Bridge River Project Water Use Plan

Downton Reservoir Fish Habitat and Population Monitoring

Implementation Year 3

Reference: BRGMON-7

BRGMON-7 Downton Reservoir Fish Habitat and Population Monitoring, Year 3 (2015) Results

Study Period: April 1 2015 to March 31 2016

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Executive Summary

Data collection for Year 3 of this proposed 10-year study was completed in 2015. Where relevant, results from previous monitoring years have also been provided and a synthesis of analyses across years will continue to be included with each new set of data collected each year. A full synthesis of all results will be conducted following the final year of data collection which is scheduled for 2022. The primary objectives of this monitoring program are: 1) To collect comprehensive information on the life history, biological characteristics, distribution, abundance and composition of the fish community in Downton Reservoir, and, 2) To provide information required to link the effects of reservoir operation on fish populations.

To-date, only rainbow trout have been captured in the reservoir and its tributaries. Five methods were employed in Year 3 (2015) to document the biological characteristics of the rainbow trout population, generate an annual abundance index, and characterize available fish habitats. These methods included:

- Habitat mapping around the perimeter of the reservoir;
- Substrate classification at two key reservoir elevations;
- Tributary spawner surveys;
- Tagged fish detections using PIT arrays in a selected stream (Trib. #13); and
- General fish population index surveys in the reservoir (by boat electrofishing).

The management of surface elevations in Downton Reservoir follows a seasonal pattern: lowest elevations occur in spring (generally April to May) and highest elevations, or full pool, occur in late summer to early fall (September). Normal minimum and maximum operating levels for Downton Reservoir are 707.7 m and 749.8 m, respectively (BC Hydro 2011). Lowest reservoir elevation in Year 3 (2015) was 720.4 m in May, which were very similar to 2013 (719.7 m) and 11 m higher than low pool elevations in 2014 (709.0 m). Maximum reservoir elevation in 2015 was 747.0 m during mid October. At this point, operating to the modified maximum reservoir elevation of 734 m is planned to begin in Year 4 (2016).

The shoreline habitat mapping in 2015 documented the proportional availability and distribution of habitat types around the entire perimeter of Downton Reservoir near full pool (~745 m elevation). At this elevation, the length of the reservoir was 25.6 km, and the total shoreline length was 60.3 km. Steep shorelines (slope > 15°) were by far the most prevalent, contributing 43.8 km (73%) to the total perimeter length. Fans were the next most prevalent habitat type in the reservoir, contributing 8.8 km (15%) to the total shoreline length. Shallow shorelines (slope <15°) and creek mouths contributed 5.7 km (9%) and 0.8 km (1%) to the total perimeter distance, respectively. At the east end of the reservoir, the face of La Joie Dam is 1.1 km long, comprising 2% of the reservoir shoreline at the elevation surveyed (~745 m).

Substrate size, interstitial depth, and slope measurements were collected from 25 sites in the reservoir drawdown zone (*n*= 20) and in select tributary streams (*n*= 5) during 2015. Between the maximum (747 m) and *modified* maximum (735 m) elevations, differences in substrate size distribution were small. The combined proportion of fines and small gravels tended to be modestly higher at the lower elevation (735 m) whereas the abundance of larger substrates (very large gravels and bigger) tended to be slightly higher at the higher elevation (747 m). Plotting the substrate size and interstitial depth data indicated a slight positive correlation between the two variables, with a high degree of deviation around the line owing to factors such as variable embeddedness. The slopes of the lines for the two reservoir elevations (735 m and 747 m) were very similar, suggesting minimal differences in the availability of interstitial cover for juvenile fish between the maximum and modified maximum elevations, based on the available data.

Reservoir operations certainly have the potential to impact the reservoir fish population, including rainbow trout spawning use of tributaries. Based on spawner survey results, peak spawn timing for Downton Reservoir rainbow trout occurred on 4 July in 2015, which was slightly later than the late June peak timing observed in previous study years. In general, this timing for the Downton Reservoir population is ~2 months later than peak spawning in other nearby contexts such as the Lower Bridge River (Burnett et al. 2016). This is likely a localized adaptation to the combined effects of reservoir operations and delayed onset of freshet inflows and preferred temperatures for spawning in this context.

Two PIT arrays were operated in Trib. #13 from 11 May to 25 June 2015. During that period of operation, eight PIT tagged fish were detected in this tributary. 75% of the tagged fish accessed the upland area above the reservoir influence, and 25% remained in the portion of the stream within the drawdown zone. Interpretation of these results for spawning distribution must be made with caution due to the small sample size and the fact that the arrays had to be removed before peak spawning because of the encroachment of reservoir water levels.

Approximately 13 kilometres of shoreline was sampled by boat electrofishing over 8 consecutive nights in early June. In total, 973 fish were captured from 51 sites. As in Years 1 and 2, all captured fish were rainbow trout. In total, 796 of these fish were marked (614 with PIT tags; 182 adipose-clipped) and another 29 rainbow trout captured by angling were also PIT tagged and released alive.

Catch-per-unit-effort (CPUE) values were generated for Year 3 (2015). The total CPUE was 7.5 fish per 100 m of shoreline compared to CPUE values of 1.7 and 5.3 fish/100 m in Year 1 (2013) and Year 2 (2014), respectively. Highest CPUEs by age were recorded for Age-1 and Age-2 rainbow trout (4.1 and 1.7 fish/100 m, respectively). Highest CPUEs by habitat type were at Creek Mouths (15.9 fish/100 m), whereas CPUEs among the other habitat types were more similar (fan=7.0; shallow=8.0; and steep=6.2 fish/100 m, respectively), which is consistent with the trends among habitat types from previous years. Highest total CPUE by longitudinal zone of the reservoir was recorded in the East zone (which is nearest the dam) in 2015; although this has varied among years to-date, reflecting that rainbow trout are generally distributed throughout the reservoir.

Scales from a subset of rainbow trout sampled in 2015 were collected for ageing analysis. Fish from the sample ranged from Age 0+ (in their first year) to Age 5. The highest proportion of captured fish were Age 1 and Age 2. The data indicate that there is extensive size overlap among the older age classes (particularly ages 3 to 5) suggesting very slow growth for these age classes. Ageing analysis also allowed us to plot the index of abundance for Age 1 and 2 rainbow trout against reservoir elevations (i.e., minimum and maximum) during their recruitment year. Generating these data across the 10-year monitoring period will enable us to determine if there is a potential causal relationship between these variables.

Recommendations for monitoring in upcoming years of the BRGMON-7 program include: 1) repeat reservoir habitat surveys at low pool (710 to 720 m reservoir elevation) and modified maximum levels (734 m) to facilitate comparison of the proportional amount and distribution of habitat types across the range of reservoir operating conditions; 2) Collect substrate measurement and interstitial space data from more sites, habitat types and reservoir elevations to facilitate comparison of these metrics for the habitats that rainbow trout use across the range of reservoir operating conditions; 3) Discontinue stream walk spawner counts since the utility of the information from these uncalibrated counts for addressing the management questions is very limited and the available budget for this program wouldn’t accommodate a more robust mark-re-sight study design in this context; 4) Repeat the population indexing survey by boat electrofishing annually, employing the same timing, methods, and effort to establish comparable catch statistics (CPUEs) for monitoring trends associated with reservoir operations in all remaining study years going forward.

The status of responses to the Management Questions and Study Hypotheses based on results up to, and including, Year 3 (2015) are presented in the summary table that follows.

Management Questions, Study Hypotheses and Interim Status

Status of responses to Management Questions based on results for Years 1 to 3

Primary Objectives	Management Questions	Year 3 (2015) Status for Management Questions
1) To collect comprehensive information on the life history, biological characteristics, distribution, abundance and composition of the fish community in Downton Reservoir, and 2) To provide information required to link the effects of reservoir operation on fish populations to a) document impacts of the operating alternative on existing reservoir fish populations, and, b) allow better future decisions regarding preferred operation of Downton Reservoir.	1. What are the basic biological characteristics of fish populations in Downton Reservoir and its tributaries?	The program is on track to answer Management Question (MQ) 1 by establishing an index of abundance, distribution and biological characteristics data for rainbow trout. **See Section 3.3, 3.5, and 3.6.**
	2. Will the selected alternative (N2-P) result in positive, negative or neutral impact on abundance and diversity of fish populations?	The program is on track to answer MQ 2 by establishing an annual index of abundance and documenting the biological characteristics of the rainbow trout population over time. Trends in these metrics, in conjunction with trends in reservoir operation, will provide information for addressing this MQ. **See Section 3.6.**
	3. Which are the key habitat factors that contribute to reduced or improved productivity of Downton Reservoir fish populations?	Based on the information collected in Years 1 to 3, the program is on track to characterize the relative importance of various habitat types and attributes in the reservoir for rainbow trout. Specific, targeted habitat data collection linked to reservoir operation level began in Year 3 (2015), providing additional information for addressing this MQ (**See Section 3.2**). That being said, it may be a challenge to tease apart the role of specific habitat factors from other key variables such as reservoir operation, minimum elevation, stream events, or other unquantified factors over the course of the monitoring period.
	4. Is there a relationship between the minimum reservoir elevation and the relative productivity of fish populations?	The program is on track to answer MQ 4 by establishing an annual index of abundance and documenting the age structure of the rainbow trout population over time. The goal is to address this MQ by correlating abundance of younger ages of fish (recruitment) with minimum reservoir elevations by year. **See Section 3.6**.
	5. Can refinements be made to the selected alternative to, without significant impact to instream flow conditions in the Middle Bridge River, improve habitat conditions or enhance fish populations in Downton Reservoir?	The program is on track to providing the relevant information for answering this MQ; however, the compilation of annual fish abundance index, biological characteristics data, and key habitat factors data for all years of the monitoring program will be required for addressing this MQ.

Responses to Study Hypotheses based on results for Years 1 to 3

Primary Objectives	Study Hypotheses	Year 3 (2015) Responses to Study Hypotheses
1) To collect comprehensive information on the life history, biological characteristics, distribution, abundance and composition of the fish community in Downton Reservoir, and 2) To provide information required to link the effects of reservoir operation on fish populations to a) document impacts of the operating alternative on existing reservoir fish populations, and, b) allow better future decisions regarding preferred operation of Downton Reservoir.	**H_1:** The annual abundance index for rainbow trout in Downton Reservoir is stable over the monitoring period.	**H_1:** not confirmed or rejected; more data needed. Requires rainbow trout population index value for the entire monitoring period (2013 to 2022). Refer to Figure 3.7 (Section 3.6).
	H_2: The annual abundance index for rainbow trout is independent of minimum reservoir elevations observed over the period of monitoring. **H_{2a}:** The annual abundance index for Age-1 rainbow trout is independent of a minimum reservoir elevation effect (sampling year minus 1). **H_{2b}:** The annual abundance index for Age-2 rainbow trout is independent of a minimum reservoir elevation effect (sampling year minus 2).	**H_2, H_{2a}, H_{2b}:** not confirmed or rejected; more data needed. Requires annual age-specific CPUEs and minimum reservoir elevation values for the entire monitoring period (2013 to 2022). Refer to Figure 3.10 (Section 3.6).
	H_3: The annual abundance index for rainbow trout is independent of maximum reservoir elevations observed over the period of monitoring. **H_{3a}:** The annual abundance index for Age-1 rainbow trout is independent of a maximum reservoir elevation effect (sampling year minus 1). **H_{3b}:** The annual abundance index for Age-2 rainbow trout is independent of a maximum reservoir elevation effect (sampling year minus 2).	**H_3, H_{3a}, H_{3b}:** not confirmed or rejected; more data needed. Requires annual age-specific CPUEs and maximum reservoir elevation values for the entire monitoring period (2013 to 2022). Refer to Figure 3.10 (Section 3.6).
	H_4: Operation of the reservoir restricts the amount of available effective spawning habitat in tributaries limiting the productivity of fish populations.	**H_4:** tentatively confirmed; more data needed. Evidence suggests that rainbow trout only use tributaries in the West zone of the reservoir basin for spawning since habitats in these streams inundate later in the year (i.e., after the incubation period). Accessible tributaries in Mid and East zones (such as Ault, Paul and Cathy creeks) are not used despite the presence of suitable habitat, likely due to inundation risk. **See Section 3.3**.
	H_{4a}: Rainbow trout spawning density in Downton Reservoir drawdown zone is minimal and therefore operations do not limit productivity of fish populations.	**H_{4a}:** tentatively rejected; more data needed. While some tributaries are not used at all (see above), the drawdown zone of Tribs. #13 and #19 are used extensively**. See Sections 3.3 and 3.5**.

Primary Objectives	Study Hypotheses	Year 3 (2015) Responses to Study Hypotheses
See above.	**H_{4b}:** Operation of the reservoir restricts fish access to tributaries limiting the productivity of fish populations.	Tentatively confirmed; more data needed. Evidence suggests that connectivity of some tributaries may be cut off at certain low reservoir elevations although typical spawning tributaries may not be affected. Requires additional access surveys at the range of reservoir elevations during the rainbow trout spawning period. Surveys for this purpose will continue in future study years.
	H_5: Habitat availability in Downton Reservoir is independent of reservoir operation, i.e., habitat characteristics are not significantly different between minimum, maximum and modified maximum reservoir elevations.	Not confirmed or rejected; more data needed. Efforts in Year 3 (2015) have begun to define habitat characteristics at maximum and modified maximum reservoir elevations. Further data collection required and planned for subsequent monitoring years to determine if differences are significant and if there are linkages to fish abundance index results.

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1) Introduction

1.1. Background

As a part of the Water Use Planning (WUP) process completed for BC Hydro's facilities in the Bridge and Seton watersheds (BRG), the Consultative Committee developed aquatic ecosystem objectives for Downton Reservoir in terms of abundance and diversity of fish populations present in the reservoir. However, due to the lack of documented information about fish populations in the reservoir available at the time, it was not possible to develop explicit population-level performance measures that reflected these objectives. Specific gaps in data and understanding were identified in: 1) the species composition, relative abundance, distribution and life history requirements of species of fish in the reservoir and adjacent tributaries, and, 2) the relationship between operating parameters of the reservoir (i.e., maximum/minimum elevation, filling schedule) and the fish population response.

Given the scope of these data gaps and the schedule of the BRG WUP it was not possible to conduct the required studies within the time available before WUP-based operational decisions needed to be made. As such, these decisions were based upon an extensive amount of qualitative judgment about which habitat and operations-related factors were most important in the regulation of fish population abundance and distribution in Downton Reservoir. To resolve these data gaps and better inform reservoir operating strategies, the Consultative Committee recommended a long term monitoring study to obtain more comprehensive information on local habitats and fish populations. A set of management questions related to fisheries management goals and associated hypotheses regarding potential environment responses to the selected WUP operations were also defined to provide direction for the study.

The Bridge River Power Development Water Use Plan was accepted by the provincial Comptroller of Water Rights in March 2011. Terms of Reference (ToR) for the Downton Reservoir Fish Habitat and Population Monitoring program were developed and approved by late 2012, and field data collection activities were initiated in 2013. Under the WUP, monitoring for this program is scheduled to continue annually until 2021. Data collection for Year 3 of this proposed 10-year study was completed in 2015.

1.2. Sampling Design

As in previous monitoring years, Year 3 (2015) field activities were focussed on providing data to meet the following sampling design included in the original study ToR (BC Hydro 2012):

a) Collecting time series information on the abundance and biological characteristics of resident fish populations and reservoir habitat conditions;

b) Correlating abundance of younger ages of fish (recruitment) with reservoir operating parameters.

c) Implementing a “stock synthesis” approach to estimating recruitment anomalies associated with operating impacts, which combines age composition and relative trend data collected during monitoring to better define recruitment changes;

d) Examining trends in growth or distribution changes with operations implemented over the course of the study period.

