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470 Granville Street, Suite 630, Vancouver, BC V6C 1V5

Whistler Ecosystems Monitoring Program

2018

PECG Project #
160253

Prepared For
Resort Municipality of Whistler

April 1, 2019

SNOWLINE
Ecological Research

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470 Granville Street, Suite 630, Vancouver, BC V6C 1V5

April 1, 2019

Ms Heather Beresford
Environmental Stewardship Manager
Resort Municipality of Whistler
4325 Blackcomb Way
Whistler, B.C. V0N 1B4

Dear Ms Beresford,

Re: Whistler Ecosystems Monitoring Program
Project #: 160253

Enclosed you will find the final Whistler Ecosystems Monitoring Program 2018 report. This report has been authored by Palmer Environmental Consulting Group Inc. (PECG) and Snowline Ecological Research (Snowline).

We hope our team-based approach will not only fulfil the conservation goals for the Resort Municipality of Whistler (RMOW) but will maintain the connection to residents and produce a report that is scientifically defensible.

Thank you for this opportunity to support you on this interesting project. Should you have any questions or require additional information, please feel free to contact May Mason (604) 837-1858 or via email at may@pecg.ca.

Yours truly,
Palmer Environmental Consulting Group Inc.

May Mason, M.Sc., R.P.Bio.
Vice-President and Senior Aquatic Ecologist

Acknowledgements

We greatly appreciate the assistance and expertise provided throughout the project by Tara Schaufele and Hilary Williamson with the Rural Municipality of Whistler (RMOW). We also appreciate the valuable field assistance of Jagoda Kozikowska with the RMOW (benthic invertebrate, beaver and tailed frog surveys), Kristen Jones (beaver surveys) and Luke Harrison (tailed frog surveys) as well as the volunteer work of Angie Fulton (fisheries surveys).

Executive Summary

The Resort Municipality of Whistler is located in the southern Coast Mountains of British Columbia, approximately 100 km north of the city of Vancouver. The study area contains a range of aquatic and terrestrial ecosystems interspersed among areas of urban development.

In 2013, the RMOW initiated the Ecosystems Monitoring Program. The program design was based on the use of species, habitat, and climate indicators, to identify temporal and spatial trends in the overall health of ecosystems in the Whistler area. Cascade Environmental Resource Group Ltd conducted the first three years of the Ecosystem Monitoring Program. In 2016, Palmer Environmental Consulting Group Inc. partnered with Snowline Ecological Research and began the next phase of the program. Changes made to the program were designed to maintain comparability and consistency with previous years to the greatest extent possible. The 2018 Ecosystems Monitoring Program components included benthic invertebrates, fish community, Coastal Tailed Frog (*Ascaphus truei*) and beaver (*Castor canadensis*). Water quality, stream temperatures and climate were also included as complementary monitoring components. Changes within each component of the program include: the addition of Millar Creek to the benthic invertebrate sampling program, the use of minnow traps in the fish sampling program, additional sampling sites for Coastal Tailed Frogs on the west side of Whistler Valley, expanded survey effort for beavers, and a preliminary data analysis for Northern Goshawks and black cottonwoods.

A total of six stream sites have been established to monitor the aquatic health of streams in the Resort Municipality of Whistler. Data collection included: benthic invertebrate sampling, fish community sampling, general water quality parameters, stream flow measurements, stream temperature measurements and reach habitat characteristics. Benthic invertebrate analyses indicated a relatively high proportion of pollution sensitive organisms in the River of Golden Dreams watershed, Crabapple Creek and 21 Mile Creek, a sign of healthy benthic invertebrate communities. In contrast, analyses of benthic invertebrate communities in Jordan Creek and Millar Creek indicated reduced community health. These trends were evident in both 2016 and 2017 samples collected from Jordan Creek.

Three species of fish were identified in the 2018 sampling efforts: Threespine Stickleback (*Gasterosteus aculeatus*), undifferentiated trout fry from resident populations of Rainbow Trout (*Oncorhynchus mykiss)* and Coastal Cutthroat Trout (*O. clarkii clarkii)* and sculpin (*Cottus* sp.). The fish communities in Jordan Creek, Crabapple Creek, 21 Mile Creek and the River of Golden Dreams were considered healthy based on their relative condition. Within Jordan Creek and Crabapple Creek, there was a decline in condition from 2016 to 2017 and 2018, similar to benthic invertebrate diversity patterns observed over the same years. As the fish community within these systems is primarily composed of fish likely 0+ year fry, it indicates the importance of the study reaches for trout rearing.

The 2018 program continued to improve upon past years' surveys of Coastal Tailed Frog (*Ascaphus truei*) and Beaver (*Castor canadensis*). A total of 15 sites were surveyed for tailed frogs, two more than the previous high in 2016. In 2018, more tailed frog sites were surveyed on the understudied west side of the valley than on the better-known east side (nine versus six, respectively). Extensive reconnaissance helped establish the first-ever surveys on three creeks on the west side of the valley: "FJ West Creek" (the unnamed creek that flows into Millar Creek west of Function Junction), Van West Creek and Sproatt Creek. Reconnaissance and surveys on these west-side creeks revealed some mapping irregularities that could be pursued and rectified in future years. Most notably, the valley bottom outflow of Sproatt Creek could not be located, and Van West Creek at Function Junction had much less volume than survey sites upstream. No effect of stream disturbances was detected based on tailed frog detections. Statistical analysis of ecological conditions in the RMOW and tadpoles found a link between stream temperature and tadpole detections. This result likely represents higher detectability of tadpoles in warmer water rather than creeks with warmer water having more tadpoles, especially within the RMOW where most mountain streams have similar temperature regimes.

The 2018 field season was the third year of rebuilding the beaver survey towards a complete population census (in which all active colonies are enumerated). More active lodges were detected than in any year since 2008, a year in which the number of active lodges was anomalously high and undoubtedly inflated by an overestimate of how many lodges were active. The total number of lodges in 2018 regardless of status (active, inactive, or unknown) was the highest to date, as was the total number of individual records of beaver activity (Including dams, sign, and sightings). In 2018 a novel observation of one and perhaps two bank burrows were deemed to house an overwintering colony when previously all colonies were assumed to overwinter in lodges. As a result of this effort, the estimate of 18 active colonies in the RMOW is the most reliable to date and provides a solid baseline for future monitoring. Based on an estimate of 5.8 (from studies elsewhere), the total number of beavers is therefore approximately 104.

In 2018, “beaver-affected wetlands” in the RMOW’s development footprint were mapped and their area calculated for the first time. The goal of this part of the program was to quantify habitat created and/or altered by beaver activity. The mapped extent of beaver activities at known sites was based primarily on vegetation types visible from orthophotos with some alterations based on field observations. Thirteen wetlands were mapped as beaver-affected areas. The area of the beaver-affected wetlands totalled 94.7 hectares, which represents at least 63% of the total wetland area remaining in the RMOW. Future field surveys will undoubtedly increase this percentage since not all beaver related flooding is visible from orthophotos.

Three terrestrial components, new to the Environmental Monitoring Program, were added as exploratory indicators for the 2018 program: black cottonwood (*Populus trichocarpa*), Northern Goshawk (*Accipiter gentilis laingi*), and Western Toad (*Anaxyrus boreas*). Black cottonwood and cottonwood forests have been identified previously as important habitat components in the valley bottom. An interpretation of RMOW mapping for this report shows how little area is currently occupied by cottonwoods, and how concentrated these areas are within the development footprint.

Annual breeding of Western Toads in the RMOW is currently only characterized in Lost Lake. While evidence of breeding has been observed in the southern half of the RMOW, as well as many adults, no annual breeding site has been confirmed. To expand the knowledge of toad breeding locations, one new site was surveyed at the northwest corner of the Highway 99 and Callaghan Forest Service Road junction. No toads at any stage, nor other amphibians were detected.

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1. Introduction

1.1 Overview

This report describes monitoring studies conducted in 2018 by Palmer Environmental Consulting Group (PECG) and Snowline Ecological Research (Snowline) on aquatic and terrestrial environments in Whistler, British Columbia. The 2018 study was the sixth year of the Ecosystem Monitoring Program and the third conducted by this team. The purpose of the program is to monitor the health of ecosystems over time through ecological indicators (proxies) to help guide the conservation of species and ecosystems and inform sustainable land use planning and development in Whistler.

Monitoring is a vital component of ecosystem management. It is therefore important that methods used to establish long-term data collection be done in a scientifically defensible manner. Appropriate selection of indicator species and monitoring methods will provide valuable insight into ecosystem health and functioning.

1.2 Background

The Whistler Biodiversity Project (WBP), funded in significant part by the Resort Municipality of Whistler (RMOW) from 2006 through 2012, began surveys in late 2004. This work led to the first publicly documented record of several important and/or at-risk species (e.g., Coastal Tailed Frog (*Ascaphus truei*), and Red-legged Frog (*Rana aurora*)), initiated the first beaver census, and greatly enhanced the inventory of species documented within Whistler. This information was summarized in a report (Brett 2007) that recommended further inventory work, as well as the identification and monitoring of indicator species. This work was the precursor to a report the RMOW commissioned that in turn proposed a framework for the establishment and application of ecological monitoring in Whistler (Askey *et al*. 2008).

The Ecosystem Monitoring Program was initiated by the RMOW in 2013. The program design was based on the use of species, habitat, and climate indicators to identify temporal and spatial trends in the overall condition of ecosystems. The initial study design and selection of indicators (Cascade 2014) was based on information from:

- Askey *et al*. (2008) proposed framework;
- Species data collected through the Whistler Biodiversity Project (Brett 2007, 2015 and later online and unpublished data); and
- Local data held by Cascade Environmental Resource Group Inc (Cascade).

Cascade was contracted to conduct the first three years (2013 through 2015) of the Ecosystem Monitoring Program (Cascade 2014, 2015, 2016). In 2016, PECG and Snowline were contracted to conduct the program for the following three years. Several changes were made to the study design in 2016 to make it more scientifically robust (e.g. adopting data collection methods which allow for statistical analysis) while maintaining comparability and consistency with previous years to the greatest extent possible. The changes implemented in 2016 included:

- The addition of benthic invertebrates as an indicator for aquatic ecosystem health;
- The use of multiple pass depletion electrofishing methods for fish;
- Alterations to previously defined species thresholds;
- Adjusting survey methodology and timing to correspond to best seasonal timing for detection;
- Changing the methodology for Coastal Tailed Frog surveys from area-constrained to time constrained and increasing the elevational range of study sites on each creek;
- Moving Pileated Woodpecker (*Dryocopus pileatus*) surveys to breeding season and expanding the scope of the cavity tree survey;
- Removal/replacement of some study sites; and
- A return to a full beaver census throughout Whistler Valley (PECG and Snowline 2017).

The 2016 report (PECG and Snowline 2017) assessed results from the modified work plan and deemed them an overall improvement that could be built upon in future years. The report also recommended additional modifications for 2017 to further increase monitoring effectiveness, including:

- The installation of two additional temperature loggers at aquatic sampling sites in Crabapple Creek and 21 Mile Creek;
- Use of the single-pass electrofishing method with no stop nets for fish sampling;
- Removal of the terrestrial component (Pileated Woodpeckers, beetles, and small mammals);
- Replacement of some 2015/2016 tailed frog creeks to increase the geographic range of the program, notably the addition of Whistler Creek (previously surveyed by the WBP and potentially at risk of impact from a new mountain bike park) and Agnew Creek (to increase representation on the west side of Whistler Valley; and
- Additional efforts towards achieving a full census of the beaver population in Whistler.

The recommendations above were implemented in 2017. Based on results in that field season, the 2017 report (PECG and Snowline 2018) recommended further modifications to continue to develop and improve the program in 2018, including:

- Complete tailed frog surveys earlier so that they are occur on sunny, warm days within a two-week period from the last week of August to the first week of September (to reduce the possibility of cold water that could reduce detection rates);
- Add previously unsampled tailed frog surveys on the west side of Whistler Valley to increase geographic range, especially where creeks are less reliant on glacial run-off;
- Research feasibility of eDNA sampling for Coastal Tailed Frogs on Blackcomb Creek (and other creeks) to apply an alternate method to detect tadpoles in creeks within which dip netting is not suitable;
- Prioritize the River of Golden Dreams for additional beaver survey efforts since past surveys have been mostly unsuccessful in accurately confirming the number of active colonies;
- Continue to conduct beaver surveys in fall (to better determine overwintering lodges) but finish surveys by mid-October to reduce the chances of snow obscuring beaver activities;
- Map and calculate the area of “beaver-affected wetlands” as an additional step towards monitoring the role of beavers in modifying and creating habitat; and

- Explore the current status (what is known and what is not yet known) about additional and important indicators, notably Northern Goshawks and black cottonwoods.

The main basis currently available for prioritizing what to monitor within the Ecosystems Monitoring Program is a ranked and summarized study of species and habitats most important to conserving biodiversity within the RMOW's development footprint (Brett 2018). Recommendations for the future of the Ecosystem Monitoring Program will build on past results within that context and propose methods to effectively monitor priority species and habitats in the future. The program should continue an adaptive management approach in which past results guide future directions.

1.3 Study Area

The RMOW located in the southern Coast Mountains of British Columbia, is approximately 100 km north of Vancouver. The study area is defined by the extent of the RMOW municipal boundaries (Figure 1-1). The study area contains a range of aquatic and terrestrial ecosystems at montane to alpine elevations. Most development (the municipal "development footprint") is in the valley bottom, from Function Junction to Green Lake.

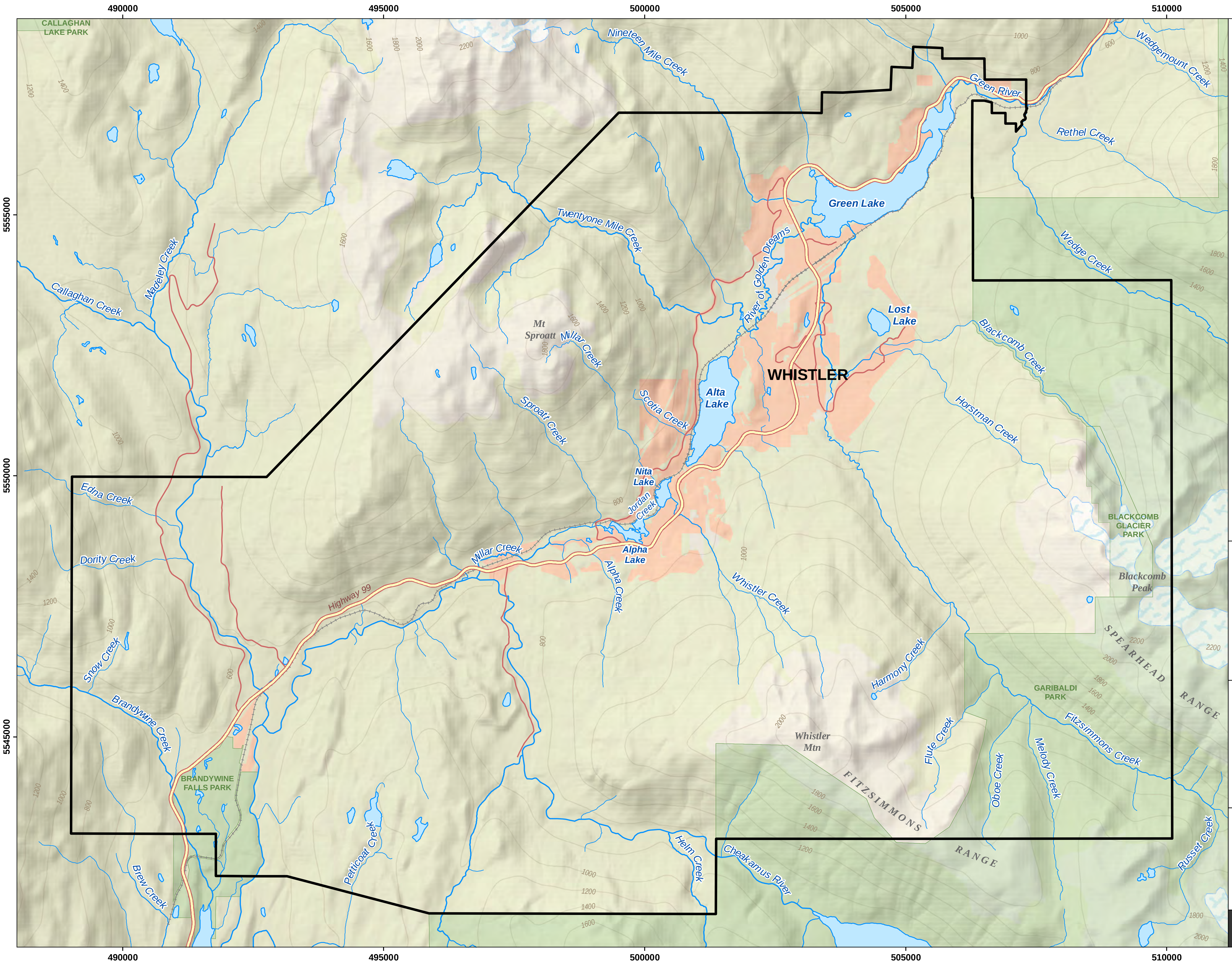
One important river system within the RMOW is the River of Golden Dreams. The River is popular for recreation and is subject to heavy traffic from kayaks, canoes, and stand-up paddle boards during the summer months. The River of Golden Dreams is the northern outlet to Alta Lake and flows north-north-easterly to Green Lake (Figure 1-1). The river is 5.4 km long and has an irregular meander pattern. Urban development encroaches on the river, especially within the first kilometer downstream of the Alta Lake and the last 1.5 km before it enters Green Lake. Highway 99 crosses the river 850 m upstream of Green Lake. 21 Mile Creek and Crabapple Creek (also known as Archibald Creek) are the major tributaries of the River of Golden Dreams. 21 Mile Creek originates at Rainbow Lake and flows for 9.1 km before entering the River of Golden Dreams. 21 Mile Creek flows into the River of Golden Dreams approximately 800 m downstream from Alta Lake, and contributes most of the flow to the river (Thomson, 1996). Crabapple/Archibald Creek drains from its headwaters on Whistler Mountain through the neighborhood of Brio and the Whistler Golf Course, before entering the River of Golden Dreams approximately 50 m downstream of 21 Mile Creek. The RMOW have identified a need to understand the potential impacts of recreational use, combined with other disturbance (e.g. urban development) on this river.

