Columbia Water Use Plan

Lower Columbia Fish Management Plan

Monitoring Program Terms of Reference

CLBMON-46 Lower Columbia River Rainbow Trout Spawning Assessment

Addendum 1
December 20, 2018

A1.0 Addendum #1 to CLBMON-46: Lower Columbia River Rainbow Trout Spawning Assessment

A1.1 Background and addendum rationale

Prior to 1992, Hugh L Keenleyside (HLK) discharge typically decreased from March to May, resulting in Rainbow Trout (*Oncorhynchus mykiss*) redd dewatering. After consultation with agencies, BC Hydro agreed to alter the spring HLK operations to keep river levels stable or increasing from April 1 to June 30. This is done through the Rainbow Trout Protection Flows (RTSPF) which have occurred annually since 1992, and have proven effective at reducing the number of redds dewatered in the Lower Columbia River (LCR).

During the Columbia River Water Use planning (WUP) process, the Consultative Committee (CC) became aware that halting the annual provision of the RTSPF could provide benefits for vegetation, wildlife, fish, and recreational objectives in Arrow Lakes Reservoir and the mid Columbia River by releasing the extra 1 Million Acre Feet (MAF) of water that would otherwise be held back to provide limited flows between April and June, and flow augmentation to the U.S. during summer. This storage release would keep reservoir levels lower during spring and summer, thereby improving vegetation survival due to later and shorter inundation, and, in turn, improving littoral productivity and wildlife habitat. Given that the Rainbow Trout flows were viewed as a successful management strategy for protecting rainbow trout populations in the LCR, this presented a significant trade-off decision for the WUP CC.

The Columbia River WUP CC recommended that BC Hydro continue to pursue the RTSPF through negotiations with the U.S., but highlighted a number of high priority items for consideration in future operations (BC Hydro 2005a, 2005b). These items included:

- Continuing annual discussions with regulatory agencies as to timing of transition from Whitefish flows to RTSPF (typically April 1);
- Minimizing the volume of water stored in Arrow Lakes Reservoir for the United States;
- Delaying the onset of storage in Arrow Lakes Reservoir for as long as possible; and,
- Releasing the additional storage of water in Arrow Lakes Reservoir as quickly as possible.

An annual monitoring program was recommended to monitor the status of the LCR Rainbow Trout population in response to the continued implementation of RTSPF with the purpose to better understand the link between the flow management strategy and the spawning Rainbow Trout abundance.

The approach of the program was to annually monitor Rainbow Trout from January to July over the implementation of the Columbia WUP to determine a) relative population abundance; b) redd numbers and distribution; c) spawn timing; and d) the response of the population to the annual implementation of Rainbow Trout spawning protection flows. (BC Hydro 2007, Section 2.2).

A BC Hydro-led Columbia River Rainbow Trout Flows Technical Forum (hereby termed Technical Committee) first met on June 22, 2018 in Castlegar, B.C. The

main objectives of the meeting were to review the results of CLBMON-46.The forum regrouped representatives of regulatory agencies, First Nations and BC Hydro.

While the results of the monitoring to date showed that rainbow trout abundance has increased over the period of RTSPF implementation, the Technical Committee members agreed that the benefits of the RTSPF (i.e., the link between flow management strategy and Rainbow Trout population abundance) was as yet unclear. Uncertainties included:

- the effectiveness of RTSPF on incubation success (egg-fry survival) of rainbow trout redds; and
- the potential for density dependence effects (Irvine et al. 2018) to reduce the condition factor of adult and sub-adult Rainbow Trout.

The Technical Committee agreed to examine options for possible approaches to assess the uncertainties.

The Technical Committee members reviewed and commented on five possible options for assessing RTSPF during a conference call held on July 31, 2018 (BC Hydro 2018a) and agreed to reconvene to recommend a mitigation strategy later in the year. During a teleconference held on October 26, 2018, members of the RTSPF were presented with a possible experimental approach (BC Hydro 2018 b) and agreed to implement it.

This addendum to the CLBMON-46 Terms of Reference (BC Hydro 2007) describes the steps to implement this experimental approach.

