



Bridge-Seton Water Use Plan

Monitoring Program Terms of Reference

BRGMON-2 Carpenter Reservoir Riparian Vegetation Monitoring

**Revision 1
January 23, 2017**

**Bridge-Seton Water Use Plan
Monitoring Program No. BRGMON-2
Carpenter Reservoir Riparian Vegetation Monitoring Program
Revision 1**

1 REVISION OVERVIEW

This Terms of Reference (TOR) revision will ensure that the BRGMON-2 continues to monitor the effectiveness of Carpenter Reservoir operating conditions on the riparian area surrounding Carpenter Lake reservoir, and the effectiveness of BRGWORKS-1 Carpenter Reservoir Drawdown Zone Revegetation Program including changes in project schedule.

2 REVISION RATIONALE

The original TOR (dated March 10, 2014) identified the need to validate the assumptions of the operational alternative recommended by the Consultative Committee (CC). Two management uncertainties were assumed by the BRG Water Use Plan (WUP) CC recommendation. First, there was a desire to validate the predictive assessment methods used for WUP development to verify the effectiveness of the recommended operational alternative. Second, the recommendation was based on the assumption that reservoir revegetation activities could be successfully implemented to provide riparian benefits to offset the impacts associated with the recommended operational alternative and there was a need to evaluate the effectiveness of the revegetation strategy.

The operation of Carpenter Reservoir is not affected operational modifications implemented in 2015 and 2016 and proposed into the foreseeable future to address seismic risks identified at La Joie Dam and other Bridge River-Seton operating constraints. The reservoir continues to be operated within the parameters of the Water Act Order.

This revision is largely intended to address shifts in focus with the BRGWORKS-1 Carpenter Reservoir Drawdown Zone Revegetation Program. The focus of BRGWORKS-1 will shift from primarily using revegetation techniques to using a broader range of treatments that would include both revegetation and physical treatments to enhance natural colonization of the riparian area within the drawdown zone ("riparian enhancement"). In addition, the program will be extended for an additional two years (from 5 to 7 years) based on preliminary results. As a result, this TOR Revision will reflect both: changes to applied riparian enhancement techniques; and the revised project schedule of BRGWORKS-1.

This revision also makes some adjustments to terminology for clarity. Table 1 below identifies the key changes and provides a brief summary of the rationale.

Table 1: Key changes to the BRGMON-2 TOR and rationale for their inclusion

Section	Change	Rationale
Overall	<ul style="list-style-type: none"> Replaced the term “revegetation” with “riparian enhancement” Removed reference to N2-2P and O3-2 operating alternatives Replaced the term “relative productivity” with “biomass” 	<ul style="list-style-type: none"> To reflect changes to the BRGWORKS-1 program N2-2P and O3-2 are references that relate to WUP options considered during WUP consultative discussion. The Order dictates the current operation so this old terminology is not relevant in the current discussion Relative productivity is a difficult metric to measure in the field, a comparative biomass sample of native riparian vegetation species (before and after) is a more attainable and accurate metric to analyze and measure
1.0 Monitoring Program Rationale	<ul style="list-style-type: none"> Added background text about the BRG <i>Water Act</i> Order applicable to this program 	<ul style="list-style-type: none"> The text from the <i>Water Act</i> Order was added to make the TOR more closely reflect what the Order requires
2.0 Monitoring Goals and Objectives	<ul style="list-style-type: none"> Added new section Defined two components of this program 	<ul style="list-style-type: none"> Relevant goals needed to be added to the TOR
Management Questions	<ul style="list-style-type: none"> Removed reference to N2-2P and O3-2 operating alternatives Added “quality and quantity of species composition, biological productivity, spatial area of the riparian area surrounding Carpenter Reservoir” to define better performance measures for Component One of the monitoring program Added “quality (as measured by diversity, distribution, and vigour) and quantity (as measured by cover, abundance and biomass) of riparian vegetation in the drawdown zone of the Carpenter Lake Reservoir” to define better performance measures for Component Two of the monitoring program Increased the length of the monitoring program 	<ul style="list-style-type: none"> N2-2P and O3-2 are old terms that are not relevant in the current discussion Previous performance measures were not well defined Length of the BRGWORKS-1 program has increased from five to seven years
Hypothesis	<ul style="list-style-type: none"> Changed wording in the hypothesis to reflect changes to the management questions 	<ul style="list-style-type: none"> Hypotheses need to be able to answer the management questions
Key Water Use Decision Affected	<ul style="list-style-type: none"> Removed reference to N2-2P and O3-2 operating alternatives 	<ul style="list-style-type: none"> N2-2P and O3-2 are old terms that are not relevant in the current discussion
Methods	<ul style="list-style-type: none"> Removed reference to N2-2P and O3-2 operating alternatives Replaced the term “relative productivity” with “biomass” Updated program timelines and schedules 	<ul style="list-style-type: none"> N2-2P2 and O3-2 are old terms that are not relevant in the current discussion Relative productivity is a difficult metric to measure in the field, and the biomass of native riparian species is a more attainable and accurate metric to analyze and measure Monitoring timelines and schedules need to reflect the physical works program

