Bridge-Seton Water Use Plan

Monitoring Program Terms of Reference

BRGMON-3 Lower Bridge River Adult Salmon and Steelhead Enumeration

Revision 1
November 30, 2018

BRGMON-3 – Lower Bridge River Adult Salmon and Steelhead Enumeration Monitoring Program Terms of Reference Revision 1

1.0 Monitoring Program Rationale

1.1 Introduction

This BRGMON-3 Adult Salmon and Steelhead Enumeration Terms of Reference (TOR) Revision 1 is submitted in compliance with the Bridge River Project Water Use Plan Order (Bridge WUP Order) dated 30 March 2011, Schedule A, Clause 10 (a, b, and c) which specifies the requirement to:

a. *Monitor how flow regimes affect spawning habitat for adult salmon and adult steelhead.*
b. *Monitor annual abundance of salmon and steelhead spawning in lower Bridge River and its relations with long term flow requirements at Terzaghi Dam.*
c. *Determine if flow releases from Carpenter Lake Reservoir have altered the life history and productivity of the Chinook salmon in lower Bridge River.*

1.2 Background

The lack of continuous flow releases from Terzaghi Dam into the Lower Bridge River has been a long standing concern of the public, First Nations, and regulatory agencies. In 1998, an agreement between BC Hydro and regulatory agencies specified that an instream flow test release and monitoring program be developed and implemented in an attempt to resolve uncertainty about response of the Lower Bridge River aquatic ecosystem to reservoir releases. The agreement specified that an experimental flow release program was to be initiated and continued until a Water Use Plan (WUP) was developed for the Bridge-Seton watershed.

As a result, on July 28, 2000, the Comptroller of Water Rights (CWR) under Section 39 of the *Water Act* ordered BC Hydro to initiate instream flow releases (as of August 1, 2000) with an annual water budget of 3 m^3/s (3 $m^3/s/y$ treatment) plus associated monitoring studies. Previous flow assessment studies (1993-1995) and ecological monitoring (1996-2000) had provided some data on the baseline no flow conditions in the Lower Bridge River (0 m^3/s); however, these data were not sufficient to estimate the effect of increased flows on the aquatic ecosystem, and therefore continued monitoring was included in the Order.

Beginning in 1999, BC Hydro embarked on developing Water Use Plans across the province. The Water Use Plan Consultative Committee for Bridge River recommended that BC Hydro evaluate the relationship between different flow releases at Terzaghi Dam and Lower Bridge River aquatic productivity. The Bridge River WUP Order, issued on March 30, 2011 under Sections 87 and 88 of the *Water Act* required a flow treatment with an increase in the annual water budget to 6 m^3/s (6 $m^3/s/y$ treatment) and a maximum discharge of 15 m^3/s. The Order also required monitoring, plus a long-term flow release recommendation

for Terzaghi Dam to be agreed upon by the CWR, regulatory agencies, St'át'imc First Nations and stakeholders by May 1, 2015 (Bridge WUP Order, Clause 9).

Aquatic productivity was to be monitored during this flow release, including juvenile salmonid abundance (in the BRGMON-1 project), the analysis of which would be supported by adult salmon and steelhead enumeration (in this BRGMON-3 project) to examine the relationship between juvenile abundance and the instream flow regime, independent of external factors such as adult escapements.

The CWR approved BRGMON-3 TOR on February 7, 2012. The results from the BRGMON-3 plus other related WUP studies were intended to inform the long-term flow recommendation by 2015.

In 2015 and 2016, BC Hydro received CWR approval to delay the flow recommendation to allow more time for further consultation. The long-term flow strategy recommendation continues to be deferred while consultation is ongoing.

In 2016, Dam Safety issued a directive to reduce storage capacity of Downton Reservoir by ~50% to manage seismic risk. In the same year, BC Hydro advanced critical infrastructure upgrades at the Bridge Generating Station which affected the volume of water that could be diverted through the generating station from Carpenter Reservoir to Seton Lake. As a result, releases higher than the annual average 6 m^3/s would need to be discharged from Terzaghi Dam down Lower Bridge River in some years, until the critical upgrades are complete.

BC Hydro received variances (March 14, 2016 and February 16, 2017) from the CWR to vary the Terzaghi Dam discharges from those specified in the WUP, and to implement a modified flow regime at Terzaghi Dam. The variances permitted BC Hydro to exceed the 6 m^3/s /y treatment hydrograph and the previous 15 m^3/s maximum discharge during the annual high flow period (~March to August). Outside of the high flow period, Terzaghi Dam has been operated according to the seasonal hydrograph limits. On February 21, 2018, the CWR confirmed that BC Hydro can continue to operate under the February 2017 variance order, while consultation is underway and until a decision is made. The CWR also recognized that BC Hydro is not currently in a position to meet Clause 9 of the WUP Order.

