Peace Project Water Use Plan

Williston Trial Tributaries

Implementation Year 5

Reference: GMSMON-17

Study Period: April 2015 to March 2016

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March 2016

GMSMON-17: Williston Trial Tributaries
Year 5 – Final Report

Report submitted to:

BC Hydro, Water License Requirements **Attn: Toby Jones, Natural Resource Specialist**

Submitted by:

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Cover photo: Rainbow Trout pair with male in spawning colours in Six Mile Creek, 23 June 2015. © N. Shaw, DWB Consulting Services Ltd.

EXECUTIVE SUMMARY

Reservoir operations have created large unproductive areas within the drawdown zone of Williston Reservoir. The low productivity of this habitat limits the area's capacity to support fish and fish access to tributaries may be restricted at low reservoir levels. Fish access to tributaries is considered to be potentially restricted by debris accumulations at tributary mouths or by the exposure of barriers to fish passage at low water levels. To address these impacts, the Williston Tributary Access Management Plan was developed within the Peace Water Use Plan to improve tributary access through management of debris and alterations to stream morphology in the drawdown zone (Anon. 2003). An inventory of potential enhancement sites was completed under GMSWORKS-19 *Williston Reservoir Trial Tributaries*. The final site selection identified one site in the Finlay Arm (Ole Creek) with debris impacts and one site in the Parsnip Reach (Six Mile Creek) with drawdown impacts.

The GMSMON-17 project is a 10-year monitoring program to assess the effectiveness of the demonstration tributary enhancement projects at improving fish access to the selected tributaries. The focus of the effectiveness monitoring program is to determine the response of fish and selected indicator groups to the tributary enhancements. Fish, vegetation, amphibians, and birds were identified as the indicator groups for effectiveness monitoring with the focus on changes in fish diversity and abundance. This report presents the results from the fifth year of monitoring under GMSMON-17. The results provide the first year of post-construction observations following completion of both enhancement project during the Year 4 (2014) monitoring period.

Remote collection of water level, water temperature, and air temperature data continued from the stream gauging stations on Six Mile and Ole Creeks. Manual discharge measurements were completed for both creeks on three separate occasions to allow for development of the stage-discharge curve for each stream. Environmental conditions in Year 5 were generally similar to previous years except for the lower water levels in June and July as a result of a below average snowpack and precipitation. The notable difference in Year 5 was the high reservoir elevations compared to the previous years and the average elevation, particularly during the spring.

Fish monitoring completed in Year 5 included habitat mapping of the drawdown zone reaches and Rainbow Trout spawner surveys. Habitat mapping was completed on all streams during the first sampling session when the reservoir was close to the annual low elevation and was supplemented by high resolution orthophotos. Habitat changes were observed in both the enhancement and control streams with the observed changes at all four sites. The observed changes at Six Mile and Ole Creek were a result of the reduced amount of braiding in the area of the enhancement works, particularly in Ole Creek. The changes at Lamonti and Factor Ross Creeks were due to natural variability. No fish sampling was completed in the drawdown zone in 2015 due to the reservoir elevation limiting the length of stream available to be sampled. Rainbow Trout were observed in all four creeks during the Year 5 spawning surveys. Redds were identified in both Six Mile and Lamonti Creeks with active redds (spawning pair present) observed in Six Mile Creek. The mark-resight component for estimating juvenile fish populations was not completed in 2015. The study Terms of Reference were revised and this component removed as it was considered unlikely to be effective in addressing the management questions.

Vegetation mapping in Year 5 identified nine habitat classes and one non-vegetated (open water) habitat class at the four sites. The vegetation communities were similar at all sites and had similar distributions in the drawdown zone. Vegetation mapping also identified nine

enhancement classes at the Six Mile and Ole Creek sites associated with the access enhancement works. Some shrub and herbaceous vegetation had established on the enhancement structures, including willow stem cuttings, annual ryegrass and a few native herbs. Vegetation cover on the enhancement structures is expected to increase in future years, particularly at upper elevations of the drawdown zone. The data collected in Year 5 provides a better characterization of the vegetation types that are present at the four study sites in comparison to vegetation data collected in previous years of the study.

Four amphibian species inhabit the four study locations, including wood frogs, spotted frogs, western toads, and long-toed salamanders. All four species were detected in Year 5 at all locations except Six Mile where long-toed salamanders and wood frogs were not detected. Nighttime surveys resulted in much higher detections of amphibians in Year 5, notably consisting of larger western toads migrating along the drawdown zone. All plots visited in Year 4 were revisited, the majority of the plots were visited twice in Year 5, and some new plots were established to broaden the survey area. Methods development for the survey of amphibians is discussed in context of landscape dynamics, sampling design, sample size, and statistics for measuring changes in abundance and diversity. A new camera box was created that improved the resolution and details of captured individuals with digital photography. The photographs are used to gather data on body measurements and skin patterns for identifying (“fingerprinting”) individuals. A statistical summary and comparison on the body measurements of captured individuals, including body lengths and morphometrics taken from the skull of individuals is provided. Variation in the size of individuals gives potential insight into the different age cohorts that are being monitored. Skin patterns of mature western toads and long-toed salamanders were digitized into software for comparing and identifying matches. No matches were found among that individuals that were digitized, indicating no recaptures.

No eggs, tadpoles, or larvae were detected in Year 5. The wetland near the drawdown zone at Six Mile was flooded in Year 5, which prevented recruitment of long-toed salamanders into the local population as likely occurred in Year 4. Western toads made use of habitat created by the constructed earth berm at Six Mile. Three western toad pairs were detected during night surveys and were in amplexus while swimming in a shallow channel of the reservoir that was also created by the earth berm. A large adult female was also detected directly on the earth berm, but no individuals were located where revegetation treatments (fiber matting and seeding) had been installed. Western toads have also been similarly detected on the exposed gravels along the constructed earth berm at Ole Creek. A new micro-habitat of long-toed salamanders was discovered under the bark of birch logs at the Factor Ross site.

Overall, the numbers of songbirds and waterbirds detected during the surveys in 2015 was higher than in the previous year. The number of detections increased at Lamonti and Ole Creeks, was consistent at Factor Ross and was slightly lower at Six Mile Creek. Waterfowl and shorebird species detected included Common Merganser, Lesser Scaup, Green-winged Teal, and Spotted Sandpiper. The low numbers of species detected within the survey circles is due to the lack of habitat (vegetation) for songbirds at the survey points, which were located along the streams near the enhancement works and within the drawdown zone. As the enhancement works, including planted vegetation, were recently completed, avian use of these areas should increase in future years when vegetation becomes established. Additionally, the information collected in these surveys will increase the knowledge base for songbird and waterbird use of the drawdown zone and adjacent areas in Williston Reservoir.

The first year of post-construction observations collected in Year 5 of the GMSMON-17 project was generally consistent with previous years. At the two control sites (Lamonti and Factor Ross

Creeks) the data contributes to the existing baseline data at these two sites. Habitat mapping identified changes in the drawdown zone portion of all four streams with the changes at the two treatment sites associated with the tributary access enhancements. Additional monitoring will be required to assess future habitat changes and evaluate the effectiveness of the access enhancements on fish habitat and their effect on the other indicator groups (vegetation, amphibians, and birds).

MANAGEMENT SUMMARY: STATUS OF GMSMON-17 MANAGEMENT QUESTIONS AND HYPOTHESES – YEAR 5

Management Question	Management Hypothesis (Null)	Year 5 (2015) Status
Does access for spring spawners (i.e., Rainbow Trout and/or Arctic Grayling) improve as a result of enhancement?	H_{01}: Access to spawning habitat in the spring period – as measured by the proportion of modified channel with sufficient depth for target fish passage – does not increase following enhancements to tributaries.	Year 5 is the first year of post-construction monitoring. It is not yet possible to determine if the enhancements have improved access. Additional monitoring and analysis will be required.
Is the area and quality of fish habitat created by the tributary enhancement maintained over time?	H_{02}: Total rearing area for fish does not increase following enhancement to tributaries.	With only a single year of post-construction data it is not possible to comment on the long term persistence and quality of habitat. Additional monitoring and analysis will be required.
Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?	H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries.	No changes in riparian vegetation have been detected in the first year of post-construction monitoring. Additional monitoring will be required for the testing of this hypothesis.
Does amphibian abundance and diversity in tributaries change as a result of enhancement?	H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.
Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?	H_{05}: Total amphibian breeding area does not change following enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.
Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?	H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.
Does abundance and diversity of waterfowl and shorebirds around tributaries change as a result of enhancement?	H_{07}: Waterfowl and shorebird abundance and diversity near tributaries does not change following tributary enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.

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Field work was completed by DWB and CBA staff. Habitat surveys were completed by Nathan Shaw (DWB) and Andrew MacInnis (CBA). The spawner surveys were completed by Nathan Shaw (DWB) and Clayton Smith. Vegetation sampling and mapping was completed by Allan Carson (CBA). Amphibian surveys were led by Mark Thompson (DWB). Songbird, waterfowl, and shorebird surveys were completed by Karl Bachmann (CBA) with assistance from Allan Carson (CBA). The hydrological analyses (rating curves) were completed by Sam Xie and reviewed by Emily Cheung P.Eng. (DWB). Andrew MacInnis (CBA Senior Fisheries Biologist) was Project Manager with assistance from Mark Thompson (DWB Senior Ecologist) the Assistant Project Manager.

Additional field work support was provided by Chu Cho Environmental Ltd., a company owned by the Tsay Keh Dene First Nations. Chu Cho Environmental staff that provided assistance in Year 5 were Mike Tilson, Stephen Friesen, and Kirk Miller.

High resolution orthophotos for the four project sites (Six Mile, Lamonti, Ole, and Factor Ross Creeks) were provided by JR Canadian Mapping Ltd using data obtained using their UAV (unmanned aerial vehicle).

The Year 5 report was written by Andrew MacInnis, Mark Thompson, Allan Carson, and Vicki Prigmore.

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1 INTRODUCTION

1.1 Background

During consultations under the Peace Water Use Plan (WUP), the Consultative Committee recognized that reservoir operations created large unproductive areas within the drawdown zone of Williston Reservoir (Anon. 2003). The resulting aquatic habitats were hypothesized to have two primary impacts on fish: the low productivity limits the area's capacity to support fish and fish access to tributaries may be restricted at low reservoir levels. The large area (~450 km^2) of the drawdown zone between the low and high water levels, provides no fish habitat when exposed and little habitat for fish when inundated (Anon. 2003). The fluctuating water levels are also a major restriction on littoral zone productivity around the reservoir.

It was observed that when water levels recede during drawdown, significant accumulations of debris were stranded at the mouths of some tributaries (Anon. 2003). Low water levels during drawdown were also observed to expose barriers to fish passage in the tributaries. Debris accumulation and associated scour was also considered to be a limiting factor in vegetation development on portions of the tributaries (BC Hydro 2008). The effect these two factors on fish access to reservoir tributaries is unknown and variable, depending on the location. The Williston Tributary Access Management Plan was developed within the WUP to improve tributary access through management of debris and alterations to stream morphology in the drawdown zone (Anon. 2003). The components of the plan were an inventory of tributaries with either debris or other physical barriers to fish passage that were potentially suitable for enhancement, selection of two tributaries for implementation of demonstration access enhancement projects, and a monitoring program to test their effectiveness in improving fish access and habitat for fish and wildlife over the life of the project. If the projects were considered to be successful, then the potential for additional tributary access projects would be assessed (Anon. 2003).

The inventory of potential enhancement sites was completed under GMSWORKS-19 *Williston Reservoir Trial Tributaries*. A total of 64 Williston Reservoir tributaries were reviewed to determine if they had access limitations due to debris or morphology by Cubberly and Hengeveld (2010). Of the 64 sites reviewed, nine candidate sites were identified for further investigation of the extent of fish access limitations and feasibility of access improvement demonstration projects. Conceptual designs were proposed for the two highest ranking sites representing two sites in the Parsnip Arm with drawdown impacts (Cubberly and Hengeveld 2010). The final site selection identified one site in the Finlay Arm (Ole Creek) with debris impacts and one of the originally selected sites in the Parsnip Reach (Six Mile Creek) with drawdown impacts. Monitoring of the effectiveness of the tributary access enhancement projects in improving fish access to reservoir tributaries will be completed under GMSMON-17 *Tributary Habitat Review*.

1.2 Monitoring Plan Overview

The GMSMON-17 project is a 10-year monitoring program to assess the effectiveness of the demonstration tributary enhancement projects at improving fish and wildlife habitat (BC Hydro 2008). This effectiveness monitoring program is designed to determine the response of fish and selected indicator groups to the tributary enhancements and to increase knowledge of wildlife use of the drawdown zone, particularly for birds and amphibians. The emphasis of the monitoring program is on determining the effectiveness of the tributary access enhancements in improving fish access and habitat. The access enhancements were also predicted to allow for establishment of riparian vegetation and potentially result in benefits for songbirds. Amphibians were also identified as an indicator group for the effectiveness monitoring program.

This report presents the results from the fifth year of the GMSMON-17 monitoring program. The results provide the first year of post-construction observations. Construction of both tributary access enhancement demonstration projects (Six Mile and Ole Creeks) was completed during spring 2014 (Year 4).

2 MANAGEMENT QUESTIONS AND HYPOTHESES

The monitoring objectives and hypotheses for GMSMON-17 were stated in the original Terms of Reference for the project (BC Hydro 2008). Following completion of Year 4 of the project, the Terms of Reference were reviewed with respect to the effectiveness of the monitoring approach in addressing the management questions. The review resulted in changes to the first management question and hypothesis in relation to changes in the abundance and diversity of fish in the tributaries following enhancement (BC Hydro 2015). The revised management questions are restated below along with a brief summary of how the testing of each hypothesis is approached in the study design.

Six key management questions regarding the effectiveness of the wetland enhancements were identified for the Tributary Habitat Review monitoring program:

1. Does access for spring spawners (i.e., Rainbow Trout and/or Arctic Grayling) improve as a result of enhancement?
2. Is the area and quality of fish habitat created by the tributary enhancement maintained over time?
3. Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?
4. Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?
5. Does amphibian abundance and diversity in tributaries change as a result of enhancement?
6. Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?

Based on these management questions, the study was designed to test the following null hypotheses:

H_{01}: Access to spawning habitat in the spring period – as measured by the proportion of modified channel area with sufficient depth for target fish passage - does not increase following enhancements to tributaries.

H_{02}: Total rearing area for fish does not increase following enhancement to tributaries.

H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries.

H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement.

H_{05}: Total amphibian breeding area does not change following enhancement.

H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.

DWB and CBA also proposed an additional management question and hypothesis that could be incorporated into the existing study design:

7. Does abundance and diversity of waterfowl and shorebirds around tributaries change as a result of enhancement?

H_{07}: Waterfowl and shorebird abundance and diversity near tributaries does not change following tributary enhancement.

The monitoring program is used to collect annual data on fish abundance, diversity, and habitat; riparian vegetation abundance and diversity; amphibian abundance, diversity, and breeding habitat; songbird abundance and diversity; and waterfowl abundance and diversity. The focus of the trial is on enhancing fish access to the tributaries but it is expected that there may be some benefits to wildlife and wildlife habitat from channel stabilisation and debris reduction allowing for increased growth of riparian vegetation.

The effectiveness monitoring approach is annual sampling of the indicator groups at locations within each stream and in adjacent riparian areas at both the treatment and control sites. The fish population monitoring includes drawdown zone reach habitat mapping, rainbow trout visual spawning surveys, and fish diversity and abundance in the drawdown zone reach of each stream by electrofishing. The review and revision of the Terms of Reference resulted in the removal of the juvenile fish sampling component of the study approach (BC Hydro 2015). Riparian vegetation is monitored using annual quadrat sampling and aerial photo analysis. Amphibians are inventoried using systematic surveys to determine relative abundance. Songbirds, waterfowl, and shorebirds are surveyed using breeding bird point counts, land-based observations, and nest searches.

3 STUDY AREA

Williston Reservoir is located in northeastern British Columbia and was created by construction of the W.A.C. Bennett Dam at the head of the Peace River Canyon, about 20 km west of Hudson's Hope, B.C (BC Hydro 2007). The reservoir extends for about 260 km along the Rocky Mountain Trench from the Finlay River in the north to the Parsnip River in the south. The reservoir is generally divided into three geographic regions (from north to south): Finlay Reach, Peace Reach and Parsnip Reach (BC Hydro 2007).

The reservoir is located within the Sub-Boreal Spruce and Boreal White and Black Spruce biogeoclimatic zones (Meidinger and Pojar 1991). The Sub-Boreal Spruce zone is the dominant zone and occurs as two subzones and variants at lower elevations along most of the reservoir (Meidinger and Pojar 1991). The Boreal White and Black Spruce zone occurs only at the northern end of the reservoir in the Finlay Arm (Meidinger and Pojar 1991). The drawdown zone consists of large areas of mud, sand, and gravel flats with stranded large woody debris. Limited amounts of vegetation occur even following extended periods of drawdown.

The water level in the reservoir varies annually with reservoir filling and drafting. The annual reservoir levels for the first five years of this study (Year 1: 2011, Year 2: 2012, Year 3: 2013, Year 4: 2014, and Year 5: 2015) are shown in Figure 1 along with the 20-year mean reservoir

level. The lowest reservoir elevations typically occur in late April – early May and the highest elevations are reached in late July – early August. In 2015, the reservoir reached its lowest level of 662.57 m on April 21. This is slightly earlier than in the previous years of the monitoring program (8 May 2011, 25 April 2012, 3 May 2013, and 26 April 2014). However, the minimum elevation in 2015 was more than 4 m above the average for this date and 2 m higher than on the same date in 2012 (the year with the next highest minimum elevation in the study period). Water levels in 2015 increased relatively rapidly until the end of May when the rate of increase declined but the elevation stayed well above reservoir elevations in previous years of the study until late June. The reservoir reached a maximum of 671.47 m on October 19 (BC Hydro CRO database) which is near the full pool elevation of 672.08 m. This peak elevation is notable in that it occurred later than in the previous years of the study and occurred at a time of year when the reservoir elevation has usually started to decline (Figure 1).

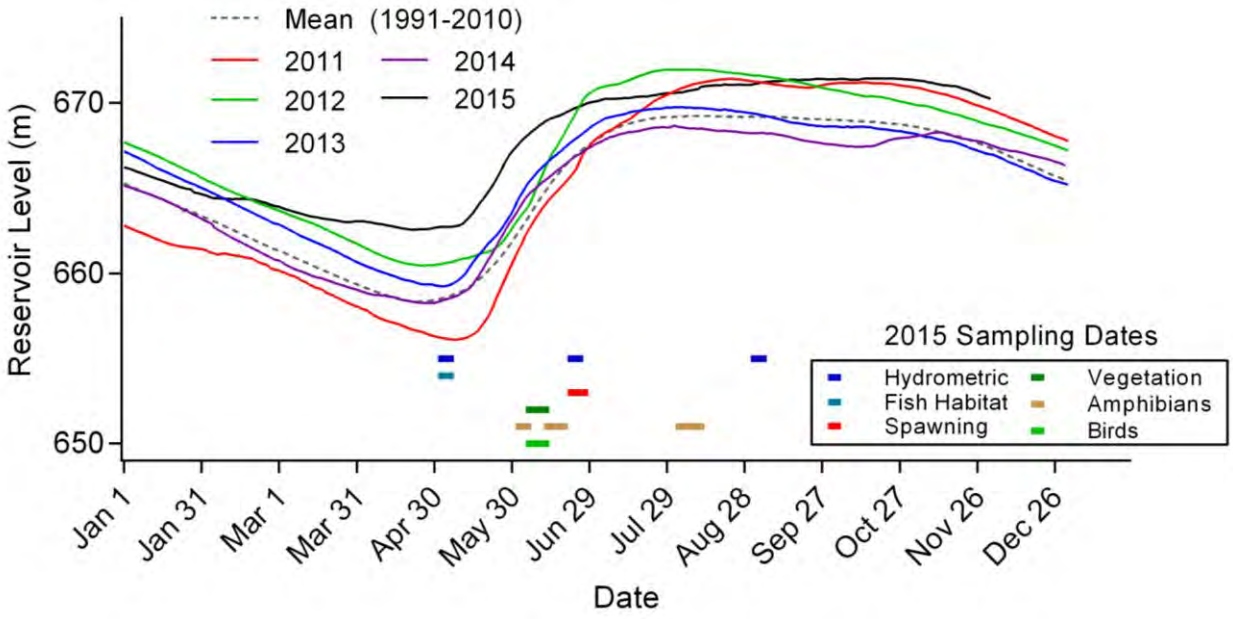

Figure 1. Annual Williston Reservoir levels for 2011 - 2015.

The two locations identified for the tributary access demonstration projects are both located in separate reaches of the reservoir (Figure 2). The Six Mile Creek site is located approximately 40 kilometres north of Mackenzie and is located within Six Mile Bay on the east side of the Parsnip Reach of the reservoir. The Ole Creek site is located on west side of the Finlay Reach approximately 160 km north of Mackenzie. Both demonstration sites are paired with control sites that will receive no enhancement works. The control site for Six Mile Creek is Lamonti Creek, also located within Six Mile Bay. Factor Ross Creek is the control site for Ole Creek and is also located on the west side of the Finlay Reach, approximately 20 km further north (Figure 2).

Six Mile and Lamonti Creeks were both identified as creeks experiencing drawdown impacts (Cubberly and Hengeveld 2010). The portion of Six Mile Creek located within the drawdown zone was characterized as being homogenous and lacking habitat complexity compared to the typical riffle-pool sequence observed above the drawdown zone. The drawdown zone portion of the channel is shallow, braided, and lacking overhead cover. This was considered to limit upstream fish passage and increase the risk of predation for downstream migration of juvenile due to the lack of cover when this portion of the channel is exposed by low reservoir levels

(Cubberly and Hengeveld 2010). Similar conditions were observed in Lamonti, although the length of channel exposed during low reservoir levels is shorter.

Ole and Factor Ross Creeks were identified as sites with tributary access impacts primarily due to debris accumulation (Cubberly and Hengeveld 2010). Debris accumulation is typically higher in the Finlay Reach than in other parts of the reservoir due to the prevailing southeast winds, (Anon. 2003).

The access enhancement treatments proposed for both Six Mile and Ole Creeks are similar in concept and intended to stabilize drawdown zone reach of the respective streams and minimize debris impacts. The preliminary design for Six Mile Creek consisted of a series of constructed berms and log jams to close off channel braids and create habitat complexity within the main channel (KWL 2014). The higher elevation berms were also to receive revegetation treatments to enhance riparian vegetation. The preliminary design for Ole Creek also included the construction of berms to close off channel braids and create habitat complexity. However, the main features of the proposed design for Ole Creek were the construction of two berms and associated debris catcher to limit the accumulation of debris at the stream mouth. Removal of existing debris was also part of the prescription for this site (KWL 2014).

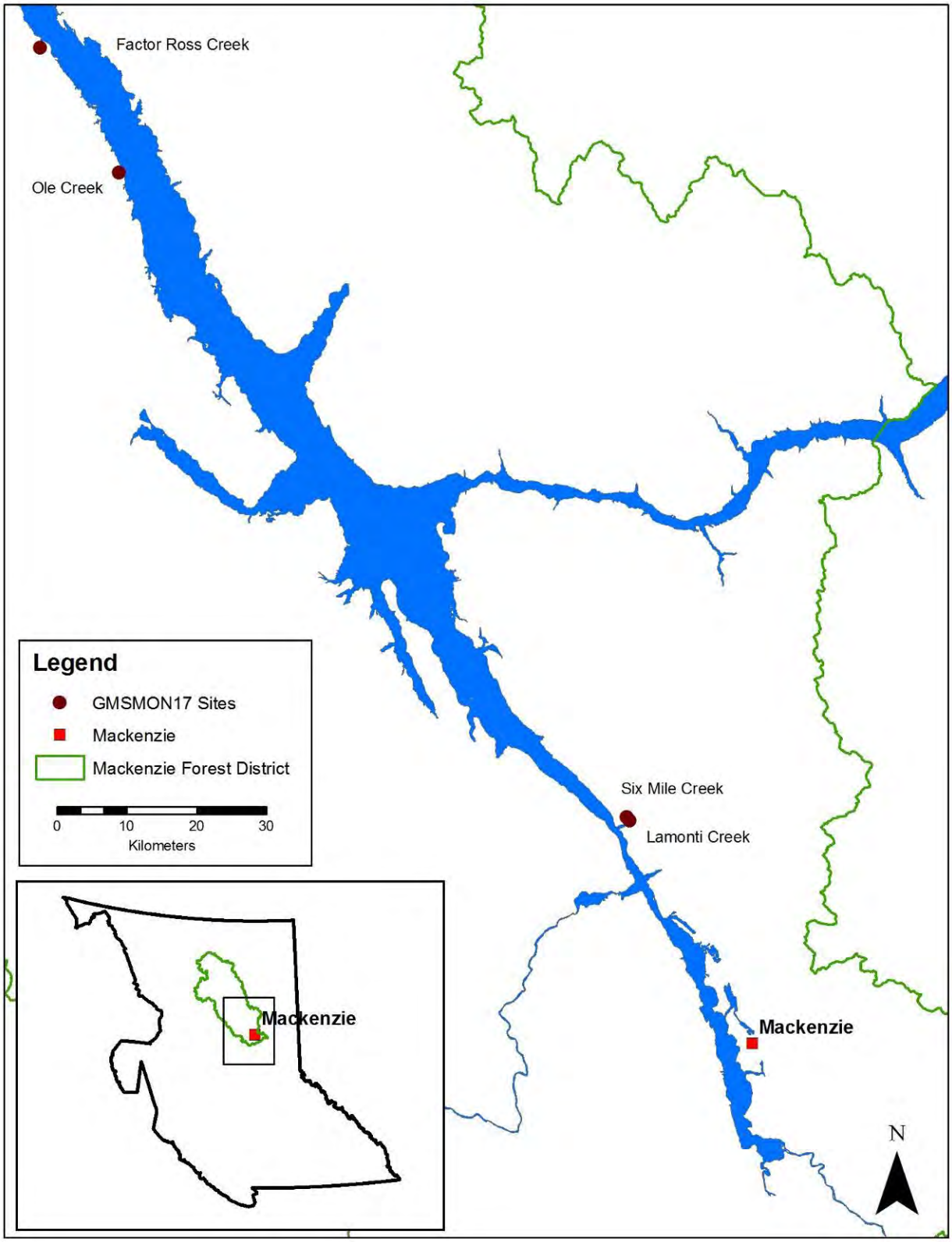

Figure 2. **Location of the two tributary access enhancement treatment sites (Six Mile and Ole Creeks) and their respective control sites (Lamonti and Factor Ross Creeks) on Williston Reservoir.**

4 METHODS

4.1 Environmental Conditions

Environmental conditions specific to each survey type were recorded at the start of each survey and periodically during the surveys. Daily mean air temperature data and precipitation prior to and during the survey period (April – August) were obtained from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto) to obtain a record of the regional conditions.

Data on local environmental conditions were obtained from the satellite enabled satellite-enabled stream gauging stations located at Ole and Six Mile Creeks. The locations and installation dates for the two stations are provided in Table 1. For complete details on the installation and equipment at the stations refer to the reports from Years 2 and 3 of the project (Golder 2013, 2014). Data recorded by the stations includes water level, water temperature, and air temperature. A staff gauge for manually recording water level was also installed at each station and a Hobo Water Temperature Pro water temperature logger (Onset Computer Corporation) was also installed at each station as a secondary record of water temperature. Data for all variables was recorded at 15 minute intervals and set to be uploaded hourly to the data server by satellite. Data was downloaded at a minimum of once a month for later analysis. Water level and temperature data were reviewed frequently in May and June to determine the timing of the Rainbow Trout spawner surveys.

Table 1. Location and installation details for satellite-enabled stream gauging stations.

Site	Station #	Neon Serial #	UTMs			Date of Installation
			Zone	E	N	
Ole Creek	1	4870	10 V	404853	6257596	May 28, 2012
Six Mile Creek	2	5012	10 U	474511	6163771	May 27, 2012

The stream gauging stations were re-surveyed on May 4 and 5, 2014 at Six Mile and Ole Creeks, respectively, to confirm that the stations had not moved. Manual discharge measurements were completed in May, June, and September for development of the rating curves for each of the streams. Two replicate measurements were completed on each date.

4.2 Fish Surveys

4.2.1 Tributary Access Assessment and Fish Habitat

The foreshore area of the Williston reservoir was inspected during the three main field visits in May, June, and September to assess each stream for potential barriers to fish passage. Habitat in the drawdown zone reach of each stream was mapped during the May site visit from the full pool elevation (672 m) down to the confluence with the Williston Reservoir (May 4 and 5, 2015 elevation: 662.7 m). Channel boundaries, habitat types, and stream area were delineated within the drawdown zone during low pool conditions of the reservoir. Features were located by tight chainage from a GPS reference point and photographed. Any debris clusters, riffles, pools, boulders, and significant gradient changes were noted and a visual inspection for fish was also completed. The habitat information was georeferenced and sketched onto orthophotos of each stream.

The drawdown zone fish habitat maps for Year 5 were based on the field surveys completed on May 4 and 5, 2015 when the reservoir was close to low pool. The habitat mapping was supplemented by high resolution orthophotos obtained by UAV flights completed in early May, a few days after the habitat mapping and at a similar reservoir elevation. The habitat mapping provides a record of annual changes in each stream channel to assist in determining the effectiveness and stability of the tributary access enhancements under low pool conditions. The habitat mapping will also provide a record of the annual stream channel changes at the control sites and provide more information on interannual variation in tributary access.

New, high resolution digital orthophotos (with a target resolution of 5 cm ground sampling distance [GSD]) for all four sites were obtained from Unmanned Aerial Vehicle (UAV) flights on May 10 and 11, 2015. The reservoir elevation was close to low pool for 2015 (662.84 – 662.92 m) and lower than when the initial UAV survey was completed on June 16-19, 2014 (reservoir elevation: 665.99 – 666.35 m). The high resolution digital orthophotos from the UAV flights completed by JR Canadian Mapping Ltd were used as the background layer for delineating stream features (e.g., debris clusters). Georeferencing interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008) and overlay of mapping icons was completed in Artweaver (Boris Eyrich Software, 2014).

Photo documentation from the established reference locations and orientations near the mouth of each study stream was continued in Year 5 (Table 2).

Table 2. Location of stream mouth photo reference sites and reference photo direction.

Site	UTMs			Height Above Ground (m)	Azimuth (°)
	Zone	E	N		
Six Mile	10 U	474658	6162760	1.6	165,60
Lamonti	10 U	475293	6161984	1.4	290,200
Ole	10 V	405814	6257625	2.0	10,80
Factor Ross	10 V	395397	6275823	1.4	340, 280,220

4.2.2 Drawdown Zone Fish Sampling

Electrofishing surveys of the of the drawdown zone reach of each stream were not completed in 2015 due to the well above average reservoir elevations. As the streams contain Bull Trout, electrofishing could not commence until after June 15 in accordance with the permit conditions (no electrofishing from September 15 – June 15). On June 16, 2015, the reservoir elevation had already exceeded 669 m limiting the amount of stream habitat in the drawdown zone. The preferred reservoir elevation for the drawdown fish sampling is less than 667 m. It is expected that completion of these surveys will not be possible every year due to rapid filling of the reservoir. In the event that conditions permitted the drawdown zone fish sampling to occur, it would have been conducted under Fish Collection Permit PG15-169567 issued by the Ministry of Forest, Lands and Natural Resource Operations.

4.2.3 Spawner Surveys

Arctic Grayling and Rainbow Trout were identified in the Terms of Reference for this monitoring program as potential target species for the spring spawning surveys. However, since Arctic Grayling were not observed during spawner surveys in Years 1 and 2, it was recommended that the surveys be changed to focus on Rainbow Trout only beginning in Year 3 (Golder 2013). Spawning surveys followed the same methodology as used in Year 3 (Golder 2014).

Foot-based visual surveys were conducted by two observers with each observer walking along one bank of the stream. One of the observers was equipped with a dry suit, mask, and snorkel to conduct snorkel surveys in locations where depth and water velocity permitted. During the snorkel surveys the other observer was stationed downstream from the snorkeler and was equipped with a throw bag for safety. The snorkel surveys were a supplement to the visual surveys to increase the detections of adult fish. The minimum length of stream surveyed was equal to the distance surveyed in the previous year of the monitoring program. When time permitted, the survey area was extended upstream, as recommended by Golder (2014). Additionally, the survey area at Six Mile Creek was extended by including a portion of its tributary, Patsuk Creek.

The Year 5 spawner surveys were completed on the four systems from June 23-26, 2015. The timing of the spawner surveys was determined by monitoring water levels and temperatures from the remote gauging stations on Six Mile and Ole Creeks. The criteria for the timing of the surveys were declining water levels (better visibility) and water temperatures of 5-7°C (expected peak spawning activity).

The date, time, crew, effort, weather condition, water temperature, water clarity, substrate, number and species of fish observed, location of fish observed, estimated sizes of fish observed, and any evidence of spawning were recorded during the spawner surveys. For locations where snorkel surveys were completed, the additional data recorded included the area surveyed and relative underwater visibility. Locations of adult Rainbow Trout and redds were noted and marked using a handheld GPS (Garmin GPSMap 62s). Additional information recorded for each redd observation included dimensions (pot and tail spill), substrate (type, size), water depth (m), and water velocity (floating chip method). The locations (GPS) and areas of suitable spawning substrates were also recorded.

The spawning surveys are conducted during a period of higher stream flows targeting Rainbow Trout (a spring spawning species), which can result in reduced visibility due to a combination of water levels and suspended materials in the water column. The timing of surveys was adapted to avoid inclement weather conditions (i.e., immediately after a major rainfall). Dates and distances of survey length for each stream are shown in Table 3.

Table 3. Spawning survey details for Year 5 (2015).

Site	Date	Stream Length Surveyed (Km)	Start	End
Lamonti	June 26, 2015	1.4	Stream mouth	~500m upstream from bridge crossing at Parsnip FSR
Six Mile	June 23, 2015	2.2	Stream mouth	~665m upstream of confluence with Patsuk Creek
Patsuk Creek (Six Mile trib.)	June 23, 2015	0.8	Confluence of Patsuk & Six Mile Creeks	Bridge at West Parsnip FSR
Ole	June 24, 2015	2.1	Stream mouth	~570m upstream from bridge crossing at Factor Ross FSR
Factor Ross	June 25, 2015	1.7	Stream mouth	~980m upstream from bridge crossing at Factor Ross FSR

4.2.4 Juvenile Fish Surveys

No juvenile and small-bodied fish surveys were completed in Year 5. This component of the project was initially put on hold for Year 5 pending completion of a review of the study Terms of Reference by BC Hydro. The revised Terms of Reference removed the juvenile fish sampling component as this approach was determined to likely be an ineffective approach to addressing the management questions for this project (BC Hydro 2015). For details on the methods and results for the juvenile fish surveys refer to Golder (2013, 2014) for Years 2 and 3 and DWB and CBA (2015) for the Year 4 results.

4.2.5 Fry Surveys

The salmonid fry surveys were conducted opportunistically during the night-time snorkel surveys for juvenile fish abundance. With the removal of the juvenile fish surveys, this component of the study was also not completed in Year 5 (2015).

4.3 Vegetation Surveys

A combination of air photo interpretation and ground sampling of terrestrial vegetation was used to describe terrestrial vegetation communities at the project sites (Province of British Columbia 2010, RISC 2010). The TEM standards (Province of British Columbia 2010) were used to complete ground sampling of terrestrial vegetation as the plant species assemblages and soil profiles identified within the project sites were not consistent with the wetland classes described by Mackenzie and Moran (2004). Mackenzie and Moran (2004) describe naturally recurring wetlands within British Columbia that are relatively stable in terms of their hydrologic cycle and plant species composition and have established over long periods of time. Due to variability of flood events in the drawdown zone from dam operations, the plant species assemblages identified in this project are in constant transition to a stable state.

All photo interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008). Digital ortho-rectified low and high resolution air photos taken of the project sites, provided by BC Hydro (approx. 100 cm pixel resolution; 2011) and JR Canadian Mapping (5 cm pixel resolution; 2015), were used as the background layers for delineating polygons. Furthermore, field notes and photographs on vegetation composition and structure from informal inspections of the study sites prior to the air photo interpretation assisted with establishing and updating habitat classes.

A habitat classification scheme based on RISC (2010) was developed to capture all the habitat classes in the study area visible at the air photo resolution available. Habitat classes were first determined from an overview of the study area to identify the larger vegetation features. As the study area was viewed at finer scales during photo interpretation, more vegetation features were identified. As new vegetation features were encountered, additional habitat classes were created to accommodate them. Each habitat class was identified based on a common plant species assemblage or substrate and elevation position within the drawdown zone. The spatial arrangement of habitat classes often followed a similar pattern.

In addition to habitat classification, an enhancement classification scheme was also developed for Six Mile and Ole creek, utilizing the high resolution air photos collected during Year 5. The objective of the classification scheme was to identify and differentiate artificial structures and surfaces from undisturbed habitats at the enhancement sites. Any new structures, or areas were ground disturbance resulted in alterations to surface materials, were identified as enhancement structures and were designated with an enhancement class.

Due to the relatively small area of the study sites, a map scale of 1:1000 was used as the initial resolution for polygon typing. Where required, a larger scale was used to differentiate similar or small area polygons. Overall, the approximate scale varied between 1:1000 and 1:200 throughout the interpretation process depending on the size of the habitat polygon and the resolution of the air photo.

Although habitat mapping was originally planned to be completed only within 50 m of the main channel on each side of the tributary, the area mapped was extended to include habitats outside of the riparian zone of the main channel (but within the drawdown zone) in order to monitor any changes to these habitats over time. Thus, delineation of habitat and enhancement class polygons included all non-flooded areas within the drawdown zone (from an elevation above the full pool level [672.08 m] to below the reservoir elevation during ground surveys and air photo collection).