Sampling to-date indicates that rainbow trout dominate the species assemblage in the reservoir, and are likely the only salmonid species present. It is expected that rainbow trout are sensitive to habitat impacts caused by Downton Reservoir operations. For these reasons, rainbow trout will be the sole target species for monitoring in this program based on their ecological and social value, and the ability to consistently sample them.

During the first two years of monitoring, a great deal of learning occurred about site access; sampling conditions; and fish distribution, densities, and catchability. This learning helped inform the approach and strategy for this program going forward, but also highlighted issues with the testability of some of the study hypotheses included in the original ToR. In addition, planned modifications to Downton Reservoir operations (related to seismic risk mitigation at La Joie Dam) also necessitated revision to the original approach.

Under the *modified* operations, the target fill elevation for Downton Reservoir will be lowered to ~734.00 meters above sea level (masl), instead of the normal maximum operating level of 749.81 masl; a reduction of ~15 meters. This difference will reduce the total storage volume of the reservoir by about 50%, and is an operational mitigation strategy to reduce seismic risk until physical works at the dam can be completed to address the issue. Under the modified operations, normal minimum reservoir levels will be unchanged although deeper drawdowns may be somewhat more frequent than in the past. The first year that modified reservoir operations are implemented will be in Year 4 of the monitoring program (2016).

In light of these operational changes and in the course of discussions about the program with the monitoring committee, including the BC Hydro Fish & Aquatic Issues Specialist, some specific changes to the study hypotheses were proposed (though the management questions remained the same). These revisions were incorporated into a ToR addendum (BC Hydro 2015) submitted to the provincial Comptroller of Water Rights in January 2015. Starting with this Year 3 (2015) report, the discussion of results will focus on the revised study hypotheses as presented in this addendum. While further changes of this magnitude are not expected, the sampling design will continue to be reviewed annually to account for new learning in this relatively untested and remote context.

1.3. Objectives, Management Questions and Study Hypotheses

The primary objectives of this monitoring program are: 1) To collect comprehensive information on the life history, biological characteristics, distribution, abundance and composition of the fish community in Downton Reservoir, and, 2) To provide information required to link the effects of reservoir operation on fish populations to a) document impacts of the operating alternative on existing reservoir fish populations, and, b) allow better future decisions regarding preferred operation of Downton Reservoir.

The primary management questions to be addressed by this monitoring program are:

1. What are the basic biological characteristics of fish populations in Downton Reservoir and its tributaries?

This management question will be evaluated using fish population abundance or index of abundance, fish distribution and biological characteristics data. The target species is rainbow trout.

2. Will the selected alternative (N2-P) result in positive, negative or neutral impact on abundance and diversity of fish populations?

This management question will be evaluated using weight-of-evidence as exhibited by trends in fish population abundance and trends in their biological characteristics in conjunction with trends in reservoir operation over the course of the monitoring program. The underlying operational cause-effect relationship associated with any response may not be evident from this analysis. However, weight-of-evidence will be used to evaluate WUP operations impacts on the reservoir rainbow trout population.

3. Which are the key habitat factors that contribute to reduced or improved productivity of Downton Reservoir fish populations?

This management questions will be evaluated using basic habitat quality and quantity data collected in the reservoir in conjunction with reservoir operations data.

4. Is there a relationship between the minimum reservoir elevation and the relative productivity of fish populations?

This management question will be evaluated using a combination of weight-of-evidence as exhibited by trends in fish population abundance and trends in their biological characteristics in conjunction with trends in reservoir operation.

5. Can refinements be made to the selected alternative to, without significant impact to instream flow conditions in the Middle Bridge River, improve habitat conditions or enhance fish populations in Downton Reservoir?

This management question will be evaluated based on insights gained from results under management questions 1-4.

The primary hypotheses (and sub-hypotheses) associated with these management questions from the Terms of Reference Addendum are:

H_1: The annual abundance index for rainbow trout in Downton Reservoir is stable over the monitoring period.

H_2: The annual abundance index for rainbow trout is independent of minimum reservoir elevations observed over the period of monitoring.

H_{2a}: The annual abundance index for Age-1 rainbow trout is independent of a minimum reservoir elevation effect (sampling year minus 1).

H_{2b}: The annual abundance index for Age-2 rainbow trout is independent of a minimum reservoir elevation effect (sampling year minus 2).

H_3: The annual abundance index for rainbow trout is independent of maximum reservoir elevations observed over the period of monitoring.

H_{3a}: The annual abundance index for Age-1 rainbow trout is independent of a maximum reservoir elevation effect (sampling year minus 1).

H_{3b}: The annual abundance index for Age-2 rainbow trout is independent of a maximum reservoir elevation effect (sampling year minus 2).

H_4: Operation of the reservoir restricts the amount of available effective spawning habitat in tributaries limiting the productivity of fish populations.

H_{4a}: Rainbow trout spawning density in Downton Reservoir drawdown zone is minimal and therefore operations do not limit productivity of fish populations.

H_{4b}: Operation of the reservoir restricts fish access to tributaries limiting the productivity of fish populations.

H_5: Habitat availability in Downton Reservoir is independent of reservoir operation, i.e., habitat characteristics are not significantly different between minimum, maximum and *modified* maximum reservoir elevations.

These hypotheses reflect the generalized effects of reservoir operations that were understood to influence habitat suitability and fish population abundance in the Downton context. The goal is to test these hypotheses by analyzing general fish population trends, relative spawning distribution and habitat use, general habitat characteristics in the reservoir, and making inferences based on a weight-of-evidence approach. Also, operations within the WUP-defined ranges were not to be specifically modified for the purposes of the study. Rather, it was understood that operational contrast would naturally be achieved by conducting the study over a 10-year time frame.

Each of these hypotheses could have significant consequences for the predicted impacts of operations on fish; however, they could not be resolved with scientific data during the WUP process. The results of this monitoring program were deemed necessary for informing operating alternatives for Downton Reservoir within the context of the Bridge-Seton generation system.

1.4. Study Area

Field studies for the Downton Reservoir Fish Habitat and Population Monitoring Program (BRGMON-7) were conducted in Downton Reservoir from La Joie dam upstream to the upper extent of the reservoir, including the lower reaches of tributary streams within this section (Figure 1.1).

Downton Reservoir elevations and the conveyance of flows into the Middle Bridge River are regulated by BC Hydro's La Joie Dam and Generating Station. The entire Bridge-Seton hydroelectric complex is integrated and the operations of each reservoir and facility are managed based on storage, conveyance, and generation decisions that account for water management priorities, electricity demands, plant maintenance requirements, fisheries impacts, as well as other values. Downton Reservoir and the La Joie facility are situated at the upstream end of the Bridge-Seton system.

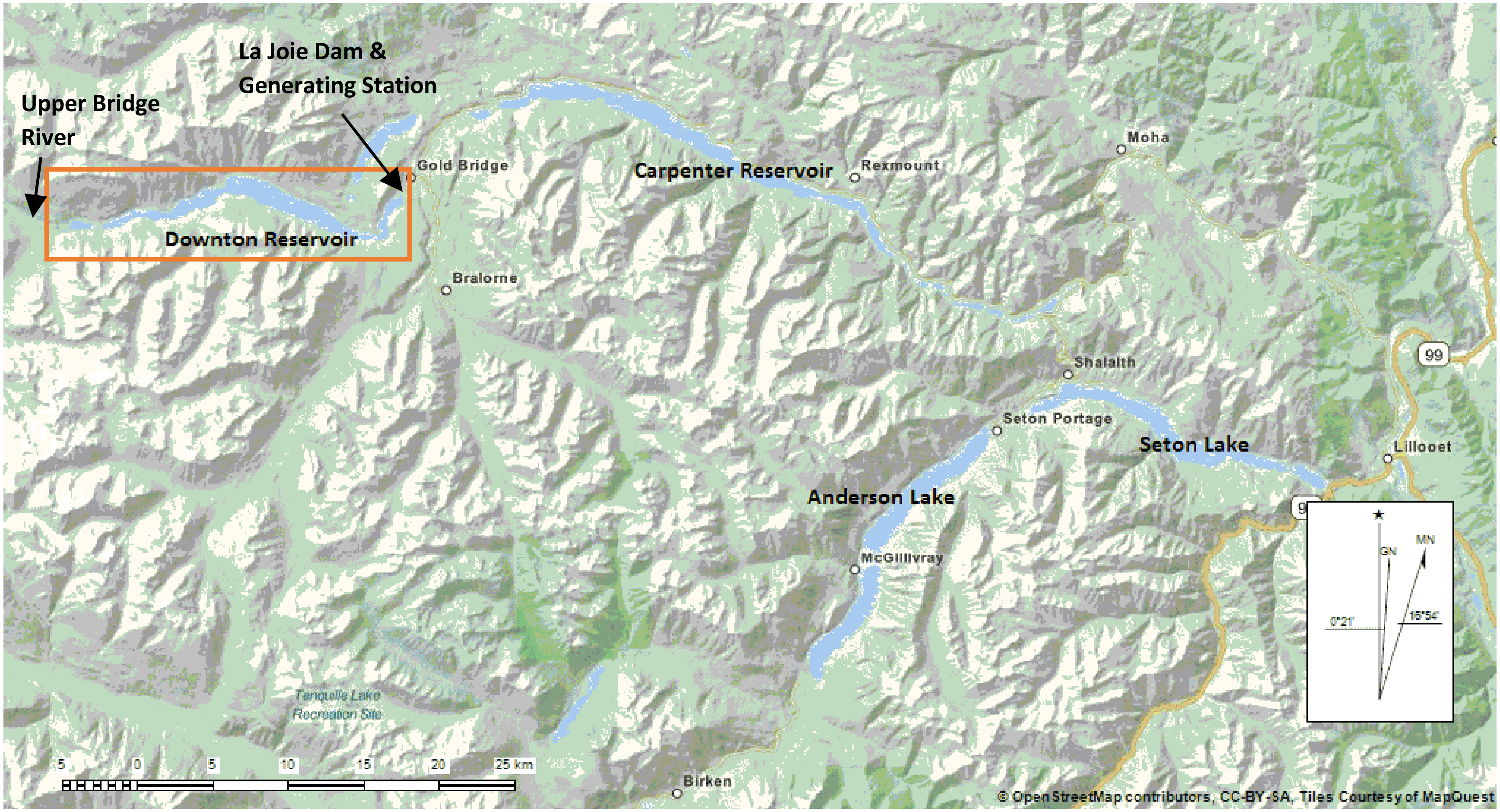

Figure 1.1 Bridge River and Seton River watersheds. The extent of the BRGMON-7 study area, which includes all of Downton Reservoir and tributaries between the Upper Bridge River inflow and La Joie Dam, is outlined by the orange rectangle.

2) Methods

The general approach to this monitoring program is to collect a long-term data set on the fish population and habitat conditions in Downton Reservoir in order to resolve data gaps and better inform the trade-off decisions made during the WUP process. Collection of information on reservoir operating parameters, habitat conditions, and the resident fish population (including life history information, age structure and an index of abundance) is intended to allow identification of potential broad scale changes. Trends in these changes over time can be used to test hypotheses (presented in Section 1.2) about the relationship between reservoir operations and population response.

2.1. Sampling Schedule

As per the original ToR, the activities associated with this monitoring program were recommended by the BRG WUP Consultative Committee for a total of 10 years. The study year covered by this report (2015) represents monitoring year 3. The general schedule of field sampling activities is presented in Table 2.1.

Table 2.1 Schedule of Field Sampling Sessions and Activities.

Field Studies	Dates (Year 3 - 2015)
Fish Population Index Survey	10 to 17 June
Supplementary Rainbow Trout Tagging	12 May; 4 June
Tributary Access Surveys	6 May; 4 June
Tributary Spawner Surveys and PIT array maintenance	6, 11, 20 May 4, 10, 18, 26 June 9, 17, 27 July
Habitat Mapping	17 to 18 August
Substrate characterization at reservoir & tributary sites	23 to 25 June
Temperature logger deployment & retrieval	11 May; 18 August; 5 November
Tributary fish sampling (fall)	21 October

2.2. Habitat Surveys

Starting in Year 3 (2015), habitat surveys were conducted to document habitat availability in the reservoir and tributaries to supplement the fish sampling data. Habitat survey activities included: a) habitat mapping; b) quantifying substrate sizes, interstitial depth, and bank slope among each of the identified habitat types; and c) characterizing habitat areas above and within the drawdown zone in four known spawning tributaries. The plan is to conduct the various habitat survey components across years to document the habitat conditions across the range of observed reservoir levels (i.e., minimum, maximum, and *modified* maximum elevations) and build a larger dataset than what is possible within the budget for a single year. Understanding how the selected habitat variables vary according to reservoir elevation may prove useful for interpreting the effects of various reservoir operating scenarios on fish population response.

Habitat Mapping

Habitat mapping involved characterizing and mapping the entire shoreline of Downton Reservoir by boat. Due to the turbidity, the habitat type observed at the water-shoreline interface was considered representative of the habitat ~5 to 10 m offshore where the fish sampling typically occurs. In 2015 the habitat mapping was conducted at 745 m elevation (during August), which corresponds to near full-pool conditions under normal operations. To accomplish the survey, the boat was propelled forward at slow speed adjacent to the shoreline (Appendix A, Plate 1). The habitat type was recorded for each unit and breaks between units were marked as waypoints on a GPS device. The GPS unit also recorded the boat track, which conformed to the shape of the shoreline in each unit, enabling more accurate measurement of shoreline length once coordinates were transferred to mapping software in the office.

The parameters recorded for the habitat mapping included: shoreline habitat type (i.e., creek mouth, fan, shallow slope <15°, or steep slope >15°); habitat sub-type (colluvium or bedrock) for steep habitats only; UTM coordinates for the start and end of each unit; boat track; and presence/absence of adjacent terrestrial vegetation. The collection of these data allowed for calculation of total shoreline length, the length and number of units for each habitat type and sub-type, as well as the proportion of shoreline that interfaces with adjacent terrestrial vegetation. These values are important for evaluating differences in these parameters across the range of reservoir operating levels and for determining the relative proportion of sites for each habitat type to be sampled during the annual fish abundance index survey (Section 2.6, below).

Substrate Measurements

Substrate can provide an important form of cover for fish, particularly for juvenile life stages. Other than the turbidity of the water, substrate and its associated interstitial spaces are among the few sources of cover available to rearing fish in the reservoir. The conception is that cover, in the form of interstitial space, is positively correlated with substrate size. With the ongoing settlement of fine sediments in the reservoir, we predict that elevations lower in the reservoir drawdown (which are inundated more of the time) will be characterized by finer substrate materials and less interstitial cover than elevations higher in the reservoir (which have a lower inundation frequency and recruitment of larger substrates from the valley sides).

Data were recorded for two elevations in Year 3 (2015): ~747 m and 735 m for the reservoir, representing maximum and *modified* maximum levels; and upland (>749 m) and drawdown (<747 m) areas for the tributaries, representing habitats outside versus inside of the reservoir zone of influence. The 2 m band of elevation between 747 m and full pool (749 m) couldn't be surveyed due to the deposition of large woody debris within this zone.