1.4 Study Design

The Ecosystems Monitoring Program is based on the use of indicators, which can reflect the health of a broader range of populations, taxa, and/or overall ecosystem health. Table 1-1 shows the indicators, field methodologies, and metrics for each 2018 program component; detailed study designs are provided in the associated component sections of this report.

Table 1-1. 2018 Ecosystems Monitoring Program.

Study Component	Indicator(s)	Methodology/ Equipment	Metrics/Parameters
Aquatic Habitat	Water Quality	*In Situ* measurements using a digital meter	• *In Situ* parameters: pH, conductivity, dissolved oxygen
	Stream Temperature	Temperature loggers set to hourly logging, installed at seven locations	• Daily and monthly summary statistics for the open water period
Aquatic Species	Benthic macroinvertebrate community	CABIN protocol	• Abundance • Taxa richness • EPT taxa richness • Percentage EPT • Diversity indices
	Fish	One-pass electrofishing and minnow traps	• Species identification • Fish length to weight relationships • Fish Health (Condition)
Riparian Species	Coastal Tailed Frog *(Ascaphus truei)*	Time constrained surveys Malt et al 2014, 2014b)	• Tadpole abundance and density • Counts of tadpoles by development stage • Water temperature and habitat descriptors
	Beaver (*Castor canadensis*)	Field inventories of beaver lodges and activity	• Number and distribution of active lodges • Area of beaver-affected wetland
Additional Species	Northern Goshawk (*Accipiter gentilis laingi*	Compilation of existing data	• Documented observations and nest locations
	Black cottonwood (*Populus trichocarpa*)	Previous RMOW mapping	• Preliminary analysis by area, age, and abundance
	Western Toad (*Anaxyrus boreas*)	Field surveys for presence	• Presence of tadpoles or metamorphs



Legend

▭	RMOW Boundary
═	Highway
—	Local Road
┼	Railway
—	Elevation Contour (200 m Interval)
—	Watercourse
▨	Lake
▨	Permanent Snow and Ice
🟧	Developed Land
🟩	Park or Protected Area

Data Sources: Developed land provided by RMOW. Legally Defined Administrative Areas of BC; Freshwater Atlas; BC Parks, Ecological Reserves, and Protected Areas all licensed under the Open Government Licence – British Columbia. Other base data from Canvec (250k) and licenced under the Open Government Licence - Canada.

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DRAWN: B. Elder
CHECKED: M. Sotiropoulos
PROJECT: 160254
DATE: Feb 25, 2019

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PALMER ENVIRONMENTAL CONSULTING GROUP INC.

CLIENT: Resort Municipality of Whistler
PROJECT: Annual Monitoring 2018

DRAFT

2018 Ecosystem Monitoring Program Study Area, Whistler, BC

FIGURE 1-1

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2. Stream Water Quality

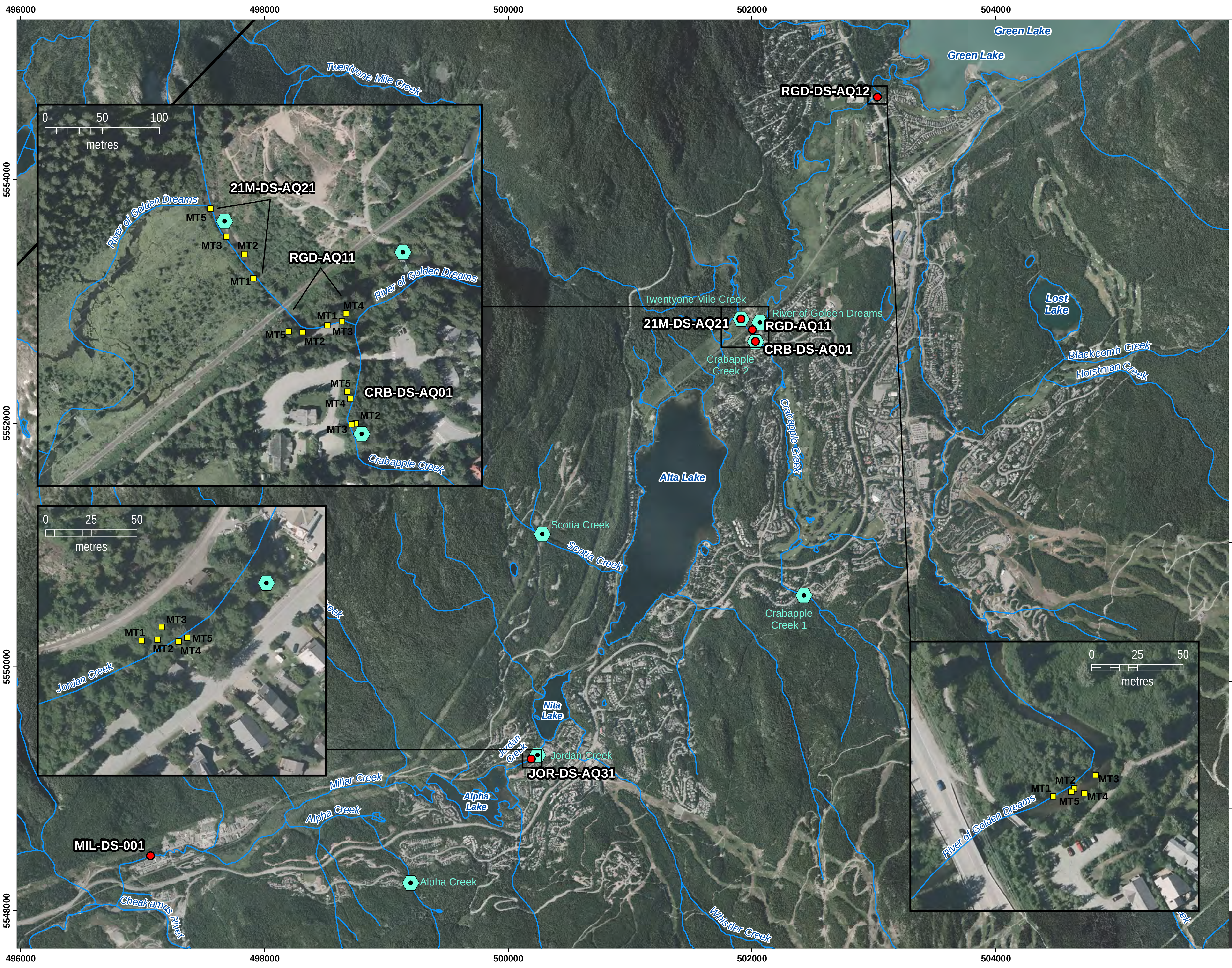
2.1 Introduction

The objective of the aquatic habitat monitoring program is to assess relative health of local aquatic habitats using *in situ* water quality and hydrology (stream flow) measurements. Measurements have been taken concurrently with aquatic species surveys to provide insight into interactions between the aquatic environment and biological trends.

2.2 Methods

2.2.1 In Situ Water Quality

In situ water quality parameters and stream temperature were measured using a hand-held YSI Water Quality Meter at six locations within the RMOW (Figure 2-1). Site specific information is provided in Table 2-1. Note that Millar Creek (MIL-DS-001) is a new site included in the 2018 program. Photo 2-1 through Photo 2-6 depict the aquatic sampling location of each of the six sites sampled in 2018. *In situ* water quality parameters measured during the 2018 field season included pH, temperature, dissolved oxygen and specific conductance.



Legend

● 2018 Aquatics Site

⬢ Temperature Logger

▪ Minnow Trap

— Watercourse

Notes:
(1) Orthoimagery (2014) provided by RMOW.
(2) Watercourse data from BC Freshwater Atlas (accessed 2017).

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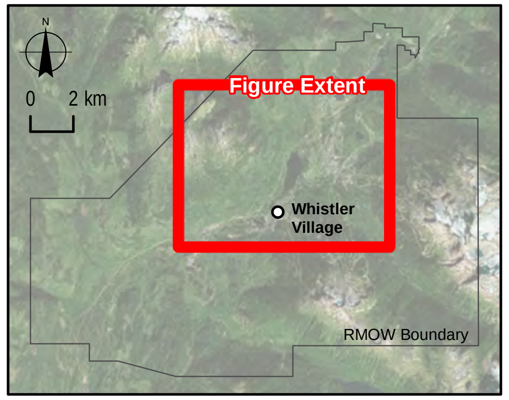

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DRAWN: B. Elder
CHECKED: M. Sotiropoulos
PROJECT: 160254
DATE: Feb 25, 2019

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UTM Zone 10N
NAD 1983

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

CLIENT: Resort Municipality of Whistler
PROJECT: Annual Monitoring 2018

DRAFT

2018 Ecosystem Monitoring Program Aquatic Sampling Sites

FIGURE 2-1

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Table 2-1. 2018 Ecosystem Monitoring Program sampling locations.

Site	UTM Location (Zone 10)		Aquatic Site ID	Access (Bridge Crossing)	Data Sampled	
	Easting	Northing			Water Quality & Benthic Invertebrates	Fish
Jordan Creek	500242	5549278	JOR-DS-AQ31	Lake Placid Road	01-Aug-18	02/03-Aug-18
Crabapple Creek (2)	502030	5552670	CRB-DS-AQ01	Lorimer Road	01-Aug-18	02/03-Aug-18
River of Golden Dreams (Upper)	502066	5552829	RGD-US-AQ11	Lorimer Road	31-Jul-18	02/03-Aug-18
River of Golden Dreams (Lower)	503035	5554687	RGD-DS-AQ12	Off Nicklaus North Golf Course	01-Aug-18	02/03-Aug-18
21 Mile Creek	501910	5552856	21M-DS-AQ21	Lorimer Road	31-Jul-18	02/03-Aug-18
Millar Creek	497099	5548450	MIL-DS-001	Function Junction	01-Aug-18	-

2.2.2 *Stream Temperature*

Seven HOBO Water Temperature Pro v2 Data Logger (Model # U22-001) temperature loggers currently record hourly temperatures of stream systems within the RMOW study area (Figure 2-1). Five loggers were deployed in December 2015. An additional two loggers were deployed for hourly temperature recordings in August of 2017. The most recently installed logger locations include 21 Mile Creek and Crabapple Creek, downstream of the original Crabapple Creek location. Table 2-2 lists the location of each temperature logger and the date the loggers were deployed and downloaded.

Daily and monthly summary statistics (means, maxima, and minima) were calculated during the open water period for each creek between August 2017 and July 2018. The temperature time series were examined to identify periods where data were suspect (e.g. elevated readings, when a logger may have been dry), and any suspect data were excluded from the calculations. Mean, minimum and maximum daily stream temperature data from August 2017 to July 2018 can be found in Appendix A.

Photo 2-1. Looking upstream at site JOR-DS-AQ31 on Jordan Creek, August 1, 2018

Photo 2-2. Looking across from right to left bank at site CRB-DS-AQ01 on Crabapple Creek, August 1, 2018

Photo 2-3. Looking upstream at site RGD-US-AQ11 on River of Golden Dreams, July 31, 2018

Photo 2-4. Looking upstream at site RGD-DS-AQ12 on River of Golden Dreams, August 1, 2018

Photo 2-5. Looking upstream at site 21M-DS-AQ21 on 21 Mile Creek, July 31, 2018

Photo 2-6. Looking upstream at site MIL-DS-001 on Millar Creek, August 1, 2018

Table 2-2. Location of Temperature Loggers installed for the Ecosystem Monitoring Program.

Site	UTM Location (Zone 10)		Location Description	Aquatic Site ID	Access (Bridge Crossing)	Installation Date	Download Date
	Easting	Northing					
Alpha Creek	499199	5548227	At Tailed Frog Site #1	-	Spring Creek Drive	15-Dec-15	03-Aug-18
Jordan Creek	500242	5549278	Near Aquatics Site	JOR-DS-AQ31	Lake Placid Road	15-Dec-15	02-Aug-18
Scotia Creek	500280	5551092	At Tailed Frog Site #2	-	Stone Bridge Drive	15-Dec-15	03-Aug-18
Crabapple Creek (1)	502426	5550589	At Tailed Frog Site #2	-	Sunridge Drive	15-Dec-15	03-Aug-18
Crabapple Creek (2)	502030	5552670	At Aquatics Site	CRB-DS-AQ01	Lorimer Road	02-Aug-17	01-Aug-18
River of Golden Dreams	502066	5552829	Near Aquatics Site	RGD-US-AQ11	Lorimer Road	15-Dec-15	02-Aug-18
21 Mile Creek	501910	5552856	At Aquatics Site	21M-DS-AQ21	Lorimer Road	02-Aug-17	31-Jul-18

2.3 Results and Discussion

2.3.1 Water Quality

In situ water quality data was collected concurrent to the benthic invertebrate sampling programs in 2018. Results are discussed in Section 3.3.2 of this report.

2.3.2 Stream Temperature

Stream temperatures were downloaded from a total of seven sites within the RNOW. Mean monthly stream temperatures in the study streams ranged from -1.37 °C in December (Scotia Creek) to 17.19 °C (Jordan Creek) in August (Figure 2-2). The highest temperatures were observed during July and August in all five creeks. Jordan Creek was the warmest creek throughout the year, similar to results from previous years. All other streams tracked similarly to one another during the year with a few variations from the constant trend. The River of Golden Dreams and 21 Mile Creek had matching temperature trends, which would be expected given that 21 Mile Creek is the main tributary of the River of Golden Dreams.

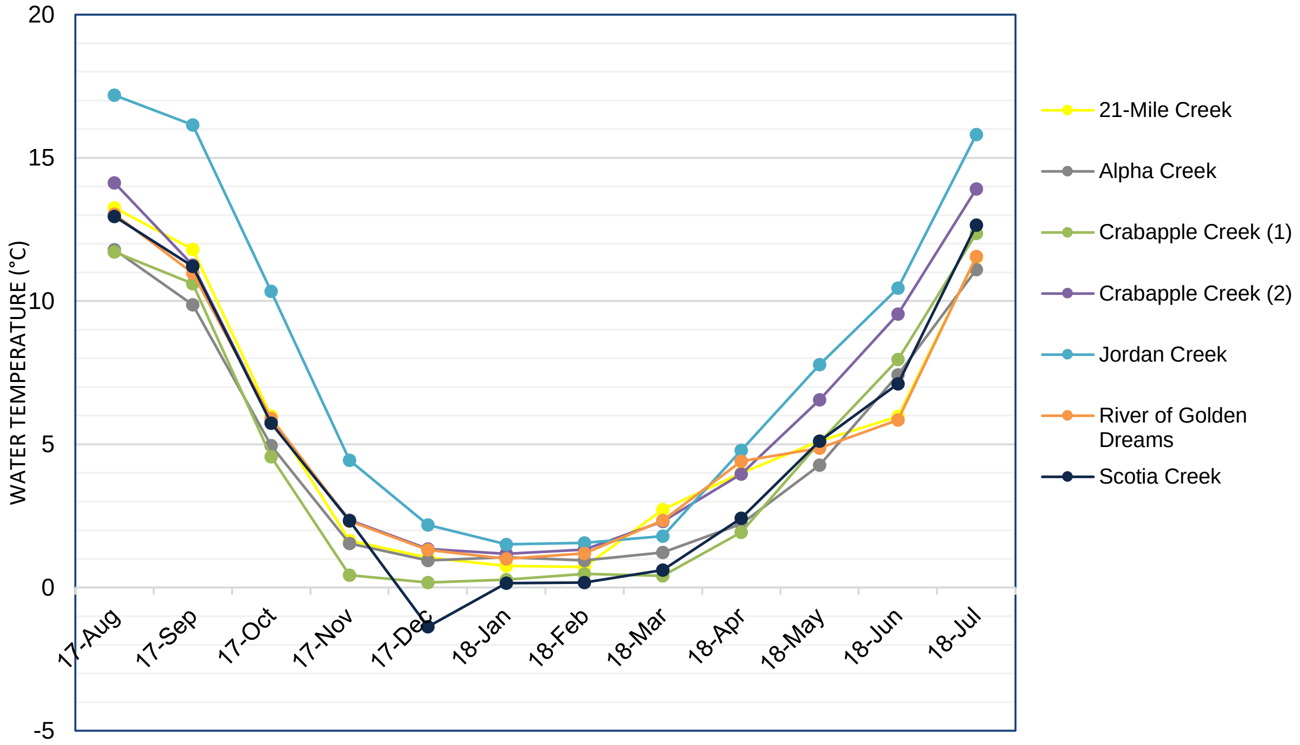

Figure 2-2. Mean monthly stream temperatures, August 2017 – July 2018.