Ground sampling of terrestrial vegetation was conducted to support the interpretation of habitat classes and provide a description of plant communities (e.g., species diversity) at the sites. Ground sampling was completed along established vegetation transects at each of the sites in early June. The timing of ground sampling was selected to aid in the identification of plant species by attempting to observe species as close to the date of flowering as possible (as inflorescence is often required to identify a species), but prior to the sites being flooded by rising reservoir levels.

In Year 5 (2015), ground sampling was completed at nine of the previously established vegetation transects including two at Six Mile Creek, two at Lamonti Creek, two at Factor Ross Creek and three at Ole Creek. Due to higher than average reservoir levels in June, some transects were already flooded at the time of sampling. There was one flooded transect at Six Mile Creek, two at Lamonti Creek, and one at Factor Ross Creek.

Ground sampling was completed on June 7-11, 2015. At each site, transects were located on riparian habitats (e.g., gravel bars and riparian benches) and enhancement structures (e.g., berms). Prior to ground sampling, a list of plant species commonly known to occur within the area was developed and reviewed. In addition, a list of red- and blue-listed species know to occur in the Mackenzie Forest District was developed using the BC Conservation Data Base (CDC; May 2015) and reviewed. The species lists for the GMSMON-15 project sites during Year 4 surveys (Airport Lagoon and Beaver Pond) were also reviewed (CBA 2015).

As the habitats being surveyed were often linear in shape, a transect-based method for vegetation sampling was selected over a grid-based method (using design components from LGL (2007) and US EPA (2002)). A 20 m long belt-line quadrat transect consisting of ten 2 m x 0.5 m rectangles was laid out (Figure 3) using a 30 m tape and 2 m measuring rod. UTM coordinates were recorded for the transect start and endpoints, and a spray-painted washer and large spike was driven in the ground at both points. A photograph was taken at the start point and end point of each transect, with a view of the area.

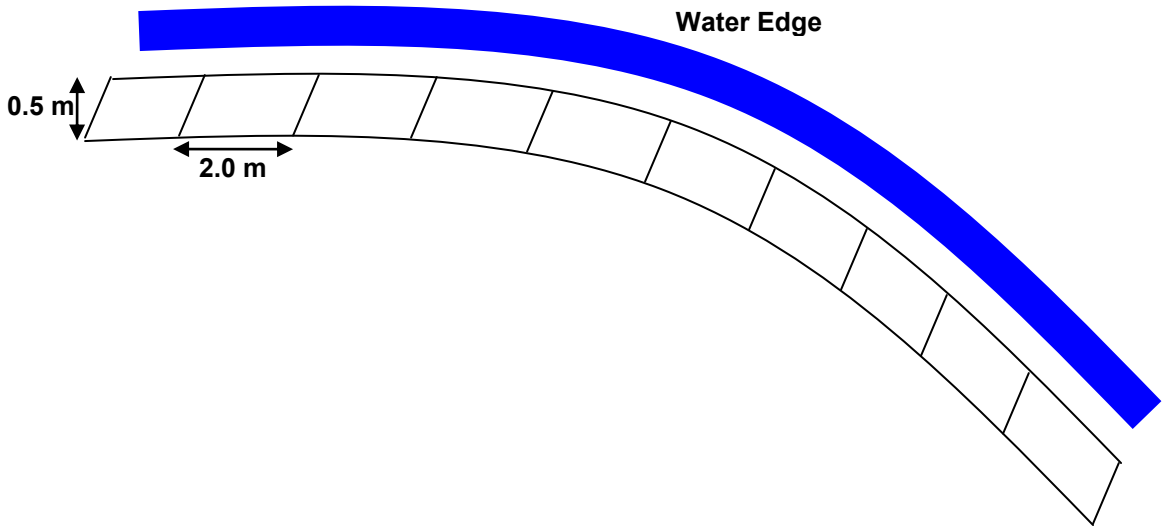

Figure 3. Belt-line quadrat transect for a sample site laid out adjacent to the riparian area.

Site and soil characteristics for the entire transect were recorded on provincial ecosystem field forms (Province of British Columbia 2010), including seral and structural stage characteristics. Site characteristics representative of the whole site were recorded and a representative location was chosen for the soil pit. Within each quadrat, vegetation was identified to species or genus and percent cover was recorded. The terrestrial ecosystem keys (Province of British Columbia 2010) were used to describe soil characteristics and MacKinnon et al. (1999) was used as a reference for species identification. Where identification of species was not possible or uncertain, samples were taken and identified in the botany laboratory of the University of Northern British Columbia (UNBC) using the Illustrated Flora of British Columbia (Douglas et al. 1998) and Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Where species identification was still problematic or where correct identification was particularly important (i.e., with a potential red-listed species), a plant taxonomy expert recommended by the BC Royal Museum was asked to confirm the initial result. Plants listed as rare or endangered at the provincial or federal level were recorded on a Rare Plant Observation Form and submitted to the BC Conservation Data Centre.

4.4 Amphibian Surveys

Survey dates for each study location are listed in Table 4. The general search strategy reported for amphibians in 2014 (DWB and CBA 2015) was replicated in 2015. Standard methods (per the RIC (1998) standards) that were used in the Year 5 surveys include: time-constrained searches, systematic search and sampling design techniques for relative abundance estimates, a stratified randomized approach for mark-capture-recapture, and morphometrics including weight and length (e.g., snout-to-vent = SVL).

Table 4. Amphibian survey dates in 2015.

Site	Survey Dates	
Six Mile	3-4 June	10 Aug
Lamonti	04-Jun	9 Aug

Factor Ross	14-15 June	4-6 Aug
Ole	17-18 June	6-7 Aug

A new three piece camera box was created for the 2015 field season. The dimensions of the box were as follows: 21 cm L × 14.5 cm D × 9 cm W. The box was made of durable 4 mm thick PVC plastic. The three pieces to the box include 1) an inner base that slides into 2) an outer sleeve that is grooved to fit a 3) flat piece that slides through the groove. All insides of the box were sprayed with a matte white paint to reduce glare. Different colors were trialed as a base to add contrast for photographed individuals; green was selected. A laminated 1 mm grid paper was applied to the green base and sprayed with a transparent matte to reduce glare. Two bright LED lights ("The Larry™") were bolted lengthwise to the outer sleeve. A 3 cm diameter hole was cut as a camera hole into the top flat piece that slides lengthwise over the outer sleeve (Figure 4).

Figure 4. The amphibian camera box disassembled (top panel) and assembled (bottom panel).

Captured amphibians (BC Wildlife Act Permit PG14-94627) were photographed, weighed (nearest 0.1 to 0.01 g), and measured (nearest 0.1 mm). Larger adults (>1.5 g) were anesthetized using Oragel™ for processing. A higher precision digital scale (0.01 g) broke at the start of the season and a lower precision digital scale (0.1 g) was used until a higher precision replacement scale was obtained. Coordinates were recorded using a Garmin GPS for all captures and general field notes were taken, including notes on habitat, body condition, and behaviour.

4.4.1 Terrestrial Surveys

Time-constrained and systematic surveys for amphibians were conducted at the four study locations. Plots established in Year 4 were revisited and new plots were established to extend the survey effort (see Results). Circular terrestrial plots were 200 m^2 in size and searched for 10 minutes each. Natural cover objects (rocks, logs-limbs, bark) that were light enough to be flipped by hand were turned over. Flipped materials were returned to their original positions to minimise disturbance. Plot surveys were extended into an undisturbed (i.e., not previously searched) area that was immediately adjacent to the plot that had previously been searched. This process increases plot sizes in 200 m^2 increments with each survey interval.

Habitat features recorded at each plot included an estimate on the percentage canopy cover, counts of class and type of coarse woody debris, dominant and sub-dominant canopy tree species, leaf litter depth, and organic soil layer depth. Incidental captures were noted while conducing light surveys as field crews traversed areas between plots; the occasional piece of debris was flipped and searched. General searches were also repeated around the amphibian point locations identified in Golder (2011, 2012, 2013), including ponded areas in the drawdown zone.

4.4.2 Wetland and Drawdown Zone Surveys

Drawdown zone plots established in Year 4 were re-surveyed in Year 5 during daylight hours. Search time was reduced to 5 minutes or less since there is very little debris or cover to conceal amphibians in the drawdown zone. Wetlands were surveyed for presence of eggs, larvae, or adults. General features on the wetlands were noted, including dominant aquatic vegetation. Night time transect surveys were trialed at Six Mile and Ole Creek between the hours of 22:00 to 03:00. GPS coordinates and time from start to finish established the transect line as a two-person crew walked and surveyed the drawdown zone. Captured individuals were stored temporarily into a breathable plastic bag and processed after the transect survey was completed.

4.4.3 Amphibian Data Analysis

A Data Management Plan (DMP) was developed for amphibians. The DMP follows the British Ecological Society (BES) (2014) guidelines. All amphibian survey detections were entered into Excel and imported into R-stats for analysis per the BES (2014) guidelines. The Photo-Identification Methods (PIMs) approach (Caorsi et al. 2012) was continued in Year 5. The PIMs approach is used for creating a digital database of photographs of captured amphibians. The digital photographic records include a scale bar for obtaining morphometric measurements and a complete overview of the body that can be used for gathering additional information on the individuals being captured including condition, gender, colour, and skin patterns.

Digital photographs of amphibians were catalogued and then uploaded into imageJ (Ferreira and Rasband 2012) or Artweaver (Boris Eyrich Software 2014) for processing, visualizing, and analysis. Photographed individuals were double checked for species identifications that were recorded in the field. The gender of amphibians were determined by: vent characteristics for long-toed salamanders (Petranka 1998); a range of sexual characteristics were used for western toads, including relative body size, colouration, skin smoothness/roughness, nuptial pads, forelimb musculature, and forelimb length (Pickwell 1972, Schueler 1982, Duellman and Trueb 1986, Halliday and Tejedo 1995, Marco et al. 1998); and nuptial pads spotted and wood frogs (Duellman and Trueb 1986). Morphometric measurements for long-toed salamanders included Snout to Vent Length (SVL), Snout to Gular Fold (SGF), Total Length (ToL), Vent Length (VL), Tail Length (TaL), and Body Area (BA). Morphometric measurements for anurans included

Snout to Urostyle Length (SUL) and Gape Width (GW); the acronym SULSVL is used in graphical outputs in reference to either SVL or SUL. The GW was used per Rogers (2009) recommendation that it may more closely reflect age of individuals.

Morphometric data was imported in R-Stats (R Core Team 2015), organized by species, year, and location and graphed, plotted, and analyzed. Bolker (2008), Gardener (2012), and Zuur et al. (2010) were used as reference guides in the data exploration process. This included visual inspection of boxplots and Cleveland plots for outliers, the Shapiro-Wilk normality test to test for normality of the data, and Spearman's rank correlation to test relations between different morphological measurements (e.g., SUL v. GW). A statistical survey that primarily focuses on the western toad data is presented for this year, because more individuals were captured for this species than other amphibian species observed. The comparative analysis includes a two way between subjects ANOVA using the ezANOVA r-stats package (R Core Team 2015) to test for morphometric size differences between sites. Linear mixed effects regression, Spearman's rank correlation, and directional t-tests were also used to explore and summarize morphometric patterns within and between sites and to determine if there were any differences between nighttime and daytime captures (daytime surveys occurred between 06:00 and 18:00).

Images of individually photographed individuals were sorted into folders named by year, location, and a unique identifier that matched the individual into the database. APHIS software (Moya et al. 2015) was used as a platform to run the I3S analysis (Speed et al. 2007). The thematic matching option was explored, but was unable to process the imagery without crashing the software. Three key landmarks and thirty addition marks are required for I3S image analysis. Long-toed salamanders and western toads were processed using this software. Images from Six Mile and Lamonti were compared in a single database as the geographic separation is not sufficient to discount migration of individuals between these locations. Image databases for Ole and Factor were analyzed separately.

The dorsal pattern was used to mark long-toed salamanders. The three key landmarks included the left and right anterior junction of the hind limbs as they meet the body and the mid-point of the spine intersecting along a perpendicular line from the posterior junction of the hind limbs (Figure 5). Thirty additional marks were achieved by marking blotches separated from the main central stripe from the anterior junction of the rear limbs to the posterior junction of the fore limbs. The edges of both sides of the central stripe were marked at the intersection of a perpendicular line drawn from the marked blotches. Additional marks included the dorsal junctions of the gular fold marking the posterior of the mandible including a perpendicular line intersecting the edges of the central stripe. The anterior ridge of the left and right eyeballs and center of the anterior snout were also marked (Figure 5).

Ventral sides of western toads were used for I3S marking (Figure 5). Three key landmarks included the posterior end of the lip line and venter. Thirty additional reference points were achieved by marking dark blotches on the belly posterior to the throat and anterior to the pelvic patch. The largest central portions of each blotch were targeted. A sub-set of 24 images were marked independently by two technicians using the I3S software to evaluate the sensitivity of the automated matching to different individuals processing and marking blotchy skin patterns according to an established rule: mark the center of each blotch on the ventral side, posterior to the gular fold, anterior to the pelvic patch, and avoid the limbs.

Figure 5. Photo identification I3S software key landmarks (yellow circles) and blotch pattern marks (red circles) for long-toed salamanders (left panel) and western toads (right panel).

Uncorrected occupancy rates (θ) for each stream study site were estimated by dividing the number of plots where any species of amphibian was detected by the total number of sites that were surveyed. These values were used to run a series of multi-season simulations in GENPRESS software (Bailey et al. 2007) to obtain standard deviations assuming an overall low detection rate (p = 0.2), constant colonization (0 or 0.2), and constant local extinction (0 or 0.2) rates. Simulation charts in Guillera-Arroita and Lahoz-Monfort (2012) were examined to determine the relative number of sampling sites that would be required to achieve statistical power of 0.8. Occupancy is related to abundance and estimates of occupancy, which require less sampling effort, can be used to estimate abundance (Royle and Nichols 2003).

4.5 Songbird and Waterfowl Surveys

Songbird and waterfowl surveys were conducted from June 7-11, 2015 following modified provincial Forest and Grassland Bird Inventory Standards (RIC 1999). Surveys were 30 minutes in duration and each one was replicated on two consecutive days. All surveys were completed within four hours of sunrise.

A centre point for each survey was established along each tributary within the drawdown zone. Upon arriving at the survey point, an initial scan for waterfowl and shorebirds was completed to note any birds that may have taken flight due to the observer's arrival at the station. All observations of songbird activity within a 75 m radius of the centre point and waterfowl and shorebird activity at any distance from the centre point were recorded and mapped. Species and activity were recorded for each observation. For songbirds, species outside of the 75 m radius were recorded but not mapped. At Six Mile Creek, an additional 30 minute transect survey was also completed along the willows planted as part of the access enhancement project to look for evidence of avian use of this vegetation.

Environmental conditions including survey start and end time, percent cloud cover, ceiling height, wind speed (Beaufort scale), precipitation, and temperature were recorded at the beginning of each point count. Based on previous experience conducting point count surveys in the cool, wet northern BC spring, surveys were conducted according to 'modified' RIC standards (RIC 1999) for environmental conditions. Acceptable conditions for surveys are as follows: wind speed ≤Beaufort 3 (gentle breeze, leaves and twigs constantly move), no precipitation >'very' light rain, and temperature > 3˚C.

5 RESULTS

5.1 Environmental Conditions

Environmental conditions were generally average during the 2015 sampling period with a few exceptions. Reservoir levels were above average throughout 2015, with well above average elevations during the end of the drawdown stage and the filling stage (March – June) (Figure 1). The reservoir elevations through April and May were higher than any previously observed in this monitoring program (Figure 1). As just over half of the annual reservoir inflows come from snow (BC Hydro 2007) the average to slightly above average snow pack in the region is an important component of the reservoir elevations observed in 2015. Snow pillow data from the two stations located closest to the Parsnip and Finlay Reach sites were downloaded from the BC River Forecast Centre. For the Parsnip reach sites (Six Mile and Lamonti Creeks) the nearest station is Pine Pass (4A02P). In 2015 the snowpack at Pine Pass was below average compared the close to average values in 2013 and slightly above average values in 2014 (Figure 6). The Aiken Lake station (4A30P) is closest to the Finlay Reach sites (Factor Ross and Ole Creeks) was close to average in 2015 and slightly lower than the average snowpack conditions in 2014 compared to the below average conditions in 2013 (Figure 7).

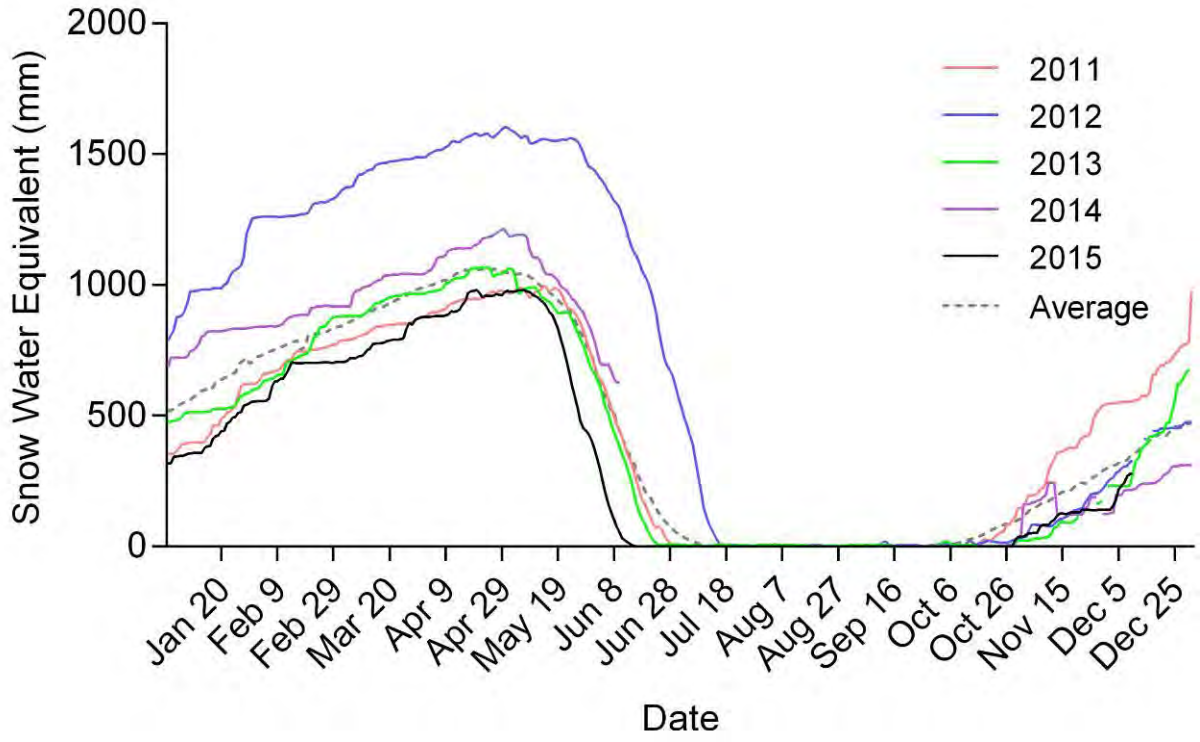

Figure 6. **Snow water equivalent for the first five years of the project from the Pine Pass (Station 4A02P) automated snow pillow monitoring station (data obtained from the BC River Forecast Centre).**

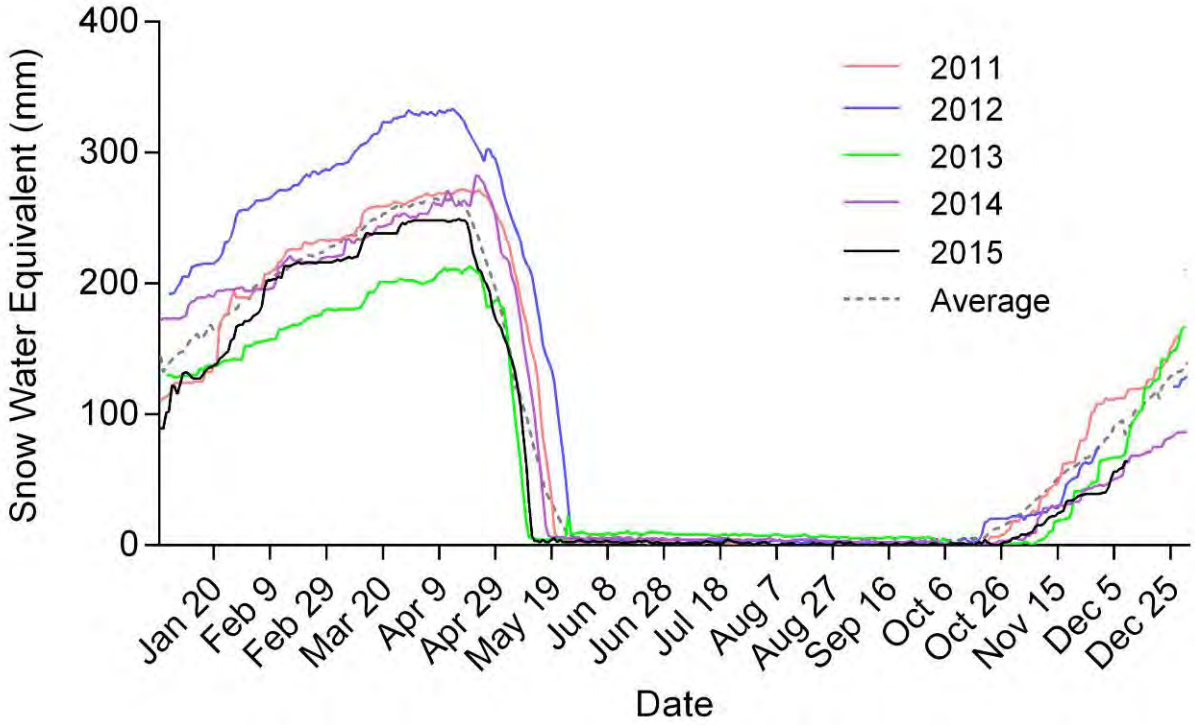

Figure 7. **Snow water equivalent for the first four years of the project from the Aiken Lake (Station 4A30P) automated snow pillow monitoring station (data obtained from the BC River Forecast Centre).**

The similar snowpacks in 2013 - 2015 also contributed to similar water levels in Six Mile and Ole Creeks in all three years. The 2013, 2014, and 2015 water levels recorded by the gauging stations for Six Mile and Ole Creeks are shown in Figure 8 and Figure 9, respectively. Peak flows in Six Mile Creek occurred at similar times in all three years but with a more rapid decline from the peak water level in 2015. Water level were lower than in either 2013 or 2014 following the peak until late July when water levels in both Six Mile and Ole Creek recovered and were either above (Six Mile) or similar to (Ole) the previous years. Data from 2012 is not shown as the record is incomplete and there are a large number of erroneous values from the Ole Creek station due to a malfunctioning water level probe. Based on precipitation data from the Mackenzie Airport (Station ID: Mackenzie Airport Auto) as an indicator of regional trends, precipitation in from April to August was close to and below average with only May being notably below average (Figure 10). Most of the precipitation in May 2015 from a single rainfall event on May 29-30.

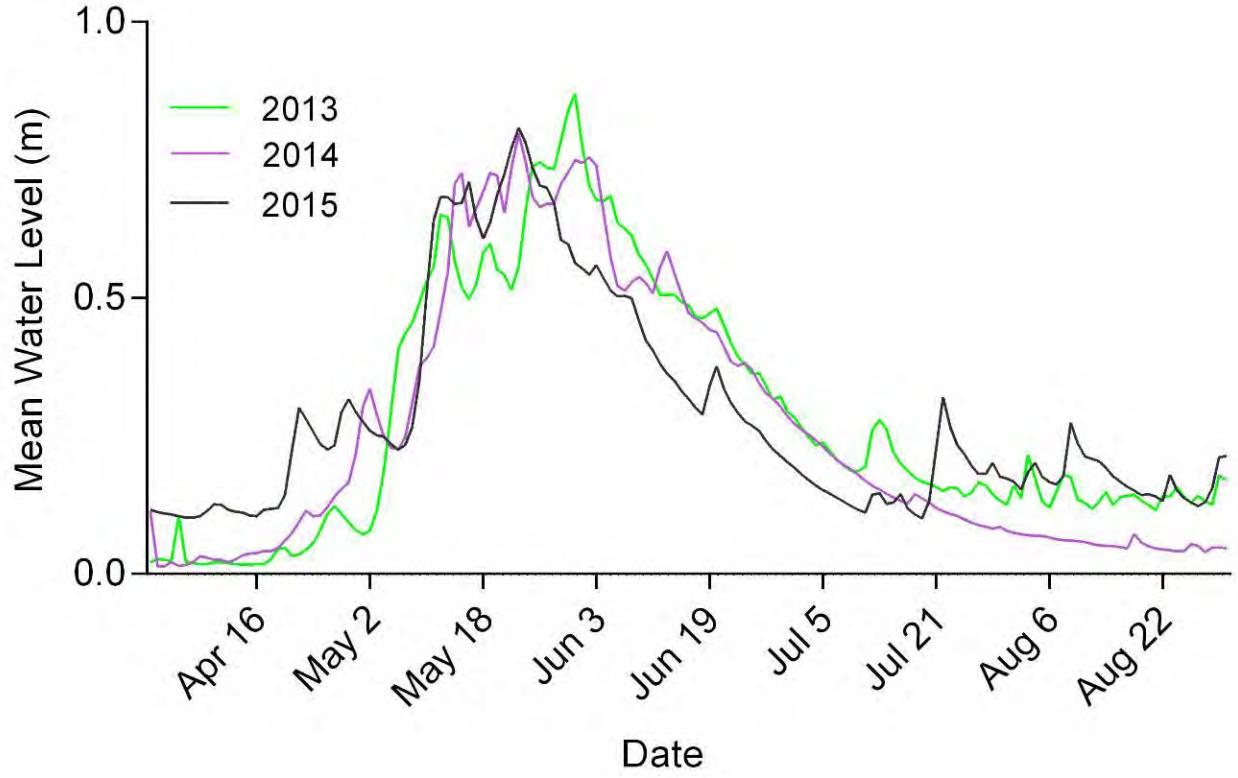

Figure 8. **Daily mean water level at the Six Mile Creek gauging station in 2013 - 2015.**

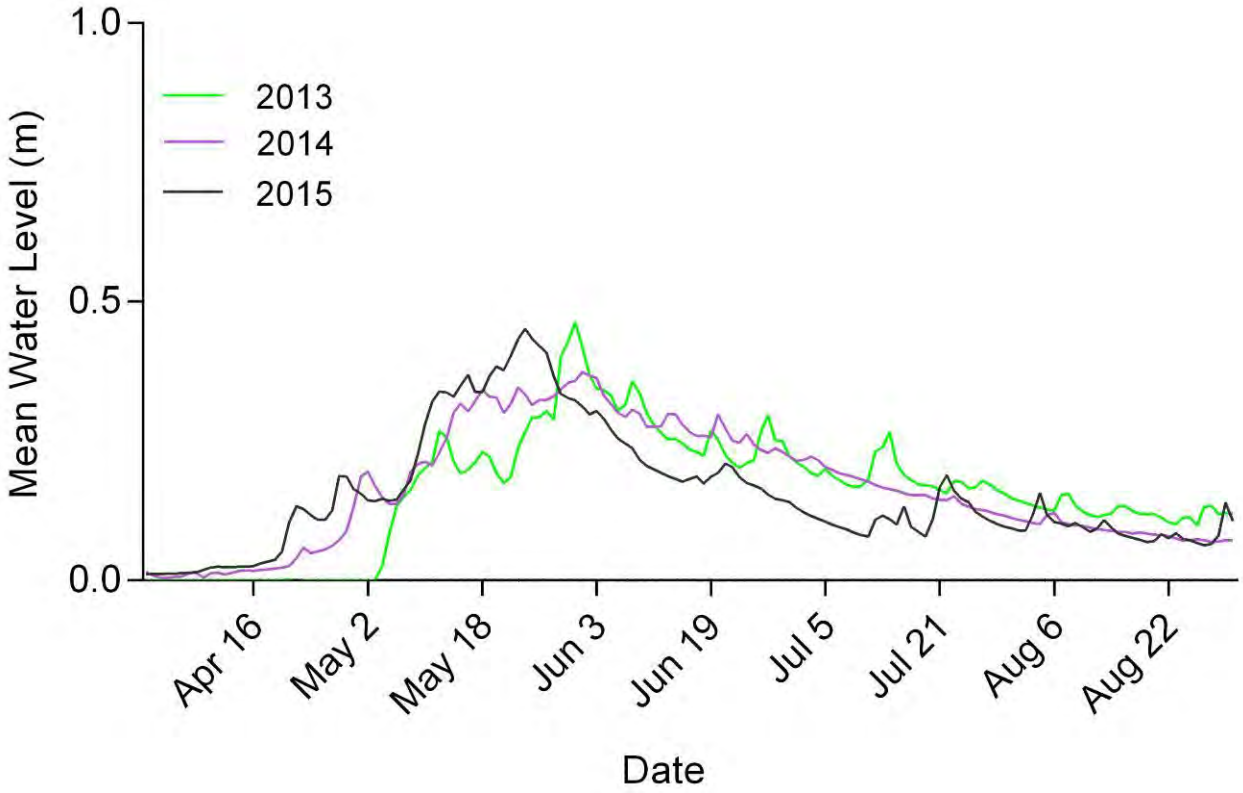

Figure 9. **Daily mean water level at the Ole Creek gauging station for 2013 - 2015.**

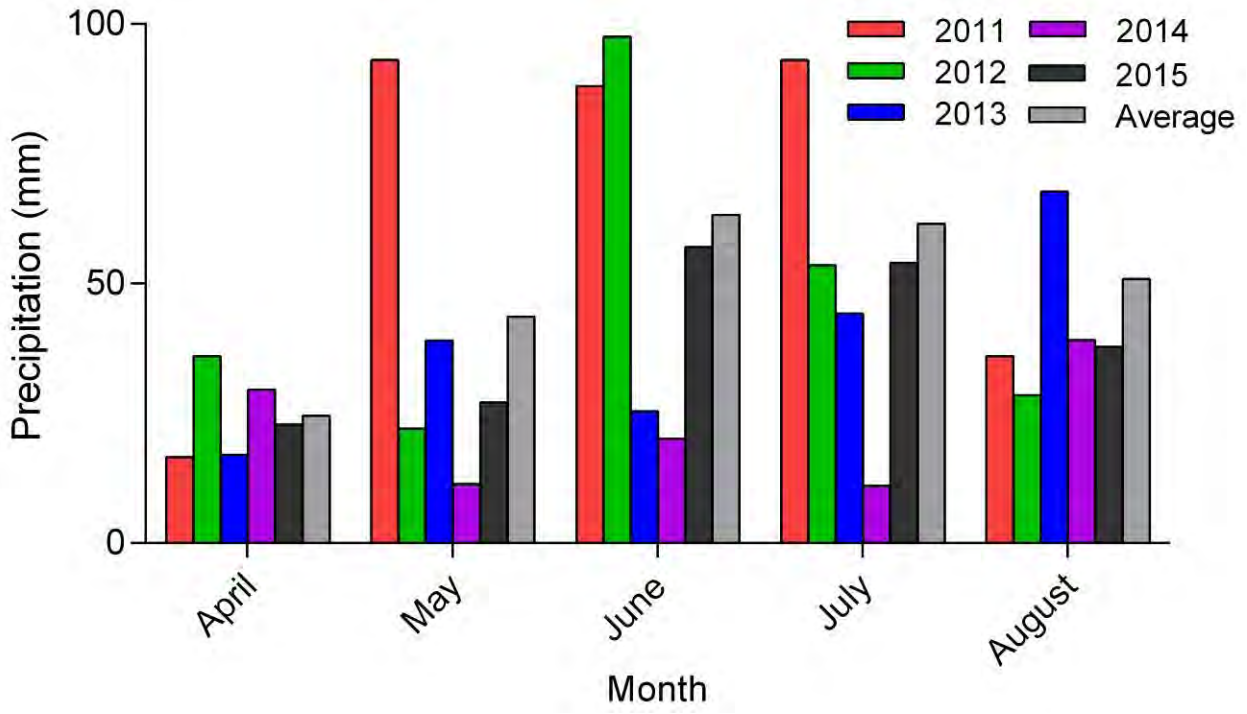

Figure 10. **Total monthly precipitation during the first five years of the project and the long term averages in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

The stream gauging stations also recorded air and water temperature. While there was little difference for either variable between 2013 and 2014 during the sampling season, there were some notable variation in 2015. Air temperatures for Six Mile and Ole Creeks are shown in Figure 11 and Figure 12. Temperatures and trends at both sites were similar in 2015 with a period of above average temperatures in May, followed by average temperatures until mid-July when temperatures dropped below average until the end of the sampling period. Water temperatures at both sites are included in Figures 11 and 12. Water temperatures in Six Mile Creek (Figure 13) are warmer than in Ole Creek (Figure 14) but both creeks followed a similar pattern. Water temperatures in both creeks reached mean temperatures above 5°C on similar dates in June 2015 and earlier than this in both 2013 and 2015. Water temperatures in both creeks continued to increase until mid-July and then decreased in conjunction with the below average air temperatures during this period. Temperatures in both creeks after mid-July were generally cooler than what was observed in 2013 and 2014.

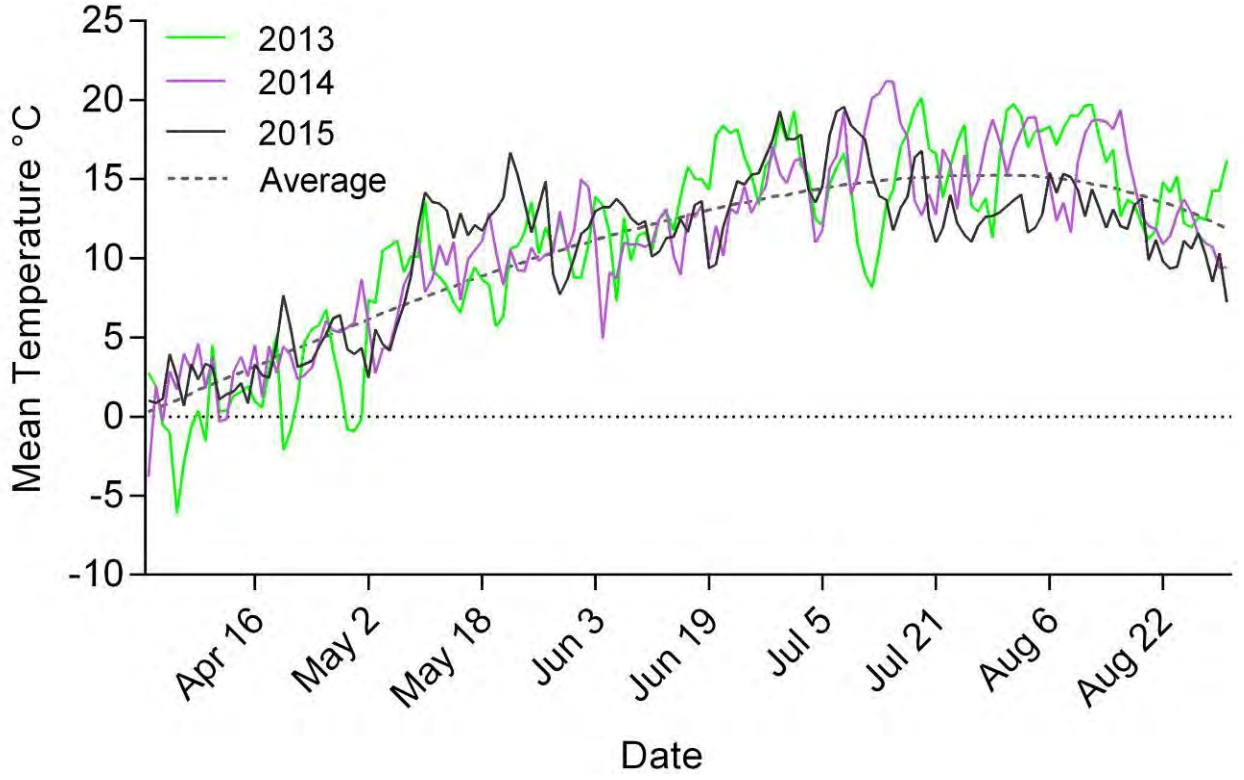

Figure 11. **Daily mean air temperature at Six Mile Creek for 2013 - 2015. Average temperature at the Mackenzie Airport included for reference (Environment Canada).**

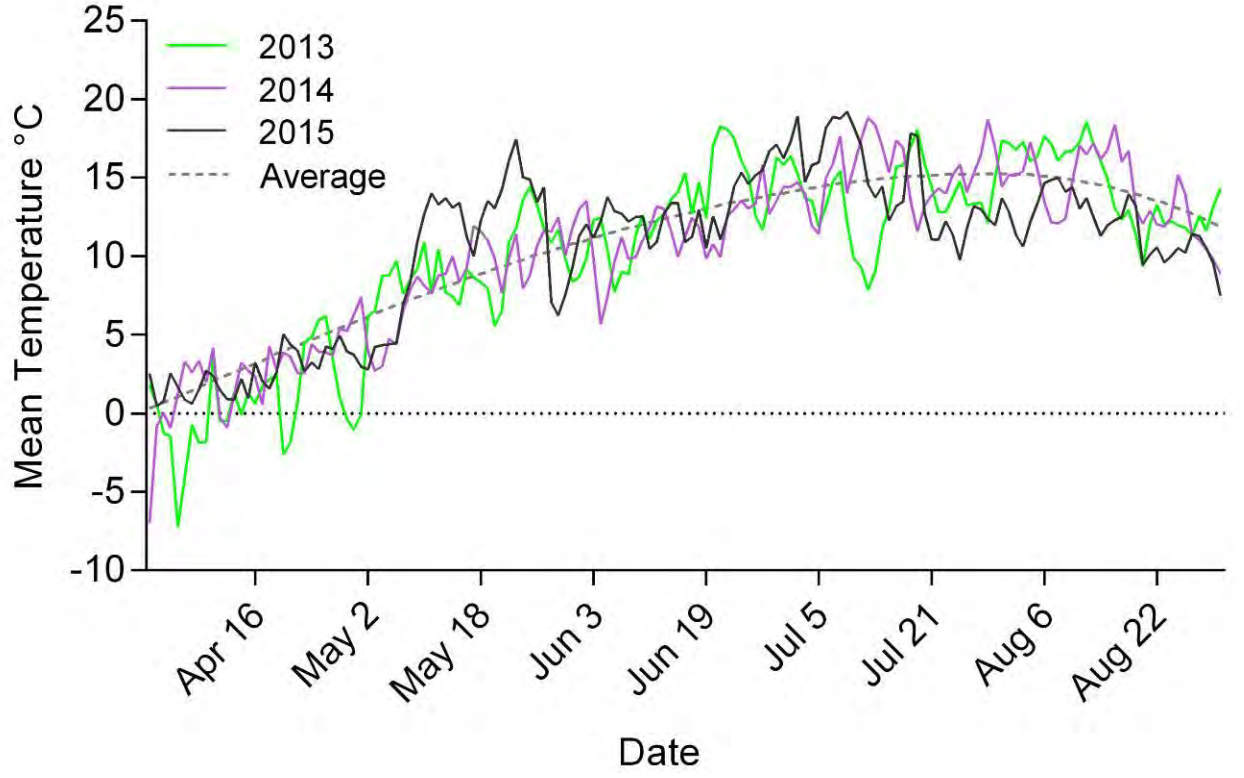

Figure 12. **Daily mean air temperature at Ole Creek for 2013 - 2015. Average temperature at the Mackenzie Airport included for reference (Environment Canada).**

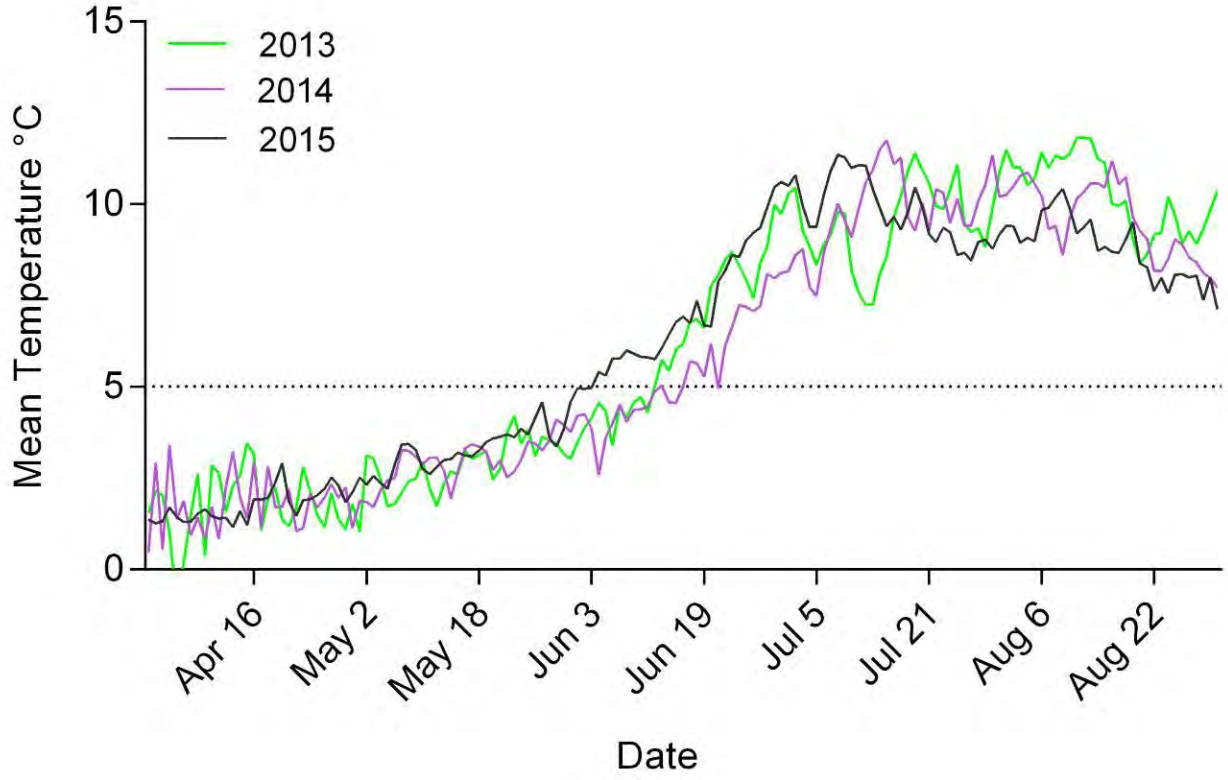

Figure 13. Daily mean water temperature in Six Mile Creek for 2013 - 2015.