Section	Change	Rationale
Interpretation of Results	<ul style="list-style-type: none">Removed reference to N2-2P and O3-2 operating alternativesAdded more detailed reporting elements, including Annual reports and a Mid-Term report	<ul style="list-style-type: none">N2-2P and O3-2 are old terms that are not relevant in the current discussionAdditional reporting elements were added to help guide BRGWORKS-1, to adaptively alter riparian enhancement treatments (adaptive management) based on monitoring results to increase the success of the treatments
Schedule	<ul style="list-style-type: none">Changed schedule to include an additional two years of monitoringUpdated schedule	<ul style="list-style-type: none">Monitoring timelines and schedules need to reflect the physical works program
Budget	<ul style="list-style-type: none">Increase in budget total	<ul style="list-style-type: none">Extension of the program requires funds to complete the two additional years of monitoring

1 Monitoring Program Rationale

The Bridge Seton Water Use Plan Consultative Committee (BRG WUP CC) recognized the value of maintaining high quality riparian habitats in the area surrounding Carpenter Lake Reservoir. Riparian habitats provide the physical structural and biological character for wildlife habitat, while contributing to environmental aesthetics (i.e., “green-up,” reduction of dust storms) and localized enhancement of the littoral productivity in the reservoir. As a result of these benefits, the protection and enhancement of quality and quantity of high quality riparian areas surrounding Carpenter Reservoir emerged as a key environmental objective in the Bridge River Water Use Plan. The Water Act Order issued by the Comptroller of Water Rights on March 30, 2011, Schedule A, Clause 6 states that a monitoring program must:

- a) Monitor the effectiveness of Carpenter Reservoir operating conditions on the riparian area surrounding Carpenter reservoir; and
- b) Monitor the effects of a short-term Reservoir revegetation program (i.e., BRGWORKS-1) with respect to Carpenter Reservoir operating conditions.

This program is required to satisfy the statements included in the Order.

2 Monitoring Goals and Objectives

The goals of the monitoring program are to:

- 1) Monitor the effects of Carpenter Reservoir operating conditions on the riparian area surrounding Carpenter Reservoir.
- 2) Monitor the effectiveness¹ of the reservoir riparian enhancement program (BRGWORKS-1: the objective of riparian enhancement is to create conditions in the drawdown zone that encourage the establishment of native species using a combination of revegetation and physical works treatments) with respect to Carpenter Lake Reservoir operating conditions.

2.1 Management Questions

The primary management questions addressed by the Carpenter Reservoir Riparian Vegetation Monitoring program are:

- 1) Do reservoir operations have a negative, neutral or positive impact on the quality² and quantity (species composition, biological productivity, spatial area) of the riparian vegetation surrounding Carpenter Reservoir?
- 2) Does the implementation of a short-term (seven year) intensive reservoir riparian enhancement program expand the quality (as measured by diversity, distribution,

¹ Monitoring the effectiveness is the process of obtaining and analyzing repeated samples of the key variables after riparian enhancement treatments to see if these interventions resulted in increased native vegetation species distribution, diversity, vigour, abundance and biomass of native riparian species in relation to the operating regime and/or other environmental variables.