3. Benthic Invertebrates

3.1 Introduction

Biomonitoring of benthic invertebrates is used to detect potential negative effects from anthropogenic activities which other biomonitoring methods (*i.e*. other species monitoring, abiotic indices) may not identify. Benthic invertebrate community composition is an important indictor of aquatic ecosystem health. These communities often show alterations in response to environmental changes earlier than other aquatic indicators, which allows for early detection of potential effects. Due to their sedentary nature, relatively long lifecycles, and high community diversity, benthic invertebrate communities provide insight into the long-term health of aquatic ecosystems within a small spatial area (i.e. site).

Benthic invertebrates have been monitored yearly in the RMOW study area since 2016 (PECG and Snowline 2017, 2018) and included assessments at four locations: Jordan Creek (JOR-DS-AQ31), Crabapple Creek (CRB-DS-AQ01), River of Golden Dreams (2 locations: RGD-AQ11 and RGD-DS-AQ12) and 21 Mile Creek (21M-DS-AQ21). The 2018 field program included the addition of Millar Creek (MIL-DS-001), a lentic system that flows out of the south end of Alpha Lake and through the Function Junction industrial area (Figure 2-1).

3.2 Methods

3.2.1 Data Collection

<u>*In Situ Parameters*</u>

The Canadian Aquatic Biomonitoring Network (CABIN, ECCC 2011) protocol was performed at six sites in 2018 (Figure 3-1) to collect benthic invertebrates. A complete list of the benthic invertebrate sampling sites is found in Table 2-1. Benthic invertebrate sampling was completed prior to fish sampling, to avoid disturbance of the substrate. At each site, a CABIN field sheet was completed, and a benthic invertebrate sample was collected. The CABIN method entails kick-net sampling for benthic invertebrates in the erosional zone (riffle, straight run, or rapid) of a representative watercourse reach. A triangular kick-net sampler with 400-micron mesh and detachable collection cup was employed for each kick-net sample. To collect a sample, one collector walked backward in the upstream direction, tracing a zig-zag pattern, and dragging the net along the bottom. The collector kicked the substrate in front of the net while moving upstream for three minutes. All invertebrates were removed from the net, placed in a clean 500 mL sampling jar, preserved using 85% ethanol and submitted to Cordillera Consulting (Summerland, BC) for taxonomic analysis. In the laboratory, benthic invertebrates were identified to the lowest possible taxonomic group by Cordillera.

Samples from sites RDG-DS-AQ12 and 21M-DS-AQ21 were sieved using the bucket swirling method to remove excess debris from the samples (ECCC 2011). A QA/QC sample was collected from the remaining debris at both locations. The sample of excess debris was processed in the laboratory to ensure that the method was effective in removing benthic invertebrates.

CABIN protocols incorporate habitat data collection, as the benthic community present at a site reflects the habitat conditions. Once the kick-sample was collected, habitat characteristics recorded at each site included canopy coverage, macrophyte coverage, riparian vegetation, periphyton coverage, substrate composition (pebble count) and slope. Average and maximum velocity were determined by measuring velocity at 6 points along a transect of the stream using the Velocity Head Rod technique, according to CABIN protocol (ECCC 2011).

Ex-Situ Parameters collected by RMOW

Stream water and sediment samples are collected annually by RMOW as part of a stream monitoring program. Samples are sent for laboratory analysis of routine chemistry, nutrients (water samples only) and metals. Water chemistry results are screened against the BC Water Quality Guidelines for the Protection of Aquatic Life (BC WQG). Sediment chemistry results are screened against the Canadian Council of Ministers of the Environment (CCME) Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs). The ISQGs and PELs are associated with occasional and frequent adverse biological effects, respectively.

3.2.2 Data Analysis

The benthic invertebrate sampling results (habitat and taxonomic data) were entered into the online CABIN database. Data from 2016, 2017 and 2018 sampling were stored in the database for ease of access, data security and to allow CABIN analyses to be performed. In 2016 and 2017, the benthic invertebrate data were analysed online using the Reference Condition Approach (RCA) adopted from Environment Canada's CABIN protocols (ECCC 2011; PECG and Snowline 2017, 2018). The primary outcome of the CABIN analyses is an assessment of whether the sites are in reference condition, meaning they are close to natural conditions (*i.e*. undisturbed by anthropogenic activity), or divergent from reference condition. The data were compared to the Fraser River-Georgia Basin Reference Model (2005) to make this assessment. The model assigns each site to a reference group based on habitat variables as well as the type and proportion of taxa present (Sylvestre *et al*. 2005).

In 2018, the River-Georgia Basin Reference Model error rates of correctly predicting a site to the appropriate reference group were noted to be unacceptably high (ranged from 37% to 61%). Although error rates associated with this model were previously lower, PECG was informed that the changes to the data used to build the model are likely the cause for the higher rates noted this year (S. Strachan (Environment Canada), pers comm. January 2019). As a result, the CABIN RCA analyses (Bray-Curtis, River Invertebrate Prediction and Classification System (RIVPACS) and Benthic Assessment of Sediment (BEAST) were not performed on samples collected in 2018. Environment Canada recommended the analysis of the data (for all three years and sites) using the updated Fraser River Reference Model (2014) in order to provide more reliable results. The Fraser River Reference Model requires a review of the habitat data to determine if the Whistler CABIN sites are within the range of habitat conditions of the reference sites, as well as GIS analysis. These tasks, and the analysis (assuming the Whistler sites are within the range of habitat conditions), are recommended as the next step in future work.

The following traditional benthic community descriptors were calculated and compared with those from previous years:

- Abundance, calculated as the total number of individuals per kick-net per site;
- Taxa richness, calculated as the total number of families present at each site;
- EPT taxa richness, defined as the total number of mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) orders per site. These three orders of aquatic insects are typically most sensitive to habitat disturbance;
- Percentage composition, calculated by dividing the density of dominant groups by the total density; and
- Shannon-Wiener diversity index, defined as: $H' = \sum_{i=1}^{R} p_i\,(\ln p_i)$
  Where R is taxa richness and p_i is the total number of individuals in the ith species divided by the total number of organisms in the sample. The Shannon-Wiener diversity index characterizes taxa diversity in a community and accounts for taxa richness as well as the proportion of each taxa (evenness).

Cordillera Consulting identified organisms to the genus-species level, where possible. The 2018 benthic invertebrate taxonomic richness is reported as number of families, the standard protocol for CABIN reports which accounts for potential misidentification of invertebrates at lower taxonomic levels (e.g. genus or species level). Organisms were grouped as follows: Ephemeroptera, Plecoptera, Trichoptera, Diptera+non-insects, and other. The grouping of Diptera+non-insects includes true flies, bivalves, molluscs, mites and worms.

3.2.3 Quality Assurance/Quality Control

Cordillera Consulting has over ten years' experience in taxonomic analysis of benthic invertebrates from streams, rivers and lakes of western Canada. The following QA/QC procedures were followed by Cordillera Consulting:

- Complete, blind re-identification and re-enumeration was completed in-house by a second taxonomist *(i.e.* not the taxonomist who originally processed the samples)
- Samples for taxonomic quality control were randomly selected and quality control procedures were conducted as the samples progressed through the laboratories.
- The second taxonomist calculated and recorded four types of errors:
    - Misidentification error;
    - Enumeration error;
    - Questionable taxonomic resolution error; and
    - Insufficient taxonomic resolution error.

The percent total identification error rate is calculated as:

$$(Sum\ of\ incorrect\ identifications \div\ total\ organisms\ counted\ in\ audit)\ \times 100$$

The average identification error rate of audited samples did not exceed 5%. All samples that exceed a 5% error rate were re-evaluated to determine whether repeated errors or patterns in error contributed.

3.3 Results and Discussion

3.3.1 Benthic Invertebrate Community Descriptors

Benthic Invertebrate Abundance

Six stream sites were sampled for benthic invertebrates following CABIN protocols between July 31 and August 1, 2018. Data for invertebrates sampled in the RMOW study area are presented in Appendix B and C.

Crabapple Creek (CRB-D-AQ01) displayed the highest total abundance (3,190) of benthic invertebrates, followed by Jordan Creek (JOR-DS-AQ31; 2,147), 21 Mile Creek (21M-DS-AQ21; 1,985), Millar Creek (MIL-DS-001; 1,560), upstream site on the River of Golden Dreams (RGD-US-AQ11; 846) and finally the downstream site on the River of Golden Dreams (RGD-DS-AQ12; 806) (Figure 3-1). The same trend was observed in 2016 and 2017 (excluding Millar Creek which was not sampled previously).

Ephemeroptera, Plecoptera and Trichoptera (EPT) abundance was highest at Crabapple Creek (2,440 EPT organisms) and lowest at the River of Golden Dreams (RGD-DS-AQ12; 293 EPT organisms) (Figure 3-1). As in 2016 and 2017, EPT abundances within the study area demonstrated similar patterns relative to total abundance among sites, except in Jordan Creek where the proportion of EPT was lower relative to other sites.

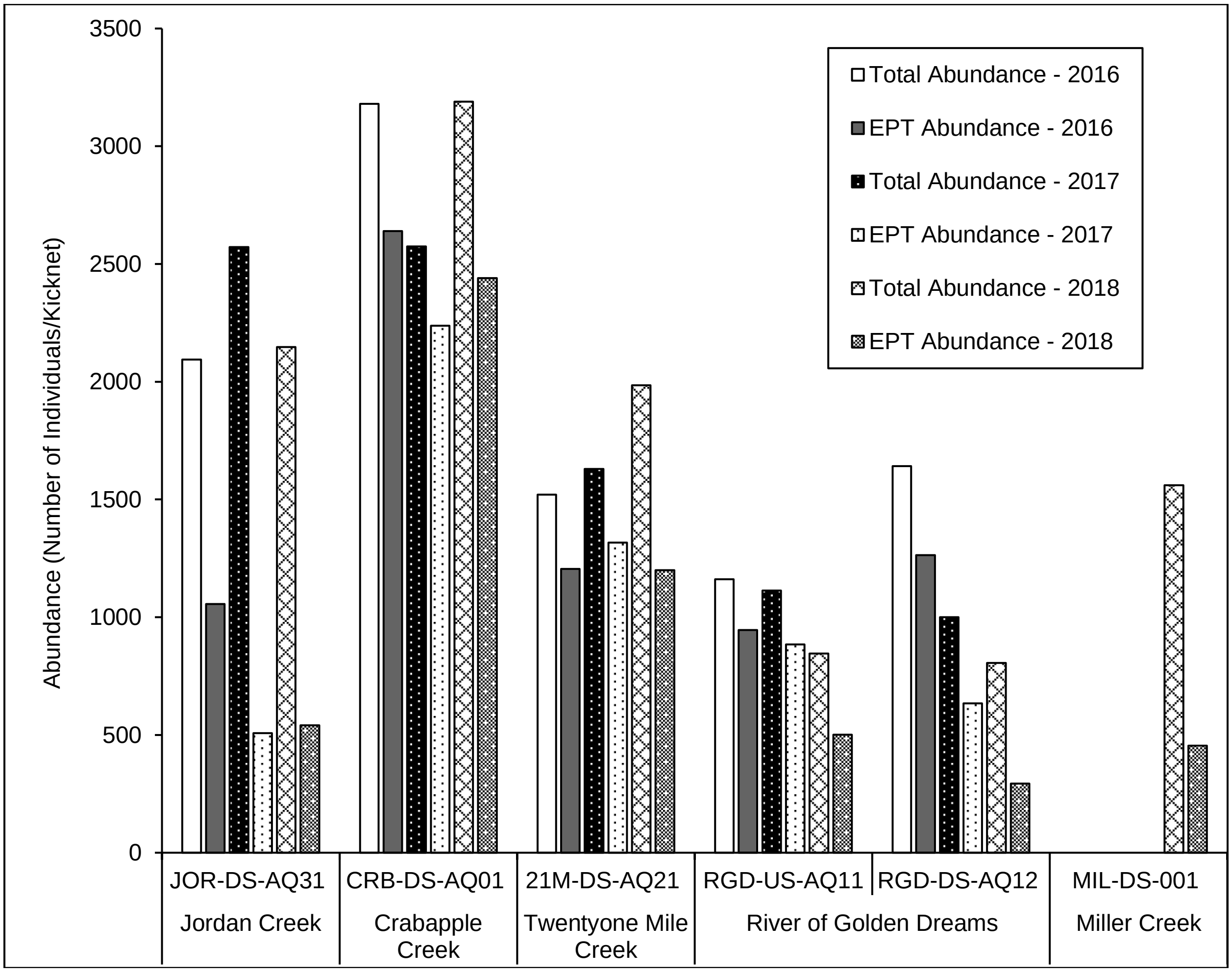

Figure 3-1. Benthic invertebrate total and Ephemeroptera, Plecoptera and Trichoptera (EPT) abundance by site and year, 2016-2018.

Benthic Invertebrate Community Composition

Figure 3-2 presents the density of benthic invertebrate communities at each sampling site in 2018. Sites Crabapple Creek, 21 Mile Creek and the upper River of Golden Dreams site (RGD-US-AQ11) which are clustered in the upper River of Golden Dreams system, had similar community structure. These sites had 40% or less of Diptera+non-insects and were dominated by Ephemeroptera (40 – 45% of the total density).

The downstream site on the River of Golden Dreams (RGD-DS-AQ12) had a higher proportion of Diptera+non-insects (53%) relative to the upstream sites (Crabapple Creek, 21 Mile Creek and River of Golden Dreams (RGD-US-AQ11) and a lower proportion of Ephemeroptera (28%). The site also had the highest proportion of invertebrates in the 'other' category (10%).

Diptera+non-insects were dominant (75%) at Jordan Creek (Figure 3-2). Notably, in 2016 Diptera+non-insects formed 50% of the community. The shift to higher proportion of Diptera in 2017 (80%) and 2018

(75%) suggests that community health may be in decline. Similarly, Diptera+non-insects were dominant (71%) at Millar Creek, a site possibly impacted by surrounding industry.