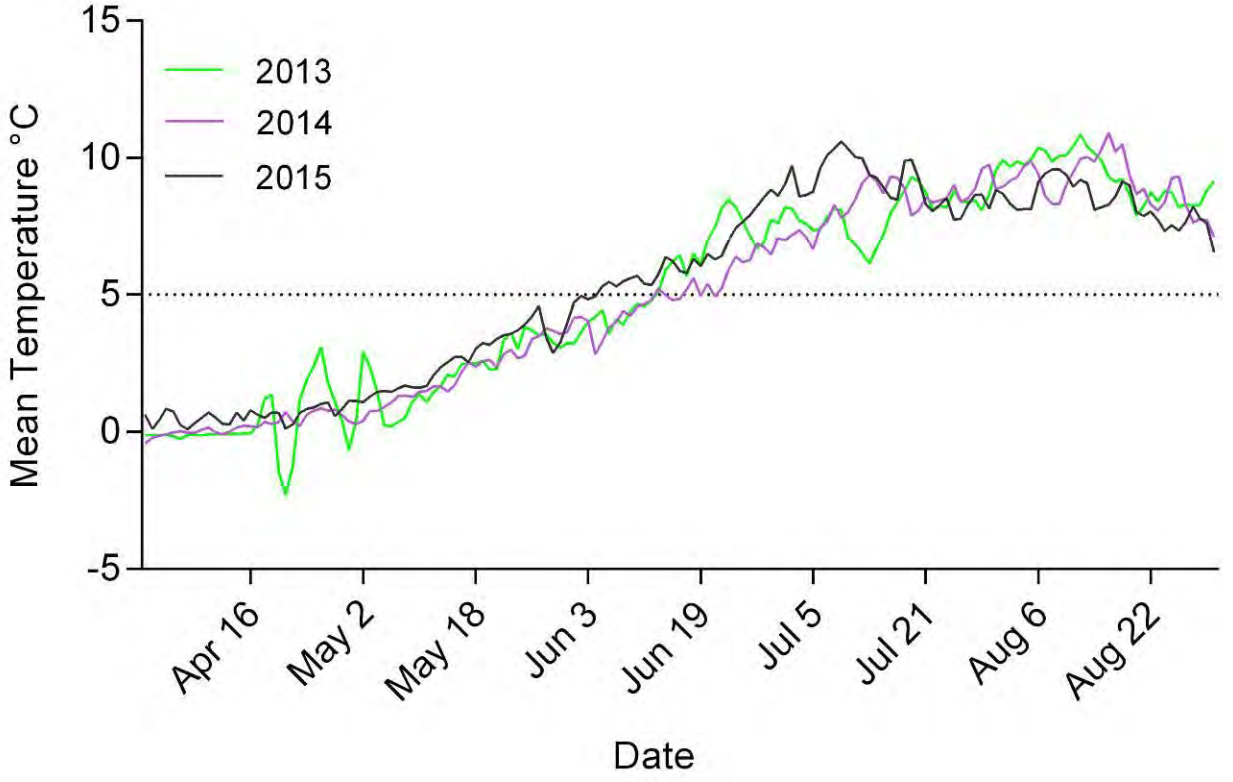

Figure 14. Daily mean water temperature in Ole Creek for 2013 - 2105.

The stream gauging stations were maintained during the first field visit on May 4-5 and the final field visit on September 2-3, 2015. The stations were in good condition and appeared to be operating normally. Photos of the stations from the maintenance visit are included in Appendix 1. The re-survey of the station elevations suggested that the stations may have moved (Table 5). However, there were no indications at either site of any movement of the stations (see Appendix 1 for photos). As the differences are consistent for all measurements at the Six Mile site, the likely explanation is that the survey rod was not fully extended in the range of measurement. The reason for the differences at the Ole site is unknown but as there was no indication that the station had moved it is assumed to be due to measurement from different parts of the station than previously. The Hobo water temperature loggers were replaced during the September maintenance visit.

The manual discharge measurements in 2015 were completed on May 4, June 26, and September 3 in Six Mile Creek and on May 5, June 24, and September 2 in Ole Creek. Measurements were completed at a range of flow rates and rating curves were calculated for both creeks. The stage rating curves and associated tables are included in Appendix 2.

Table 5. Surveyed elevations for stream-gauging stations.

Component	2015 Re-survey		Original Survey (m)	Difference Between Surveys (m)
	Elevation (m)	Difference from Benchmark (m)		
Six Mile Creek Station (5018)				
Benchmark	-0.040	-	-	-
Upstream Nail	2.48	2.52	2.47	-0.05
Top of T-post	2.42	2.46	2.42	-0.04
Top of Stilling Pipe	1.93	1.97	1.93	-0.04
Top of Staff Gauge	2.895	2.935	2.89	-0.045
Ole Creek Station (4078)				
Benchmark	-0.215	-	-	-
Top of Rebar	-	-	1.317	-
Top of Stilling Pipe	1.135	1.35	1.096	-0.254
Top of Staff Gauge	2.26	2.475	2.049	-0.426

5.2 Fish Surveys

5.2.1 Tributary Access Assessment and Fish Habitat

The early spring assessments were completed at low reservoir elevations (662.7 m) and low stream discharge. The reservoir was ice-free and little snow was present in the forested areas around the streams but the drawdown zone was snow and ice free. During the late June field visit, the reservoir was at a high level (669.8 m) and the streams flows had declined from the peak freshet values. In September, the streams were at very low discharge and the reservoir elevation was at 671.2 m and still rising. Based on the reservoir elevations there were no

concerns for fish access to the tributaries in either June or September. Photographs from the photo reference points (Table 2) in 2015 are included in Appendix 3.

No significant physical barriers were observed within the drawdown zone during the site visits in 2015 with the exception of two temporary barriers created by LWD in one of the channels at Facto Ross Creek. No other barriers to upstream fish migration observed during sampling in 2015. Further details of the access assessments and drawdown zone habitat mapping are provided below for each stream. The habitat maps are included in Appendix 4.

5.2.1.1 Six Mile Creek

Habitat surveys of Six Mile Creek were completed on May 4, 2015 at close to the annual minimum reservoir elevation for 2015 (2015 minimum: 662.57 m, May 4 elevation: 662.73 m). Habitat mapping was completed on a total of 498 m of stream channel in the drawdown zone from the photo reference point downstream to the confluence with the reservoir (Appendix 4, Map 1). No barriers to fish passage were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 5 and 6).

The channel consisted of a long riffle for the first 256 m from the upstream limit of the drawdown zone with minimal holding water in the form of pools or large eddies. Gradients were generally consistent at 2% with a short section at 3% from 0+200 to 0+256 m. Substrates consisted of cobbles and gravels with intermittent boulders. There was a single braid present in this section of the channel that was also present in 2014 prior to construction of the access enhancements. From 0+256 m to 0+304 m was mapped as run habitat in 2015 at 1% gradient compared to the 2% riffle observed in 2014. The channel in this section also appeared to be more incised compared to 2014. The next section of stream (0+304 – 0+334 m) was mapped as riffle with a gradient at 2%. Prior to construction in 2014, the gradient of this section was recorded at 4%. Following the riffle, a section of pool habitat with large woody debris on the right downstream bank was located at 0+334 to 0+356 m. This section was mapped as a run in 2014 and the LWD was not mapped, although it was present in photos of the site. Below the pool to the confluence with the reservoir, the stream split into two channels that were mapped as riffles with decreasing gradients (2% - 1%) from the pool to the confluence with the reservoir. No additional braids were identified in either channel. The lowest elevation and most braided portion of Six Mile Creek occurs beyond was not exposed during drawdown in 2015 and changes to this section of stream could not be assessed for post construction changes. No fish were observed during the assessment.

By the June 23 site visit, there was essentially no stream length in the drawdown zone as a result of the high reservoir elevations. The elevation on June 23 was 669.7 m and still rising. This was a full meter higher than the peak elevation of 668.7 m in 2014. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 7 and 8). Water levels in the stream were moderate. During the final stream visit on September 3, there was no stream length in the drawdown zone and no physical barriers to fish habitat were observed (Appendix 3, Photos 9 and 10). There appeared to be no change to the enhancement works since construction. However, there was little or no vegetation growth observed in most of the brush mats and seeded areas.

5.2.1.2 Lamonti Creek

Habitat surveys of Lamonti Creek were completed on May 4, 2015 with 398 m of stream channel mapped in the drawdown zone from the photo reference site downstream to the confluence with the reservoir (Appendix 4, Map 2). No barriers to fish passage were observed in the drawdown

zone or at the photo monitoring point (Appendix 3, Photos 11 and 12). The amount of braiding observed was reduced from what was observed in 2014 with the closure of a couple of braids that were mapped in 2014. Braiding increased with distance downstream although there was only a single outlet into the reservoir at the time of the habitat survey. The gradients were generally consistent at 2% and the morphology was predominantly riffle with minimal cover. The limited cover and velocity breaks that did exist were provided by LWD. Where braided channels were present, they were generally wide and shallow. Due to the high reservoir elevation at the time of the surveys, there were no channels that connected to Six Mile Creek. One of the channels that connected to Six Mile Creek in 2014 was dry at the time of the 2015 survey. Similar to Six Mile Creek, substrates became finer moving downstream (boulder/cobble to cobble/gravel). No fish were observed during the assessment.

There was minimal stream length in the drawdown zone by June 26, 2015 due to the high reservoir elevation. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 13 and 14). Water levels in the stream were moderate. During the final stream visit on September 3, 2015 there was no stream length in the drawdown zone and no physical barriers to fish habitat were observed (Appendix 3, Photos 15 and 16).

5.2.1.3 Ole Creek

Habitat surveys of Ole Creek were completed on May 5, 2015. A total of 296 m of stream channel was mapped in the drawdown zone from the photo reference site to the confluence with the reservoir (Appendix 4, Map 3). No barriers to fish passage were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 17 and 18). The stream was flowing in a single channel for the entire length except for a short section starting at approximately 0+210 m and ending at 0+225 m where the channel split into two. However, both channels were within the single channel created as a result of the access enhancement project. The multiple braids that were present in 2014, prior to construction, were absent in 2015. The gradient ranged from 2-5.5% with most of the drawdown zone portion of the stream having a gradient of 2-3%. The entire drawdown portion of the stream was riffle morphology with the exception of a short section of run located at 0+225 m to 0+255 m. While there were no velocity breaks created by pools or woody debris cover there were multiple small eddies located behind boulders and large cobble in the stream. The substrate decreased in size from boulder and cobble in the upper part of the drawdown zone (0 to 0+160 m) to cobble and then cobble and gravel, and sand at the confluence with the reservoir. No fish were observed during the assessment.

Woody debris was limited and the majority was located at the confluence with the reservoir. The reservoir elevation in 2014 did not reach a level high enough to remobilize much of the debris stranded in the upper elevations of the drawdown zone. Little new woody debris associated with the peak elevation in 2014 was observed and what debris was present was below the elevation of the debris catcher constructed as part of the tributary access enhancements. Therefore the effectiveness of this component of the access enhancement works could not be assessed.

Stream length in the drawdown zone was reduced to less than 35 m by rising reservoir elevation by June 24, 2015. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 19 and 20). Water levels in the stream were moderate. During the final stream visit on September 2, 2015, there was no stream length in the drawdown zone and no physical barriers to fish habitat were observed (Appendix 3, Photos 21 and 22). Woody debris was observed floating at the mouth of the creek during the September inspection (Appendix 3, Photo 22) but not a barrier to fish passage.

5.2.1.4 Factor Ross

Habitat surveys were completed on Factor Ross Creek on May 5, 2015. A total of 307 m of stream channel was mapped in the drawdown zone from the photo reference site to the confluence with reservoir (Appendix 4, Map 4). No physical barriers were observed at the photo monitoring point (Appendix 3, Photos 23 and 24). In the drawdown zone, two small cascades over woody debris were present at 0+246 m and approximately 0+260 m. The two cascades were located on a single braid and no cascade was present on the other braids. The cascades were not considered complete barriers but would likely limit some upstream fish passage when exposed.

The stream was relatively confined for the first 146 m before the channel braided. The upper section of the stream was primarily a long riffle with boulder and cobble substrates. Velocity breaks were provided by woody debris along the margins and large cobble and occasional boulders throughout this section. Two pools located at 0+101 m and 0+160 m also provided velocity relief. The stream gradient was generally <2% with short sections of 4% gradient located above each of the pools. While a couple of divided channels were located between 0+055 m and 0+207 m, the majority of braiding occurred from 0+207 m to the confluence. The braided section consisted of multiple shallow channels flowing among numerous stumps and buried woody debris. The channels had scoured through the fine sand and silt to expose a cobble and gravel substrate. Woody debris in the form of stumps and logs was prevalent throughout the braided section and continued down to the confluence with reservoir. The flow through the woody debris in this section has created habitat complexity that was not observed in the other three streams. No fish were observed during the assessment.

Stream length in the drawdown zone was absent by the time of the June 25, 2016 site visit due to the high reservoir elevation. No physical barriers were observed in the drawdown zone or at the photo monitoring point (Appendix 3, Photos 25 and 26). Water levels in the stream were moderate. Water levels in the stream were moderate. During the final stream visit on September 2, 2015, there was no stream length in the drawdown zone and no physical barriers to fish habitat were observed (Appendix 3, Photos 27 and 28).

5.2.1 Spawner Surveys

Spawner surveys were conducted from June 23-26, 2015 once the daily mean water temperatures in Six Mile and Ole Creeks were consistently above 5°C, as recorded by the remote monitoring stations. The approximate stream lengths assessed during the surveys were 2.2 km for Six Mile Creek, 0.8 km for Patsuk Creek, 1.4 km for Lamonti Creek, 2.1 km for Ole Creek, and 1.7 km for Factor Ross Creek (Table 6). Horizontal visibility in Six Mile and Lamonti Creeks was 3.8 m and 7.8 m respectively (Table 6), allowing the snorkeler to observe the majority of the area within the assessed spawning habitat with relative confidence. In Ole Creek the visibility was 6.7 m while Factor Ross Creek was measured at 2.3 m (Table 6). In general, visibility in all four creeks was good during the spawning assessments with excellent visibility in Lamonti and Ole Creeks. Water temperatures measured in the field during spawner surveys ranged from 9.0°C to 9.5°C, which is adequate for Rainbow Trout spawning (Table 6). The spawning survey field data for the four systems is included in Appendix 5. Maps showing the locations of suitable spawning substrates are included in Appendix 6.

Table 6. Conditions during spring 2015 Rainbow Trout spawner surveys in Williston Reservoir study tributaries.

Site	Date Surveyed	Approximate Stream Length Surveyed (km)	Water Temperature (°C)	Horizontal Visibility (m)
Six Mile	June 23, 2015	2.2	9.0	3.8
Lamonti	June 26, 2015	1.4	9.5	7.8
Ole	June 24, 2015	2.1	9.5	6.7
Factor Ross	June 25, 2015	1.7	9.0	2.3

Six Mile and Patsuk Creeks had a total of 84.9 m² and 4.5 m² of suitable spawning substrate over the assessed area, respectively in 2015 (Table 7). This is a reduction in area compared to 2014 (Table 7). However, not all suitable habitat was recorded in Patsuk Creek in 2015. Two inactive redds and one active redd were observed in Six Mile Creek above the confluence with Patsuk Creek. No active redds or Rainbow Trout were observed in Patsuk Creek. Two of the four mature Rainbow Trout observed within Six Mile Creek were on the active redd.

Lamonti Creek had the highest number of redds observed and only a single adult Rainbow Trout observed (Table 7). Four redds were identified, one of which had a single fish at the redd site. The area of suitable spawning habitat identified in the assessed portion of Lamonti Creek was 14.4 m².

No active redds were observed in Ole Creek or Factor Ross Creek (Table 7). Two Rainbow Trout (approximately 200 mm) were observed in Ole Creek in separate locations with no spawning habitat nearby. A single Rainbow Trout (approximately 200 mm) was observed in Factor Ross Creek during the survey with suitable spawning habitat near the observation (Table 8). In total, 18.5 m² and 24.3 m² of suitable spawning substrate was observed in Ole Creek and Factor Ross Creek, respectively in 2015 (Table 7).

Table 7. Summary of results from the 2014 and 2015 Rainbow Trout spawning surveys.

Site	Year	Spawning Habitat Area (m^2)	No. of Redds	No. of Rainbow Trout	Comments
Six Mile	2014	111	-	2	Two mature Rainbow Trout observed in area with no spawning habitat
	2015	84.9	3	4	Redds located upstream of Patsuk Creek confluence. Two of the Rainbow Trout observed in a large pool with no evidence of spawning activity.
Patsuk	2014	212	-	-	
	2015	4.5[a]	-	-	
Lamonti	2014	31.1	5	8	Rainbow Trout observations include 2 mature females and a spawning pair.
	2015	14.4	4	1	One adult Rainbow Trout observed on a redd.
Ole	2014	32.13	-	-	

	2015	18.5	-	2	Two Rainbow Trout in separate locations with no evidence of spawning activity.
Factor Ross	2014	34.8	-	-	Two mature fish observed, assumed to be salmonids
	2015	24.3	-	1	One Rainbow trout of approximately 200 mm length.

[a] – not all spawning habitat are was recorded in 2015

5.3 Vegetation Surveys

In Year 5 of the project, a total of ten habitat classes describing vegetation communities at enhancement and reference sites were identified and mapped, including ten habitat classes at Six Mile Creek, seven classes at Lamonti Creek, six classes at Ole Creek and seven at Factor Ross Creek. Habitat class BS, GS, SD, SF, SW and SP were common to all sites, whereas WH, WS and WW were only found at Six Mile Creek (Table 8). A total of 152 polygons were identified and mapped across the study sites covering 67.26 ha (Table 9). The number of polygons for each habitat class ranged from one (classes WW, SW, SP) to 18 (class GS) (Table 9). The percentage of total area covered by habitat classes ranged from 0.55% (class SW) to 36.48% (class SF) across all sites. A detailed description and photo-illustrations of habitat classes are provided in Appendix 8.

The most abundant habitat classes at the Six Mile Creek site (Figure 15) by number of polygons were GS (12 polygons) and SW (12 polygons) (Table 9). All other classes had nine or fewer polygons. By area, habitat classes BS and SF accounted for the largest area, covering 54.44% of the total area at the Six Mile Creek site. The next largest habitat class by area was class SP, accounting for 13.39% of the total area at this site. All other classes at this site had a cover of <9% (Table 9).

At the Lamonti Creek site (Figure 16), the most abundant habitat classes by number of polygons were GS (18 polygons), OV (six polygons) (Table 9). All other classes had four or fewer polygons. By area, habitat classes BS, SF, OV and SP, accounted for the largest area, covering 79.26% of the total area at the Lamonti Creek site. The next largest habitat class by area was class GS, accounting for 11.37% of the total area at this site. All other classes at this site had a cover of <6% (Table 9).

The most abundant habitat classes at the Ole Creek site (Figure 17) by number of polygons were GS (10 polygons and SD (three polygons) (Table 9). All other classes had two or fewer polygons. By area, habitat classes SF and BS accounted for the largest area, covering 65.01% of the total area at the Ole Creek site. The next largest habitat class by area was class GS, accounting for 16.60% of the total area at this site. All other classes at this site had a cover of <11% (Table 9).

For the Factor Ross site (Figure 18), the most abundant habitat classes by number of polygons were BS (11 polygons), SW (four polygons) (Table 9). All other classes had three or fewer polygons. By area, habitat classes SF and SP accounted for the largest area, covering 60.84% of the total area at the Factor Ross Creek site. The next largest habitat class by area was class BS, accounting for 17.26% of the total area at this site. All other classes at this site had a cover of <12% (Table 9).

Table 8. Habitat classification summary for enhancement and reference sites in Year 5.

Year 5		Site			
Habitat Class	**Habitat Class Description**	**Six Mile Creek**	**Lamonti Creek**	**Ole Creek**	**Factor Ross Creek**
BS	Basin Silt	√	√	√	√
GS	Gravel and Sand	√	√	√	√
OV	Organic Veneer	√	√		√
SD	Shoreline Driftwood	√	√	√	√
SF	Shoreline Forest	√	√	√	√
SW	Shoreline Willow	√	√	√	√
SP	Streams and Ponds	√	√	√	√
WH	Wetland Horsetail	√			
WS	Wetland Sedge	√			
WW	Wetland Willow	√			

Table 9. Number of polygons and area for habitat classes identified during photo interpretation for enhancement and reference sites in Year 5 (2015). Refer to Appendix 10 for detailed descriptions of the habitat classes.

Site	Habitat Class	Habitat Class Description	Area (ha)			
			Number of Polygons	Mean	Total	Percent of Total Area
Six Mile Creek	BS	Basin Silt	7	0.94	6.55	35.78
	GS	Gravel and Sand	12	0.08	0.93	5.05
	OV	Organic Veneer	9	0.17	1.49	8.16
	SD	Shoreline Driftwood	9	0.16	1.47	8.04
	SF	Shoreline Forest	4	0.85	3.42	18.66
	SW	Shoreline Willow	12	0.08	0.99	5.41
	SP	Streams and Ponds	3	0.82	2.45	13.39
	WH	Wetland Horsetail	3	0.07	0.20	1.09
	WS	Wetland Sedge	6	0.06	0.33	1.81
	WW	Wetland Willow	1	0.48	0.48	2.63
			66		**18.31**	**100.00**
Lamonti Creek	BS	Basin Silt	4	1.16	4.6382	28.16
	GS	Gravel and Sand	18	0.10	1.8727	11.37
	OV	Organic Veneer	6	0.35	2.0779	12.62
	SD	Shoreline Driftwood	4	0.22	0.8791	5.34
	SF	Shoreline Forest	3	1.45	4.3474	26.40
	SW	Shoreline Willow	2	0.33	0.6648	4.04
	SP	Streams and Ponds	4	0.50	1.9898	12.08
			41		**16.47**	**100.00**
Ole Creek	BS	Basin Silt	2	1.30	2.61	32.02
	GS	Gravel and Sand	10	0.14	1.35	16.60
	SD	Shoreline Driftwood	3	0.19	0.56	6.89
	SF	Shoreline Forest	2	1.34	2.69	32.99
	SW	Shoreline Willow	1	0.04	0.04	0.55
	SP	Streams and Ponds	1	0.89	0.89	10.90
			19		**8.14**	**100.00**
Factor Ross Creek	BS	Basin Silt	11	0.38	4.20	17.26
	GS	Gravel and Sand	3	0.91	2.72	11.18
	OV	Organic Veneer	2	0.28	0.56	2.30
	SD	Shoreline Driftwood	3	0.46	1.39	5.71
	SF	Shoreline Forest	2	4.44	8.88	36.48
	SW	Shoreline Willow	4	0.16	0.66	2.71
	SP	Streams and Ponds	1	5.93	5.93	24.36
			26	**0.94**	**24.34**	**100.00**

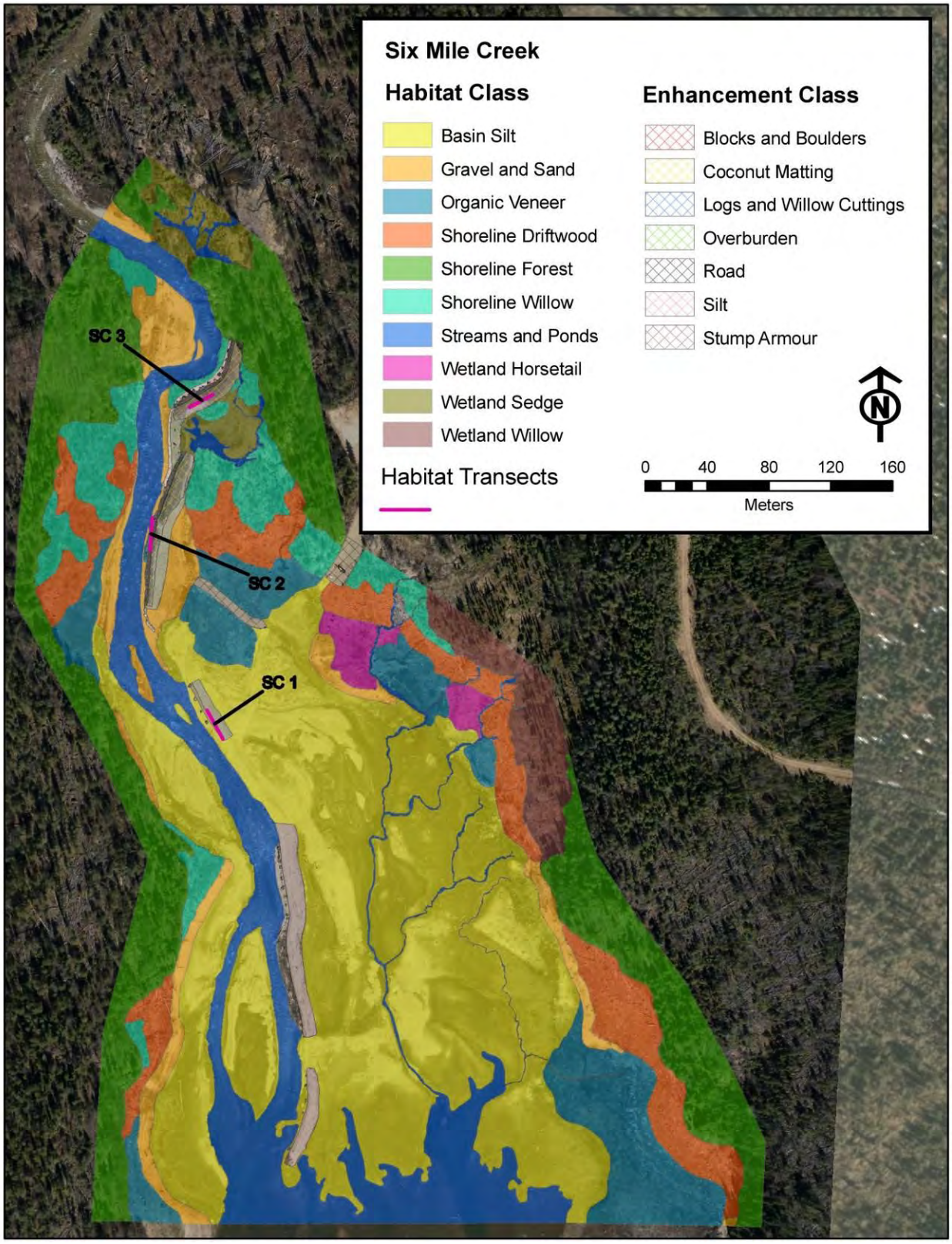

Figure 15. Habitat classes and transect locations at Six Mile Creek.

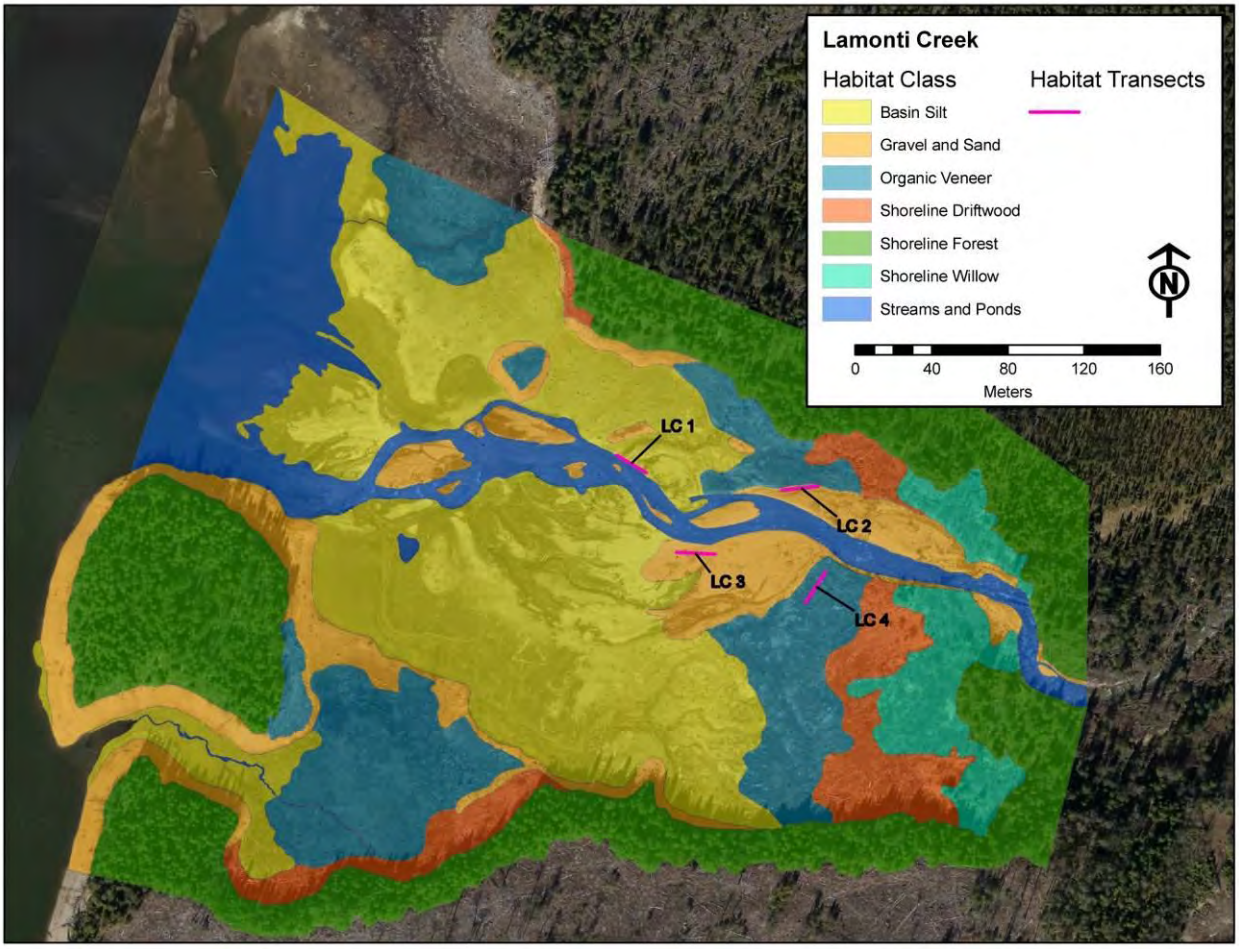

Figure 16. Habitat classes and transect locations at Lamonti Creek.

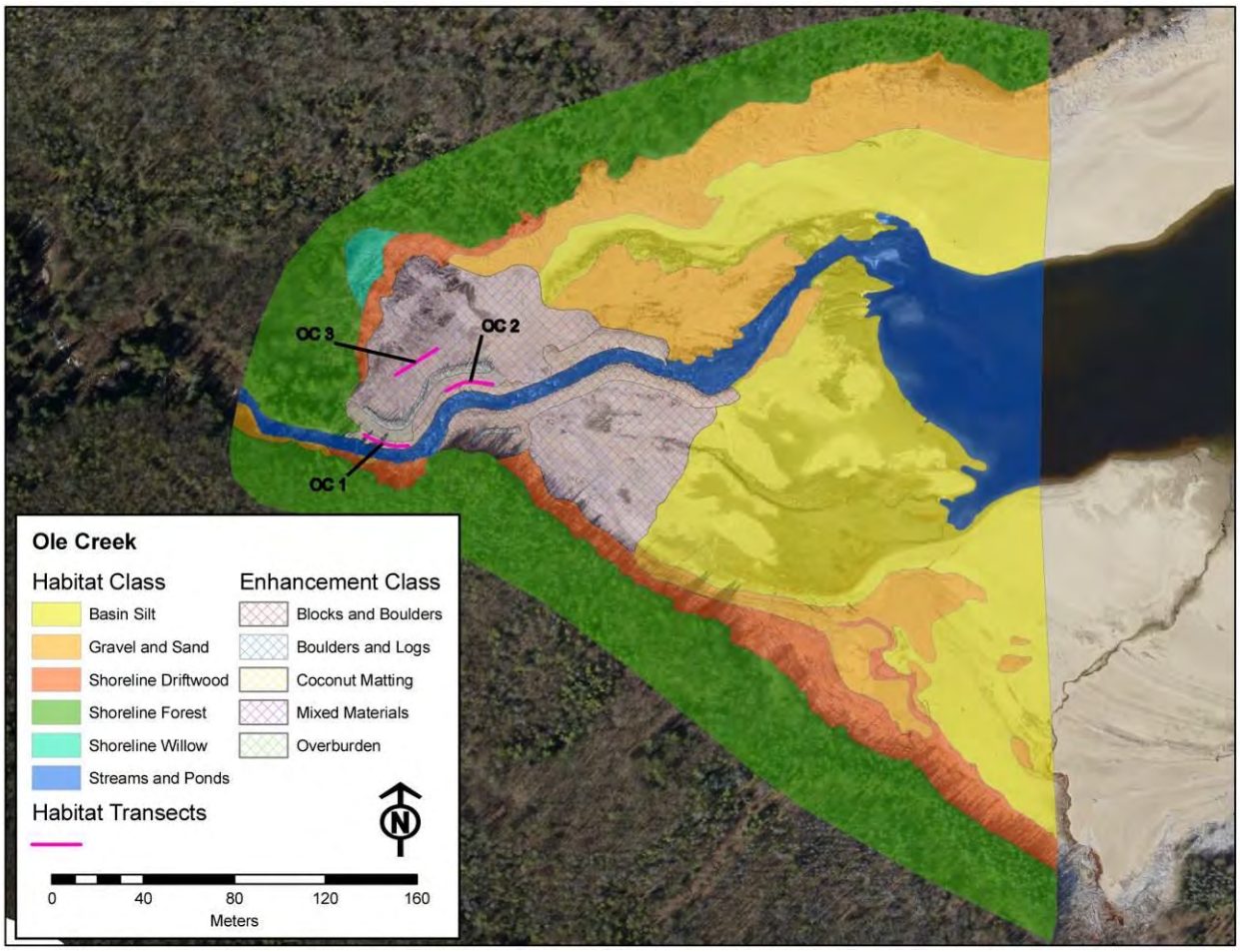

Figure 17. Habitat classes and transect locations at Ole Creek.