Efforts in Year 3 (2015) were primarily focussed on sites within the reservoir drawdown zone to collect information from accessible elevations before they became inundated by the filling reservoir for the remainder of the season. The upland areas of reservoir tributaries were a secondary focus during this initial year since these habitats remain accessible every field season. Data from additional sites across all habitat types will continue to be collected in future monitoring years to bolster the size of the substrate measurement dataset and include additional elevations (i.e., low pool and upland data for tributaries).

Substrate measurement locations were selected from the list of fish sampling sites in the reservoir (2015 *n*=20), as well as in tributaries that are generally accessible to fish from the reservoir (2015 *n*=5; Figure 2.1). At each site, a tape measure was laid out for 30 m (parallel to a selected elevation; i.e., ~747 m near full pool or 734 m *modified* maximum level for reservoir sites) or along the stream axis for tributary sites. The piece of substrate directly under each 1 m marker (from 0 to 30 m) was measured for the length of its intermediate axis (neither the longest nor shortest of the three mutually perpendicular sides of each particle – also known as the b-axis) as well as the interstitial space associated with the substrate. As such, 31 measurements were recorded for each elevational zone at each site.

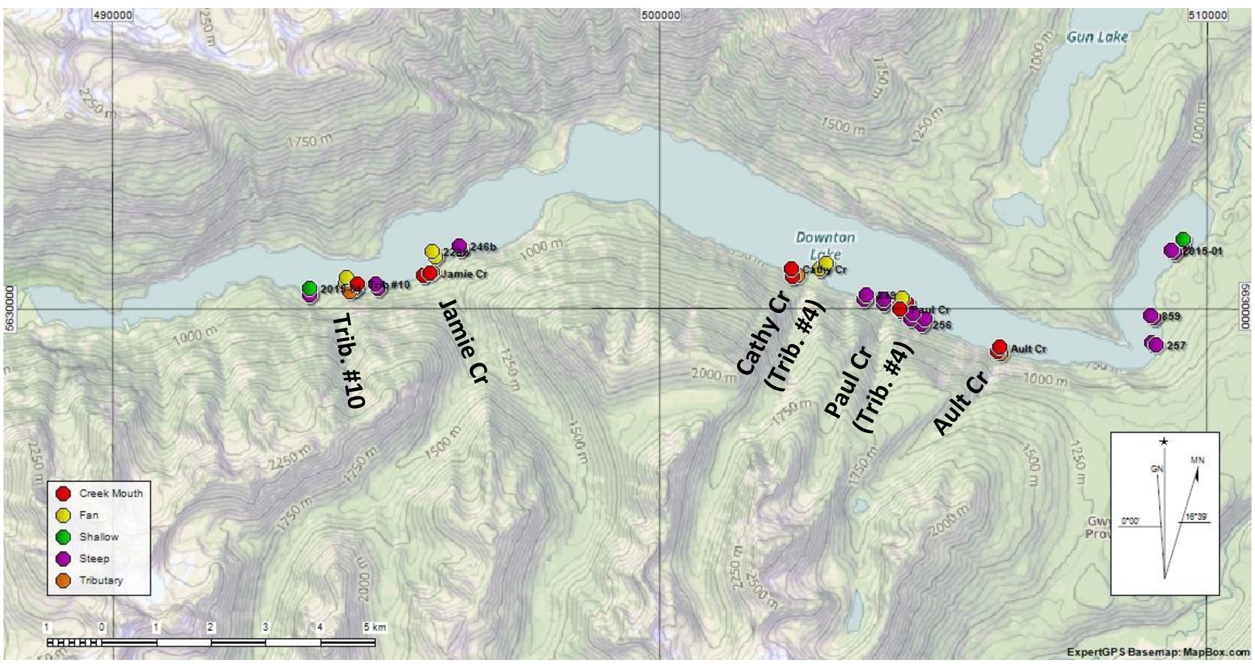

Figure 2.1 Year 3 (2015) substrate measurement locations. Paired dots at each location refer to measurement transects at 749 m (maximum reservoir level) and 734 m (*modified* maximum level) at each location. Surveyed tributaries are also indicated.

The b-axis of individual substrate pieces was measured using a large field caliper (manufactured by Haglöf Sweden) which was graduated in millimetres (Appendix A, Plate 2). Plastic tubing (13 mm outside diameter, graduated in centimetres) was used to measure the depth of interstitial spaces accessible from the substrate surface before it was disturbed (as per Finstad et al. 2007).

Attempts were made in each case to find the opening under each piece of substrate with the deepest interstitial space measurement, and this value was recorded (to the nearest 0.5 cm). Care was taken to ensure that the substrate was not moved while this measurement was being taken.

Any particles finer than sand were assigned a B-axis value of 0.2 cm, which was the minimum measurable value in the field, and bedrock was assigned a B-axis value of 200.0 cm, since values larger than this were not measurable using the methods employed (or considered relevant for the purposes of the investigation). Where particles were completely embedded, or if the interstitial opening was narrower than the diameter of the tubing, an interstitial depth value of 0 cm was assigned. For analysis, substrate b-axis measurements were compiled as the proportion of total substrate count by substrate category. The substrate categories were adapted from those defined by Wentworth (1922; Table 2.2).

Table 2.2 Substrate size categories used to group the b-axis measurement data adapted from the scale developed by Wentworth (1922).

Substrate Size Category	Size Range (cm)
Fines or Bedrock	<0.2
Small Gravel	0.3 – 1.6
Large Gravel	1.7 – 3.2
Very Large Gravel	3.3 – 6.4
Small Cobble	6.5 – 12.8
Large Cobble	12.9 – 25.6
Boulder	>25.7

2.3. Tributary Spawner Surveys

Tributary spawner surveys were conducted to maintain the annual index of the relative abundance and distribution of fish spawning in select tributaries of Downton Reservoir. The surveys focussed on rainbow trout, as this is the sole target species for the monitoring program and eggs deposited at lower elevations by this species may be impacted by backwatering effects of the reservoir as it fills. Spawner surveys were conducted (or at least attempted) on a weekly basis during the rainbow trout spawning period (generally May to July in Downton Reservoir) to get a relative weekly count. Access to known spawning tributaries by road can be hampered by slides and avalanches at this time of year, which precluded some surveys.

The primary rainbow trout spawning tributaries identified by the program up to Year 2 (2014) included: Tributary (Trib.) #13, Trib. #16, Trib. #19, and Tram Creek (Figure 1.2). Three tributaries were consistently assessed in Year 3 (2015). These included: Trib. #5 (Cathy Creek), Trib. #13, and Tram Creek. A record of rainbow trout spawning in Trib. #13 and Tram Creek had already

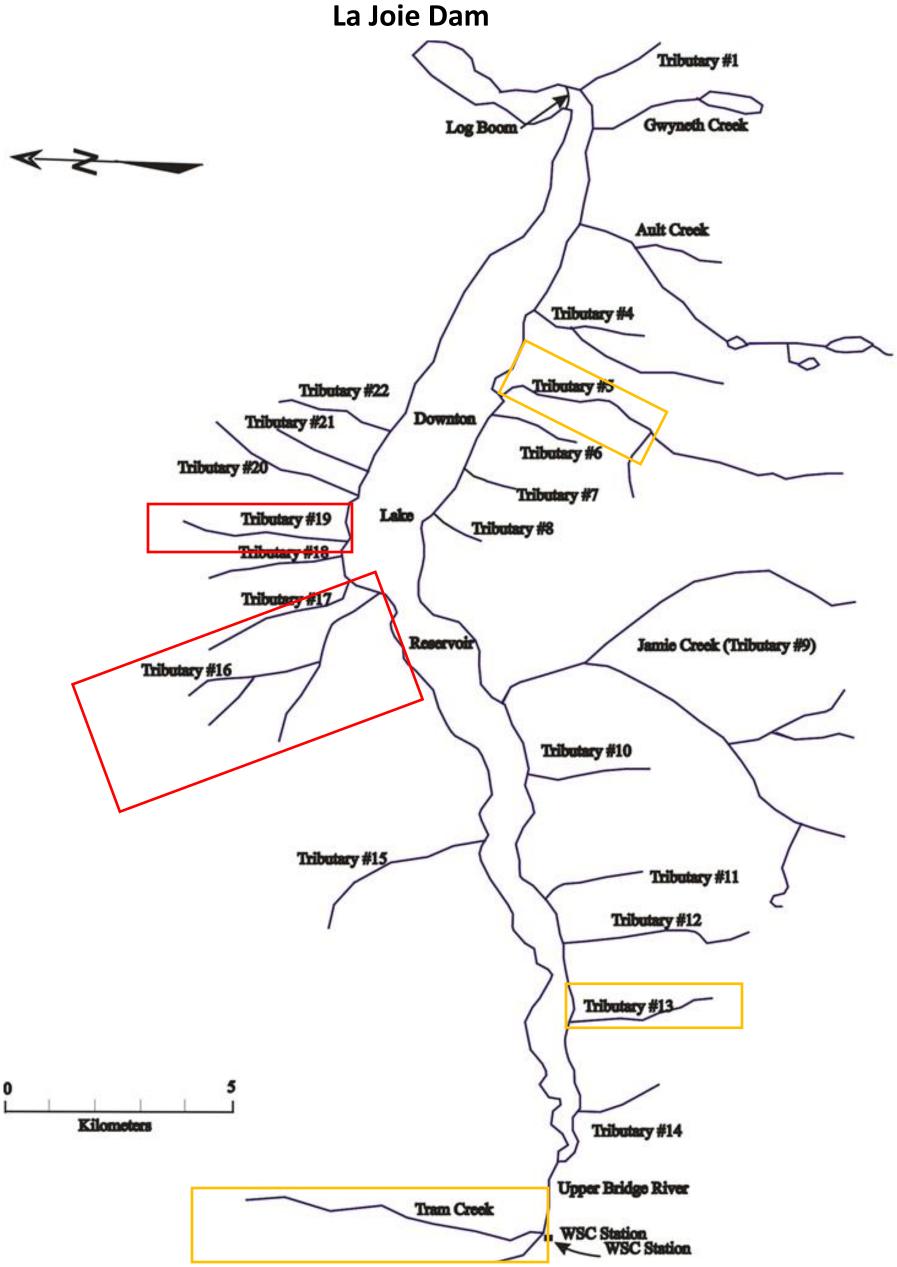

Figure 2.2 Downton Reservoir and relative location of tributaries. Identified rainbow trout spawning tributaries are outlined (Yellow = surveyed in Year 3 (2015); Red = Spawning use previously documented by not surveyed in Year 3 (2015) due to access issues).

been established for several years before the start of this monitoring program. Cathy Creek had not been previously identified as a priority spawning stream, but was added in 2015 because it has suitable substrate and flows, good connectivity with the reservoir throughout the spawning period, and is readily accessible by survey crews. Since the start of Year 2, the road to the north side of the reservoir was completely blocked by heavy windfall and a large slide, which has precluded land access to Trib. #16 and Trib. #19 since that time. Access to these tributaries by boat was also not feasible due to more involved logistics and budgetary limitations. As such, these two tributaries were not assessed in Year 3 (2015).

Rainbow trout spawners in each surveyed stream were enumerated by one person on each shoreline of the creek starting at the reservoir confluence walking upstream until either reaching a fish migration boundary or until no further fish had been observed (for several hundred meters; Appendix A, Plate 3). Downton Reservoir sits in a fairly steep-sided valley, so the accessible length of most tributary streams is relatively short (i.e., less than 1 km). Each crew member wore a hat and polarized sunglasses to minimize glare and ambient light interference. Numbers of fish observed in each tributary, and their relative location (upstream or downstream of 749 m full pool elevation), were reconciled between the two observers in the field and recorded on standardized data sheets for each survey. The other recorded parameters included: date, time of day, water temperature, qualitative assessment of visibility (good, fair, or poor) and stage level (high, moderate, low, dry), and any comments pertaining to the conditions of the survey.

2.4. Tributary Access Surveys

Under the *modified* operations, the target fill elevation for Downton Reservoir will be lowered, which will decrease the total storage volume of the reservoir significantly. In order to maximize the available storage, BC Hydro may need to draw the reservoir down to lower elevations on a more frequent basis than in past. Since the period of lowest elevations typically overlaps with at least some portion of the rainbow trout migration and spawning period, concern was raised about the potential impact of these operations on fish access to spawning tributaries.

To assess this impact and characterize potential reservoir elevations of concern, tributary access surveys were conducted on a couple of dates during the rainbow trout migration and spawning period to identify and document areas where access may be blocked or obstructed. This was noted for Ault Creek in May 2014 when reservoir elevations were <710 m and creek flows were low (i.e., pre-freshet; Refer to Sneep 2015 for more information and photos). In this case stream flows went to ground before reaching the reservoir edge.

Tributary access surveys were initiated in Year 3 (2015), the first year that the modified operations were proposed. They were timed to target the conditions at the start of the rainbow trout migration and spawning period. The surveys involved a field crew visiting creek mouths (on foot or by boat) to assess connectivity and continuity between the creeks and the reservoir pool or the section of the Upper Bridge River channel that winds through the reservoir basin under drawdown conditions. Each creek was assigned an access score of TRUE (continuously connected with no apparent access issues) or FALSE (not connected or blocked). Crews recorded notes about any observations in the field book and took photos.

2.5. PIT Array Monitoring

As a part of the annual fish sampling on Downton Reservoir, captured rainbow trout of sufficient size and condition are routinely implanted with Passive Integrated Transponder (PIT) tags to document their movement, growth, and rate of recapture between sampling events. For the first time in 2015, movement of PIT tagged rainbow trout into a known spawning tributary, and proportional migration of those fish within versus above the drawdown zone was assessed by the installation of two fixed PIT antenna arrays in Tributary #13 (see Figure 1.2). One PIT reader was deployed near the mouth of the creek (confluence with the Upper Bridge River) and one at the interface between the top of the drawdown zone and the upland (Figure 2.3). The arrays were powered by sets of three 12V deep cycle batteries connected in parallel which were replaced with fully charged sets weekly. The arrays were operated from 12 May to 26 June 2015.

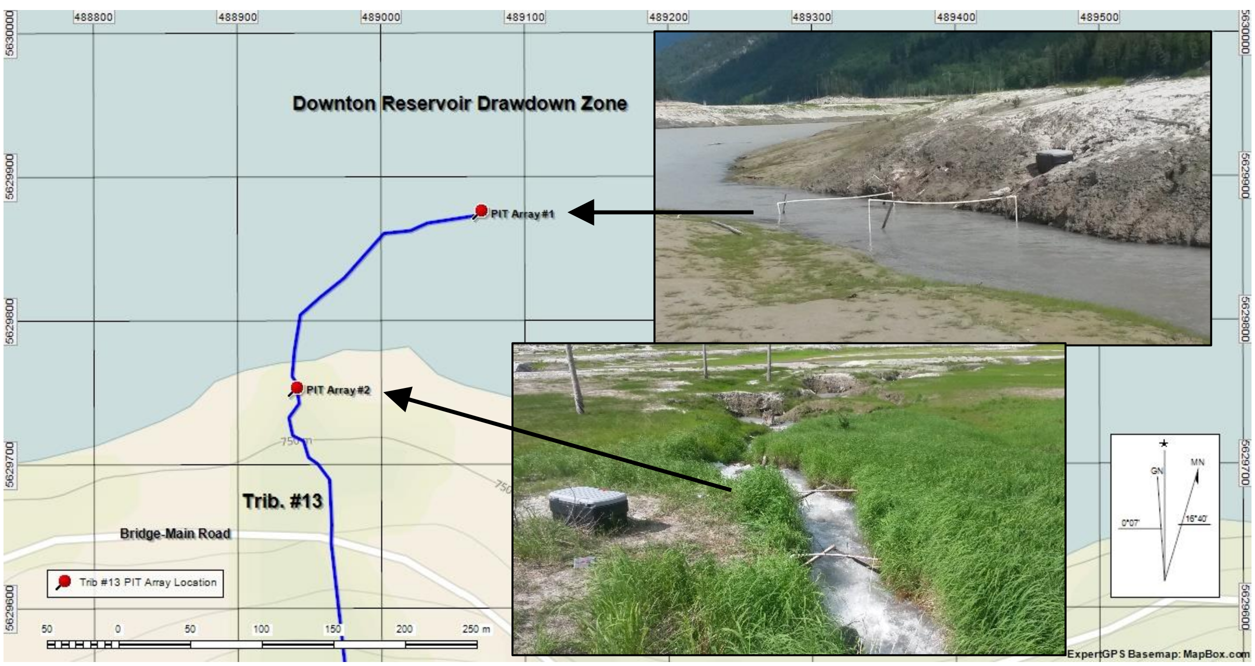

Figure 2.3 Locations of PIT arrays (outfitted with swim-through loop antennas) deployed in Trib. #13 spanning the drawdown zone between its confluence with the Upper Bridge River (PIT Array #1) and the reservoir full pool elevation (749 m; PIT array #2).