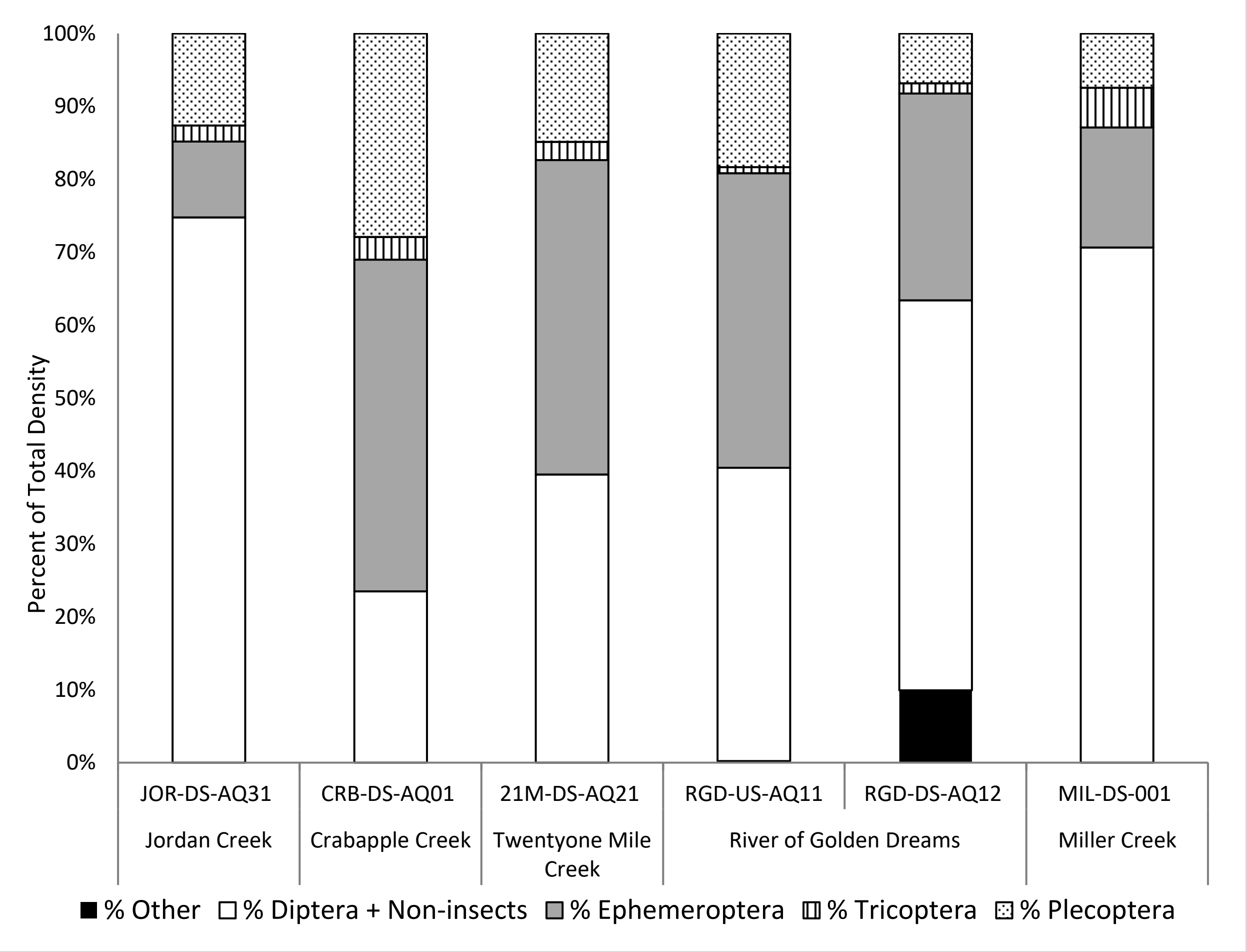

Figure 3-2. Relative densities of benthic invertebrate communities by site, 2018.

Benthic Invertebrate Taxonomic Richness and Diversity

Taxonomic richness was highest on the downstream site on the River of Golden Dreams (25 families) and lowest at Jordan Creek (15 families) (Figure 3-3). Taxa richness was higher at all sites compared with data from 2016 and 2017. All sites except Jordan Creek had almost double the number of families in 2018 compared with previous years (Figure 3-3). Taxa richness at Jordan Creek was only slightly higher in 2018 (15) relative to 2016 (12) and 2017 (13).

Richness of EPT taxa ranged from nine families at Crabapple Creek, Millar Creek and the River of Golden Dreams downstream site (RGD-DS-AQ12), to 13 families at the River of Golden Dreams upstream site (RGD-US-AQ11) and 21 Mile Creek (Figure 3-4). Overall, 2018 EPT taxa richness was higher compared to previous years; all sites had 2 to 7 more families in 2018 relative to 2017.

Taxa from the EPT orders were dominant at Crabapple Creek, 21 Mile Creek and the upstream River of Golden Dreams site (RGD-US-AQ11). All three of these sites are in the River of Golden Dreams watershed and EPT orders formed upwards of 60% of the benthic invertebrate community at each site (Figure 3-5). The downstream site on the River of Golden Dreams (RGD-DS-AQ12) had 37% EPT taxa, a notable decrease from 77% in 2016 and 63% in 2016. In keeping with 2016 and 2017, Jordan Creek had a lower proportion of EPT organisms (25%, Figure 3-5) and was dominated by Diptera, which are generally more tolerant of organic pollution. Millar Creek also had a relatively low proportion of EPT taxa (29%).

The downstream site on the River of Golden Dreams (RGD-DS-AQ12) supported the highest diversity value (2.32, Figure 3-6), followed by 21 Mile Creek and the upstream site on the River of Golden Dreams (RGD-US-AQ11). Crabapple Creek and Jordan Creek had lower diversity values (1.91 and 1.38 respectively). Overall, diversity was higher at the sites than in 2016 and 2017. Millar Creek had the second lowest diversity score (1.79)

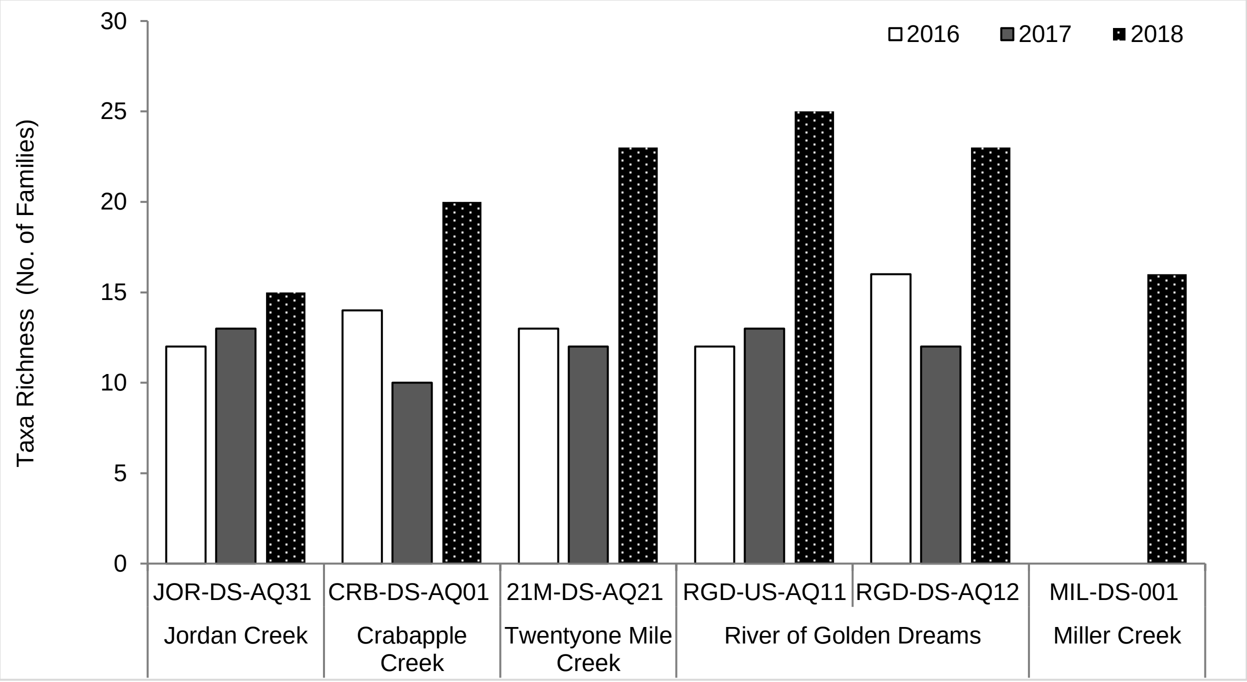

Figure 3-3. Benthic invertebrate community taxa richness, 2016-2018.

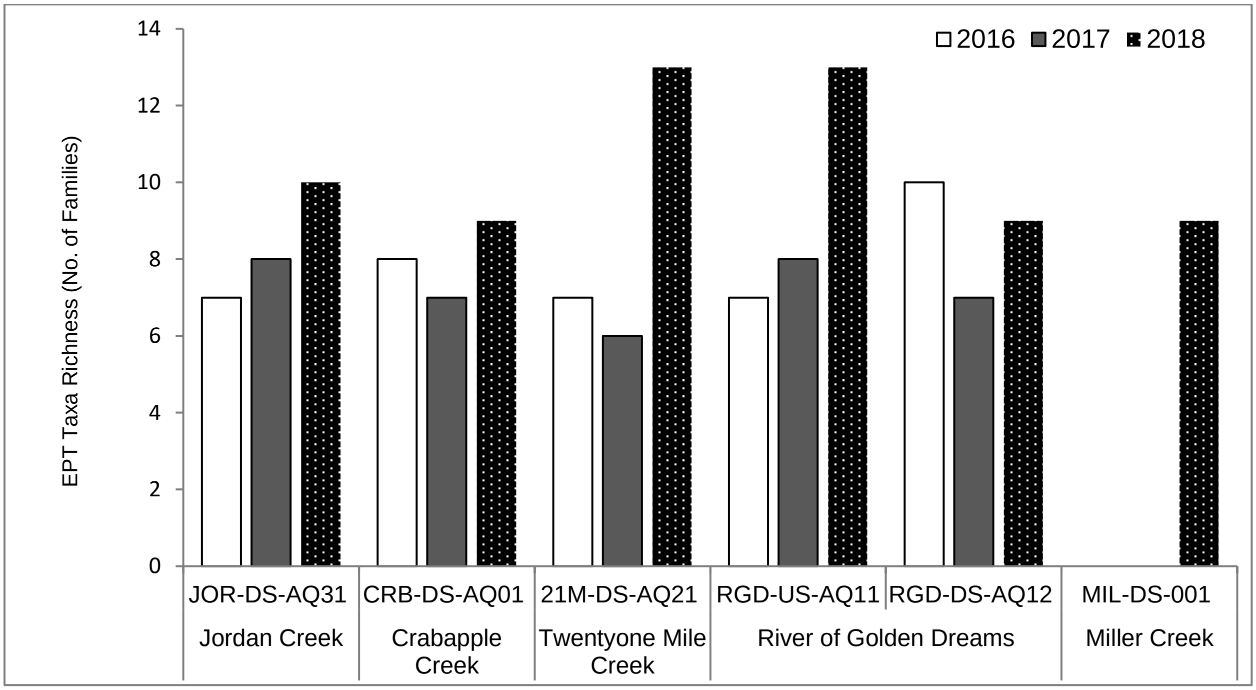

Figure 3-4. Benthic invertebrate community EPT taxa richness, 2016-2018.

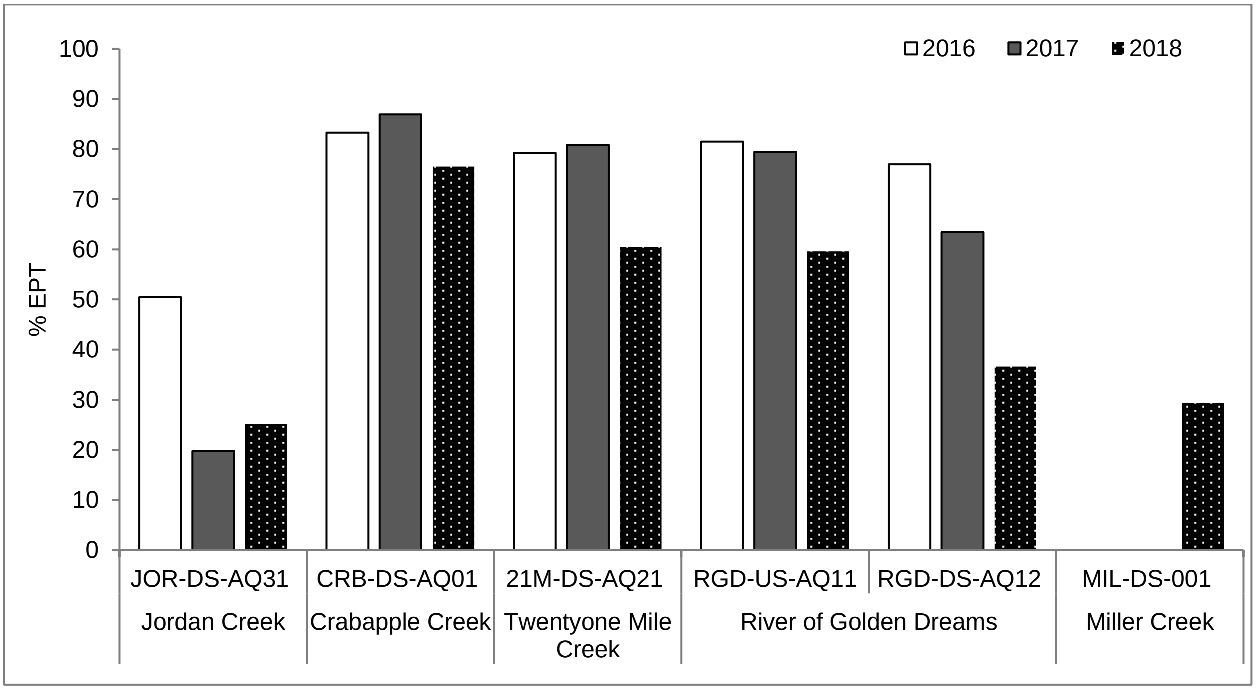

Figure 3-5. Benthic invertebrate community % EPT, 2016-2018.

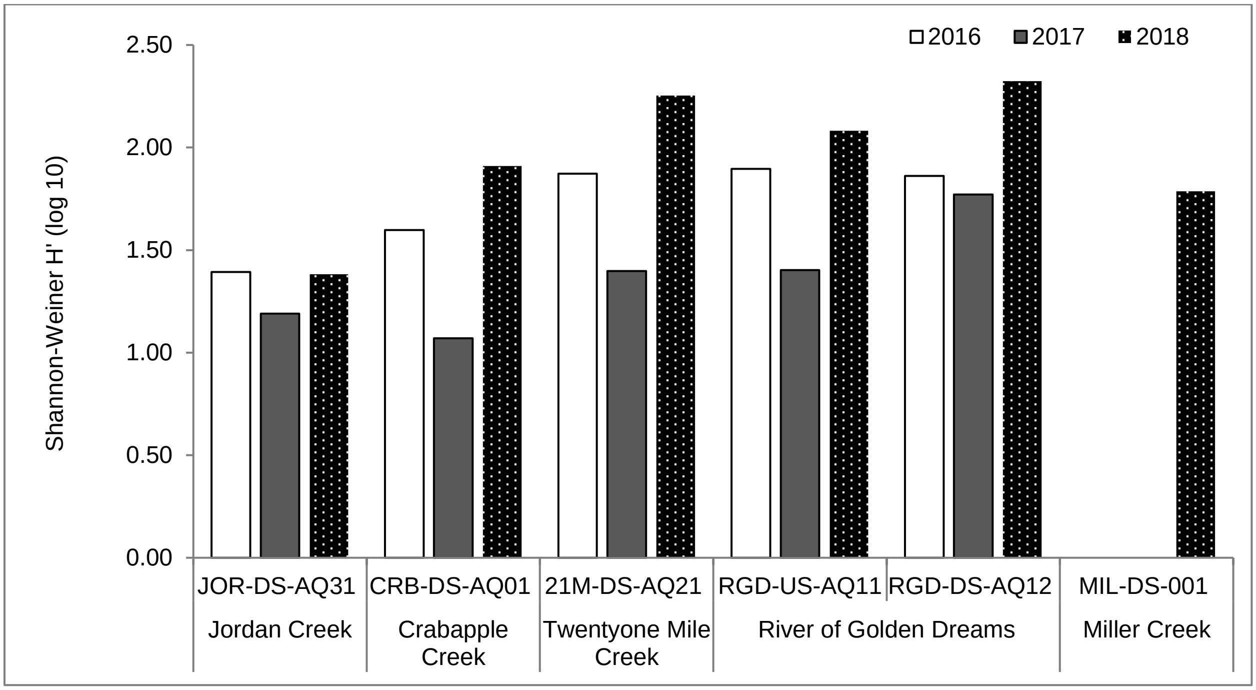

Figure 3-6. Shannon-Weiner indices, 2016-2018.

3.3.2 Water Quality

In situ water quality parameters, recorded as per CABIN protocols, are presented in Table 3-1.

Table 3-1. In situ water quality results, 2016-2018.