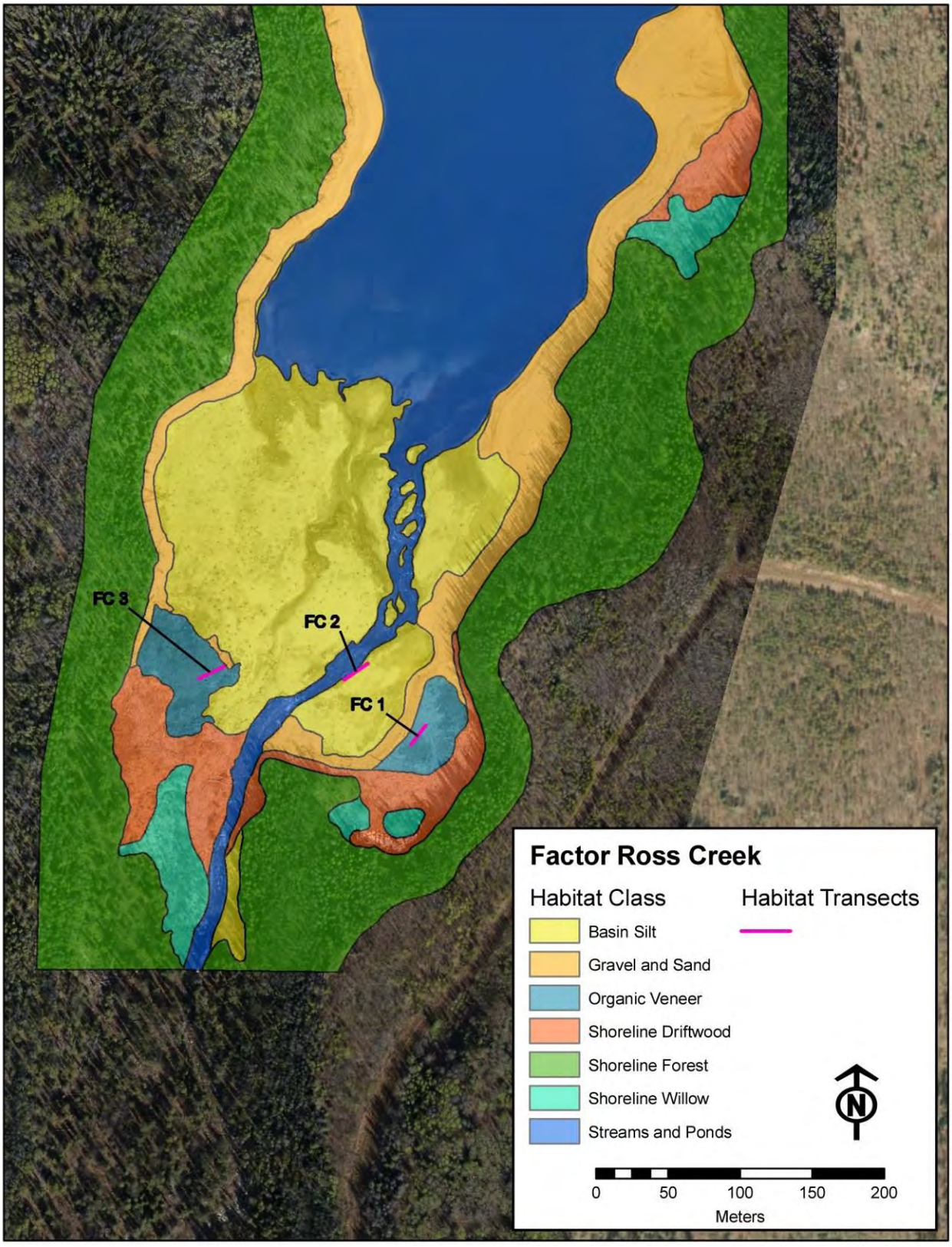

Figure 18. Habitat classes and transect locations at Factor Ross Creek.

A total of nine enhancement classes describing vegetation at Six Mile Creek and Ole Creek were identified and mapped, including seven classes at Six Mile Creek and five at Ole Creek. Enhancement class BB, CM and OB were common to all sites, whereas BL, LW, MM, RD, ST and SA were only found at one of the two sites (Table 10). A total of 46 polygons were identified and mapped across the two sites covering 1.62 ha (Table 11). The number of polygons for each enhancement class ranged from one (classes CM and OB) to 3 (class BB, CM and OB) (Table 11). The percentage of total area covered by enhancement classes ranged from 0.82% (class OB) to 75.11% (class MM) across both sites. A detailed description and photo-illustrations of enhancement classes are provided in Appendix 9.

The most abundant enhancement classes at the Six Mile Creek site (Figure 15) by number of polygons were BB, CM and OB (three polygons each) (Table 11). All other classes had two or fewer polygons. By area, enhancement classes ST and CM accounted for the largest area, covering 57.08% of the total enhanced area at the Six Mile Creek site. The next largest habitat class by area was class OB, accounting for 17.05% of the total area at this site. All other classes at this site had a cover of <13% (Table 11).

At the Ole Creek site (Figure 17), the most abundant enhancement class by number of polygons was BB (three polygons) (Table 11). All other classes had two or fewer polygons. By area, enhancement classes BB and MM accounted for the largest area, covering 94.23% of the total enhanced area at the Ole Creek site. All other classes at this site had a cover of <4% (Table 11).

Table 10. Enhancement classification summary for Six Mile and Ole Creek sites in Year 5.

Habitat Class	Habitat Class Description	Site	
		Six Mile Creek	Ole Creek
BB	Blocks and Boulders	√	√
BL	Boulders and Logs		√
CM	Coconut Matting	√	√
LW	Logs and Willow Cuttings	√	
MM	Mixed Materials		√
OB	Overburden	√	√
RD	Road	√	
ST	Silt	√	
SA	Stump Armour	√	

Table 11. Number of polygons and area for enhancement classes identified during photo interpretation for Six Mile and Ole Creeks in Year 5. Refer to Appendix 11 for detailed descriptions of the enhancement classes.

Site	Enhancement Class	Enhancement Class Description	Number of Polygons	Area (ha)		Percent of Total Area
				Mean	Total	
Six Mile Creek	BB	Blocks and Boulders	3	0.01	0.02	4.46
	CM	Coconut Matting	3	0.04	0.12	22.10
	LW	Logs and Willow Cuttings	2	0.02	0.04	7.44
	OB	Overburden	3	0.03	0.09	17.05
	RD	Road	2	0.04	0.07	12.98
	ST	Silt	2	0.10	0.19	34.98
	SA	Stump Armour	22	<0.01	0.01	0.99
			37		**0.55**	**100.00**
Ole Creek	BB	Blocks and Boulders	3	0.07	0.21	19.12
	BL	Boulders and Logs	2	0.02	0.03	3.13
	CM	Coconut Matting	1	0.02	0.02	1.82
	MM	Mixed Materials	2	0.40	0.81	75.11
	OB	Overburden	1	0.01	0.01	0.82
			9		**1.07**	**100.00**

Vegetation transects at the enhancement sites were located on enhancement structures or on areas disturbed by construction of enhancements and generally consisted of poor nutrient soils, with slight to moderate slopes, and flooding at these locations is expected to be frequent to annual flooding (Table 12). Vegetation on the enhancements consisted of both live and dead shrubs and herbs. Where willow stem cuttings were planted, survival varied. At Six Mile Creek, survival of willow stem cuttings appeared to be low to moderate. At Ole Creek, all stem cuttings planted during Year 4 (with the exception of 1 cutting that displayed a single live shoot) had died; the high mortality may have been due to the nature in which the cuttings were planted (e.g., shallow depth, damaged tissue from pounding into hard ground). Where structures were seeded with annual ryegrass, seeds germinated in both the Year 4 and Year 5 growing season, resulting in seeded areas with either established live grass cover or a matt of dead grass cover. Native plant species (e.g., Norwegian cinquefoil [*Potentilla norvegica*], marsh water cress [*Rorippa palustris*]) were also observed colonizing some of the enhancement structures at Six Mile and Ole Creek. However, these incidences did not amount to any significant vegetation cover. Photographs illustrating vegetation transects are provided in Appendix 10.

Vegetation transects at the reference sites were located on natural features (i.e., benches) and in close proximity to the main stream channel. Transects located on benches generally consisted of nutrient rich soils, with flat to slight slopes, and flooding is expected to be frequent to annual (Table 12). Transects located in close proximity to the stream channel consisted of nutrient poor soils with a slight slope and flooding is expected to be annual (Table 12). The structural stage of vegetation on the benches was graminoid-dominated (2b) and sparse on areas near the main stream channel. The surface substrate on the benches appear to be soils of past forest cover, consisting of a decomposed organic layer overlaying mineral layers (Table 12); surface

substrates along the main stream channels are mineral with little to no organic content (Table 12). Photographs illustrating vegetation transects are provided in Appendix 11.

Table 12. Site characteristics for vegetation transects sampled at enhancement and reference sites in Year 5.

Site	Transect	BGC Unit	Water Source[1]	Soil Moisture Regime[2]	Soil Nutrient Regime[3]	Successional Status[4]	Structural Stage[5]	Elevation (m)	Slope (%)	Aspect (°)	% Organic Matter[6]	% Rocks[6]	% Decayed Wood[6]	% Mineral Soil[6]	% Bedrock[6]	% Water[6]	Drainage[7]	Flood Regime[8]
Six Mile Creek	SC 1	SBSmk2	P	2	B	NV	1a	666	2	158	0	45	0	55	0	0	r	A
	SC 2	SBSmk2	P	2	B	NV	1a	671	2	182	83	10	1	6	0	0	r	F
	SC 3	SBSmk2	P	n/a	n/a	NV	1a	677	1	172	100	0	0	0	0	0	n/a	R
Lamonti Creek	LC 1	SBSmk2	F	5	A	DC	1a	663	1	210	0	7	1	87	0	5	r	A
	LC 2	SBSmk2	G	5	D	DC	2b	672	2	230	85	0	5	10	0	0	w	F
	LC 3	SBSmk2	F	1	A	NV	1a	670	1	294	0	65	1	34	0	0	f	A
	LC 4	SBSmk2	G	5	D	DC	2b	672	3	257	73	3	7	17	0	0	r	F
Ole Creek	OC 1	SBSmk2	P	2	B	NV	1a	680	38	188	0	18	4	78	0	0	r	R
	OC 2	SBSmk2	P	1	A	NV	1a	677	2	068	0	10	0	90	0	0	x	A
	OC 3	SBSmk2	G	3	C	NV	1a	675	4	048	0	4	11	85	0	0	r	A
Factor Ross Creek	FC 1	SBSmk2	P	5	D	DC	2b	676	1	014	5	4	5	86	0	0	r	A
	FC 2	SBSmk2	F	5	A	NV	1a	678	2	002	0	0	3	97	0	0	w	A
	FC 3	SBSmk2	P	5	D	DC	2b	677	1	012	88	0	2	10	0	0	w	A

[1] P=Precipitation, G=Groundwater, S=Snowmelt, F=Stream sub-irrigation and flooding, M=Mineral spring, T=Tidal, freshwater, E=Tidal, saltwater, Z=Permafrost
[2] 0=Very Xeric, 1 = Xeric, 2 = Subxeric, 3= Submesic, 4= Mesic, 5= Subhygric, 6=Hygric, 7=Subhygric, 8=Hydric
[3] A=Very poor, B=Poor, C=Medium, D=Rich E=Very rich, F=Saline
[4] NV=Non-vegetated, DC =Disclimax
[5] 2a= Forb dominated – includes non-graminoid herbs and ferns; 2b= Graminoid dominated – includes grasses, sedges, reeds, and rushes
[6] Values represent observations in 2014 (transects flooded during 2015 survey; these include SC1, LC1, LC3 and FC2) and 2015 (all others).
[7] v=very poorly drained, p=poorly drained =imperfectly drained, m=moderately well drained, w=well drained, r=rapidly drained, x = very rapidly drained
[8] A=annual flood, F=frequent flooding, O=occasional, R=rare flood

During Year 5 ground sampling for terrestrial vegetation, a total of 25 herb and two moss species were recorded across the 13 vegetation transects. Average percent herb cover by transect ranged from 0% to 14.7% (Table 13). Average percent moss cover ranged from 0% to 3.0%. A summary of the terrestrial plant species and percent cover for each transect is provided in Appendix 12.

Table 13. Vegetation cover for vegetation transects sampled at the tributary enhancement and reference sites in Year 5.

Site	Transect	No. herb species	Average % Herb cover	No. moss/ lichen species	Average % Moss/Lichen Cover	No. shrub species	Average % shrub cover
Six Mile	SC 2	9	9.9	1	0.7	0	0
	SC 3	0	0	0	0	0	0
Lamonti	LC 2	11	10.7	1	3.0	0	0
	LC 4	7	14.7	1	2.8	0	0
Ole	OC 1	3	4.1	0	0	0	0
	OC 2	2	1.0	0	0	0	0
	OC 3	6	0.8	0	0	0	0
Factor Ross	FC 1	10	9.3	0	0	0	0
	FC 3	8	7.9	1	1.2	0	0

Values represent the number of species and the average % cover based on plot surveys completed in 2015.

A majority of the terrestrial plant species observed at the study sites during Year 5 ground sampling were common to habitat classes located in the upper elevations of the drawdown zone (e.g., habitat class OV and SD). Areas in the lower elevations of the drawdown zone (e.g., habitat class SG, BS) were are either sparsely vegetated or non-vegetated. Examples of the most common species observed along vegetation survey transects (observed at 3 or more transects) included grasses (Gramineae) sedges (*Carex* spp.), common horsetail (*Equisetum arvense*), water sedge (*Carex aquatilis*) and purslane speedwell (*Veronica peregrina* var. *xalapensis*). From general observations of vegetation at the sites, plant species observed to be common within the drawdown zone (but not necessarily observed along the survey transects) included bluejoint (*Calamagrostis canadensis*), swamp horsetail (*Equisetum fluviatile*), dwarf scrouring-rush (*Equisetum scirpoides*), Norwegian cinquefoil (*Potentilla norvegica*) and tower mustard (*Turritis glauca*).

5.4 Amphibian Surveys

A total of 232 amphibians were observed or captured through the 2015 field season (Table 14). Western toads were encountered and caught more frequently than any other species. A 100% encounter rate occurred for western toads in the drawdown zone during night surveys. Encounter rates were highest during the June surveys and during night time surveys at Six Mile and Ole where specific effort was allocated to include night surveys (Figure 19). Detection as a function of occupancy for resurvey of plots during the daytime is moderate for Lamonti (33% detection; Figure 20), Factor Ross (38% detection; Figure 21), and Ole (41% detection; Figure 22) and low for Six Mile (17% detection; Figure 23). Data for 2012-2013 are not included as the locations are ambiguous for amphibian species detections reported in Golder (2013, 2014).

Table 14. Amphibian detections (observations + captures) by species and location in Year 5.

Species	Six Mile	Lamonti	Ole	Factor	All Sites
Western toad	32	5	40	18	88
Columbia spotted frog	4	1	4	38	47
Wood frog	0	1	7	26	34
Long-toed Salamander	0	1	2	8	11
Ranidae sp?	3	0	1	18	22

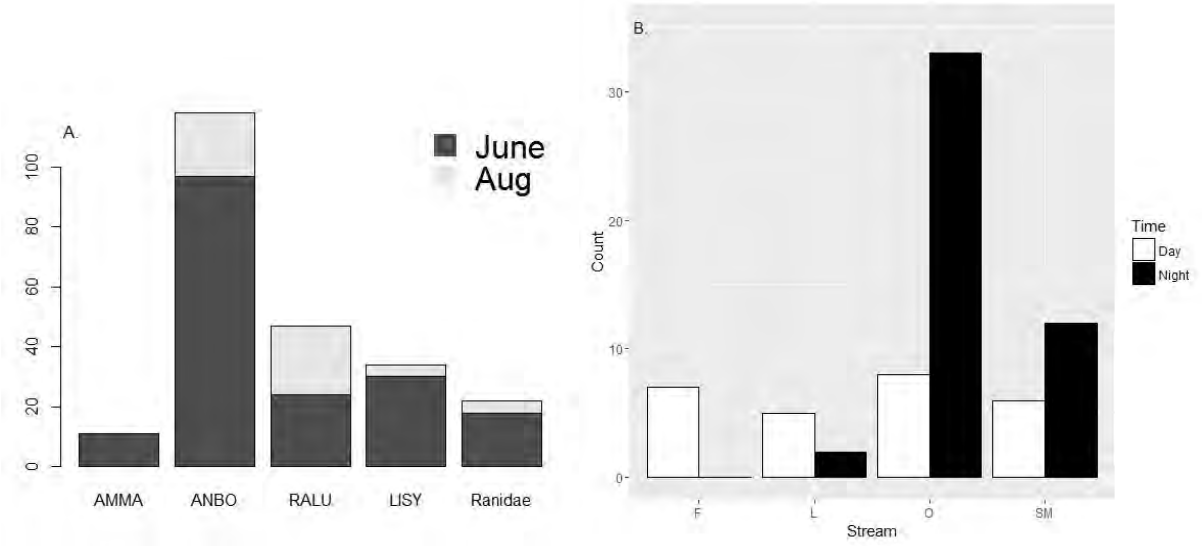

Figure 19. a) Amphibian species detection counts by month of survey, b) detection counts by night and day. (AMMA = *A. macrodactylum*, ANBO = *A. boreas*, LISY = *L. sylvaticus*, RANID = RALU or LISY.

Key	
Not Visited	AMMA
No Detect	ANBO
LISY	RALU

		Lamonti											
		LA1	LA1.01	LA1.02	LA1.03	LA1.04	LA2	LA2.01	LA2.02	LA2.03	LA3.01	LA5.01	LA5.02
2011													
2014	June												
	July												
2015	June												
	Aug												

Figure 20. Upland plot survey for Lamonti by year and species detection.

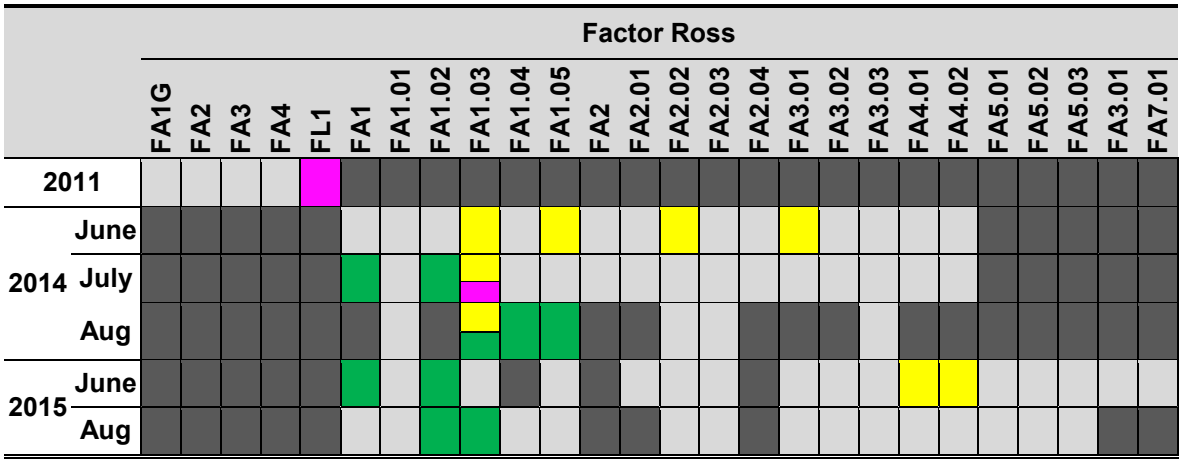

Figure 21. Upland plot survey for Factor Ross by year and species detection; key as in Figure 20.

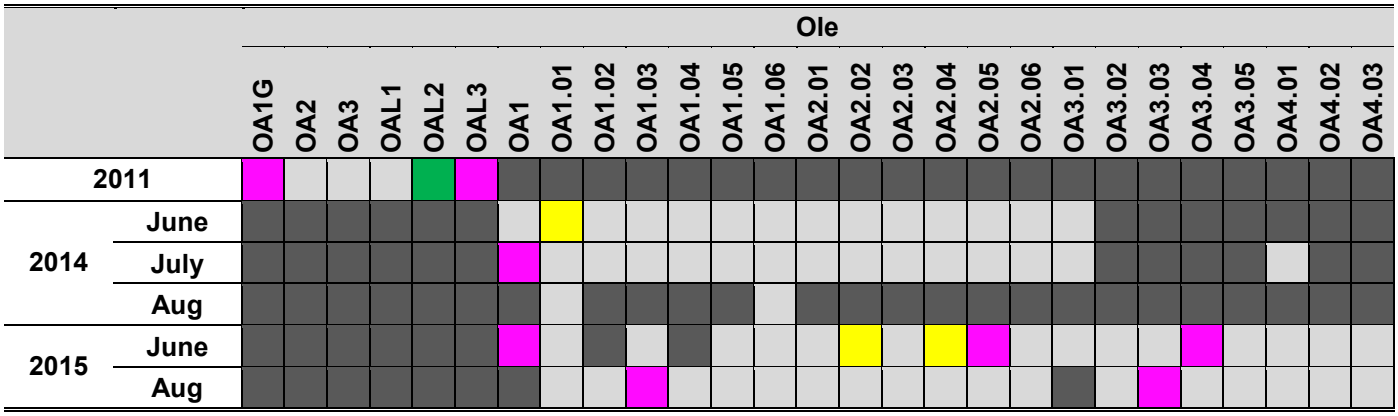

Figure 22. Upland plot survey for Ole by year and species detection; key as in Figure 20.

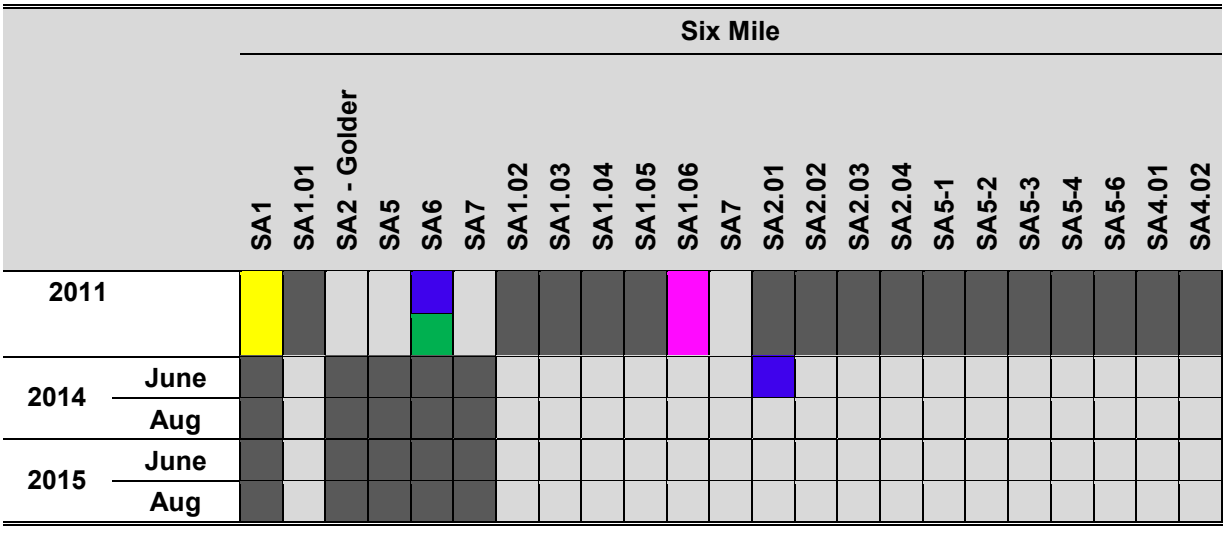

Figure 23. Upland plot survey for Six Mile by year and species detection; key as in Figure 20.

No recaptures of individuals were identified by using of the I3S (Speed et al. 2007, Moya et al. 2015) matching software. A total of 23 of the 24 toads that were re-marked independently by a second technician were always paired together as the top choice in the list of possible matched candidates identified by the I3S software. The single toad that was not properly paired was ranked #17 in the match list, which was likely due to dirt and debris on its skin and the individual's body was also contorted at the posterior (Figure 24).

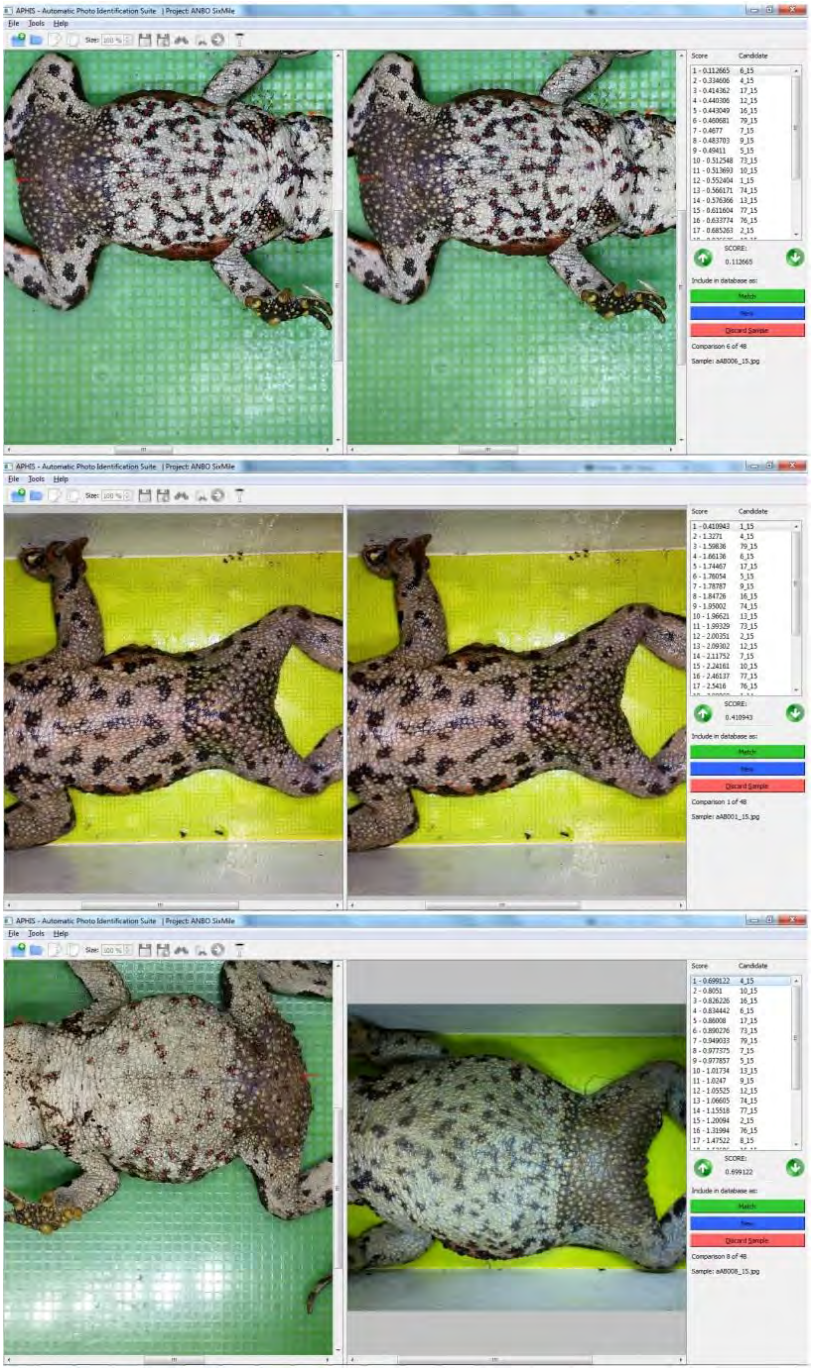

Figure 24. Panel images of I3S independent toad matching. Top two panels show independently scored toad images that matched. Bottom panel shows the single mismatch out of 24 comparisons.

Standard deviations for detection rates were nearly as large as the estimates for occupancy in all scenarios tested (data not shown). Estimates from the detection data (i.e., $\bar{\psi}$ = total number of detections / total number of survey sites) provide sample estimates of occupancy for each site, without proper accounting for probabilities for resampling gives: Six Mile = 0.11, Lamonti = 0.08, Ole = 0.35, Factor = 0.40. Using GENPRESS simulation data from Guillera-Arroita and Lahoz-Monfort (2012) and assuming a low probability of detection (p = 0.2) and the calculated estimates of occupancy suggests that from 150-500 sites need to be resampled six times at each location to achieve power 0.8 to detect a decline in occupancy.

An r-stat's pairplot of Year 5 western toad morphometric data from all sites is illustrated as an example of the morphometric data pattern (Figure 25). An outlier was identified in the data that was re-assessed as an incorrect measurement entry by re-measuring from the original photo record. Only the Year 5 data is illustrated in detail because the sample sizes are large enough to give potentially biologically meaningful results. Data from all the sites are included in the pairplot illustration (Figure 25) where the same general pattern exists between sites. The raw morphometric data are not normally distributed (Shapiro-Wilk normality test, p = 0.05) and a bimodal shape is apparent in the histograms (Figure 25). However, Six Mile data was not significantly different from normality and this may be due to the larger sample size from this location. The data were log transformed to account for non-normality, which improved the distribution and was used for all subsequent analyses.

Western toad captures at Factor Ross Creek were generally smaller, possibly indicating that younger individuals were preferentially captured or are more abundant at this location, but could also be an artifact of sampling during daytime only at this location due to access limitations (Figure 26). There is a pattern of significantly larger western toads being captured during night-time surveys (Figure 27); which is in agreement with a best fit likelihood model that was fitted to the data. There is a significant size difference (SUL and GW) in western toads (ANOVA analysis, p = 0.05) between sites, between night-time and day-time surveys (Figure 26 and Figure 27), and there is also a bias of more female being detected (Figure 28). Gender differences are analyzed and presented for western toads only as sample sizes were too small for other species where the gender could be distinguished. More female toads were captured at all sites than males and females were slightly larger on average (Figure 28). Gender differences is shown separately from pooled data of all stream sites for Six Mile and Ole as detection rates were higher at these locations (Figure 28).

Visual inspection of comparative plots and tests for normality and correlation between GW and SUL indicate that Six Mile data exhibits a more normal distribution, while Ole exhibits a non-normal bimodal pattern; effects of small sample size are apparent for other sites (

Table 15). While there is a general correlation between GW and SUL graphing of data shows how the variance in SUL is greater for all anurans (Figure 29); GW is not measured for long-toed salamanders, but BA is illustrated for comparison. All morphometric data in the long-toed salamander are normally distributed (Table 16). Tail length (=TaL) is not significantly correlated with most of the morphometrics and is only significantly correlated with the total length (ToL) of the animal.

A total of 3 breeding pairs of toads were observed in amplexus (Figure 30) during a night-time survey in a slow flow inlet formed by the earth berm barrier that separated this area from the fast flow of Six Mile Creek. Adult toads were also observed migrating along the periphery of the water and on the constructed earth berm itself. A wood frog was detected at the bottom of Six Mile Creek (Figure 31) during fish spawner surveys, which offers important insight into stream as habitat for this species. Drawdown zone water levels were higher than average in 2015 and completely flooded the wetland area nearest the drawdown zone at Six Mile Creek. Flooding at this location prevented recruitment in Year 5 as so no long-toed salamander eggs or tadpoles were detected at this site as they were in Year 4. A new type of upland microhabitat was discovered for the long-toed salamander at Factor Ross Creek. Salamanders were detected deep in burrows under the bark of partially decomposed birch logs (Figure 32). These logs were mostly hard and intact except for decay along the top-most exposed portion. The salamanders were exposed by cutting the bark with a knife and peeling it back to reveal the burrow. Four individuals were located at two separate locations using this survey method.

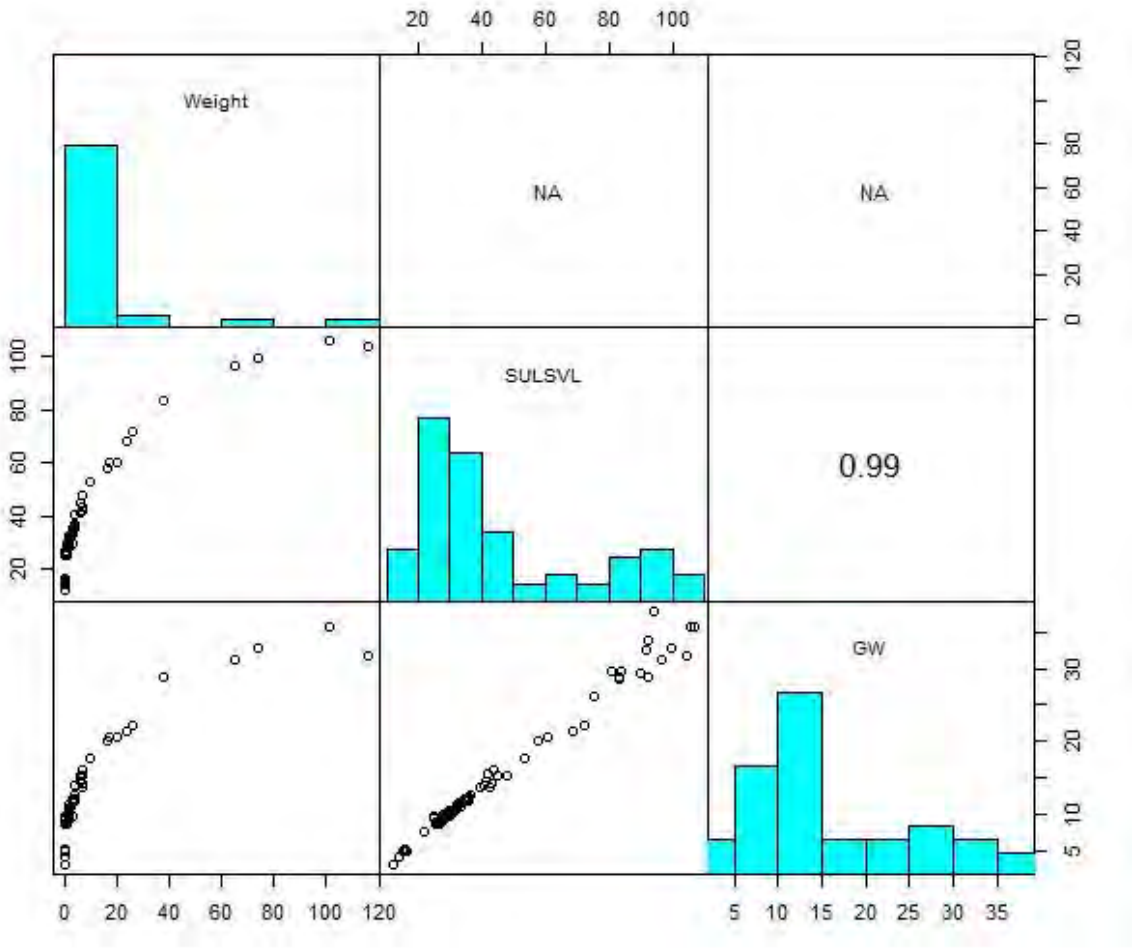

Figure 25. Pairs plot for western toad (lower panels), histograms of morphometric data (diagonal), and correlation coefficients (upper panels).

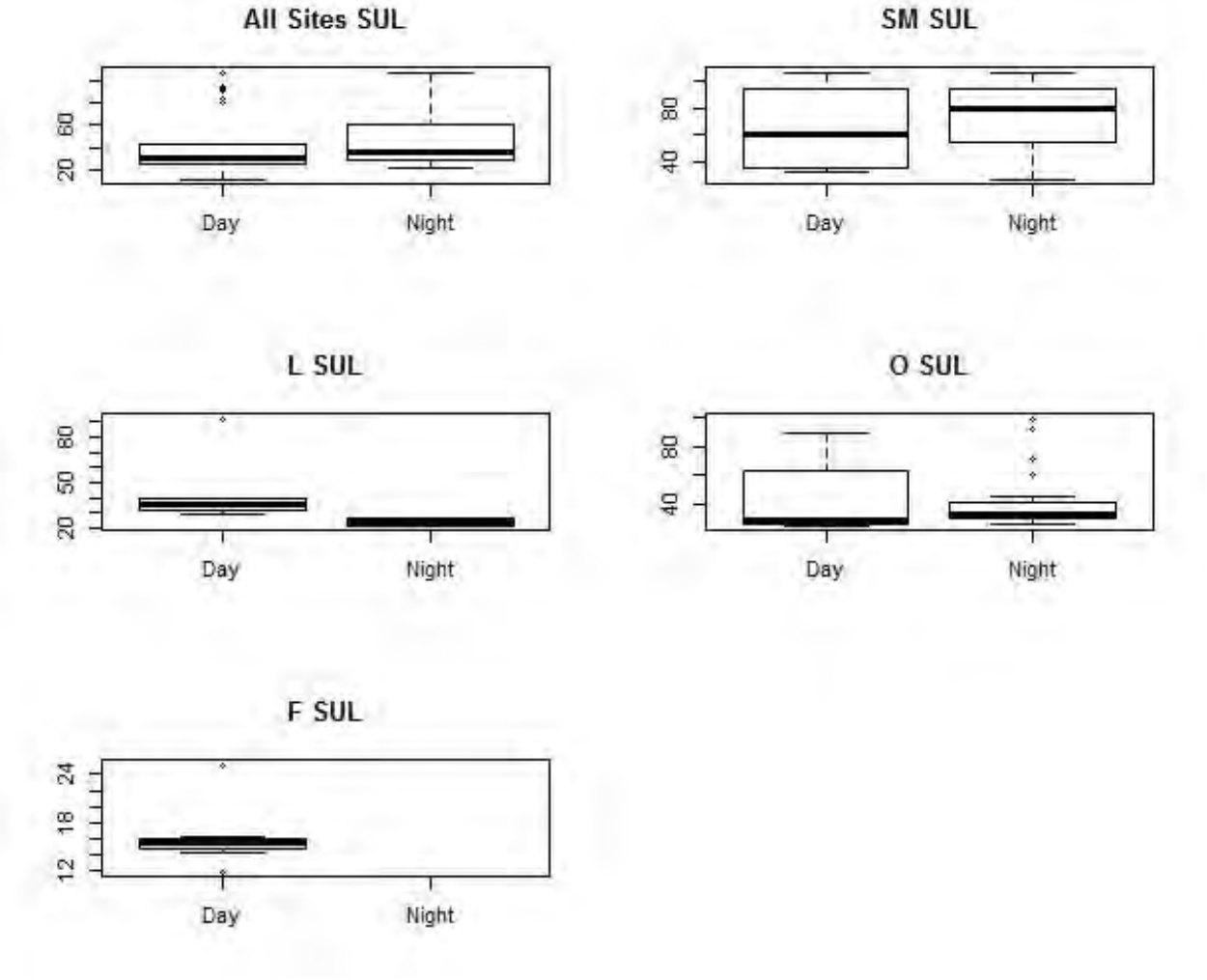

Figure 26. Box plots of western toad snout-to-urostyle (SUL) lengths in 2015 relative to time of survey (Day v. Night) and by stream site (SM = Six Mile, L = Lamonti, O = Ole, F = Factor).