The PIT tags and array infrastructure were manufactured by Oregon RFID, based in Portland, Oregon. An Oregon RFID reader is a self-contained monitoring station that records detections of half duplex (HDX) PIT tags that pass within range of the antennas. The readers are designed for long term unattended operation (within the limits of battery charge) and tag detections are stored on an SD flash memory card. The readers and batteries were contained in rugged cargo boxes for protection from the elements in the exposed drawdown zone.

The antennas were designed as vertically-mounted loops that span the channel cross-section, and each reader was outfitted with two of them (one installed upstream of the other). The antennas were constructed using 12 AWG stranded wire coiled inside of a rectangular frame made with 1-inch PVC pipe. Tagged fish are detected as they swim through the antennas, and the antenna number and time of detection are logged, as well as the PIT tag number and the strength of the signal. During post-processing of the logged detections, these parameters can allow determination of arrival date, direction of fish travel past the antennas, departure date, and residence time for each tagged fish that enters and exits the stream during the spawning period.

2.6. Fish Population Index Survey

The fish population index surveys are intended to provide information on the inter-annual variation in the relative abundance, distribution and growth rate of rainbow trout in the reservoir. The index survey data is collected in near shore areas of the littoral zone by a standardized boat electrofishing (boat EF) method, which is generally most effective within the ~0.5 to 3.0 m range of water depths. In Year 3 (2015), sampling effort was combined into one extended survey in the spring (June). In the first two years of monitoring, index surveys were conducted during both spring (June) and fall (October) periods as directed in the original ToR (BC Hydro 2012); however, this meant splitting effort across two sessions and limiting the distance that could be sampled per survey. Based on the results from Years 1 and 2, it was clear that maximizing the length of shoreline sampled was important for establishing a representative population index.

Site selection in Year 3 (2015) followed a stratified design similar to the process previously described for Year 1 (Sneep 2015). The strata were the four main habitat types identified during the shoreline habitat mapping survey (i.e., creek mouth, fan, shallow slope, and steep slope). The number of sites selected for each strata was based on two main objectives: 1) generally assign the number of sites to each strata according to the contribution of each type to the total shoreline length of the reservoir at the sampled elevation; and 2) ensure each habitat type is adequately represented by a sufficient sample size of sites to facilitate comparison of results between types. The specific locations of the sites were based on GPS coordinates that were randomly selected along the shoreline within each of the pre-determined habitat strata to avoid the potential for high-grading the sampled sections in the field.

Sites were also distributed throughout the basin so that each of the longitudinal zones (i.e., West end, Mid-reservoir, and East end) were represented (Figure 2.4). For the purposes of the data analyses, the west end has been arbitrarily defined as the 5+ km portion of the reservoir (and drawdown zone) west of the UTM easting line 500000 (which lies just east of Trib. #20); the Mid-reservoir has been defined as the ~5 km section between the UTM easting lines

500000 and 505000; and the east end is ~5 km between easting line 505000 and the dam (at ~510000).

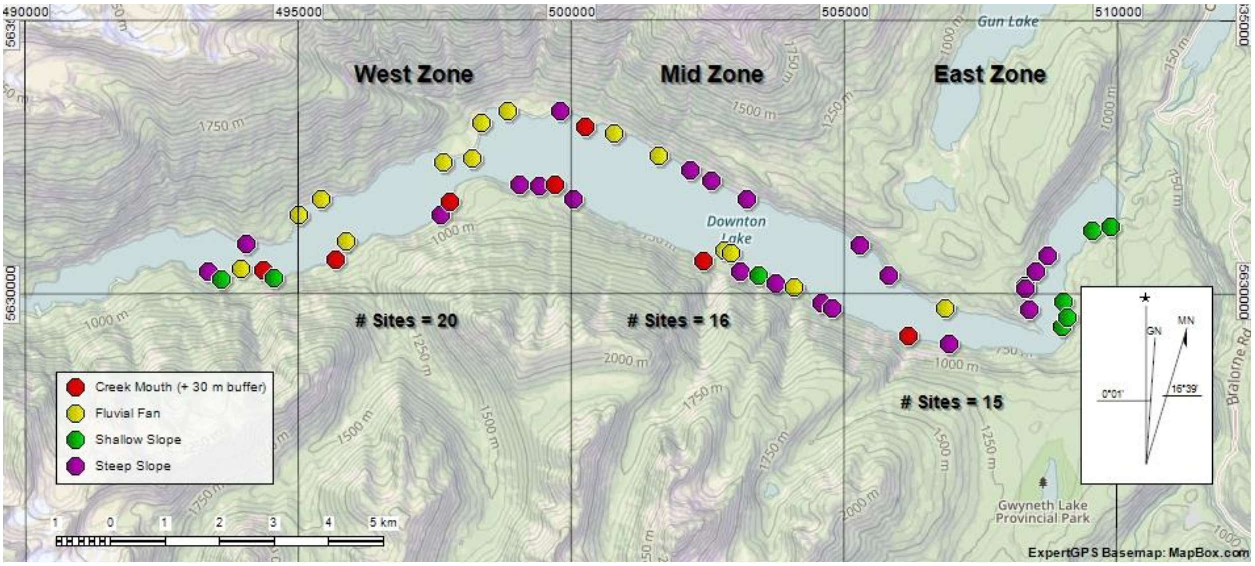

Figure 2.4 The three longitudinal zones (west, mid, and east) and the distribution of sites for the fish population index survey conducted in June 2015.

Boat EF is conducted by running an electrical current through the water between a set of boom-mounted anodes extended off the front of the boat and a cathode array, while propelling the boat forward at slow speed (~1 to 2 km/h). Within the electrical field that this generates, fish are stunned and drawn up to the surface where they can be netted by crew members standing on a bow platform and transferred to an on-board fish holding tank. Not all stunned fish are observed by the netters, and not all of the observed fish are successfully netted. Therefore, catches represent an annual index which is standardized by ensuring that methods and effort are consistently applied across years.

Boat electrofishing was conducted at night (Appendix A, Plate 4). At each site, the boat was maneuvered to a pre-designated starting point (GPS coordinate) along the reservoir perimeter from which a section of edge habitat was electrofished. The following boat EF settings were used: Electrofisher = Smith-Root 5.0 GPP; Voltage Range = High (50 – 1000 V); % of Power = 40% to 60%; Output = ca. 2 to 3 amps; DC Current Mode; Frequency = 60 DC pulses/sec. A total of 51 sites were sampled (Creek Mouth *n*= 7; Fan *n*= 14; Shallow *n*= 9; Steep *n*= 21) covering 13,042 m of shoreline length. Sampling effort was based on a target site length of 300 m for steep, shallow, and fan habitat types. Site length for creek mouths was targeted to extend ~50 m on either side of the tributary inflow. Each site spanned only one habitat type and was sampled in a single pass.

All fish collection efforts were accompanied by detailed sampling of the biological characteristics of the captured fish, as well as measurement of general sampling conditions (i.e., temperature and secchi depth). Fish were measured for length and weight, evaluated for sex and sexual maturity (as possible), and aging structures were collected. Individual coded (PIT) tags were applied to all captured fish of appropriate size and condition to provide information on inter-annual recapture rate, as well as movement and growth patterns.

To assist in developing an understanding of the recruitment, life history, growth characteristics and age class structure of the rainbow trout population in Downton Reservoir, fish sampling included collection of age structures (i.e., scales) from captured fish. Approximately five to ten scales were collected from selected fish from the preferred area above the lateral line and immediately behind the dorsal fin. Samples were placed in coin envelopes marked with appropriate data for cross-reference. Scale samples were taken from a target of 8 to 10 fish for each 10 mm size range between 60 mm and 360 mm forklength in order to determine the size distribution for each age class and allow assignment of ages to fish that were not scale sampled. To assign ages to the rest of the fish, the proportions of each age class for fish that were *aged* were then applied to the fish that were *not aged*, such that the proportions within each 10 mm size bin were maintained.

2.7. Supplementary Rainbow Trout Tagging

Based on the proposed approach, the recapture of tagged fish is important for defining growth rates and movement patterns between study years. Additionally, PIT tagged fish were required for the PIT array monitoring to describe spawner movement into, within, and back out of a known spawning tributary (described in Section 2.4). While it was understood that the majority of fish available for tagging would be captured during the boat EF surveys, it was recognized that this could also be supplemented at low cost by angling. Therefore, some supplemental tagging for rainbow trout was also proposed. However, in the interest of dedicating as much effort to the annual abundance index surveys as possible, these supplementary tagging surveys have been conducted on an opportunistic basis (i.e., when other activities in the study area are being conducted) and limited to a few dates per year.

For these supplemental tagging surveys, fish were captured by angling using hooks baited with cured salmon roe. To improve capture probability, angling effort was focussed on reservoir areas with the highest fish densities, which was generally adjacent to tributary mouths. In Year 3 (2015), a total of 6.8 person-hours of angling effort was directed at the confluence areas of the following tributaries: Ault Creek (3.6 person-hours), Cathy Creek (2.0 person-hours), and Jamie Creek (1.2 person-hours). The angling occurred on 12 May and 4 June, 2015. As with the boat EF surveys: length and weight were measured, sex and maturity were assessed, ageing structures were collected, and a PIT tag was applied to all captured fish.

2.8. Laboratory Analysis

Laboratory analysis (scale reading to determine fish ages) was conducted on 174 scale samples by Cynthia Fell (Instream Fisheries Research). After a period of air-drying, scales were pressed under heat to transfer precise images onto soft plastic strips. The images were magnified using a microfiche reader following the methods of Mackay et al. (1990). These data will allow analysis of trends in the abundance index of specific age classes and how this index correlates with reservoir operation (i.e., annual minimum and maximum elevations). In addition, this will allow estimation of average growth rates of the different year classes of rainbow trout in the reservoir which will contribute to an understanding of how different operating strategies influence fish condition (size-at-age).

2.9. Data Management

All field data collected for this project were recorded into field notebooks or on standardized datasheets specifically developed for this program. A standardized data entry template was developed in MS Excel, and all data entry was conducted by SER technicians. Data quality assurance (QA) checks were completed by the Project Manager.

All entered data were compiled into an active Microsoft Excel (2013) database that already includes the data from years 1 and 2 of this monitoring program. As this program proceeds, this database will: facilitate data sharing between monitoring programs; continue to be updated each year as new data are collected and entered; and be stored in multiple locations (i.e., office computer, external hard drive, and online storage such as “Dropbox”). All data and document files have been backed up to ensure data security and integrity.

3) Results

3.1. Reservoir Elevations

Records of Downton Reservoir surface elevations were provided by BC Hydro for the period 1 January to 31 December 2015, which are illustrated in Figure 3.1. Daily surface elevations for monitoring years 1 (2013) and 2 (2014) are also included for reference.

The management of surface elevation in Downton Reservoir follows a seasonal pattern: lowest elevations occur in spring (generally April to May) and highest elevations, or full pool, occur in late summer to early fall (August and September). The timing, duration and magnitude of low pool and full pool elevations vary from year-to-year, as well as the rates of drawdown and fill between these periods. We are tracking these statistics for each study year as they may prove to be informative variables related to fish recruitment, survival and growth, which will ultimately be evaluated at the end of the monitoring period.

At the start of 2015, reservoir elevation was 741.0 m, which was higher than the previous two monitoring years. The mean drawdown and fill rates for the reservoir were -14 cm/day and +33 cm/day, respectively (Table 3.1). Lowest reservoir elevation (i.e., 720.4 m) occurred on 11 May, and full pool elevations occurred across an extended period from 22 July to 22 October 2015 (max. = 747.0 m on 19 October). The total differential between low pool and full pool was 26.6 m in 2015. The reservoir had been drawn down to 740.1 m by the end of December.

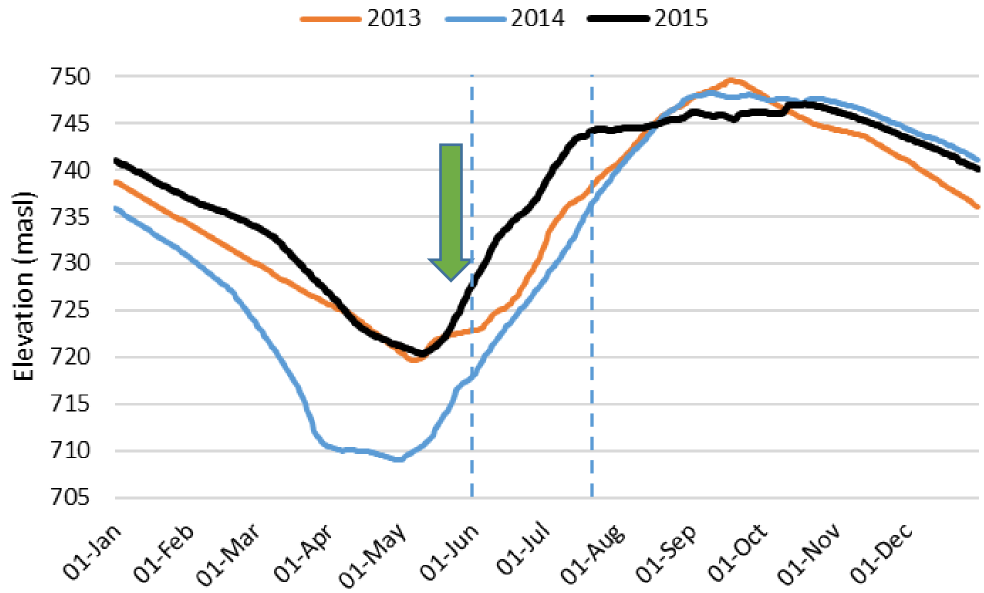

Figure 3.1 Daily surface elevations in Downton Reservoir, 2013 to 2015. For reference, the blue dashed lines bracket the observed rainbow trout spawning period and the green arrow indicates the timing of the annual population index survey.

Table 3.1 Minimum and maximum reservoir elevations, and mean and maximum drawdown and fill rates for Downton Reservoir during study years 1 to 3 (2013 to 2015).