From 2016 to 2018 the hydrograph peak and duration during the high flow period were shaped by inflow volumes and advice from regulatory agencies, with Terzaghi Dam discharges reaching 97 m^3/s in 2016, 127 m^3/s in 2017, and 100 m^3/s in 2018.

Despite modified operations and increased peak flows during the high flow period, the BRGMON-3 adult salmon and steelhead enumeration program can continue largely as outlined in the original TOR. Monitoring under BRGMON-3 primarily occurs during the fall spawning period when Terzaghi Dam discharges are forecast to meet the 6 m^3/s/y treatment hydrograph. Therefore, with the exception of 2016 when damage to the resistivity counter prevented enumeration in that year, and some overlap of the high flow period with the steelhead migration period, BRGMON-3 monitoring has continued. While this TOR Revision includes a change to enumeration methods for the new equipment following high flow damage, changes in this TOR Revision are primarily to improve clarity of the TOR and to address methodological gaps including the addition of spawning habitat assessments not included in the original TOR.

1.3 Revision Rationale and Summary of Key Changes

The primary objectives of the BRGMON-3 project are to 1) generate high precision estimates for Chinook salmon, coho salmon, and steelhead trout escapement to be provided to BRGMON-1 to reduce uncertainty in the response of juvenile salmonids abundance to the instream flow regime, and 2) quantify the quality and quantity of spawning habitat in the Lower Bridge River.

Changes in this TOR Revision will ensure these primary BRGMON-3 objectives are met. The key changes and rationale are described below. Appendix A provides more detail on the key changes made in this revision compared to the BRGMON-3 TOR dated January 23, 2012.

1.3.1 The TOR has been improved by including specific management questions and management hypotheses.

Management questions were outlined in the original TOR but specific questions were not included. It was intended that the information from BRGMON-3 would be incorporated into the BRGMON-1 analysis reporting and the management questions outlined under BRGMON-3 would be addressed under BRGMON-1.

This revision adds management questions and hypotheses specific to the BRGMON-3 program to make this TOR consistent with all other WUP TORs.

1.3.2 Enumeration techniques have been updated for new equipment used after high flow damage.

In 2016, high flows partial damaged the resistivity counter and the decision was made to replace a section of the resistivity counter with an imaging sonar. The imaging sonar could be removed during the high flow period to eliminate the risk of damage and then be reinstalled to enumerate adult salmon in the fall and steelhead in the spring. A portion of the resistivity counter remained in the river to provide full-river enumeration coverage while the sonar imaging was being used.

This TOR Revision updates the enumeration techniques section of the original TOR to include the combination resistivity and sonar counter. All incremental maintenance and analysis costs associated with enumerating fish with the imaging sonar will be covered by BC Hydro Modified Operations Monitoring (Section 1.4).

1.3.3 Visual survey and radio telemetry tasks have been extended to ensure sufficient data are collected to meet the original BRGMON-3 objectives.

The original TOR included simultaneous enumeration of fish using the resistivity counter and visual surveys for a period of five years. As part of the visual surveys, radio telemetry for Chinook salmon, coho salmon, and steelhead trout was used to provide estimates of observer efficiency while also providing river-wide abundance estimates and spawning distribution data. It was expected that five years of simultaneous resistivity counter and visual survey data would allow for development of a relationship between counter and visual surveys escapement estimates to validate historic visual count data. However, review of monitoring results identified that simultaneous data collection was limited to two years during the first six years of the program. This was a result of the following:

- The resistivity counter was installed (~0.8 km upstream of the Yalakom River confluence) in fall 2013 and was fully operational for 2014;
- Visual surveys and radio telemetry began in 2012, generating escapement estimates for two years prior to counter installation (2012, 2013) and two years of overlapping data collection (2014, 2015);
- Limited mobile tracking occurred downstream of the Yalakom River and the downstream telemetry station was only operated in 2013 and 2014 due to access issues; and
- No counter data were collected in 2016 due to damage to the resistivity counter during high discharges (described in section 1.3.2 above). Although the damaged resistivity counter was replaced with a sonar counter in 2017, limited data were collected in 2017 due to unforeseen data loss.

This TOR Revision will extend annual visual surveys and radio telemetry to the end of the BRGMON-3 monitoring period to ensure that three additional years of simultaneous counter and visual survey data are collected. If sufficient years of simultaneous data are collected prior to the end of the program, the visual surveys and radio telemetry will be discontinued. The cost of one additional year of visual surveys and radio telemetry will be covered by BC Hydro Modified Operations Monitoring (Section 1.4) to compensate for the loss of the counter data in 2016.