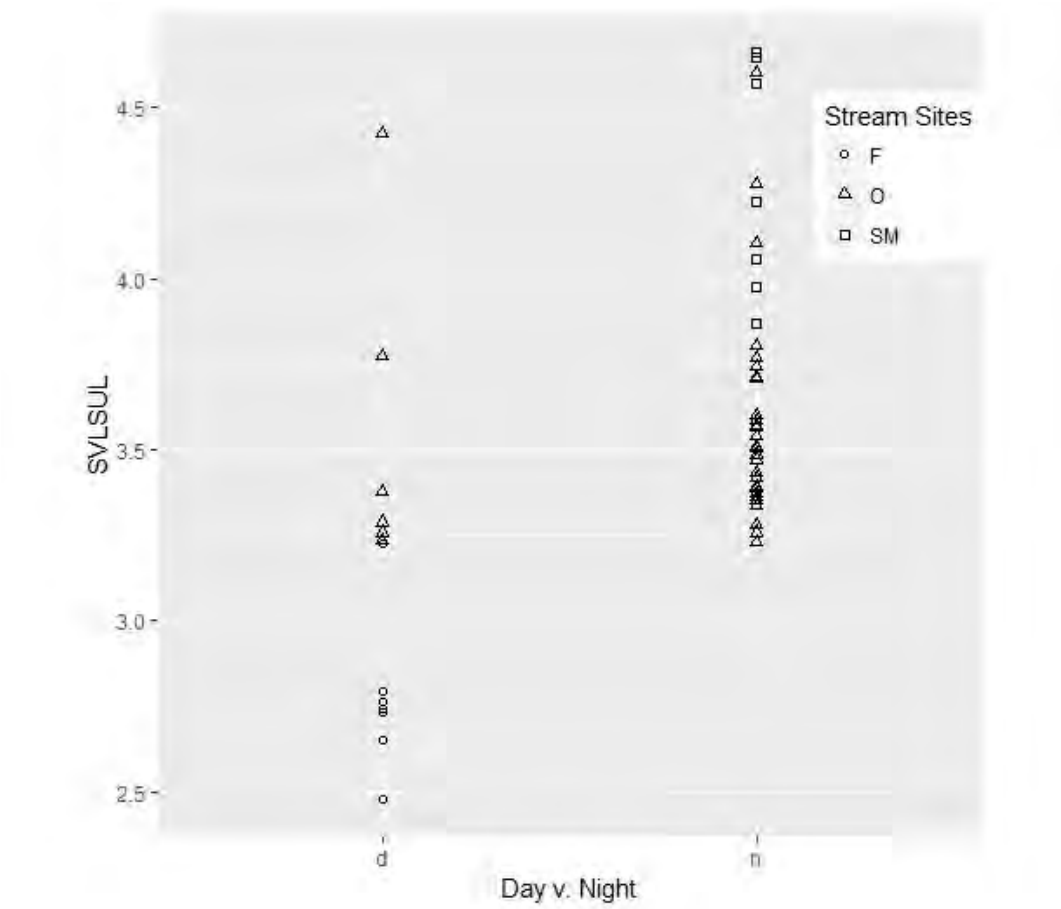

Figure 27. Graph showing the spread of sizes of individuals captured by snout-to-urostyle (SVLSUL) length relative to time of survey (Day v. Night), and with stream site (F= Factor, O = Ole, and SM = Six Mile).

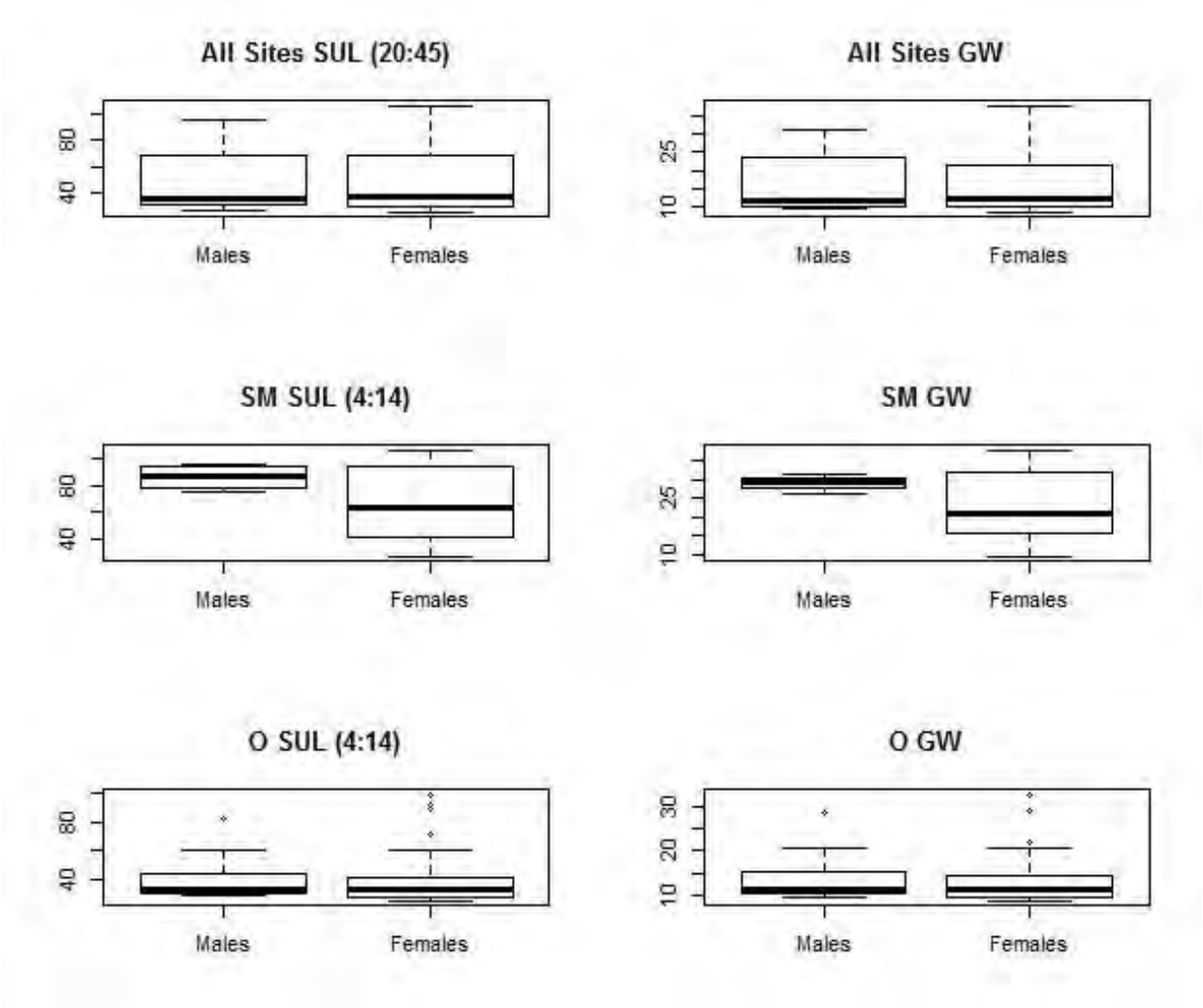

Figure 28. Boxplots of morphometric data by gender for all sites pooled, Six Mile (SM), and Ole (O); the ratios indicate sample sizes of Males:Females.

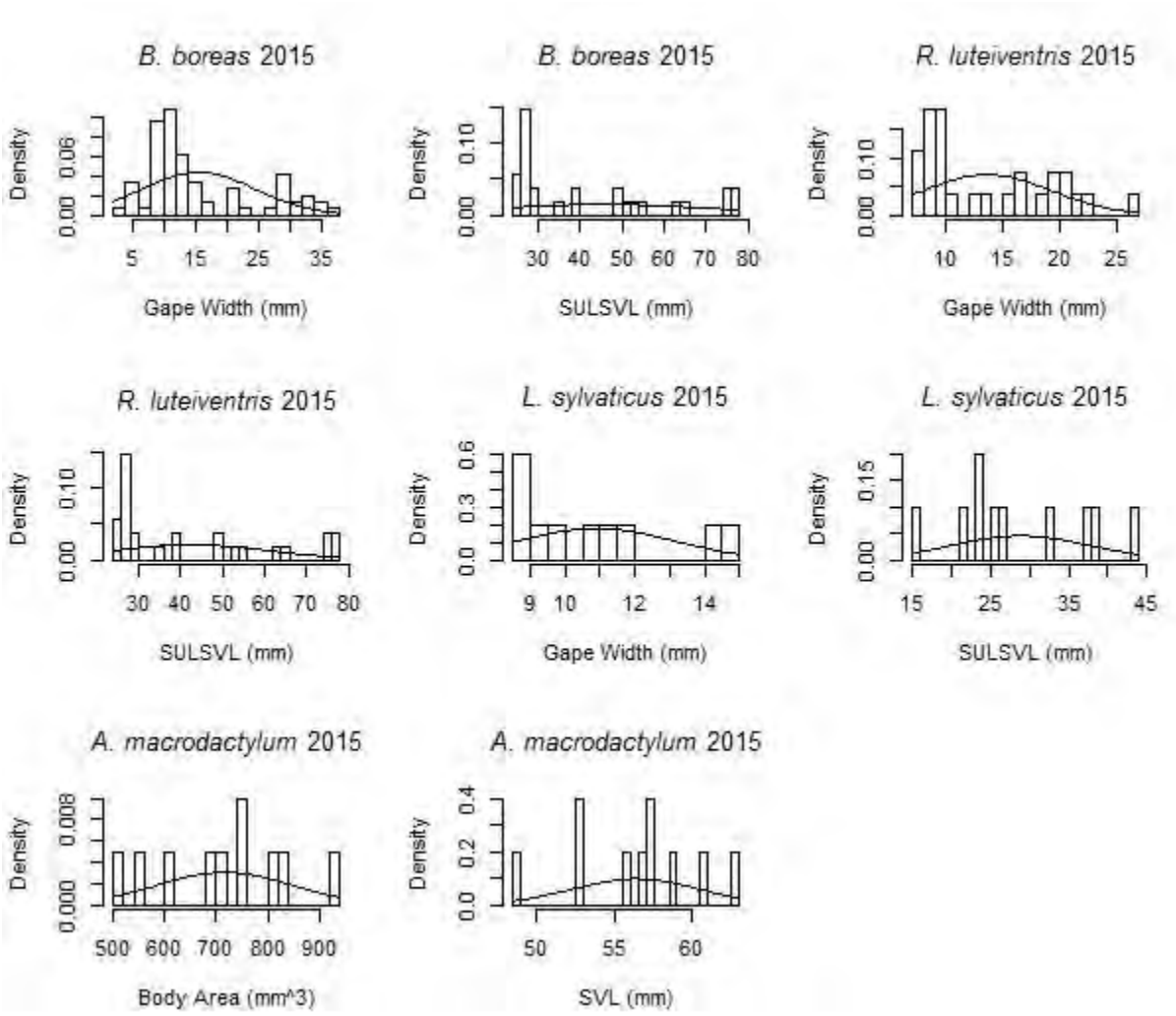

Figure 29. Density histograms of morphometric data showing the spread and general pattern for the different species pooled for all study sites.

Table 15. Summary statistics showing tests for normal distribution and correlation; normally distributed data ($p > 0.01$) were tested for correlation.

Species	Site	*n*	Shapiro-Wilk Normality (*p*)		Spearman Correlation	
			SUL	GW	Rho	*p*
Western toad	Six Mile	18	0.1759	0.5452	0.9256966	2.20E-16
	Lamonti	7	0.002889	0.001855	NA	NA
	Ole	41	1.10E-07	0.01295	NA	NA
	Factor	7	0.02458	1.06E-07	NA	NA
	All Sites	73	1.60E-07	1.46E-07	NA	NA
Columbia spotted frog	Six Mile	4	0.2766	0.7793	1	0.08333
	Lamonti	1	NA	NA	NA	NA
	Ole	2	NA	NA	NA	NA
	Factor	20	3.34E-05	0.0001456	NA	NA
	All Sites	27	0.0002859	0.001861	NA	NA
Wood frog	Six Mile	0	NA	NA	NA	NA
	Lamonti	1	NA	NA	NA	NA
	Ole	3	0.7237	0.08518	1	0.3333
	Factor	6	0.02478	0.07285	0.7714286	0.1028
	All Sites	10	0.6479	0.08916	0.769697	0.01367

Table 16. Morphological summary statistics for long-toed salamander adults showing tests for normal distribution and correlation; normally distributed data ($p > 0.01$) were tested for correlation.

Shapiro-Wilk Normality		Spearman Correlation					
p	*n*						
SVL		**SVL**	**STG**	**ToL**	**VL**	**TaL**	**BA**
0.8934	6		0.885714	0.771429	0.885714	0.714286	0.942857
STG							
0.9571	6	**0.03333***		0.942857	0.828571	0.828571	0.942857
ToL							
0.712	6	0.1028	**0.01667***		0.771429	0.942857	0.828571
VL							
0.5211	6	**0.03333***	0.05833	0.1028		0.828571	0.942857
TaL							
0.8883	6	0.1361	0.05833	**0.01667***	0.05833		0.771429
BA							
0.7225	6	**0.01667***	**0.01667***	0.05833	**0.01667***	0.1028	

Figure 30. Western toads mating in amplexus at Six Mile Creek.

Figure 31. Wood frog situated on underwater substrate at Six Mile Creek.

Figure 32. Long-toed salamander burrows (A & F) discovered under the bark of relatively intact pieces of birch (*Betula papyrifera*). Panels B-C show one individual in the burrow of the log in Panel A. Panel D shows a break in the log where an entry route was exposed for the log in Panel A. Panel E exhibits another log where two individuals were found together (F) in a single burrow.

5.5 Songbird and Waterbird Surveys

Songbird and waterfowl abundance were slightly higher in 2015 (72 detections including 81 individuals) than in 2014 (62 detections including 66 individuals) (Table 17). Detections within the 75 m survey radius in Year 5 were higher at Lamonti and Ole Creeks when compared to the previous year. They were consistent at Factor Ross Creek and slightly lower at Six Mile Creek (Table 17). No species at risk were detected. However, the Cape May Warbler, a provincially blue listed species, was detected at Lamonti Creek.

Table 17. Summary of all songbird, waterfowl, and shorebird detections at Six Mile, Lamonti, Ole, and Factor Ross Creeks in the 2014 and 2015 surveys.

Group	Metric	Site										
		Six Mile 1		Six Mile 2		Lamonti 1		Lamonti 2	Ole		Factor Ross	
		2014	2015	2014	2015	2014*	2015	2015	2014	2015	2014	2015
Songbirds	Species	12	4	7	6	4	15	10	9	13	8	8
	Detections	17	4	9	8	6	19	10	12	17	11	10
Waterfowl	Species	2	1	-	-	1	4	-	1	0	1	1
	Detections	3	1	-	-	2	11	-	2	0	1	1
Shorebirds	Species	1	1	-	-	1	1	-	1	0	1	1
	Detections	8	6	-	-	4	4	-	1	0	2	3
Totals	Species	15	6	7	6	6	20	10	11	13	10	10
	Detections	28	11	9	8	12	34	10	15	17	14	14

*A single transect was used for 2014 surveys at Lamonti Creek.

Species richness within the 75 m survey radii and the waterfowl surveys was also slightly higher in 2015 (33 species) than in Year 4 (27 species). Observations beyond the 75m radii included four additional species (Pacific Wren, Red-breasted Sapsucker, Townsend's Warbler, and Common Loon). A total of seven species recorded during Year 4 surveys were not detected during the 2015 surveys and nine species not detected in 2014 were observed this year (Table 17). Most notably the Olive-Sided Flycatcher not detected this year and the Cape May Warbler not recorded in 2014, are both provincially blue listed species.

Table 18. Summary of differences between species detected during the 2014 and 2015 surveys.

Detected in 2014 but not in 2015	Detected in 2015 but not in 2014
Black-Backed Woodpecker	Black-Capped Chickadee
Blackpoll Warbler	Cape May Warbler*
Common Raven	Cassin's Vireo
Northern Rough-Winged Swallow	Common Merganser
Olive-Sided Flycatcher*	Dusky Flycatcher
Song Sparrow	Green-Winged Teal
Western Wood-Pewee	Magnolia Warbler
	Ruby-Crowned Kinglet

*Provincially Blue Listed Species.

In Year 5, waterfowl species were detected at all sites with the exception of Ole Creek. Species diversity and abundance were highest at Lamonti Creek where Common Merganser, Lesser Scaup, Green-Winged Teal, and Canada Goose were detected. Common Merganser was also detected at Six Mile Creek and a single Common Loon was observed at Factor Ross Creek. Goldeneye present in Year 4, were not detected in 2015.

The only shorebird species recorded during the 2015 survey effort was the Spotted Sandpiper. They were detected at all sites with the exception of Ole Creek and were most abundant at Six Mile Creek (7 individuals). No nests were detected during the Year 5 effort.

6 DISCUSSION

The results presented in this report are from the fifth year of a ten-year monitoring program. The focus of field activities in Year 5 was to continue data collection at each site following the previously established methods for fish, vegetation, amphibians, songbirds, and waterbirds. The only exception to this were the August juvenile fish surveys which were removed from the study following revisions to the Terms of Reference midway through the Year 5 (BC Hydro 2015). The tributary access enhancement projects were completed at both Six Mile and Ole Creeks in late May and early June 2014, so the data collected from both of these sites in Year 5 is the first year of post-construction observations. The data collected from Lamonti and Factor Ross Creeks adds to the baseline data for the two control sites. A summary of the progress towards addressing the management questions and hypotheses is provided in Table 19.

Table 19. The status of the GMSMON-17 management questions and hypotheses following completion of Year 5 of the monitoring program.

Management Question	Management Hypothesis (Null)	Year 5 (2015) Status
Does access for spring spawners (i.e., Rainbow Trout and/or Arctic Grayling) improve as a result of enhancement?	H_{01}: Access to spawning habitat in the spring period – as measured by the proportion of modified channel with sufficient depth for target fish passage – does not increase following enhancements to tributaries.	Year 5 is the first year of post-construction monitoring. It is not yet possible to determine if the enhancements have improved access. Additional monitoring and analysis will be required.
Is the area and quality of fish habitat created by the tributary enhancement maintained over time?	H_{02}: Total rearing area for fish does not increase following enhancement to tributaries	With only a single year of post-construction data it is not possible to comment on the long term persistence and quality of habitat. Additional monitoring and analysis will be required.
Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?	H_{03}: Riparian vegetation abundance and diversity along the tributaries does not increase following enhancement to tributaries;	No changes in riparian vegetation have been detected in the first year of post-construction monitoring. Additional monitoring will be required for the testing of this hypothesis.
Does amphibian abundance and diversity in tributaries change as a result of enhancement?	H_{04}: Amphibian abundance and diversity in and near tributaries does not change following tributary enhancement	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.
Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?	H_{05}: Total amphibian breeding area does not change following enhancement	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.
Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?	H_{06}: Song bird abundance and diversity near tributaries does not increase following tributary enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.

Management Question	Management Hypothesis (Null)	Year 5 (2015) Status
Does abundance and diversity of waterfowl and shorebirds around tributaries change as a result of enhancement?	H_{07}: Waterfowl and shorebird abundance and diversity near tributaries does not change following tributary enhancement.	Testing of this hypothesis is not yet possible as Year 5 is the first year of post-construction monitoring. Additional monitoring will be required.

6.1 Environmental Conditions

The general conditions observed at the Parsnip and Finlay Reach sites in Year 5 were similar to those observed in the previous two years of the project and close to average values. The regional snowpack for the winter of 2014-2015 was below average for the Pine Pass station (Parsnip Reach sites) and close to average for the Aiken Lake station (Finlay Reach sites). The similarity in regional snowpack over Years 3, 4, and 5 also resulted in similar water levels in Six Mile and Ole Creeks for all three years. The lower water levels after spring freshet are likely a combination of the lower snowpack in the winter of 2014-2015, earlier melt, and below average spring precipitation (particularly in May). Water levels recovered later in the summer as a result of near average precipitation and cooler temperatures. Peaks in stream flows in both streams usually corresponded with regional rainfall events.

Air temperatures recorded at both Six Mile and Ole Creeks in Year 5 followed similar patterns with Ole Creek air temperatures almost identical to those observed at Six Mile Creek. The same pattern was true for water temperatures at both sites but with cooler temperatures observed in Ole Creek. The water temperatures warmed earlier in both Six Mile and Ole Creeks in Year 5 and exceeded 5°C on an earlier date compared to the previous two years. This period also coincides with the predicted and observed spawning time for Rainbow Trout and likely contributed to the spawning survey results in Year 5. Other than the early initial warming, the only other difference in water temperatures in Year 5 was the cooler temperatures in both creeks beginning in late July and continuing through August.

The rating curves and stage discharge tables were updated for both Six Mile and Ole Creeks based on the manual discharge measurements recorded across a variety of discharge levels in Year 5. Re-surveying the gauging stations and stream cross-sections will be required in future years to confirm that the staff gauges have not moved and that the stream cross-section profiles do not change.

6.2 Fish

6.2.1 Tributary Access and Fish Habitat

As in Year 4 (DWB and CBA 2015), the only physical barrier to upstream fish passage was observed during the early May survey in Factor Ross Creek (Appendix 4, Map 4). The two cascades created by woody debris were observed in the lower portion of Factor Ross Creek but at a location further upstream than in Year 4. While the cascades may have limited some fish passage, they were not considered complete barriers to upstream migration by adult spawning Arctic Grayling or Rainbow Trout. The barriers were also observed on a single braid of the channel and no barriers were present in the other braids. Both barriers were close to the confluence with the reservoir and would be submerged by the time spawning Rainbow Trout would likely be migrating upstream. No physical barriers to upstream fish access were observed in any of the four project streams in the first three years of the monitoring program (2011-2013) (Golder 2012, 2013, 2014).

Of the four streams, Factor Ross Creek had the highest level of habitat complexity in the drawdown zone as a result of stream channel interaction with an abundance of stumps and LWD (Appendix 4, Map 4). The debris created small to large pools and eddies that provide cover and resting areas for fish. Stumps were not as visible at the other streams and were considered to have been either washed away due to more consistent flows through the drawdown zone or buried by sediment deposits resulting in longer riffles. Based on the amount of woody debris present in the drawdown zone at Factor Ross Creek, this site is likely to continue to have the highest habitat complexity of the four streams. The location of habitat features and any barriers in Factor Ross Creek is expected to be highly variable from year to year.

While the highest level of habitat complexity was observed at Factor Ross Creek, the drawdown zone portion of all four streams was considered lower quality habitat consisting of heavily braided shallow channels, long fast-flowing riffles, with little to no cover, pools, or resting areas despite the lack of physical or debris blockages. However, the access enhancements completed at Six Mile and Ole Creek in 2014 have reduced the amount of braiding present in both of these streams in the area of the enhancements, particularly in Ole Creek. The channelization of both streams has increased water depth and is expected to result in changes to channel morphology that will assist in fish passage. The deeper riffles with large substrate offer more cover due to surface turbulence than the shallow riffles with smaller substrates that existed prior to enhancement works. Braiding processes may continue to dominate at elevations below the access enhancements but the extent may be altered by the upstream changes. No changes in the extent of channel braiding at the enhancement sites could be assessed in Year 5 due to the well above average reservoir elevation during the spring habitat survey.

The lack of suitable habitat and the cold temperatures experienced in the early spring in the drawdown zone were considered to be potential deterrents to fish migration upstream from the reservoir despite the presence of more suitable habitats upstream (Binder and Stevens 2004, Golder 2014). The first year of post-construction observations in Year 5 suggest that the access enhancements may have resulted in some improvements to fish passage in Six Mile and Ole Creeks. Both control sites (Lamonti and Factor Ross Creeks) are expected to be highly variable in the drawdown zone but fish passage in both creeks is facilitated by small scale habitat features created by buried woody debris. The identification of Rainbow Trout in Six Mile, Lamonti, and Factor Ross Creeks as well as redds in Lamonti and Six Mile Creeks suggests that adfluvial fish are moving upstream by the late spring in those streams. Upstream migration in 2015 was likely also aided by the high reservoir levels that reduced the length of stream in the drawdown zone.

The maximum reservoir level of 671.47 m in Year 5 was above average and was 0.61 m less than the full pool elevation of 672.08 m (Figure 1). Due to the above average reservoir elevation throughout Year 5, there was little or no exposed portion of the drawdown zone reaches of each stream in either the June or September surveys. The reservoir elevation had exceeded 669 m by mid-June in Year 5, which is a higher elevation than during the August surveys in Year 4. No barriers to fish passage were observed in the Year 4 August surveys or Year 5 June surveys. The high reservoir elevations in June of Year 5 would be likely to facilitate passage for adfluvial Rainbow Trout. The high reservoir elevation in August and September would have also facilitated passage for fall spawning fish species. As previously suggested (Cubberly and Hengeveld 2010, Golder 2014), tributary access for adfluvial fall spawners is not considered an issue. However, the enhancement works to improve access for spring spawners may also improve or maintain tributary access for adfluvial fall spawning species such as Bull Trout in years with low stream discharge and low reservoir levels.

Photos at the established photo reference sites were continued in Year 5 even though they are located too far upstream to show any stream channel changes that would affect fish access or the effectiveness of the enhancement works. However, the photo reference points do offer a long term record of the general conditions at each site and are easily completed during other sampling activities. While the enhancement works do extend up to the photo reference sites on Six Mile and Ole Creek, the stream channels at the upper limits of the drawdown zone for all four streams appear to be relatively stable and are unlikely to be the locations of large changes in stream morphology. The enhancement works also extend well downstream into the drawdown zone and out of the effective field of view for the photo reference sites. Therefore the continued collection of high resolution orthophotos and annual mapping of the drawdown zone portion of each stream is considered to be a more effective approach in assessing the tributary access enhancements and changes at the control sites.

6.2.2 Spawner Surveys

The Rainbow Trout spring spawner surveys were completed once stream temperatures were consistently above 5°C in late June (temperatures were recorded at 9.0 to 9.5°C during the surveys). The surveys included all areas surveyed in previous years and the upstream extension to the survey area that was added in Year 4. The portion of Patsuk Creek, a tributary of Six Mile Creek, downstream of the West Parsnip FSR was also included in the spawner survey in Year 5. A total of seven redds were observed in Year 5 with three redds in Six Mile Creek and four redds in Lamonti Creek. Two pairs of adult Rainbow Trout were also observed in Six Mile Creek, with one of the pairs associated with a redd and the other pair located in a deep pool with no indications of spawning activity nearby. The single adult Rainbow Trout observed in Lamonti Creek was also associated with a redd. A single Rainbow Trout was observed in Factor Ross Creek and two were observed in Ole Creek but there was no evidence of spawning activity in either creek.

The observation of spawning activity in both Six Mile and Lamonti Creeks confirms that the timing of the surveys in late June with the observed water temperatures was appropriate. The mean daily water temperature in Six Mile Creek was 2°C warmer than during the surveys in 2015 compared to last year's surveys. The observation of a pair of adult Rainbow Trout associated with a redd and two other redds in Six Mile Creek confirm that the general timing of the spawning surveys is appropriate and will assist in fine-tuning the timing of future surveys. Daily mean water temperatures that are consistently above 5°C are the initial indicator for the timing of the surveys and the observations in 2015 suggest that the surveys should occur once the daily mean water temperature is close to 7°C.

Observations on the timing of fry emergence in Lamonti Creek in Year 4, suggested that Lamonti Creek may be slightly warmer than Six Mile Creek (DWB and CBA 2015). The Year 5 spawning observations also indicate that Lamonti Creek is warmer than Six Mile Creek. There were four redds identified in Lamonti Creek and only a single adult Rainbow Trout indicating that spawning had already occurred while there was still active spawning in Six Mile Creek. The mean daily water temperatures in Ole Creek at the time of the spawning surveys were approximately 1°C or more cooler than Six Mile Creek.

The lack of redd observations during the previous years of the program and in Factor Ross and Ole Creeks in Year 5 is not considered evidence of an absence of spawning as the surveys are completed over a short time frame during the spawning period (Golder 2014). However, spawning has been confirmed in previous years by the identification of Rainbow Trout fry and juveniles in all four streams during the August field surveys (Golder 2014).

The area of suitable spawning substrate identified was lower than what was identified in 2014 but still exceeded what was reported in 2013. The increase in area reported in the Year 4 surveys is partly a result of a greater length was assessed in each stream. The reduction in area observed in 2015 may be associated with the lower water level compared to 2014. A lower water level would reduce the wetted width and the area of habitat potentially available. Unmeasured natural changes in channel morphology may also have contributed to the increase in area of spawning substrates. The reduction in spawning habitat area in Patsuk Creek was a result of several large sections of suitable substrate not being recorded in 2015. Despite having suitably sized substrate, these areas were considered lower quality spawning habitat due to the lack of nearby cover. All observations of spawning activity have been recorded in areas where suitable substrate was located near good cover. Annual changes in the area of spawning substrates will continue to be verified through continuation of the spring spawner surveys.

6.3 Vegetation

Terrestrial vegetation mapping during Year 5 identified nine habitat classes and one non-vegetated (open water) habitat class at the four sites. With the exception of three wetland habitat classes identified at Six Mile Creek and one habitat class absent at Ole Creek, the vegetation communities documented at the enhancement and reference sites were very similar and their distribution throughout the drawdown zone followed a similar pattern. The general pattern, beginning at the forest edge and moving down the drawdown zone in bands relatively parallel to the shoreline, begins with willows and grasses, followed by a moderate to high cover of coarse woody debris, transitioning into sparsely vegetated organic and coarse mineral soil surfaces and ending on non-vegetated silt flats that meet the reservoir body at low pool.

Vegetation mapping also identified nine enhancement classes at Six Mile and Ole Creek sites. Enhancement structures at the two sites were for the most part similar and were concentrated along the edge of the main stream channels. During Year 5 ground sampling, some shrub and herbaceous vegetation had established on the enhancement structures, including willow stem cuttings, annual ryegrass and a few native herbs (Appendix 10, transects SC 2, SC 3 and OC 1). Vegetation cover is expected to increase on the enhancement structures in the following years.

With the exception of the undisturbed forest cover at shoreline, the habitat classes observed at the four sites have developed in response to the annual flooding regime from reservoir operations. As the timing of reservoir filling and the maximum elevation reached varies from year to year, the species present in each of the habitat classes is expected to be variable, particularly in higher elevation habitat classes that may not be flooded every year. In a year where the reservoir level does not reach full pool, species less tolerant to flooding may colonize the drawdown zone during the following growing season (e.g., GMSMON 15, Airport Lagoon site, 2011; CBA 2015). In comparison, during a year where full pool is reached, species that are less tolerant to flooding are for the most part absent.

All terrestrial species identified during Year 5 ground sampling are likely to be tolerant to flooding events. A majority of these species are adapted to wet soils that are often saturated for a portion of or the entire growing season (e.g., lady's thumb, common and swamp horsetail, bluejoint and water sedge). Many of these species have also been observed as regularly occurring in other areas of the Williston reservoir (e.g., GMSMON 15 Airport Lagoon and Beaver Pond sites; CBA 2015).

6.4 Amphibians

The management questions and hypotheses pertaining to amphibians require information that can be used to measure and detect changes in abundance, diversity, and habitat complexity as it relates to the tributary access enhancements at Six Mile and Ole Creek. Methods adopted into the amphibian surveys in Year's 4-5 were modified from previous survey years in response to low detection, to find ways that could effective address the management questions, and to follow on best practices per the applicable provincial RIC standards (1998). A catch per unit effort (CPUE) approach was described in the Year 4 report that used time-constrained search as a measure of effort (DWB and CBA 2015), but the CPUE approach "is not suitable for accurate long-term monitoring" (Durso and Seigel 2015, p. 503). It is compromised by problems associated with detectability (Royle and Nichols 2003, Bailey et al. 2004b, O'Donnell and Semlitsch 2015) and without a rigorous sampling design established before impact it provides an illegitimate test for the BACI approach.

There is a shift in ecological literature recommending that researchers investigate the number of sample sites occupied by animals rather than obtaining estimates of abundance (i.e., number of animals within a given area) (Royle and Nichols 2003). This shift stems in particular reference to amphibian studies where detection rates are low, while abundance is high (Bailey et al. 2004b, Mazerolle 2015). However, it is important to note that there is a relationship between occupancy and abundance, estimates of both are influenced by the probability of detection, occupancy estimation requires less sampling effort, and occupancy estimates can be used to estimate abundance (Royle and Nichols 2003, Bailey et al. 2004b). Therefore, there is an emphasis to study occupancy as it relates to management research question #4 concerning abundance. The number of sites included in this study is well below the amount required to detect a change in occupancy with confidence (power = 0.8); sampling effort for estimating occupancy requires less effort than is required for obtaining estimates of abundance.

An effective sampling design is needed to obtain unbiased and representative estimates of abundance and diversity for a given population. The initial sampling approach (Golder 2012, 2013, 2014) is characterized as a combination of accessibility, haphazard, and judgemental sampling. These sampling approaches cannot yield statistically defensible data about population density, abundance, or occupancy (Bailey et al. 2004b, Krebs 2014). Likewise, the pattern of plot and transect establishment in Year 4 and 5 was field fit and varied according to topography, access, and habitat considerations. Drier sites, high slopes, blowdown areas lacking canopy cover, or locations lacking large coarse woody debris as ground cover are generally avoided. While judgemental sampling is not recommended (Krebs 2014), it is a necessary approach for initial establishment of the sampling strategy as the habitat variables are unknown to effectively stratify the study into a randomized design.

A landscape-scale analysis is needed to effectively answer research questions pertaining to habitat alteration as amphibians migrate through and are affected by different parts of a landscape in relation to their complex life history (Trenham and Shaffer 2005). A goal of the upland plot method is to gather a more comprehensive understanding of the spatial ecology of amphibians in the study areas in relation to management questions #4 and #5. Abundance in and near tributaries is predicated upon the population as a whole as amphibians migrate within and away from the drawdown zone and through the landscape. Survey in the landscape is also applicable to management question #5 concerning the area and quality of wetland breeding habitat because the ratio between aquatic to terrestrial habitat has an effect on population abundance, occupancy in wetland, metapopulation structure, and overall habitat quality (Mazerolle et al. 2005, Burgett and Chase 2015).

Lamonti and Factor Ross Creeks were established in this project to serve as independent control study sites. However, it is unlikely that Six Mile and Lamonti Creek form independent sampling sites for amphibians, which has implications for the study design as it relates to control sites for amphibians. In particular, western toads are known cover home range sizes in excess of >2 km^2 and up to 7 km^2 (COSEWIC 2012). Spotted frogs are known to migrate >1km (Pilliod et al. 2002), and wood frogs <0.5 km (Baldwin et al. 2006). Salamanders generally have smaller home ranges than frogs and toads (Wells 2007). The upland salamander detection at Lamonti (site LA2.01; Appendix 13 Map 10) is approximately 650 m away from the nearest known breeding wetland to the south and nearly as distant from the reservoir. Long-toed salamanders are known to migrate seasonally in areas averaging 188 m^2 (Sheppard 1977). However, these noted estimates on migration distance were obtained from telemetry studies that can underestimate the actual movement patterns (Trenham and Shaffer 2005). Nonetheless, these relative estimates of migratory behaviour for the species included in this study indicate that Six Mile and Lamonti Creek cannot be treated as independent study sites in relation to research management question #5, because their demographic or metapopulation ecology is more than likely to be linked.

Population sinks may occur at the Six Mile study location in relation to a larger metapopulation network that stretches across the landscape. This inference is based on flooding of the wetland at Six Mile, which has occurred historically (see DWB and CBA 2015) and also occurred in 2015. The biology of long-toed salamander larvae is not adapted to stream environments, so they would not be capable of manage with the currents observed at this location. They are also highly sensitive to predation by fish that can wipe out populations (Lannoo 2005). Hence, flooding of the wetland or any eggs that are deposited in pools within the drawdown zone (per the discovery of eggs in the drawdown zone (Golder 2013) means that these larvae are unlikely to survive to metamorphosis or contribute biologically meaningful number of adults to the surrounding metapopulation network. It is assumed that the local metapopulation connects into the pothole lakes located approximately 600 m to the south of Lamonti Creek. The measurement of environmental parameters at the amphibian breeding locations (including temperature, pH, top depth of eggs, deepest depth of eggs, slope, aspect and general notes on egg substrate attachment sites) was initially proposed as a component of the study. However, there are few wetlands in the study area, precluding detailed and repeated investigation using egg count surveys or tracking of developing larvae. Only three breeding habitats have been detected in the study areas, two of these exist at Six Mile and one is a ditchline habitat at Ole Creek.