Study Year	Reservoir Elevations (m)			Drawdown Rates (cm/day)[a]		Fill Rates (cm/day)[b]	
	Min.	Max.	Diff.	Mean	Maximum	Mean	Maximum
1 (2013)	719.7	749.5	29.8	-15	-21	+23	+73
2 (2014)	709.0	748.2	39.2	-20	-80	+31	+81
3 (2015)	720.4	747.0	26.6	-14	-30	+33	+58

[a] Calculated between the end of the full pool period and the start of the low pool period.
[b] Calculated between the end of the low pool period and the start of the full pool period.

3.2. Habitat Surveys

Habitat Mapping

The shoreline habitat mapping in 2015 documented the proportional availability and distribution of habitat types around the entire perimeter of Downton Reservoir near full pool (745 m elevation) in August (Figure 3.2). At this elevation, the length of the reservoir was 25.6 km, and the total shoreline length was 60.3 km (Table 3.2). The total length of shoreline associated with adjacent or overhanging terrestrial vegetation was 21.3 km (or 35% of the reservoir perimeter). By extension, this indicates that approximately two-thirds of the reservoir did not directly interact with terrestrial vegetation at this elevation. Terrestrial vegetation can be an important source of allochthonous nutrients to littoral food webs in aquatic systems

(Perrin et al. 2016). Documenting differences in the availability of overhanging vegetation among the different reservoir elevations may provide relevant information for supporting the fish size-at-age analysis at the conclusion of the monitor.

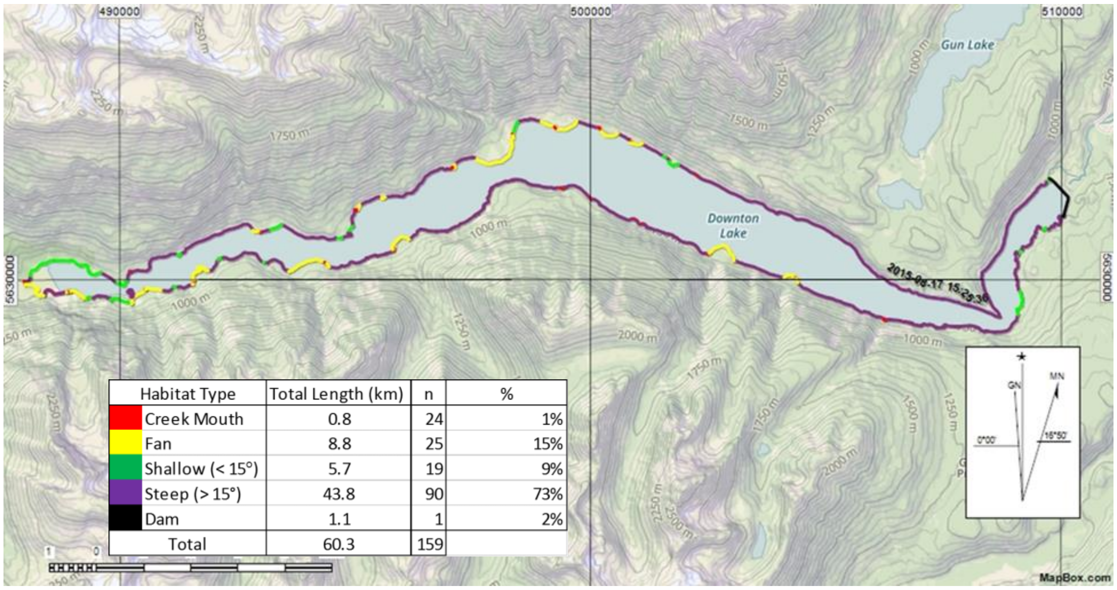

Figure 3.2 Results of a shoreline habitat mapping survey conducted at 745 m (near full pool) reservoir elevation in August 2015.

Shallow shorelines and fans were the habitat strata most associated with adjacent terrestrial vegetation at near full pool (identified for 71% and 69% of the length for these units, respectively). Approximately half (47%) of the length of creek mouth habitat was associated with terrestrial vegetation, whereas the majority of steep habitats were *un*vegetated within proximity of the shoreline (i.e., 25% vegetated).

Table 3.2 Summary of habitat strata contributions to total shoreline length in Downton Reservoir based on the Year 3 (2015) full pool habitat mapping (745 m elevation).

Habitat Type	Habitat Sub-type	Total Length (m)	Number of Units	% Contribution by length	% Vegetated
Creek Mouth		834	24	**1%**	47%
Fan		8,784	25	**15%**	69%
Shallow (< 15°)		5,729	19	**9%**	71%
Steep (> 15°)	Bedrock	10,474	37	17%	14%
	Colluvium	33,367	53	55%	28%
	Total Steep	43,842	90	**73%**	25%
Dam		1,140	1	**2%**	0%
Totals		**60,329**	**159**		**35%**

Of the habitat types identified for this monitoring program, steep shorelines (slope > 15°; *n*= 90 units) were by far the most prevalent, contributing 43.8 km (73%) to the total perimeter length (see table included in Figure 3.2). Approximately three-quarters (33.3 km) of this steep terrain was made up of alluvial or colluvial material (rocks, boulders and other sediment particles; Appendix A, Plate 5), and one-quarter (10.5 km) was bedrock (Appendix A, Plate 6). Fans (*n*= 25 units) were the next most prevalent habitat type in the reservoir, contributing 8.8 km (15%) to the total shoreline length. Fans, which are generally shallow, are formed by alluvial processes associated with streams and intermittent drainages in the valley (Appendix A, Plate 7).

The remaining habitats were shallow shorelines (slope <15°; *n*= 19) and creek mouths (*n*= 24), which contributed 5.7 km (9%) and 0.8 km (1%) to the total perimeter distance, respectively. At the east end of the reservoir, the face of La Joie Dam face is 1.1 km long, comprising 2% of the reservoir shoreline.

Substrate Measurements

Substrate size, interstitial depth, and slope measurements were collected from 25 sites in the reservoir drawdown zone (*n*= 20) and in select tributary streams (*n*= 5) during 2015 (Table 3.3).

Data from the reservoir sites sampled in 2015 indicate that fines and small gravels were the most dominant substrate classes. Fines were by far the most abundant of any 0.2 cm size increment, and the relative proportions diminished with increasing substrate size (Figure 3.3). This pattern was generally true for each of the identified reservoir habitat types as well (Table 3.4).

Table 3.3 Number of sites, sampled distance, and mean slope for substrate measurements in each habitat type at 735 m and 747 m reservoir elevations, 2015.

Habitat Type	Elevation	# of Sites	Sampled Distance (m)	Mean Slope (°)
Creek Mouth	735	5	150	14.3
	747	5	150	14.9
Fan	735	4	120	12.0
	747	4	120	12.0
Shallow	735	2	60	11.2
	747	0		
Steep	735	9	270	22.4
	747	11	330	22.1
Tributary	Drawdown[a]	5	137	13.3
	Upland[a]	1	30	12.3
Total	735	25	737	16.4
	747	21	630	18.0

[a] Drawdown = tributary site within the reservoir drawdown zone (i.e., between ~709 and 749 m elevation); Upland = tributary site above the reservoir maximum elevation (>749 m).

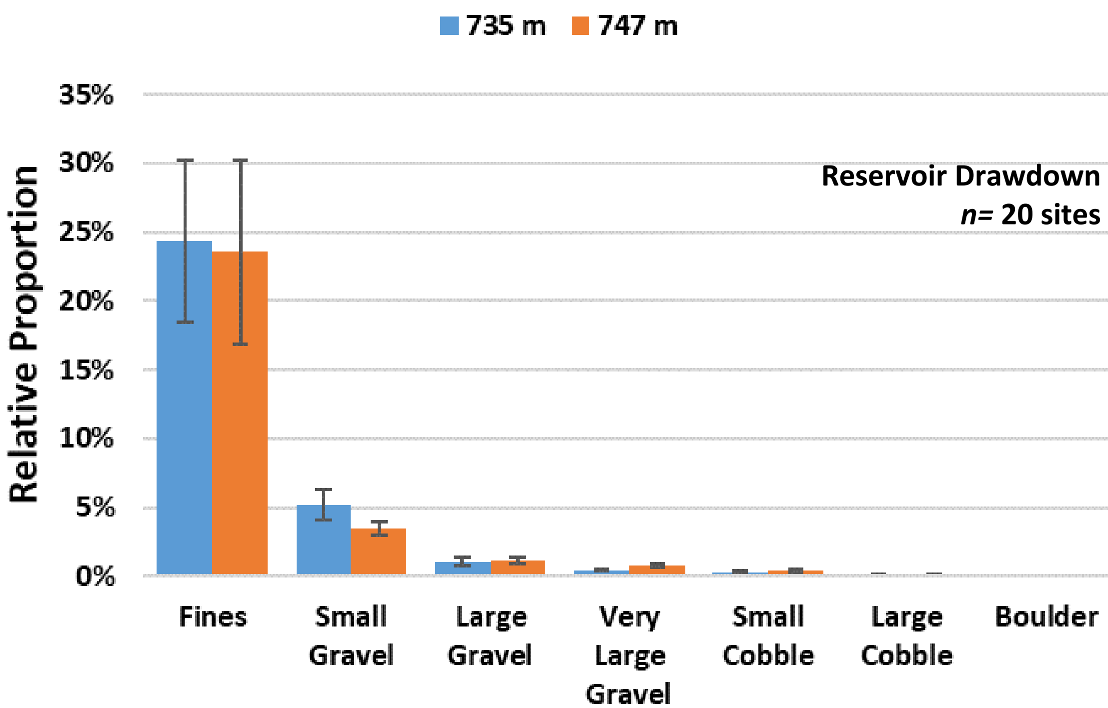

Figure 3.3 **The mean proportions of sediment particles (+/- 1 SD) by size category for two elevations (corresponding to maximum and *modified* maximum operations) within the Downton Reservoir drawdown zone (2015 data).**

Table 3.4 **Mean proportions of sediment particles per 0.2 cm size increment for each substrate category by habitat type at two elevations corresponding to maximum (747 m) and *modified* maximum operations (735 m) within the Downton Reservoir drawdown zone (2015 data).**

Substrate Type	Size Range (cm)	Habitat Type							
		Creek Mouth		Fan		Shallow		Steep	
		735	747	735	747	735	747	735	747
Fines	0.0 – 0.2	0.28	0.26	0.24	0.22	0.31	0.19	0.21	0.24
Small Gravel	0.3 – 1.6	0.01	0.02	0.05	0.05	0.08	0.04	0.07	0.03
Large Gravel	1.7 – 3.2	0.02	0.02	0.01	0.01	<0.01	0.01	0.01	0.01
Very Lg Gravel	3.3 – 6.4	0.01	<0.01	0.01	0.01	<0.01	0.01	<0.01	0.01
Small Cobble	6.5 – 12.8	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Large Cobble	12.9 – 25.6	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boulder	25.7 – 162.9	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Plotting the substrate size and interstitial depth data indicated a slight positive correlation between the two variables, with a high degree of deviation around the line owing to factors such as variable embeddedness, etc. (Figure 3.4). The slopes of the lines for the two reservoir elevations (735 m and 747 m) were very similar, suggesting minimal differences in the availability of interstitial cover for juvenile fish between the two, based on these data. Going forward, these plots will be updated with data from additional sites and reservoir elevations to further document any potential differences that may have relevance to fish use.

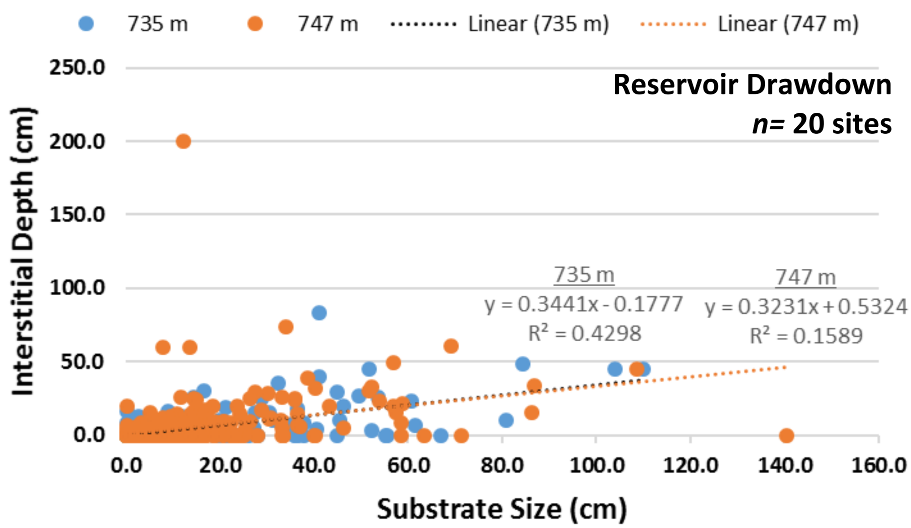

Figure 3.4 Regression for substrate size and interstitial depth measurements from two elevations (corresponding to maximum and *modified* maximum operations) within the Downton Reservoir drawdown zone (2015 data).

As of the end of Year 3 (2015) data collection, there were too few data for the upland zone (*n*= 1 site) to support analysis for tributary sites at this point. Along with additional reservoir sites, this will continue to be an area of focus for data collection in future years to facilitate this comparison.

3.3. Tributary Spawner Surveys

Ten tributary spawner surveys were conducted in Year 3 (2015) between 6 May and 27 July. Surveys were conducted in Trib. #13 and Tram Creek (known spawning tributaries based on past surveys), as well as Cathy Creek which was included in the surveys for the first time based on observation of consistently suitable flow levels, adequate connectivity to the reservoir for fish access, and the availability of suitable-sized substrates for spawning. The total counts in each tributary for each survey are presented in Figure 3.5.

The numbers of spawners observed in Trib. #13 were lower in Year 3 (2015; peak *n*= 19) than in years 1 and 2 (2013 and 2014; peak n= 135 and 50, respectively). Whereas, the numbers observed in Tram Creek were somewhat higher than previous years (peak *n*= 9 (Year 3 – 2015); 4 (Year 2 – 2014); and 1 (Year 1 – 2013)). Spawners were not observed on any of the survey dates in Cathy Creek, though the reasons for this were not immediately apparent in the field. The date of peak spawner count was 4 July in both Trib. #13 and Tram Creek in Year 3 (2015). This was approximately two weeks later than the peak spawner dates in years 1 and 2 (18 June

2013 and 19 June 2014, respectively). Based on the results to-date, spawning appears to occur between early June and late July, which is approximately two months later than rainbow trout populations lower in the watershed (i.e., Lower Bridge River; Burnett et al. 2016).

