Program is expected to be able to estimate entrainment rates with reasonable accuracy by Operation Year 4.

APPROACH

This Program will estimate the number, size-class, and survival rates of target fish species that pass through the turbines and hydropower facilities at Site C. The relative impact of fish entrainment on the abundance and distribution of Bull Trout and Arctic Grayling will be estimated as the proportion of the population that is entrained through Site C. Comparisons of Kokanee biomass and/or age-structure will use Kokanee in the Williston Peace Reach as a reference population.

For Kokanee, entrainment monitoring will be contingent upon results of the Site C Reservoir Fish Community Monitoring Program (Mon-1a) that indicate lower-than-predicted Kokanee productivity in the reservoir. If Kokanee productivity in the reservoir is lower than expected, the contingent data collected under this Program will provide insight into the relative influence of Kokanee entering Site C Reservoir from the Williston Peace Reach and the downstream entrainment for this species through Site C.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection

[8] EAC, Condition #7, Pages 8 to 9
[9] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat
[10] EIS, Volume 2, Appendix Q1

    - Task 2a - Williston Peace Reach Kokanee Spawner Survey
    - Task 2b - Monitoring of Entrainment Rates
    - Task 2c - Monitoring Survival Rates of Entrained Fish
- Task 3 – Data Analysis
    - Task 3a - Williston Peace Reach Kokanee Spawner Survey
    - Task 3b - Monitoring of Entrainment Rates
    - Task 3c - Monitoring Survival Rates of Entrained Fish
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Williston Peace Reach Kokanee Spawner Survey. The Kokanee spawner survey aims to provide an annual index of Williston Peace Reach Kokanee abundance that can provide an index of Kokanee recruitment from Williston Reservoir into Site C Reservoir. A relevant set of index streams (e.g., Carbon and Dunlevy creeks) will be identified during Construction Year 9 that is likely to provide a reliable estimate ahead of the first year of spawner counts (scheduled for the fall of Operation Year 1). Spawner counts will be used to generate area-under-the-curve population estimates (Parsons and Skalski 2010) using spawner residence times for Kokanee from the literature (e.g., Beauchamp et al. 1994). Work conducted in Construction Year 9 includes identifying site access locations and the duration of the spawning period at selected sites. Spawner counts will be conducted annually between Operation Years 1 and 10. When combined with data on water flow volumes, Kokanee spawner abundance will provide a measure of trends and inter-annual variation in Kokanee recruitment from Williston Reservoir into Site C Reservoir. These data parameterize the Kokanee population model[11], which is designed to assess the drivers of Kokanee abundance and how these drivers relate to Site C operations. Kokanee data from the Site C Reservoir Fish Community Monitoring Program (Mon-1a) will provide information on the density of Kokanee in the Site C Reservoir. If Kokanee densities are lower than predicted, information from Williston Peace Reach spawner count data over the 10 year monitoring period can be used to determine if this is a result of lower than predicted

[11] EIS, Volume 2, Appendix Q3

Kokanee recruitment from upstream. If kokanee density is lower than predicted, contingent studies estimating Kokanee entrainment rates or predation rates will be needed.

Task 2b. Monitoring of Entrainment Rates. Entrainment rates will be estimated using the general telemetry design of tagging and releasing upstream of the project measuring the proportion of these fish that are detected downstream of the project. Experience from other hydroelectric systems has shown that in addition to this general design, information on the presence of tagged fish in the forebay from tracking provides supporting information for both the analyses and the understanding of entrainment risk. As a result, Task 2b is organized into two components:

1) *Forebay Use Estimate*: This component will quantify time spent by tagged fish in the forebay and in areas upstream of the forebay to calculate the probability of each of the target species being present in the forebay. Data needed for this component will be collected by the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b) from fish telemetry tags deployed as part of other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. For planning, costs associated with tagging and monitoring the movements of fish will be covered by these other monitoring programs.
2) *Forebay Entrainment Estimate*: This component will determine the likelihood of entrainment for fish in the forebay. Data for this task will be collected by the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b) using data from fish tagged as part of other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

The probability of entrainment, paired with the probability of forebay presence, will be used to estimate the overall probability of entrainment for target species of fish in the reservoir. The approach will be applied to adult Arctic Grayling and Bull Trout. Entrainment rates will be estimated for years with suitable telemetry data collected by the Site C Acoustic Telemetry Array System; however, suitable data are expected for Operation Years 1 to 4. If results from the Site C Reservoir Fish Community Monitoring Program (Mon-1a) indicate lower than expected pelagic fish densities in Site C Reservoir after the initial four years of monitoring under that program (i.e., Operation Years 1 to 4), then Kokanee entrainment estimates will need to be measured using alternative measures (e.g., Biosonics 2013) to estimate entrainment losses as a proportion of the total population.

The number of fish entrained per year can be calculated using estimates of Kokanee and Bull Trout abundance in the reservoir obtained under other programs (i.e., Site C Reservoir Fish Community Monitoring Program Mon-1a) and the entrainment rate estimate under this task.

Task 2c. Monitoring Survival Rates of Entrained Fish. Mortality associated with turbine passage will be assessed using a mark-recapture design that involves tailrace netting of balloon tags. With this method, a balloon tag is attached to a fish, which is then introduced into the turbine intake and recovered in the tailrace. The balloon tag inflates after a given amount of time, causing the fish to float to the surface where it can be recaptured downstream of the dam (OTA 1995). The use of balloon tags aids in recovery efficiency of tagged fish when compared to standard mark-recapture studies. For planning, this task is expected include 100 to 150 balloon-tagged fish and consists of potentially lethal methods. Due to the conservation concerns for Bull Trout and Arctic Grayling in the Peace River, this task is expected to balloon tag other species, such as adult Rainbow Trout, Mountain Whitefish, Lake Whitefish, Lake Trout, or Kokanee, with the results from these species being extrapolated to target species.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be

incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Analyses for the Site C Fish Entrainment Monitoring Program will be similar to analyses employed during entrainment studies at other hydroelectric facilities (e.g., BioSonics 2013, Cope and Prince 2012, Hatfield et al. 2013, and Martins et al. 2012). In general terms, data collected under this program will be compared to model results documented in the EIS[12].

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[13].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented.

[12] EIS, Volume 2, Appendix Q4, Attachment C3, Turbine Passage Survival Estimates.
[13] Decision Statement, October 14, 2014, Section 18 Record Keeping.

For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Entrainment Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted at the end of Operation Year 4. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of the Program will be used to validate predictions and address uncertainties in the EIS regarding entrainment rates and entrainment survival rates related to the Project and to assess the effectiveness of fish and fish habitat mitigation measures.

Information from this Program will provide information to understand the effectiveness of fish passage management and to interpret result of fish community monitoring programs. Data and results from this Program should be interpreted in conjunction with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, through the exchange of information at annual workshops (Task 6), and through the program's synthesis review (Task 7).

SCHEDULE

A tentative schedule for each Task within the Program is detailed below. Work associated with Task 1 (Project Coordination) would be ongoing on an "as needed" basis. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period. This would provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop prior to the next year's field season.

For the Williston Peace Reach Kokanee Spawner Survey (Task 2a), a pre-survey assessment will be conducted during Construction Year 9, with surveys being conducted annually each fall from Operations Years 1 to 10.

Monitoring of Entrainment Rates (Task 2b) will be conducted during years with adequate telemetry data collected by the Site C Acoustic Telemetry Array System. For planning purposes, Task 2b is scheduled annually between Operation Years 1 and 4.

Monitoring Survival Rates of Entrained Fish (Task 2c) will be conducted during Operation Year 4.

REFERENCES

BC Hydro (2006), Fish Entrainment Risk Screening and Evaluation Methodology, BC Hydro, Report No. E478.

Beauchamp, D. A., P. E. Budy, B. C. Allen, and J. M. Godfrey. 1994. Timing, distribution, and abundance of kokanees spawning in a Lake Tahoe tributary. The Great Basin Naturalist 54:130-141.

BioSonics. 2013. Revelstoke reservoir Kokanee behavior and entrainment rate assessment. Prepared for BC Hydro. Final Report, 14 January 2013. File MCA/REV FESMON#2. BioSonics Inc., Seattle, WA.

Cope, S., A. Prince. 2012. BC Hydro Aberfeldie Dam Fish Entrainment Strategy, Bull River Fish Entrainment – Telemetry Study. Draft Report, February 2012. Prepared for BC Hydro. Prepared by Westslope Fisheries Ltd., Cranbrook, BC.

Fisheries and Oceans Canada (DFO). 2007. Practitioner's Guide to Fish Passage for DFO Habitat Management Staff. Accessed on 10-Jan-2012 from: http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/passage/pdf/Guide-to-Fish-Passageeng.pdf

Franke, G.F., D.R. Webb, R.K. Fisher, D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of environmentally advanced hydropower turbine system design concepts. Idaho National Engineering and Environmental Laboratory.

Hatfield, T., T. Sullivan, and S. Johnson. 2013. John Hart Facility, Evaluation of Entrainment Assessment Methods. Draft Report v2. Prepared for BC Hydro, Burnaby, BC. Prepared by Ecofish Research Ltd and R2 Resource Consultants, 28 March 2013.

Martins, E.G., L.F.G. Gutowsky, P.M. Harrison, D.A. Patterson, M. Power, and S.J. Cooke. 2012. Entrainment vulnerability of adult Bull Trout and Burbot at the Mica Dam. Prepared for BC Hydro. Prepared by Carleton University, University of Waterloo, and Fisheries and Oceans Canada, December 10, 2013.

Office of Technology Assessment (OTA). 1995. Fish Passage Technologies: Protection at Hydropower Facilities, OTA-ENV-641 (Washington, DC: US Government Printing Office, September 1995).

Parsons, A.L. and J.R Skalski. 2010. Quantitative Assessment of Salmonid Escapement Techniques. Reviews in Fisheries Science 18: 301-314.

Appendix L

Mon-11 Site C TDG Monitoring Program

SITE C TDG MONITORING PROGRAM

SUMMARY

ID	Site C Mon-11 - Site C TDG Monitoring Program
Description	This Program will evaluate Total Dissolved Gas (TDG) supersaturation and potential effects on downstream fish populations resulting from Gas Bubble Disease (GBD) during Project construction and operation.
Key Project components / locations	TDG will be monitored from Site C downstream to the Many Islands area in Alberta (or to the downstream extent that TDG is above established thresholds)
Monitoring Category	Effectiveness and Validation Monitoring
Conditionality of Initiation	This Program will be undertaken during reservoir filling, and during periods of Site C spillway operation
Closely related studies	Mon-2 – Peace River Fish Community Monitoring Program Mon-9 – Peace River Water and Sediment Quality Monitoring Program
Schedule	Construction Years 5 to 9 and opportunistically during Operation Years 1 to 10.

RATIONALE

BACKGROUND

The focus of the Site C TDG Monitoring Program (this Program) is to monitor the effects of spilling water from the Site C Clean Energy Project (the Project) on Total Dissolved Gas pressure (TDG) and associated effects on fish health. TDG is air dissolved in water and is commonly expressed as a percentage of the amount of air that water will hold when it is in equilibrium (100%) with the atmosphere at ambient water surface conditions. Beneath the water's surface, pressure increases with increasing depth due to the hydrostatic pressure (weight of water). This increased pressure increases the amount of atmospheric gases that the water will hold when in equilibrium (saturated) at the specific depth. Thus, an increase in depth results in an increase in hydrostatic pressure and greater amounts of air in solution at equilibrium.

When air bubbles are entrained in water and the air-water mixture is carried to a substantial depth, entrained air dissolves into solution due to hydrostatic pressure, resulting in water that is supersaturated with gas relative to equilibrium at surface (atmospheric) pressure. For example, water 2 m deep will hold at equilibrium 120% of the air the same water will hold at surface pressure. If the water remains at depth there is no potential for the amount of dissolved gas to decrease. For this reason, once water at depth is supersaturated relative to the atmospheric pressure at the surface, the supersaturation tends to remain unless there is considerable turbulence and exposure of the water to surface pressure, which allows dissolved gas to come out of solution. The depth below which hydrostatic pressure is sufficient for gas to remain dissolved in supersaturated water is referred to as the compensation depth.

The effects of TDG supersaturation on fish and invertebrates depend on a variety of factors, including the level of supersaturation, water depth, and duration of exposure (Weitkamp 2008). Gas Bubble Disease (GBD) occurs in fish and invertebrates exposed to TDG supersaturation at depths less than the compensation depth, when dissolved gas comes out of solution and forms bubbles in the blood and other tissues. GBD can range from mild cases with a few visible bubbles, to severe cases with numerous bubbles, hemorrhaging, exophthalmia (bulging eye), and possibly death. Fish that remain at depths at or greater than the compensation depth generally do not develop GBD because hydrostatic pressure compensates for supersaturated gas pressure and prevents bubbles from forming. TDG supersaturation results in little or no gas bubble disease (GBD) at levels up to 120% of saturation when compensating depths (i.e., 2 m or more) are available (Weitkamp 2013).

The Project has the potential to produce TDG supersaturation in the Peace River downstream of the dam at levels that may cause GBD. The effects of TDG are site-specific and depend on fish population distribution and habitat use, physical habitat conditions, and the period of exposure to TDG supersaturation (Fidler 2003; Weitkamp 2008). The Peace River supports a diverse community of large- and small-bodied fish that seasonally use different mainstem and tributary habitats[1]. The physical characteristics of the Peace River (e.g., channel morphology, water depth, and water velocity), and the distributions of fish populations may restrict exposure to TDG supersaturation to portions of each population.

TDG supersaturation has occurred occasionally in the Peace River for a number of years (Guillaud 2012). TDG levels monitored immediately downstream of existing dams on the Peace River at times exceeded 130% of saturation; but typically did not exceed 115% during most previous spills and rarely exceeded 120%. In 1996, an emergency release of water at W.A.C. Bennett Dam resulted in nearly a month of high spillway discharges. These discharges resulted in prolonged periods of TDG supersaturation (Wilby 1997). During this period, TDG levels averaged 123% and reached a maximum of 129%. Downstream monitoring during spill events in 1996 and 2002 (AMEC 2008)

[1] EIS, Volume 2, Appendix O

showed that signs of GDB in fish were consistently present, primarily in the form of bubbles in fins, and in a few cases, bubbles within gill lamellae. No evidence was found of fish mortalities resulting from GBD.

TDG supersaturation could occur at the Project during construction and operation. Computer models of TDG production were used during the design of the Project to minimize TDG production during the operation of the Project's spillway. As described in the Site C Clean Energy Project Environmental Impact Statement (EIS), the river channelization and river diversion phases of Project construction are not expected to increase TDG in the river above baseline levels; however, during the first stage of reservoir filling, the EIS states that there may be periods when TDG equals 120% (±5%)[2].

The operation of Site C may elevate TDG concentrations downstream of the dam through powerhouse operations under low turbine flow conditions and through spillway operations. Normal turbine operations will not raise TDG above 110%. During occasional low flow conditions, turbine operation may raise TDG supersaturation by introducing air under pressure during synchronous condense operation (no load turbine operation) and during periods of rough load conditions through atmospheric control (valve/injection). In this situation, turbine discharge volume will be low but TDG concentrations in the outflow from a single turbine may exceed 120% saturation. Depending on the duration of the low flow turbine operation, specific operations of adjacent turbines, and local tailwater mixing processes, this may create spatial zones immediately downstream of the dam with elevated TDG concentration.

The Project's spillway is expected to be used infrequently during project operation, as turbines are likely to discharge most Peace River flows. Spill events may occur in some years during high flow events in late spring and early summer when the total river flow exceeds the generating capacity of the Project's turbines, requiring spill to occur for days to weeks.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management questions (management questions) to be addressed by this Program are as follows:

1. Do TDG levels in the Peace River downstream of the Project stay within predictions from the EIS during the reservoir filling phase of Project construction and Project operation or increase downstream of the Project relative to the forebay?
2. If TDG levels downstream of the Project exceed predictions, are adverse effects to fish survival observed?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

H_1: During reservoir filling and operation of the Project, TDG levels downstream of the Project will be as predicted in the EIS, or will not increase downstream of the Project relative to levels the forebay.

H_2: Elevated TDG levels downstream of the Project will not result in adverse effects on fish health.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding TDG downstream of the Project and its effects on fish, will help inform the assessment of the effects of the Project on the fish community. In addition, the information will be used to

[2] EIS, Volume 2, Section 12.4.3.4

verify predictions in the EIS[3] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[4]) and the Federal Decision Statement[5].

BC Hydro has undertaken two general approaches to mitigate potential effects of TDG generation on fish and fish habitat:

1. Modifying the design of the Project's spillway to reduce the magnitude of TDG generated; and
2. Developing an operational plan to reduce the magnitude, duration, and geographic extent of TDG generation during reservoir filling.

To reduce the magnitude of TDG generated during the use of the spillway, BC Hydro undertook an engineering assessment of alternative spillway designs and selected a jet deflector spillway design.

To further reduce the potential for TDG generation during reservoir filling, an iterative process was undertaken to develop and refine an operation procedure to reduce the magnitude and duration of exposure of fish and aquatic life to elevated TDG levels. These measures include initiating spillway discharge operations through multiple gates to reduce the rate of discharge at each gate, and minimizing the operation of turbines in water discharge ranges that produce 'rough load' operation. The information from this Program will assess the effectiveness of these operating procedures.

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to validate predictions and address uncertainties identified in the EIS regarding levels of TDG downstream of the Project and its effects on the fish community by monitoring TDG levels and instances of GBD downstream of the Project.

The spatial scope of this Program is limited to Site C Reservoir and the Peace River downstream of the project to the Many Islands area in Alberta.

The temporal scope of this Program includes Construction Years 8 and 9 and Operation Years 1 to 10.

APPROACH

Monitoring of TDG in Site C Reservoir and in the Peace River downstream of the Project will include continuous monitoring using in situ loggers and periodic spot-checks during periods when high TDG levels are expected (e.g., during spill events).

Downstream fish health and population effects associated with GBD will be evaluated through the Peace River Fish Community Monitoring Program (Mon-2) and the Site C Fishway Effectiveness Monitoring Program (Mon-13).

The monitoring program will focus on two phases of the Project's development: 1) reservoir filling (Construction Years 8 and 9); and 2) Project operation (Operation Years 1 to 10). Monitoring TDG levels during operation will be done opportunistically during spill periods or unusually low flow periods.

[3] EIS, Volume 2, Section 12
[4] EAC, Condition #7, Pages 8 to 9
[5] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – TDG Monitoring
    - Task 2b – TDG Effects on Fish
- Task 3 – Data Analysis
    - Task 3a - TDG Monitoring
    - Task 3b - TDG Effects on Fish
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. TDG Monitoring. TDG data loggers will be installed at multiple stations, including the Site C forebay, the Site C tailwater, and the Peace River downstream of the Pine River confluence. Stations installed in the Site C tailwater will be positioned far enough downstream to allow adequate mixing of spill and turbine discharge upstream. Stations installed downstream of the Project will include recorders on both banks of the river. The location of TDG monitoring stations employed during previous monitoring programs will be considered during installation (DES 2014). Water temperatures also will be monitored at each station during sampling.

TDG data collection will include a combination of continuous data collection and spot measurements using protocols established by Schmidt et al. (2001). TDG equipment will make continuous measurements (e.g., five-minute intervals) over each study period. TDG meters will be checked and serviced to verify proper functioning and ensure malfunctions are corrected as soon as possible. TDG meters will be recalibrated as needed. Portable TDG meters will be used to investigate mixing assumptions and to cross-check continuous monitoring stations as a measure of quality control.

Spot TDG measurements will be taken when possible to coincide with substantial changes in discharge during the study period. Data collected during spot measurements will include the following:

- Date, time, and crew;
- Site ID and GPS references;
- Calibration information;
- Total gas pressure (ΔP, TDG %);
- Barometric pressure;
- Air and water temperature;
- Dissolved oxygen; and
- Water depth

Task 2b. TDG Effects on Fish. Fish populations will be monitored upstream and downstream of the Project as part of the Site C Reservoir Fish Community Monitoring Program (Mon-1a) and the Peace River Fish Community Monitoring Program (Mon-2), respectively. TDG measurements can be compared with changes in fish abundance and population structure over time to infer potential for GBD affecting fish populations. Multiple factors can affect fish populations; therefore, a weight-of-evidence approach will be required to evaluate any effects of GBD on fish populations. This approach will include measurements of TDG (Task 2a), monitoring fish activities to assess levels of exposure to elevated TDG, and the examination of fish for evidence of GBD.