Western toad tadpoles are generally avoided by fish as toxins in their skin make them unpalatable (Kiesecker et al. 1996). Tadpoles and larvae of the other species are sensitive to fish predation and generally breed in fish-free habitats (Lannoo 2005). This means that the reservoir may offer more opportunity as brood habitat for western toads and could explain the disproportionate rates of detection for this species. The earth berm structure at Six Mile may have created additional habitat for western toads by creating a slower flowing back channel where they were observed in amplexus pairs.

The earth berm structure and modifications to the wetland as Six Mile Creek did not prevent flooding of the lower wetland in 2015 and is likely to buffer against this flooding during years when the reservoir levels are higher earlier in the season (e.g., Figure 1; see also DWB and CBA 2015). Flooding of the lower wetland introduces potential problems for developing tadpoles and larvae. If long-toed salamanders or other anurans had laid eggs in this site early in the 2015 season, then they would have been flooded and subjected to the harsher reservoir environment including fish predation, changes in temperature, and higher flow rates that they are not adapted to. Seasonal rates and levels of the reservoir where unique in 2015 (Figure 1), such that an early

season higher pool level may change pooling conditions and amphibian occupancy within the drawdown zone in Year 6.

The effect of earth berm construction on western toad populations remains to be determined, but may have negatively impacted salamanders locally that were previously living under the debris that was removed from along the margins. While there is a possibility that the salamanders could simply redistribute to other available habitat, there appears to be little habitat of this type (debris with an organic rather than sandy/silty substrate) within the study areas. Wood frogs also seem to occur or use habitat where the organic veneer intersects with the shoreline driftwood (Figures 15-18; Appendix Maps 11-12).

The inclusion of nocturnal searches was recommended in the Year 4 report as many amphibians are more active at night (Buderman and Liebgold 2012). Night-time surveys proved effective in terms of a greater number of raw detections (Figure 19b). More amphibian species were detected in Year 5 than Year 4, which means that improvements in sampling design are improving detection, but at a cost of lacking an unbiased sampling design. However, even with increasing levels of detection, sample sizes remain too small generally to obtain a statistical inference on occupancy or abundance with enough power to distinguish between a type I and type II error. A key recommendation when occupancy is low is to devote more effort to surveying more sites rather than directing efforts on repeating sampling (Mackenzie and Royle 2005). Alternatively, it may be feasible to utilize morphometric data to address BACI related questions, which is discussed further below in relation to the summary results on morphometric data.

Western toads stand in contrast to other species in the study area as they are readily detected, especially at night (Figure 19b). A more systematic approach to running line transects within the areas already being surveyed can be used to obtain unbiased estimates of density of western toads in the drawdown zone. Habitat classes mapped for drawdown zone (Figures 15-18) can be used as sample strata for an effective study design. Key assumptions of the line transect and distance sampling methods is that the populations are distributed at random for unbiased calculation of a shape detection function (Chelgren et al. 2011, Krebs 2014).

In additional reference to research question #5 it is also important to distinguish the terms of habitat use, habitat selection, and performance (Gaillard et al. 2010, Boyce et al. 2016). Habitat use can be inferred from observing organisms associating with certain habitat features, habitat selection is the probability that some components are used disproportionately more than their relative availability, and performance is a measure of how habitat use translates into population fitness and can be used to estimate abundance (Boyce et al. 2016). While western toads were observed in amplexus pairs and directly on the earth berms structure at Six Mile, this is only an index of habitat use and does not address the research questions. However, continued monitoring of the population in relation to these observations of the habitat being used could prove effective for answering questions about habitat performance and availability.

The PIM approach is becoming increasingly popular in amphibian studies (e.g., Carafa and Biondi 2004, Gamble et al. 2008, Caorsi et al. 2012) and has even proven more effective than toe-clipping in some studies (Caorsi et al. 2012). The advantage of the PIM approach is that a cumulative atlas of scaled photos can be used to maintain quality checks into the reported biology of photographed individuals. Data such as the body-mass-index (Davis et al. 2008) or body asymmetry (Wright and Zamudio 2002) can be retroactively investigated with a well-maintained database. A Data Management Plan (DMP) is being used to manage this project to ensure that the PIM information and other data is properly archived for long-term accessibility and to provide a detailed account of amphibian populations in the area. Data on body condition

has strong potential applicability to management question #4. Other studies have identified relations between body condition as an index of habitat alteration (Speed et al. 2007, Moya et al. 2015) and abundance. Body condition is an indicator of environmental stress, habitat quality, and applicable demographics (Wright and Zamudio 2002, Bancila et al. 2010). Body condition can be a sign of relative reproductive capability as exhibited by changes in stressed populations having reduced rates of reproduction.

Skeletochronology and mark-recapture are the only methods for reliable aging of amphibians (Halliday and Verrell 1988, Russell et al. 1996). However, Rogers (2009) determined that the gape width (GW) of the boreal toad (*Anaxyrus boreas boreas*) was significantly correlated with age. While there were no re-captures using the I3S approach for marking skin patterns in western toads and long-toed salamanders, the technique developed in this study can be used to identify individuals if recaptured in subsequent years. Recapturing of individuals can be used to calculate estimates of abundance and to potentially track growth rates relative to age. A key limitation of the I3S approach is that younger/smaller individuals (<10 mm GW) lack the identifying marks.

The density histograms of GW versus SUL for pooled data of all study sites (Figure 29) shows that each morphometric parameter gives a different picture of morphometric diversity. If GW is used as a proxy for age, then the western toad populations appear to exhibit an r-selection type of population curve. There are fewer of the smallest (youngest) individuals (<10 mm) represented in the chart, but a large number of the next size class (10-15 mm) is detected, followed by reduction in numbers as GW (age) increases; this general pattern also occurs in Six Mile (Figure 25) and Ole (data not shown). If GW proves effective as a reliable indicator of age, then this provides a potential means to track cohort structure over time given sufficient census sizes of the populations. It is important to track the statistics on the morphometric parameters (Table 15 and Table 16) to understand growth patterns in relation to the inferences being drawn from the data. For example, long-toed salamanders sometimes drop their tails as an anti-predatory defense, which has the potential to influence the relationship of tail length relative to other morphometric parameters. Information gathered on salamander tails may also provide a useful index of body condition as they are used to store anti-predatory defense skin secretions that also acts as a high-energy protein source (Williams and Larsen 1986).

Gender determination can be complex while working in the field and the PIM approach can be used to improve on field determinations. The vent area of long-toed salamanders are being photographed in high resolution to use Petranka's (1998) illustration of an ambystomatid male versus female vent anatomy to determine gender. A table is being developed within our DMP to record what features are being used to track gender for other species. In western toads, for example, females tend to be larger whereas males tend to have smoother skin and are less warty (Pickwell 1972). This species may also exhibit a relative degree of color dimorphism with females ranging from yellow to reddish while males tend to be more yellow in color. Red is generally characteristic of females, green is generally characteristic of males. The frequency of predominantly reddish females ranges from 100% on the coast to 38% east of the Rocky Mountains (Schueler 1982). However, reddish males and green females were observed in amplexus in this study during the Six Mile night-time surveys. Other publications have reported that females have a more contrasting pattern of dark spots or blotches, whereas male throats become gray or black over time (Pickwell 1972, Schueler 1982). Males have more muscular and longer forelimbs than females (Olson 1989) and can be measured by use of our digital photograph records. The nuptial pad of males to during breeding season is a striking diagnostic as they develop on the forelimbs at sexual maturity (Duellman and Trueb 1986). Sexual dimorphism in the other species (e.g., King and King 1991) through the season is more complex.

It is important to continue to track gender differences as there are often notable differences in the ecology and habitat selection of males versus females (Wells 2007).

The discovery of long-toed salamander burrows within hard pieces of birch logs will serve to increase detection rates for this species. The use of this habitat type has since been confirmed in surveys conducted elsewhere. This was an important discovery and a natural history note has been published on this finding (Thompson and McDermot-Fouts 2015). However, this requires cutting into logs that may provide valuable habitat otherwise. A technique that involves re-suturing the bark with staples, duct tape, or glue after it has been cut and peeled is being considered. This problem is similar to the concern of searching in a plot that requires disturbance to the ground and other pieces of coarse woody debris that likely causes a negative influence on the probability of recapture.

6.5 Songbirds and Waterbirds

Birding survey points were located within the drawdown zone, along streams near the enhancement works. Habitat diversity is extremely limited with little to no established vegetation within the 75 m radii. This is likely the primary limiting factor in relation to both species richness and abundance. There were no unusual songbird, waterfowl or shorebird detections at any of the study sites. Waterbird and shorebird surveys were first completed in Year 4. Though slightly higher than the previous year, abundance and diversity remained low during the Year 5 surveys.

Higher than average water levels in Year 5 required survey points to be moved to higher elevations at both Lamonti Creek and Factor Ross Creek. The reservoir level also decreased the amount of available terrestrial habitat within the survey radii. Water noise levels at Six Mile Creek made it challenging to complete point count surveys at that site.

Terrestrial habitat diversity, quality and quantity increases with distance from the drawdown zone. Incidental observations for birds outside of the 75 m range were higher than the number of detections within the survey plots in most cases. Pre-construction surveys detected a total of 70 species at these sites (Golder 2012). However, those surveys included more points and covered a wider variety of habitats at each of the sites.

Re-vegetation efforts formed part of the enhancement works at Ole and Six Mile Creeks. This has the potential to improve habitat availability and may result in increased avian use in the coming years.

7 CONCLUSIONS

The first year of post-construction observations collected in Year 5 of the GMSMON-17 project are generally consistent with data collected in the previous years. Data collected at the two control sites (Lamonti and Factor Ross Creeks) in Year 5 adds to the existing baseline data at these two sites. At the two tributary enhancement sites (Six Mile and Ole Creeks) the tributary access enhancement projects were constructed in spring 2014 so the data collected from these two sites is a the first year of post-construction observations. Construction activities may have had some influence on the data collected for all indicator groups (fish, vegetation, amphibians, and birds) and this will need to be considered in future analyses to assess the effectiveness of the projects.

One of the key management questions relating to fish within the monitoring program was revised as a result of a review of the project Terms of Reference in 2015 (BC Hydro 2015). The change was a shift from focusing on changes in fish abundance and diversity to improved access for spring spawners as a result of the tributary access enhancements. The management question related to changes in fish habitat quantity and quality from the tributary access enhancements was unchanged. As the management questions are targeted at post-enhancement results and the enhancement work was only completed in June 2014, no conclusions can be reached yet with respect to the success of the projects. The initial observations in Six Mile and Ole Creeks suggest that the access enhancement works have resulted in habitat changes in the drawdown zone portions of both streams, particularly for Ole Creek. Due to the high reservoir elevation in spring 2015, the effect of the access enhancements on the streams below the enhancements could not be determined. This will be assessed on an opportunistic basis in future years if the reservoir reaches more typical low pool elevations. The Year 6 surveys will also allow for an initial determination of the effectiveness of the debris catcher constructed at Ole Creek. The peak reservoir elevation in 2015 was close to full pool and would have resulted in the remobilization of much of the debris stranded at upper elevations in the drawdown zone.

The area and quality of fish habitat as a result of the enhancement works can now be monitored through the combination of high resolution orthophotos (obtained by UAV), habitat mapping, and photo referencing tasks. The habitat data is highly important to the study questions. Continuing the early season UAV data acquisition will prove invaluable for quantifying changes in habitat complexity and stream channel characteristics at both the enhancement and control sites. Assessing the tributary channels through the drawdown zone will provide information on annual changes in accessibility and channel stability for both the enhancement and control streams. With the revision to the Terms of Reference to focus more on habitat measures, future analyses will focus on using the UAV orthophotos for quantifying changes in habitat as a result of the access enhancements. The habitat monitoring will be supported by habitat usage information by fish through the drawdown zone sampling program and spawner surveys in the spring.

For terrestrial vegetation, the baseline data collected in Year 5 provides a better characterization of the vegetation types that are present at the four study sites in comparison to vegetation data collected in previous years of the study. The proposed tributary enhancements are likely to increase vegetation establishment along the stream channels within the drawdown zone over time; however, the abundance and diversity of vegetation in these areas is still expected to be primarily influenced by annual reservoir elevations. Changes in vegetation communities as a result of the tributary enhancements is most likely to be observed on the enhancement structures themselves and on areas adjacent to the structures where the ground has been disturbed as a result of construction activities.

Data collected in Year 5 provides a better understanding of the amphibian populations in relation to the management questions. Additional insight into amphibian populations in the study area can be obtained in the longer-term over the duration of the GMSMON-17 study using the methods that have been developed in Year 4 and 5. The current sampling effort and rates of detection are too low to obtain reliable estimates of occupancy, which requires less effort than is required for estimates of abundance. The relationship between occupancy, presence-absence, and detection (Bailey et al. 2004a, O'Donnell and Semlitsch 2015) is of relevance to the research management questions on abundance, diversity, and habitat quality. R-stats is being used to address these issues using recent advances in technique (e.g., Mazerolle 2015) that are building on the work by MacKenzie and Royle (2005) and MacKenzie et al. (2006).

Survey methods adopted in Year 4 and 5, including night time surveys, have improved levels of detection. Night time surveys and transects will be continued in Year 6 as this has proven highly effective for western toad surveys, but will be modified slightly to avoid potential sampling bias using the techniques outlined in Chelgren et al. (2011) and Krebs (2014). More effort will be directed to searching in new plots in surrounding areas rather than allocating effort on re-sampling plots for the other species where detection rates are low, per recommendations in MacKenzie and Royle (2005). While occupancy and abundance statistics may be limited by current rates of detection, the distribution maps and other behavioural information is providing valuable data that can be used to address some components of the management questions. For example, it can be concluded that the constructed earth berm at Six Mile Creek and Ole Creek has not excluded western toads and may have increased available breeding habitat within the reservoir itself. However, observational information can only give details on habitat use, whereas information on selection and performance requires information on amount of habitat availability as it relates to fecundity or abundance (see Gaillard et al. 2010, Boyce et al. 2016).

The amphibian component presents unique challenges to the study as they are highly philopatric and their migratory behaviour into upland environment requires an extension of the research into the landscape to effectively address the full-scope of the research management questions on abundance, diversity, and habitat quality. Continuation of the surveys including the morphometric analysis offers potential means to address the project management questions in terms of body condition as it may relate to changes in abundance or by using GW as a proxy for age to track cohort structure over time. Eggs or tadpoles of western toads have not been detected in the reservoir and it may be worthwhile to investigate this further. There is also a significant difference in body size of western toads between study sites, with larger individuals being detected at Six Mile, mid-sized individuals at Ole, and smaller individuals at Factor, which requires an explanation in relation to the management questions. These patterns may have existed prior to the construction of the earth berms and may also be attributable to detection/capture rates.

Consistent with previous years, songbird and waterbird abundance and species richness were relatively low. The physical enhancement works were designed to improve tributary access and were not expected to have a significant impact on songbird habitat (Golder 2012). Re-vegetation efforts at Ole and Six Mile Creeks have the potential to provide new or improved habitat within the drawdown zone, which may increase avian use within the study sites. Increases in abundance and species richness will likely be dependent upon the successful establishment of vegetation at these sites. These surveys continue to increase the knowledge base relating to songbird and waterbird use of the drawdown zone and adjacent areas in Williston Reservoir. This information will be useful in planning and assessing the viability of future projects around the reservoir.

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Appendix 1. Photos of the Six Mile and Ole Creek stream gauging stations in May 2015.

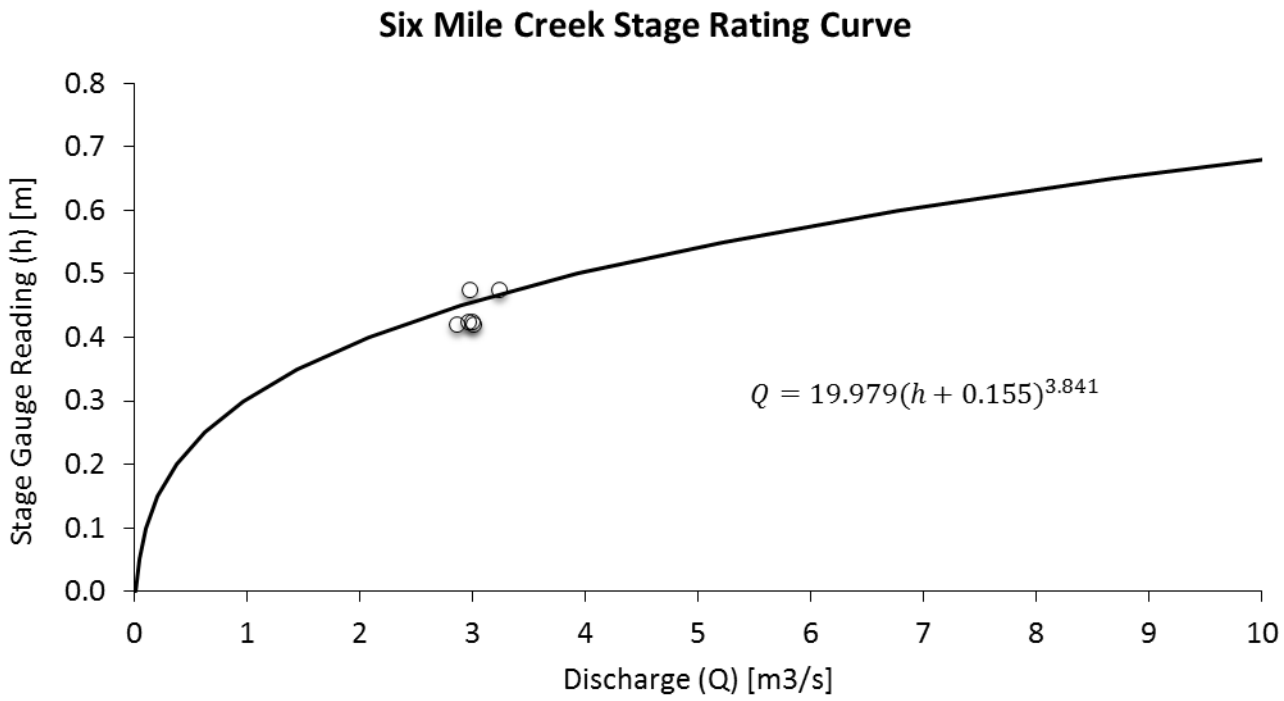
Photo 1. Gauging station on Six Mile Creek with temperature probe installed.

Photo 2. Gauging station on Six Mile Creek

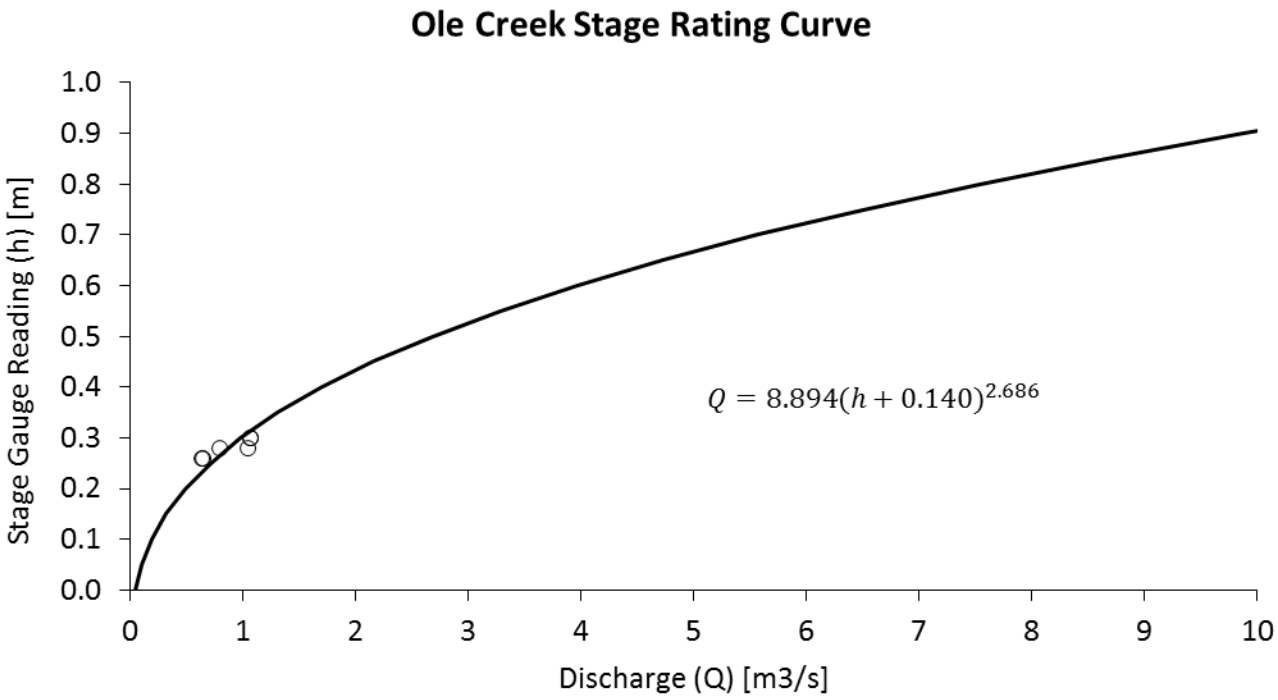
Photo 3. Gauging station on Ole Creek.

Photo 4. Gauging Station on Ole Creek.

Appendix 2. Rating curves and stage-discharge tables for Six Mile and Ole Creeks.



Stage Reading, h (m)	Discharge, Q (m^3/s)	Stage Reading, h (m)	Discharge, Q (m^3/s)
0.00	0.02	1.05	40.90
0.05	0.05	1.10	47.81
0.10	0.10	1.15	55.55
0.15	0.21	1.20	64.18
0.20	0.37	1.25	73.77
0.25	0.62	1.30	84.37
0.30	0.97	1.35	96.07
0.35	1.45	1.40	108.92
0.40	2.08	1.45	123.00
0.45	2.90	1.50	138.38
0.50	3.93	1.55	155.14
0.55	5.22	1.60	173.36
0.60	6.79	1.65	193.12
0.65	8.68	1.70	214.49
0.70	10.95	1.75	237.56
0.75	13.62	1.80	262.42
0.80	16.74	1.85	289.16
0.85	20.37	1.90	317.85
0.90	24.54	1.95	348.60
0.95	29.32	2.00	381.50
1.00	34.75		



Stage Reading, h (m)	Discharge, Q (m^3/s)	Stage Reading, h (m)	Discharge, Q (m^3/s)
0.00	0.05	1.05	14.19
0.05	0.10	1.10	15.85
0.10	0.19	1.15	17.63
0.15	0.32	1.20	19.52
0.20	0.49	1.25	21.54
0.25	0.71	1.30	23.69
0.30	0.98	1.35	25.96
0.35	1.31	1.40	28.37
0.40	1.70	1.45	30.91
0.45	2.16	1.50	33.59
0.50	2.68	1.55	36.41
0.55	3.28	1.60	39.38
0.60	3.96	1.65	42.50
0.65	4.72	1.70	45.76
0.70	5.57	1.75	49.18
0.75	6.50	1.80	52.75
0.80	7.53	1.85	56.48
0.85	8.66	1.90	60.38
0.90	9.88	1.95	64.43
0.95	11.21	2.00	68.66
1.00	12.65		

Appendix 3. 2015 photos from the photo monitoring points on Six Mile, Lamonti, Ole, and Factor Ross Creeks.

Photo 5. Six Mile Creek on May 4, 2015 from reference location (azimuth = 165°).

Photo 6. Six Mile Creek on May 4, 2015 from reference location (azimuth = 60°).

Photo 7. Six Mile Creek on June 23, 2015 from reference location (azimuth = 165°).

Photo 8. Six Mile Creek on June 23, 2015 from reference location (azimuth = 60°).

Photo 9. Six Mile Creek on September 3, 2015 from reference location (azimuth = 165°).

Photo 10. Six Mile Creek on September 3, 2015 from reference location (azimuth = 60°).

Photo 11. Lamonti Creek on May 4, 2015 from reference location (azimuth = 200°).

Photo 12. Lamonti Creek on May 4, 2015 from reference location (azimuth = 290°).

Photo 13. Lamonti Creek on June 26, 2015 from reference location (azimuth = 200°).

Photo 14. Lamonti Creek on June 26, 2015 from reference location (azimuth = 290°).

Photo 15. Lamonti Creek on September 3, 2015 from reference location (azimuth = 200°).

Photo 16. Lamonti Creek on September 3, 2015 from reference location (azimuth = 290°).

Photo 17. Ole Creek on May 5, 2015 from reference location (azimuth = 10°).

Photo 18. Ole Creek on May 5, 2015 from reference location (azimuth = 80°).

Photo 19. Ole Creek on June 24, 2015 from reference location (azimuth = 10°).

Photo 20. Ole Creek on June 24, 2015 from reference location (azimuth = 80°).

Photo 21. Ole Creek on September 2, 2015 from reference location (azimuth = 10°).

Photo 22. Ole Creek on September 2, 2015 from reference location (azimuth = 80°).

Photo 23. Factor Ross Creek on May 5, 2015 from reference site.location (azimuth = 340°).

Photo 24. Factor Ross Creek on May 5, 2015 from reference site.location (azimuth = 280°).

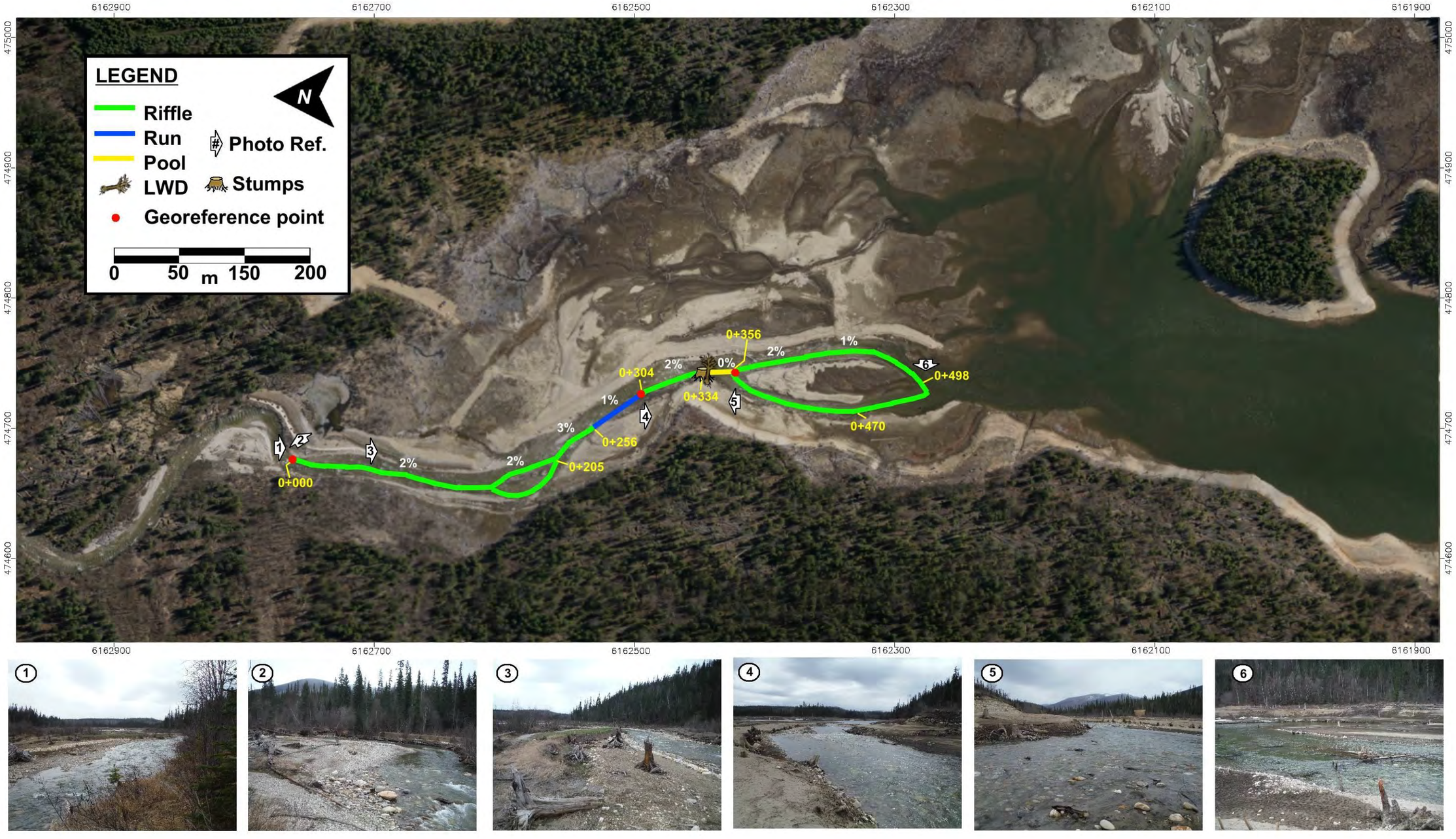
Photo 25. Factor Ross Creek on June 25, 2015 from reference site.location (azimuth = 340°).

Photo 26. Factor Ross Creek on June 25, 2015 from reference site.location (azimuth = 280°).

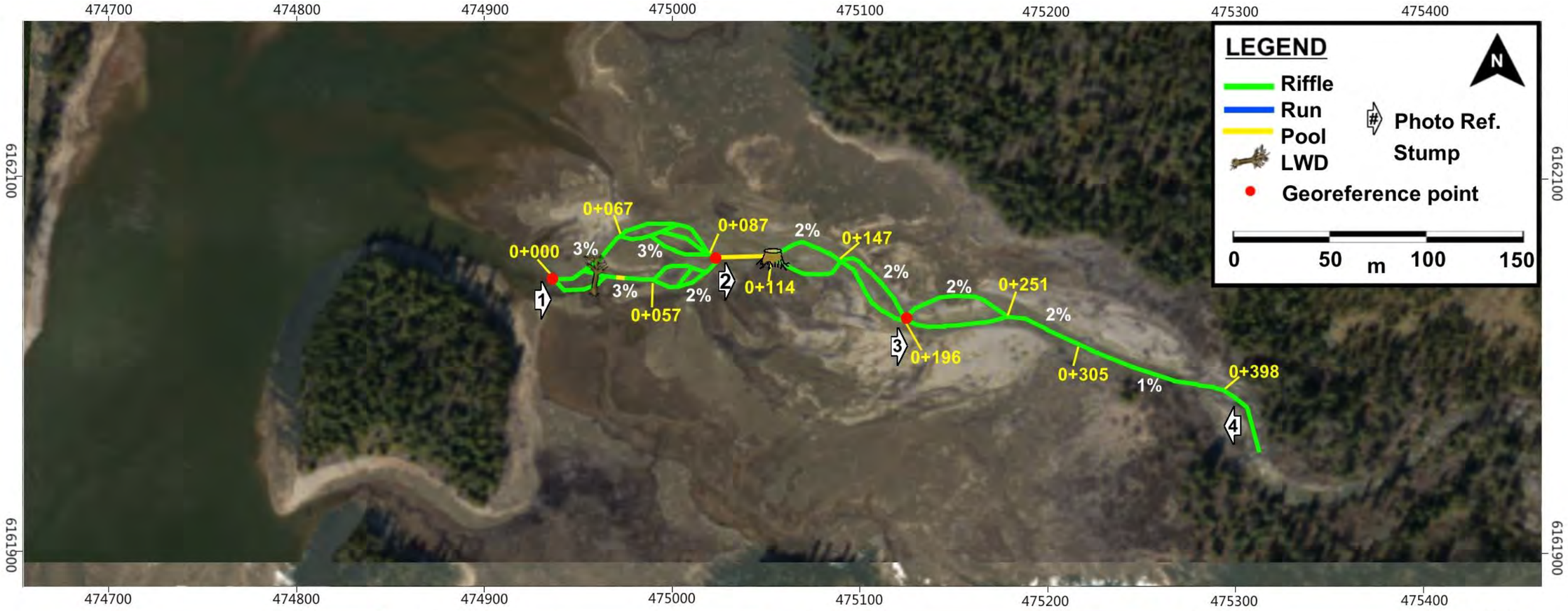
Photo 27. Factor Ross Creek on September 2, 2015 from reference site.location (azimuth = 340°).

Photo 28. Factor Ross Creek on September 2, 2015 from reference site.location (azimuth = 280°).

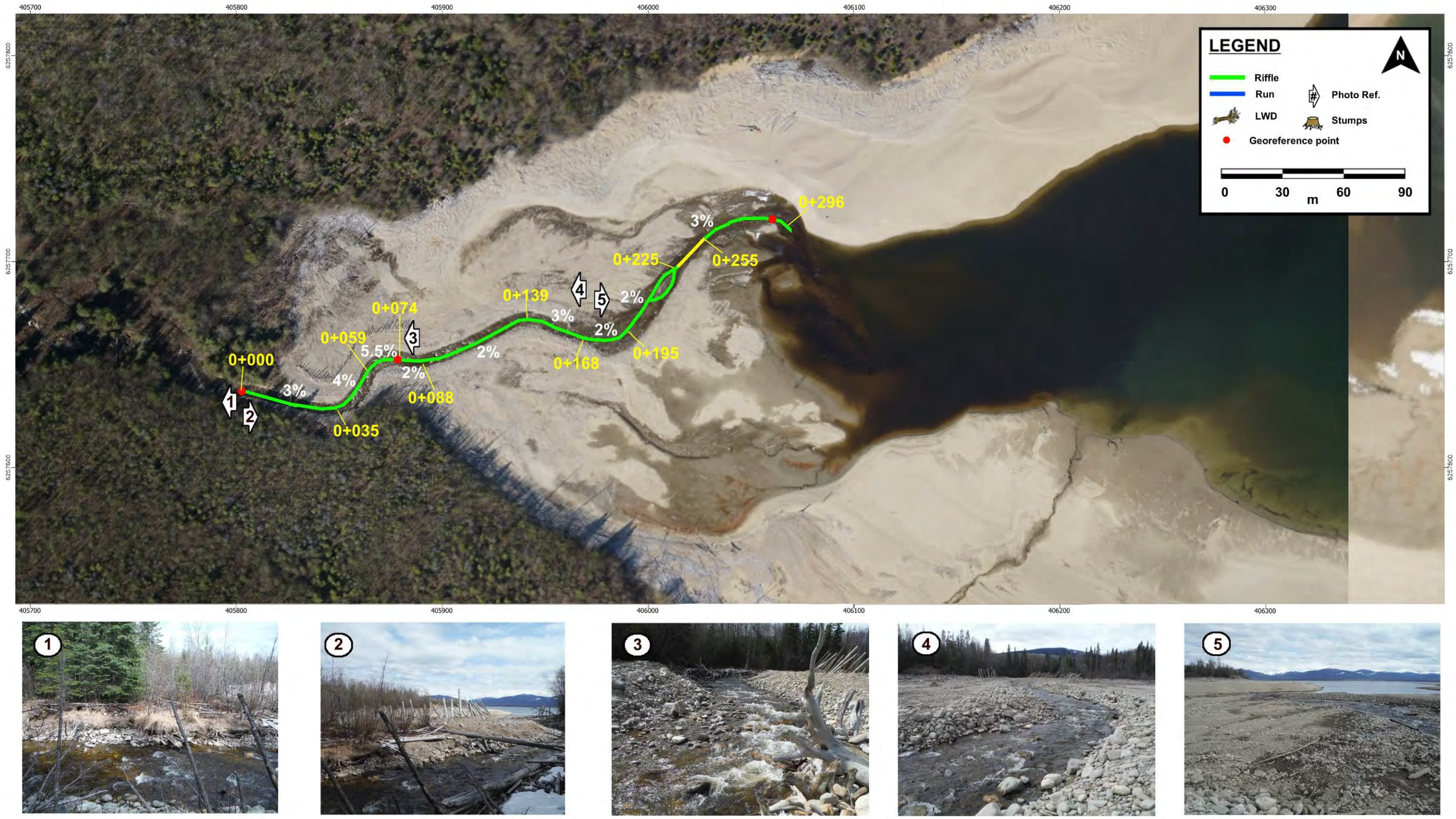
Appendix 4. Drawdown zone stream habitat maps for Six Mile, Lamonti, Ole, and Factor Ross Creeks.