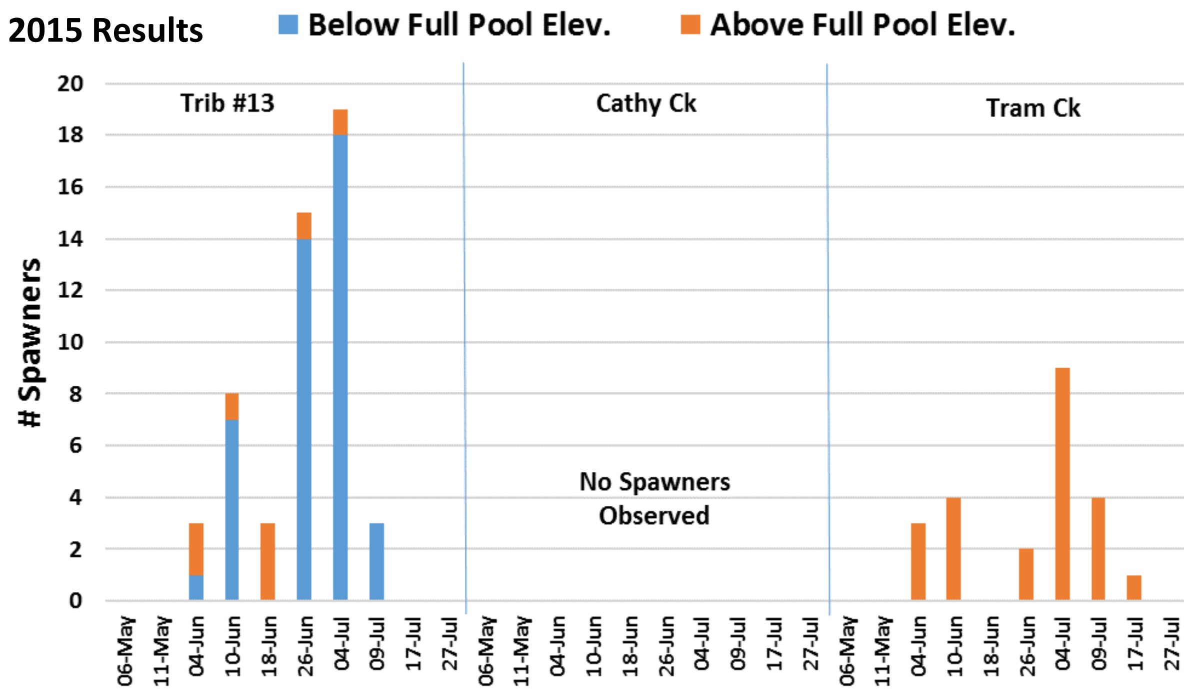

Figure 3.5 Results of surveys to enumerate rainbow trout spawners in selected Downton Reservoir tributaries, May to July 2015. The blue bars represent the number observed in the creek below full pool elevation (< 749.8 m), and the orange bars represent the number above (> 749.8 m).

It's important to note that the results of these surveys are uncalibrated by methods such as mark-recapture so observer efficiency is not quantified and the numbers don't take into account the variable effects on "sight-ability" of the fish among surveys. As such, they represent a rough index of spawner timing and abundance in a few key tributaries. However, the between-year changes and differences do highlight that spawn timing and tributary selection by rainbow trout spawners may be quite flexible in Downton Reservoir according to the particular characteristics of reservoir elevation, temperatures, tributary access, flow, fine sediment deposition, etc. in any given year. The ability to opportunistically select a suitable spawning tributary based on conditions would no doubt be a highly selective survival adaptation in this context.

Spawning use of the Upper Bridge River remains unknown due to the high turbidity conditions throughout the year which precluded the visual-based assessment methods applied in each of the study years to-date. Visibility in the surveyed creeks was generally moderate (ca. 1 to 2 m) –

fish in shallow habitats were readily observed; however, turbidity affected visibility to the bottom of deeper pools on some dates.

As in previous years, the majority of spawners in Trib. #13 were observed in the zone below maximum reservoir elevation (<749 m) during almost every survey (i.e., from 60% to 90% of the total). The smaller proportion (i.e., from 10% to 40%) represented the surveyed zone above maximum reservoir elevation (>749 m). Suitable spawning substrates were available both above and below the maximum reservoir elevation (i.e., 749 m; Appendix A, Plates 8 and 9) and fish in each of these zones exhibited spawning behaviours, particularly during the surveys around the peak spawner count date (4 July 2015). Since it wasn't possible to document specifically where each fish spawned based on the survey frequency and method, it was assumed that the number of fish counted in each zone represents the relative proportion that spawned there. Tram Creek is a tributary to the Upper Bridge River; as such, all of this habitat, and the eggs deposited in it by spawners, are outside the influence of the reservoir.

3.4. Tributary Access Surveys

The tributary access survey dates in Year 3 (2015) were: 6 May and 4 June. Reservoir elevations on these dates were 720.7 m and 729.2 m, respectively. Across the rainbow trout migration and spawning period, the reservoir filled from 722 m in mid-May to 744 m by the end of July. In this case the lowest elevations were > 10 m higher than those observed in Year 2 (2014) when potential access issues were noted for Ault Creek (though it should be noted that this has not been identified as a spawning tributary to-date).

The creeks visited in Year 3 (2015) included: Ault Creek, Paul Creek, Cathy Creek, Jamie Creek, Trib. #10, Trib. #13, Trib. #16 and Trib. #19. Access issues were not identified on either of the survey dates at any of the surveyed tributaries during this monitoring year (Table 3.5).

Table 3.5 Tributary-Reservoir surface flow connectivity scores as assessed during the tributary access surveys (TRUE = connected; FALSE = disconnected).

Tributary	Reservoir Zone[a]	Reservoir Elevation Observed (m) and Date		
		709 (8-May-14)	721 (6-May-15)	729 (4-Jun-15)
Ault Creek	East	FALSE	TRUE	TRUE
Trib. #4 (Paul Cr.)	Mid	TRUE	TRUE	TRUE
Trib. #5 (Cathy Cr.)	Mid	TRUE	TRUE	TRUE
Trib. #19	Mid	TRUE	TRUE	TRUE
Trib. #16	West	TRUE	TRUE	TRUE
Jamie Creek	West	TRUE	TRUE	TRUE
Trib. #10	West	FALSE	TRUE	TRUE
Trib. #13	West	TRUE	TRUE	TRUE

[a] Reservoir longitudinal zone as described in Section 2.6.

3.5. PIT Array Monitoring

The PIT arrays were operated in Trib. #13 from 11 May to 25 June 2015. The monitoring in Year 3 (2015) couldn't be extended beyond this date in June due to the rapid filling of the reservoir and encroaching water levels. During that period of operation, eight PIT tagged fish were detected in Trib. #13 (Table 3.6). There was a maximum number of 727 tagged fish available in the reservoir at that time (not factoring in potential mortality since initial capture). Original capture locations for the detected fish were from all four habitat types and all three zones of the reservoir (Figure 3.6).

Table 3.6 Summary of PIT tagged rainbow trout detected by the PIT reader antennas in Trib. #13 during Year 3 (2015) monitoring, including original capture information.

Tag Code[a]	Original Capture Information					Year 3 (2015) Age[b] (est.)
	Method	Date	Length (mm)	Weight (g)	Age[b] (est.)	
080932	Angling	25-Jun-13	256	n/a	3	5
080946	Angling	25-Jun-13	245	n/a	3	5
585662	Boat EF	6-Oct-14	335	321	3	4
650032	Boat EF	6-Oct-14	337	388	4	5
650137	Boat EF	7-Oct-14	144	46	1	2
650513	Boat EF	9-Jun-14	244	147	3	4
650740	Boat EF	9-Jun-14	246	169	3	4
650952	Boat EF	13-Jun-15	305	317	4	4

[a] The prefix to each of these tag codes is: 900 226000
[b] Estimated based on 2015 size-at-age data from scale ageing.

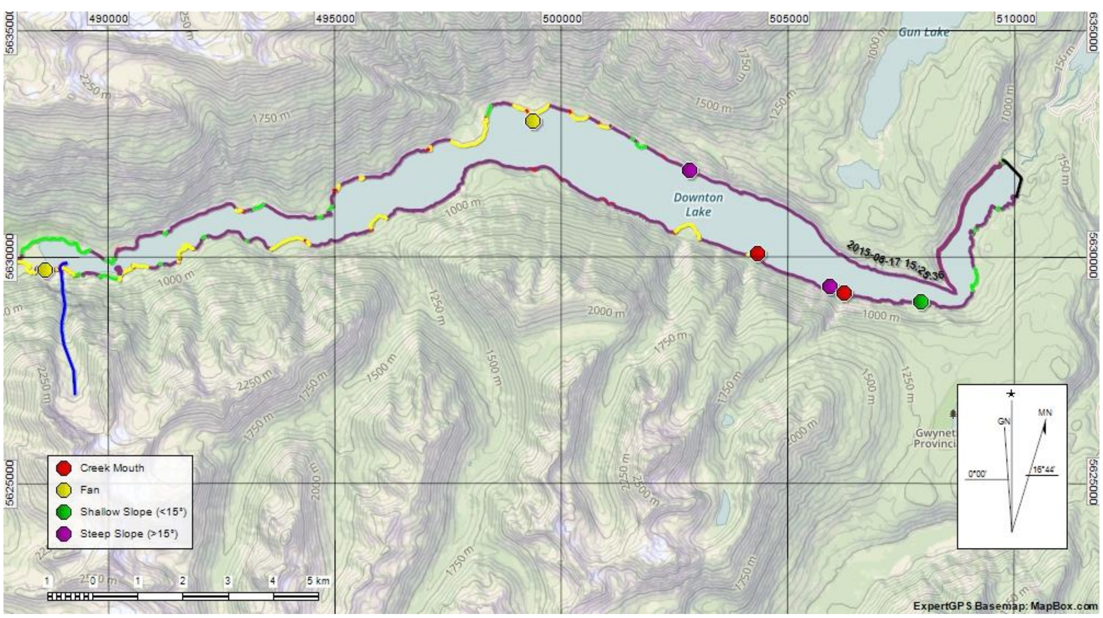

Figure 3.6 Map of the original capture locations for tagged fish detected by the PIT arrays in Trib. #13 (highlighted in blue) during Year 3 (2015) monitoring.

The dates of initial detection varied among the tagged fish from 19 May to 25 June (the date the readers had to be removed). Three of the eight detected fish (~37%) moved past both antennas at each reader location suggesting they accessed the upland zone (>749 m) during their spawning migration. Five of the eight detected fish (~63%) did not move farther upstream than the lower antenna of the upland reader suggesting that, while they ascended up as far as ~747 m elevation, they remained within the drawdown zone (<749 m) during the detection period in Year 3 (2015).

3.6. Fish Indexing Surveys

A total of 973 fish were captured by boat electrofishing during the annual fish index survey in Year 3 (2015). Fifty-one sites were sampled, including 7 Creek Mouths, 14 Fans, 9 Shallow shorelines, and 21 Steep shorelines (Table 3.7). The total shoreline distance sampled was just over 13 km, or 35% of the total reservoir perimeter at the survey elevation (~722 m). As in previous years, all captured fish were rainbow trout. In total, 614 of these fish were marked with PIT tags and an additional 182 fish were adipose fin-clipped. Fish that were too small (< 100 mm fork length) or in poor condition when processed, were not tagged. Nine tagged fish were recaptured in 2015; 7 were within-session recaptures, 1 was a within-year recapture, and 1 was a recapture of a fish originally tagged in 2014 (Tables 3.10 and 3.11 in the next sub-section, below).

Table 3.7 Summary of fish capture results from the boat electrofishing index survey in June 2015. All captured fish were rainbow trout.

Metric	Units	Habitat Type			
		Cr. Mouth	Fan	Shallow	Steep
Sites	#	7	14	9	21
Effort	total seconds	3086	9398	5023	13908
	total meters	990	3926	1964	6162
Catch	# of fish	157	275	157	384
	# of fish marked	124	211	142[a]	319[a]
	# of recaptures	1	3	0	5
CPUE	fish/site	22.4	19.6	17.4	18.3
		19.1			
	(fish/sec)·100	5.1	2.9	3.1	2.8
		3.1			
	(fish/meter)·100	15.9	7.0	8.0	6.2
		7.5			

[a] This total includes fish that were adipose-clipped (ran out of PIT tags); Totals of 73 and 109 of the marked fish in Shallow and Steep habitats were fin clipped, respectively.

Catch-per-unit-effort (CPUE) values, by all measures, were greatest at Creek Mouths, followed by Shallow shorelines and Fan habitats, and then by Steep shorelines; although differences were fairly modest between the latter three types. Total CPUE values (for all types combined) were: 19.1 fish/site; 3.1 fish/100 sec; or 7.5 fish/100 m. Going forward, these CPUE metric values (pooled by habitat type and total for the reservoir) will continue to be generated annually and compared as a reflection of trends in population index between monitoring years (Table 3.8; Figure 3.7). While CPUE values were higher across the board in Year 3 (2015) relative to the first 2 years, the trends between habitat types has been consistent.

Table 3.8 Summary of Catch-per-unit-effort values (fish per 100 m of shoreline) by habitat type in June for monitoring years 1 to 3.

Habitat Type	CPUE values (fish/meter)·100		
	Year 1 (2013)[a]	Year 2 (2014)	Year 3 (2015)
Creek Mouth	5.1	14.3	15.9
Fan	1.6	3.8	7.0
Shallow Slope	ns[b]	1.3	8.0
Steep Slope	0.8	2.6	6.2
Total	**1.7**	**5.3**	**7.5**

[a] Note: Data for Year 1 was collected by a different consultant and capture efficiencies seemed anomalously low. Results for this first year should be viewed with caution. [b]Shallow slope habitats were not sampled in June 2013.

[Note: Sampling in Year 1 was conducted by a different consultant with different sampling gear and capture efficiencies were anomalously low for this first year without adequate explanation (refer to Year 1 and 2 monitoring report; Sneep 2015). As such, the CPUE results have been excluded from Figure 3.7 to account for uncertainties in the comparability of the data with subsequent years when the sampling effort by the current researchers is known to be consistent and comparable.]

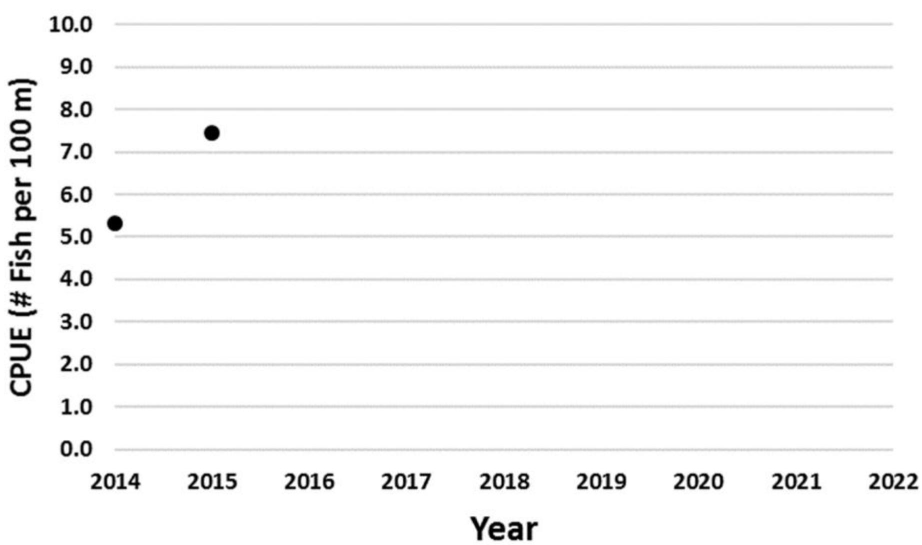

Figure 3.7 Catch-per-unit-effort summary for each monitoring year from 2014 (Year 2) to 2022 (Year 10). Currently only data up to 2015 was available for this report. See note above about exclusion of the 2013 (Year 1) data point.

A summary of the distribution of effort (# of sites), catch, and CPUE by longitudinal zone of the reservoir (as defined in Section 2.2) is provided in Table 3.9. In Year 3 (2015), the highest CPUE was documented in the East zone of the reservoir. Previously, highest catch rates were in the Mid and West zones, which suggests this is likely variable across years and premature at this point to identify any potential trends. The distribution of catches according to habitat type and zone of the reservoir are illustrated in Figure 3.8.

Table 3.9 Summary of the seasonal fish distribution according to longitudinal zone of Downton Reservoir, June 2015.