Telemetry tags will be implanted into select fish species as part of other components of the Hydro's Site C Fisheries and Aquatic Habitat Monitoring Program and monitored by the Site C Acoustic Telemetry Array System (Task 2d of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program; Mon-1b). Some of the telemetry tags used by other programs will have depth sensors with sub-metre resolution, allowing the precise tracking of vertical movements (i.e., depths) of these fish. Vertical and horizontal fish tracking data can be compared with TDG measurements to assess potential exposure of fish to high TDG levels, and, therefore, the potential for GBD and impacts on fish health. For planning, the costs associated with interpreting and analyzing these data regarding TDG are covered by this Program; however, costs associated with implanting and monitoring the movements of these tags are covered under other components of the Hydro's Site C Fisheries and Aquatic Habitat Monitoring Program.

All fish collected under the Peace River Fish Community Monitoring Program (Mon-2) and the Site C Fishway Effectiveness Monitoring Program (Mon-13) will be inspected for signs of GBD. These data will be provided to this Program for consideration during analyses.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a and 2b are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Descriptive statistics will summarize data collected under Tasks 2a and 2b. TDG levels in the forebay of the Project will be used as the base TDG level. Analyses will show relationships between TDG levels, fish movement activities (i.e., vertical and horizontal position), and discharge rates. Spatial and temporal variations in these variables will be analyzed when appropriate. Analyses will identify Site C spill discharge rates and environmental conditions that result in TDG levels exceeding 110% saturation. When appropriate, data will be compared with TDG levels predicted in the EIS and with environmental guidelines.

This Program will evaluate potential downstream fish health and population-level effects associated with GBD using fish health observations collected under components of the Hydro's Site C Fisheries and Aquatic Habitat Monitoring Program, TDG thresholds derived from available literature, and EIS predictions regarding TDG levels.

Temporal and spatial habitat use, channel morphology (i.e., the provision of depth compensation habitat), and flow patterns will be considered during analyses.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[6].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams,

[6] Decision Statement, October 14, 2014, Section 18 Record Keeping.

and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C TDG Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted in Operation Years 5 and 10 to align with reviews being conducted under other monitoring programs. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the relationship between TDG levels and discharge during reservoir filling and Project operation. Higher than predicted TDG levels may indicate a need to examine operating procedures to reduce TDG levels. If evidence suggests that TDG levels do not affect fish health or survival, then further monitoring may not be required. Evidence will include TDG measurements, fish activity measurements, GBD symptoms, and fish population trends.

SCHEDULE

TDG monitoring (Task 2a) and TDG Effects on Fish (Task 2b) will begin with the onset of reservoir filling (Construction Year 8) and will continue annually until Operation Year 10. Monitoring during Operation Years 1 to 10 could end earlier if the data strongly indicates that Project operations do not adversely affect fish health and populations due to elevated TDG levels. If further information is required to understand risks to fish health, after, major spill events may continue to be opportunistically monitored after Operation Year 10. TDG measurements will be timed to occur when elevated TDG levels are considered most likely, including reservoir filling and periods of spill during operation.

REFERENCES

AMEC. 2008. Peace River Fisheries and aquatic resources literature summary. AMEC File: VE51567 report to BC Hydro, Vancouver, British Columbia. 77 p.

Diversified Environmental Services Ltd. (DES). 2014. Peace River Water Use Plan. Peace River Baseline TDGP/Temperature. GMSWORKS-2. Year 5 Monitoring Program – Final Report. January 2013 to December 2013. Prepared for BC Hydro, Burnaby. 20 p. + 5 app.

Fidler, L. 2003. TGP performance measures for the Columbia River WUP, a brief summary. Unpublished report to B.C. Hydro, Castlegar, British Columbia. 8 p.

Guillaud, C. 2012. Origin and frequency of spill at Site C. Memorandum from Klohn Crippen Berger to John Croockewit, BC Hydro.

Schmidt, D., C. Powell, K. Wilby, and S. Wilson. 2001. BC Hydro Total Dissolved Gas Pressure Monitoring Protocol. Prepared for the BC Hydro Total Gas Pressure Steering Committee. BC Hydro Power Supply Environment Report No. SFP99-Gen-09. 49 p+4 app. Smith (2010) Ref

Weitkamp, D. E. 2008. Total dissolved gas supersaturation biological effects, review of literature 1980-2007, Draft. Report by Parametrix to Avista Utilities, Spokane, Washington and four other utilities. 65 p.

Weitkamp, D. E. 2013. Literature relevant to total dissolved gas regulation. Report by Leon Environmental LLC to B. C. Hydro, Vancouver, British Columbia. 15 p.

Wilby, K. 1997. 1996 Spillway discharge environmental monitoring overview Peace River generating facilities. Strategic Fisheries Report No. SFP96-PR-O4. BC Hydro, Vancouver, British Columbia. 161 p.

Appendix M

Mon-12 Site C Fish Stranding Monitoring Program

SITE C FISH STRANDING MONITORING PROGRAM

SUMMARY

ID	Site C Mon-12 – Site C Fish Stranding Monitoring Program
Description	This Program will assess Site C construction and operation effects associated with flow fluctuations and fish stranding on the fish community.
Key Project components / locations	Baseline Data Collection during Construction Years 2 to 5. Construction Monitoring during Construction Years 5 to 9. Operation Monitoring during Operation Years 1 to 5.
Monitoring Category	Effects Assessment Monitoring – Comparison of Baseline data to Construction and Operation Phase data.
Conditionality of Initiation	This Program will commence in Construction Year 2.
Closely related studies	• Mon-2 – Peace River Fish Community Monitoring Program • Mon-3 – Peace River Physical Habitat Monitoring Program
Schedule	Construction Years 2 to 9 and Operation Years 1 to 5

RATIONALE

BACKGROUND

Fish stranding is the separation of fish from their primary water body and can lead to injury or mortality (Lewis et al. 2013). Changes to river flow and water level can dewater habitat and strand fish, which can lead to mortality through desiccation, freezing, or increased predation (Lewis et al. 2013). Stranding can occur when fish become isolated in a side channel or pool, trapped in the substrate (i.e., interstitial stranding), or beached on substrate (Cathcart 2005).

Variables that contribute to fish stranding fall into two categories: variables within direct management control and variables outside of direct management control. Stranding variables within direct management control include the time-of-day that flow reductions occur, stage ramping rates (i.e., the range and rate of water level change), and the wetted history of the area that will be dewatered. Variables outside of direct management control include habitat characteristics (e.g., slope, substrate size, etc.) and water temperature. The species, size, and number of the fish present in the dewatered area also are variables that are outside of direct management control (Golder and Poisson 2012). Stranding risk also can be indirectly influenced via instream works, such as increasing the depth of a channel or bank slope in high risk areas.

Existing Conditions

Within-day variations in flow and water level on the Peace River occur in part due to hydroelectric operations at Peace Canyon Dam (PCD), where outflows fluctuate within the water licence limits throughout the day to meet variable electricity demand. The variability is most pronounced directly downstream of PCD. In general, this variation is reduced with distance downstream[1].

Project Construction

The potential for indirect fish mortality as a result of increased fluctuation in water levels and resultant dewatering of fish habitat exists within the Diversion Headpond. The additional fish habitat created in the diversion headpond (along the Peace River and the Moberly River) will be repeatedly dewatered, potentially stranding fish.

As described in the Environmental Impact Statement[2] (IES) for the Site C Clean Energy Project (the Project), he risk of fish stranding from rapid fluctuations in water level (>10 cm/h) is predicted to increase negligibly (+6% annual average) in the headpond compared to existing conditions, considering the rate of change of water level and wetted width. However, a larger wetted area will be dewatered when compared to existing conditions, which may lead to increased numbers of fish being isolated and subsequently stranded in small pools and channels that are cut off from the main channel. There is uncertainty whether the increased wetted area will lead to increased fish stranding, as there is extensive dewatering under current conditions, well beyond the threshold of fluctuation that would be expected to regularly strand fish. Additional fluctuations in water level and wetted width may not increase the frequency and magnitude of fish stranding. Downstream of the diversion tunnels to Taylor, water level fluctuations will be reduced, reducing the risk of fish stranding below that present under the existing condition. The reduced stranding risk in this stream section will counteract the increased stranding risk along the headpond. The net stranding risk may be neutral; regardless, mitigation of fish stranding along the headpond is necessary.

Fish stranding related to habitat dewatering from Project construction activities within the dam site and other auxiliary areas (e.g., Hudson's Hope Shoreline Protection, Highway 29 realignment) will be mitigated through standard industry fish salvage and relocation management practices described in the Project Construction Environmental Management Plan and supporting contractor Environmental Protection Plans (EPPs).

[1] EIS, Volume 2, Section 11.4.2.4.3
[2] EIS, Volume 2, Section 11.4

Project Operation

The risk of fish stranding during Project operations will depend on the daily range of flows and the rates of flow change. Expected water level changes upstream[3] and downstream[4] of the Project are described in the EIS. Overall, the daily range of Reservoir water levels is predicted to be 0.6 m or less 60% of the time, and 1.0 m or less 75% of the time. These ranges are similar to observed conditions in the Peace River at Hudson's Hope, immediately downstream of PCD[5]. Fish stranding risk in Reservoir during operations is expected to be low.

In the Peace River downstream of the Project, the daily range of water levels will be greatest immediately downstream of the dam, with daily water level changes increasing from 0.5 m to 1.0 m. This change will decrease with distance downstream from the dam. At the Project tailrace, daily water level changes are expected in increase from 0.4 m to 0.8 m[6]. The risk of stranding will be most prominent in the section of the Peace River between the Project and the Pine River confluence (i.e., Reach 1); however, overall stranding risk will extend downstream as far as the Town of Peace River Alberta[7].

In summary, during construction, fish stranding risk upstream of the construction area is expected to increase relative to baseline conditions in Construction Years 5 to 9 due to headpond water level fluctuations; however, downstream of the construction area there is no predicted change in water level fluctuations or stranding risk. During operation, there is predicted to be no change in stranding risk in the Reservoir compared to baseline conditions; however, stranding risk will increase immediately downstream of the dam. This risk will decline with distance downstream of the dam.

FISHERIES MANAGEMENT QUESTIONS

The primary fisheries management question (management question) to be addressed by the Site C Fish Stranding Monitoring Program (this Program) is as follows:

1. What is the magnitude of fish stranding in the Diversion Headpond relative to baseline conditions?
2. Which species and life stages of fish are most affected by stranding in the Diversion Headpond relative to baseline conditions?
3. During Project operation, what is the magnitude of fish stranding by species and life stage in the Peace River downstream of the Project relative to baseline conditions?
4. Do mitigation strategies (i.e., fish salvage and habitat enhancement) reduce fish stranding rates relative to baseline conditions?

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

H_1: During Project construction, fish stranding in the Diversion Headpond increases relative to baseline conditions.

H_2: During Project operation, fish stranding in the Peace River between the Project and the Pine River confluence increases relative to baseline conditions.

H_3: During Project operation, fish stranding in the Peace River between the Pine River confluence and the Many Islands area in Alberta is similar to baseline conditions.

[3] EIS, Volume 2, Section 11.4.4
[4] EIS, Volume 2, Section 11.4.5
[5] EIS, Volume 2, Appendix D1
[6] EIS, Volume 2, Appendix D2
[7] EIS, Volume 2, Section 11.4.5.2.5

H_4: Proposed mitigation measures in the headpond during the river diversion phase of Project construction and side channel enhancement and contouring in the Peace River downstream of the Project during operations are effective in reducing fish stranding rates.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding fish stranding in the Diversion Headpond and the Peace River downstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement. In addition, the information will be used to verify predictions in the EIS[8] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[9]) and the Federal Decision Statement[10].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to monitor the effects of flow fluctuations associated with the construction and operations of the Project on fish communities, and to answer the management questions by collecting data necessary to draw inferences and test the management hypotheses.

During construction, the spatial scope of this Program is limited to the Diversion Headpond (i.e., from the dam site upstream for to near the Wilder Creek confluence) and the Peace River from the dam site downstream to the Many Islands area in Alberta. During operation, the spatial scope of this Program is limited to the Peace River between the dam site and the Many Islands area in Alberta; fish stranding will not be monitored within the Reservoir. The spatial extent of the Site C Fish Stranding Monitoring Program has been guided by physical modelling[11], fisheries studies[12], and information obtained from Aboriginal groups, the public, and stakeholders.

The temporal scope of this Program encompasses Construction Years 2 to 9, and Operation Years 1 to 5.

APPROACH

This Program builds on the general sampling approaches developed by BC Hydro as part of the Lower Columbia River Fish Stranding Assessment and Ramping Protocol (CLBMON-42) and Lower Duncan River Fish Stranding Impact Monitoring Program (DDMMON-16). These programs were designed to monitor and assess fish stranding risk on the Columbia River downstream of Hugh L. Keenleyside Dam, Kootenay River downstream of Brilliant Dam (Golder 2014) and Duncan River downstream of Duncan Dam (Golder 2013).

The study area to be monitored by this Program can be divided into sections:

1) The Site C Diversion Headpond that is expected to extend from the dam site upstream for up to 18[13] km (to near the Wilder Creek confluence) during river diversion (Construction Years 5 to 8).
2) The Peace River from dam site downstream to the Many Islands area in Alberta (approximately 122 km).

For the purposes of this Program, the Peace River downstream of the Project is divided into three reaches:

[8] EIS, Volume 2, Section 12
[9] EAC, Condition #7, Pages 8 to 9
[10] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat
[11] EIS, Volume 2, Appendix D
[12] EIS, Volume 2, Appendix O
[13] The extent of the headpond will depend on the final design of the diversion works.

1) Reach 1: Site C downstream to the Pine River confluence (approximately 16 km);
2) Reach 2: Pine River confluence downstream to the Alces River confluence (approximately 42 km); and
3) Reach 3: Alces River confluence to the Many Islands area in Alberta (approximately 63 km).

During Construction Years 2 to 5, assessments of stranding will be undertaken in the area that will become part of the Diversion Headpond, and in the Peace River downstream of the construction area to identify baseline levels of fish stranding. These data will allow the development of a focused fish salvage plan for use during Construction Years 6 to 9 to reduce the effects of stranding due to headpond fluctuations.

Downstream of the Project, areas where dewatering occurs will be identified and monitored. In addition, areas where side channel enhancement and channel contouring is planned will be monitored.

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Identification of Monitoring Sites
    - Task 2b - Monitoring Stranding Sites
- Task 3 – Data Analysis
    - Task 3a - Identification of Monitoring Sites
    - Task 3b - Monitoring Stranding Sites
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 15 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Identification of Monitoring Sites. This task will consist of a review of available data (e.g., aerial photos, hydraulic modelling data, literature review, etc.) and a reconnaissance survey of the study area to identify monitoring sites that have a potential to strand fish.

The stranding risk of each identified monitoring site will be determined using the following habitat characteristics:

- Gradient of shoreline (high risk sites typically have a gradient of <4%; Bauersfeld 1978; Flodmark 2004);
- Total area (large areas of dewatered habitat will increase the risk of fish stranding);
- Presence of physical cover; and
- Side Channel or Main Channel habitat.

The spatial area of each monitoring site will be calculated using GIS, which will require output from two hydraulic models (i.e., Mike 11 and River2D). These data will characterize the wetted areas of each monitoring site under various flow levels. BC Hydro will provide the required model outputs to this Program; therefore, costs associated with running models are not included in this Program budget.

Each identified monitoring site will be photographed from multiple viewpoints at various water levels during field surveys to assist in data analysis and interpretation.

Sites will be identified in consultation with regulatory agencies.

Task 2b. Monitoring Stranding Sites. Fish stranding in the Diversion Headpond and in the Peace River downstream of the Project will be assessed at all monitoring sites identified in Task 2a or at a subset of monitoring sites, depending on the number of sites identified and through consultation with regulatory agencies. Different reaches are expected to have different levels of stranding risk and, therefore, will require varying levels of sampling effort. Monitoring will include two different assessment types: Annual Index Fish Stranding Assessments and Expanded Fish Stranding Assessments.

Annual Index Fish Stranding Assessments: The Annual Index Fish Stranding Assessment will focus on portions of the study area that are expected to have the highest risk of stranding fish. This assessment will include the Diversion Headpond during construction and Reach 1 of the Peace River downstream of the Project during operation. For planning purposes, the Annual Index Fish Stranding Assessment will be conducted up to 10 times during each study year to assess stranding risk during planned and unplanned water level reductions.

Expanded Fish Stranding Assessments: The Expanded Fish Stranding Assessment will focus on the portions of the study area that are expected to have a lower risk of stranding fish and will include assessments of monitoring sites located in Reach 2 and Reach 3. Reach 2 will be monitored during Construction Year 2 and every other year beginning in Construction Year 3. Reach 3 will be monitored during every third year of the program (see Schedule below). All Expanded Fish Stranding Assessments will coincide with Annual Index Fish Stranding Assessments.

For both assessment types, monitoring sites will be assessed on the same day that the flow reduction occurred when possible to minimize fish mortalities due to stranding or predation. Conducting the assessments as quickly as possible following a reduction will provide a more accurate estimate of stranding. It may take several days for the full effect of a reduction to reach monitoring sites located near the downstream limit of the study area; therefore, the Expanded Fish Stranding Assessment Program may be conducted over multiple days.

Stranded fish in dewatered areas will be enumerated visually. Isolated pools will be sampled for fish using the most appropriate method for the conditions (e.g., backpack electrofishing, beach seining, dip-netting). Where required, three-pass depletion methods will be used to determine efficiency (see Anon 1995 for sampling and analysis procedures).

During each assessment, data recorded at each monitoring site will include, but not be limited to, the following data:

- Crew, date, time, and location;

- Site description;
- Photo-documentation;
- Total number and description (e.g., area extent, cover availability, substrate type) of isolated pools and dewatered areas;
- Description of weather;
- The Project operating conditions (e.g., discharge, river stage, etc.);
- Air temperature, mainstem water temperature, isolated pool water temperature (if applicable);
- Sampling gear type by pool;
- Number, species, and condition (i.e., live, injured, or dead) of fish observed;
- Number, species, and condition of fish that were salvaged (i.e., returned to the main channel);

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a and 2b are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Data analyses will follow standard approaches. The approach used on the Columbia and Kootenay (Golder 2014) and Duncan (Golder 2013) rivers are provided as a reference. Data will be analyzed to assess total stranding risk based on study area, phase of Site C development, season, and fish species and life stages observed. Total fish stranding will be calculated by extrapolating observed fish stranding densities over the entire dewatered area within the reach. Dewatered locations and area (m^2) can be defined by the results of hydrodynamic modeling (e.g., Mike 11 and River2D) as supplied by BC Hydro. Specific stranding estimates will be calculated for both isolated pools and interstitial stranding areas. The magnitude and rate of each flow reduction assessed also will be examined in relation to fish stranding.

Overall, analyses will compare total stranding estimates during river diversion and operation to estimates obtained during baseline monitoring. This comparison will be completed for all species of interest for this program.

If applicable, the effectiveness of mitigation measures will be analyzed by comparing before and after data from mitigated areas.

Task 4. Reporting. Individual stranding assessment summaries will be generated after each survey. These summaries will be limited to summarizing results from each assessment, such as a summary of Project operations, the number of pools stranded at each site, and the number, species, and size of fish that were stranded and returned to the mainstem.

A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[14].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Fish Stranding Monitoring Program Synthesis Review

will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management

[14] Decision Statement, October 14, 2014, Section 18 Record Keeping.

actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted during Construction Years 5 and 9, and during Operation Year 5 to facilitate data and information sharing between this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. The synthesis reports will collate all data collected under the program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

This Program will provide a better understanding of fish stranding as related to the Project. The Program will evaluate the effectiveness of mitigation measures. In particular, BC Hydro's proposed fish salvage program for the Diversion Headpond will be informed by data collected during the early stages of this Program.

Fish stranding data collected upstream of the dam site during river channelization will be used as baseline data for comparisons with headpond stranding data collected during river diversion. Downstream of the Project, data collected between Construction Years 2 to 9 will be used to compare against data collected during Operation Years 1 to 5.

SCHEDULE

A tentative schedule for each Task within the Program is detailed below. Work associated with Task 1 (Project Coordination) would be ongoing on an "as needed" basis. Ideally, the annual workshop (Task 6) will be conducted during the late spring to early summer period. This would provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop prior to the next year's field season.