Creek	Site ID	Date	Dissolved oxygen (mg/L)	pH	Specific Conductance (µS/cm)	Water Temperature (°C)
Jordan Creek	JOR-DS-AQ31	03-Aug-2016	9.32	7.1	63.6	15.8
	JOR-DS-AQ31	26-Jul-2017	8.9*	7.1	105.1	14.9
	JOR-DS-AQ31	**01-Aug-2018**	**7.74***	**7.1**	**65.4**	**18.8**
Crabapple Creek	CRB-DS-AQ01	02-Aug-2016	9.35	7.6	217.8	12.7
	CRB-DS-AQ01	25-Jul-2017	11.6	7.4	336.3	12
	CRB-DS-AQ01	**01-Aug-2018**	**7.53***	**7.5**	**194.4**	**16**
21 Mile Creek	21M-DS-AQ21	03-Aug-2016	9.39	6.3*	40.5	12
	21M-DS-AQ21	25-Jul-2017	11.33	7.1	40	11.6
	21M-DS-AQ21	**31-Jul-2018**	**14.6**	**6.2***	**38.1**	**19.9**
River of Golden Dreams (Upper)	RGD-US-AQ11	03-Aug-2016	8.27*	7.3	64	11.7
	RGD-US-AQ11	25-Jul-2017	11.02	7.1	50.5	10.5
	RGD-US-AQ11	**31-Jul-2018**	**7.5***	**7.2**	**35.6**	**15.5**

Creek	Site ID	Date	Dissolved oxygen (mg/L)	pH	Specific Conductance (µS/cm)	Water Temperature (°C)
River of Golden Dreams (Lower)	RGD-DS-AQ12	05-Aug-2016	9.89	7.8	69	15.2
	RGD-DS-AQ12	25-Jul-2017	9.77	7	73.3	13
	RGD-DS-AQ12	**01-Aug-2018**	**8.16***	**6.7**	**48.3**	**17.8**
Millar Creek	**MIL-DS-001**	**01-Aug-2018**	**6.75***	**6.8**	**81.2**	**21**

Notes: 2018 results are **bolded**; values below guideline are identified with an asterisk (*) next to the value.

Dissolved oxygen ranged from 6.75 mg/L to 14.6 mg/L across all sites and years. The BC WQG for dissolved oxygen is an instantaneous minimum of 5 mg/L for all fish life stages other than buried embryo/alevin and 9 mg/L for buried embryo/alevin life stages (BC MOE, 1997). This guideline for dissolved oxygen is not specific to benthic invertebrates, however; low dissolved oxygen can result in reduced benthic invertebrate community diversity. *In situ* dissolved oxygen was above 5 mg/L at all sites in all years. The lowest reading was at Millar Creek in 2018 (6.75 mg/L). Low dissolved oxygen may be related to nutrient inputs but can also be associated with high water temperature and low flow conditions that typically occur in summer. Water temperature at Millar Creek was 21°C (the highest recorded water temperature across all sites and years). Dissolved oxygen was above 7 mg/L at all other sites on all sampling occasions, but was occasionally below the upper guideline of 9 mg/L.

PH ranged from 6.2 to 7.8 across all sites and years. The BC water quality guideline for pH is 6.5 to 9.0. Readings below 6.5 were recorded at 21 Mile Creek in 2016 and 2018, but this was not reflected by reduced benthic invertebrate diversity or abundance.

Specific conductance ranged from 35.6 to 336.3 across all sites and years. There is no BC guideline for specific conductance. High specific conductance is associated with high dissolved ions. Crabapple Creek had notably higher specific conductance (194.4 to 336.3) than all other sites.

Water and sediment quality data were provided by the RMOW and were reviewed alongside the CABIN sampling results. The RMOW's water and sediment quality monitoring program rotates streams on an annual basis to achieve a larger coverage of streams in the area. Table 3-2 presents sampling information in relation to benthic invertebrate sampling conducted for the Biomonitoring program led by PECG.

Table 3-2. Summary of overlap of benthic and water/sediment sampling, 2016-2018.

Stream	Sample Year	Water/Sediment Sampling			Benthic invertebrate sampling		
		Sample Date	Water	Sediment	Benthic site	Location relative to water/sediment site	Sample Date
Jordan Creek (upstream)	2016	Oct 12	x		JOR-DS-AQ31	100 m DS	Aug 03
Jordan Creek (downstream)	2016	Oct 12	x		JOR-DS-AQ31	250 m US	Aug 03
River of Golden Dreams (downstream)*	2016	Oct 12	x		RGD-US-AQ11, RGD-DS-AQ12	100 m US from AQ11, 3.5 km DS from AQ12	Aug 05
21 Mile Creek	2017	Sept 21	x	x	21M-DS-AQ21	4 km DS	Jul 25
Crabapple Creek	2018	Sept 11	x	x	CRB-DS-AQ01	Co-located	Aug 01
Millar Creek	2018	Sept 10	x	x	MIL-DS-001	Co-located	Aug 01

Notes: DS = downstream, US = upstream; * indicates that there is another water quality sampling site on the River of Golden Dreams not listed in this table as it is upstream of the confluence with 21 Mile Creek.

Water quality sampling was conducted at two sites on Jordan Creek and one site on the River of Golden Dreams in 2016. No water quality sampling was conducted in 2017 and 2018 and sediment quality was not assessed at this site during any of the three years that benthic invertebrates were assessed. There were no exceedances of BC WQG at any of the sites on these watercourses (BC MOE 1997). In addition, most of total metals analyzed and the more bioavailable dissolved metals, were below laboratory detection limits.

On 21 Mile Creek, a single site was sampled for water quality and sediment in 2017. No exceedances of BC WQG (BC MOE 1997) and CCME (CCME 2014) sediment guidelines existed at the site during 2017 water quality monitoring. Water and sediment quality at this site should be interpreted with caution in relation to conditions at the benthic site, as the benthic site is located approximately 4 km downstream.

Two sites were sampled for water quality and sediment quality in 2018 including one on Crabapple Creek and one on Millar Creek. There was a single exceedance of the ISQG for copper in sediment at Millar Creek (CCME 2014). Sediment copper concentration was 90.3 mg/kg (dry weight) and the ISQG is 35.7 mg/kg. However, the concentration is below the PEL guideline of 197 mg/kg (CCME 2014).

Taxa from the EPT orders are sensitive to pollution and therefore act as an indicator of poor habitat or impaired benthic community health. The proportion of EPT taxa at the River of Golden Dreams sites was notably lower in 2018 relative to the two previous years. The greatest decrease occurred at the downstream site (79% EPT in 2017 to 37% EPT in 2018). This may be indicative of a decline in habitat quality, but further monitoring is required to determine if this is a long-term trend. The lower numbers in 2018 may also be related to the low flow conditions encountered in 2018.

Pronounced dominance of Diptera and low proportion of EPT taxa at Jordan Creek and Millar Creek may be indicative of impaired habitat, as Diptera is typically more tolerant of organic pollution than EPT taxa. However, water quality data from Jordan Creek in 2016 and water quality and sediment quality data from Millar Creek in 2018 did not show evidence of impairment. Dominance of Diptera can also be associated with naturally occurring low dissolved oxygen. It has been previously theorized that the construction of Nita Lake Lodge in 2000 may have resulted in discharge of iron-rich water into Jordan Creek upstream of the JOR-DS-AQ31 site, thus altering the benthic invertebrate community in the creek. However, water quality results from 2016 in Jordan Creek and water quality and sediment quality results in Millar Creek in 2018 do not reflect elevated levels of iron relative to guidelines. Further investigation into the chemical properties of the stream in Jordan Creek (e.g. sediment quality) in addition to conditions at Millar Creek are needed to characterize any potential effects to the benthic invertebrate community in these streams. Further monitoring of these creeks is recommended.

The composition of benthic invertebrates within Jordan Creek compared to other creeks within the RMOW may also be related to an organic material observed covering the substrate within the creek. Through photo identification, the organic material is potentially Didymo (*Didymosphenia geminata;* Photo 3-1). Didymo is a freshwater diatom native to British Columbia but is considered a nuisance species due to its rapid spread and invasive characteristics. Didymo has been given the nickname ‘Rock Snot’ due to its slimy brown, beige and/or white appearance. It begins as a slimy layer or ‘bloom’ on rocks and can thicken into large mats that greatly affects the appearance of aquatic systems. More importantly, Didymo significantly affects the aquatic ecosystem through habitat and food web alterations. Didymo can alter aquatic species composition, reduce the spawning habitat of fish and increase decomposition rates which deplete dissolved oxygen levels within waterways (ISCBC 2017). Benthic invertebrate communities at Jordan Creek, where Didymo was potentially detected showed decreased EPT abundance relative to total abundance, which could potentially be attributed to the presence of this diatom.

Didymo was first identified in the RMOW in 2009 at two locations. It was recorded near Cheakamus Crossing in March 2009 at a location that’s never subsequently been confirmed.[1] In September 2009, Didymo was also recorded in Whistler Creek next to the Legends Hotel[2] but has not been observed there since.[3] Since Whistler Creek is part of the same drainage as Jordan Creek it is possible Didymo spread downstream. The Sea to Sky Invasive Species Council has been notified of this record by email. In-stream confirmation of the Jordan Creek photo-identification as well as any future monitoring and genetic sample confirmation should be conducted to confirm the presence of this species and control should be coordinated with The Sea to Sky Invasive Species Council. This new record highlights the potential need to prevent the spread of Didymo as much as possible, for example, by cleaning equipment before moving from between waterways as detailed in Invasive Species Council of BC’s (ISCBC) protocols (ISCBC 2017).

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[1] *Reported by Chris Perrin (Limnotek) to Heather Beresford, and subsequently reported to Bob Brett.*

[2] *B. Brett memo to Sea to Sky Invasive Species Council, January 2010.*

[3] *B. Brett annual surveys for the Sea to Sky Invasive Species Council (unpubl. data since 2009).*

Photo 3-1. Substrate from Jordan Creek with potential evidence of Didymo, or Rock Snot. Photo taken by M. Sotiropoulos on August 1, 2018.

Habitat conditions, such as substrate and water temperature, have a direct relationship to the benthic community expected at a site. Crabapple Creek and both sites on the River of Golden Dreams were pebble-dominated, while 21 Mile Creek and Jordan Creek had coarser substrate (cobble-dominated). Coarse substrate is preferred by many EPT species, while finer substrates (sand, silt and organics) generally supports more Diptera and Oligochaeta. Jordan Creek had the lowest EPT abundance among the sample sites, despite the dominance of coarse substrate. Water temperatures in Jordan Creek were also warmer than the other study streams and this may decrease habitat suitability for sensitive EPT taxa.

4. Fish Community

4.1 Introduction

The objective of the aquatic species monitoring program was to assess relative aquatic health of local watercourses using important indicator species such as Kokanee Salmon (*Oncorhynchus nerka*), Bull Trout (*Salvelinus confluentus)*, Rainbow Trout (*O. mykiss)* and Coastal Cutthroat Trout (*O. clarkii clarkii).* The 2018 fisheries program remained consistent with the previous methodologies used in 2017 with the exception that minnow traps were added in 2018 to augment data collected via electrofishing and allowed for sampling of fish within the River of Golden Dreams.

Kokanee Salmon are present in the study streams, with known spawning areas in the River of Golden Dreams. Bull Trout*,* as well as Cutthroat Trout, are native to the Whistler area, but observations of these species are rare. Both species are blue-listed, indicating that they are considered vulnerable in BC. The Lower Mainland populations of Coastal Cutthroat Trout are in serious decline (BC MoFLNRO 2017a). Within the Whistler area, Cutthroat Trout are believed to have hybridized with Rainbow Trout. Populations of Bull Trout are also in decline in BC and throughout the global range of this species (BC MoFLNRO 2017b). Bull Trout are very similar in shape and coloration to Dolly Varden (*Salvelinus malma*) and genetic analysis is required to definitively differentiate individuals of these species. Rainbow Trout are ubiquitous in the study streams and were stocked in Rainbow Lake (the headwater lake of 21 Mile Creek) in the late 1970s or early 1980s (Eric Crowe, pers. comm). Sculpin (*Cottus sp.*) and Threespine Stickleback (*Gasterosteus aculeatus*) are also common.

4.2 Methods

4.2.1 Data Collection

Streams were sampled for fish between August 2 and August 3, 2018. Table 4-1 provides a complete list of 2018 fish sampling sites.

The fish community within RMOW streams were sampled in 2018 under the Scientific Fish Collection Permit SU18-348275 issued by the BC Ministry of Forests Lands and Natural Resource Operations (BC MoFLNRO). The fish community was sampled using a combination of backpack electrofishing and minnow traps. Electrofishing was not completed in The River of Golden Dreams due to human safety concerns; only minnow traps were used at these locations. Electrofishing was completed at stream sites by a two-person crew using a Smith-Root LR-24 backpack electrofisher following methods outlined in Johnston et al. (2007). Only one electrofishing pass was made at each site; no stop nets were used. Electrofisher voltage, duty cycle and frequency settings were adjusted based on site conditions in order to maximize efficiency and minimize the risk of injury to fish. Electrofisher settings are summarized in Table 4-1. The electrofishing effort was recorded for each site.

Minnow traps were set at each stream site after electrofishing was completed as well as at the River of Golden Dreams where no electrofishing could be conducted. Traps consisted of two cylinders made of 6.35

mm galvanized steel wire mesh with a conical entrance, measuring 42 cm long and 23 cm in diameter. The cylinders were clipped together, baited with cat food and set overnight. Table 4-1 provides a summary of total fishing effort for gear used at each stream site.

All fish captured were identified to species, enumerated and measured for length (to the nearest 1 mm) and wet weight (to the nearest 0.1 g using a Scout Pro 400 g scale). Fork length was measured for salmonid fish species and total length was measured for other species. Any lesions, parasites, or other anomalies on fish were recorded before the fish were released live back at the site of capture.

Table 4-1. Fish sampling methods and effort at stream sites in the RMOW study areas, 2018.

Creek	Site ID	Gear Type	Date Sampled/Set	Minnow Trapping			Electrofishing			
				Date Retrieved	Number of Traps	Total Effort (hrs)	Voltage (V)	Frequency (Hz)	Duty Cycle (%)	Total Effort (sec)
Jordan Creek	JOR-DS-AQ31	EF	02-Aug-18	-	-	-	290	30	15	963
		MT	02-Aug-18	03-Aug-18	5	95.83	-	-	-	-
Crabapple Creek	CRB-DS-AQ01	EF	02-Aug-18	-	-	-	240	30	12	953
		MT	02-Aug-18	03-Aug-18	5	115.20	-	-	-	-
River of Golden	RGD-US-AQ11	MT	02-Aug-18	03-Aug-18	5	119.01	-	-	-	-
River of Golden	RGD-DS-AQ12	MT	02-Aug-18	03-Aug-18	5	100.78	-	-	-	-
21 Mile Creek	21M-DS-AQ21	EF	02-Aug-18	-	-	-	445	20	15	1105
		MT	02-Aug-18	03-Aug-18	5	101.03	-	-	-	-

Notes: MT = Minnow Trap, EF = Electrofishing, V = Voltage, Hz = , ms = milliseconds

The River of Golden Dreams was not electrofished due to human safety concerns.

4.2.2 Data Analysis

Field identification of juvenile trout can be confounded where Rainbow Trout occur in the same geographic area and frequently encounter on another (sympatry) with Coastal Cutthroat Trout, in part because hybridization commonly occurs between the two species and because hybrids themselves are difficult to differentiate (Baumsteiger 2005). Visual identification error rates for juvenile trout (sympatric Coastal Cutthroat and Rainbow Trout populations) can be quite high without genetic analyses to corroborate genotypes. Similar to 2017 (PECG and Snowline 2018), 2018 field crews did not identify any suspected hybrid offspring of Coastal Cutthroat and Rainbow Trout (Photo 4-1). In the absence of genetic analyses to provide accurate identification of individual fish and the fact that a suspected hybrid was identified in 2016 within the Ecosystem Monitoring Program study area (Photo 4-2; PECG and Snowline 2017), results are discussed in terms of 'unknown' trout within this report.

Photo 4-1. Rainbow Trout (fork length 94 mm) captured in Crabapple Creek (CRB-DS-AQ01) during 2018 electrofishing efforts. Date: August 2, 2018.

Photo 4-2. Suspected hybrid trout (fork length 84 mm) captured in 21 Mile Creek in 2016 (21M-DS-AQ21). Date: August 6, 2016.

Fish Abundance

Fish community data was summarized by calculating catch-per-unit-effort (CPUE) for each individual fishing effort, gear type and fish species captured. CPUE is an index of relative abundance that can be used to compare fish populations among different areas with the assumption that catch is proportional to the amount of effort for each gear-type used. CPUE is defined as the number of fish captured per sampling device per unit time. CPUE is summarized for each gear type and by species.

Electrofishing:
*CPUE=number of fish caught * [100/(electrofishing effort, hr)]*

Minnow Traps:
*CPUE=number of fish caught per trap * [24 hr/(set time, hr)]*

Length, Weight and Condition

Mean length and weight were calculated for each fish species; further analyses were only completed on trout, as this species was proposed as an indicator species in the past and the focus of analysis in previous Whistler Ecosystem Monitoring reports (PECG and Snowline 2017, 2018).