²“Quality” is defined as a measure of how effectively enhancement sites meet the interests the requirements outlined in the Order (Schedule A, Clause 4) and the WUP CC: implement a short term revegetation program to mitigate the effects of dust storms, increase the aesthetic quality, enhance the quality of riparian habitats, and provide localized improvements in the quality and productivity of aquatic habitats in areas affected by the drafting of the Carpenter Lake Reservoir

- and vigour) and quantity (as measured by cover, abundance and biomass) of riparian habitats in the drawdown zone of the Carpenter Lake Reservoir.
- 3) Does the implementation of a short-term seven-year intensive reservoir riparian enhancement program mitigate the effects of dust storms and increase the aesthetic quality of the drawdown zone in the Carpenter Lake Reservoir.

2.2 Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Riparian Vegetation

Three primary hypotheses (and sub hypotheses) associated with the two management questions are presented below. The first hypothesis is associated with providing assurance that the implemented reservoir operating regime is not reducing the riparian area surrounding Carpenter Reservoir. This management hypothesis and the sub-hypotheses can be tested directly with the proposed monitoring program:

- H₁: Implementation of operations will not result in a reduction of riparian habitats in the area surrounding Carpenter Reservoir
- H_{1A}: There is no significant change in the spatial extent of the vegetated area in the drawdown zone of Carpenter Reservoir.
- H_{1B}: There is no significant change in the species composition of the plant community in the vegetated area of the drawdown zone of Carpenter Lake.
- H_{1C}: There is no significant change in the biomass of the native riparian community in the vegetated area of the drawdown zone of Carpenter Lake.

A second hypothesis is associated with the assumption that short-term (< 56 days, Inundation Tolerance) incursions into the reservoir buffer would not significantly influence the quality or spatial extent of drawdown zone vegetation. This flexibility in reservoir operation reduces the frequency and magnitude of spills into Lower Bridge River and Seton River. However, this hypothesis is difficult to directly test because of uncertainty in the inflow patterns into the reservoir and the long time period required to fully capture any operating impacts on vegetation community dynamics. Empirical data collected in this program over the review period will be opportunistic, and if this scenario occurs, the data will be evaluated to determine whether it supports the hypothesis:

- H₂: Incursions of less than 56 days into the reservoir buffer do not significantly impact riparian community.

The third hypothesis was associated with the expected success of the reservoir riparian enhancement program. The BRG CC expressed concern that a riparian enhancement program should not be an annual program in perpetuity, but was justified to “jump start” the vegetation colonization process in the area between the Gun Creek Fan and the Tyaughton Lake Road Junction. This hypothesis will be tested directly through the evaluation of the reservoir riparian enhancement component of the proposed program.

- H₃: Implementation of a riparian enhancement program between the Gun Creek Fan and the Tyaughton Lake Road Junction within the drawdown zone will support the basis for continued natural re-colonization of native vegetation communities and species.

- H_{3A}: There is no significant difference in native vegetation establishment (based on species distribution, diversity, vigour, biomass and abundance) at control versus treatment locations.
- H_{3B}: There is no significant difference in the cover of native vegetation in control versus treatment locations.
- H_{3C}: There is no significant difference in native vegetation establishment and the cover of native vegetation communities (based on species distribution, diversity, vigour, biomass and abundance) arising from different revegetation prescriptions.
- H_{3D}: There is no significant difference in the species composition of naturally re-colonizing vegetation in treated versus control areas.

2.3 Key Water Use Decision Affected

The results of this study can be used to inform discussions around trade-offs between reservoir operations and impacts to vegetation communities and other values associated with Carpenter Reservoir operations.

The information is critical to support future decisions that involve establishment of the appropriate balance between protection and enhancement of riparian areas surrounding Carpenter Reservoir and protection of downstream values (i.e., spills in Lower Bridge and Seton Rivers) and upstream values (i.e., entrainment and stranding of fish in Downton Reservoir).