The schedule of assessments each study year will depend on changes to flows due to dam operations. The timing of theses assessments should consider seasonal operations and the life histories of fish species present in the study area. A breakdown of the stranding assessments required by reach up to Operation Year 5 is presented in Table 1. For planning purposes, it is assumed that 10 surveys will be conducted during each study year.

Stranding assessments will commence in Construction Year 2. Initial study years will involve refinement of monitoring sites based on field-truthing model predictions, as well as learning what ramping rates increase stranding risk. After reservoir filling near the end of Construction Year 8, monitoring upstream of Site C will not be required due to the reduced stranding risk in the reservoir.

Table 1: Estimated schedule to conduct the Site C Fish Stranding Monitoring Program (Mon-12).

Project Phase	Project Years	Annual Index Fish Stranding Assessment			Expanded Fish Stranding Assessment		Synthesis Review
		Baseline	Diversion Headpond Area	Reach 1[a]	Reach 2[b]	Reach 3[c]	
Construction	2	X	X	X	X		
	3	X	X	X	X	X	
	4	X	X	X			
	5	X	X	X	X		X
	6		X	X		X	
	7		X	X	X		
	8		X	X			
	9			X	X	X	X
Operation	1			X			
	2			X	X		
	3			X		X	

	4			X	X		
	5			X			X

[a] Reach 1 – The Peace River from Site C downstream to the Pine River confluence.

[b] Reach 2 – The Peace River from the Pine River confluence downstream to the BC-Alberta border.

[c] Reach 3 – The Peace River from the BC-Alberta border to the Many Islands area in Alberta.

REFERENCES

Anonymous, 1995. Lake and stream inventory standards and procedures. Fisheries Branch, Ministry of Environment Lands and Parks.

Bauersfeld, K. 1978. Stranding of juvenile salmon by flow reductions at Mayfield Dam on the Cowlitz River, 1976. Washington Department of Fisheries.

Cathcart, J. 2005. Study of flow ramping rates for hydropower developments. Consultant's report prepared by Knight Piesold Ltd. (Ref. No. Va103-79/2-1) for the Department of Fisheries and oceans Canada.

Flodmark, L.E.W. 2004. Hydropeaking—a potential threat or just a nuisance? Experiments with daily discharge fluctuations and their effects on juvenile salmonids. Ph.D. Thesis, Faculty of Mathematics and Natural Sciences, University of Oslo.

Golder Associates Ltd. 2014. Lower Columbia River [CLBMON #42(A)] and Kootenay River Fish Stranding Assessments: Annual summary (April 2013 to April 2014). Report prepared for BC Hydro, Columbia Power Corporation, and FortisBC, Castlegar, BC. Golder Report No. 10-1492-0042 and 10-1492-0100: 25p. + 1 app.

Golder Associates Ltd. 2013. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 5 data report (April 2012 to April 2013). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12-1492-0117F: 25 p. + 3 app.

Golder Associates Ltd. and Poisson Consulting Ltd. 2012. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 4 summary report (April 2011 to January 2012). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 10-1492-0110D: 39 p. + 2 app.

Lewis, F.J.A., A.J. Harwood, C. Zyla, K.D. Ganshorn, and T. Hatfield. 2013. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88 p.

Appendix N

Mon-13 Site C Fishway Effectiveness Monitoring Program

SITE C FISHWAY EFFECTIVENESS MONITORING PROGRAM

SUMMARY

ID	Site C Mon-13 – Site C Fishway Effectiveness Monitoring Program
Description	This Program will investigate the performance of both the temporary and permanent fishways at Site C.
Key Project components / locations	Monitoring effectiveness of the temporary fishway during river diversion and the permanent fishway during Project operation.
Monitoring Category	Effectiveness and Validation Monitoring
Conditionality of Initiation	This Program will be undertaken when the temporary or permanent fishways become operational.
Closely related studies	• Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-10 – Site C Entrainment Monitoring Program • Mon-14 – Site C Trap and Haul Fish Release Location Monitoring Program
Schedule	Construction Years 5 to 9 Operations Years 1 to 4, and 10 to 11.

RATIONALE

BACKGROUND

Upstream fish movements will be affected during the construction and operation of the Site C Clean Energy Project (the Project). In the absence of mitigation, the diversion tunnels, dam, and generating station will block upstream fish movements[1]. Upstream fish passage will mitigated using a staged approach to the design, construction, operation and evaluation of trap and haul facilities, as described in the EIS (Volume 2 Appendix Q1 Fish Passage Management Plan). A temporary trap and haul facility will we operated during the river diversion phase of construction, and a permanent facility during operation of the Project. A monitoring and assessment program was recommended to reduce key uncertainties and inform the operation of the trap and haul facilities. Key uncertainties include the effectiveness of attracting fish from the Peace River into the trap and haul facility fish ladder entrance and the attraction flow required to do so. The Site C Fishway Effectiveness Monitoring Program (this Program) is a component of this monitoring.

Monitoring will include five species, Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout. These species may attempt to migrate upstream given known spawning areas upstream of the Site C dam site, are identified as indicator species in local provincial management objectives (BC Ministry of Environment 2009; BC Government 2011), and were identified during the environmental assessment process as important for Aboriginal groups and anglers.

FISHERIES MANAGEMENT QUESTIONS

The fisheries management questions (management questions) that will be answered by this Program are detailed below. Each question will be evaluated separately for each fish species.

1. Does the temporary fishway provide effective upstream passage for migrating Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout that are attempting to migrate upstream during the construction of the Project?
2. Does the permanent fishway provide effective upstream passage for migrating Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout that are attempting to migrate upstream during the operation of the Project?

MANAGEMENT HYPOTHESES

This Program will monitor the effectiveness of both the temporary and permanent fishways during construction and operation, respectively. Each hypothesis will be tested separately for the permanent and temporary fishways and for each fish species.

Hypotheses related to both the temporary and permanent fishways are as follows:

[1] EIS, Volume 2, Section 12.4.6

H_1: Arctic Grayling, Bull Trout, Burbot, Rainbow Trout, and Mountain Whitefish locate and use the fishway.

H_2: Fishway attraction and passage efficiency are as predicted in the EIS (Volume 2 Appendix Q3).

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding the effectiveness of the temporary and permanent fishways, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[2] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[3]) and the Federal Decision Statement[4].

Data collected during this Program will be used to guide the effective operation of the fishway. Information obtained from temporary fishway during the river diversion phase of construction may guide final design and operation of the permanent facility. In particular, information on the magnitude and timing of attraction flows at the fishway entrance needed to attract fish will guide the efficient operation of the facilities, including the energy requirements to pump the attraction flow from the tailrace.

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address the management questions posed by collecting data necessary to draw inferences and to test the hypotheses. The scope of this monitoring program will be monitoring the response of fish to the fishway up to the time that they are released upstream or returned to the Peace River downstream.

The spatial scope of this Program is limited to the Project tailrace and the fishway facilities; however, telemetry data from other areas of the Peace River will be used as needed to interpret results.

This Program will assess the effectiveness of the temporary fishway during Construction Years 5 to 9 and the effectiveness of the permanent fishway during Operation Years 1 to 4 and 10 to 11.

This program will collect information on fishway attraction. Costs associated with the operation of the fishway facilities and the fish enumeration equipment within the fishway are not included in this program.

APPROACH

This Program is expected to use acoustic and radio telemetry, PIT tag detection arrays, and an automated camera recording system to monitor the movements of fish as they approach, enter, and navigate the temporary and permanent fishways within the range of river water levels and flows that the facilities are expected to operate under.

[2] EIS, Volume 2, Section 12
[3] EAC, Condition #7, Pages 8 to 9
[4] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

Overall fishway 'effectiveness' will be estimated by looking at various testable attributes of 'efficiency', including fish attraction efficiency and fish passage efficiency (Bunt et al. 2012). Time delays associated with fishway passage (Castro-Santos et al. 2009) will be measured as part of this Program. The most reliable methods of understanding the efficiency of a fishway to attract fish and allow their upstream movement is through the use of electronic tags, including radio tags, acoustic tags, and passive integrated transponder (PIT) tags (Cooke and Hinch 2013). Telemetry data collected during other monitoring programs (e.g., Mon-14 – Site C Trap and Haul Fish Release Location Monitoring Program) for fish after they are released from the trap and haul facility will be analyzed to understand the relationship between post-passage fish condition and subsequent migration to spawning tributaries.

A sample of fish collected in the fishway can be implanted with both telemetry tags and PIT tags. By employing two different methods to monitor fish movements, detection efficiency between methods can be studied, improving the robustness of passage efficiency estimates. Tasks under several other components of the Site C Fisheries and Aquatic Habitat Monitoring Program include the use of either telemetry or PIT tags. Individual fish tagged under these components will supplement assessments of efficiency and allows the use of data from multiple capture methods and release locations.

Monitoring fish and movements after their release upstream of the Project are not covered under this Program but will be monitored under the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14).

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Site C Tailrace and Fishway Telemetry Assessment
    - Task 2b – Attraction Efficiency and Entrance Accessibility Assessment
    - Task 2c – Contingent Radio Telemetry Surveys in Site C Tailwater
- Task 3 – Data Analysis
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Site C Tailrace and Fishway Telemetry System. The movements of adult Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout in the area downstream of Site C (downstream of the diversion tunnel outlet during construction and in the tailrace area during operations) is expected to be monitored using dual-mode (acoustic and radio), multi-year (i.e., two or more years) telemetry tags. All telemetry tags deployed under this Program will be compatible with the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b).

Where feasible for this Program, telemetry tags will target sexually mature fish to increase the likelihood of monitoring fish that are motivated to migrate upstream of Site C.

Telemetry tags will be deployed via two different components of the Site C Fisheries and Aquatic Habitat Monitoring Program for study under this Program. First, telemetry tags will be released under the Peace River Large Fish Indexing Survey (Task 2a) of the Peace River Fish Community Monitoring Program (Mon-2). Data collected from these tags also will yield information on attraction efficiency, which is defined as the proportion of fish tagged and released in downstream areas that are subsequently located within the zone of the fishway entrance, and close enough to detect the attraction flow (Cooke and Hinch 2013). Data from these fish also will improve the resolution of fish migrant estimates by gathering data from fish collected from various locations downstream of Site C. For planning purposes, the costs of the telemetry tags will be covered by this Program; however, costs associated with implanting the tags will be covered by the Peace River Fish Community Monitoring Program (Mon-2). Deploying these tags as part of the Peace River Fish Community Monitoring Program (Mon-2) eliminates the need to have a dedicated fish collection program downstream of Site C as part of this Program.

Second, as sample of adult Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout encountered in the sorting facilities of the temporary and permanent fishways will be implanted with telemetry tags and released downstream of the tailrace. The movements of these fish will be monitored to see if they continue their migration back upstream and into the fishways. If tagged fish concentrate in areas away from the fishways, it may be possible to assess what conditions attract them to this alternate location, which may allow enhancements to the attractiveness of the fishway entrance. Telemetry tagged fish that return the fishways are expected to be released upstream of Site C.

During Construction Years 5 and 6 and Operation Years 1 to 3, a sample of the fish encountered in the fishways will be implanted with telemetry tags and released upstream of the dam to be monitored under the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14). For planning, the costs of these telemetry tags will be covered by the Site C Trap and Haul Fish Release Location Monitoring Program (Mon-14); however, costs associated with implanting the tags will be covered by this Program.

All Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout implanted with telemetry tags during this Program will also be implanted with PIT tags. Fin ray samples will be collected from all fish that are implanted with telemetry tags and from all Arctic Grayling and Bull Trout. These samples will be used for microchemistry analysis as needed to determine the fish's origin. These data are particularly important for Bull Trout and Arctic Grayling to determine if these fish originated from upstream (i.e., the Halfway and Moberly rivers) or downstream (e.g., the Pine River) sources. Samples collected from Arctic Grayling and Bull Trout will be

provided to the Peace River Arctic Grayling and Bull Trout Movement Assessment (Task 2a) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b) for analysis.

The number of Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout that will be tagged during each tag deployment year will depend on the number of fish encountered in the fishway. Monitoring priority, and therefore the number of tags deployed, should be given to Arctic Grayling and Bull Trout given the management interest for these species. Tags will be deployed during Construction Years 5, 6, and 8, and during Operation Years 1, 3 and 10.

Acoustic telemetry receivers will be deployed in the Site C tailrace area as part of the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b). Coordination between the various components of the Site C Fisheries and Aquatic Habitat Monitoring Program that will be using the data from these receivers will be required to ensure the position of receivers is suitable to attain all program objectives.

Two radio receivers and two PIT detector arrays will monitor fish movement within the fishways. These systems also will provide a means of testing detection efficiencies between the various systems (i.e., acoustic, radio, PIT). The PIT tag detectors are expected to be installed at the upstream and downstream ends of the fishways to assess the time required for tagged fish to ascend the fishways and whether fish enter and leave the fishway without ascending to the fishway collection pool.

Telemetry (both acoustic and radio) and PIT tag detection arrays are expected to be removed during winter months to prevent damage.

Task 2b. Attraction Efficiency and Entrance Accessibility Assessment. This task will determine the attraction flow that successfully attracts fish to the fishway entrance and will determine fishway entrance efficiency. Fishway entrance efficiency is defined as the proportion of tagged fish attracted to the fishway that actually entered the structure (Cooke and Hinch 2013). The minimum effective attraction flow may vary depending on river flow; therefore, attraction flow also will be evaluated during data analysis as a percentage of river discharge and as the absolute quantity of attraction flow.

The volume of attraction flow at the fishways will be altered on weekly during the assessments. The number and species of fish entering the fishway will be monitored at each flow rate using an automated camera recording system similar to a VAKI Riverwatcher. These data will be combined with telemetry and PIT tag data to assess to the most effective attraction flow. Ideally, the camera will be operational whenever the temporary and permanent fishways are operational.

The automated camera recording system will be installed and incorporated into entrance structure designs of both the temporary and permanent fishways. For planning, costs of the automated camera equipment, installation, power for the system, and maintenance of the camera will be covered by the Fishway and Trap and Haul facility. These costs are not covered by this Program.

Conceptually, the temporary fishway designs includes a high velocity jet (HVJ). The HVJ will produce a fast-moving stream of water that is designed to attract fish to the entrance of the fishway. Data regarding the efficacy of HVJ's are limited. Ideally, the volume, velocity, and position of water released by the HVJ will be alterable on both the temporary and permanent fishways to assist in experimentally testing the HVJ's effectiveness in attracting fish to the entrance.

Task 2c. Contingent Radio Telemetry Surveys in Site C Tailwater. Acoustic telemetry receivers positioned in the Site C tailrace are expected to provide continuous positional data for fish in the tailrace that are suitable to address the objectives of this Program. However, hydroelectric facilities can generate high levels of hydroacoustic noise in the tailrace area that can interfere with acoustic telemetry systems. If the Acoustic Telemetry Array System yields insufficient movement data for acoustic tagged fish in the area of the diversion tunnel outlets during Construction Year 5, fixed radio telemetry will be used as an alternative means of collecting positional data for fish in the tailwater.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a to 2c are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Movement data from tagged fish collected in the tailwater and fishway will be used to understand fishway attraction efficiencies and passage efficiencies for both the temporary or permanent fishways.

Data recorded by the automated camera recording system will be summarized in relation to the program's objectives.

Analyses will include accepted techniques, such as those used in the literature on fishway evaluations (Castro-Santos et. al. (2009); Cooke and Hinch (2013).

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[5].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Fishway Effectiveness Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted after Construction Year 9 to facilitate data and information gathered during the operation of the temporary fishway. A second synthesis review will be conducted after Operation Year 4 to facilitate data and information sharing between this Program and other Site C Monitoring Programs. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

[5] Decision Statement, October 14, 2014, Section 18 Record Keeping.

Results of this Program will be used to validate predictions and address uncertainties in the EIS regarding the movements of large-bodied migrant fish species and the effectiveness of the temporary and permanent fishways. In particular, information from this Program on entrance into the fishway under a range fishway attraction flows and river conditions will inform the operation of the temporary and permanent fishways.

Data and results from this Program will be interpreted in conjunction with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, through the exchange of information at annual workshops (Task 6) and through the program's synthesis reviews (Task 7).

SCHEDULE

A tentative schedule for each Task within the Program is detailed below. Work associated with Task 1 (Project Coordination) would be ongoing on an "as needed" basis. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period. This would provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop prior to the next year's field season.

Field work for this Program will be completed between April and October of Construction Years 5 to 9 and Operation Years 1 to 4, and year 10 and 11.

Telemetry tags are tentatively scheduled to be deployed during Construction Years 5, 6, and 8 and during Operation Years, 1, 3 and 10.

The synthesis review (Task 7) will be conducted during Construction Year 9 and again during Operation Year 4.

REFERENCES

BC Government. 2011. DRAFT Fish, Wildlife and Ecosystem resources and Objectives for the Lower Peace River Watershed – Site C Project Area. 25 p. + appendices.

BC Ministry of Environment. 2009. DRAFT Ministry of Environment Fish and Wildlife Interim Objectives for Site C Project Area.

Bunt. C. M., T. Castro-Santos and A. Haro. 2012. Performance of fish passage structures at upstream barriers to migration. River Research and Applications 28:457–478.

Cooke, S.J. and S.G. Hinch. 2013. Improving the reliability of fishway attraction and passage efficiency estimates to inform fishway engineering, science, and practice. Ecological Engineering 58: 123-132.

Castro-Santos, T., A. Cotel, and P. Webb. 2009. Fishway evaluations for better bioengineering: an integrative approach. American Fisheries Society Symposium 69: 557–575.

Appendix O

Mon-14 Site C Trap and Haul Fish Release Location Monitoring

SITE C TRAP AND HAUL FISH RELEASE LOCATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-14 - Site C Trap and Haul Fish Release Location Monitoring Program
Description	This Program will investigate the optimum fish release locations for fish collected at the Site C fishways and released upstream.
Key Project components / locations	Fish collected at either the temporary or permanent Site C fishways will be transported upstream of the dam site and released. This Program will evaluate the survival of fish released at various locations during river diversion and the initial years of operation.
Monitoring Category	Effectiveness and Validation Monitoring
Closely related studies	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-10 – Site C Fish Entrainment Monitoring Program • Mon-13 – Site C Fishway Effectiveness Monitoring Program
Schedule	Construction Years 5 and 6 and Operations Year 1 to 3

RATIONALE

BACKGROUND

Upstream fish movements will be affected during the construction and operation of the Site C Clean Energy Project (the Project). In the absence of mitigation, the diversion tunnels, dam, and generating station will block upstream fish movements[1]. Upstream fish passage will mitigated using a staged approach to the design, construction, operation and evaluation of trap and haul facilities, as described in the EIS (Volume 2 Appendix Q1 Fish Passage Management Plan). A temporary trap and haul facility will we operated during the river diversion phase of construction, and a permanent facility during operation of the Project. A monitoring and assessment program was recommended to reduce key uncertainties and inform the operation of the trap and haul facilities. Key uncertainties include the location to release fish and their movements following release. The Site C Trap and Haul Fish Release Location Monitoring Program (this Program) is a component of this monitoring.

Monitoring is expected to include five species, Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout. These species may attempt to migrate upstream given known spawning areas upstream of the Site C dam site, are identified as indicator species in local provincial management objectives (BC Ministry of Environment 2009; BC Government 2011), and were identified during the environmental assessment process as important for Aboriginal groups and anglers.

This Program will evaluate the effectiveness of various fish release locations in Site C Reservoir or tributaries by using telemetry (both acoustic and radio) to track the movement of fish after they are transported from the trap and haul facility and released upstream. This Program will specifically monitor fish following release; selection of release locations will be made under the Fish Passage Management Plan.

Several factors are expected to be taken into account when selecting release location, including fish holding times (Portz et al. 2006), truck access, potential for predation upon release, and the ability of released fish to be able to continue their upstream migration (as described in the EIS Volume 2 Appendix Q1). The closest release locations to Site C will result in the shortest time period that fish are held in the transport pods, which would likely reduce fish stress and effort to transport fish. However, release locations too close to Site C (i.e., near the approach channel) may result in fall back. Fall back is defined as the behavior of passing downstream through a dam shortly after upstream passage or transport, prior to reaching spawning or rearing areas (Reischel and Bjornn 2003; Schmetterling 2003). For this Program, fall back will be defined as passing downstream of Site C within a short period of time after release upstream of the dam. Fish that are entrained through the dam months after transport and release will not be classified as fall back. Fish release locations too far upstream from Site C may result in fish being inadvertently released upstream of their natal spawning tributary (e.g., releasing an Arctic Grayling destined for the Moberly River at a location closer to the Halfway River).