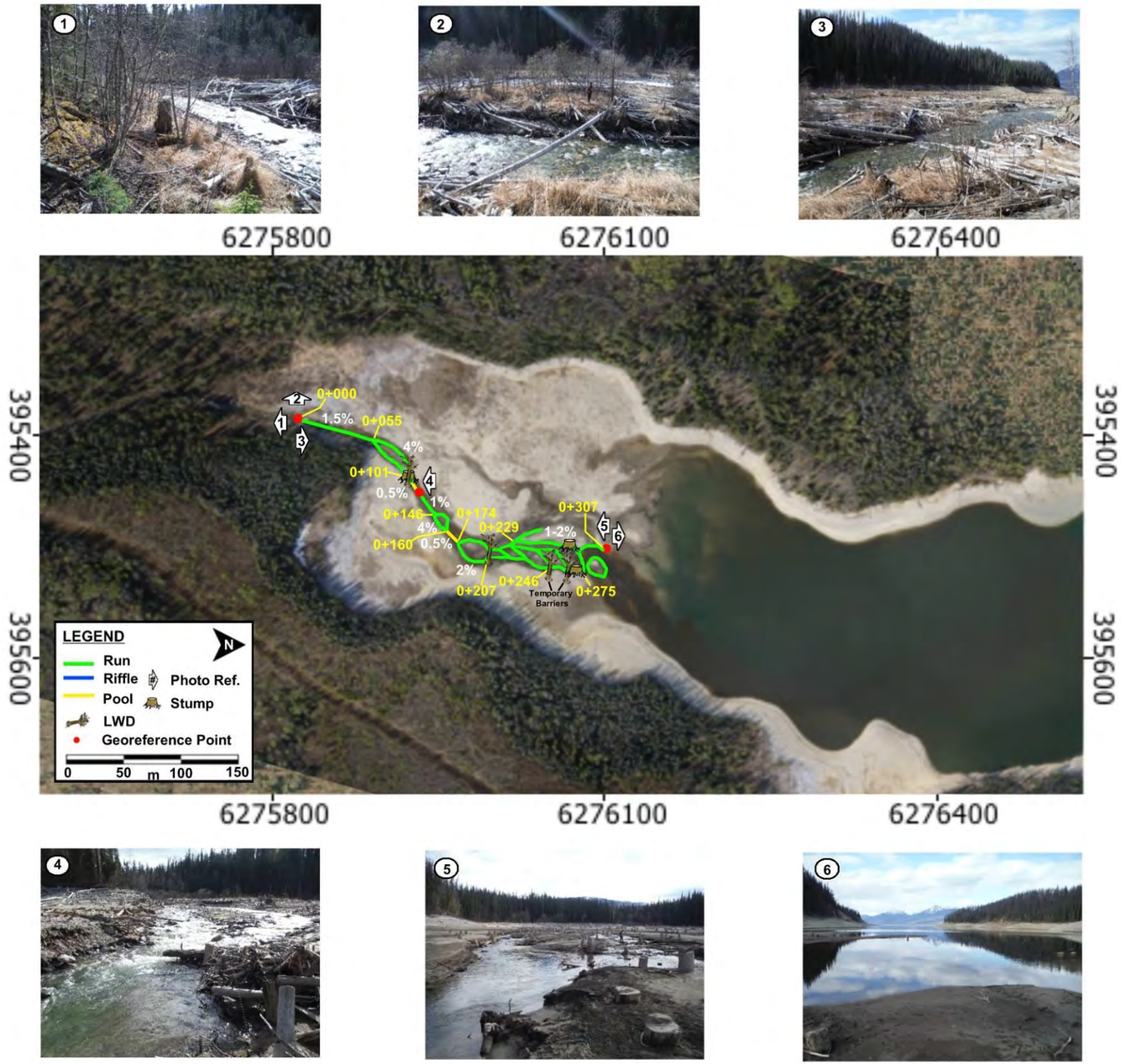
Map 1. Drawdown zone stream habitat map for Six Mile Creek in May 2015. Photos taken on May 4, 2015 at a reservoir elevation of 662.7 m and stream level of 0.249 m (discharge = 0.615 m^3/s).



Map 2. Drawdown zone stream habitat map for Lamonti Creek in May 2015. Photos taken on May 5, 2015 at a reservoir elevation of 662.7 m.



Map 3. Drawdown zone stream habitat map for Ole Creek in May 2015. Photos taken on May 5, 2015 at a reservoir elevation of 662.7 m and stream level of 0.143 m (discharge = 0.3 m^3/s).



Map 4. Drawdown zone stream habitat map for Factor Ross Creek in May 2015. Photos taken on May 5, 2015 at a reservoir elevation of 662.7 m

Appendix 5. Spawning survey results from June 23-26, 2015 from the four Williston Reservoir tributaries.

Tributary	UTM Coordinates			Fish Observed	Dimensions		Area (m²)	Comment
	Zone	Easting	Northing		X	Y		
	10U	474503	6183758	No	1	2.5	2.5	LDB-suitable gravel substrate with cover nearby
	10U	474508	6163748	No	2	3	6	LDB - suitable gravels with moderate veg cover and variable velocities.
	10U	474502	6163706	No	1.5	4	6	LDB - good velocity, good cover, depth (30-60 cm), undercut banks.
	10U	474555	6163661	No	0.75	2	1.5	LDB - suitable substrate, cover, velocity and depth (0.75-1.1)
	10U	474628	6163518	No	1	5	5	RDB of side channel, great LWD cover, good gravels, depth 15-30cm. Good flows.
	10 U	474455	6163863	No	0.5	2.5	1.25	RDB - good cover, suitable substrate, good flow/velocity, depth 25-40 cm.
	10U	474430	6163934	No	1.5	4.5	6.75	RDB - good cover and gravels, good flows, depths from 40-65 cm.
Six Mile	10 U	474467	6164178	2 Rainbow Trout	0.75	1	0.75	Channel Centre - 2 RB (35 cm TL, 27cm TL) in tail of relatively large pool. No obvious spawning activity and no redds in immediate area. Good substrate (gravels) overhanging veg. Depth 20-35 cm.
	10U	474487	6164189	No	0.5	1	0.5	RDB - two small patches with favorable attributes in depth 30-40 cm. Good cover and flow.
	10U	474488	6164203	No	4	4	16	Channel Center - LWD covering large area with suitable gravel and flows.
	10 U	474422	6164287	2 Rainbow Trout	5	5	25	Active redd with 2 RB observed tending. Redd appears to be broken in to 3 sections all with notable pots and tails. In and around alders growing in channel (recent change to channel path) located just above beginning of braid. Lots of good cover - small gravels
	10 U	474414	6164381	No	2	4	8	RDB – redd, no occupants observed. Pot located just behind substantial LWD crossing stream.

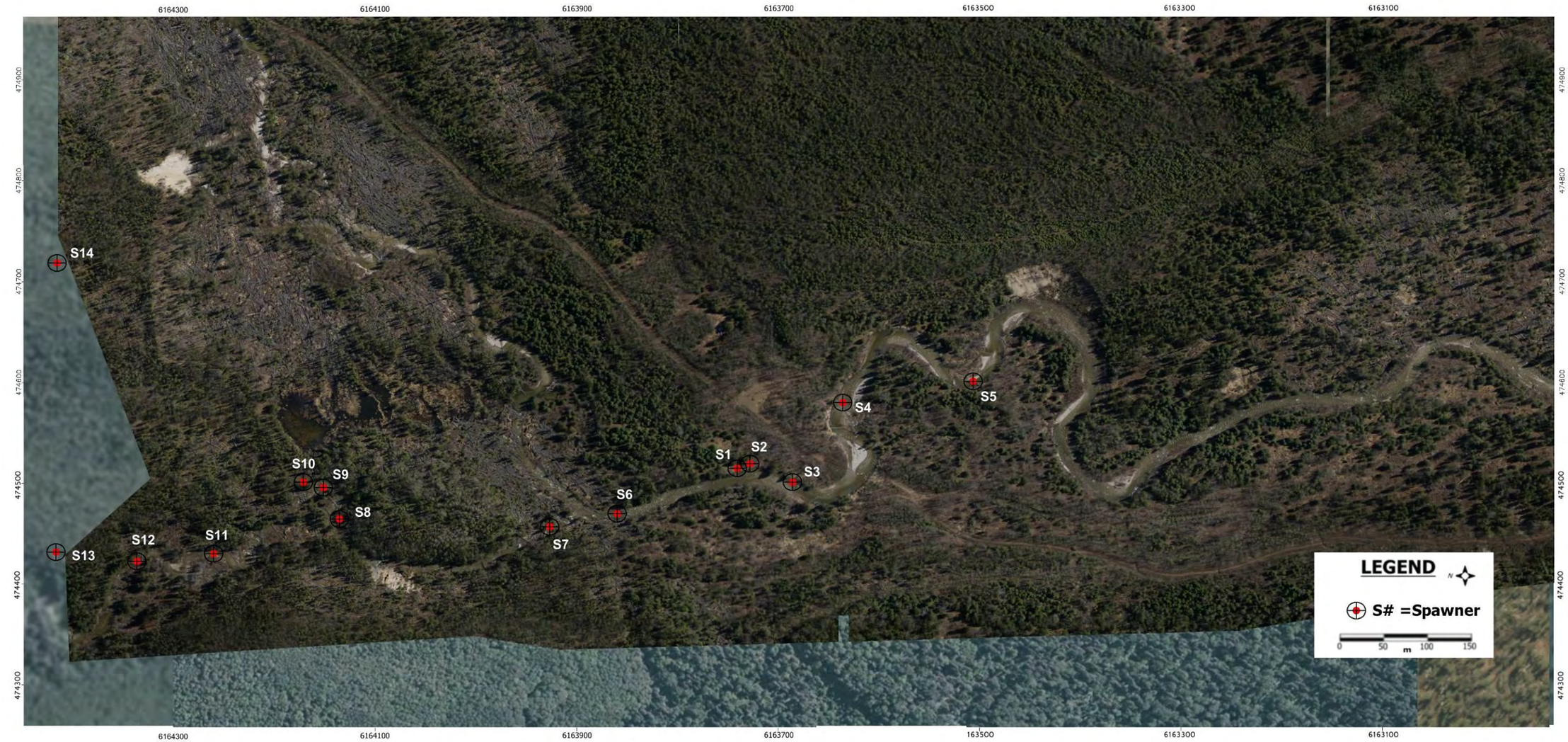
Tributary	UTM Coordinates			Fish Observed	Dimensions		Area (m²)	Comment
	10U	474418	6164428	No	1.25	4.5	5.625	LDB - redd with no activity observed.
			Six Mile Total				**84.875**	
Patsuk	10 U	474726	6164428	No	1.5	3	4.5	LDB - smaller pea gravels located under overhanging veg. Good flows with depth of 15 cm.
			Patsuk Total				**4.5**	
Lamonti	10 U	474306	6161947	No	2.55	0.34	0.867	LDB - redd observed under thick section of LWD.
	10 U	475391	6161979	No	0.75	1.5	1.125	Suitable gravels and flow with good structure (LWD) on either side. Good escape cover. Depth approx. 40 cm.
	10 U	475512	6161912	No	0.5	1.5	0.75	LDB – braid, possible redd. Area very soft with discernable pot and tail. Just small size. Other suitable gravels in general area but unused. No fish noted in the area. LWD in front with good flows.
	10 U	475519	6161913	No	1	2.5	2.5	LDB – braid, good gravels with good flows, cover and depth.
	10 U	475685	6161918	No	0.5	1.75	0.875	Center - good gravels deposited by flows under LWD cover.
	10 U	475703	6161923	No	0.5	2.5	1.25	RDB - good flows, boulder/cobble interspersed in gravel. Good cover along RDB.
	10 U	475703	6161923	No	0.5	1.75	0.875	Center - good flows, boulder/cobble interspersed in gravel. Some overhanging vegetation.
	10 U	476025	6161808	No	0.5	3	1.5	Suitable narrow section broken among boulders along edge of creek. Moderate cover and flow, depth approx. 5-17 cm.
	10 U	476240	6161808	No	0.5	1.5	0.75	RDB - small patch on edge of tailout with overhanging veg. Depth - 30-40 cm. Good flow - not the best cover but could find escape cover just above.
	10 U	476342	6161820	No	0.3	2.5	0.75	RDB - section narrow and tight to bank containing good gravels, cover, and flow. Depth varies (10-20 cm). Softer gravel patch noted towards bottom but could not confirm fish presence. Good LWD above.

Tributary	UTM Coordinates			Fish Observed	Dimensions		Area (m²)	Comment
	10 U	476467	6161824	1 Rainbow Trout	0.612	0.82	0.50184	Redd observed under/beside log jam. Great cover, flows and substrate. RB observed in structure directly beside redd.
	10 U	476694	6161563	No	1	2	2	RL - suitable substrate at tailout. Good cover and flow. Depth - 45cm
	10 U	476750	6161583	No	1.02	0.62	0.6324	LDB - Redd observed under overhanging veg on inside turn of tail out. No fish observed at redd.
Lamonti Total							**14.376**	
	10 V	395363	6275742	No	0.75	4	3	LDB - good substrate tucked in along undercut bank with LWD out in front dissipating velocities.
	10 V	395376	6275555	No	1	2	2	Center channel - substrate located directly behind LWD across creek with overhanging branches, moderate and high velocity may be limiting factor. Depth 15-25 cm.
	10 V	395218	6275281	No	1	2	2	RDB - moderate substrate with good LWD cover and flows. Depth 15-25cm.
	10 V	395154	6275159	No	0.5	1	0.5	Center - suitable gravels in tail out of pool - ample flow and depth (50-75cm). LWD behind and in front.
Factor Ross	10V	395130	6274912	No	1.25	6	7.5	LDB - good gravels with moderate cover and depth (25-35 cm), good flow. Alongside large log jam.
	10V	395174	6274906	yes	1.25	3	3.75	RDB - overhanging alder providing good cover. Good substrate flow and depth (25-35 cm). Lots of LWD just above. Observed 2 MW and 1 RB (all approx. 22 cm). No digging activity noted in area.
	10V	395171	6274890	1 Mountain Whitefish	1.5	6	9	RDB - good substrate nested tight to log jam. Depth approx. 30-40 cm. Overhanging alder over lower portion. Ideal gravel bar noted last year just to left of noted habitat. Water level noticeably lower than last year. No sign of use. 1 MW observed in deeper section above.
	10 V	395169	6274879	No	1	1.5	1.5	LDB - suitable substrate under LWD, good flows and depth (30 cm).
Factor Ross Total							**24.25**	

Tributary	UTM Coordinates			Fish Observed	Dimensions		Area (m²)	Comment
	10 V	404623	6257631	No	0.3	1	0.3	RDB - small patch of good gravels along creek edge with moderate cover and good flows. LWD cluster just above serves as cover.
	10 V	404532	6257683	No	0.5	1	0.5	RDB - small patch of good gravels located directly under LWD (fresh) with good velocity but limited depth (10-20 cm).
	10 V	404453	6257707	No	0.2	1.2	0.24	LDB - suitable flows on edge of thalweg under overhanging devil's club.
	10V	404270	6257739	No	0.5	0.75	0.375	LDB - located in braid with good cover, depth (10-15 cm). Moderate substrate.
	10V	404258	6257736	No	1	1.5	1.5	RDB - good material and flows. Higher exposure but good canopy cover.
	10V	404211	6257710	No	0.75	2	1.5	RDB - great cover and substrate. Depth: 25-35 cm. Suitable velocity.
Ole	10 V	404290	6259694	yes	0.75	2.25	1.6875	RDB - good habitat located on edge of pool. LWD and good overhanging cover above. BT observed in location.
	10 V	404820	6257589	No	0.75	4	3	RDB - pockets of good substrate scattered down along small braid on RDB. Great cover and varying depths (20-40 cm).
	10 V	405241	6257844	No	0.5	2.5	1.25	LDB - great overhanging veg (alder). Mixed substrate with good flows and depth (10-20 cm).
	10 V	405557	6257791	No	0.75	1.25	0.9375	Centre - tail out of pool - good/moderate substrate. Moderate - poor cover but great security cover in a pool just ahead. Depth varies (15-35 cm). Moderate flows.
	10 V	405664	6257718	No	0.3	1.3	0.39	LDB -one of 4 sections along short stretch with potential for use. Good cover from canopy but LWD and undercut banks lacking. Good substrate and good flows (10-25 cm).

Tributary	UTM Coordinates		Fish Observed	Dimensions		Area (m²)	Comment
	10 V 405664	6257718	No	0.5	1.5	0.75	RDB -one of 4 sections along short stretch with potential for use. Good cover from Canopy but LWD and undercut banks lacking. Good substrate and good flows (10-25 cm).
	10 V 405664	6257718	No	0.5	1	0.5	RDB -one of 4 sections along short stretch with potential for use. Good cover from Canopy but LWD and undercut banks lacking. Good substrate and good flows (10-25 cm).
	10 V 405683	6257701	No	1	2	2	Found at head of 2 adjacent braids. Good substrates, flows, cover and depth.
	10 V 405683	6257701	No	0.5	1	0.5	Found at head of 2 adjacent braids. Good substrates, flows, cover and depth.
	10 V 405689	6257690	no	1.25	1.75	2.1875	Braid - good substrates, flows, cover and depth.
	10 V 405789	6257639	No	0.5	1.75	0.875	LDB - Good substrate and flows. Depth approx. 15 cm and moderate cover.
Ole Total						**18.4925**	

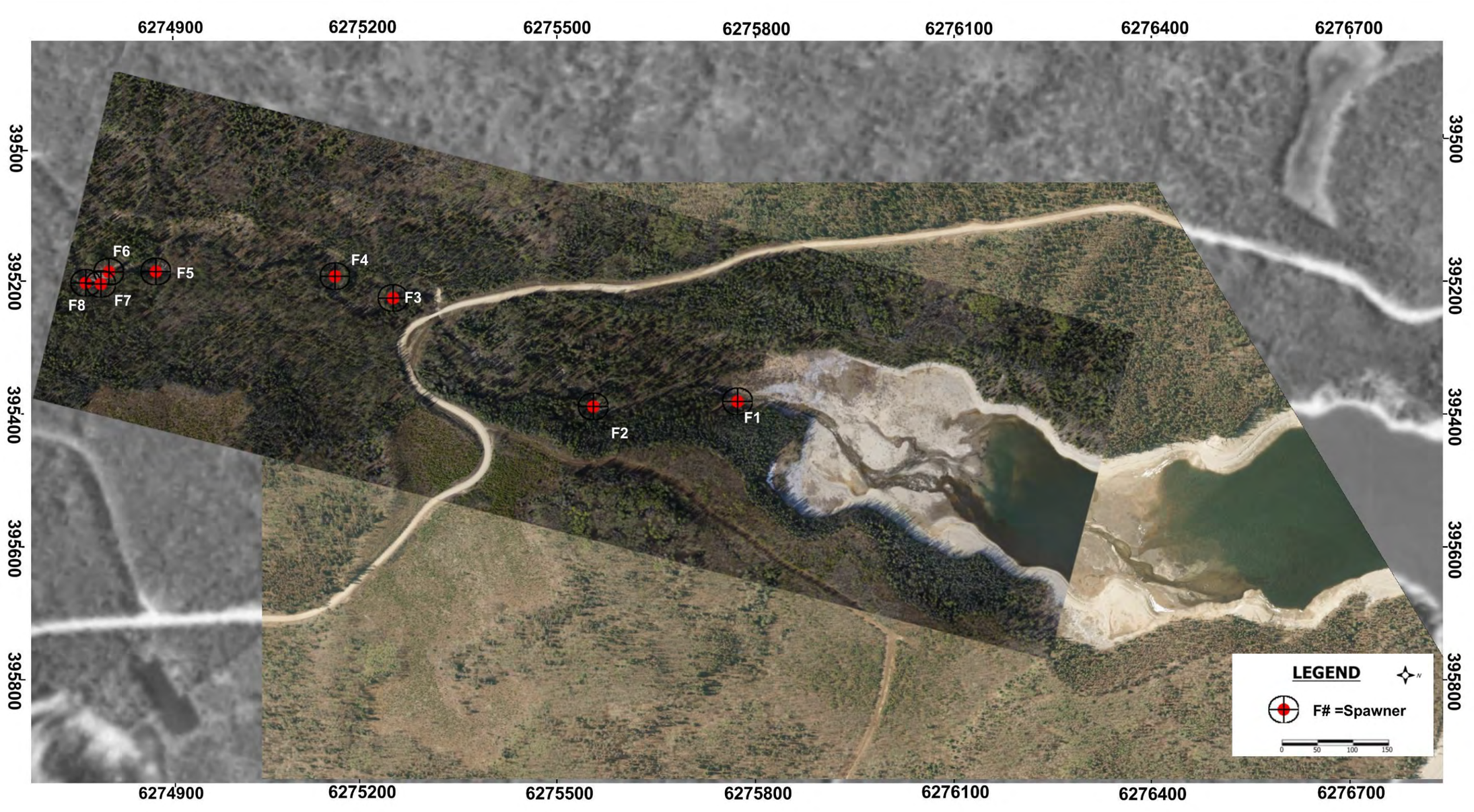
Appendix 6. Rainbow Trout spawning survey location maps for Six Mile, Lamonti, Ole, and Factor Ross Creeks.



Map 5. Rainbow Trout spawning survey location map for Six Mile Creek in 2015.

Map 6. Rainbow Trout spawning survey location map for Lamonti Creek in 2015.

Map 7. Rainbow Trout spawning survey location map for Ole Creek in 2015.



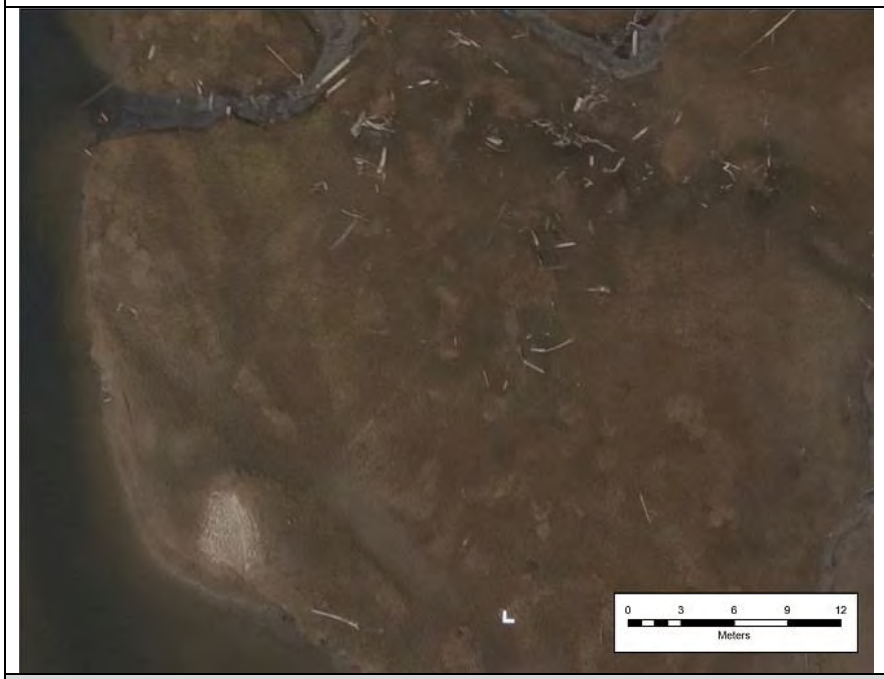
Map 8. Rainbow Trout spawning survey location map for Factor Ross Creek in 2015.

Appendix 7. Locations of vegetation belt-transects.

Site	Transect[1]	UTM Zone	Easting	Northing
Six Mile Creek	SC1-1	10U	474716	6162533
	SC1-2	10U	474705	6162552
	SC2-1	10U	474668	6162655
	SC2-2	10U	474670	6162676
	SC3-1	10U	474697	6162745
	SC3-2	10U	474712	6162753
Lamonti Creek	LC1-1	10U	475082	6162074
	LC1-2	10U	475098	6162065
	LC2-1	10U	475169	6162056
	LC2-2	10U	475187	6162058
	LC3-1	10U	475113	6162023
	LC3-2	10U	475133	6162022
	LC4-1	10U	475181	6161997
	LC4-2	10U	475192	6162013
Ole Creek	OC1-1	10V	405833	6257636
	OC1-2	10V	405831	6257638
	OC2-1	10V	405887	6257660
	OC2-2	10V	405867	6257657
	OC3-1	10V	405863	6257675
	OC3-2	10V	405844	6257664
Factor Ross Creek	FC1-1	10V	395521	6275897
	FC1-2	10V	395511	6275884
	FC2-1	10V	395481	6275940
	FC2-2	10V	395464	6275928
	FC3-1	10V	395380	6275938
	FC3-2	10V	395363	6275929

[1] -The ‘1’ suffix denoted the beginning of a transect and the ‘2’ suffix the end

Appendix 8. Habitat class descriptions in the draw-down zone at enhancement and control sites.

<table>
<tr><th colspan="2">BASIN SILT (BS)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2">Basin Silt (BS): Lacustrine surface material with a plain surface expression and low to minimal coarse woody debris cover. Vegetation cover within the basin areas is relatively absent; however, occassional herbaceous germinants, including lady’s thumb (Persicaria maculosa) may be observed in the early spring, prior to flooding. Soils are mainly silt and sand textured. Groundwater is the main water source and reservoir flooding is expected to occur annually.</td></tr>
</table>

Gravel and Sand	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Gravel and Sand (GS): Fluvial and glaciofluvial surface materials with undulating or gently sloping surface expressions and low coarse woody debris cover. Vegetation cover is sparse to absent, with the exeption of occasional patches localized to surface depressions within intermittent water channels and coarse woody debris structures. Soils are coarse textured, consisting of gravel and sand. Precipitation and stream sub-irrigation are the main water sources and reservoir flooding is expected to occur annually.	

Organic Veneer (OV)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Organic Veneer (OV): Organic surface material with a gently sloped surface expression and low coarse woody debris cover. Vegetation cover is sparse to low; species commonly observed include bluejoint, sedges, including bronze sedge (*Carex aenea*) and water sedge (*Carex aquatilis*), and purslane speedwell (*Veronica peregrina var. xalapensis*). Soils appear to be remnant of past forest cover, with an organic horzion overlaying silt and clay mineral horizons. Groundwater is the main water source and reservoir flooding is expected to occur annually.	

Shoreline Driftwood (SD)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Shoreline Driftwood (SD): Organic and glacialfluvial surface materials (depending on location and slope within the drawdown zone) on gently sloped surface expression with moderate to high coarse woody debris cover. Vegetation cover is low to moderate on organic surface materials and sparse to absent on glacialfluvial surfaces (i.e., gravel and sand). Species commonly observed include bluejoint, common horsetail (in wet depressions), marsh yellow cress (*Rorippa palustris*), tower mustard and Norwegian cinquefoil (*Potentilla norvegica*). Soils are either remnant of past forest cover (gentle slopes) or gravel and sand substrates (moderate slopes) occuring in the upper drawdown zone. Precipitation and groundwater are the main water sources and reservoir flooding is expected to occur annually to frequently.	

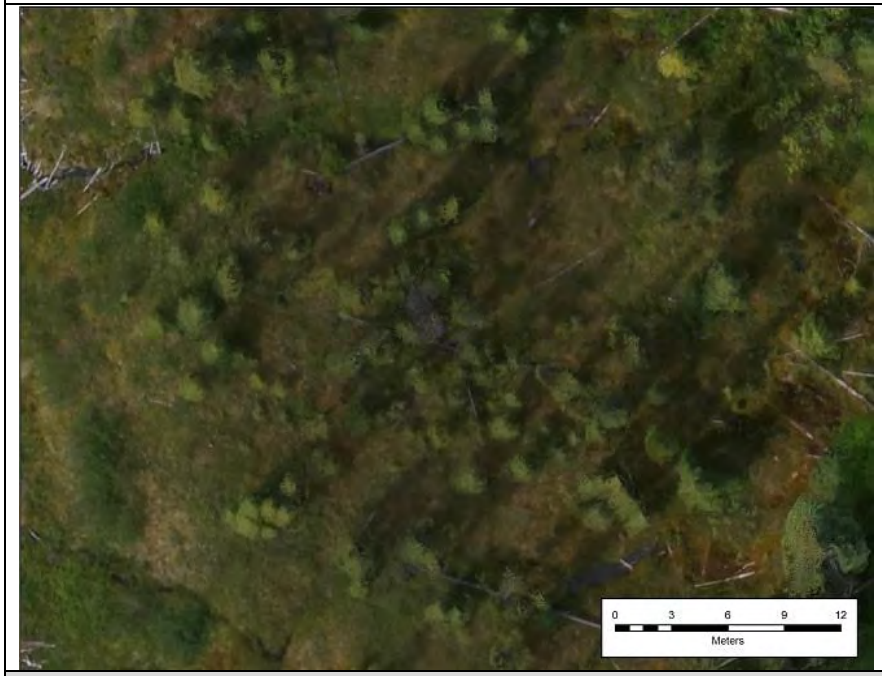
Shoreline Forest (SF):	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Shoreline Forest (SF): Undisturbed forest cover above the upper limits of the drawdown zone. Forest cover at the study sites is representative of the Williston variant for the moist cool subzone of the Sub-boreal Spruce Biogeoclimatic zone (SBSmk2). At Six Mile, Lamonti and Factor Ross Creek study sites, the tree cover along the shoreline is primarily coniferous; dominant tree species include lodgepole pine (*Pinus contorta* var. *latifolia*), subalpine fir (*Abies lasiocarpa*) and hybrid white spruce (*Picea glauca x engelmannii*), with Black Spruce (*Picea mariana*) occurring on wet sites. At Ole Creek, tree cover along the shoreline is primarily deciduous and diverse (shown in representative photographs above); species include trembling aspen (*Populus tremuloides*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), paper birch (*Betula papryifera*), hybrid spruce, subalpine fir and lodgepole pine; large willow (*Salix* spp.) and Sitka alder (*Alnus viridis* ssp. *sinuata*) also occur within the tree canopy. Groundwater and precipitation are the main water sources and reservoir flooding is not expected to occur.	

Shoreline Willow (SW)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Shoreline Willow (SW): Organic surface materials on plain to gently sloping surface expressions with low to moderate coarse woody debris cover. Vegetation cover is moderate to high and consists of willow domianted shrub cover and a grass dominated (e.g., bluejoint [*Calamagrostis canadensis*]) herbaceous cover. Reservoir flooding is expected to be frequent to rare.	

Streams and Ponds (SP)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Streams and Ponds (SP): Areas of perennial water cover, including creeks, small streams, ponds and the reservoir.	

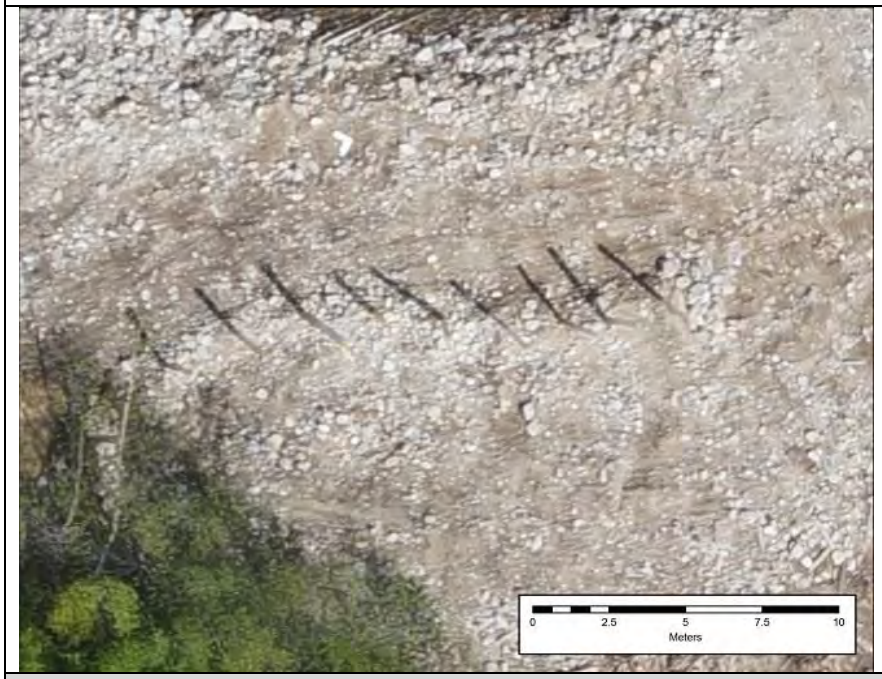
Wetland Horsetail (WH)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Wetland Horsetail (WH): Gently sloping areas within the upper drawdown zone that experience seepage from uphill perennial water sources, as well as along the edges of small streams. Vegetation cover is moderate to high and is dominated by bryophytes and swamp horsetail (*Equisetum fluviatile*). Other herbaceous species observed includes yellow monkey flower (*Mimulus gluttatus*) and bluejoint. Groundwater is the main water source and reservoir flooding is expected to occur annually.	

Wetland Sedge (WS)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Wetland Sedge (WS): Organic surface materials with a plain surface expression and low to sparse coarse woody debris cover. Vegetation cover is high and dominated by graminoids (e.g., grasses, sedges and rushes). Species observed include sedges, bluejoint, swamp horsetail, common horsetail (*Equisetum arvense*), dwarf scouring-rush (*Equisetum scirpoides*), marsh yellow cress and willows. Groundwater is the main water source and reservoir flooding is expected to be frequent to not occuring.	

Wetland Willow (WW)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Wetland Willow (WW): Organic surface materials on a plain surface expression with sparse to absent coarse woody debris cover. Vegetation cover is high and dominated by bryophytes (e.g., sphagnum mosses) and willows. Black spruce (*Picea mariana*) may also be present. Groundwater is the main water source and reservoir flooding is expected to be frequent to rare.	

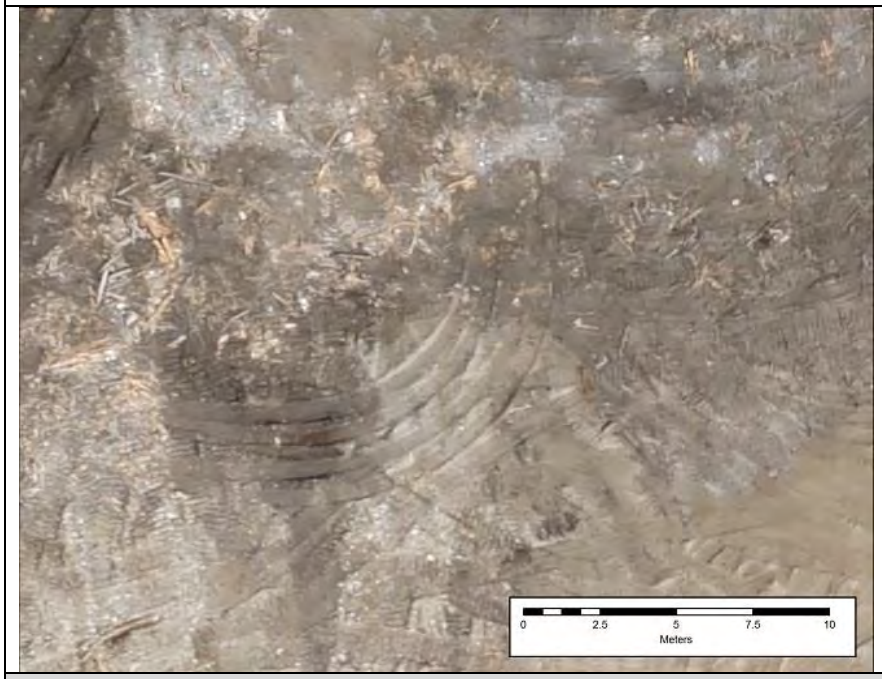
Appendix 9. Enhancement class descriptions in the draw-down zone at enhancement and reference sites.

<table>
<tr><th colspan="2">Blocks and Boulders (BB)</th></tr>
<tr><td colspan="2">Representative Photographs</td></tr>
<tr><th>Aerial View</th><th>Ground View</th></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td colspan="2">Description</td></tr>
<tr><td colspan="2">Blocks and Boulders (BB): Structures constructed using glaciofluvial materials creating gentle to moderately sloped surface expressions. Vegetation and coarse woody debris cover is absent. Surface materials are coarse textured and include blocks, boulders, cobble, gravel and sand. Precipitation is the main water source and reservoir flooding is expected to occur annually.</td></tr>
</table>

Blocks and Logs (BL)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Blocks and Logs (BL): Structures constructed using glaciofluvial materials and large logs, creating gentle to moderately sloped surface expressions and standing wood structures. Surface materials are coarse textured and include blocks, boulders, cobble, gravel and sand. Precipitation is the main water source and reservoir flooding is expected to occur annually.	

Coconut Matting (CM)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Coconut Matting (CM): An artificial organic matting material placed along the surface of constructed berms with a gently sloped surface expression. Vegetation cover consists mostly of annual ryegrass (e.g, live or dead cover) and a few herbs including clover (*Trifolium spp.*), Norwegian cinquefoil and marsh yellow cress; coarse woody debris cover is absent. Precipitation is the main water source and reservoir flooding is expected to be annual to rare (depending on the location of the matting within the drawdown zone).	

Logs and Willow Cuttings (LW)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Logs and Willow Cuttings (LW): Large logs with intact rooting bases and live willow stem cuttings implanted into the side wall of constructed berms with a gentle to moderately sloped surface expression. Precipitation is the main water source and reservoir flooding is expected to be annual to rare (depending on the location of the matting within the drawdown zone).	

Mixed Materials (MM)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Mixed Materials (MM): Areas surrounding enhancement structures where the surface materials that were present prior to construction have been disturbed and/or mixed with other materials (e.g., overburden, silts and coarse woody debris). The surface expression is gently sloping. Vegetation is mostly absent with a few herbs germinants emerging prior to flooding; course woody debris cover is low to absent. Precipitation and groundwater are the main water sources and reservoir flooding is expected to occur annually.	

Overburden (OB):	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Overburden (OB): Mineral soils sourced from areas outside the drawdown zone and used as surface materials in the construction of roadways and berms. These soils have been spread over coconut matting on the berms. The surface expression is gently sloped. Vegetation and coarse woody debris cover is absent. Precipitation is the main water source and reservoir flooding is expected to occur annually.	

Road (RD)	
Representative Photographs	
Aerial View	**Ground View**
	
Description	
Road (RD): Compacted mineral soils on gently to moderate surface expressions. Vegetation and coarse woody debris cover is absent. Reservoir flooding is not expected to rare.	

Silt (ST)	
Representative Photographs	
Aerial View	**Ground View**
	Not Available[1]
Description	
Silt (ST): Lacustrine surface material sourced from the basin and used in the construction of berms in the lower drawdown zone. Vegetation is absent. Precipitation is the main water source and reservoir flooding is expected to occur annually.	

Stump Armour (ST)	
Representative Photographs	
Aerial View	**Ground View**
	Not Available[1]
Description	
Stump Armour (SA): Large logs with intact rooting bases implanted into the side wall of constructed berms with a gentle to moderately sloped surface expression. Precipitation is the main water source and reservoir flooding is expected to be annual.	

Appendix 10. Photographs illustrating vegetation transects at enhancement sites.