A1.2 Key Water Use Decision Affected

The key operating decision that will be affected by this program is the continued annual implementation of the Rainbow Trout Spawning protection flows in the LCR. Results from this extended study and associated inferences from other monitoring programs (i.e., CLBMON-45 Lower Columbia River Fish Indexing) in the LCR will determine if these flows:

a) improve incubation success of Rainbow Trout redds; and, if so, whether

b) those improvements result in increased Rainbow Trout abundance.

This addendum focuses on incubation success to address a key uncertainty identified in the original monitoring program. Where the spawning protection flows are seen to significantly increase incubation success, protection flows will be considered for further implementation. Alternatively, spawning protection flows may not be required if incubation success is not seen to meaningfully contribute to Rainbow Trout abundance.

A2.0 Monitoring Program Proposal

A2.1 Objective and Scope

The primary objective of the experimental protocol for the Rainbow Trout Spawning Assessment monitoring program is to reduce uncertainties pertaining to flow management effects on Rainbow Trout egg mortality in the LCR.

The geographical scope of the monitoring program is the LCR downstream of Hugh Keenleyside L. Dam and the Lower Kootenay River downstream of Brilliant Dam.

A2.2 Approach

The approach of this program is to acquire empirical data on eggs/alevins mortality to validate and update a Rainbow Trout abundance model of the LCR and Lower Kootenay River based on discharge, temperature and spatial and temporal distribution of spawning. The updated model will help assess the link between flow management and the LCR Rainbow Trout population. The methods will follow those of the last year of implementation to survey redds and spawner abundance (Irvine et al 2018) coupled to an experimental protocol designed to track eggs/alevins survival in function of environmental variables (Appendix A).

The study will consist of monitoring Rainbow Trout redds, alternating application of RTSPF, with the first year (2019) scheduled without protection flows, for a possible duration of five years, as agreed by the Technical Committee (Option 2A). There will be a Technical Committee meeting at the end of the second year to review the results and decide whether further study is warranted. Where management questions have been sufficiently answered or where there is no likelihood of furthering their understanding, the study will be suspended.

A2.3 Methods

The following tasks are required to complete adult habitat use monitoring in the Middle Columbia River:

A2.3.1 Task 1: Project Management / Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include, but not be limited to: 1) budget management; 2) study team management; 3) logistic coordination; 4) technical oversight in field and analyses components; and 5) facilitation of data transfer among other investigators.

A safety plan must be developed and submitted to the BC Hydro contact for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

A2.3.2 Task 2 Field sampling

Rainbow Trout redds and spawners will be monitored in the Lower Columbia River as per the methods described in Irvine et al (2018).

Rainbow Trout eggs and alevins will be monitored for survival at two locations, the oxbow on the Lower Kootenay River, and Norn's Creek fan on the Lower Columbia River. Environmental data (air and water temperature, solar radiation, stage height) will also be collected. Please refer to Appendix A (Egg and Alevin Mortality Study Design) for further details.

A2.3.3 Task 3: Data Analyses and Reporting

An annual technical report will be completed for each year of the monitoring program. This report will document methods, and results as they pertain to the

specific objectives of this monitoring program. At the completion of the monitoring period, a detailed report will be prepared to synthesize the data collected over the term of the program.

The proponents will present to the Technical Committee the results of the experiment (i.e., an updated model to clarify the link between the flow management strategy and Rainbow Trout population abundance) during a meeting whose objective will be to decide whether additional years of experimentation might be warranted. This meeting will be held at a date set to give BC Hydro sufficient time to consider the recommendation.

Reports will follow the standard format that is being developed for WUP monitoring programs. All reports will be provided in soft copy as Microsoft Word and unprotected Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files.

2.0 Interpretation of Monitoring Program Results

The results from this program will help clarify the link between the Rainbow Trout flow management strategy and the LCR Rainbow Trout population abundance through assessing the effect of RTSPF on egg to fry survival and its influence on subsequent recruitment in the Rainbow Trout population through modelling. If the updated population model demonstrates a negative effect of the absence of RB flows on egg/alevin survival and this effect is subsequently mirrored in trends from Rainbow Trout surveys (CLBMON-45 Lower Columbia Fish Population Index Surveys) the use of RTSPF will be validated. If there is little demonstrated link between the RTSPF and the LCR Rainbow Trout population, the use of RTSPF may be reconsidered.