This Program is expected to provide information to inform decisions on fish release.

FISHERIES MANAGEMENT QUESTION

The fisheries management question (management question) that will be addressed by this Program for each species is as follows:

1. What are effective locations within Site C Reservoir and tributaries to release Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout captured at the Site C Trap and Haul Facility?

[1] EIS, Volume 2, Section 12.4.6

Information gathered by this Program during Project construction will provide input into the fish release plan that will be implemented during operation years.

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

H_1: Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout migrants captured at the Site C Trap and Haul Facility and released into Site C Reservoir will continue their migration with no fall back through the dam or mortality (within 48 hours) after release.

This hypothesis provides addresses the general response of fish to transport and release. A potentially confounding factor may be the 'motivation' of individual fish released. Bull Trout for example have a protracted upstream migration that from Peace downstream of the Project to spawning areas in the Halfway watershed, that occur over a period of months for individually tagged fish (summarized in the EIS Volume 2 Appendix O). These factors will be taken into account during the evaluation comparisons with the broader literature on the topic, which is dominated by tracking of anadromous salmonids during their spawning migrations.

H_2: There will be no differences in the behavior or survival among Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout released at different locations within Site C Reservoir or tributaries

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding the effectiveness of fish release locations upstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In particular, the information will guide fish transport and release plans under the Fish Passage Management Plan. In addition, the information will be used to verify predictions in the EIS[2] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[3]) and the Federal Decision Statement[4].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address the management question posed by collecting data necessary to draw inferences and to test the management hypotheses. The scope of this Program will monitor a sample of fish following transport and after release in Site C Reservoir. These results will be evaluated and recommendations on the release locations for each species will be provided.

The temporal scope of this Program includes Construction Years 5 and 6 for the temporary trap and haul facility, and Operation Years 1 to 3 for the permanent trap and haul facility. The development over time of Bull Trout or Lake Trout populations in Site C Reservoir may result in altered predation rates at some release locations over time. Contingent study years would include Operation Years 5, 10, 15, 20, 25, or 30. These study years will be implemented if data from the Site C Reservoir Fish Community Monitoring Program (Mon-1a) suggest substantial changes to the reservoir fish community that could influence the effectiveness of designated fish release locations.

[2] EIS, Volume 2, Section 12
[3] EAC, Condition #7, Pages 8 to 9
[4] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

APPROACH

The general approach is to implant a telemetry tags in a sample of fish being processed at the temporary or permanent fishways so that their movements can be monitored after release using telemetry data collected under the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b). Supporting information may be obtained from the expected larger portion of fish that are implanted with Passive Integrated Transponder (PIT) tags during operation of the fishways and subsequently detected under other monitoring programs, such as Mon-1b.

Monitoring will occur during both Project construction and operation. Information obtained during construction will be used to guide monitoring during operations and taking into account that physical conditions will change following reservoir formation.

TASKS

The trap and haul facilities will operate from April through October. This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
- Task 3 – Data Analysis
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2. Data Collection. Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout all migrate at different times of the year. Therefore, field work to implant telemetry transmitters will be conducted during distinct sampling periods that will coincide with each species' migratory period.

Select Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout will be implanted with dual-mode (acoustic and radio) telemetry tags. All telemetry tags deployed under this Program will be compatible with

the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b). For this Program, telemetry tags will only be deployed into sexually mature fish (where feasible) to increase the likelihood of monitoring fish that are motivated to migrate to upstream spawning areas. All telemetry tagged fish also will be implanted with PIT tags.

Telemetry tagged fish will be transported to select release locations upstream of Site C.

It is anticipated that some fish (e.g., Arctic Grayling, Burbot, and Mountain Whitefish) will be destined for the Moberly River, while others will be destined for the Halfway River (e.g., Bull Trout and Mountain Whitefish) or Maurice, Lynx, or Farrell creeks (Rainbow Trout). Release sites will vary by species based on the anticipated destination of each species.

Potential release locations include the Site C Reservoir forebay for fish expected to migrate to the Moberly River, the Cache Creek boat launch for fish expected to migrate to the Halfway River, and the Lynx Creek and Hudson's Hope boat launches for fish expected to migrate to Maurice, Lynx, or Farrell creeks. For each release location, physical habitat, water temperature, water velocity, and descriptions of available cover will be documented. Water quality in the transport container (e.g., water temperature, dissolved oxygen) will be monitored by Trap and Haul facility personnel; these parameters will not be recorded by this Program.

Movements of telemetry tagged fish will be monitored by the Site C Acoustic Telemetry Array System (Task 2d) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b). The Site C Acoustic Telemetry Array System encompasses the Peace River, Site C Reservoir, and the inundated portions of Site C Reservoir tributaries. Under the current program, the movements of telemetry tagged fish will not be monitored in the riverine portions of Site C Reservoir tributaries. Fish will be classified as reaching their intended spawning areas if data suggest they successfully migrated upstream of the inundated portions of Site C Reservoir tributaries. Similarly, fall back will be assumed if tagged fish are detected by acoustic telemetry receivers located downstream of Site C. Fall back also will be assumed if PIT tagged fish released upstream of Site C are recaptured downstream of Site C under the Peace River Fish Community Monitoring Program (Mon-2). Dedicated telemetry surveys will not be required as part of this Program.

During Construction Year 6, the methodology will be adjusted based on results from Construction Year 5. An adaptive approach will be used, where fish sorting, release locations, or other protocols will be modified in subsequent years of the Program to identify procedures that minimize the effects of capture and transportation on migration.

Fish tagged as part of other components of the Site C Fisheries and Aquatic Habitat Monitoring Program may be encountered in the Site C trap and haul facilities. Telemetry data from these fish will be included in analyses under this Program when possible. Previous handling and encounter histories of these fish should be considered when interpreting results from these fish.

For planning, this Program includes funds to implant telemetry tags into 20 Arctic Grayling, Bull Trout, Burbot, Mountain Whitefish, and Rainbow Trout (i.e., 100 tags in total) during each study year. Ideally, tags will only be implanted into sexually mature fish that are being encountered at the fishways for the first time. Implanting tags into only initially captured fish will limit biases associated with repeated capture and handling, or repeated use of the trap and haul facilities. Conversely, programs in other watersheds have shown that those fish captured in the facility, released downstream and that enter the facility for the second time are more likely to be seeking upstream spawning locations. Sampling decisions will need to adapt based on information obtained and the specific fish transport and release plans developed under the Fish Passage Management Plan.

A fin ray sample will be collected from each Bull Trout implanted with a telemetry tag. These samples will be provided to the Peace River Arctic Grayling and Bull Trout Movement Assessment (Task 2a) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b) for microchemistry analysis.

Task 3: Data Analysis*.* Analyses to be conducted under Task 2 are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Movement data from tagged fish will be assessed by species and release location for both construction and operational phases of the project. Data will be summarized and release locations will be ranked by species based on mortality and fall back rates, and the ratio of each species that successfully migrate to known spawning tributaries.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[5].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

[5] Decision Statement, October 14, 2014, Section 18 Record Keeping.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Trap and Haul Fish Release Location Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted in Operation Year 3 to facilitate data and information sharing between this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring programs.

INTERPRETATION OF MONITORING PROGRAM RESULTS

This Program should be interpreted in terms of an adaptive management framework, where the study design (release locations and transportation procedures) is modified based on previous study years. For instance, release locations that result in high rates of fall back or mortality do not need to be investigated further and can be replaced with locations more likely to be effective based on previous results. This approach will improve the ability of the program to identify optimum locations and procedures, and maximize benefits to migratory fish populations.

Results from this Program will be interpreted in the context of other closely related monitoring programs. For instance, the effectiveness of different release locations and fish transportation in general, may depend on the environmental conditions following fishway passage. Statistical tests of the management hypotheses will focus on fish movements after use of the trap and haul facilities and upstream release; however, these findings must be considered in terms of each fish's entire migration and other confounding factors.

SCHEDULE

Field work for this Program will be completed during Construction Years 5 and 6 and during Operation Years 1 to 3. The gradual development of Bull Trout or Lake Trout populations in Site C Reservoir over time may alter the effectiveness of identified fish release locations (i.e., due to increased predation rates). For this reason, single years of monitoring could be repeated for select species and location every 5 years beginning in Operation Year 5. This timing would coordinate with telemetry collected under other monitoring programs. These monitoring years will not be required if results of the Site C Reservoir Fish Community Monitoring Program (Mon-1a) suggest low abundance of these piscivorous fish.

The temporary and permanent trap and haul facilities will be operational from April to October of each study year. Telemetry tags will be deployed opportunistically during this time period. The timing of tag deployment will depend on each species' migratory period and catch-rates observed at the trap and haul facilities.

The synthesis review of this Program will be conducted in Operation Year 3.

REFERENCES

BC Government. 2011. DRAFT Fish, Wildlife and Ecosystem resources and Objectives for the Lower Peace River Watershed – Site C Project Area. 25 p. + appendices.

BC Ministry of Environment. 2009. DRAFT Ministry of Environment Fish and Wildlife Interim Objectives for Site C Project Area.

Portz, D. E., C.M. Woodley, and, J.J. Cech Jr. 2006. Stress-associated impacts of short-term holding on fishes. Reviews in Fish Biology and Fisheries 16: 125-170.

Reischel, T. S. and T.C. Bjornn. 2003. Influence of fishway placement on fallback of adult salmon at the Bonneville Dam on the Columbia River. North American Journal of Fisheries Management 23: 1215-1224.

Schmetterling, D. A. 2003. Reconnecting a fragmented river: movements of westslope cutthroat trout and bull trout after transport upstream of Milltown Dam, Montana. North American Journal of Fisheries Management 23: 721-731.

Appendix P

Mon-15 Site C Small Fish Translocation Monitoring

SITE C SMALL-FISH TRANSLOCATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-15 - Site C Small-Fish Translocation Monitoring Program
Description	This program will monitor small-fish species populations in the Peace River to determine the effects of the Project on genetic structure, movement, and genetic exchange of these species.
Key Project components / locations	Construction and Operation
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-2 – Peace River Fish Community Monitoring Program
Schedule	Continuous

RATIONALE

BACKGROUND

The approach to upstream fish passage as described in Site C Clean Energy Project Environmental Impact Statement (EIS) is targeted towards large-sized fish species (i.e., fish >200 mm fork length [FL] at maturity) such as Bull Trout[1]. These fish species generally undertake extensive movements. Small-fish species (fish <200 mm FL at maturity), such as shiner and dace species, do not undertake extensive migrations or movements and ongoing upstream and downstream passage are not required to meet population abundance objectives for these species. The construction of Site C Clean Energy Project (the Project) will result in two separate (i.e., upstream and downstream) populations of small-fish species. Some movements may occur between upstream and downstream locations (e.g., through entrainment); however, the extent that these movements will contribute to genetic exchange between locations is uncertain. In addition, small-fish species may not be passed upstream by the trap and haul facility[1], further limiting the amount of genetic exchange.

To address the uncertainty regarding the Project's effects on genetic structure, movement, and genetic exchange of small-fish species, a small-fish translocation program will be investigated at a conceptual level. Based on available information, there is no precedent for such a translocation program, although a recent program of capture and translocation for non-anadromous salmonids reflected this concept (Epifanio et al. 2003). Such a program would first study the population structure of small-fish species and determine whether facilitating genetic exchange between upstream and downstream populations could result in a conservation benefit. Contingent on identifying the potential for such a benefit, the program would evaluate the technical options for implementing a capture and translocation program in terms of feasibility, cost, and potential conservation benefit[1].

Species with local movement patterns (e.g., small fish species) would not be affected by blocked upstream passage because they can complete their entire life histories in habitats located downstream of Site C[2]. The EIS states the following regarding size distinction:

> "The rationale for size distinction relates to the relative difference between large fish species and small fish species in their ability to move extended distances. In fluvial systems like the regulated Peace River, adults of large fish species are capable of moving long distances upstream against the river current. Due to their small size, small fish species undertake shorter upstream movements compared to large fish species. Small fish species and younger age classes of large fish species can complete long distance movements during downstream dispersal[3]."

The patterns of habitat use by small-fish species currently fit the criteria for an isolation-by-distance model of genetic differentiation among populations. In this model, individuals move freely among local populations but the probability of movement declines with distance between sites. The pattern of genetic differentiation at neutral loci can be used to infer the probability of movement among geographic locations (e.g., Taylor et al. 2003). From a conservation perspective, artificial and natural barriers to movement have the potential to enhance the process of adaptation to local environmental conditions. However, barriers also may lead to the loss of genetic variation in smaller local populations. This loss of variation may reduce the potential for the species to adapt to future environmental conditions. The decision to move fish around a new barrier has to balance the likelihood of disrupting the current patterns of local adaptation by promoting excessive movement, against the likelihood of losing genetic variation within each population as a result of excessive restrictions on movement.

[1] EIS, Volume 2, Appendix Q
[2] EIS, Volume 2, Section 12.4.6
[3] EIS, Volume 2, Section 12.3.2.2

FISHERIES MANAGEMENT QUESTION

The primary fisheries management question (management question) to be addressed by the Site C Small-Fish Translocation Monitoring Program (this Program) is as follows:

- How does Site C affect genetic structure, movement, and genetic exchange of small-fish species?

Information collected under this Program will support decisions regarding potential management actions for small-fish translocation that would support conservation objectives. This Program can be presented as a step-wise series of management questions and investigations. These questions could be investigated concurrently to provide a weight-of-evidence to support the ultimate decision regarding initiating a small-fish translocation program:

1. Are there genetically distinguishable 'local populations' upstream and downstream of Site C?

   The current pattern of differentiation at neutral loci can be used to define the current pattern of genetic exchange among geographic locations (e.g., Taylor et al. 2003). Genetic sampling, as opposed to documentation of movements by individual fish, has the advantage of integrating the entire process of movement, successful reproduction, and survival of offspring. Techniques for detecting and analyzing patterns of genetic differentiation continue to advance rapidly, which suggests that the uncertainty associated with decisions on facilitating fish movement will continue to decline.

2. Would the Project potentially affect the current pattern of genetic diversity?

   The Project will only affect genetic exchange that is currently taking place, and genetic testing can be used to determine that rate of exchange. The rate of exchange that disrupts genetic drift of adaptively neutral variation is very small: one per generation. As a result, an observation of genetic differentiation among populations at two geographic locations is a very sensitive test indicating that the current rate of genetic exchange is negligible. Patterns of genetic variation as a function of distance can be used to infer the rates of effective movement as a function of distance.

3. Would a translocation program partially maintain this genetic exchange? If so, how effective would this genetic exchange program be at meeting provincial management objectives for conservation?

   The decision on translocation would have to be tied to observations of new genetic differentiation or loss of genetic diversity. This type of monitoring is well developed in species where a decline in abundance and changes to movement patterns may alter existing patterns of genetic variation (e.g. Van Doornik et al. 2011).

MANAGEMENT HYPOTHESES

This Program focuses on monitoring patterns of genetic variation through genetic sample analysis to address the following hypotheses:

H_1: Genetically distinguishable 'local populations' of small-fish species will be located upstream and downstream of Site C.

H_2: The current pattern of genetic diversity of small-fish species will not be affected by the construction of Site C.

H_3: A translocation program could partially maintain genetic exchange of small-fish species if genetic exchange is affected by Site C.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding the genetic variation of small-bodied fish upstream and downstream of the Project, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on fish passage management and habitat enhancement. In addition, the information will be used to verify predictions in the EIS[4] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[5]) and the Federal Decision Statement[6].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to reduce uncertainty concerning the effects of the Project on gene flow among populations of small-fish species upstream and downstream of Site C. Populations currently connected by low levels of gene flow may become fragmented by the presence of the Site C or Site C Reservoir. This fragmentation can lead to loss of genetic variation within populations that may reduce population viability. The outcome of this Program will inform decisions on the number and locations of transfers that will be required to avoid the negative consequences of fragmentation. Sampling prior to river diversion will provide baseline data that will be compared with data collected after Project completion.

Sampling will be restricted to locations on tributaries just upstream of the inundation zone and to two locations on the Peace River downstream of Site C; one upstream and one downstream of the Pine River confluence. Only species that are currently present both upstream and downstream of Site C will be sampled. Focal species will include those that show little evidence of genetic divergence. Species that currently have patterns of strong differentiation upstream and downstream of Site C are not good candidates for translocation.

Overall, this Program will prevent the loss of genetic variation at the population level while preserving adaptive variation. A translocation program should not be implemented unless there is evidence of a loss of genetic material from a population or increasing divergence among populations. Small-fish species that are currently present in low abundances (e.g., Spottail Shiner, Pearl Dace) are of particular concern.

APPROACH

The proposed approach will collect a series of genetic samples and store most of them for future laboratory and statistical analyses. The first pre- versus post- construction/operations comparisons will take place 10 years after river diversion (i.e., 10 years after Construction Year 5). The actual processing of most of the baseline samples will be delayed until this time due to the rapid evolution of the technology associated with processing genetic information.

Before actual translocation events are implemented, genetic and habitat data will be integrated into a simulation model that will be used to evaluate the outcomes of alternative translocation options (e.g., Jager 2006).

[4] EIS, Volume 2, Section 12
[5] EAC, Condition #7, Pages 8 to 9
[6] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

TASKS

This Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
- Task 3 – Data Analysis
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2. Data Collection. Sampling and data collection will use methods similar to those used to evaluate the effects of increasing fragmentation in Cutthroat Trout (Cegelski et al. 2006), Bull Trout (DeHaan et al. 2011), and Chinook Salmon (Neville et al. 2007). Field work consists of collecting and preserving tissue samples, usually fin clips, in individual vials. Typical sample sizes are 30 individuals for each species and site. Samples will be collected using methods appropriate for long-term storage. Given the long time frame of this Program, proper sample storage is critical to the success of this project.

Upstream of Site C, samples will be collected during the Site C Reservoir Tributaries Fish Population Indexing Survey (Task 2c) of the Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program (Mon-1b). The Site C Reservoir Tributaries Fish Population Indexing Survey will use a combination of fish collection techniques (i.e., small-fish boat electroshocking, backpack electrofishing, beach seining, and hoop netting) in Maurice and Lynx creeks and the Moberly Rivers. Samples will be collected under this program during Construction Years 3 and 4 and Operation Years 1, 5, 10, 15, 20, 25, and 30.

Downstream of Site C, samples will be collected during the Peace River Fish Composition and Abundance Survey (Task 2b) of the Peace River Fish Community Monitoring Program (Mon-2). The Peace River Fish Composition and Abundance Survey will use a combination of fish collection techniques (i.e., small-fish boat electroshocking, backpack electrofishing, beach seining, and hoop netting) in the Peace River between Site C and Pine River

confluence. Samples will be collected under this program during Construction Years 6 and 7 and Operation Years 1, 5, 10, 15, 20, 25, and 30.

Samples will be collected from as many different small-fish species as possible (up to 30 samples for each species at each location during each study year). Based on data summarized in the EIS[1], the following small-fish species are present in the study area: Brook Stickleback, Finescale Dace , Flathead Chub, Lake Chub, Longnose Dace, Northern Redbelly Dace, Peamouth, Northern Pearl Dace , Prickly Sculpin, Redside Shiner, Slimy Sculpin, Spoonhead Sculpin, Spottail Shiner, and Trout-perch.

Task 3. Data Analysis. Analyses to be conducted under Task 2 are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

Select samples will be analyzed after Construction Years 3 and 6 to test the suitability of the samples and the selected method at monitoring changes in the genetic structure, movement, and genetic exchange of small-fish species upstream and downstream of Site C. During Construction Years 3 and 6, analyses will be limited to approximately three representative species. Good candidate species include Slimy Sculpin (due to the current availability of genetic markers for this species and previous investigations in Williston Reservoir that focused on this species; Clarke et al. 2004), Longnose Dace (due to the current availability of genetic markers), and Redside Shiner (due to their high abundance upstream and downstream of Site C and their potential movements patterns. Based on results of these initial analyses, the Program may be modified to ensure that objectives will be met.

Further lab analyses will be delayed until approximately Operation Year 5 (i.e., 10 years after river diversion). For planning purposes, additional analyses are scheduled for Operation Years 10, 20, and 30. This schedule is designed to give time for differentiation to occur and to take advantage of new technological developments.