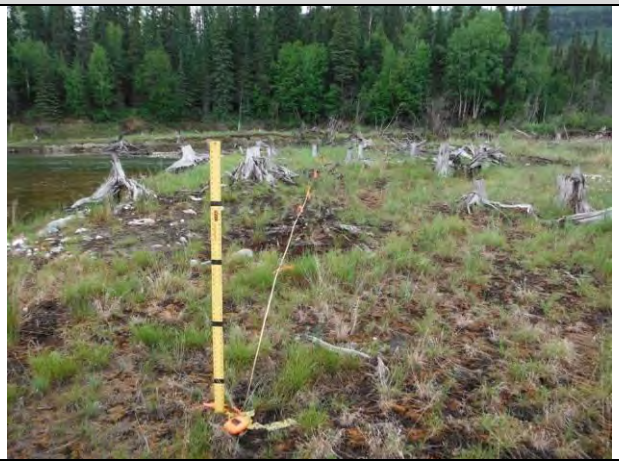
Representative Photographs	
SC 1	
	Not Available[1]
2014	**2015**
SC 2	
	
2014	**2015**
SC 3	
	
2014	**2015**

[1]Photo not available due to flooding of transect at the time of sampling.

Representative Photographs	
OC 1	
	
2014	**2015**
OC 2	
	
2014	**2015**
OC 3	
	
2014	**2015**

Appendix 11. Photographs illustrating vegetation transects at control sites.

Representative Photographs	
LC1	
	Not Available[1]
2014	**2015**
LC2	
	
2014	**2015**
LC3	
	Not Available[1]
2014	**2015**

Representative Photographs	
LC4	
	
2014	**2015**

[1]Photo not available due to flooding of transect at the time of sampling.

Representative Photographs	
FC1	
	
2014	**2015**
FC2	
	Not Available[1]
2014	**2015**

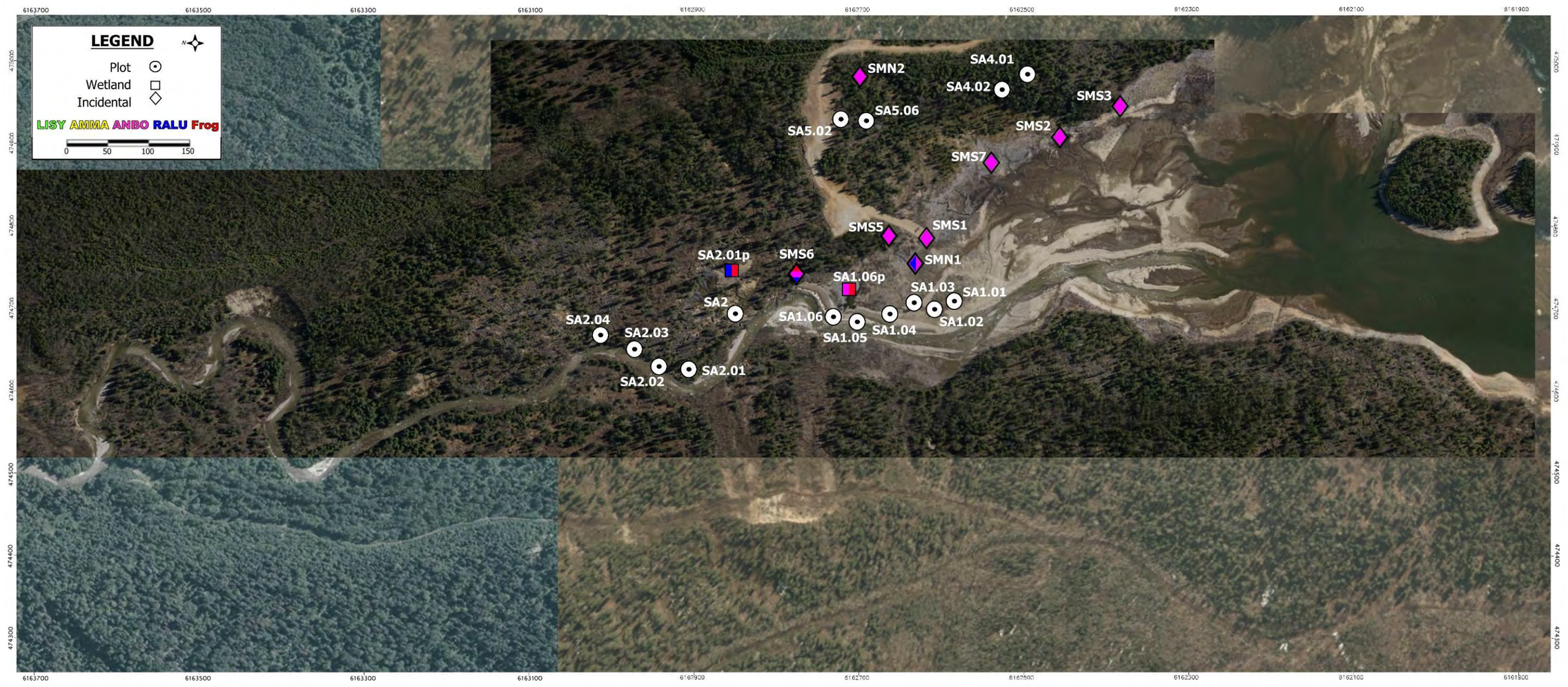
Representative Photographs	
FC3	
	
2014	**2015**

[1]Photo not available due to flooding of transect at the time of sampling.

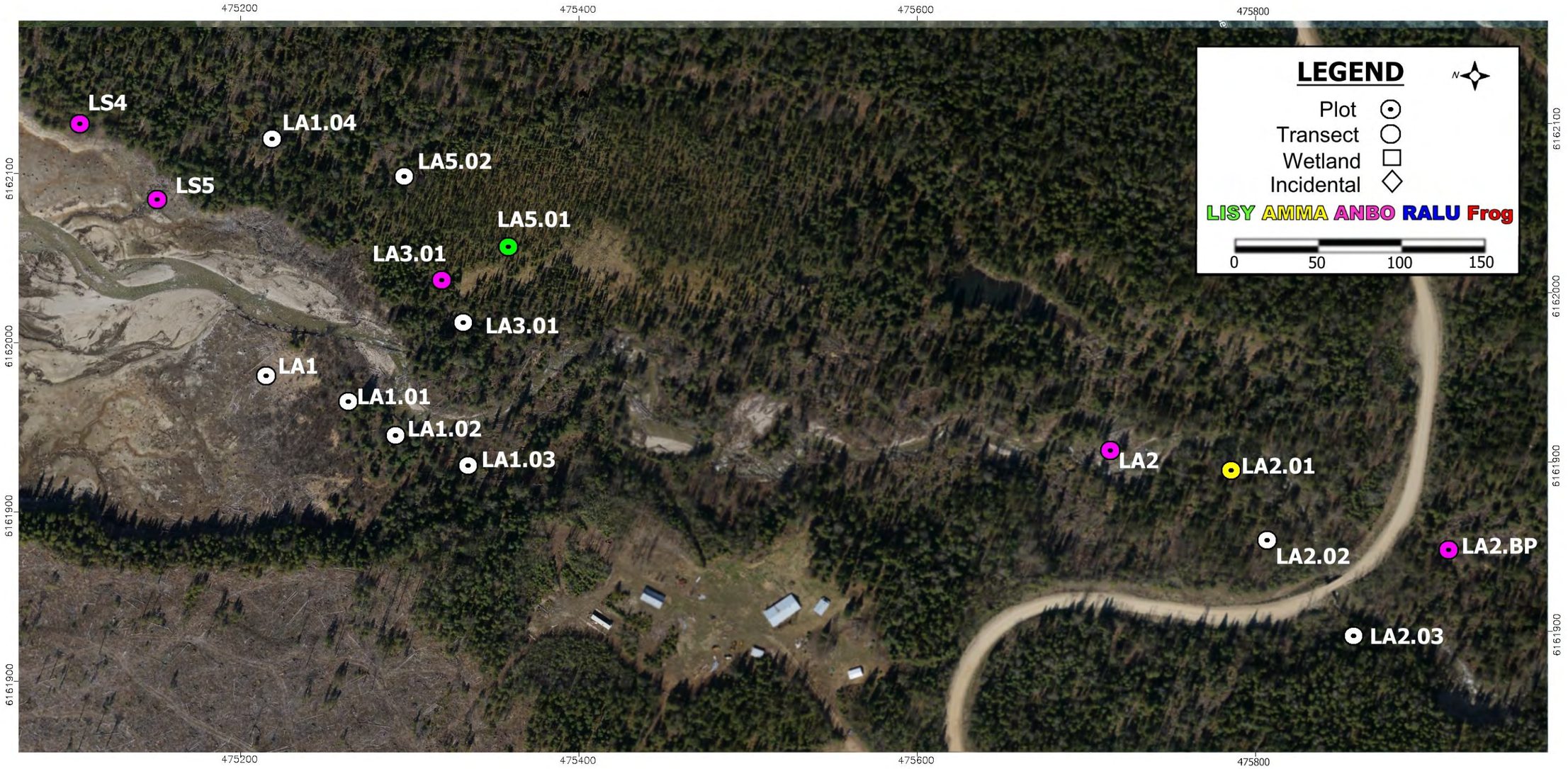
Appendix 12. Summary of percent cover by plant species averaged across 10 quadrats in a 20 m belt-transect for vegetation transects sampled in Year 5 at enhancement and reference sites.

Group	Species	Transect									Total
		SC2	SC3	LC2	LC4	FC1	FC3	OC1	OC2	OC3	
Herbs/Forbs/ Graminoids	little meadow foxtail	0.0	0.0	0.5	0.2	0.0	4.2	0.0	0.0	0.0	**4.8**
	bluejoint	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	**0.5**
	water sedge	0.7	0.0	0.7	0.0	0.5	0.0	0.0	0.0	0.0	**1.8**
	bronze sedge	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	**0.3**
	sedge sp.	0.0	0.0	2.8	6.5	0.4	0.6	0.0	0.0	0.1	**10.4**
	golden corydalis	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	**0.1**
	smooth hawksbeard	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	**0.5**
	common horsetail	0.1	0.0	0.1	0.3	2.1	0.8	0.0	0.0	0.1	**3.5**
	scouring rush	7.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	**8.0**
	grass sp.	0.5	0.0	0.1	0.1	4.2	0.0	1.4	0.8	0.1	**7.2**
	Norwegian cinquefoil	0.1	0.0	3.3	1.9	1.2	1.0	0.0	0.0	0.0	**7.6**
	marsh yellowcress	0.5	0.0	0.7	0.0	0.0	0.5	0.0	0.0	0.0	**1.7**
	umbellate starwort	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	**0.2**
	hair bentgrass	0.0	0.0	0.3	5.3	0.0	0.6	0.0	0.0	0.0	**6.2**
	small bedstraw	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	**0.9**
	dock sp.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	**0.1**
	Penn,s buttercup	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
	fall rye	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.2	0.0	**2.8**
	clover sp.	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.2	**0.4**
	unknown 108	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
	unknown 110	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
	unknown 111	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
	unknown 112	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	**0.2**
	unknown 118	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.1**
	purslane speedwell	0.0	0.0	1.0	0.0	0.0	0.1	0.0	0.0	0.0	**1.0**
		9	**0**	**11**	**7**	**10**	**8**	**3**	**2**	**6**	
Bryophytes	marsh threadmoss	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.7**
	unknown 114	0.0	0.0	3.0	2.8	0.0	1.2	0.0	0.0	0.0	**7.0**
		1	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	

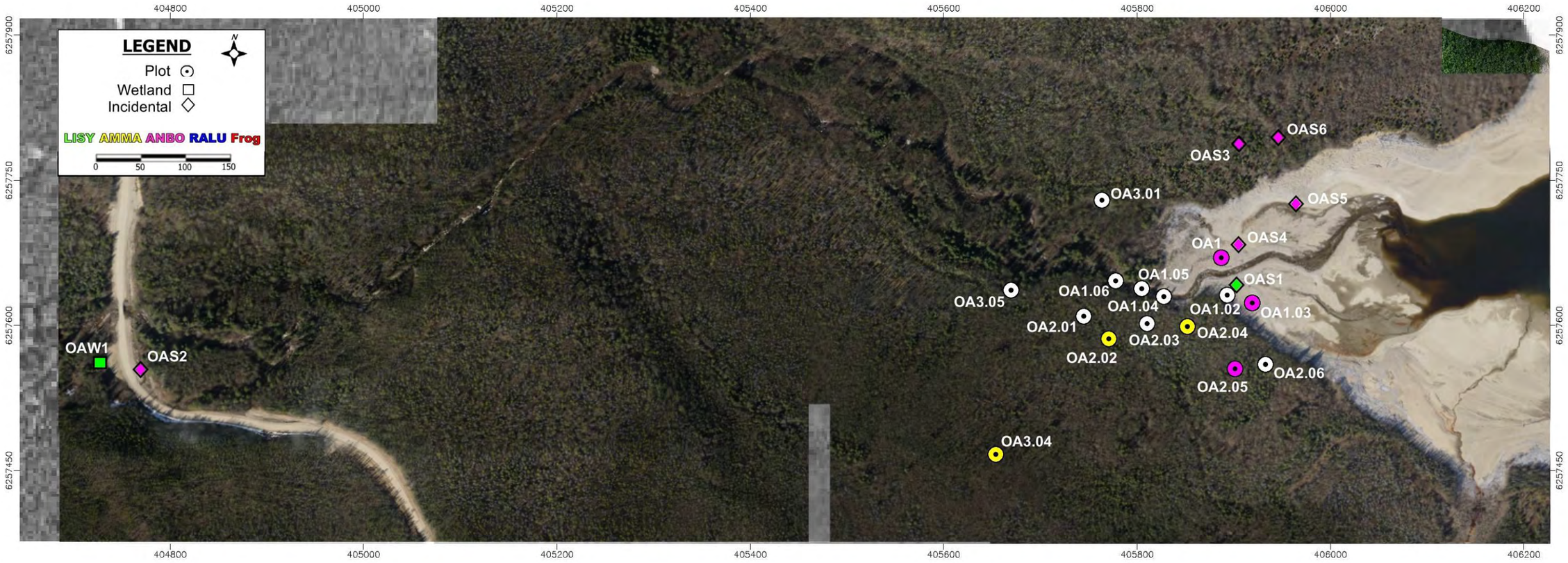
Appendix 13. Amphibian survey plots and transects with locations of amphibian detections in 2015.



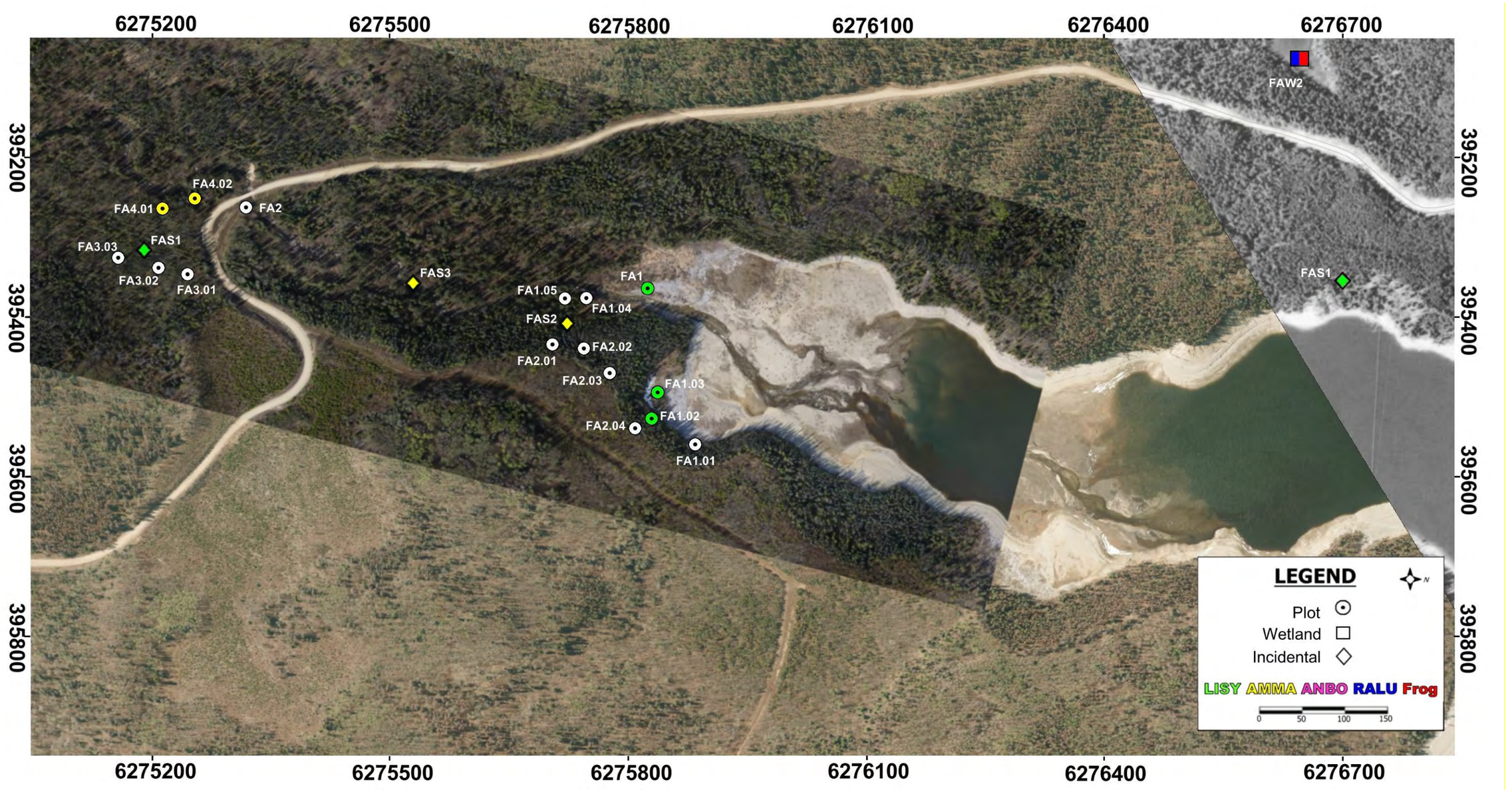
Map 9. Six Mile Creek amphibian survey locations and detections.



Map 10. **Lamonti Creek amphibian survey locations and detections.**



Map 11. Ole Creek amphibian survey locations and detections.



Map 12. Factor Ross Creek amphibian survey locations and detections.

Appendix 14. Summary of the 2015 amphibian survey plot and transect results.

Date	Location	Plot-Site Code	Crew	Plot (P) / Spot (S) / Transect (T) / Wetland (W)	UTM			Tally					Snake Obs.	Notes
					Zone	East	North	AMMA LTS	ANBO WT	RALU SF	LISY WF	Unident. Frog		
3-Jun-15	Six Mile	SA1.06p	MT/CS	W	10	474688	6162735	0	2	0	0	1	0	
3-Jun-15	Six Mile	SA2	MT/CS	W	10	474700	6162854	0	0	0	0	0	0	
3-Jun-15	Six Mile	SA4.01	MT/CS	P	10	474895	6162494	0	0	0	0	0	0	Rained all night, ground was soaked
3-Jun-15	Six Mile	SA4.02	MT/CS	P	10	474879	6162563	0	0	0	0	0	0	Small stream cutting through plot.
3-Jun-15	Six Mile	SMS1	MT/CS	S	10	474785	6162619	0	1	0	0	0	0	
3-Jun-15	Six Mile	SA1.01	MT/CS	P	10	474708	6162583	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA2	MT/CS	P	10	474700	6162854	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA2.01	MT/CS	P	10	474618	6162912	0	0	0	0	0	0	
3-Jun-15	Six Mile	SMS4	MT/CS	S	10	474616	6162922	0	1	0	0	0	0	
3-Jun-15	Six Mile	SA2.02	MT/CS	P	10	474636	6162945	0	0	0	0	0	0	
3-Jun-15	Six Mile	SA2.03	MT/CS	P	10	474650	6162992	0	0	0	0	0	0	
3-Jun-15	Six Mile	SA2.04	MT/CS	P	10	474665	6163034	0	0	0	0	0	0	
3-Jun-15	Six Mile	SA1.03	MT/CS	P	10	474701	6162639	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA1.04	MT/CS	P	10	474693	6162672	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA1.05	MT/CS	P	10	474680	6162694	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA1.06	MT/CS	P	10	474686	6162723	0	0	0	0	0	0	Search time reduced - drawdown zone
3-Jun-15	Six Mile	SA1.02	MT/CS	P	10	474687	6162610	0	0	0	0	0	0	Search time reduced - drawdown zone
4-Jun-15	Six Mile	SA5.02	MT/CS	P	10	474935	6162722	0	0	0	0	0	0	
4-Jun-15	Six Mile	SA5.06	MT/CS	P	10	474933	6162690	0	0	0	0	0	0	
4-Jun-15	Six Mile	SMS2	MT/CS	S	10	474912	6162446	0	1	0	0	0	0	
4-Jun-15	Six Mile	SMS3	MT/CS	S	10	474947	6162384	0	1	0	0	0	0	
4-Jun-15	Six Mile	LS4	MT/CS	S	10	475122	6162105	0	1	0	0	0	0	Previously SMS4
4-Jun-15	Six Mile	LS5	MT/CS	S	10	475161	6162063	0	2	0	0	0	0	Previously SMS5
4-Jun-15	Six Mile	SMN1	MT/CS	T	10	474736	6162622	0	13	1	0	0	0	Night time transect.
4-Jun-15	Lamonti	LA1.01	MT/CS	P	10	475274	6161948	0	0	0	0	0	0	
4-Jun-15	Lamonti	LA1.02	MT/CS	P	10	475313	6161931	0	0	0	0	0	0	
4-Jun-15	Lamonti	LA1.03	MT/CS	P	10	475356	6161920	0	0	0	0	0	0	Stream 6^{0}C - Plot around spring stream.
4-Jun-15	Lamonti	LA3.01	MT/CS	P	10	475335	6162013	0	3	0	0	0	0	Small stream - 11^{0}C - Make a plot next year. Named the plot in 2015.
4-Jun-15	Lamonti	LAS1	MT/CS	S	10	475378	6162037	0	0	0	1	0	0	Bog habitat - stream 9.5^{0}C
4-Jun-15	Lamonti	LA1.04	MT/CS	P	10	475215	6162105	0	0	0	0	0	0	Good habitat here - turned this into a plot.
4-Jun-15	Six Mile	SMS7	MT/CS	S	10	474873	6162535	0	1	0	0	0	0	Photo wasn't taken. Was originally labelled LAS2
4-Jun-15	Lamonti	LA2	MT/CS	P	10	475758	6161922	0	1	0	0	0	0	Notes about toad in previous photo set - check with photos.
4-Jun-15	Lamonti	LA2.01	MT/CS	P	10	475811	6161907	1	0	0	0	0	0	Ran out of time to do full habitat classification.
4-Jun-15	Lamonti	LA2.02	MT/CS	P	10	475827	6161880	0	0	0	0	0	0	Semi-dry site.
4-Jun-15	Lamonti	LA2.03	MT/CS	P	10	475907	6161814	0	0	0	0	0	0	
4-Jun-15	Lamonti	LA2.bp	MT/CS	S	10	475970	6161867	0	1	0	0	0	0	

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					Zone	East	North	AMMA LTS	ANBO WT	RALU SF	LISY WF	Unident. Frog		
13-Jun-15	Factor	FA4.02	MT/AMF	P	10	395226	6275255	3	0	0	0	0	0	Caught 1 during survey - 2 others in birch bark. Including them with search bc did not add much time to effort.
13-Jun-15	Factor	FA4.01	MT/AMF	P	10	395237	6275202	1	0	0	0	0	0	Didn't weigh the salamander for some reason?
13-Jun-15	Factor	FAS1	MT/AMF	S	10	395293	65275192	0	0	0	1	0	0	
13-Jun-15	Factor	FA3.03	MT/AMF	P	10	395294	6275167	0	0	0	0	0	0	
13-Jun-15	Factor	FA3.02	MT/AMF	P	10	395290	6275209	0	0	0	0	0	0	Light drizzle of rain.
14-Jun-15	Factor	FAW2	MT/AMF	W	10	394866	6276788	0	0	3	0	0	0	
14-Jun-15	Factor	FAW3	MT/AMF/KM/SF	W	10	393696	6273035	0	19	15	11	10	0	
14-Jun-15	Factor	FAS1	MT/AMF	S	10	395327	6276703	0	0	0	1	0	0	Sunny warm
14-Jun-15	Factor	FA1.05	MT/AMF	P	10	395390	6275636	0	0	0	0	0	0	
14-Jun-15	Factor	FA2.01	MT/AMF	P	10	395416	6275696	0	0	0	0	0	0	
14-Jun-15	Factor	FAS2	MT/AMF	S	10	395384	6275734	2	0	0	0	0	0	Birch bark discovery
14-Jun-15	Factor	FA2.02	MT/AMF	P	10	395423	6275738	0	0	0	0	0	0	
14-Jun-15	Factor	FA2.03	MT/AMF	P	10	395430	6275792	0	0	0	0	0	0	
14-Jun-15	Factor	FA1.03	MT/AMF	P	10	395475	6275837	0	0	0	0	0	0	
14-Jun-15	Factor	FA1.02	MT/AMF	P	10	395508	6275817	0	0	0	1	0	0	
14-Jun-15	Factor	FA1.01	MT/AMF	P	10	395555	6275876	0	0	0	0	0	0	Drier - 29^{0}C today.
14-Jun-15	Factor	FA1	MT/AMF	P	10	395341	6275833	0	0	0	7	0	0	Caught 2 - observed 5.
15-Jun-15	Factor	FAW1	MT/AMF	W	10	395866	6274948	1	6	1	1	5	0	AMMA obs is egg mass.
15-Jun-15	Factor	FAW5	MT/AMF	W	10	396660	6273498	0	8	0	0	1	0	
15-Jun-15	Factor	FA5.01	MT/AMF	P	10	394181	6274126	0	0	0	0	0	0	
15-Jun-15	Factor	FA5.02	MT/AMF	P	10	394610	6274588	0	0	0	0	0	0	
15-Jun-15	Factor	FA5.03	MT/AMF	P	10	394731	6274776	0	0	0	0	0	0	
15-Jun-15	Factor	FA3.01	MT/AMF	P	10	395317	6275253	0	0	0	0	0	0	Stream here as well - see aquatic database.
15-Jun-15	Factor	FAS3	SF/KM	S	10	395330	6275526	1	0	0	0	0	0	Caught in Class 3, Type 2,3,4,5 - Aspen log. Under moss on log.
15-Jun-15	Factor	FA7.01	MT/AMF	P	10	395740	6275009	0	0	0	0	0	0	
17-Jun-15	Ole	OA1	MT/AMF	P	10	405864	6257666	0	4	0	0	0	0	Overcast - cool breeze.
17-Jun-15	Ole	OA1.01	MT/AMF	P	10	405848	6257607	0	0	0	0	0	0	
17-Jun-15	Ole	OAS1	MT/AMF	S	10	405882	6257644	0	0	0	1	0	0	
17-Jun-15	Ole	OA1.03	MT/AMF	P	10	405898	6257621	0	0	0	0	0	0	
17-Jun-15	Ole	OA2.06	MT/AMF	P	10	405913	6257543	0	0	0	0	0	0	
17-Jun-15	Ole	OA2.05	MT/AMF	P	10	405875	6257536	0	1	0	0	0	0	
17-Jun-15	Ole	OA2.04	MT/AMF	P	10	405835	6257599	1	0	0	0	0	0	
17-Jun-15	Ole	OA2.03	MT/AMF	P	10	405782	6257588	0	0	0	0	0	0	
17-Jun-15	Ole	OA2.02	MT/AMF	P	10	405746	6257587	1	0	0	0	0	0	Tail damage - looked like it just ate something. Caught on top of log in moss.
17-Jun-15	Ole	OA2.01	MT/AMF	P	10	405714	6257602	0	0	0	0	0	0	
17-Jun-15	Ole	OA1.05	MT/AMF	P	10	405781	6257634	0	0	0	0	0	0	
17-Jun-15	Ole	OA1.06	MT/AMF	P	10	405731	6257647	0	0	0	0	0	0	
18-Jun-15	Ole	OAST1	MT/AMF	W	10	405556	6256336	0	0	0	1	0	0	

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					Zone	East	North	AMMA LTS	ANBO WT	RALU SF	LISY WF	Unident. Frog		
18-Jun-15	Ole	OAST2	MT/AMF	W	10	405963	6256148	0	0	0	1	1	0	
18-Jun-15	Ole	OAST3	MT/AMF	W	10	406001	6256529	0	0	0	1	0	0	
18-Jun-15	Ole	OAW3	MT/AMF	W	10	403820	6256523	0	0	4	0	0	0	
18-Jun-15	Ole	OAW1	MT/AMF	W	10	404719	6257578	0	0	0	2	0	0	
18-Jun-15	Ole	OAS2	MT/AMF	S	10	405914	6256670	0	0	0	1	0	0	Bog area. Frog observed.
18-Jun-15	Ole	OA4.01	MT/AMF	P	10	405492	6256588	0	0	0	0	0	0	
18-Jun-15	Ole	OA4.02	MT/AMF	P	10	405339	6256542	0	0	0	0	0	0	
18-Jun-15	Ole	OA4.03	MT/AMF	P	10	405174	6256614	0	0	0	0	0	0	
18-Jun-15	Ole	OAS2	MT/AMF	S	10	404743	6257568	0	1	0	0	0	0	
18-Jun-15	Ole	OA3.02	MT/AMF	P	10	405519	6257192	0	0	0	0	0	0	
18-Jun-15	Ole	OA3.03	MT/AMF	P	10	405700	6257237	0	0	0	0	0	0	
18-Jun-15	Ole	OA3.04	MT/AMF	P	10	405671	6257466	0	1	0	0	0	0	
18-Jun-15	Ole	OA3.05	MT/AMF	P	10	405676	6257617	0	0	0	0	0	0	
18-Jun-15	Ole	OA3.01	MT/AMF	P	10	405731	6257697	0	0	0	0	0	0	Over an old ephemeral stream bed.
18-Jun-15	Ole	ON2	MT/AMF	T	10	406933	6257735	0	28	0	0	0	0	
18-Jun-15	Ole	OAS3	MT/AMF	S	10	405898	6257779	0	1	0	0	0	0	
4-Aug-15	Factor	FA3.01	AMF	P	10	395331	6275262	0	0	0	0	0	0	
4-Aug-15	Factor	FA3.02	AMF/CS	P	10	395430	6275792	0	0	0	0	0	0	
4-Aug-15	Factor	FA3.03	AMF/CS	P	10	395294	6275167	0	0	0	0	0	0	
4-Aug-15	Factor	FA4.01	AMF/CS	P	10	395237	6275202	0	0	0	0	0	0	
4-Aug-15	Factor	FA4.02	AMF/CS	P	10	395226	6275255	0	0	0	0	0	0	
5-Aug-15	Factor	FAW2	AMF/CS	W	10	395058	6276673	0	0	0	0	2	0	
5-Aug-15	Factor	FA1.05	AMF/CS	P	10	395416	6275696	0	0	0	0	0	0	
5-Aug-15	Factor	FA1.04	AMF/CS	P	10	395373	6275726	0	0	0	0	0	0	Search time cut short due to wasp nest.
5-Aug-15	Factor	FA2.02	AMF/CS	P	10	395423	6275738	0	0	0	0	0	0	
5-Aug-15	Factor	FA2.03	AMF/CS	P	10	395430	6275792	0	0	0	0	0	0	
5-Aug-15	Factor	FA1.02	AMF/CS	P	10	395508	6275817	0	0	0	2	0	0	Partly flooded - near reservoir, wood frogs observed not caught.
5-Aug-15	Factor	FA1.03	AMF/CS	P	10	395475	6275837	0	0	0	1	0	0	
5-Aug-15	Factor	FA1.01	AMF/CS	P	10	395555	6275876	0	0	0	0	0	0	Completely flooded - could not survey.
5-Aug-15	Factor	FA1	AMF/CS	P	10	395341	6275833	0	0	0	0	0	0	Completely flooded - could not survey.
5-Aug-15	Factor	FAW3	AMF/CS	W	10	393805	6273005	0	6	15	0	0	0	
5-Aug-15	Factor	FAW3	AMF/CS	W	10	393805	6273005	0	1	3	0	0	0	Captured after timed search
5-Aug-15	Factor	FA5.01	AMF/CS	P	10	394181	6274126	0	0	0	0	0	0	
6-Aug-15	Factor	FA5.02	AMF/CS	P	10	394610	6274588	0	0	0	0	0	0	
6-Aug-15	Factor	FA5.03	AMF/CS	P	10	394731	6274776	0	0	0	0	0	0	
6-Aug-15	Factor	FAW1	AMF/CS	W	10	395770	6274887	0	0	1	1	0	0	
6-Aug-15	Ole	OA1.01	AMF/CS	P	10	405848	6257607	0	0	0	0	0	0	
6-Aug-15	Ole	OA1.02	AMF/CS	P	10	405879	6257639	0	0	0	0	0	0	Completely flooded - could not survey.
6-Aug-15	Ole	OA1.03	AMF/CS	P	10	405898	6257621	0	1	0	0	0	0	
6-Aug-15	Ole	OA2.06	AMF/CS	P	10	405904	6257558	0	0	0	0	0	0	

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6-Aug-15	Ole	OA2.05	AMF/CS	P	10	405873	6257560	0	0	0	0	0	0	
6-Aug-15	Ole	OA2.04	AMF/CS	P	10	405829	6257588	0	0	0	0	0	0	
6-Aug-15	Ole	ON1	AMF/CS	T	10	405836	6257682	0	3	0	0	0	0	
7-Aug-15	Ole	OA1.04	AMF/CS	P	10	405819	6257632	0	0	0	0	0	0	
7-Aug-15	Ole	OA1.05	AMF/CS	P	10	405787	6257636	0	0	0	0	0	0	
7-Aug-15	Ole	OA2.03	AMF/CS	P	10	405787	6257600	0	0	0	0	0	0	
7-Aug-15	Ole	OA1.06	AMF/CS	P	10	405751	6257638	0	0	0	0	0	0	
7-Aug-15	Ole	OA2.02	AMF/CS	P	10	405751	6257595	0	0	0	0	0	0	
7-Aug-15	Ole	OA2.01	AMF/CS	P	10	405725	6257602	0	0	0	0	0	0	
7-Aug-15	Ole	OA3.05	AMF/CS	P	10	405676	6257617	0	0	0	0	0	0	
7-Aug-15	Ole	OA3.04	AMF/CS	P	10	405671	6257466	0	0	0	0	0	0	
7-Aug-15	Ole	OA3.03	AMF/CS	P	10	405700	6257237	0	1	0	0	0	0	
7-Aug-15	Ole	OA3.02	AMF/CS	P	10	405519	6257192	0	0	0	0	0	0	
7-Aug-15	Ole	OA4.03	AMF/CS	P	10	405174	6256614	0	0	0	0	0	0	
7-Aug-15	Ole	OA4.02	AMF/CS	P	10	405339	6256542	0	0	0	0	0	0	
7-Aug-15	Ole	OA4.01	AMF/CS	P	10	405492	6256588	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA2BP	AMF/CS	W	10	475964	6161870	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA2.03	AMF/CS	P	10	475917	6161811	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA2.02	AMF/CS	P	10	475827	6161880	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA2.01	AMF/CS	P	10	475811	6161907	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA2	AMF/CS	P	10	475758	6161922	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA1.03	AMF/CS	P	10	475356	6161920	0	0	0	0	0	0	Small side swale / NCD
9-Aug-15	Lamonti	LA1.02	AMF/CS	P	10	475313	6161931	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA1	AMF/CS	P	10	475233	6161975	0	0	0	0	0	0	Passive search - walk through.
9-Aug-15	Lamonti	LA1.01	AMF/CS	P	10	475284	6161954	0	0	0	0	0	0	
9-Aug-15	Lamonti	LA5.01	AMF/CS	P	10	475378	6162037	0	0	1	0	0	0	
9-Aug-15	Lamonti	LA5.02	AMF/CS	P	10	475247	6162097	0	0	0	0	0	0	
9-Aug-15	Six Mile	SMN2	AMF/CS	T	10	475012	6162706	0	6	0	0	0	0	
10-Aug-15	Six Mile	SA5.02	AMF/CS	P	10	474935	6162722	0	0	0	0	0	0	
10-Aug-15	Six Mile	SA5.06	AMF/CS	P	10	474933	6162690	0	0	0	0	0	0	
10-Aug-15	Six Mile	SA4.01	AMF/CS	P	10	474895	6162494	0	0	0	0	0	0	Flooded - no search
10-Aug-15	Six Mile	SA4.02	AMF/CS	P	10	474879	6162563	0	0	0	0	0	0	Flooded - no search
10-Aug-15	Six Mile	SA1	AMF/CS	P	10	474708	6162583	0	0	0	0	0	0	Flooded - no search
10-Aug-15	Six Mile	SA1.06P	AMF/CS	W	10	474688	6162735	0	1	0	0	0	0	Flooded - no search
10-Aug-15	Six Mile	SMS5	AMF/CS	S	10	474767	6162674	0	0	0	0	0	1	
10-Aug-15	Six Mile	SMS6	AMF/CS	S	10	474724	6162788	0	2	2	0	1	0	Searched on the earth berm between stream and pond.
10-Aug-15	Six Mile	SA2.04	AMF/CS	P	10	474657	6163011	0	0	0	0	0	0	
10-Aug-15	Six Mile	SA2.03	AMF/CS	P	10	474643	6162969	0	0	0	0	0	0	
10-Aug-15	Six Mile	SA2.02	AMF/CS	P	10	474623	6162940	0	0	0	0	0	0	
10-Aug-15	Six Mile	SA2.01	AMF/CS	P	10	474618	6162912	0	0	0	0	0	0	

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10-Aug-15	Six Mile	SA.2.01p	AMF/CS	W	10	474740	6162851	0	0	1	0	1	0	