1.3.4 Methods to quantify spawning habitat quantity and quality were not specified in the original BRGMON-3 TOR and have been added.

As there was no specific management question in the original TOR related to spawning habitat, the methods in the TOR to address this uncertainty were limited. Spawning habitat monitoring to date has included detailed assessment of Chinook salmon redds in 2014-2017, providing estimates of habitat quality of redds but no estimate of habitat quantity. Habitat surveys from BRGMON-1 were used to extrapolate Chinook salmon spawning preferences to the estimate total spawning habitat for Chinook salmon in the Lower Bridge River. However, this approach provided only a coarse estimate of spawning habitat quantity.

In this TOR Revision, we have added spawning habitat surveys and habitat flow modelling to generate an estimate of spawning habitat quality and quantity. It is estimated that under the 6 m^3/s/y treatment, spawning habitat in the Lower Bridge River could have been quantified with two years of data collection as spawning habitat was expected to remain stable during this flow regime. However, due to modified flow regime, changes to spawning habitat are occurring and require annual monitoring. Therefore, one year of habitat monitoring will be covered by BC Hydro Modified Operations Monitoring (Section 1.4). For continuity, annual Chinook salmon redd assessment will continue.

1.4 Modified Operations Monitoring Not Included in this Revision

While operating under the CWR approved variances, BC Hydro has implemented additional modified operations monitoring (since 2016) in response to the modified flow regime. This monitoring is considered separate from monitoring under the BRGMON-3 TOR and has not been included in TOR expenditures to date. Modified operations monitoring has included:

- Expanded adult salmon and steelhead visual surveys to include areas downstream of the Yalakom River to identify spawning locations and habitat;
- Topographic and erosion/deposition surveys to quantify substrate composition and inform spawning substrate mobilization (Embark 2017; Ellis et al. 2018); and
- One year of spawning habitat surveys in spring 2018 to estimate spawning habitat quality and quantity prior to high discharges in 2018.

Where we have increased years of monitoring or cost for modified operations beyond that which is required to address the TOR objectives, these additions have been excluded from the WUP budget. These include:

- One year of spawning habitat surveys in 2019 and habitat modelling that will inform habitat changes under the modified flow regime;
- One year of visual surveys and radio telemetry costs in 2019 to compensate for the loss of simultaneous counter/visual survey data due to high discharge in 2016; and
- Any additional counter maintenance and data analysis that is required to generate an escapement estimate using the sonar imaging system (annually).

Results of both WUP and modified operations monitoring will be integrated into a single comprehensive annual report to help inform future flow regime decisions. Reporting costs will be appropriately pro-rated to WUP and modified operations according to the scope of each of the programs. Modified operations monitoring will be responsive in the short term to adapt to annual results and will help inform the mitigation required to address any negative effects of the modified flow regime. Modified operations monitoring will not be included in any subsequent revision or addendum for BRGMON-3.

1.5 Management Questions

Management questions were not specified in the original BRGMON-3 TOR (dated January 23, 2012) but two uncertainties were discussed. The first uncertainty addressed the use of juvenile salmonid standing crop biomass as the primary indicator of aquatic productivity response, identifying a need to accurately quantify adult escapement to the Lower Bridge River to support this analysis. The second discussion addressed uncertainty around spawning habitat availability in the Lower Bridge River.

The management questions in this TOR Revision have been developed to address these uncertainties. The management questions are:

1) What is the annual abundance, timing, and distribution of adult salmon and steelhead spawning in the Lower Bridge River and are these aspects of spawning affected by the instream flow regime?

2) What is the quality and quantity of spawning habitat in the Lower Bridge River and how is spawning habitat affected by the instream flow regime?

1.6 Management Hypothesis

Management hypotheses were not specified in the original BRGMON-3 TOR and have been included this TOR Revision to guide the selection of key response variables. The hypotheses presented here are not an exhaustive list and other

hypotheses could be examined. Alternative hypotheses were not developed because explanatory variables may change with the analysis of monitoring data.

Null hypotheses associated with Management Question 1 (annual abundance, timing, and distribution of spawning salmon and steelhead) are:

$H_{1.1}$: There is no relationship between the instream flow regime and the abundance of spawning salmon and steelhead in the Lower Bridge River.
$H_{1.2}$: There is no relationship between the instream flow regime and the timing of spawning salmon and steelhead in the Lower Bridge River.
$H_{1.3}$: There is no relationship between the instream flow regime and the distribution of spawning salmon and steelhead in the Lower Bridge River.

Null hypotheses associated with Management Question 2 (quality and quantity of spawning habitat) are:

$H_{2.1}$: The instream flow regime does not affect spawning habitat quality in the Lower Bridge River.
$H_{2.2}$: The instream flow regime does not change spawning habitat quantity or distribution in the Lower Bridge River.