Site-specific length-age regressions for trout were calculated as:

$$log_{10}(W) = a + b \times log_{10}(L) \quad (1)$$

where *W* = weight (g), *L* = length (mm), *a* = the intercept of the regression and *b* = the slope of the regression.

One sample t-tests were performed on estimated weight-length slope coefficients to determine if slopes significantly differed from the isometric growth value of three. Isometric fish growth occurs when length and weight increase at the same rate as the fish grows, whereas allometric growth occurs when length and weight increase at different rates during fish growth. Isometric and allometric growth are used to understand length-weight relationships in organisms. Slope coefficients of the estimated weight-length slope used in t-tests were estimated using species-specific linear regressions. Isometric growth is a requirement for calculating fish condition using the Fulton condition factor (K), as it assumes that fish shape does not change with increasing length. Trout condition could not be assessed using the Fulton condition factor, due to allometric growth. Instead, the relative condition factor (K_n) was used to characterize fish condition:

$$K_n = \frac{W}{W'} \quad (2)$$

where *W* = fish actual weight (g) and *W'* = predicted length-specific weight using the length-weight regression outlined in Equation 1.

4.2.3 Quality Assurance/Quality Control

Field equipment was calibrated prior to the start of the field season, properly maintained and kept clean and free of excess water. The YSI meter was re-calibrated multiple times while in the field. All scales were regularly tared to maintain accuracy while in use. Care was taken to clean equipment between samples to prevent cross contamination.

All data was recorded on waterproof paper and examined for completeness and accuracy. All captured fish were identified to the lowest possible taxonomic level and a subset were photographed for verification of species identification.

All fisheries field data were transferred to electronic spreadsheets in the office. The spreadsheets were compared with the field notes to identify and correct transcription errors. A variety of other measures were taken to further ensure the validity of the data. For example, fish weights were plotted against fish lengths for each species separately to identify outliers that may have been due to errors in recording or transcription. Outliers were excluded from the analyzed dataset.

4.3 Results and Discussion

4.3.1.1 CPUE and Biological Data

In 2018, fish community assessments were completed at five stream sites within the RMOW study area (Figure 2-1). Fish catch-per-unit-effort (CPUE) by species and sampling gear are presented in Table 4-2 and Table 4-3. Biological data for fish sampled in the RMOW study area are presented in Appendix D.

Table 4-2. **Electrofishing effort and fish caught in surveys conducted in the RMOW study area, 2018.**

Creek	**Site ID**	**Sampling Date**	**Effort (sec)**	**Fish Captured**				**CPUE (fish/100 sec)**			
				CC	TR	TSB	All Species	CC	TR	TSB	All Species
Jordan Creek	JOR-DS-AQ31	02-Aug-18	963	6	3	0	9	0.62	0.31	0	0.93
Crabapple Creek	CRB-DS-AQ01	02-Aug-18	953	16	5	3	24	1.68	0.52	0.31	2.52
21 Mile Creek	21M-DS-AQ21	02-Aug-18	1105	15	0	0	15	1.36	0	0	1.36

Notes: CPUE = catch-per-unit-effort, CC = Sculpin (General), TR = trout, TSB = Threespine Stickleback

Table 4-3. **Minnow trap effort and fish caught in surveys conducted in the RMOW study area, 2018.**

Creek	**Site**	**Set/Retrieval Dates**	**Number of MT**	**Total Effort (hrs)**	**Fish Captured**				**CPUE (fish/100 sec)**			
					CC	TR	TSB	All Species	CC	TR	TSB	All Species
Jordan Creek	JOR-DS-AQ31	02-Aug-18 /03-Aug-18	5	95.83	0	3	7	10	0	0.15	0.35	0.50
Crabapple Creek	CRB-DS-AQ01	02-Aug-18 /03-Aug-18	5	95.83	1	3	18	22	0.05	0.15	0.90	1.10
River of Golden Dreams (Upper)	RGD-US-AQ11	02-Aug-18 /03-Aug-18	5	119.01	2	0	16	18	0.08	0	0.65	0.73
River of Golden Dreams (Lower)	RGD-DS-AQ12	02-Aug-18 /03-Aug-18	5	100.78	11	4	30	45	0.52	0.19	1.43	2.14
21 Mile Creek	21M-DS-AQ21	02-Aug-18 /03-Aug-18	5	115.20	3	2	4	9	0.13	0.08	0.65	0.73

Notes: MT = Minnow Trap, hrs = hours, CPUE = catch-per-unit-effort, CC = Sculpin (General), TR = trout, TSB = Threespine Stickleback, A total of 152 fish were captured during 2018 electrofishing and minnow trap efforts. Three fish species were identified in streams sampled in 2018, including unidentified trout, Sculpin and Threespine Stickleback. No Bull Trout or Dolly Varden were observed. Sculpin represented the overall dominant fish species captured during 2018 electrofishing efforts, comprising approximately 67% of the capture in both Jordan Creek and Crabapple Creek and the entire catch in 21 Mile Creek (Figure 4-1). Threespine Stickleback dominated the catch using minnow trapping at all five sampling locations (Figure 4-2). Overall, trout have shown a decline in capture since 2016. No trout were captured at the upstream site of the River of Golden Dreams where only minnow traps were deployed.

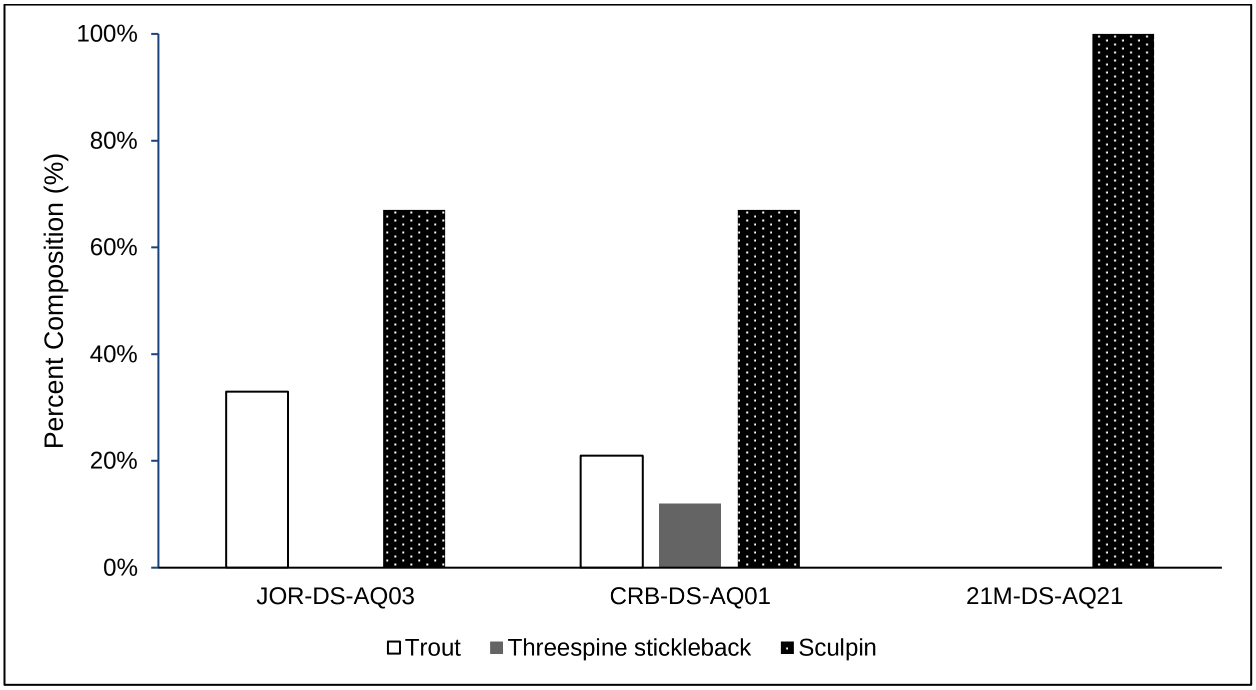

Figure 4-1. Percent composition of fish species captured electrofishing streams in RMOW study area, 2018.

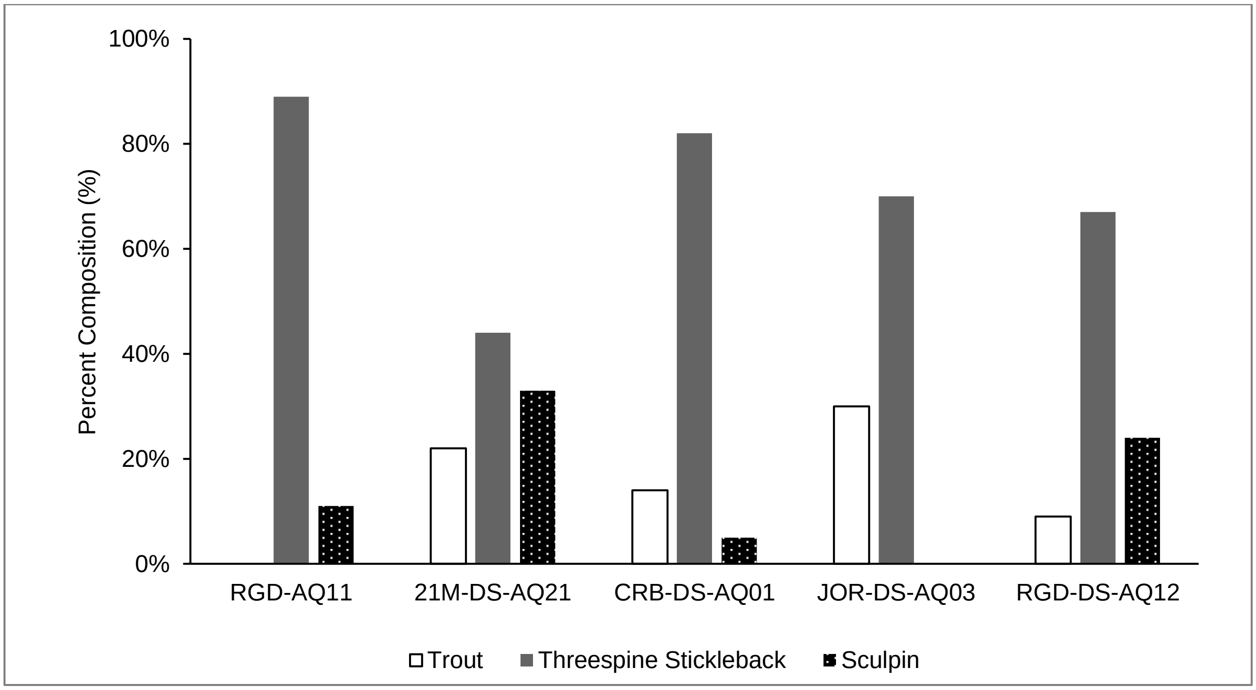

Figure 4-2. Percent composition of fish species captured in streams using minnow traps, 2018.

4.3.1.2 Lengths, Weights and Condition

The mean length and weight of each fish sampled in 2018 is presented in Figure 4-4. A length-frequency analysis for trout sampled in 2016, 2017 and 2018 is presented in Figure 4-3. Note that the larger numbers of fish captured in 2016 (n=102) relative to 2017 and 2018 is most likely due to the multiple pass depletion electrofishing method used in that year (PECG and Snowline 2017).

In 2018, trout were consistently the largest fish species captured in the study area. Amongst all sites, trout ranged in length from 32 mm to 123 mm and in weight from 0.2 g to 19.4 g (Figure 4-4). The largest trout were captured in the downstream location on the River of Golden Dreams (RGD-DS-AQ12) followed by Crabapple Creek and 21 Mile Creek.

Table 4-4. Length and weights of fish captured in the RMOW study area, 2018.

Creek	Site ID	Species	n	Length (mm)				Weight (g)			
				Min	Mean	Max	SD	Min	Mean	Max	SD
Jordan Creek	JOR-DS-AQ03	CC	6	55	67	76	9.5	1.6	3.9	5.9	1.9
		TR	6	32	68	115	31.1	0.2	5.2	15.7	6.0
		TSB	7	45	52	55	3.8	0.7	1.4	1.9	0.4
Crabapple Creek	CRB-DS-AQ01	CC	17	41	55	90	13.4	0.6	2.1	8.8	2.0
		TR	8	37	69	105	27.1	0.5	5.0	13.4	4.6
		TSB	21	49	55	60	3.6	1.1	1.7	2.4	0.4
River of Golden Dreams (Upper)	RGD-US-AQ11	CC	2	52	60	68	11.3	1.2	2.8	4.3	2.2
		TR	0	0	0	0	0.0	0.0	0.0	0.0	0.0
		TSB	16	6	51	62	13.1	0.6	1.7	2.6	0.4
River of Golden Dreams (Lower)	RGD-DS-AQ12	CC	11	45	53	63	5.2	0.7	1.6	2.5	0.5
		TR	4	70	92	123	24.8	3.1	9.4	19.4	7.5
		TSB	30	38	46	59	5.1	0.5	1.1	3.0	0.5
21 Mile Creek	21M-DS-AQ21	CC	18	44	63	93	15.7	1.0	3.3	9.1	2.4
		TR	2	70	82	94	17.0	3.6	5.9	8.2	3.3
		TSB	4	50	53	55	2.4	1.3	1.5	1.7	0.2
All Sites		CC	54	41	59	93	13.1	0.6	2.6	9.1	2.1
		TR	20	32	75	123	27.1	0.2	6.0	19.4	5.5
		TSB	78	6	50	62	7.8	0.5	1.4	3.0	0.5

Notes: CC = Sculpin (General), TR = trout, TSB = Threespine Stickleback,

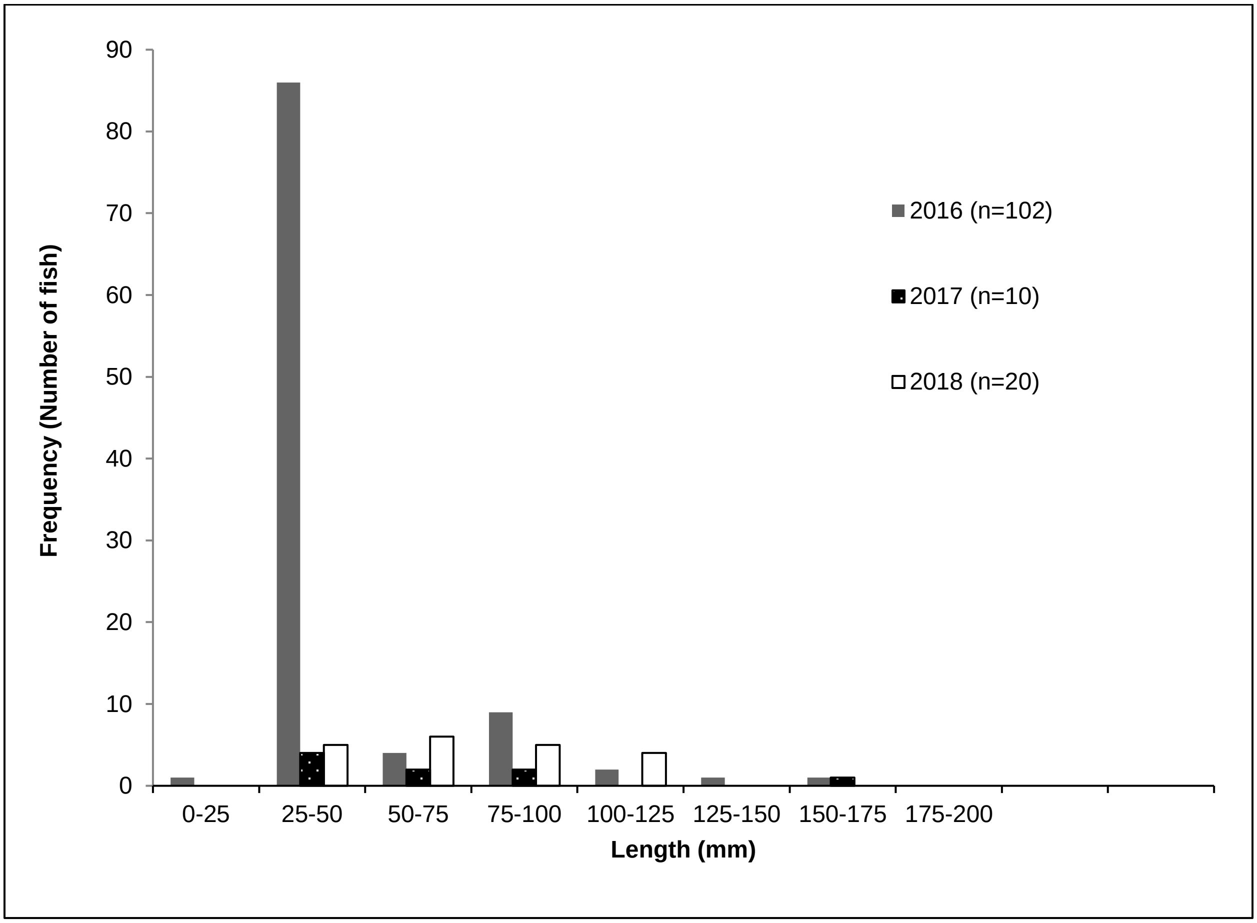

Figure 4-3. Length-frequency analysis for sampled trout (electrofishing and minnow trap collection methods) in study streams, August 2016, 2017 and 2018.