3 Monitoring Program Proposal

3.1 Objective and Scope

The objective of Carpenter Reservoir Riparian Vegetation Monitoring Program is to document the response of the riparian community surrounding the reservoir, to reservoir operations. The scope of this program is to employ before and after aerial photography, vegetation transects and ground surveys to assess changes in area extent, vegetation species composition, vegetation cover, and where possible, biomass over a ten-year period.

3.2 Approach

The proposed monitoring program has three components. The first component is the quantification of changes in spatial extent, species composition, and biomass of the riparian area surrounding Carpenter Reservoir that occur as a result of the operating strategy of the reservoir. The second component is the detailed evaluation of the intensive riparian enhancement program, which will be used to increase the spatial extent of vegetated area within the Carpenter drawdown zone. The third component will be opportunistic only, and will study the impacts of reservoir incursions of less than 56 days into the reservoir buffer on the riparian community. If the incursion occurs during this program study period, monitoring and analysis methods will be determined at that time. Program analysis of the program field data will draw inferences on the overall effect of the operations and vegetation enhancement on the riparian communities. The program is to be conducted over an approximately ten-year period, and the implementation of each component will occur periodically through the review period (refer to the Schedule section below).

3.3 Methods

The proposed monitoring program has the following primary tasks:

3.3.1 Task 1 Project 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) staff selection, 3) logistic coordination, 4) technical oversight in field and analysis components; and 5) liaison with regulatory and first nations groups.

3.3.2 Task 2 Riparian Vegetation Mapping and Analysis

Aerial Photography

To assess the impacts of reservoir operations on the spatial extent of riparian vegetation adjacent to and within Carpenter Reservoir drawdown zone aerial photography was taken in 2013 and will be taken at the end of the study period, approximately ten years later. Low level spatial geo-referenced color air photos will be used to develop GIS based maps of the riparian vegetation and interpreted to estimate changes in the spatial extent and location of vegetation occurring after ten years. The observed patterns will be interpreted based on inundation frequencies imposed by the implemented reservoir operations and by site specific habitat conditions within the drawdown zone.

Vegetation Transect Surveys

Transect surveys will:

- 1) Ground truth assessments of general changes in species composition occurring over the entire spatial area of the reservoir;
- 2) Provide detailed descriptions of site topography; and
- 3) Provide a detailed assessment of the changes in native and non-native vegetation species composition and biomass (at a selected number of control plots) of riparian habitats resulting from reservoir operations.

During the baseline data collection in 2013, approximately 30 transects (with permanent benchmarking) were installed and surveyed to establish baseline conditions for vegetation species composition and elevation patterns of establishment associated with reservoir inundation history in the Carpenter Reservoir. At the end of the study period, approximately ten years later, baseline vegetation surveys (including the biomass sampling) will be repeated. Based on the data collected, a quantitative assessment will be undertaken of the changes in species composition with particular attention to spatial changes in riparian vegetation along elevation gradients in relation to inundation history within the drawdown zone.

3.3.3 Task 3 Evaluation of BRGWORKS-1 Carpenter Reservoir Drawdown Zone Riparian Enhancement Program

BRGWORKS-1 will be evaluated under this project to ensure full integration of the response of vegetation to both operational changes and the enhancement strategy. The approach is described below.

Field surveys will be done for a subset of the BRGWORKS-1 treatment locations and adjacent control areas prior to, during and following the implementation of treatments. The following will be conducted prior to the initiation of any treatment activities:

- 1) Develop permanent benchmarks for monitoring sites;
- 2) Collect topographic and abiotic descriptions (e.g. soil texture, erosion and sedimentation processes) of the treatment and control locations; and
- 3) Quantify site specific baseline conditions for extent of vegetated area, species composition (native and non-native species attributes will be collected and recorded separately) and biomass (biomass only collected in Year 5 - 2017, and Year 10 – 2022 within a representative sample from control and treatment plots).

These activities will be continued annually during the implementation of treatment activities to allow documentation over time as changes in spatial extent of naturally occurring and planted vegetation, species composition, and cover. The collection of vegetation data will include native and non-native species to evaluate vegetation response to riparian treatments. Documentation of non-native species response to treatments is important for analysis of the treatment success.