Sample Session	Metric	Longitudinal Zone of the Reservoir[a]		
		West	Mid	East
June	# of Sites	20	16	15
	Catch (# of Fish)	292	303	378
	CPUE (fish/m)·100	**6.1**	**7.0**	**9.7**

[a] As defined in Section 2.2; West is furthest from the dam and East is closest to the dam.

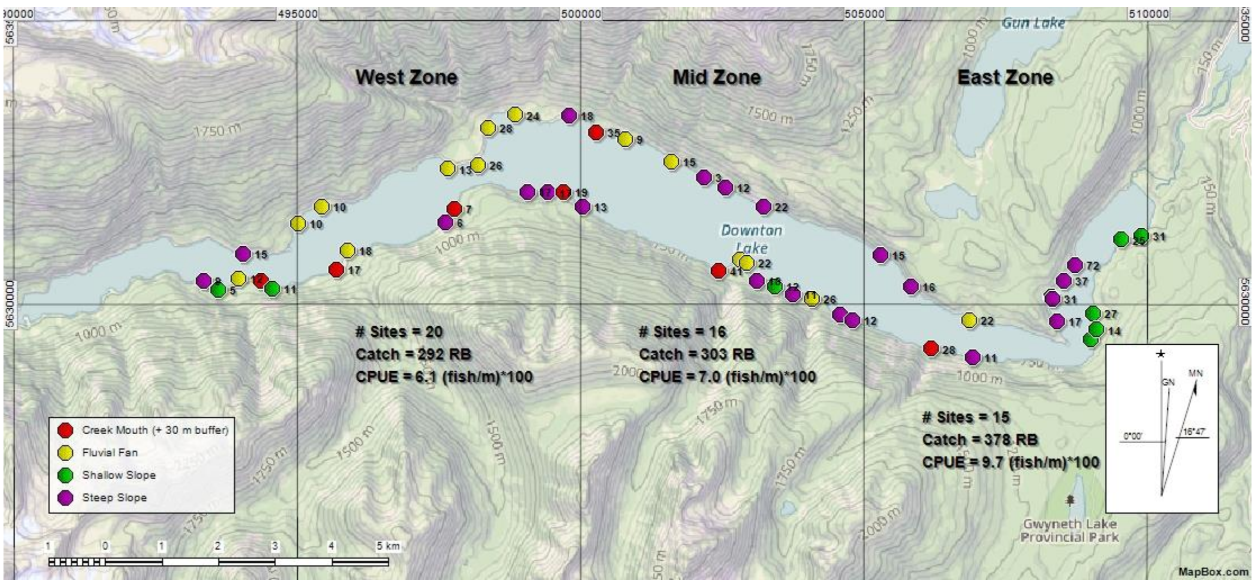

Figure 3.8 The distribution of sites and catches of rainbow trout by habitat type and longitudinal zone of the reservoir, June 2015. Catches at individual sites are represented by the numbers next to each coloured dot.

Recaptures of Tagged Fish

A total of seven fish that were marked with PIT tags were recaptured at different sites within the same session in Year 3 (2015; Table 3.10). Four of these fish had moved shorter distances (i.e., 0.4 to 3.5 km) within the same zone, and three had moved more substantial distances (4.8 to 9.8 km) within a few days between capture and recapture locations. These data reveal that rainbow trout can exhibit significant movements within the reservoir even on a daily basis.

Table 3.10 Summary of within-session rainbow trout recaptures during monitoring Year 3 (2015).

Tag Code[a]	Original Capture Data			Recapture Data			Dist. (km)
	Date	Zone	Site[b]	Date	Zone	Site[b]	
650909	11-Jun-15	East	842	12-Jun-15	West	234	6.0
650986	11-Jun-15	Mid	249	13-Jun-15	Mid	225	1.1
734680	12-Jun-15	Mid	229	13-Jun-15	Mid	806	3.5
734712	10-Jun-15	East	859	14-Jun-15	East	236	0.8
734742	10-Jun-15	East	235	14-Jun-15	East	254	0.4
734764	11-Jun-15	Mid	249	14-Jun-15	East	236	4.8
650943	11-Jun-15	Mid	224	16-Jun-15	West	878b	9.8

[a] The prefix to each of these tag codes is: 900 226000
[b] Refer to the map in Appendix A of Year 1 and 2 report for site locations (Sneep 2015).

The number of recaptured fish represented ~1% of the total catch in Year 3 (2015). Given the low proportion of recaptured fish to-date, it is not feasible to generate a population estimate as too many assumptions about capture efficiencies and mortality rates would need to be made. However, the data suggest that the rainbow trout population size in Downton Reservoir is apparently fairly large (i.e., likely >100,000 fish).

In addition to five fish recaptured in Year 2, there was 1 additional between-season and 1 between-year recapture in Year 3 (2015). Original capture and recapture information for these fish is summarized in Table 3.11. Across all years, four fish were recaptured in their original capture location (either Ault Creek or Jamie Creek confluences); one had moved from the Trib. #19 confluence to the Jamie Creek confluence (distance = 4.7 km southwest), one had moved 7.6 km from the Trib. #16 fan east towards the dam, and one had moved from the Ault Creek confluence to the fan across the reservoir from Jamie Creek (distance = 11.0 km west).

Table 3.11 Summary of inter-session and inter-year rainbow trout recaptures (Years 1 to 3).

Tag Code[a]	Original Capture Data				Recapture Data				Dist. (km)
	Date[b]	Zone	FL (mm)	Wt (g)	Date[b]	Zone	FL (mm)	Wt (g)	
086704	22-May-13	East	329	350	9-Jun-14	East	324	278	0.0
077392	25-Jun-13	East	302	n/a	9-Jun-14	East	300	224	0.0
650514	9-Jun-14	West	320	296	6-Oct-14	West	320	n/a	4.7
585156	8-Oct-13	West	172	71	7-Oct-14	East	280	259	7.6
586629	16-Jul-13	West	326	331	6-Oct-14	West	322	234	0.2
585701	10-Jun-14	East	337	n/a	10-Jun-15	East	337	n/a	0.0
734711	12-May-15	East	293	n/a	16-Jun-15	West	298	269	11.0

[a] The prefix to each of these tag codes is: 900 226000
[b] In years 1 and 2 there were two shorter sample sessions, one in June and one in October.

One fish was likely Age-2 based on size (172 mm) when initially captured, and an Age-3 size (280 mm) when recaptured a year later based on scale ageing analysis (see section below). This represents 100+ mm of growth in one year for this fish. The other fish were all larger (Age-3 to Age-5), but showed no evidence of growth between seasons or years. This suggests the possibility of significant size overlap (i.e., very slow growth) after Age-3 (which is confirmed by the scale ageing analysis), and that food sources for larger fish may be particularly limited in the reservoir.

Length-Frequency, Size-at-Age, and Age-specific trends

A length-frequency histogram for rainbow trout captured by boat electrofishing in Year 3 (2015) is presented in Figure 3.9. The horizontal arrows in this figure indicate the age class breaks determined by analysis of 174 scale samples spanning the full range of available size classes (broken into 10 mm size increments between 50 and 370 mm). The assigned ages from the scale reading were applied to all of the captured fish according to size. There is typically size overlap (in some cases, significant) between age classes, which confirms the conclusions from the fish recapture data that growth rate slows particularly after Age 3.

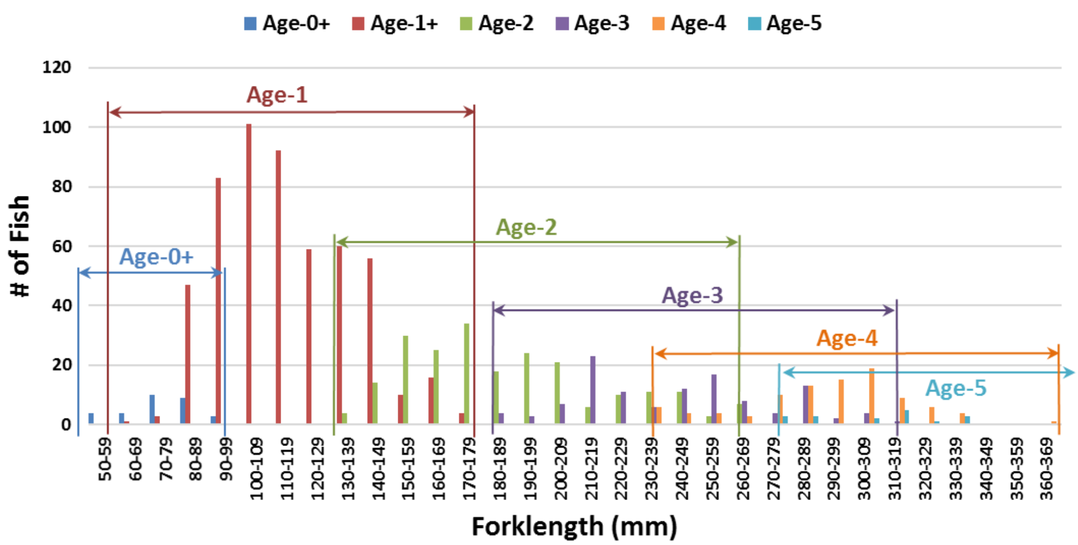

Figure 3.9 Length frequency histogram for rainbow trout captured during a boat electrofishing mark-recapture survey in Downton Reservoir, June 2015. Size ranges for each available age class are shown.

According to the median size values for fish between ages 0+ to 4 (based on scale ageing), the highest rates of growth occurred for rainbow trout age 2 and 3 (67 and 63 mm per year, respectively; Table 3.12). Slowest growth was for Age 1 fish. Growth rates beyond Age 4 couldn't be adequately assessed due to the more limited sample size (*n*= 17) and undetermined maximum size for this age class. Age 1 and 2 fish were the most abundant age classes in the sample (within each habitat type and overall).

Table 3.12 Size and growth statistics for a range of ages of rainbow trout captured in Downton Reservoir during Year 3 (2015).

Age	*n*	Forklength (mm)			Median Growth (mm per year)
		Minimum	Median	Maximum	
0+	30	56	**75**	92	~45[a]
1	532	60	**113**	175	38
2	218	137	**180**	269	67
3	115	180	**243**	311	63
4	94	233	**292**	360	49

[a] Assuming a median alevin length of ~30 mm at emergence.

Assignment of age classes allowed for the comparison of CPUE for each age class by habitat type (Figure 3.10). The range of available age classes were represented in each habitat type (except no fish classified as Age-5 were captured in steep habitat sites in Year 3 (2015)). Year-specific CPUEs for the most abundant age groups in the sample (Age 1 and Age 2 in Year *t*) were also compared with the minimum and maximum reservoir operating levels they experienced in their year of recruitment (Year *t-1* or *t-2*, respectively; Figure 3.11). While there are still too few data points to reliably fit a regression line to the points, these figures will continue to be populated as each new year of data becomes available such that any potential trends can be determined by the end of the monitor.

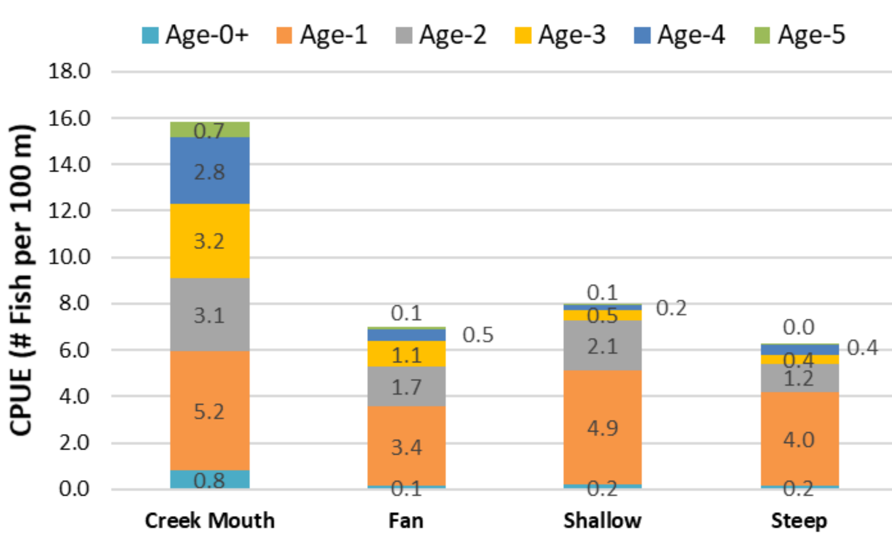

Figure 3.10 Catch-per-unit effort (fish/100 m) by age class for each habitat type in Downton Reservoir based on the results of the boat electrofishing survey in Year 3, June 2015.

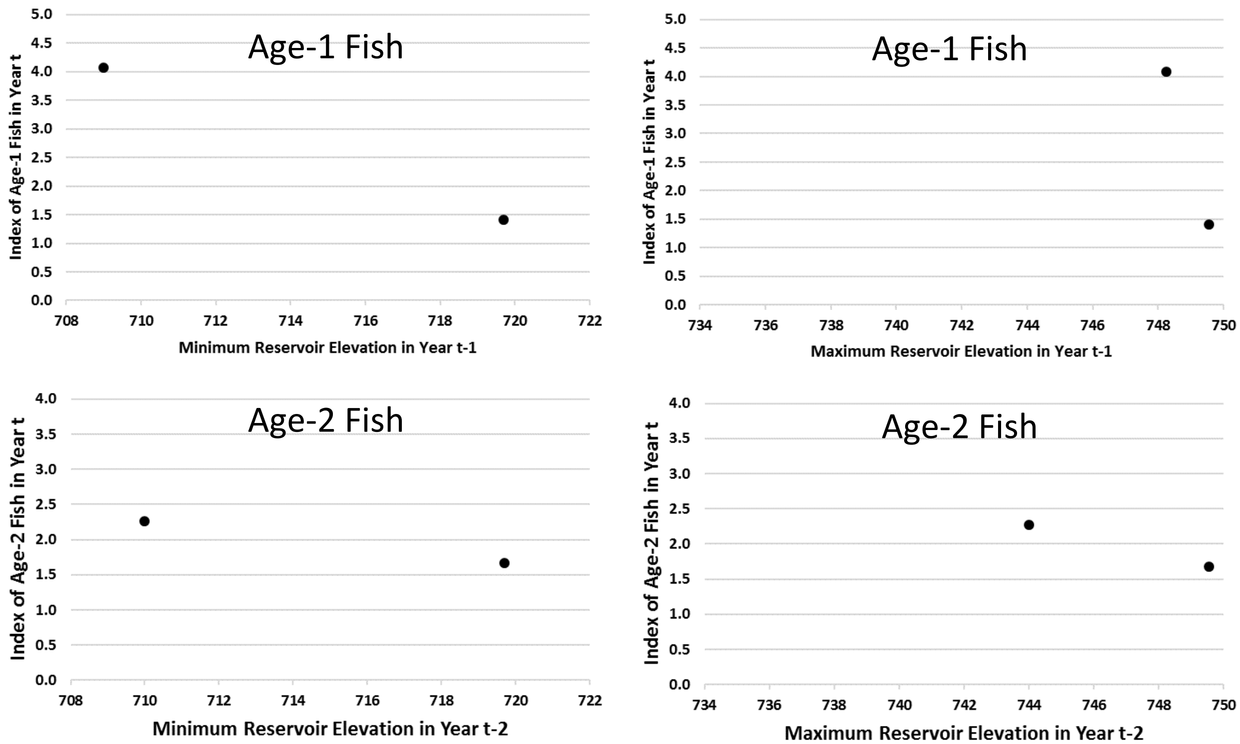

Figure 3.11 Plots of annual CPUE in Year *t* for Age 1 fish (upper panels) and Age 2 fish (lower panels) against minimum (left panels) and maximum (right panels) reservoir elevations in Year *t-1* and *t-2* for ages 1 and 2 fish, respectively.