3.0 Schedule

The duration for this program is for five years, alternating between one year without and the next with RTSPF.

	2019			2020			2021			2022			2023		
Item	Spring	Summer	Fall/ Winter	Spring	Summer	Fall/ Winter	Spring	Summer	Fall/ Winter	Spring	Summer	Fall/ Winter	Spring	Summer	Fall/ Winter
Experiment (no Rainbow flows)	**X**						**X**						**X**		
Rainbow Flows				**X**						X					
Analyses & reporting			X			X			X			X			X
Technical Committee meeting						X									X
Final report															X

4.0 Budget

Total Revised Program Cost: $1,582,142

5.0 References

BC Hydro. 2005a. Consultative Committee report: Columbia River Water Use Plan, Volumes 1 and 2. Report prepared for the Columbia River Water Use Plan Consultative Committee by BC Hydro, Burnaby, BC.

BC Hydro. 2005b. Columbia River Project, Draft Water Use Plan. 38 pp. + appendices

BC Hydro 2007. CLBMON-46 Lower Columbia River Rainbow Trout Spawning Assessment. Terms of Reference. Available at *https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/lower-columbia-fish.html*

BC Hydro 2018a. RBT Conference Call Notes July 31 2018. Internal memo.

BC Hydro 2018b. RBT Conference Call Notes Oct 26 2018. Internal memo.

Casas-Mulet, R., Saltveit, S.J., and Alfredsen, K.T. 2016. Hydrological and thermal effects of hydropeaking on early life stages of salmonids: A modelling approach for implementing mitigation strategies. Science of The Total Environment **573**: 1660–1672. doi:10.1016/j.scitotenv.2016.09.208.

Irvine, R.L., J.T.A. Baxter, and J.L. Thorley. 2018. WLR Monitoring Study No. CLBMON-46 (Year 10) Lower Columbia River Rainbow Trout Spawning Assessment. Columbia River Water Use Plan. BC Hydro, Castlegar. A Mountain Water Research and Poisson Consulting Ltd. Final Report

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Appendix A

Egg and Alevin Mortality Study Design

Lower Columbia Rainbow Trout Flows

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Introduction

Understanding the factors which cause egg mortality on the Lower Columbia River (LCR) and Lower Kootenay River (LKR) is critical to managing dam flows so that sufficient Rainbow Trout eggs survive to repopulate the rivers. Although results from previous studies can be used to estimate mortality thresholds for temperature and exposure time (Casas-Mulet et al. 2016) their interactions with other factors has not been well studied. The exposure time, particularly for eggs, is heavily dependent on the hyporheic flow of a specific river system as well as weather conditions, and is also influenced by the elevation difference between a dewatered redd and the water surface. Additionally, the sediment composition of a river plays a significant role in determining the amount of time that water is retained in bank storage after water levels drop, which in turn influences the dynamics of dewatering. Consequently, thresholds for mortality in eggs and alevin are often likely to be site specific and may not be transferrable from other systems. For example, Rainbow Trout eggs in the LCR and LKR apparently tolerate higher temperatures than the literature suggests for this lifestage (Irvine et al. 2018). As a result, much uncertainty remains concerning the sensitivity of the Rainbow Trout inter-gravel life stages to temperature and exposure time and how these variables are influenced by air temperature and atmospheric conditions.

In order to address these and other uncertainties experimental flow manipulations are proposed that involve the cessation of Rainbow Trout Spawning Protection Flows (RTSPFs) in the LCR for at least one year, followed by resumption of flows the following year.

The purpose of this document is to outline a study design for the first three years[1] that reduces the uncertainty in:

- the timing of late-season redd construction and dewatering on the LCR and LKR;
- the number of accumulated thermal units (ATUs) for hatch and emergence;
- the temperature and exposure thresholds for eggs and alevins on the LCR and LKR;
- the effect of air temperature and direct sunlight on the inter-gravel temperatures in exposed redds;
- the effect of surface water elevation and rainfall on the exposure thresholds.