A final survey will be conducted two years after the completion of the BRGWORKS-1 program activities after two years with no activity. The objective of these final surveys is to evaluate the overall success of the program for improving the spatial extent of riparian vegetation and the encouragement of natural colonization of native species in the drawdown zone.

3.3.4 Task 4 Reporting

Annual reports, a mid-term comprehensive report and a detailed final synthesis report will be prepared prior to the review of the Water Use Plan that outlines the findings from the program as they relate to the primary components described above.

3.4 Interpretation of Monitoring Program Results

The data and information collected in the proposed monitoring programs will be used to assess the degree to which management objectives and technical expectations were met by the operations and BRGWORKS-1 together.

Annual Reporting will include:

- 1) Summary of treatment methods employed in BRGWORKS-1 from the previous year;
- 2) Annual reservoir inundation pattern summary graph including previous year records and BRGWORKS-1 treatment dates on the graph;
- 3) Highlight annual treatment success and failures;
- 4) Annual weather patterns, observational notes; and
- 5) Adaptive management considerations and recommendations for riparian enhancement treatments and treatment adjustments for BRGMWORKS-1 for the next year.

Mid-term Comprehensive Report will include annual reporting information above in addition to the following:

- 1) Summary of monitoring methods used to survey BRGWORKS-1 treatment areas;
- 2) Reservoir inundation pattern summary graph;
- 3) Summarize treatments to date;
- 4) Highlight observed trends in the data;
- 5) Highlight treatment successes and failures to date;
- 6) Adaptive management analysis based on the results to date, and recommend a riparian enhancement treatment plan for the remaining treatment years of BRGWORKS-1 based on observed trends in the data.

Upon completion of the program, a synthesis report will be prepared for use in the next review of the Bridge River Water Use Plan. This synthesis will include, but may not be limited to:

- 1) Quantitative assessment of the changes in spatial extent, species composition, and biomass of non-native and native riparian vegetation surrounding Carpenter Reservoir associated with the operating regime.
- 2) Quantitative assessment of the supplemental benefits of the implementation of extensive riparian enhancement for improving the spatial extent, species composition, cover, and biomass of vegetated areas within the drawdown zone in Carpenter Reservoir.
- 3) Evaluation of the extent to which management objectives for protection and enhancement of the riparian areas surrounding Carpenter Reservoir were achieved by the current operating regime and intensive riparian enhancement program.

3.5 Schedule

The schedule for the annual activities is necessarily phased to accommodate the requirements of the program. The first year of the program (Year 1 – 2013) collected baseline data and resulted in the refinement of a detailed plan for the seven-year long riparian enhancement program covered under BRGWORKS-1. In Years 3 through 8, the BRGWORKS-1 implementation will continue with annual site specific evaluation monitoring under BRGMON-2. It is proposed that no work be conducted in Year 9. In the final year immediately prior to the end of the study period (Year 10 – 2022), Year 1 activities will be repeated including aerial photography, biomass sampling, and baseline vegetation transect surveys. A final assessment of observed changes in the riparian area surrounding Carpenter Reservoir will be completed in Year 10. The schedule for the proposed program is provided below in Table 1.

Table 1 BRGMON-2 Component 1 and 2 Schedule

Component	Task	Year 1 (2013)	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8 (last year for BRGWORKS-1 implementation)	Year 9	Year 10 (2022)
1,2	Project Coordination	X	X	X	X	X	X	X	X	X	X
1	Aerial Photography	X									X
1	Transect Surveys	X									X
2	Riparian Enhancement Monitoring			X	X	X	X	X	X		X
1,2	Biomass Sampling	X*				X					X
1,2	Annual Reports	X		X	X	X		X	X		
	Mid-Term Comprehensive Report						X				
1,2	Detailed Synthesis Report										X

*Photos were taken at plots within each transect which can be used to estimate productivity.

3.6 Budget

Total revised program cost \$696,760.

4 References Cited

Stevens, L E., Mast, J.N. Korman, J. Higgins, P. 2001. Natural and Anthropogenic Flow Regime Impacts on Black Cottonwood (*Populus trichocarpa*) In the Bridge –Seton River System, BC.