Condition

The length to weight relationship of all the trout sampled in 2016, 2017, and 2018 are presented in Figure 4-4. The length-weight linear regression for juvenile trout collected in 2018 was significant (Linear regression, slope = 3.2, R^2 = 0.82, df = 13, p < 0,05). Due to a slope value greater than 3.0 (3.2), trout growth was shown to be positively allometric (t-test, t = 2.43, df = 13, p = 0.031), that is, fish length increased more quickly relative to weight. In 2016, trout growth was also allometric but in this year was negatively allometric (slope value less than 3.0), thus showing weight increasing quickly relative to length. Conversely, in 2017 trout growth was shown to be isometric (t-test, t = 0.76, df = 7, P = 0.47) with fish having relatively similar ratios between growth in length and weight. Overall, the length to weight relationship for trout in the RMOW showed slight variations in growth that may be related to changes in food source over the years. As benthic invertebrate taxa richness (Figure 3-3) was greatest in 2018, this could relate to the greater weight increase relative to fish length.

Due to the low sample size of trout in 2017 and 2018, statistics derived from this data have limited power and therefore results should be interpreted with caution. For example, even though the length-weight relationships of 2016, 2017, and 2018 trout appear similar (Figure 4-4), statistical analysis showed significant differences in trout growth relationships (isometric vs. allometric). As trout captured in 2018 show allometric growth, relative condition was used to asses fish condition. Refer to Section 4.2.2 for detailed analyses.

Mean relative condition (Kn) for trout captured in RMOW from 2016 to 2018 is presented in Figure 4-5. In salmonids, a condition of 1 is considered normal for a healthy fish. Therefore, all trout sampled within the RMOW in 2018 were considered healthy based on the relative condition index. Within the four sites where trout were captured, all showed similar condition values for 2018. Within Jordan Creek and Crabapple Creek, there was a decline in condition from 2016 to 2017 and 2018, similar to benthic invertebrate diversity patterns observed over those three years (Figure 3-6; Figure 4-5). In addition, the condition of trout within Jordan Creek showed similar patterns observed with benthic invertebrate EPT taxa, indicating that fish may be living in an impaired habitat.

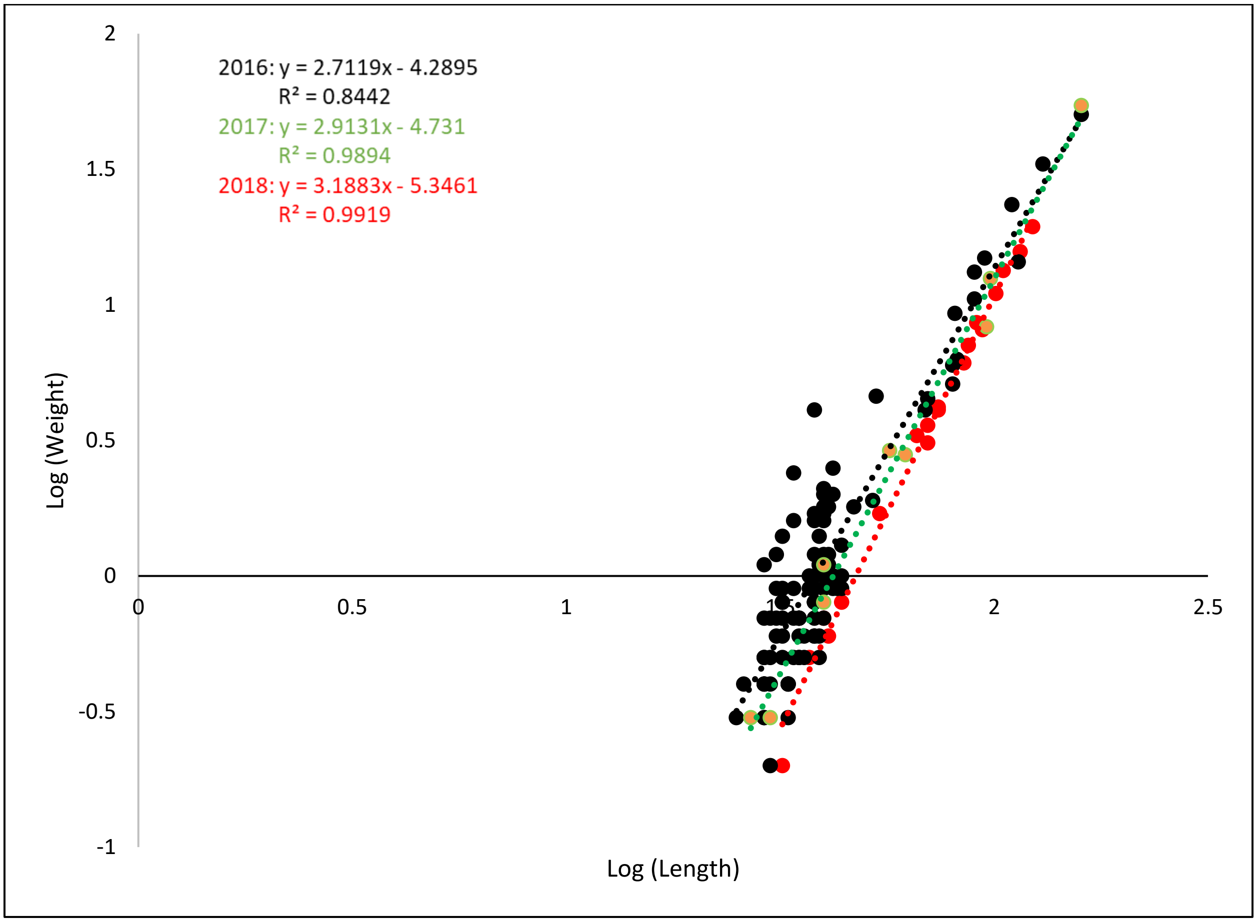

Figure 4-4. Weight-length relationship for juvenile trout captured in the RMOW study streams, 2016 - 2018.

The purpose of the fish sampling program was to develop a greater understanding of the fish communities in the streams within the study area and to help identify any potential impacts to these sites. The 2018 sampling program built upon the work completed in 2016 and 2017 to allow for the identification of temporal changes to the fish community. Fish community health is a product of the environment in which they live in. As fish occupy a higher trophic level and are longer-lived compared to other aquatic organisms (*e.g.* benthic invertebrates), fish community data can provide information on the long-term health of a system.

The fish communities within the Ecosystems Monitoring Program study area are inhabited by 0+ year fry and juvenile trout, demonstrating the importance of the study reaches as rearing and feeding habitat. As recommended in previous years, the collection of aging structures from trout captured within the study area would contribute to a greater understanding of the trout community inhabiting these systems within the RMOW.

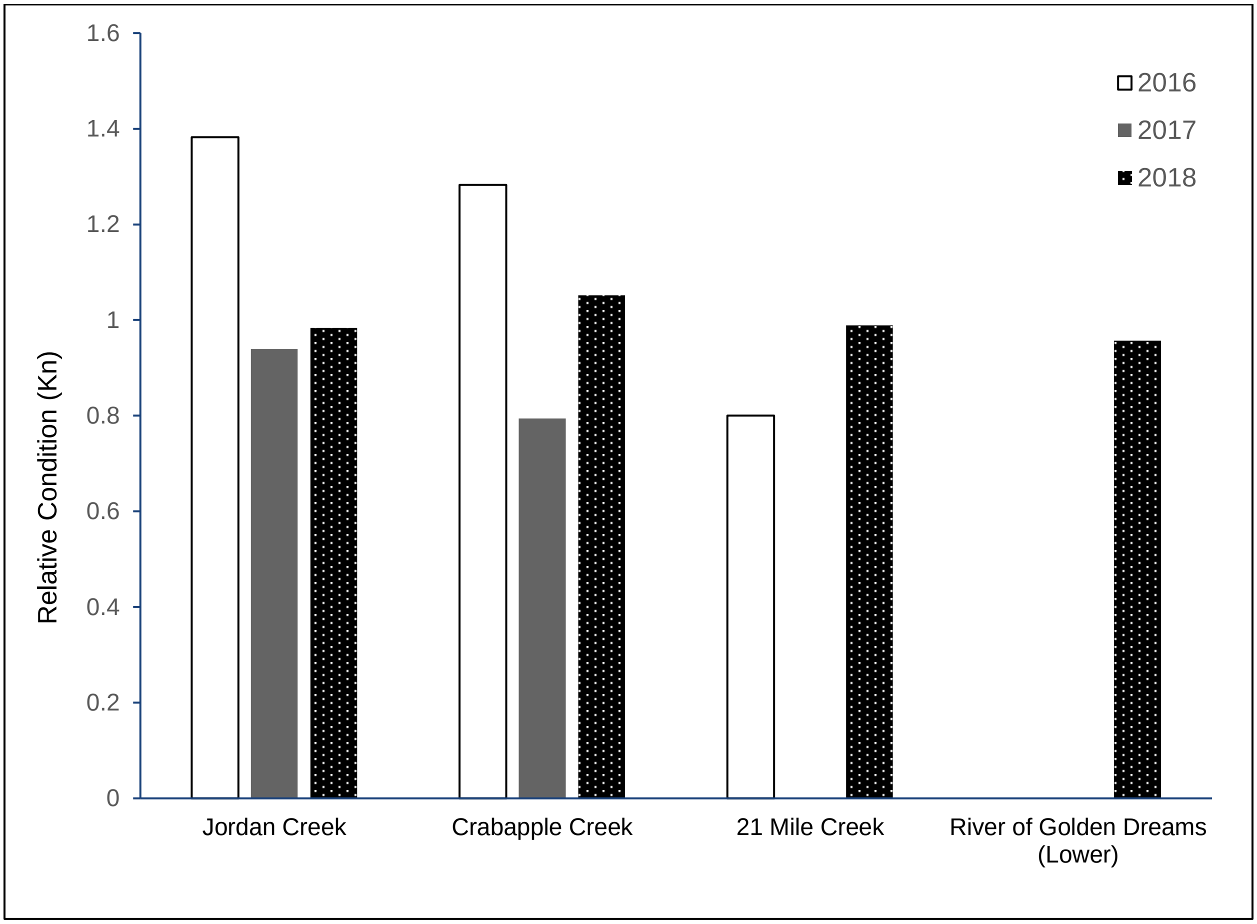

Figure 4-5. Relative condition of trout captured in the RMOW study area, 2016 - 2018.

5. Coastal Tailed Frogs

5.1 Introduction

Amphibians have long been used as indicators of ecosystem health. They have physiological constraints and sensitivities due to subcutaneous respiration, specialized adaptations and microhabitat requirements, as well as a dual life cycle that utilizes aquatic and terrestrial habitats. These characteristics make them susceptible to perturbations in both habitat types and suitable indicator species of ecosystem health.

Stream-dwelling amphibians such as the Coastal Tailed Frog (*Ascaphus truei*) serve a vital role as indicators of stream health as they require flowing, clear, cold water throughout their lifecycle (Matsuda et al. 2006) and are vulnerable to habitat alteration and degradation such as siltation and algal growth. They are also highly philopatric,[4] long-lived and maintain relatively stable populations. These attributes make them more trackable and reliable as indicators of potential biotic diversity in stream ecosystems than anadromous fish and their relative abundance can be a useful indicator of stream condition (Welsh and Ollivier 1998).

Ideal habitats for tailed frogs are smaller, fast-flowing (gradients usually >10%) mountainside streams that are cool (typically 10 to 15ºC in late summer, but at least 5º C for egg development), have a cobble-boulder substrate with rounded to subangular-shaped rocks, and a cascade or step pool morphology (Matsuda et al. 2006; BC MOE 2015). These characteristics describe many of the streams that drain into the Whistler Valley. Tadpoles have been detected in most Whistler streams surveyed to date (Wind 2005-2009; Cascade 2014 to 2016; PECG and Snowline 2017, 2018).

As of 2004, the only public documentation of Coastal Tailed Frogs near the RMOW was in Brandywine Creek (Leigh-Spencer 2004), presumably from surveys before the construction of the Independent Power Project (IPP) built on that creek. In late 2004, the Whistler Biodiversity Project began the first valley-wide survey of breeding populations (tadpoles) in 16 creeks in the area (Wind 2005-2009; Brett 2007). Surveys conducted since then, as part of the Environmental Monitoring Program (Cascade 2013-2015; PECG and Snowline 2017, 2018), continue to expand our understanding of the distribution and abundance of Coastal Tailed Frogs. In 2017, Coastal Tailed Frog was down-listed in BC from Blue (Special Concern) to Yellow (Not at Risk; CDC 2019). It remains a species of Special Concern under the Species at Risk Act (Government of Canada 2019).

5.2 Methods

5.2.1 Site Selection

In 2016, Coastal Tailed Frog surveys were continued at three of the four creeks previously sampled in 2015 (Figure 5-1; Cascade 2015). 19 Mile Creek, which was surveyed in 2015 was replaced with Whistler Creek in 2016 for three reasons:

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[4] *Adults typically breed in the stream in which they hatched.*

1. No tadpoles were detected in 19 Mile Creek during the two previous years or in 2006 by the WBP (Wind 2006)[5];
2. Although a strong population of tailed frogs was detected at multiple points throughout the Whistler Creek system by the WBP (Wind 2006, 2008, 2009) it hadn't been sampled since; and
3. The construction of an expanded bike park adjacent to Whistler Creek provided further justification to update the survey at this location.

The 2016 program expanded and standardized the elevational range of sites. The program continued the previous approach of surveying three reaches on each creek but changed some sampling sites to achieve (as much as possible) a standardized range in which one site was near valley bottom, one at approx. 800 m and one at approx. 1000 m. This elevational range was meant to include one site within the development footprint, a second at the upper end of it and a third above the development footprint (as a control site). Due to access and/or topography of the area, it was not feasible to establish equivalent elevations on some creeks (Figure 5-1).

The 2017 program retained Archibald Creek and Whistler Creek to continue multi-year comparisons in these heavily used areas on Whistler Mountain. Two new creeks, Horstman Creek and Agnew Creek, were added as replacements for Alpha and Scotia creeks (Figure 5-1; Table 5-1). Alpha and Scotia creeks had been surveyed extensively in the past by the WBP and Cascade (Wind 2005-2009; Cascade 2014, 2015, 2016) and detections of tailed frogs remained relatively similar in 2016. Horstman Creek was added in 2017 as it had many detections of tailed frogs in surveys conducted by the WBP in 2006 yet had not been surveyed since. This site was added to increase the spatial distribution of creeks northward, as well as to add another monitoring year to a creek within the ski area footprint. Agnew Creek was also added to the 2017 program to increase the representation of creeks on the west side of Whistler Valley. This area has relatively few creeks that are easily accessible and/or suitable for standard sampling methods. Prior to 2017, Agnew Creek had not previously been sampled for Coastal Tailed Frogs.

The 2017 report (PECG and Snowline 2018) recommended that the 2018 work plan should:

- Rotate out at least one creek and increase representation on the west side of the valley;
- Survey Agnew Creek for a second year as no tadpoles were detected in 2017 despite apparently suitable habitat; and
- Continue to monitor Whistler and Archibald creeks as indicators in these busy bike park and areas.

In 2018, 15 sites were surveyed on seven creeks; more than any year to date in the Ecosystem Monitoring Program (Figure 5-1; Table 5-1). Detailed site data is presented in Appendix G. Whistler and Archibald creeks were again retained in the survey to allow multi-year comparisons, especially as bike park activities continue to expand in those areas. Agnew Creek was retained for a second year to detect the presence of tailed frogs, while Horstman Creek was rotated out of the program to allow new creeks to be surveyed. Most notably, the 2018 survey included the sampling of three new creek sites on the west side of the valley (FJ West Creek, Van West Creek and Sproatt Creek) and the first higher-elevation site on Scotia Creek.