1.7 Key Water Use Decision Affected

Results of the BRGMON-3 Adult Salmon and Steelhead Enumeration program will support the development of a long-term flow recommendation for the Lower Bridge River by informing aquatic productivity analyses carried out under BRGMON-1 and informing the response of adult salmon and steelhead to different instream flow regimes.

2.0 Monitoring Program Proposal

2.1 Objective and Scope

The main objective of the BRGMON-3 monitoring program is to provide rigorous estimates of the abundance and distribution of salmon and steelhead spawning in the Lower Bridge River. These data will support BRGMON-1 estimates of the response of juvenile salmonid abundance to the instream flow regime by ensuring changes in abundance are not confounded by changes in adult escapement associated with external factors such as changes in marine survival. This will reduce uncertainty about the relationship between the instream flow regime and the relative productivity of the Lower Bridge River. The BRGMON-3 program will also address data gaps associated spawning timing, spawning distribution, and spawning habitat quality and quantity. The scope of this program is limited to enumerating adult salmon and steelhead, monitoring spawning distribution and habitat through visual surveys and telemetry, and habitat assessments.

2.2 Approach

The BRGMON-3 program will develop and refine an annual stock assessment methodology to estimate the abundance, timing, and distribution of spawning Chinook salmon, coho salmon, and steelhead trout. Less intensive supplemental surveys will be carried out to estimate the abundance of sockeye salmon and pink salmon. The stock assessment methodology will include use of a counter installed upstream of the Yalakom River confluence combined with streamwalks

to estimate abundance of fish spawning upstream of the counter. Radio telemetry will be used to estimate streamwalk observer efficiency and provide data on spawning distribution and migration timing throughout the Lower Bridge River. Spawning habitat surveys and flow modelling will be used to assess how the instream flow regime affects spawning habitat quality and quantity and detailed redd assessments used to determine spawning habitat use. The influence of the instream flow regime on adult abundance will be qualitatively assessed by comparing the abundance trends of salmon and steelhead on the Lower Bridge River with other rivers in the Fraser River watershed.

2.3 Methods

2.3.1 Task 1: Project Coordination

Project coordination will involve the general administration and technical oversight of the tasks addressing management questions. Project coordination is required for each task and will include but not be limited to budget management, staff selection, logistics planning, technical oversight in both field and analysis components, and liaison with regulatory agencies and First Nations.

2.3.2 Task 2: Salmon and Steelhead Enumeration

Resistivity and Sonar Counter Operations

The combination resistivity/sonar counter, located ~0.8 km upstream of the Yalakom River confluence, will be operated during the migration period for anadromous salmon (~August 1 to January 15) to enumerate Chinook and coho salmon, and steelhead trout (~April 1 to June 30) migrating into Reach 3 and Reach 4 of the Lower Bridge River (Figure 1). Operation of the counter and the subsequent analysis will produce high precision estimates of salmonid escapement (80% confidence intervals +/- 15% of estimate) to be compared with visual survey results and allow for back calculated estimates of whole-river spawner abundance pre-WUP (prior to 2012). If river conditions permit, counter operations should be optimized, for example, through the use of a fence to confine migrating salmon to limit the need to operate both the sonar and resistivity counters. Use of a fence could also be used to provide a means to support collection of adult carcasses and otoliths for BRGMON-1 studies (that will inform Chinook salmon life history analyses to be completed under BRGMON-1).