3.7. Supplemental Rainbow Trout Tagging

Supplemental tagging surveys were conducted on four dates in Year 1 (2013), three in Year 2 (2014), and two in Year 3 (2015; more effort was focussed on angling in the first year which has since shifted more to boat EF in recent years). In addition to the number of fish tagged by boat EF sampling during the fish indexing surveys (described in Section 3.3), totals of 182, 31, and 29 rainbow trout were caught by angling in years 1, 2 and 3, respectively, and all fish were a tag-able size (Table 3.13); Sizes ranged from 192 to 437 mm across years.

Table 3.13 Total numbers of PIT tags applied by sampling method during each sampling year to-date. Note: the numbers applied to fish captured by boat EF are included for comparison purposes.

Year	Capture Method		Total	# of Recaptures
	Boat EF	Angling		
2013	205	182	387	5
2014	309	31	340	7
2015	614	29	643	9
Total (to-date)	1,128	242	**1,370**	21

Three of the fish recaptured during the boat EF surveys were originally caught by angling during these supplemental tagging events. These angling surveys also provided additional scale samples for ageing purposes.

4) Discussion

In terms of reservoir operations, the Year 3 (2015) low pool elevation, elevation differential (i.e., minimum vs. maximum), and mean drawdown rate were very similar to the values for Year 1. Whereas the full pool elevation and mean fill rate were more similar to Year 2. Most notably, the lowest reservoir elevations in years 1 and 3 were ~11 m higher than in Year 2, and the duration of the low pool and full pool periods have also been very different between years. These inter-annual variations should provide some interesting operational contrast for analyzing the fish abundance index information across the monitoring years, though any conclusions would still be premature at this point due to the limited number of data points (n= 3).

The habitat mapping survey provided information on the distribution of the selected habitat types (creek mouths, fans, shallow slope and steep slope shorelines) around the perimeter of the reservoir at 745 m (near full pool) elevation and the interaction of the reservoir edge with adjacent terrestrial vegetation, which provides potential food sources for fish in the reservoir. Repeat surveys at other key reservoir elevations (i.e., modified maximum (734 m) and low pool (<720 m) in future years will document changes in the availability and distribution of these habitat types across the range of operations during the study period. This information is used to inform sample site distribution for the fish population index survey, and could be a potential explanatory variable for changes in the fish abundance index across different reservoir operations among years. Documenting differences in the availability of overhanging vegetation among the different reservoir elevations may provide relevant information for supporting the fish size-at-age analysis at the conclusion of the monitor.

Starting in Year 3 (2015), we also set out to assess whether substrate size and interstitial space, as a proxy for rearing or spawning habitat suitability (according to habitat type), was correlated to elevation within the reservoir drawdown, or upland vs. drawdown zone for tributaries. Collection of data on substrate size and interstitial space (as a surrogate for salmonid shelter availability) was undertaken to assess potential differences in composition and cover availability across a range of elevations within the drawdown zone and between habitat types.

Between elevations representing the maximum (747 m) and *modified* maximum (735 m), differences in substrate size distribution were small based on the limited data set available from one year of data collection. The combined proportion of fines and small gravels tended to be modestly higher at the lower elevation (735 m) whereas the abundance of larger substrates (very large gravels and bigger) tended to be slightly higher at the higher elevation (747 m). However, based on the degree of overlap among the standard deviations for most size categories, these differences from the available set of data were not significant.

It was not possible to collect a fully representative set of substrate measurement data within a single study year given the constraints of the budget. As such, the Year 3 (2015) substrate measurement results are preliminary and we think it is worthwhile to continue collecting these data until a sufficient sample size is available across habitat strata and reservoir elevations before any firm conclusions about differences vs no differences can reliably be made. Based on observation, there is an apparent difference in substrate size and embeddedness at the top of the drawdown zone vs the bottom (and presumably a gradient in between) based on duration of inundation. We are planning to collect additional substrate data in Year 4 (2016) and Year 5 (2017). Analyses of all of these data together will help determine if there are meaningful results from this and if any further substrate data collection is warranted going forward.

Reservoir operations certainly have the potential to impact the reservoir fish population, including rainbow trout spawning success. Rainbow trout access the lower reaches of reservoir tributaries to spawn during the late spring to early summer (i.e., mid-May to late July), which corresponds with the time when Downton Reservoir is generally starting to fill from its lowest elevation. Tributary access surveys for rainbow trout spawners were conducted on 2 dates (6 May and 4 June) to coincide with the start of the rainbow trout spawning migration. Issues with access to tributary streams were not identified at the range of reservoir elevations across the migration and spawning period in Year 3 (2015). These surveys should be continued to document any connectivity issues in future years, such that access scores in Table 3.5 can be populated for the range of reservoir operations.

Based on spawner survey results, peak spawn timing for Downton Reservoir rainbow trout typically occurs in late June or early July, which is at least a month later than peak spawning in other nearby contexts such as the Lower Bridge River. This spawn timing is likely an adaptation to the colder temperatures, low stream flows and low reservoir elevations that persist in the study area until at least mid-May. Spawners were observed in Trib. #13 and Tram Creek (as they have been consistently in the past), but not in Cathy Creek (where they haven't been noted previously). Tribs. #16 and #19 couldn't be surveyed in Year 3 (2015) due to access issues.

The spawner survey results highlight that rainbow trout spawners do use the portion of tributary streams within the reservoir drawdown zone, which can subsequently become inundated if the reservoir elevation gets high enough during the incubation period. However, this may also be why the tributaries used for spawning are all concentrated in the Mid and West portions of the reservoir, which inundate later in the year as the reservoir fills, compared with creeks in the East end. In other words, spawning stream selection may already be highly selective for minimizing inundation risk during the incubation period.

Other parameters, such as differing gradient or substrate suitability among streams, could also be potential factors driving the observed spawning distribution among zones of the reservoir. However, spawning use of streams to the east of Trib. #19 have not been documented, despite the presence of suitable flows, gradient and substrate in at least some of them (e.g., Trib. #5 aka Cathy Creek, Trib. #4 aka Paul Creek, and Ault Creek). Collection of additional habitat survey data in upcoming years of the program may help sort out whether potential differences in measured habitat variables can further explain the observed patterns of spawning use.

Based on the above, the modified operation of La Joie Dam (i.e., reduced full pool elevation) may provide benefits in terms of a reduced proportion of eggs at risk of inundation by the reservoir and an increase in useable stream length above the *modified* maximum reservoir level. Data collected by the PIT arrays in Trib. #13 during Year 3 (2015) monitoring indicated that ~37% of the tagged fish accessed the upland area above the reservoir influence, and ~63% remained in the portion of the stream within the drawdown zone, which corroborates the relative proportions between zones suggested by the spawner survey data. However, these results must be viewed with caution at this point due to the small sample size. Further PIT array monitoring planned for Year 4 (2016) should add to this data set. The truncated detection period (i.e., ending before the conclusion of the spawning period) also precluded estimation of residence time in the stream for these fish, unfortunately.

In 2015, the fish index survey followed a stratified design based on the same approach employed in Year 1. Attempts were made in Year 2 to determine if habitat-stratified capture probabilities could be quantified in this context using a mark-recapture approach to allow for estimation of population size based on catch results. However, the efforts confirmed that this was not successful in this context, so focus in Year 3 (2015) shifted back to establishing an annual index of abundance by standardizing the method and effort (to the extent possible) going forward. In order to maximize the proportion of reservoir littoral area sampled, fish indexing effort was concentrated into one longer session in spring, rather than dividing effort across two shorter sessions (spring and fall) as was the case in Years 1 and 2. In order to establish a reliable index, it was clear that effort needed to cover as much sampling distance as possible within the constraints of the available budget.

The sample timing for the fish index survey in Year 3 (2015) was slightly later than preferred due to the timing of fish migration into tributaries for spawning (for a portion of fish ages 3 and up). Going forward, the survey timing will be targeted for the end of May and beginning of June to capture fish prior to the typical spawn migration timing. Furthermore, the main age classes of interest for tracking an annual recruitment index (Age 1 and 2 fish) primarily reside in the reservoir year-round, so catches for these fish should not be affected by migrations or potential changes in spawn timing across the study period.

As in previous years, creek mouths had the highest total CPUE value among the sampled habitat types (15.9 fish/100 m; Table 3.7). Notably, it was the Age 1, 2 and 3 fish that contributed the most to the total (i.e., more so than the number of Age 4 and 5 fish) in this habitat. Also, the CPUEs for *every* age class were higher at creek mouths than at any other habitat type. In addition, this is the habitat type where highest catch rates by angling have occurred throughout the year, and where CPUEs were similarly highest when an additional boat electrofishing session was conducted in October during Years 1 and 2 (Sneep 2015). Together, these results indicate that the more abundant catch at creek mouths reflects not just pre-spawning aggregations of the older, mature fish in these habitats in June, but also greater use by every age class in general throughout the year.

It is clear from the index survey results that tributaries and their confluence areas provide important habitats for rainbow trout in Downton Reservoir. They are a source of spawning areas, thermal refuge, and food (likely in the form of drifting invertebrates). Given these important contributions, it is not surprising that the highest fish densities tend to be concentrated around creek mouths and their adjacent habitats. Similar to the results of a productivity assessment in Carpenter Reservoir in 2000, high turbidity and large seasonal fluctuation in surface elevation may limit food production within most of the reservoir drawdown zone (Josh Korman, pers. comm.). These factors, combined with other physical habitat characteristics (e.g., the high proportion of steep shorelines, predominance of fines in bottom sediments, and limited interaction with terrestrial sources of nutrients) are also likely drivers behind the observed patterns in habitat-stratified fish distribution.

Going forward, the CPUE metric values provided in this report will continue to be generated annually and compared as a reflection of trends in population index between monitoring years. While CPUE values were higher across the board in Year 3 (2015) relative to the first 2 years, the trends between habitat types was consistent. There are still too few data points to reliably fit a regression line to the CPUE vs reservoir operation (minimum or maximum levels) relationship; The figures generated for this report will continue to be populated as each new year of data becomes available such that any potential trends can be determined by the end of the monitor.

For comparative purposes, the assessment of abundance trends across the years of monitoring will continue to focus primarily on the younger age classes (i.e., Age 1 and 2 fish). Fish from these age classes have consistently been the most abundant in the sample to-date, occupy the reservoir throughout the year, and are the most appropriate ages for potentially linking the effects of reservoir operations with recruitment. Differences in the abundance of the older age classes (i.e., ages 4 and up) across years may be noted, but won’t necessarily be relied upon for drawing conclusions about reservoir operations effects. A wider array of additional factors may be involved in determining the number of older-age fish in the sample from year-to-year (e.g., changes in spawn timing or migrations, etc.).

Based on the recapture rates for marked fish from previous study years, we will not likely be able to estimate the total population size based on mark-recapture information alone, and the error in such estimates would likely be too large to detect a trend in total population size across years with any statistical significance. However, the sample size of fish from the current monitoring effort should be sufficient for monitoring trends in the relative abundance of each age class, particularly focussing on Age 1s and 2s, for linking with annual differences in reservoir operation (i.e., minimum and maximum reservoir elevations) by the end of the study period.

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Appendix A – Photo Plates

Plate 1 Habitat mapping involved characterizing and mapping the entire shoreline of Downton Reservoir from a boat propelled forward at slow speed adjacent to the shoreline.

Plate 2 The b-axis of individual substrate pieces was measured using a large field caliper (manufactured by Haglöf Sweden) which was graduated in millimetres.

Plate 3 Rainbow trout spawners in each surveyed stream were enumerated by one person on each shoreline of the creek starting at the reservoir confluence walking upstream.

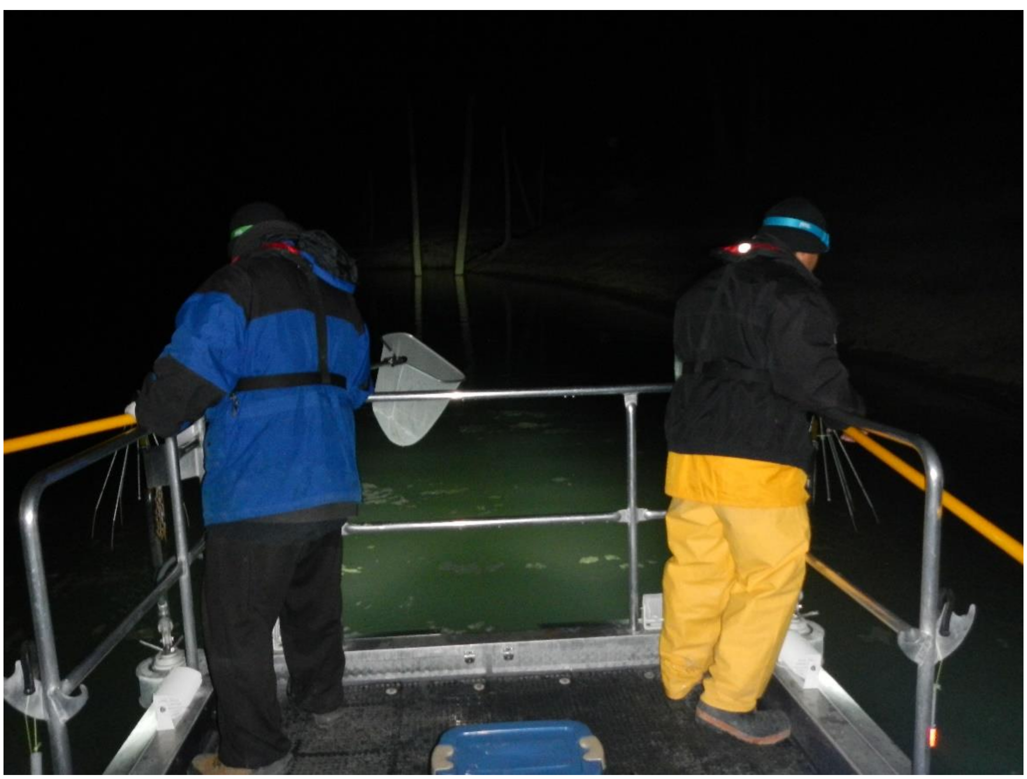

Plate 4 Boat EF is conducted at night by running an electrical current through the water between a set of boom-mounted anodes extended off the front of the boat and a cathode array, while propelling the boat forward at slow speed.

Plate 5 Approx. three-quarters (33.3 km) of the shoreline terrain characterized as steep was made up of alluvial or colluvial material (rocks, boulders and other sediment particles).

Plate 6 One-quarter (10.5 km) of the shoreline terrain characterized as steep was bedrock.

Plate 7 The Ault Creek mouth and fan. Fans were the second most prevalent habitat type in the reservoir, contributing 8.8 km (15%) to the total shoreline length. Fans, which generally have a shallow slope, are formed by alluvial processes associated with streams and intermittent drainages in the valley.

Plate 8 An example of spawning habitat within the reservoir drawdown zone (<749 m elevation) in Trib. #13 containing suitable substrates for rainbow trout spawning. Spawners have been observed using this habitat in each study year (to-date).

Plate 9 Close-up of substrate in Trib. #13 spawning habitat shown in Plate 8 (above). AA battery placed in photo frame for size reference.