Both laboratory and statistical analysis methods used to monitor population genetic data continue to evolve. Detailed methodologies that are currently appropriate for this program can be found in many papers (e.g., Petrou et al. 2014, Baumsteiger and Aguilar 2014). Due to rapid developments in the field of genetics, detailed methods and protocols are not provided at this time, but will be prepared and reviewed prior to analysis of samples.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual

report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[7].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Small Fish Translocation Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

[7] Decision Statement, October 14, 2014, Section 18 Record Keeping.

The synthesis review will be conducted during Operation Year 5, facilitating data and information sharing between this Program and other Site C monitoring programs. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

This Program will identify species with populations upstream and downstream of Site C that are genetically similar, and document any divergence or loss of genetic variation between populations of these species over time. With the aid of a computer simulation model, this information will be integrated into the decisions concerning the translocation of small-fish species between areas.

Details on the species, number, timing, and locations of translocations will depend on the outcome of the program. In general, genetic differentiation that is rapid or large will trigger the transfer of larger numbers of individuals to sites where genetic changes are larger. Additional genetic sampling in the years following a translocation event will be required to evaluate the success of the transfer and the need for additional translocation activities.

SCHEDULE

Genetic samples will be collected upstream of Site C during Construction Years 3 and 4 (i.e., prior to river diversion) and will be collected downstream of Site C during Construction Years 6 and 7 (i.e., during river diversion). During operation, genetic samples will be collected during Operation Years 1, 5, 10, 15, 20, 25, and 30.

Preliminary analyses will be conducted during Construction Years 3 and 6 and detailed analyses will be conducted during Operation Years 5, 10, 20, and 30. A synthesis review is scheduled for Operation Year 5.

REFERENCES

Baumsteiger, J and A Aguilar. 2014. Impact of dams on distribution, population structure, and hybridization of two species of California freshwater sculpin (Cottus). Conservation Genetics 15: xx-xx.

Clarke et al. 2004. Discrimination of habitat use by slimy sculpin (Cottus cognatus) in tributaries of the Williston Reservoir using natural elemental signatures. http://www.bchydro.com/pwcp/pdfs/reports/pwfwcp_report_no_288.pdf

Cegelski, Christine C; Campbell, Matthew R; Meyer, Kevin A; Powell, Madison S. 2006. Multiscale Genetic Structure of Yellowstone Cutthroat Trout in the Upper Snake River Basin. Transactions of the American Fisheries Society135(3): 711-726.

DeHaan, Patrick W; Bernall, Shana R; DosSantos, Joseph M; Lockard, Lawrence L; Ardren, William R. 2011. Use of genetic markers to aid in re-establishing migratory connectivity in a fragmented metapopulation of bull trout (Salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences 68(11): 1952-1969.

Epifanio, J; Haas, G; Pratt, K; Rieman, B; Spruell, P; et al. 2003. Integrating conservation genetic considerations into conservation planning: a case study of bull trout in the Lake Pend Oreille - lower Clark Fork River system. Fisheries 28 (8): 10-21.

Jager, Henriette I. 2006. Chutes and ladders and other games we play with rivers. II. Simulated effects of translocation on white sturgeon. Canadian Journal of Fisheries and Aquatic Sciences 63(10): 176-185.

Neville, Helen; Isaak, Daniel; Thurow, Russell; Dunham, Jason; Rieman, Bruce. 2007. Microsatellite variation reveals weak genetic structure and retention of genetic variability in threatened Chinook salmon (Oncorhynchus tshawytscha) within a Snake River watershed. Conservation Genetics 8(1): 133-147.

Petrou E. L., J. E. Seeb, L. Hauser, M. J. Witteveen et al. 2014. Fine-scale sampling reveals distinct isolation by distance patterns in chum salmon (Oncorhynchus keta) populations occupying a glacially dynamic environment. Conservation Genetics 15:229–243.

Taylor, EB; Stamford, MD; Baxter, JS. 2003. Population subdivision in westslope cutthroat trout (Oncorhynchus clarki lewisi) at the northern periphery of its range: evolutionary inferences and conservation implications. MOLECULAR ECOLOGY 12(10): 2609-2622.

Van Doornik, Donald M; Waples, Robin S; Baird, Melissa C; Moran, Paul; Berntson, Ewann A. 2011. Genetic Monitoring Reveals Genetic Stability within and among Threatened Chinook Salmon Populations in the Salmon River, Idaho. North American Journal of Fisheries Management 31(1): 96-105.

Appendix Q

Mon-16 Site C Reservoir Constructed Shallow Water Habitat Areas Sediment and Vegetation Monitoring Program

SITE C RESERVOIR CONSTRUCTED SHALLOW WATER HABITAT AREAS SEDIMENT AND VEGETATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-16 - Site C Reservoir Constructed Shallow Water Habitat Areas Sediment and Vegetation Monitoring Program
Description	This monitoring program will investigate the suitability of benthic substrates in constructed shallow water habitats in Site C Reservoir for aquatic plants as well as monitor the natural colonization of aquatic plants in these habitats.
Key Project components / locations	Reservoir Operation
Monitoring Category	Validation Monitoring
Closely related programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program
Schedule	Select years during Operation Years 1 to 20

RATIONALE

BACKGROUND

The Fisheries and Aquatic Habitat Management Plan for the Site C Clean Energy Project (the Project) includes the construction of five shallow water habitats along the new reservoir shoreline and prior to reservoir filling. These sites are referred to as: Km 22-24, Km 25-27, Km 34-35, Km 42-44, and Km 49-52 (river kilometre values are measured downstream from W.A.C. Bennett Dam; Km 0.0). The intent is to provide shallow habitat to benefit the fish and aquatic organisms. One uncertainty is the extent that aquatic vegetation will colonize these habitats, which is expected to depend in part on the sediment deposition at these sites. The Site C Reservoir Constructed Shallow Water Habitat Areas Sediment and Vegetation Monitoring Program (this Program) will monitor vegetation development, substrate conditions and depths at these sites.

The littoral zone is the shallow areas along the reservoir shoreline between maximum normal reservoir level (MNRL) of 461.8 m and 6 m below MNRL, which support higher aquatic production considered based on light penetration to bottom sediments supporting algal growth and growth of rooted aquatic plants (EIS, Vol. 2, App P, Part 3). The sites are designed to an elevation range between 456 and 459.75 masl (m above sea level) in order to maintain a minimum water depth above the minimum normal reservoir elevation of 460.0 masl and within 6 m of the mnrl[1].

The two most upstream sites (Km 22-24 and Km 25-27) are located in the vicinity of the PCD scour zone and, therefore, have different sediment transport potential and mechanisms when compared to the three most downstream sites (Km 34-35, Km 42-44, and Km 49-52). The two upstream sites also are most likely to experience the highest flow velocities due to limited reservoir inundation and low sediment accumulation due to limited sediment supply from upstream sources and local tributaries (as modeled in the Site C Clean Energy Project Environmental Impact Statement [EIS])[1]. Results from an integrated hydrodynamic and sediment transport model for the proposed reservoir indicate that the primary transport mechanism along the two upstream sites will be from wind generated waves reworking sediment along the shoreline[1]. Following 10 years of Project operation, the hydrographic and sediment transport model estimates that sediment deposition at the two upstream sites will range between 0 to 0.2 m of sand-sized material[1].

The predicted sediment transport mechanisms at the three downstream sites include wind generated waves and seasonal input from local tributaries. Lynx Creek, Dry Creek, and Farrell Creek are the primary contributors of discharge and sediment load for the three downstream sites. The Lynx Creek confluence is located directly upslope from site Km 34-35. Site Km 42-44 is located between the Dry Creek confluence (upstream) and the Farrell Creek confluence (downstream). Site Km 49-52 is approximately 4 km downstream from Farrell Creek. Within the immediate vicinity of the tributaries, the sediment deposition after 10 years of Project operation is estimated to be between 0.2 to 1.7 m as the delta fan migrates upslope from the base-level[1]. Model results estimate that sediment deposition at the three downstream sites will range from 0.1 to 0.4 m after 10 years of Project operation.

FISHERIES MANAGEMENT QUESTIONS

The fisheries management question (management question) that will be answered by this Program is as follows:

1. Are shallow water habtitat areas constructed in Site C Reservoir effective in providing benthic substrates suitable for aquatic plant colonization?
2. Do shallow water habitats maintain the water depths as designed?

[1] Section 6.2.3.1 Site C Reservoir Shoreline Enhancement, of the Fisheries and Aquatic Habitat Management Plan

Constructed habitat at KM 22-24 is intended to provide gravel spawning habitat. The intended function of this habitat is expected to preclude the establishment of aquatic vegetation at this site.

MANAGEMENT HYPOTHESES

This Program focuses on monitoring that addresses the following hypotheses:

- H_1: Substrate at the shallow water sites is suitable for aquatic vegetation.
- H_2: Aquatic vegetation will naturally colonize the shallow water sites.
- H_3: Sediment deposition or erosion at constructed shallow water habitat areas in Site C Reservoir will not significantly affect the suitability of these sites for aquatic plant colonization.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Information from this Program regarding constructed shallow water habitat areas in Site C Reservoir, together with information from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, will inform decisions on habitat enhancement by providing data on aquatic vegetation colonization at these sites. In addition, the information will be used to verify predictions in the EIS[2] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[3]) and the Federal Decision Statement[4].

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objectives of this Program are to monitor the shallow water sites and to assess the suitability of benthic substrates in constructed shallow water habitats of Site C Reservoir for aquatic planting, to monitor the natural colonization of aquatic plants in these habitats, and to document changes in site conditions that may affect the success of aquatic plantings and/or the natural colonization of aquatic plants.

The spatial scope of this Program is limited to the five proposed constructed shallow water habitat areas along the Site C Reservoir shoreline: Km 22-24, Km 25-27, Km 34-35, Km 42-44, and Km 49-52. The elevation and water depth at each site will be monitored, as will substrate and vegetation development.

The temporal scope of this Program is limited to Operation Years 2, 5, 10, 15, and 20.

APPROACH

The general approach is to survey substrate composition and aquatic vegetation at the shallow water sites.

A 20-year study timeline is proposed for this Program beginning in Operation Year 1; however, management decisions and monitoring program scope changes can be made at any point depending on the results of annual studies.

TASKS

[2] EIS, Volume 2, Section 12
[3] EAC, Condition #7, Pages 8 to 9
[4] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

This Program will include the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Substrate Monitoring
    - Task 2b – Aquatic Plant Monitoring
- Task 3 – Data Analysis
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. A summary of field surveys (i.e., Task 2) is provided in Table 2.

Task 1. Project coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Substrate Monitoring. Surveys will characterize the elevation of the sites and corresponding water depths, as well as the substrate at each constructed shallow water habitat site using standard methods.

Changes in the reservoir shoreline at the shallow water sites will be collected to qualitatively assess shoreline erosion and potential sediment supply to the shallow water habitat. Photographic monitoring will employ GPS points as markers for recurring photo collection. Additional information on changes in the reservoir shoreline will obtained from the Monitoring Site C Shoreline Monitoring

Task 2b. Aquatic Plant Monitoring. The natural colonization of aquatic vegetation over successive sample years will be monitored at each of the constructed shallow water habitat areas by mapping the linear extent of aquatic vegetation along the shoreline or by using a GPS. GPS mapping will be based on Resource Inventory Committee (RIC) standards to ensure spatially accurate data (Crown Registry and Geographic Base Branch 2008). Specific requirements for quality assurance and quality control are provided by the RIC and Sensitive Habitat Inventory Methodology (Mason and Knight 2001) and will be followed during field data collection.

There are no defined standards or guidelines on the use of quantitative methods to monitor and assess aquatic plants (Madsen and Wersal 2012). A number of methods may be used to monitor the natural colonization of aquatic vegetation beds to support development of species lists and percent composition in each of the

constructed shallow water habitat areas (e.g., rake sampling, coring, quadrats, box sampler such as the Ekman dredge, ponar dredge).

Aquatic plant species will be separated, identified, and the percent composition of each sample collected will be visually estimated. Observer variability in visual percent composition and percent cover estimates will be minimized by providing observer training and appropriate protocols. The field crew will endeavor to collect multiple samples from each aquatic vegetation bed to better determine species richness and diversity indices. The number of samples within a bed will be determined in the field based on the size of the bed and the complexity of the aquatic vegetation community. Percent cover within delineated aquatic vegetation beds also will be estimated in the field.

Task 3. Data Analysis. Analyses to be conducted under Tasks 2a and 2b are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate.

Benthic substrate and aquatic vegetation mapping will consist of polygon delineations of unique features and include descriptive summaries regarding composition and spatial extent.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes occurring over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[5].

[5] Decision Statement, October 14, 2014, Section 18 Record Keeping.

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

Task 7. Synthesis Review. The Site C Reservoir Constructed Shallow Water Habitat Areas Vegetation and Sediment Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

The synthesis review will be conducted during Operation Year 5, facilitating data and information sharing between this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. The synthesis reports will collate all data collected under this Program and, when possible, link findings to other monitoring program studies.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of this Program will be used to evaluate predictions and address uncertainties in the EIS regarding the projects effects on fish and fish habitat upstream of Site C, and to assess the effectiveness of fish and fish habitat mitigation measures.

Study reports will document the findings of the current year of the program, include discussions on how the current year's data compared to previous study years, and include results and discussions on all pertinent hypothesis testing.

SCHEDULE

This Program is expected to be conducted during Operation Years 1, 5, 10, 15, and 20.

REFERENCES

Madsen, J.D. and R. M. Wersal. 2012. A Review of Aquatic Plant Monitoring and Assessment Methods. Prepared for Aquatic Ecosystem Restoration Foundation.

Mason, B., and R. Knight. 2001. Sensitive habitat inventory and mapping. Community MappingNetwork, Vancouver, British Columbia. 315pp + viii. M. Johannes, Editor.

Crown Registry and Geographic Base Branch. 2008. British Columbia standards, specifications and guidelines for resource surveys using Global Positioning Systems (GPS) technology – release 4.0. [Online] http://www.for.gov.bc.ca/hts/risc/pubs/other/gps/gps_standard_2008.pdf

Appendix R

Peace River Water Level Fluctuation Monitoring Program

PEACE RIVER WATER LEVEL FLUCTUATION MONITORING PROGRAM

SUMMARY

ID	Site C Mon-17 – Peace River Water Level Fluctuation Monitoring Program
Description	This Program will investigate the effects of water level fluctuations on the catchability of Peace River fish and the biomass and production of periphyton, downstream of Site C.
Key Project components / locations	Construction and Operation / Peace River downstream to the Many Islands area in Alberta
Monitoring Category	Effectiveness and Validation Monitoring
Closely related programs	• Site C Mon-2 – Peace River Fish Community Monitoring Program • Site C Mon-3 – Peace River Physical Habitat Monitoring Program • Site C Mon-7 – Peace River Fish Food Organisms Monitoring Program •
Expected timeline	Construction Years 2 to 4 and Operation Years 1 to 3.

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, regulatory agencies, and stakeholders. For the Peace River downstream of the Site C Clean Energy Project (the Project), changes to the typical daily hydrograph could affect fish populations by altering the amount or quality of fish habitat, thereby influencing fish growth or survival (as summarized in the Environmental Impact Statement [EIS] Volume 2 Section 12). During Project operation, daily discharge fluctuations are expected become more increase and phase shifted to different times of the day. The daily range of water levels is predicted to increase from 0.5 m to 1.0 m at the Site C tailrace, increase from 0.4 m to 0.8 m near Taylor, BC, and increase from 0.5 to 0.9 m near the Alces River confluence[3]. While operations at Peace Canyon can vary for a based on a number of factors, there are at times daily patterns in the operations. For example, the following summary is based on information from summer (July 20 to Sept 20 to capture the period when fish sampling typically occurs) discharge during 2014 (high flow) and 2015 (low flow). During this time, daily peak Peace River discharge at the Taylor gauge typically occurs between 2:00 am and 6:00 am but during Site C operations the daily pattern is expected to be similar to the current Hudson's Hope hydrograph, which typically peaks between 2:00 pm and 6:00 pm. However, these patterns were not consistent. Flows at the Alces River confluence currently lag those at Taylor by approximately 5 to 6 hours. Peak flows at the Alces River confluence are expected to shift from between 7:00 am and 12:00 pm to 7:00 pm and 12:00 am.

The Peace River Water Level Fluctuation Monitoring Program (the Program) will focus on providing the information necessary to integrate these hydrological changes into the sampling design of the overall Site C Fisheries and Aquatic Habitat Monitoring Program. Specific issues include the sensitivity of electrofishing catchability to discharge under the Peace River Fish Community Monitoring Program (Mon-2) and the comparability of sampling sites for before/after comparisons under the Peace River Fish Food Organisms Monitoring Program (Mon-7). Secondly, the Program will focus on a synthesis of information from the Site C Fisheries and Aquatic Habitat Monitoring Program to develop cause and effect links between changes in hydrology and changes in fish and fish habitat. Most of the data used in this synthesis will be collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, including the Peace River Physical Habitat Monitoring Program (Mon-3), the Peace River Water and Sediment Quality Monitoring Program (Mon-9), the Peace River Riparian Vegetation Monitoring Program (Mon-5), the Peace River Fish Food Organisms Monitoring Program (Mon-7) and the Peace River Fish Community Monitoring Program (Mon-2).

MANAGEMENT QUESTIONS

The overarching relevance for this Program reflects that the construction and operation of the Project will affect fish and fish habitat in different ways. Hence, the focus of this Program is guided by the following management questions:

1. How do changes in the hydrological regime affect estimates of catchability protocols used in the Peace River Fish Community Monitoring Program (Mon-2)?
2. How do changes in the hydrological regime affect fish and fish habitat of the Peace River?

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 11.4.5.2.5

MANAGEMENT HYPOTHESES

Management hypotheses that address the management questions, posed as a series of null hypotheses, are as follows:

H_1: Species specific catchability at a sampling site in the Peace River is independent of the flow at the time of sampling.

H_2: Periphyton production among sites in the Peace River is independent of the magnitude and timing of flow fluctuations.

H_3: Biomass of invertebrates among sites in the Peace River is independent of the magnitude and timing of flow fluctuations.

H_4: Species specific fish growth among sites in the Peace River is independent of the magnitude and timing of flow fluctuations.

H_5: Species specific fish density among sites in the Peace River is independent of the magnitude and timing of flow fluctuations.

KEY MITIGATION AND OFFSETTING QUESTIONS AFFECTED

Data collected or analyzed under this Program will be designed such that point samples can be extrapolated to reach scale estimates of the net change in fish and fish habitat that result from Project operations. Information from this Program will be used in determining the number and placement of sample sites required to document changes and residual effects of Project operation on periphyton, benthos, and fish. Information on fish catchability as a function of flow will be integrated into fish abundance estimates in the Peace River below the Project.

Information consolidated by this Program will be used to verify predictions in the EIS[4] and provide supporting data for conditions listed in the Provincial Environmental Assessment Certificate (EAC[5]) and the Federal Decision Statement[6]. Information on periphyton, benthos, and fish will inform decisions on mitigation by providing insight into the causal links between Project-related hydrological effects and changes in the trophic structure.

MONITORING PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objective of this Program is to address uncertainties regarding the role of hydrographic changes in determining the species composition, biomass, and production of the fish community following the start of Project operations. These uncertainties include daily effects of flow on electrofishing catchability and seasonal effects of the magnitude and timing of flow fluctuations on periphyton, benthos, and fish production.

The spatial scope of this Program is limited to the portion of the Peace River situated between the Site C dam site and the Many Islands area in Alberta.

The temporal scope of the Program includes Construction Years 2 to 4 and Operation Years 1 to 20; however, most tasks (see below) will be completed by Operation Year 3.

[4] EIS, Volume 2, Section 12
[5] EAC, Condition #7, Pages 8 to 9
[6] Decision Statement, October 14, 2014, Section 8 Fish and Fish Habitat

APPROACH

Most of the data utilized in this Program will be collected in association with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. These components use general sampling approaches developed for baseline studies that characterized the trophic structure of the Peace River that was used for the EIS effects assessment. Benthos and periphyton data will be collected in association with Peace River Fish Food Organisms Monitoring Program (Mon-7) sampling activities and fish data will be collected in association with Peace River Fish Community Monitoring Program (Mon-2) sampling activities. Where practical, data from different components of BC Hydro's Site C Fisheries and Aquatic Habitat Monitoring Program has been coordinated such that it is collected from the same locations to maximize the utility of the data for analyses across different ecological components (e.g., fish relative abundance vs. fish food abundance). In addition, data will be spatially and methodologically consistent with data collected during baseline studies and WLR studies when feasible.

Electrofishing catchability as a function of flow will be analyzed using existing data.