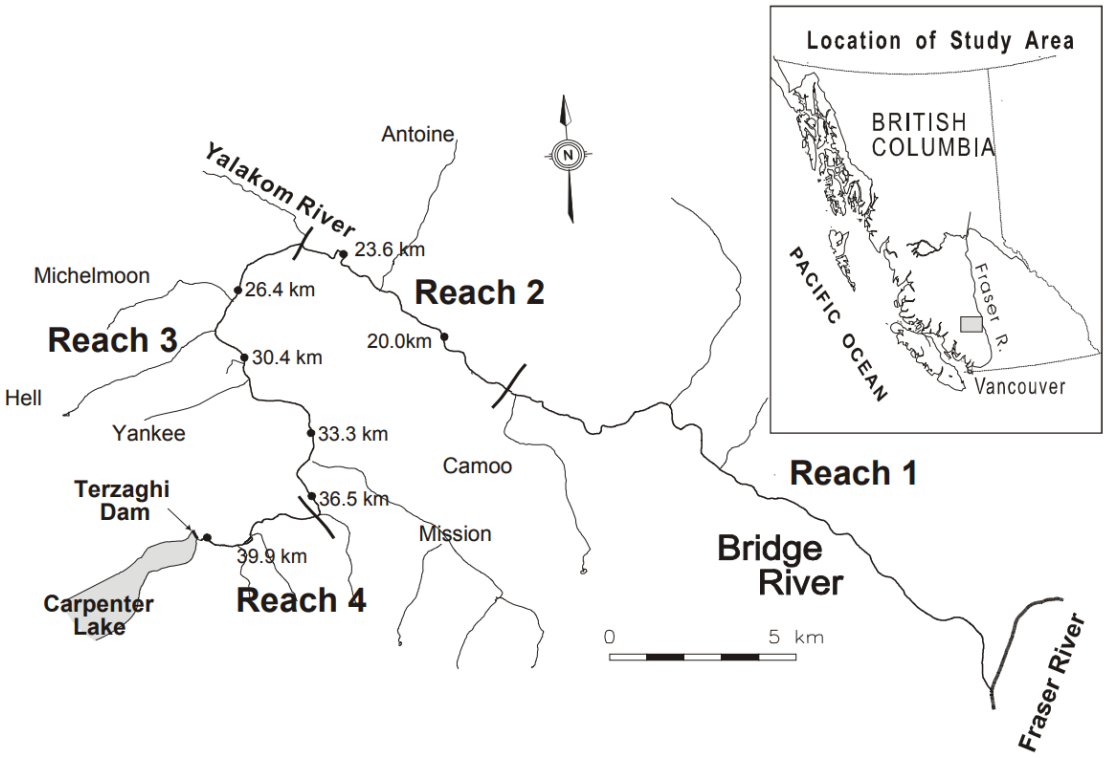
Visual Counts

Weekly visual streambank counts will be undertaken for Chinook salmon, sockeye salmon, pink salmon (odd years), coho salmon, and steelhead trout in Reach 3 and 4 (Figure 1). Methods will replicate those used in 2010 surveys with Reach 3 and 4 divided into 8-10 previously defined segments to identify key areas for spawning to support assessments of spawning distribution in response to the instream flow regime. Opportunistic otolith and DNA/scale collection should take place whenever mortalities are accessible during visual counts and GPS locations of holding location and redds should be recorded.

Greater survey effort will be applied to Chinook salmon, coho salmon, and steelhead trout as the juveniles of these species rear in the Lower Bridge River and changes in juvenile abundance is a key indicator of the effects of the

instream flow regime. Pink salmon and sockeye salmon fry do not rear in the system and therefore a lower level of effort should be applied to estimating the escapement and distribution of these species. Escapement data for pink and sockeye salmon is still useful for understanding changes in productivity, as carcasses form these species affects nutrient dynamics in the river and high abundance of these species could also affect counter data analysis.

Figure 1: Overview of the Lower Bridge River. Breaks for Reach 1 to Reach 4 are shown.



2.3.3 Task 3: Radio Telemetry Studies

Fish Capture and Tagging

Up to 30 Chinook salmon and 30 coho salmon will be angled for collection and radio tagging. Fish will be targeted throughout the Lower Bridge River but primarily in the lower reaches to capture migration through the lower reaches of the Bridge River. Effort will be made to distribute radio tags spatially, temporally, and across sexes. Sampling at the time of tagging will include fork length, sex, scales, photograph, and a DNA sample. Scales will be analyzed for age to assess life history type and DNA analyses performed to confirm stock ID. Any summer-run steelhead trout captured during Chinook salmon and coho salmon angling will be opportunistically sampled using the procedures but radio tags will not be applied due to the long holding time of these fish prior to spawning. Visual tags should be applied to Chinook salmon and coho salmon to allow for estimates of observer efficiency during visual count surveys.

Up to 25 steelhead trout will be angled in the late-winter/spring either at the Seton River-Fraser River confluence or in the Lower Bridge River. The Seton-Fraser confluence has been found to be a holding area for steelhead trout with the majority of steelhead trout tagged in this area entering the Lower Bridge

River. A portion of the steelhead trout tagged in this area entered the Seton River, supporting WUP studies in that system (BRGMON-9). Supplemental tagging can also occur in the Lower Bridge River itself to increase tagging numbers, if required.

Telemetry

Fixed and mobile telemetry will be used to track salmon and steelhead migration behaviour and timing. Five fixed stations will be installed in the Lower Bridge River and Yalakom River and operated from ~August 1 to ~January 15 for Chinook salmon and coho salmon and from ~April 1 to ~June 30 for steelhead trout. Each station should each be installed with upstream and downstream antennas to corroborate fish location estimates during mobile tracking and refine estimates of fish migration timing and migration behaviour. Stations will be installed at the following locations:

- Near the confluence of the Fraser River (~0.7 Rkm)
- Near the Reach 1/2 boundary (~19 Rkm)
- At the Yalakom River confluence (~25.5 Rkm)
- In the Yalakom River upstream of the Yalakom-Bridge confluence to assess fish use of the Yalakom River.
- Near the Reach 3/4 boundary (~37.7 Rkm)

A sixth receiver will also be installed in the Seton River to support an understanding of the fate of steelhead trout tagged at the Seton River-Fraser River confluence.