A2.4 Study Area

Monitoring of late-season redd construction will occur in all years while environmental monitoring and excavation of redds will take place in Years 1 (and 3 if agreed upon). Depending on the amount of information collected in Year 1 the level of environmental monitoring and redd excavation may be

[1] The third year is subject to approval by the Rainbow Flows Technical Forum

reduced in Year 3. The environmental monitoring will occur at the most highly used spawning sites on each of two River sections:

1. Oxbow on the LKR (8% of spawning),
2. Norn's Creek Fan on the LCR above the LKR, and (47% of spawning)

In all cases, loggers will be deployed in duplicate to reduce the chances of data losses. At Norn's Creek Fan, the duplicates will be located upstream of the confluence with Norn's Creek to allow the influence of Norn's Creek to be quantified.

Environmental data collected will be air and water temperature, solar radiation, and stage height. Redd excavations will focus on assessing survival of eggs/alevins in relationship to the environmental parameters.

The redd and environmental data will be used to establish eggs/alevins survival rates which will then be used to inform mortality thresholds for dewatering duration and temperature. This data will also be used to confirm that 320 and 480 ATUs are required for hatch and emergence.

A time series comparison between inter-gravel and air temperature (the latter coupled with solar radiation) will help determine the average amount of time needed for the temperature in dewatered gravel to adjust to the external air temperature. This can then be used to indicate when the temperatures in dewatered redds are approaching mortality thresholds.

Environmental Monitoring

Temperature Transects

Monitoring interstitial temperature at several depths will allow for thorough coverage of a broad range of elevations in the water table and provide valuable information on the influence of temperature on egg and alevin mortality.

The transects will span an elevation range consistent with observed highs and lows for the spawning period at each site.

Early in 2019, when dam discharge levels are very low (March 11th to 12th) two transects of temperature loggers, a primary and duplicate one, will be buried in the spawning gravels at each of the two sites. Dam discharge may need to be temporarily reduced. The transects will run perpendicular to the river channel and, at six separate one meter elevation increments, three loggers will be buried in the gravels to depths of 10, 20 and 30 cm, respectively. This will result in 18 loggers per transect for a total of 72 temperature loggers. The loggers will record the temperature on the hour every hour.

A shaded primary and duplicate air temperature loggers will be deployed in general surface locations that are representative for all three sites to record the hourly air temperature. To correct for temperature logger differences, all the temperature loggers will be activated and simultaneously placed in a bucket of water at a relatively stable temperature for 12 hours. At the end of the study the same procedure will be repeated to correct for temperature logger drift.

Solar Radiation

In order to quantify the effect of insolation on inter-gravel temperatures, a primary and duplicate light sensor will be installed in the general surface locations.

Stage Height

A level logger will be installed at each transect to accurately record changes in stage height every 15 minutes. A primary and duplicate level loggers will also be deployed at the general surface locations to correct for changes in barometric pressure.

Excavation

Egg and alevin mortality will be monitored through excavations to better understand the relationship between duration of dewatering and mortality. The excavations will focus on dewatered redds as close to the temperature monitoring locations as possible for which the date range of egg deposition is known.

Excavations will take place at a range of intervals following exposure. These intervals will be adjusted based on the air temperature, rainfall, size of the elevation drop and observed mortality rates.

The following data will be recorded for each excavated redd:

- Date and time of excavation
- Geocoordinates of redd
- Elevation above water surface (measured using a reference pole and clinometer)
- Egg/alevin burial depth
- Whether or not the eggs/alevins are wetted
- Number of eggs/alevins assessed
- Egg/alevin mortality rate
- Likely cause of death

Retrieval

Equipment retrieval will occur in early September. Dam flows may need to be temporarily reduced.

Equipment

Description	Quantity	Use
Water temperature logger	72	Monitor inter-gravel temperature at various depths
Air temperature logger	2	Monitor air temperature at each monitoring location
Solar shield	2	Ensure accurate reading of ambient air temperature
Sunlight sensor	2	Calibrate for effects of insolation on temperatures
Levelloggers	6	Monitor water surface elevation
Barometric pressure meter	2	Correct for barometric pressure (levelloggers)
Optic USB Base Station	1	Data upload unit

Waterproof Shuttle	1	Data upload/backup field unit
Staff Gauge	4	Real-time stage height