The effect of shifts in the time of flow peaking on periphyton accrual will be documented using within and between site variations in accrual rates. Within-site accrual rates will be used to estimate accrual as a function of depth and current velocity and will include sites in the dewatered zone. These models will be used to predict the effects of peak flow timing and will be validated using before and after comparisons at individual sites, supplemented by data from years that differ in seasonal average flows. The effects of flow peaking on benthos biomass will be examined in a similar experimental design. Current data strongly indicated that benthos biomass is negligible in the dewatered zone, if required, this can be confirmed by additional sampling in varial zone.

The effects of flow variation on fish growth will be examined using daily and seasonal growth data. The design is similar to that used for the lower trophic levels except that within site variance is estimated from daily growth rings on age-0 fish otoliths on days with and without flow peaking. The effects of flow peaking on growth of older fish will be inferred from a weight of evidence approach using data on: the behavior and growth of tagged fish, the abundance of fish food organisms, and variation in growth among years.

The effects of flow variation on fish community composition will be inferred from species composition in electrofishing catches, combined with habitat suitability information and data on fish habitat generated in Mon-3 and Mon-9.

The effects of flow variation on the survival of young fish will be inferred from cohort analysis of selected indicator species. Daily water level variation differs among years. For example, during the July to September period, the average daily range in water level at Hudson's Hope was 1.0 m in 2014 versus 0.63 m in 2015. This among year variation in peaking strength will be combined with relative fish year class strength from cohort analysis to generate an indicator of recruitment as a function of peaking strength.

TASKS

The Program includes the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Supplementary Sampling of Benthos and Periphyton
    - Task 2b – Supplementary Sampling of Small Fish
    - Task 2c – Supplementary Sampling of Large Fish
    - Task 2d – Catchability vs Flow Assessment

- Task 3 – Data Analysis
    - Task 3a – Periphyton Accrual and Benthos Biomass Assessment
    - Task 3b – Fish Growth Assessment
    - Task 3c – Fish Community Composition Assessment
    - Task 3d – Fish Recruitment Assessment
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop
- Task 7 – Synthesis Review

Individual tasks within this Program are described below. The monitoring design presented is a 'reference design' that has been developed to address the management questions based on experience monitoring in the Peace River and other systems and input during the regulatory process for the Project. During implementation, departures from the approaches described here may be suggested if the alternative approach is supported with a defensible rationale (including consistency with baseline data) and if management questions are adequately addressed and in a cost-effective manner. Further, advances in the understanding of aquatic ecosystems, and field and analytical techniques are expected over the approximately 40 year duration of this Program and would be evaluated given these criteria.

Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of this Program with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program. Sampling under Tasks 2a to 2d, and analyses conducted under Tasks 3a to 3d are briefly described below. For all tasks, data collected under other components of the Site C Fisheries and Aquatic Habitat Monitoring Program will be incorporated into analyses and discussion, when appropriate. Consideration during analyses also will be given to confounding factors that may have affected results.

While the supplementary data collection tasks are listed under this program to provide a full summary, the information expected to be collected under the corresponding tasks in the other programs (i.e., Task 2a - Supplementary Sampling of Benthos and Periphyton would be collected under the Mon-7 Peace River Fish Food Organisms Monitoring Program).

Task 1. Project coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Most of the data collection activities under this Program are supplementary to tasks in other monitoring programs. Costs of materials needed to collect these samples (e.g., sample jars, preservative, and labels) as well as funding for analysis and interpretation of the samples will be covered under this Program; however, time associated with collecting these samples will be covered by the task that collects the sample.

Task 2a – Supplementary Sampling of Benthos and Periphyton: Periphyton and benthos will be sampled over a range of substrate elevations that are exposed to different hydrologic conditions at a given site. Sampling protocols will be the same as those employed under the Peace River Fish Food Organisms Monitoring Program (Mon-7). The highest elevation sampled will be a position that is exposed to a daily sequence of flooding and dewatering. The lowest elevation will be near the lowest bed elevation, which under present flows is approximately 2 m deep. Other positions will be between these two elevations. The same layout must occur at all sites among reaches. This approach was used during the EIS. To take advantage of existing data from the EIS, the sampling layout for new data collections that are part of this Program will be arranged in the same way.

Task 2b – Supplementary Sampling of Small Fish. Approximately 20 to 30 Age-0 and Age-1 otoliths per year will be collected from 3 indicator species collected under the Peace River Fish Composition and Abundance Survey (Task 2b) of Mon-2. Samples will be collected during periods when there are strong contrasts in the daily range of water levels just prior to sampling. If insufficient numbers cannot be collected from 3 indicator species, otoliths from other species (e.g. sucker species) will be collected. Collections will continue for at least 3 years. All samples will be collected from sites with low gradient shorelines. For each fish, the width of daily growth rings will be measured for the 30 to 50 day period prior to capture.

Task 2c – Supplementary Sampling of Large Fish. Additional fish age data may be required for fish sampled under the Peace River Fish Community Monitoring Program (Mon-2). Random samples across all age classes are preferred but, in practice, consistent samples are adequate for this purpose. Otoliths are optimal but for fish that are to be released alive, other aging structures may be utilized. In order to generate adequate sample sizes and to ensure strong contrasts in hydrological conditions among years, 10 to 15 years of data will be required. If sampling takes place in sequential years, most of the 50 to 100 fish per year that are required can be taken from the most abundant 2 to 3 annual cohorts.

Task 2d – Catchability vs Flow Assessment .This analysis will compare boat electrofishing CPUE conducted during high and low flows. Boat electrofishing under the Peace River Large Fish Index program (Mon-2, Task 2a) completes approximately 6 sessions (or passes) at each site over a period of approximately 6 weeks. Comparisons of CPUE from sessions under a range of flows will be reviewed to determine relationships between catchability and flow variation.

Task 3a – Periphyton Accrual and Benthos Biomass Assessment. Periphyton and benthos data will be incorporated into analyses designed to examine the importance of flow variables (depth and water velocity at the sampler) and other habitat conditions (light attenuation, nutrient concentrations, etc.) on the accrual of periphyton and benthos metrics. Sampling for new data collections under this Program mirrors previous data collection activities; therefore, new and existing data will be integrated into a single analysis.

Task 3b – Fish Growth Assessment. The width of daily growth rings will be compared to flow history prior to sampling. Uniform widths will be taken as evidence the daily flow variations do not affect growth. If variations in widths are present, then the sequence of widths will be correlated with the sequence of variations in daily flow ranges. Otolith analyses may not necessarily capture the last day of growth prior to capture; therefore, lags can be used to improve flow vs. width correlation.

Task 3c – Fish Community Composition Assessment. This analysis will use both planned data collection from the Peace River Fish Community Monitoring Program (Mon-2) and existing data from comparable sample methods (e.g., Golder and Gazey 2015). A long term data set (> 20 years) is required in order to capture enough variation in flow fluctuations among years and among sites within years that is minimally correlated with other variables (e.g. turbidity, temperature) that affect fish community composition.

Task 3d – Fish Recruitment Assessment. This analysis uses age structure data from the Peace River Fish Community Monitoring Program (Mon-2) to identify correlations between year class strength and seasonal patterns in flow fluctuations in a retrospective analysis. Lower than normal representation of a cohort across several sampling years will be taken as evidence of poor recruitment. The size distribution of aged and un-aged fish will be compared as a check for biases in the selection of fish for ageing relative to the entire annual catch.

Task 4. Reporting. A report will follow the conclusion of each year of this program and will document the findings of the year, including a discussion of results in the context of the management questions and hypotheses. Each report will compare and identify trends between years, where applicable. If applicable, information from related

monitoring programs will be reviewed and integrated into each report. Each monitoring report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results;
7) Trends or changes over time; and
8) An assessment of findings as they relate to the management question and hypotheses.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[7].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. BC Hydro will host workshops at least annually with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshops will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in the workshops, which are expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

[7] Condition #18 of the Federal Decision Statement for the Project.

Task 7. Synthesis Review. The Peace River Water Level Fluctuations Monitoring Program Synthesis Review will use a weight-of-evidence approach that adheres to the guiding principles used to develop the Monitoring Plan to compile, analyze, and interpret the results of the individual tasks under this Program, including input from the annual workshops (Task 6) and findings from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, to evaluate this Program's hypotheses. Individual tasks under this Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program provide multiple lines of evidence that will be considered together to evaluate whether management questions are being adequately evaluated. A diagnostic approach to determine likely causes of observations and identify suitable management actions can be employed. The findings will be documented in a report presented at the annual workshop every five years, where stakeholders will provide feedback before the report is finalized. This process will inform potential management actions that include adaptive adjustments to the Program, retooling of hypotheses, contingent monitoring, or the implementation of mitigation measures.

Task 7 will be conducted every 5 years to facilitate data and information sharing between the Program and other components of the Site C Fisheries and Aquatic Habitat Monitoring Program.

INTERPRETATION OF MONITORING PROGRAM RESULTS

Results of the Program will be used to validate predictions and address uncertainties in the EIS regarding the Project's effects on Peace River fish that employ the use of varial habitat areas downstream of the Project to fulfill their life histories.

To date, results from various BC Hydro WLR studies (BC Hydro 2007) suggest that while it is possible for projects to detect changes in various parameters, linking the reasons for observed changes to a single cause is difficult. For this reason, data and results from each task within this Program will be interpreted in conjunction with each other, through the exchange of information at annual workshops (Task 6), and through the synthesis review (Task 7). Similarly, overall results from the Program will be interpreted in conjunction with results from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program when drawing overall conclusions.

SCHEDULE

A reference schedule for the Program is detailed below. Work associated with Task 1 (Project Coordination) will be ongoing on an "as needed" basis. Ideally, the annual workshop(s) (Task 6) will be conducted during the late spring to early summer period to provide proponents with enough time to finalize previous year's reports prior to the workshop while still providing enough time to implement any changes identified during the workshop before the next year's field season. The synthesis review (Task 7) will be conducted every 5 years beginning in Operation Year 5.

Task 2a – Supplementary sampling of benthos and periphyton: Construction Years 2 to 4 and Operation Years 1 to 3.

Task 2b – Supplementary sampling of small fish otoliths. Construction Years 2 to 4, Operation Years 1 to 3.

Task 2c – Supplementary sampling of large fish ages. Will take place each year in conjunction with Mon-2, Tasks 2a and 2b.

Task 2d – Catchability vs Flow Assessment. Will take place in Operations Years 1 to 6 or until 30 Sites are sampled, and reviewed.

REFERENCES

Golder Associates Ltd. and W.J. Gazey Research. 2015. GMSMON-2 Peace Project Water Use Plan – Peace River Fish Index – 2014 Investigations. Report prepared for BC Hydro, Burnaby, British Columbia. Golder Report No. 1400753: 68 pages + 6 appendices.

Appendix S

Tributary Mitigation Opportunities Evaluation Program

TRIBUTARY MITIGATION OPPORTUNITIES EVALUATION PROGRAM

SUMMARY	
ID	Tributary Mitigation Opportunities Evaluation Program
Description	This Program will identify enhancement opportunities for stream dependent indicator species described in the EIS including Arctic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Rainbow Trout, and Walleye.
Key Project components / locations	Assessments of tributaries to Site C Reservoir and the Beatton River and the identification of potential mitigation projects for indicator species.
Closely related monitoring programs	• Mon-1a – Site C Reservoir Fish Community Monitoring Program • Mon-1b – Site C Reservoir Tributaries Fish Community and Spawning Monitoring Program • Mon-2 – Peace River Fish Community Monitoring Program
Schedule	Construction Years 3 to 4 and Operation Year 2

TABLE OF CONTENTS

RATIONALE

BACKGROUND

Fish[1] and fish habitat[2] are valued components (VCs) of the Peace River because of their importance to Aboriginal groups, the public, and stakeholders. In addition, potential impacts on fish and fish habitat are regulated both federally, by the *Fisheries Act* and the *Species at Risk Act*, and provincially, by the Freshwater Fisheries Program Plan, amongst other guiding documents. The Site C Environmental Impact Statement (EIS) identifies a variety of pathways that the Site C project could affect fish and fish habitat upstream and downstream of the project[3]. Direct effects on fish habitat in tributaries, such as inundation and changes in depth and velocity, will be limited to the lower reaches of each tributary; however, fish use of unaffected upstream reaches is expected to continue following project completion[4].

In British Columbia, watershed assessment procedures have been developed to identify stream habitat enhancement opportunities by comparing current habitat conditions to desired conditions (Johnston and Slaney 1996; Porter et. al 2013, Pickard et. al. 2014). Tributary fish habitat can be enhanced either directly through activities in the stream channel, or indirectly through activities in riparian and upslope areas. Generally, the goal of these activities is to enhance ecosystem functions by improving spawning gravel quality, rearing habitat, overwintering habitat, or food production. Slaney and Zaldokas (1997) provide practical guidance on available techniques in the context of a Watershed Restoration Procedures manual for watersheds damaged by land use activities, especially logging. General steps include the following: a watershed physical and biological assessment; a determination of key issues (e.g., a headwater land slide); a determination of limiting habitats; a restoration plan; implementation of mitigation; and monitoring the effectiveness of mitigation. Opportunities for habitat enhancement can be limited if existing habitat conditions closely match optimal conditions for target species.

The purpose of the Site C Tributary Mitigation Opportunities Evaluation Program (TMOEP) is to identify enhancement opportunities in tributaries affected by the Project for seven indicator species identified in the EIS[5] (i.e., Arctic Grayling, Bull Trout, Burbot, Goldeye, Mountain Whitefish, Rainbow Trout, and Walleye). The program will develop a preliminary list of mitigation opportunities based on existing information and expert opinion of local biologists. This will be followed by standardized watershed basin assessments to evaluate watershed status to ensure that mitigation activities are focused on areas where benefit to fish are expected to be greatest. The TMOEP will use a combination of the Project Type logical approach and the Multi-species analytical approach described by Beechie et. al. (2008). In this approach, Project Types that have a high probability of success, relatively quick response time, and long duration should be implemented before other techniques. The approach also emphasizes suites of landscape processes considered necessary to conserve multiple species. If necessary, a decision support system, such as the one described by Gregory et al. (2012) can be used to resolve issues of conflicting stakeholder values or uncertainty in projected outcomes.

The Watershed Status Evaluation Protocol (WSEP; Pickard et. al. 2014), a BC provincial initiative, will be used to evaluate watershed status. This protocol was designed to assess forestry-related cumulative impact effects but will be widely used for land use evaluation. Much of the terrestrial portion of the Site C Local Assessment Area (LAA)

[1] Fish includes fish abundance, biomass, composition, health, and survival.
[2] Fish habitat includes water quality, sediment quality, lower trophic levels (periphyton and benthic invertebrates), and physical habitat.
[3] EIS, Volume 2, Section 12.4
[4] EIS, Volume 2, Section 12
[5] EIS, Volume 2, Section 12.3

has been impacted by forestry, oil and gas, and farming activities; therefore, using these protocols in the TMOEP will complement WSEP assessments linked to other land use activities.

In WSEP, 'Watershed 'Watershed Status' describes the extent to which the interaction of watershed components (i.e., upslope, riparian, and stream channel) and watershed processes (i.e., hydrological, vegetation, soil, channel structure, thermal energy transfer, and system productivity) combine to produce suitable conditions for sustaining fish populations. In the TMOEP, the purpose of the WSEP is to determine watershed status in terms of a "proper functioning condition" (PFC) scale. Mitigation activities in watersheds with high PFC scores are less likely to result in additional benefits to fish populations and will therefore receive lower priority. Low PFC scores would raise the priority of previously identified mitigation opportunities, and trigger a search for new opportunities in these watersheds.

The WSEP process has two levels of assessment: Tier 1 and Tier 2. A Tier 1 assessment is completed by using remote-sensed and broad scale habitat information to produce GIS layers that describe Watershed Risk Status (Porter et. al. 2013). The Tier 1 assessment is a desktop exercise that is applied to 3rd order and greater watersheds in the area of interest. To confirm current habitat conditions in a watershed as summarized during a Tier 1 assessment, a more intensive, field-based, Tier 2 assessment can be conducted using three modules: 1) Riparian/Fish survey; 2) Fish Passage; and 3) Sediment Delivery. Scored ratings from each module are used to develop a watershed scale score that indicates the current functional status of the watershed. Some mitigation opportunities can be identified during the WSEP Tier 2 field sampling program; however, the WSEP is geared towards forestry-related disturbances and additional criteria may need to be developed for other land uses within a watershed. The identification of additional potential mitigation sites will be pursued by focusing on watersheds with low Tier 1 PFC scores and the factors that produce a low score.

TRIBUTARY MITIGATION OPPORTUNITIES EVALUATION - PROGRAM SCOPE

PROGRAM GOALS

The overarching goal of the TMOEP is identify opportunities to mitigate/offset the effects of Site C by identifying habitat enhancement opportunities for indicator species in tributary watersheds. To identify and prioritize enhancement actions, the TMOEP sets clear goals for enhancement activities, conducts office- and field-based assessments of current watershed conditions, identifies enhancement actions necessary to meet defined goals, and prioritizes actions based on assessment results. The program reflects the need to identify mitigation and offsetting opportunities for fish populations that are expected to be affected by the construction and operation of Site C. Implementation of the mitigation opportunities identified in this program will be considered for delivery under the Fisheries and Aquatic Habitat Monitoring and Follow-up Program[6].

Information generated under the TMOEP will support decisions regarding potential mitigation actions designed to enhance populations of indicator species that utilize tributary habitats to fulfill portions of their lifecycles. The geographic scope of the TMOEP includes permanently flowing tributaries affected by the Site C Reservoir, as well as a downstream candidate stream (i.e., the Beatton River) in consideration of potential Project operational effects

[6] Described in Section 5 Procedure to Evaluate and Implement Future Compensation Actions, of the Fisheries and Aquatic Habitat Monitoring and Follow-up Program (draft, dated Oct 23 2015).

on downstream flows. The Beatton River is included due to its high fish diversity and because it supports feeding and spawning activities for two of the indicator species (i.e., Goldeye and Walleye[7]).

Of the seven indicator species identified above, three (Burbot, Goldeye, and Walleye) are coolwater species and four are coldwater species (Arctic Grayling, Bull Trout, Mountain Whitefish, and Rainbow Trout; Mainstream 2012)

The Site C Fisheries and Aquatic Habitat Monitoring Program will test hypotheses concerning the effects of Site Project on fish populations. The role of the TMOEP is to provide information on mitigation and offsetting opportunities in tributary watersheds upstream of the reaches directly affected (i.e., inundated) by the reservoir and a downstream candidate tributary, the Beatton River. This information will be used to match opportunities with needs for mitigation for individual species. This process will ensure that appropriate mitigation measures are implemented along with any additional studies that are required to verify the effectiveness of the mitigation.

SUMMARY OF TRIBUTARY HABITAT

A substantial body of information is available on the status of the seven indicator species within the Peace River and its tributaries, and the overall conditions of each watershed (e.g., Mainstream 2011). In addition to the EIS, this information includes Provincial databases and previous watershed evaluations (e.g., Berry 1998). In general, available data indicate that opportunities to enhance habitat for indicator species in these tributaries are limited by individual species habitat requirements and the characteristics of the tributaries.

TRIBUTARIES TO THE PEACE RIVER UPSTREAM OF SITE C

Six major tributaries flow into the Peace River between Peace Canyon Dam (PCN) and Site C (Table 1). Arctic Grayling have been recorded in Maurice and Cache creeks and the Halfway and Moberly rivers; however, most spawning and early rearing of the Peace River Arctic Grayling population is believed to occur in the Moberly River[8]. Bull Trout have been recorded in Maurice and Cache creeks, and in the Moberly River; however, almost all spawning and early rearing of Peace River Bull Trout is believed to occur in the Halfway River watershed[8]. Maurice Creek supports a Rainbow Trout population. This species also has been recorded in Lynx, Cache, and Farrell creeks and are abundant throughout most of the Halfway River watershed. Burbot have been recorded in the Halfway and Moberly rivers, as well as occasionally in Wilder Creek. Goldeye and Walleye are rarely found upstream of the Site C location and are likely to be excluded from the Site C Trap and Haul program; therefore, mitigation for these species will not be considered for tributaries located upstream of Site C.

Table 1. Major Peace River tributaries located between Peace Canyon Dam and Site C, their provincial watershed codes, stream order, and indicator fish species presences.