Mobile tracking with a hand held receiver will be conducted over the entire river at a minimum of once per week while tagged fish are in the system. In Reach 3 and 4, mobile tracking will occur immediately prior to visual surveys to locate the number of fish in each streamwalk section and provide an estimate of observer efficiency. During the peak spawning period for each species, mobile telemetry will be used to identify spawning locations and, where access permits, individual redds will be located and GPS location recorded. The use of mobile telemetry to locate redds or approximate spawning locations is particularly important for coho salmon and steelhead as increased water turbidity reduces visibility during the spawning period. Any observations of untagged fish during mobile tracking will also be recorded.

2.3.4 Task 4: Spawning Habitat Quality and Quantity

Key spawning habitat areas across the Lower Bridge River will be identified using radio telemetry and visual survey results, then assessed for spawning habitat quality and quantity using the using the methods outlined in Lewis et al. (2004).

Historic spawning surveys have identified Reach 3 and 4 as the key spawning habitats for Chinook salmon and up to 15 spawning areas will be assessed in Reach 3 and Reach 4. Cross-sectional transects will be conducted at each site to collect data on water depth and velocity with the number and spacing of transects determined by site characteristics. Transects will also include substrate measurements including visually-assessed dominant substrate type and substrate measurements to generate grain size distributions estimates along each transect.

Coho salmon spawning locations have been difficult to identify due to increased fall turbidity in the Lower Bridge River. Coho salmon also spawn later in the year when flows from Terzaghi Dam are lower (1.5 m^3/s) than during the Chinook salmon spawning period (3.0 m^3/s). As a result, where it is possible to identify coho salmon spawning locations using visual surveys or mobile radio telemetry, additional habitat surveys may be required for coho salmon, as spawning habitats used by coho salmon would be different than those selected by Chinook salmon. Up to 15 additional spawning areas will be surveyed for coho salmon spawning habitat in Reach 3 and 4.

Reach 1 and 2 of the Lower Bridge River will also be assessed for spawning habitat quality and quantity where spawning habitat is identified through visual surveys or mobile radio telemetry. Up to 10 spawning areas will be surveys carried out in Reach 1 and 2 following the same methods outlined above. Separate spawning areas may be considered for Chinook salmon and coho salmon in Reach 1 and 2 if sufficient spawning activity is identified in these reaches.

Habitat flow modelling will also be used to assess spawning habitat quantity throughout the Lower Bridge River. BC Hydro's Telemac2D model will be used to estimate water depths and velocities across all reaches to identify key spawning areas and estimate total spawning habitat availability based upon Habitat Suitability Index (HSI) curves for Chinook salmon, coho salmon, and steelhead trout spawning. Substrate quality in modeled spawning habitat will be inferred using data from spawning habitat surveys or ground surveys, if required.

Detailed assessment of Chinook salmon and coho salmon redds have been carried out under BRGMON-3 and will be continued with the same methods for the duration of the WUP monitoring period to inform spawning habitat quality at identified spawning locations. Any redds identified during mobile tracking or visual count surveys will be marked and detailed measurements recorded including depth and velocity, substrate size, temperature loggers, and GPS location.

2.3.5 Task 5: Analysis and Reporting

Counter and Visual Count Escapement Estimates

Sonar enumeration data or resistivity/sonar data will be combined to generate an estimate of Chinook salmon, coho salmon, and steelhead trout escapement in Reach 3 and 4. Data should be validated to remove erroneous detections and estimate (with required 80% confidence intervals +/- 15% of estimate) the number of Chinook salmon, coho salmon and steelhead that returned. Spawning timing should also be estimated from the counter data and visual survey data on spawning actively

Visual surveys will be used to estimate the relative distribution of spawning throughout the streamwalk reaches of the Lower Bridge River and generate Area-Under-the-Curve (AUC) estimates for the abundance of Chinook salmon and coho salmon. Visual surveys should also be used to estimate the approximate abundance of pink salmon (odd years) and sockeye salmon spawning in the Lower Bridge River. Visual counts should be used in conjunction with telemetry data to annually assess spawning distribution to describe any year-to-year changes in spawning locations in response to the instream flow

regime or other factors such as water temperature or changes in spawning habitat. Counter and AUC abundance estimates will be compared to develop and annually update the relationship between the two abundance estimates methods that will then be used to back-calculate refined estimates of spawner abundance made prior to 2012. Lower Bridge River abundance estimates will also be compared to stock assessment data for other Fraser River Chinook salmon and coho salmon populations to describe Lower Bridge River population trends relative to other populations. This comparison will attempt to qualitatively assess any effects of the instream flow regime relative to external factors that affect Fraser River salmon population as a whole.

Telemetry Data

Fixed and mobile telemetry data will be combined with visual count surveys to generate observer efficiency estimates for Reach 3 and 4 Chinook salmon and coho salmon surveys. Telemetry results will also be used to refine spawning distribution estimates and migration timing for tagged species across the whole river to provide linkages to the instream flow regime and spawning habitat. Data on individual detection histories and spawning locations will be recorded to develop a georeferenced inventory of spawning locations that can be mapped to qualitatively examine changes in spawning distribution in response to the instream flow regime.

Spawning Habitat Quality and Quantity

Results from habitat surveys will be modeled with HSI curves to generate Weighted Useable Area (WUA) estimates for spawning habitat for Chinook salmon and coho salmon. Results from habitat modelling will be compared to WUA estimates generated from the Telemac2D model to assess model predictions and, if possible, extrapolate results to a whole river spawning habitat availability estimate. Redd assessment data will be compared to known habitat preferences for spawning Chinook salmon and coho salmon to assess the quality of spawning habitat used by salmon. This analysis will help inform whether spawning habitat quantity is sufficient in the Lower Bridge River as spawning habitat quantity may change with the instream flow regime and in sub-optimal habitat quality could affect spawning success.

Reporting

A single technical report will be prepared annually that summarizes the key qualitative observations and empirical results from the BRGMON-3 monitoring and modified operations monitoring. Key results will be synthesized annually to summarize data across the monitoring period and support BC Hydro decision-making around the instream flow regime. Results will be used to address the management questions of both BRGMON-3 and modified operations monitoring. At the end of the current BRGMON-3 monitoring program period, a final synthesis report summarizing all BRGMON-3 and modified flow regime results will be prepared.

2.4 Interpretation of Monitoring Program Results

Escapement estimates from BRGMON-3 will be provided to the BRGMON-1 program to support analyses of the relationship between the instream flow regime, key aquatic productivity changes, and the response of juvenile salmonid

populations. Escapement data will be compared with regional escapement data to evaluate trends in abundance. Upon completion of the works requiring the modified operations, these data will be interpreted to help define a long-term flow recommendation for the Lower Bridge River.

2.5 Schedule

The program will be implemented each year until the end of the BRGMON-3 monitoring program in 2021. The timing of individual components of the work is described within the BRGMON-3 and modified operations monitoring tasks above.

2.6 Budget

Total revised program cost: $3,450,066.

References

Embark Engineering. 2017. Lower Bridge River Sediment and Erosion. Prepared for St'át'imc Eco-Resources and BC Hydro. July 2017. Embark No. 12999.010.

Ellis, E., C. Davey, A. Taleghani, B. Whitehouse, and B. Eaton. 2018. Lower Bridge River Sediment and Erosion Monitoring 2017. Unpublished report prepared for St'át'imc Eco-Resources and BC Hydro. January 2018. KWL #3781.003-300.

Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. Assessment Methods or Aquatic Habitat and Instream Flow Characteristics in Support of Applications to Dam, Divert, or Extract Water from Streams in British Columbia. Prepared for Ministry of Water, Land and Air Proection and Ministry of Sustainable Resource Management.

Appendix A: Summary of the key changes made to in this revision compared to the BRGMON-3 TOR dated January 23, 2012.

Section	Changes	Rationale
1.1 Introduction	• Clarified references to the WUP Order	• Provides appropriate references
1.2 Background	• Updated the background section summarizing the pre-WUP and WUP flow treatments. • BC HydroAdded background on the capital improvements requiring the modified flow regime and the resulting variances	• Added new relevant history and background since the original Terms of Reference from 2012.
1.3 Revision Rationale and Summary of Key Changes	• Summarizes the changes in the Revision and the rationale for the changes. • Added management questions and hypotheses. • Extended visual surveys and radio telemetry studies to the end of the WUP monitoring period. • Described that monitoring related spawning habitat quality and quantity was not included in the original TOR and has been added. • Apportioned costs for monitoring according to the data requirements for BRGMON-3 and modified operations.	• New section added with detailed rationale presented in text. • Management questions were not present in the original BRGMON-3 TOR. • Additional visual survey and radio telemetry data are required to define the relationship between visual and counter abundance estimates. • No methods to quantity spawning habitat quality and quantity were outlined in the original BRGMON-3 TOR although this work was specified in the Order. • Spawning habitat surveys have been added to the BRGMON-3 TOR. • Data gathered will be reported on in the BRGMON-3 annual report to address the newly added management questions on abundance and spawning habitat.
1.4 Modified Operations Monitoring not included in this Revision	• Outlined the additional monitoring being implemented by BC Hydro as part of the variance applications for the modified flow regime. • Clarified how the WUP and modified operations monitoring will be integrated in reporting and costs handled by each program.	• New section added. • BC Hydro will be carrying out additional monitoring needed to address questions associated with modified operations. • A portion of costs associated with the counter, visual surveys, and radio telemetry will be covered by BC Hydro modified operation monitoring in compensation for data loss due to high discharges.
1.5 Management Questions	• Two new management questions we added to address uncertainties identified in the original TOR.	• Management questions were not specified in the original TOR.
1.6 Management Hypothesis	• Added management hypotheses to specify response variables to be tested.	• New section. Management hypotheses were not specified in the original TOR.
1.7 Key Water Use Decisions Affected	• Unchanged but reworded for clarity.	