Stream Name	Watershed Code	Indicator Species Present[a]						
		Arctic Grayling	Bull Trout	Burbot	Goldeye	Mountain Whitefish	Rainbow Trout	Walleye
Maurice Creek	230-797200	X	X			X	X	
Lynx Creek	230-792800	X				X	X	
Farrell Creek	230-786200	X				X	X	
Cache Creek	230-760300	X	X			X	X	

[7] EIS, Volume 2, Section 12.3.2.1
[8] EIS, Volume 2, Section 12.3.3

Halfway River	235	X	X	X		X	X	
Wilder Creek	230-752800			X				
Moberly River	230-744800	X	X	X		X		

[a] Data summarized from the Site C EIS[4] and the BC Ministry of Environment (MoE) online database (FIDQ 2014).

TRIBUTARIES TO THE PEACE RIVER DOWNSTREAM OF SITE C

Downstream of Site C, tributary habitat loss is expected to be minimal; however, the lower reaches of some tributaries will experience some changes in water levels[9], water temperatures[10], and water quality[10] that could change habitat use by fish.

There are four major tributaries to the Peace River between Site C and the BC-Alberta border (Table 2). Of these four tributaries, the Pine River is the largest. Arctic Grayling, Burbot, Bull Trout, Mountain Whitefish, Rainbow Trout, and Walleye have been recorded in the Pine River. The Beatton River is the second largest tributary. Arctic Grayling, Bull Trout, Burbot, Walleye and Goldeye have been recorded in the Beatton River. Both Goldeye and Walleye are known to spawn in the Beatton River[7] and in other tributaries downstream of the BC-Alberta border (AMEC and LGL, 2010; Mainstream 2012).

Table 2. Major tributaries to the Peace River between the Site C location and the BC-Alberta border, their provincial watershed codes, stream order, and presence of indicator fish species.

Stream Name	Watershed Code	Target Species Present[a]						
		Arctic Grayling	Bull Trout	Burbot	Goldeye	Mountain Whitefish	Rainbow Trout	Walleye
Pine River	234	X	X	X		X	X	X
Beatton River	233	X	X	X	X	X		X
Kiskatinaw River	232	X		X		X	X	X
Alces River	230-702700	X		X		X		

[a] Data summarized from the Site C EIS[4] and the BC MoE online database (FIDQ 2014).

With the development of Site C, the utilization of the downstream Peace River is expected to change. The Beatton River has been chosen as the highest priority for tributary enhancement due to its close proximity to Site C and its role in reproduction for Goldeye and Walleye (Mainstream 2006, 2012).

IDENTIFYING AND PRIORITIZING MITIGATION OPPORTUNITIES

Careful assessment and planning is required to ensure that each selected mitigation activity is designed to address an issue that is limiting the targeted fish population. Installation of physical structures in streams can be successful, but are prone to failure over time in high energy streams (Roni et al. 2002). The goal of mitigation should be to restore natural processes that create and maintain fish habitat (e.g., sediment supply, recruitment of woody debris from riparian areas, channel migration, side channel development). In watersheds with limited viable mitigation opportunities (due to access issues, high probability of mechanical failure, etc.) smaller tributaries in the area can

[9] EIS, Volume 2, Appendix D2
[10] EIS, Volume 2, Section 12.4.2.2

be assessed with a goal of supporting forage fish species or supporting feeding activities. The need for restoration of these processes (i.e. watershed status) will be evaluated using the WSEP methodology. The EIS[4] will provide information on fish distribution and fish habitat use to be used as general guidance on fish values in Site C tributaries.

Mitigation opportunities will be identified in a two stage process. An initial list will be generated by experts with knowledge of the species and watersheds under consideration. A WSEP Tier 1 evaluation of watershed status, combined with existing information on fish use and fish values, will be used to prioritize these opportunities. A field survey of selected opportunities, funded by the TMOEP, will provide additional details on site conditions and probability of success for these projects.

If additional mitigation is required, a WSEP Tier 2 evaluation are expected to be performed in watersheds with low PFC scores on the Tier 1 evaluation and high, or potentially high, fisheries values. The WSEP Tier 2 evaluation will be used to confirm watershed status results from the Tier 1 evaluation and to provide the initial field information on the potential for additional mitigation opportunities. Following the WSEP Tier 2 evaluation, a field survey designed to identify mitigation opportunities will be conducted by scientists with experience in hydraulic engineering and fisheries issues. For each potential mitigation opportunity, this survey will confirm fish access to the site and document the location, project type, ground conditions, mitigation options, potential for mitigation success, and accessibility for mitigation equipment. Results of the survey will be used to generate a list of additional mitigation projects. This list will be prioritized using data from the WSEP Tier 1 and Tier 2 surveys, data on fish distribution and abundance, and the field assessment of each project.

This process will focus mitigation activities on watersheds with poor watershed status and high fisheries values. The key considerations in quantifying fisheries values are fish production potential and the presence of fish species with high ranks under the Provincial Conservation Framework. Enhancement projects that supply habitat for multiple species and multiple life stages also will receive a higher weight than single-species projects. The WSEP evaluation process will help to optimize the locations and effectiveness of mitigation activities. The role of other land use activities will be integrated into the ranking system using a series of watershed-specific questions concerning geomorphology, hydrology, fish and other aquatic resources, past forest harvesting, agriculture, and proposed land uses (Wilford and Lalonde 2004), which will ensure a coordinated approach in a regional planning context.

PROGRAM PROPOSAL

OBJECTIVE AND SCOPE

The objectives of the Tributary Mitigation Opportunities Evaluation Program are as follows:

1. Develop an initial list of mitigation opportunities using currently available information and expert opinion of local fisheries biologists;
2. Use WSEP Tier 1 assessments on 3rd order and greater watersheds within the Maurice, Lynx, Farrell, Cache, Halfway, Moberly, and Beatton drainages to prioritize the mitigation opportunities identified by experts;
3. Provide information necessary to develop mitigation proposals;

If additional mitigation opportunities are required, the objectives and scope are expected to be expanded to include the following:

4. Use the WSEP Tier 1 assessments to identify additional watersheds where additional mitigation opportunities would be of most benefit in improving watershed functioning;
5. Use WSEP Tier 2 level assessments to confirm the Tier 1 results and identify the type of mitigation required;
6. Identify additional mitigation opportunities by collecting additional field data in selected watersheds;
7. Prioritize and report on mitigation opportunities by completing an evaluation process, and assembling the data necessary to submit selected mitigation proposals;

TASKS

Conceptually, the Tributary Mitigation Opportunities Evaluation Program will include the following tasks:

- Task 1 – Project Coordination
- Task 2 – Data Collection
    - Task 2a – Initial Mitigation Project Identification
    - Task 2b – WSEP Tier 1 Assessments
    - Task 2c – Identification of Additional Candidate Watersheds
    - Task 2d – Identification of Additional Mitigation Opportunities
- Task 3 – Data Analysis
    - Task 3a –Prioritization of Viable Mitigation Projects
    - Task 3b –Prioritization of Additional Mitigation Opportunities
- Task 4 – Reporting
- Task 5 – Data Management
- Task 6 – Annual Workshop

Individual tasks within TMOEP are described in detail below. Contractors are free to suggest departures from the approaches described here if the alternative approach is supported with a defensible rationale and if project objectives are adequately addressed. Efficiencies may be gained by combining different aspects of various tasks together. In addition, efficiencies may be gained by combining different aspects of the TMOEP with other Site C Monitoring Programs.

Task 1. Project Coordination. Project coordination will involve the general administrative and technical oversight of this Program. Project coordination will include but not be limited to 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight of field and analysis components; 5) the facilitation of data transfers between BC Hydro and various stakeholders, consultants, and investigators associated with the Project; and 6) report submissions to BC Hydro.

Task 2a. Initial Mitigation Project Identification. Potential mitigation projects will be identified using existing data and expert opinion by experienced fisheries biologists and geotechnical/hydraulic engineers familiar with the Peace River area. The use of existing data will facilitate the rapid identification of obvious mitigation opportunities with minimal investment of resources. Target watersheds include Maurice, Lynx, Farrell, and Cache creeks and the Halfway and Moberly rivers upstream of Site C, and the Beatton River downstream of Site C. Information regarding target species, type of activity, location, machine access options, costs, and the probability of success will be summarized for further evaluation. Site visits are expected to be required to document the fish habitat characteristics associated with each mitigation opportunity.

Task 2b. WSEP Tier 1 Assessments. Watershed status assessments are expected to be conducted on all 3rd order and greater watersheds within the study area that support populations of the target species, or are directly upstream of target species habitat, in order to ensure that the same level of information and detail is available for each watershed. WSEP Tier 1 assessment methodologies (Pickard et. al 2014) will be used to summarize existing information available for each watershed to identify factors that may impair ecological functionality and limit fish production. Collection of field data is not required. Principal data sources for a Tier 1 Assessment generally include:

- BC MoE and BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) aquatic biophysical maps and spatial layers (GIS products);
- BC MoE and BC FLNRO Resource and Analysis Branch (RAB) surveys and maps;
- BC Hydro, DFO, BC MoE and BC FLNRO special reports and studies (e.g. EcoCat); and
- Forest licensee's file information.

Much of this information can be accessed through the Data BC portal (https://apps.gov.bc.ca/pub/dwds/home.so). In addition, the Forest and Range Evaluation Program website provides links to other helpful websites (https://www.for.gov.bc.ca/hfp/frep/values/fish.htm#links).

Tasks 2c and 2d are contingent on the need for further mitigation/offsetting for Site C fisheries effects.

Task 2c Identification of Additional Candidate Watersheds. Information from Task 2b, combined with existing fish use data and mitigation needs identified in the EIS, will be used to select watersheds with poor functionality and high fisheries values as candidates for further assessment using WSEP Tier 2 protocols. The WSEP Tier 2 assessment currently consists of three field modules designed to evaluate the current condition of the watershed in terms of: 1) riparian and stream channel function; 2) sediment delivery processes; and 3) habitat connectivity for fish, with the potential for additional modules in future versions of the protocol. These assessments will be used to identify the type of mitigation that would provide the most benefit in each candidate watershed along with some information on potential mitigation opportunities.

Existing assessment procedures focus on salmonid stream habitat requirements. The habitat requirements of Burbot, Goldeye, and Walleye will need to be specifically considered when assessing the Moberly and Beatton River watersheds.

Task 2d Identification of Additional Mitigation Opportunities. Mitigation opportunities will be identified using information from Task 2c, supplemented by field visits and further assessment of areas that contribute to poor functionality in the candidate watersheds (e.g., areas with higher road densities or stream crossings). Information regarding target species, type of activity (e.g. bank stabilization, culvert removal), location, machine access options, costs, potential fisheries benefits, and the probability of success will be summarized for each opportunity.

Task 3. Data Analysis. For Task 2c, data collected under other monitoring programs should be incorporated into analyses and discussion, when appropriate. Consideration during analyses also should be given to confounding factors, sampling conditions, biases in methodologies, and sampling effects that may have affected results.

Analyses will include accepted techniques as detailed in Pickard (2014) and other protocols as they become available by the BC MoE and the BC FLNRO. The priority ranking system will be finalized in coordination with BC Hydro.

Task 3a. Prioritization of Viable Mitigation Projects. Information on potential projects (Task 2a) and current functioning conditions of target watersheds (Task 2b) will be used to rank potential projects identified in Task 2a in

terms of benefits to fisheries values and costs of mitigation. This material can then be used to prepare mitigation proposals. The prioritization for implementing mitigation projects will follow a criteria evaluation process similar to Beechie et. al. (2008). Criteria will include benefits to species where mitigation is required, benefits to other species, and costs of implementation.

This task also will evaluate the need for additional mitigation by comparing the projected benefits of viable opportunities identified in this task with the requirements for mitigation under the EIS, broken out into species and watershed specific requirements. This comparison will be used to direct the search for additional mitigation opportunities in Tasks 2c and 2d.

Task 3b. Prioritization of Additional Mitigation Opportunities. Information from Tasks 2c and 2d will be used to rank potential projects in a process similar to Task 3a. Further activity under Tasks 2c and 2d may be required as uncertainties concerning the effects of Site C on fisheries values are resolved by future monitoring activities.

Task 4. Reporting. A report will follow the conclusion of Task 3a that will document the findings of the Tier 1 Assessments (Task 2b) and provide a prioritized list of opportunities identified in Task 2a. A similar report will follow the conclusion of Task 3b. These reports will provide justification for the prioritization methods and document the outcome of the prioritization process, including a discussion of results in the context of the objectives of the TMOEP. If applicable, information from related Site C Fisheries and Aquatic Habitat Monitoring Programs will be reviewed and integrated into each report. Each report will include the following:

1) An executive summary of the project;
2) Field methods, including maps that indicate sampling locations;
3) Description of sources of error and steps taken as part of quality assurance;
4) Representative photographs of the study area;
5) Environmental data collected, presented in tabular or graphical form;
6) Description of statistical analyses and results; and
7) An assessment of findings as they relate to the programs objectives.

Deliverables will be provided in a standardized format. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a standardized database format, accompanied with any necessary descriptions and metadata. Models, if created, will be included as a digital archive with each annual report and documented in the report appendices if not already included in the annual reports. Quality assurance procedures also will be included. All photos will be submitted electronically. Reports will be submitted in both MS Word and PDF format.

Task 5. Data Management. Data collected under this Program will conform to BC Hydro's established Site C data standards, which will to ensure compliance with Project conditions, long-term data consistency, compatibility with other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, and usability by BC Hydro, government agencies, and various stakeholders.

The location, date and time, and persons involved will be recorded for all data collected under this Program. Similarly, the date, persons involved, analytical techniques, methods, or procedures employed will be recorded for all analyses conducted as part of this Program[11].

All raw data will be provided in digital formats that have been approved by BC Hydro, such as MS-Excel spreadsheets or MS-Access databases. These deliverables will include all data used to derive results. Derived data also will be provided in an appropriate digital format. Where database queries are used to generate report tables, these reports and their corresponding queries will be included with the deliverable.

A document detailing metadata will be provided with each digital deliverable. The document will describe each field in the deliverable, including measurement units and any special codes, lists of all possible codes for each field and their interpretation (if applicable), and a description of all quality control procedures and checks applied to the data. When possible, validation checks for each field (e.g., maximum, minimum, values list) will be documented. For any field derived from other data, a description of how that field was derived will be provided. Alternatively, a reference to a description such that the calculation can be reproduced using the data will be provided.

Task 6. Annual Workshop. An annual workshop will be hosted by BC Hydro with the objectives of reviewing key results from the Site C Fisheries and Aquatic Habitat Monitoring Program. The workshop will provide a forum for exchanging ideas and data among and between Site C Fisheries and Aquatic Habitat Monitoring Program teams, and provide input regarding adapting programs to better answer each program's management questions and hypotheses. Proponents involved in this Program will participate in this annual workshop during each study year, which is expected to also include key personnel from other components of the Site C Fisheries and Aquatic Habitat Monitoring Program, agencies, First Nations, BC Hydro, and independent scientists reviewing the programs. Information will be presented with respect to this Program's management question and hypotheses.

IMPLEMENTATION OF MITIGATION OPPORTUNITIES

The mitigation selection process follows a defined sequence of events. Data for each species collected through the Site C Fisheries and Aquatic Habitat Programs will be assessed to determine whether species show evidence of declining population abundance that can be linked to the construction or operation of Site C. Selected enhancement opportunities will be implemented under the Fisheries and Aquatic Habitat Monitoring and Follow-up Program[12]. Follow-up monitoring will be used to evaluate the need for additional mitigation or offsetting after the completion of this program.

SCHEDULE

The TMOEP will be initiated during Construction Year 3. A tentative schedule for each task within the program is detailed below (Table 3). As noted in previous sections, the proposed schedule is dependent on identified needs for enhancement. Work associated with Task 1 (Project Coordination) would be ongoing on an "as needed" basis.

Table 3. Proposed schedule by task for the Site C Tributary Mitigation Opportunities Evaluation Program.

Timing	Event
Construction Year 3	Task 2a: Initial Mitigation Project Identification

[11] Condition #18 of the Federal Decision Statement for the Project.

[12] Described in Section 5 Procedure to Evaluate and Implement Future Compensation Actions, of the Fisheries and Aquatic Habitat Monitoring and Follow-up Program (draft, dated Oct 23 2015).

Construction Year 3	Task 2b: WSEP Tier 1 Assessments
Construction Year 4	Task 2c: Identification of Additional Candidate Watersheds
Construction Year 4	Task 2d: Identification of Additional Mitigation Opportunities
Construction Year 4	Task 3a: Prioritization of Viable Mitigation Projects
Operation Year 2	Task 3b: Prioritization of Additional Mitigation Opportunities

REFERENCES

AMEC Earth & Environmental and LGL Limited. 2008a. Peace River fish and aquatic Investigations – Peace River and tributary summer fish distribution, habitat assessment and radio telemetry studies 2005. Prepared for BC Hydro. 93 p.

AMEC Earth & Environmental and LGL Limited. 2008b. Peace River fish and aquatic investigations – Peace River and tributary summer fish distribution, habitat assessment and radio telemetry studies 2006. Prepared for BC Hydro. 181 p.

AMEC Earth & Environmental and LGL Limited. 2010. Peace River fisheries investigation Peace River and Pine River radio telemetry study 2009. VE51567. 135 p. + appendices

Baxter, J. S., & J.D. McPhail. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bull trout (*Salvelinus confluentus*) from egg to alevin. Canadian Journal of Zoology, 77(8), 1233-1239.

Beechie, T., G. Pess, P. Roni, and G. Giannico. 2008. Setting River Restoration Priorities: a Review of Approaches and a General Protocol for Identifying and Prioritizing Actions. North American Journal of Fisheries Management 28:891–905.

Berry, J. 1998. Level 1 Watershed Assessment Interpretation and Recommendations, Ft. St. John Timber Supply Area. Available at: http://www.env.gov.bc.ca/clir/ accessed Nov. 10, 2014.

Decker, S. and J. Hagen. 2007. Distribution of Adfluvial Bull Trout Production in Tributaries of the Arrow Lakes Reservoir and the Feasibility of Monitoring Juvenile and Adult Abundance. Prepared for: Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC. 98 p. + appendices

Euchner, T. and Mainstream Aquatics Ltd. 2013. SITE C Clean Energy Project Fisheries Studies. 2012 Upper Halfway River Watershed Bull Trout Spawning Survey. Prepared for BC Hydro, Site C Project, Corporate Affairs. 24 p. + Appendices.

FIDQ. (Fisheries Inventory Data Query) 2014. BC Ministry of Environment online data warehouse FIDQ tool. Available: http://www.env.gov.bc.ca/fish/fidq/index.html; accessed on Dec 2, 2014.

Ford, B. S., P. S. Higgins, A. F. Lewis, K. L. Cooper, T. A. Watson, G. L. Ennis, & R. L. Sweeting. 1992. Literature reviews of the life history, habitat requirements, and mitigation/compensation strategies for 13 species of sport fish in the Peace and Columbia River drainages of British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2321: 342 p.

Gregory, R., L. Failing, M. Harstone, G. Long, T. McDaniels, and D. Ohlson. 2012. Structured decision making: a practical guide to environmental management choices. John Wiley & Sons.

Johnston N.T. and P.A. Slaney. 1996. Fish Habitat Assessment Procedures. Province Of BC, Watershed Restoration Technical Circular No. 8. http://www.for.gov.bc.ca/hfd/library/ffip/Johnston_NT1996.pdf Accessed Nov. 10, 2014.

Mackay, C.A. and B.G. Blackman. 2012. Relative abundance of Arctic grayling (*Thymallus arcticus*) in the Parsnip River in 2005. Fish and Wildlife Compensation Program – Peace Region Report No. 351. 18p.

Mainstream Aquatics Ltd. 2006. Fish movement study (2004/05) – Dunvegan Hydroelectric Project. Prepared for Glacier Power Ltd. Mainstream Report No. 05011F: 70 p. + app.

Mainstream Aquatics Ltd. 2011. Site C Clean Energy Project Fisheries Studies – 2010 Peace River Tributaries Overview Study. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 10014D: 191 p. + appendices.

Mainstream Aquatics Ltd. 2012. Site C Project Clean Energy Project, Environmental Impact Statement. Vol. 2, Sec. 12, App. O- Fish and Fish Habitat Technical Data Report. Prepared for BC Hydro Site C Project, Corporate Affairs Report No. 12002F: 239 p.

Mainstream Aquatics Ltd. and T. Euchner. 2009. Site C Project Fisheries Studies. Upper Halfway River Watershed Bull Trout Spawning Survey 2008. Prepared for B.C. Hydro Site C Project, Corporate Affairs 8th Floor, 333 Dunsmuir Street Vancouver, British Columbia. 15 p. + app.

McPhail, J.D. 1997. A review of burbot (*Lota lota*) life history and habitat use in relation to compensation and improvement opportunities. Canadian Manuscript Report of Fish Aquatic Science 2397: 37 p.

McPhail, J. D. 2007. Freshwater Fishes of British Columbia (The) (Vol.6). University of Alberta.

Moussalli, E., and R. Hilborn. 1986. Optimal stock size and harvest rate in multistage life history models. Canadian Journal of Fisheries and Aquatic Sciences 43:135-141.

Northcote, T. G. 1993. A review of management and enhancement options for the Arctic grayling (*Thymallus arcticus*) with special reference to the Williston Reservoir watershed in British Columbia. Province of British Columbia, Ministry of Environment, Lands and Parks, Fisheries Branch.

Northcote, T.G., and G.L. Ennis 1994. Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities. Reviews in Fisheries Science 2: 347-371.

Pickard, D., M. Porter, L. Reese-Hansen, R. Thompson, D. Tripp, B. Carson, P. Tschaplinski, T. Larden, and S. Casley. 2014. Fish Values: Watershed Status Evaluation, Version 1.0. BC Ministry of Forests, Lands and Natural Resource Operations and BC Ministry of the Environment (MOE), Victoria, BC.

Porter, M., S. Casley, D. Pickard, E. Snead, and K. Wieckowski. 2013. Draft Version 3.2. 2013. Tier 1 Watershed-level fish values monitoring protocol. Draft report prepared by ESSA Technologies Ltd. for British Columbia Ministry of Forests, Lands and Natural Resource Operations and BC Ministry of the Environment (MOE), Victoria, BC. 28 p.

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat suitability information: Rainbow Trout. Fish and Wildlife Serv., Fort Collins, CO (USA). USFWS-BSP, Fort Collins, CO (USA).

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Polluck, and G.R. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22:1–20.

Slaney, P.A. and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures. Prov. Of BC, Watershed Restoration Technical Circular No. 9. http://www.env.gov.bc.ca/wld/documents/wrp/wrtc_9.pdf Accessed Nov. 10, 2014.

Stewart, D.B., N.J. Mochnacz, C.D. Sawatzky, T.J. Carmichael, and J.D. Reist. 2007a. Fish life history and habitat use in the Northwest Territories: bull trout (*Salvelinus confluentus*). Canadian Manuscript Report for Fisheries and Aquatic Sciences. 2801: vi + 46 p.

Stewart, D.B., N.J. Mochnacz, JD Reist, T.J. Carmichael, and C.D. Sawatzky. 2007b. Fish life history and habitat use in the Northwest Territories: Arctic grayling (*Thymallus arcticus*). Canadian Manuscript Report Fisheries and Aquatic Sciences 2797: vi + 55 p.

Wilford, D., and R. Lalonde. 2004. A Framework for Effective Watershed Monitoring. Streamline Watershed Management Bulletin 8 (1): 5-10.

Appendix T

Fisheries and Aquatic Monitoring and Follow-up Program Background

1.0 The Site C Clean Energy Project

The Site C Clean Energy Project (the Project) will be the third dam and generating station on the Peace River in northeast B.C. The Project will provide 1,100 megawatts of capacity and about 5,100 gigawatt hours of energy each year to the province's integrated electricity system. The Project will be a source of clean, reliable and cost-effective electricity for BC Hydro's customers for more than 100 years.

The key components of the Project are:

- an earthfill dam, approximately 1,050 metres long and 60 metres high above the riverbed;
- an 83 kilometre long reservoir that will be, on average, two to three times the width of the current river;
- a generating station with six 183 MW generating units;
- two new 500 kilovolt AC transmission lines that will connect the Project facilities to the Peace Canyon Substation, along an existing right-of-way;
- realignment of six segments of Highway 29 over a total distance of approximately 30 kilometers; and
- construction of a berm at Hudson's Hope.

The Project will also include the construction of temporary access roads, a temporary bridge across the Peace River, and worker accommodation at the dam site.

Project Benefits

The Project will provide important benefits to British Columbia and Canada. It will serve the public interest by delivering long term, reliable electricity to meet growing demand; contribute to employment, economic development, ratepayer, taxpayer and community benefits; meet the need for electricity with lower GHG impact than other resource options; contribute to sustainability by optimizing the use of existing hydroelectric facilities, delivering approximately 35 per cent of the energy produced at the W.A.C. Bennett Dam, with only five per cent of the reservoir area; and include an honourable process of engagement with Aboriginal groups and the potential for accommodation of their interests.

2.0 Environmental Assessment Process

The environmental assessment of the Project has been carried out in accordance with the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the *BC Environmental Assessment Act* (BCEAA), and the Federal-Provincial *Agreement to Conduct a Cooperative Environmental Assessment, Including the Establishment of a Joint Review Panel of the Site C Clean Energy Project*. The assessment considered the environmental, economic, social, heritage and health effects and benefits of the Project, and included the engagement of Aboriginal groups, the public, all levels of government, and other stakeholders in the assessment process.

Detailed findings of the environmental assessment are documented in the Site C Clean Energy Project Environmental Impact Statement (EIS), which was completed in accordance with the Environmental Impact Statement Guidelines (EIS Guidelines) issued by the Minister of Environment of Canada and the Executive Director of the Environmental Assessment Office of British Columbia. The EIS was submitted to regulatory agencies in January 2013, and amended in August 2013 following a 60 day public comment period on the assessment, including open

house sessions in Fort St. John, Hudson's Hope, Dawson Creek, Chetwynd, town of Peace River (Alberta) and Prince George.

In August 2013, an independent Joint Review Panel (JRP) commenced its evaluation of the EIS, and in December 2013 and January 2014 undertook five weeks of public hearings on the Project in 11 communities in the Peace region, including six Aboriginal communities. In May 2014, the JRP provided the provincial and federal governments with a report summarizing the Panel's rationale, conclusions and recommendations relating to the environmental assessment of the Project. On completion of the JRP stage of the environmental assessment, the CEA Agency and BCEAO consulted with Aboriginal groups on the JRP report, and finalized key documents of the environmental assessment for inclusion in a Referral Package for the Provincial Ministers of Environment and Forests, Lands and Natural Resource Operations.

Construction of the Project is also subject to regulatory permits and authorizations, and other approvals. In addition, the Crown has a duty to consult and, where appropriate, accommodate Aboriginal groups.

3.0 Environmental Assessment Findings

The environmental assessment of the Project focused on 22 valued components (VCs), or aspects of the biophysical and human setting that are considered important by Aboriginal groups, the public, the scientific community, and government agencies. In the EIS, valued components were categorized under five pillars: environmental, economic, social, heritage and health. For each VC, the assessment of the potential effects of the Project components and activities during construction and operations was based on a comparison of the biophysical and human environments between the predicted future conditions with the Project, and the predicted future conditions without the Project.

Potential adverse effects on each VC are described in the EIS along with technically and economically feasible mitigation measures, their potential effectiveness, as well as specific follow-up and related commitments for implementation. If a residual effect was found on a VC, the effect was evaluated for significance. Residual effects were categorized using criteria related to direction, magnitude, geographic extent, context, level of confidence and probability, in accordance with the EIS Guidelines.

The assessment found that the effects of the Project will largely be mitigated through careful, comprehensive mitigation programs and ongoing monitoring during construction and operations. The EIS indicates that the Project is unlikely to result in a significant adverse effect for most of the valued components. However, a determination of a significant effect of the Project was found on four VCs: Fish and Fish Habitat, Wildlife Resources, Vegetation and Ecological Communities, and Current Use of Lands and Resources for Traditional Purposes.

4.0 Environmental Assessment Conclusion

On October 14, 2014, the Provincial Ministers of Environment and of Forests, Lands and Natural Resource Operation decided that the Project is in the public interest and that the benefits provided by the Project outweigh the risks of significant adverse environmental, social and heritage effects (http://www.newsroom.gov.bc.ca/2014/10/site-c-project-granted-environmental-assessment-approval.html). The Ministers have issued an Environmental Assessment Certificate setting conditions under which the Project can proceed.

Further, on November 25, 2014, The Minister of Environment of Canada issued a Decision Statement confirming that, while the Project has the potential to result in some significant adverse effects, the Federal Cabinet has concluded that those effects are justified in the

circumstances. The Decision Statement sets out the conditions under which the Project can proceed.

5.0 Fish and Fish Habitat Valued Component

Section 12 of the EIS, as amended (July 2013) describes the assessment of potential effects of the Project on fish and fish habitat including the following:

- Changes in Fish Habitat: Quality and quantity of fish habitats, habitat availability, water depth, velocity, water temperature, sedimentation, water quality, ice regime, aquatic productivity, food resources, and competition for food and habitat
- Changes in Fish Health and Survival: Species diversity; fish population distribution, fish population relative abundance, fish population biomass, sedimentation, stranding, fish entrainment, and total dissolved gas
- Changes in Fish Movement: Fish species population, movement patterns and general life history parameters (i.e., access to habitats), swim speeds, and fish entrainment

The Local Assessment Area for fish and fish habitat includes the following:

- The Peace River in the proposed reservoir area;
- Tributaries entering the proposed reservoir;
- Peace River downstream of the proposed Site C Dam to the Many Islands Area, Alberta;
- Watercourses and water bodies within the transmission line and roadway rights-of-way;
- Watercourses and water bodies within the Project activity zone; and
- Riparian areas adjacent to identified watercourses and water bodies;

Mitigation measures were proposed in the EIS to avoid, reduce, or compensate for the potential adverse effects on fish and fish habitat of construction and operation of the Project. These included standard mitigation measures to be implemented during construction activities, and other mitigation measures such as specific features in the design of the Project, and habitat works at the dam site or in the Local Assessment Area. After implementation of mitigation measures, the EIS predicted a significant adverse effect on the fish and fish habitat as a result of the potential for the loss of indigenous fish populations or distinct groups of fish. A monitoring and follow-up program was proposed in the EIS to determine the effectiveness of the measures implemented to mitigate the adverse effects of the project on fish and fish habitat.

6.0 Consultation

BC Hydro began consultation on the Project in late 2007, before any decision to advance the Project to an environmental assessment. BC Hydro's consultation with the public, stakeholders, regional and local governments, regulatory agencies, and Aboriginal groups is described in EIS Section 9, Information Distribution and Consultation. Additional information on the consultation process and a summary of issues and concerns raised during consultation are provided in:

- EIS, Volume 1, Appendix G, Public Information Distribution and Consulting Supporting Documentation
- EIS, Volume 1, Appendix H, Aboriginal Information Distribution and Consultation Supporting Documentation

- EIS, Volume 1, Appendix I, Government Agency Information Distribution and Consultation Supporting Documentation
- EIS, Volume 5, Appendix A01 to A29, Parts 2 and 2A, Aboriginal Consultation Summaries
- Technical Memo: Aboriginal Consultation

BC Hydro engaged Provincial (MOE and FLNR) fisheries staff early in the development of the FAHMFP with ongoing correspondence between summer 2014 and fall 2015. Provincial fisheries agency feedback was a key consideration in FAHMFP development with focus on development of robust monitoring programs focussed on Peace River fisheries objectives outlined in BC Government (2011).

In accordance with EAC Condition 7, this final Fisheries and Aquatic Habitat Monitoring and Follow-up Program is submitted to the Ministry of Forests, Lands and Natural Resource Operations, BC Ministry of Environment, and Aboriginal groups named in the EAC conditions.

BC Hydro is committed to ongoing consultation on fisheries and aquatic habitat monitoring and follow-up during construction of the Project, and will continue to consider input received in the future development of the plan.

7.0 Fish and Fish Habitat Baseline Conditions

The baseline conditions for fish and fish habitat are described in terms of the following (from EIS, Section 12.3 with amendment as required):

- Fish ecology, including description of fish communities, identification of species composition, distribution, relative abundance, migration and movement patterns, and general life history parameters;
- Fish habitats, including an evaluation of the quality and quantity of fish habitats in the Local Assessment Area. These include critical or sensitive areas such as spawning, rearing, and overwintering habitats and migration routes; and
- Changes in environmental factors (e.g., food, water temperature, sediment transport).

In total, 32 fish species have been recorded in the Fish and Fish Habitat Local Assessment Area. These species may have traditional use, recreational use, or management value. All fish species listed in Table 1 have ecological function value and have the potential to be affected by the Project.

In general, the lower sections of Peace River tributaries provide important spawning and early rearing habitats for suckers and minnows. Important spawning and rearing habitats for sport fish have been recorded only in upstream areas of large tributaries.

The complete description of fish and fish habitat baseline conditions is found in EIS, Volume 2, Appendix O Fish and Fish Habitat Technical Data Report.

8.0 Potential Effects of the Project on Fish and Fish Habitat

The following is a summary of the effects assessment for Fish and Fish Habitat (EIS, Section 12).

The assessment of the potential effects of the Project on fish and fish habitat was conducted in accordance with the methodology required by the EIS Guidelines. This methodology provided a

structured approach to assess and communicate results of the assessment by category of effects for each project component during construction and operations of the Project. An initial step was to assess the potential for interactions between project components or activities, and fish and fish habitat (EIS, Volume 2, Appendix A, Table 2). From this exercise, interactions that may result in an adverse effect were assessed in EIS, Section 12 Fish and Fish Habitat Effects Assessment. Interactions were not carried forward into the effects assessment if standard mitigation measures to avoid or reduce the potential effects are available during construction and well understood to be effective. The implementation of the standard mitigation measures is described in the CEMP.

EIS, Sections 12.1 to 12.2 introduce the assessment approach, and describe the use of models as part of a weight of evidence approach to predictions:

> "The effects assessment of fish and fish habitat uses a first principles approach that includes computer modelling of water quality, water temperature and ice regime, fluvial geomorphology, sediment transport, aquatic productivity, and fish population dynamics. Modelling was used as a tool to inform and support information collected by baseline studies. This combined approach was used to support the prediction of potential effects to fish and fish habitat caused by the Project."

An important component of the assessment was a quantitative ecosystem approach to analyze the range of possible changes in fish and fish habitat, both upstream and downstream of the proposed Site C Dam (Volume 2, Appendix P Part 3 Future Conditions in the Peace River). The methods used are centred on a weight of evidence approach based on multiple performance measures and analyses to assess a range of possible changes in aquatic habitat and fish biomass that may result from operation of the Project. The modelling examined the pathways of effect and ecosystem interactions illustrated in Figure 12.2 of Section 12. The following key metrics were evaluated:

- Total habitat area before and after construction, and during operation of the Project
- Primary production (biomass and production of phytoplankton and periphyton)
- Secondary production (biomass and production of benthos and zooplankton)
- Fish production and biomass (total, as well as by species groups)
- Fish harvest

This approach was informed by discussions with DFO and MOE staff, allowing the approach and specific methodologies, including modeling and metrics, to address emerging directions in fish habitat assessment, and anticipated changes in the approach to regulation. As a result of this work, the assessment in the EIS is consistent with DFO's Fisheries Protection Policy Statement, which states that "very large-scale impacts that are likely to result in ecosystem transformation which require the most detailed estimates of impacts to productivity, likely involving quantitative fish population models." The above-listed metrics of fisheries productivity are consistent with those recommended in DFO's conceptual framework for a science-based interpretation of ongoing productivity of fisheries (DFO 2013a; Randall et al. 2013).

The potential effects of the project on fish and fish habitat were organized into three categories of effects: changes to fish habitat, changes to fish health and fish survival, and changes to fish movement. Potential effects that could occur during construction and operation phases of the Project were grouped as follows (Section 12.4):

Table 1. **Potential Effects of the Project by Categories of Effects during Construction and Operations of the Project.**

Category of Effect	Construction Phase	Operation Phase
Change in Fish Habitat	• Change in fish habitat due to the construction of the dam and generating station, Highway 29 and Hudson's Hope Shoreline Protection • Change in habitat due to construction headpond and reservoir filling	• Transformation of reservoir habitat during reservoir operations • Downstream habitat changes
Fish Health and Survival	• Sediment inputs from the construction of the dam and generating station, Highway 29 and Hudson's Hope shoreline protection • Sediment inputs from construction headpond and reservoir filling • Stranding of fish • Fish entrainment • Total dissolved gas supersaturation	• Stranding of fish • Fish entrainment • Total dissolved gas supersaturation
Fish Movement	• Hindered fish movement	• Hindered fish movement

Section 12.5 of the EIS addressed the following:

- Assessment of potential effects before mitigation
- Identification of potential mitigation activities
- Assessment of whether there would likely be a potential residual effect after mitigation

A summary of the residual effects of the Project on fish and fish habitat are (from pages 12-37 to 12-39 of the EIS) as follows:

- The reservoir will eliminate 28.0 km^2 of habitat in the Peace River mainstem (predominantly deep run/glide habitat) and 1.63 km^2 of tributary habitat (a mix of pool, riffles, runs and other habitat types). These habitat losses will be offset by the creation of 93 km^2 of reservoir habitat, of which 9.42 km^2 will be littoral habitat (< 6 m deep), and 83.57 km^2 will be limnetic habitat. The total area will increase by 3.3-fold as the river is converted to a reservoir. [pg. 12-37 to 12-38 of EIS]
- Phytoplankton biomass densities ($t•km^{-2}$ or $g•m^{-2}$) are expected to increase about 30X relative to current biomass densities, in both the early and long term. Average periphyton densities in the reservoir are expected to decrease to 5% of their current value in both the early and long term, as only the littoral zone of the Site C reservoir (10.1% of the area) will grow periphyton, and periphyton production per unit area is expected to be

> less than in the Peace River. When future conditions are compared to current conditions, it is expected that there will be about a 2.7-fold increase in algal biomass (tonnes of periphyton plus phytoplankton) and a 1.8-fold increase in primary production (t/year of primary production). [pg 12-38 of EIS]

- Total secondary production in the Site C reservoir (i.e., littoral and profundal benthic production plus pelagic zooplankton production) is expected to be very similar to the total current rates of benthic production in both the mainstem Peace River and the area of tributaries that will be flooded when the reservoir is created. Overall reservoir secondary production is estimated to be 89% to 121% of current Peace River secondary production. The form of secondary production will change from being 100% benthic in the current system to a mix of benthic (74% to 81%) and zooplankton production (19% to 26%) in the reservoir. [pg 12-38 of EIS]
- Results for the most likely fish community scenario indicate about a 1.8-fold increase in total biomass of harvestable fish in the Site C reservoir relative to what currently exists in the Peace River, though with a very different species composition. Group 1 fish (burbot, lake trout, rainbow trout, walleye, northern pike) are expected to increase in their overall biomass, as increases in burbot, lake trout, northern pike, and rainbow trout offset decreases in walleye. The total biomass of group 2 passage-sensitive species (Arctic grayling, mountain whitefish, bull trout) is expected to decline, due to declines in the biomass of mountain whitefish and Arctic grayling. Bull trout are expected to increase in the reservoir over the longer term under two of the three fish community scenarios (maximum, most likely), and decline under the minimum scenario. The changes in overall biomass are driven most strongly by a substantial increase in group 3 planktivorous fish species (kokanee and lake whitefish) over both the near and long term.

Residual effects were characterized and a determination of significance was made, as described in EIS, Section 12.6 as follows:

> The project is predicted to have a significant adverse effect on the fish and fish habitat VC as a result of the potential for the loss of indigenous fish populations or distinct groups of fish. The three distinct groups of fish that may be lost are the adfluvial component of the Moberly River Arctic grayling, migratory (adfluvial) bull trout that spawn in the Halfway River, and mountain whitefish that rear in the Peace River and spawn in tributaries of the Peace River or the Peace River mainstem upstream of the Site C Dam site. The loss of these distinct groups occurs because of loss of river habitat, reduced fish health and survival during construction and reservoir filling, and hindered fish movement. Although these distinct groups will be affected, the species as a whole of Arctic grayling, bull trout and mountain whitefish will continue to be present in Peace River tributaries and downstream of the reservoir and may persist in the reservoir.[41]

The EIS described the uncertainty associated with these predictions. In accordance with Section 12.8 of the EIS and to be included as a component of the FAHMFP, monitoring and follow-up programs will be implemented to verify the accuracy of the predictions and effectiveness of the mitigation measures. The requirement for the monitoring and follow-up programs became a condition of the EAC and federal Decision Statement, and is described in the Section 4.0 Fisheries and Aquatic Habitat Monitoring.

[41] EIS, Section 12.6.3.2, pp. 19-24