Section	Changes	Rationale
2.1 Objective and Scope	• Clarified this section to align the terminology with the rest of the TOR. • The objective of the BRGMON-3 program remains the same; however, the scope has been updated to include use of the modified operations monitoring results.	• The objective of the program is unchanged from the original TOR. • BRGMON-3 reporting will draw upon results of the modified operations monitoring to address the management questions.
2.2 Approach	• Shortened this section to describe the approach as developed in 2012 to 2017. • Removed section specifying PIT tagging (only) of Chinook, steelhead, coho, sockeye and pink salmon.	• A counter type had not yet been decided for the original TOR but was constructed and implemented in 2013-2018. • PIT tagging alone does not provide enough specificity to determine spawning location or distribution.
2.3 Methods	• *Task 2* '*Salmon and Steelhead Escapement Surveys*' renamed to '*Salmon and Steelhead Enumeration*' and includes the subcategories of *Resistivity and Sonar Counter Operations* and *Visual Counts.* Radio telemetry moved to a separate task. • Outlined the use of the current resistivity and sonar counter. • Extended visual counts to the end of the monitoring period. • Created a new *Task 3: Radio Telemetry Studies.* Added new collection areas established in 2012-2017 and specified sampling of any incidentally caught summer steelhead during Chinook and coho angling. Expanded the operating dates for the fish counter. • Minor updates to radio telemetry methods including additional receiver locations and updates to sample sizes. • Extension of telemetry to the end of the BRGMON-3 monitoring period. • Habitat monitoring has been specified in *Task 4: Spawning Habitat Quality and Quantity*. • In *Task 5: Analysis and Reporting,* replaced the requirement for a 2015 synthesis report with a requirement for annual reporting of trends and a 2021 synthesis report. • Added a requirement for an annual report that summarized monitoring results to date from both WUP and modified operation monitoring, and carries out detailed data analyses.	• All enumeration methods combined into a single section for clarity. • The counter now makes use of both resistivity and sonar enumeration methods but may be reduced to sonar in the future. • Ongoing visual surveys are needed to gather sufficient data to compare with counter. Only two years of data collection have occurred to date and five years were recommended in the original TOR. • All telemetry methods combined into a single section for clarity. • New collection sites for salmon and steelhead were established in 2012-2017. FLNRORD requested any incidental summer steelhead captured during fish angling for salmon are sampled. Reports of Chinook salmon entering earlier support advancing the start date of counter operations to ~August 1. • Radio telemetry sites were added to determine if any species spawn in the Yalakom River. A radio receiver on the Seton River was added as fish may enter the Seton River after being tagged. • Extended telemetry is required for observer efficiency estimates during the visual surveys. • Habitat quality and quantity were not outlined in the original TOR and have been added as part of Task 4. • Detailed annual report integrating WUP and modified operations monitoring will allow for improved annual management of the LBR hydrograph (short term objective). • Annual reporting will need to take into account the modified flow regime to fully address the BRGMON-3 management questions and hypotheses.

Section	Changes	Rationale
2.4 Interpretation of Monitoring Program Results	• This section has been updated for clarity and to clearly specify comparison with regional abundance trends.	• Comparison with regional trends will help determine if results are due to the flow regime or external factors.
2.5 Schedule	• No changes to the seasonal timing of WUP monitoring components. • Visual counts and radio telemetry extended to Year 10.	
2.6 Budget	• Updated as required to incorporate new monitoring components. • Timing of the synthesis report shifted from 2015 prior to long term flow recommendation to 2021 (as described in 2.3 above) • Reporting budget has been included as a pro-rated proportion of WUP reporting and additional modified flow regime monitoring.	
3.0 References	• Updated as required.	