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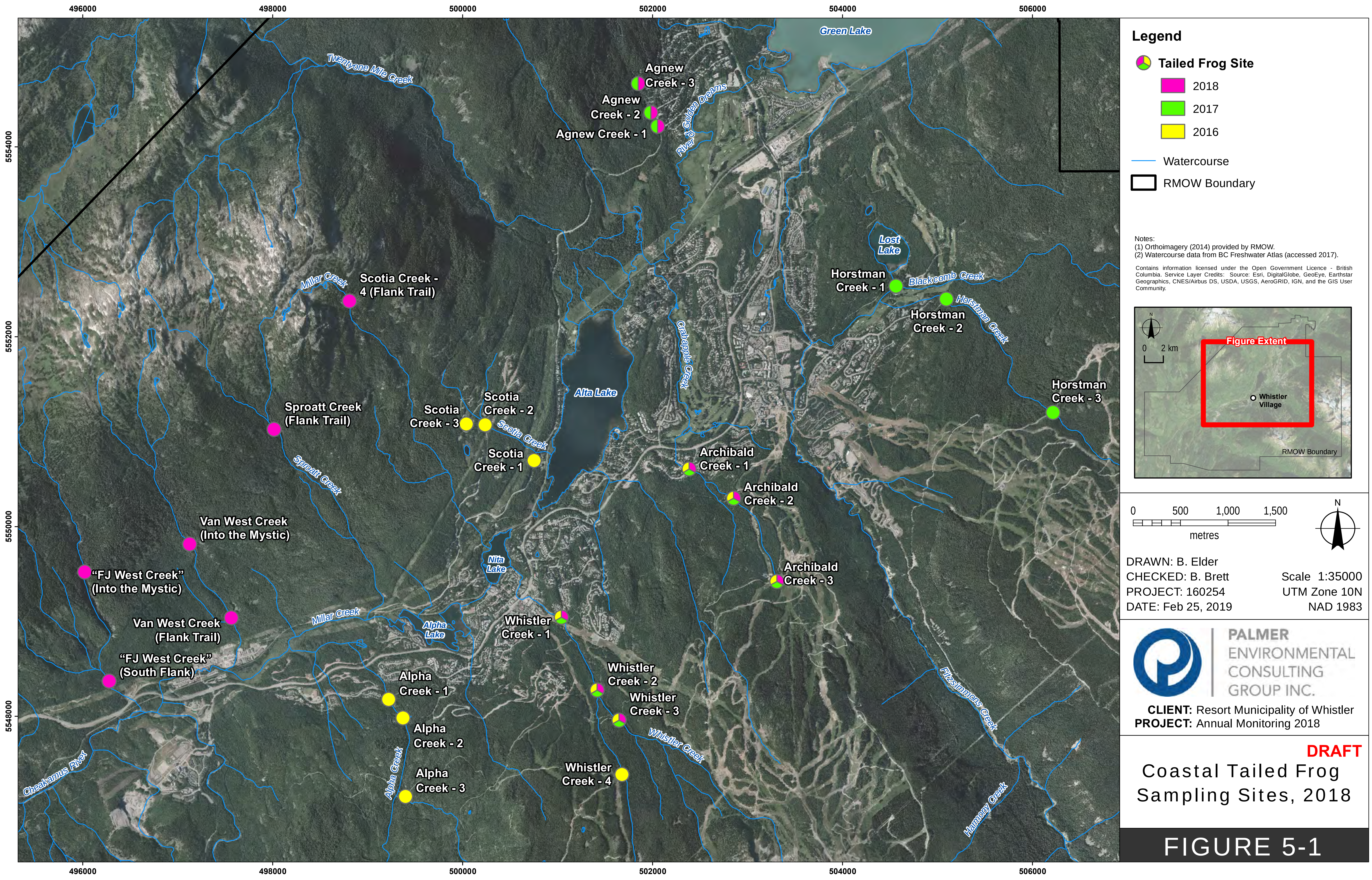
[5] *While it is possible tailed frogs are in that system, the sampling sites surveyed in all three years (upstream and downstream of Highway 99) did not provide confirmation. Future surveys at sites located at higher elevations and/or eDNA testing could help determine whether tailed frogs do or do not occupy in 19 Mile Creek.*



Notes:
(1) Orthoimagery (2014) provided by RMOW.
(2) Watercourse data from BC Freshwater Atlas (accessed 2017).

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DRAWN: B. Elder
CHECKED: B. Brett
PROJECT: 160254
DATE: Feb 25, 2019

Scale 1:35000
UTM Zone 10N
NAD 1983

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

CLIENT: Resort Municipality of Whistler
PROJECT: Annual Monitoring 2018

DRAFT

Coastal Tailed Frog Sampling Sites, 2018

FIGURE 5-1

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Table 5-1. Coastal Tailed Frog sampling sites, 2018.

Site	Valley Side	Date	UTM Location (10U)		Elev. (m)	Weather	Air Temp. (°C)	Water Temp. (°C)
			Easting	Northing				
Agnew Creek - 1	West	2018-09-06	502069	5554207	666	Sunny	12	8.0
Agnew Creek - 2	West	2018-09-04	501982	5554360	680	Sunny	14	8.1
Agnew Creek - 3	West	2018-09-04	501848	5554666	735	Sunny	14	8.1
Archibald Creek - 1	East	2018-09-06	502387	5550606	695	Sunny	15	9.1
Archibald Creek - 2	East	2018-09-06	502854	5550298	835	Sunny	12	8.1
Archibald Creek - 3	East	2018-09-06	503310	5549422	1026	Sunny	13	7.2
FJ West Creek (South Flank)	West	2018-09-06	496383	5548374	648	Sunny	23	10.2
FJ West Creek (Into the Mystic)	West	2018-09-05	496022	5549522	1119	Sunny	19	9.0
Scotia Creek - 4 (Flank Trail)	West	2018-09-05	499477	5551280	1000	Sunny	15	9.0
Sproatt Creek (Flank Trail)	West	2018-09-05	498483	5550455	996	Sunny	13	9.1
Van West (Flank Trail)	West	2018-09-05	497563	5549038	706	Sunny	18	10.0
Van West (Into the Mystic)	West	2018-09-05	497125	5549816	1036	Sunny	14	10.0
Whistler Creek - 1	East	2018-09-04	501041	5549045	692	Sunny	10	8.2
Whistler Creek - 2	East	2018-09-04	501417	5548276	879	Sunny	12	8.0
Whistler Creek - 3	East	2018-09-04	501649	5547961	972	Sunny	14	8.1
				Average	**846**		**15**	**8.7**

Notes: Elev. = Elevation, Temp. = Temperature.

In the past, difficult access and lower (even ephemeral) stream flows[6] had limited the number of creeks that could be surveyed on the west side of Whistler Valley. The two reasons for adding new creeks on the west side of the valley (in addition to Agnew Creek) were to:

1. increase geographic range of the survey; and
2. provide baseline data in the event of climate-driven changes in run-off, most importantly, changes in timing and flow due to the loss of glaciers.

The success in establishing survey sites on the three new creeks (Sproatt, Van West and "FJ West" [7]) and one new site on Scotia Creek[8] (Scotia Creek-4) was due to an extensive reconnaissance prior to surveys; and a crew willing and able to access the sites on mountain bikes, which greatly increased the number of sites that could be surveyed within the allotted time.

On the east side of the valley, sites were mainly chosen by accessibility via the Flank Trail as roads were lacking in this area. To be consistent with sites sampled in the previous two years, the goal was to sample each creek at three elevations, but this was not always possible due to access and time. For all four creeks

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[6] *Far more creeks on the west side have at least some contribution of glacial meltwater.*

[7] *No name for this creek could be found on municipal or other maps. The unofficial name of FJ West Creek was chosen to reflect that it flows into Millar Creek just west of Function Junction.*

[8] *Although there is a sign at this creek that reads "Nita Creek," this designation proved incorrect during fieldwork. See Section 5.3.6 for a discussion of possible inaccuracies in stream mapping.*

sites accessed by the mid Flank Trail, the goal of establishing an upper elevational sampling point (approx. 1000 m) was met. A second, low-elevation site was sampled on FJ West Creek, but access and topography may prevent the future establishment of a site between the two current sites. A second, mid-elevation site was sampled on Van West Creek. There is also access via a bike trail to a second, mid-elevation site on Sproatt Creek that could be surveyed in the future. It remains unclear if a third, low-elevation site can be found on Van West or Sproatt Creek. Extensive ground-truthing could not find the low-elevation outflow for Sproatt Creek and the creek that crossed Function Junction and mapped as Van West had much less flow than the higher elevation sites. These challenges are discussed further in Section 5.3.6. The new Scotia Creek site, the fourth site now established in that system, extends the elevational range to match most others in the program since 2016.

The elevational range of 2018 sites once again met the general aim of sampling within three elevational bands so that one site is near valley bottom, one approx. 800 m and one approx. 1000 m or higher (Table 5-2). Future surveys will hopefully add sites on the three new creeks (FJ West Creek, Van West Creek and Sproatt Creek) to include three sites at each location.

Table 5-2. Coastal Tailed Frog sampling sites by elevation and elevational range, 2018.

Site	Valley Side	2015		2016		2017		2018	
		Elev. (m)	**Range (m)**	**Elev. (m)**	**Range (m)**	**Elev. (m)**	**Range (m)**	**Elev. (m)**	**Range (m)**
Agnew Creek - 1	West	-	-	-	-	666	69	666	69
Agnew Creek - 2		-	-	-	-	680		680	
Agnew Creek - 3		-	-	-	-	735		735	
Alpha Creek - 1	East	676	49	684	179	-	-	-	-
Alpha Creek - 2		720		714		-	-	-	-
Alpha Creek - 3		725		863		-	-	-	-
Archibald Creek - 1	East	685	48	695	331	695	331	695	331
Archibald Creek - 2		695		835		835		835	
Archibald Creek - 3		733		1026		1026		1026	
FJ West (South Flank)	West	-	-	-	-	-	-	648	471
FJ West (Into the Mystic)		-	-	-	-	-	-	1119	
Horstman Creek - 1	East					687	519	-	-
Horstman Creek - 2		-	-	-	-	736		-	-
Horstman Creek - 3		-	-	-	-	1206		-	-
Scotia Creek - 1	East	661	153	661	156	-	-	n/a	-
Scotia Creek - 2		765		773		-	-	n/a	-
Scotia Creek - 3		814		817		-	-	n/a	-
Scotia Creek - 4		n/a	-	n/a	-	-	-	1000	339
Sproatt Creek (Flank Trail)	West	-	-	-	-	-	-	996	0
Van West (Flank Trail)	West	-	-	-	-	-	-	706	330
Van West (Into the Mystic)		--	-	-	-	-	-	1036	
Whistler Creek - 1	East	-		693	437	693	292	693	292
Whistler Creek - 2		-	--	875		875		875	
Whistler Creek - 3		-	-	985		985		985	
Whistler Creek - 4		-	-	1130					
Average Range (m)		**83**		**276**		**303**		**262**	

Notes: Elev. = Elevation; n/a = not applicable; dashes indicate sites not sampled.

The elevational range for Scotia Creek sampling points is now 339 m, though that range has not yet been sampled within a single year.

5.2.2 Sampling Design

All previous surveys for tailed frog tadpoles in the RMOW study area by the WBP (Wind 2005-2009) and the RMOW's Environmental Monitoring Program (Cascade 2014, 2015, 2016; PECG and Snowline 2017, 2018) have followed similar methodologies in conducting Coastal Tailed Frog surveys. The only significant change between WBP surveys and surveys conducted between 2013 and 2015 was the use of an area-constrained approach instead of a time-constrained approach. WBP surveys used a 30-minute time-constrained approach to maximize the probability of detecting the presence of tailed frogs. As the original goal of the Environmental Monitoring Program was instead to monitor relative abundance, surveys in 2013-2015 used the area-constrained method, recommended for that purpose by the BC Resource Inventory Committee (BC MELP 2000).

Between 2013 and 2015 streams were sampled at fixed 5 m stream lengths for a total of 30 minutes (Cascade 2014, 2015, 2016). Low tadpole densities in Whistler-area streams typically result in a low number of detections regardless of method,[9] and results with the area-constrained method used from 2013 to 2015 were considerably lower than previous WBP results from time-constrained surveys (Wind 2005-2009). Surveys in 2016 therefore returned to the time-constrained approach of 30 minutes total sampling time, regardless of area (PECG and Snowline 2016, 2017) which greatly increased detections and therefore statistical power (Malt et al. 2014a, 2014b) of the study.[10]

Both methods measured how much area was sampled at each site and surveyed for the same amount of time (30 minutes per site) which allows direct comparisons between years, regardless of method (within some statistical limitations). An unexpected outcome in 2016 and 2017 was that the return to a time-constrained approach did not significantly alter how much area was surveyed at each stream reach. That is, average survey areas in 2016 (23.2 m^2) and 2017 (19.7 m^2) were similar to the stream areas surveyed in 2015 (average 19.7 m^2). This similarity should also increase the reliability of comparisons between the two approaches.

Data collection methods were otherwise the same for all tailed frog surveys since 2004 and generally followed recommendations of the BC Resource Inventory Committee (BC MELP 2000). The in-stream surveys consisted of overturning unembedded cover objects such as rocks with dipnets held immediately downstream to catch any dislodged animals (Photo 5-1, Photo 5-2). Rocks were also swept by hand to detect any clinging tailed frog larvae before being set back in their original positions, as were large anchored rocks and large woody debris. Data collected at each site included:

- Site characteristics such as location, weather, overhead cover and stand type;
- Stream characteristics such as morphology, substrate size and shape, slope and bankfull and wetted widths;

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[9] *Bruce Bury (in a 2016 email to Brent Matsuda and Bob Brett) recommends that detections should be >2 tadpoles/m^2 to ensure statistical power. Virtually all sites sampled to date in Whistler have revealed densities far lower.*

[10] *These increases are reported in a multi-year comparison included in the results section (Section 5.3).*

- Overhead canopy cover, forest type (coniferous, deciduous, or mixed) and forest successional stage;
- Water and air temperature; and
- Total survey area (measured with a cloth tape to the nearest 0.1 m).

Photo 5-1. Luke Harrison and Jagoda Kozikowska dipnetting for tadpoles in Whistler Creek.

Photo 5-2. Captured tadpoles are transferred to a bucket until they are measured, classified to cohort and development stage, and released upstream

Data collected for tadpole captures also followed standard methods, including a measurement of total length for tadpoles (snout to ventral length for later stages). From 2013 through 2016, tadpoles were then classed into cohorts defined by Malt et al (2014a, 2014b) which served as proxies for age classes (e.g., first year - T1; second year - T2, etc.) as follows:

- T0 (hatchling <15 mm);[11]
- T1 (tadpole, no visible hind legs);
- T2 (tadpole, recognizable hind legs with knees that do not extend beyond the anal fold (Photo 5-3);
- T3 (tadpole, conspicuous hind legs with knees that extend out from body (Photo 5-4); and
- Non-tadpole – metamorph (tail plus front legs), juvenile (no tail, small, no nuptial pads); and adult (larger than juvenile, male has tail and nuptial pads, females larger than males).

Non-tadpoles, or post metamorphosis individuals, were classed as metamorphs (non-resorbed tail), juveniles (no tail, smaller than adults, no nuptial pads on males) or adults (larger than juveniles, males have a cloacal "tail," nuptial pads and are smaller than females; Corkran and Thoms 1996; Jones et al. 2005).

This tadpole classification scheme was used in the 2013-2015 surveys[12] and was also followed in 2016 though doubts emerged regarding the accuracy of using developmental stages as a reliable proxy for age class. During test surveys conducted prior to 2017, some discrepancies between length and developmental

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[11] *No hatchlings have been reported to date in Whistler surveys conducted in late August and September.*

[12] *Candace Rose-Taylor, email to Bob Brett.*

stages within and between streams were again encountered. These observations intensified questions about whether developmental stages were reliable proxies for the number of years since hatching, especially between streams that have different growing conditions. This doubt was later confirmed by Pierre Friele[13] who emphasized that the link between developmental stage, length and age is even more tenuous when applied across large geographic gradients in which climate differs. As a result, the 2017 and 2018 surveys measured the length of each tadpole and classified them by more detailed developmental stages as follows:

Developmental Stage 0 - Hatchling (<15 mm);
Developmental Stage 1 - No visible hind legs;
Developmental Stage 2 - Bulge only, hind legs not defined;
Developmental Stage 3 - Hind legs visible but covered;
Developmental Stage 4 - Hind feet protruding; and
Developmental Stage 5 - Hind knees protruding outside body.

Photo 5-3. Tadpole cohort 2 (T2). This individual's developmental stage is transitional between developmental stages 2 and 3 (hind legs covered but just starting to be defined).

Photo 5-4. Tadpole cohort 3 (T3); and developmental stage 6 (hind knees protruding outside body).

For consistency with past reports, the classes above were grouped according to Malt et al's (2014a, 2014b) T0 through T3 classifications. Detailed classifications are summarized in Appendix H. Future analyses may be able to use these detailed classifications to calibrate a reliable relationship between age and developmental stage in Whistler-area creeks.

To prevent recaptures, all individuals were placed in buckets and released upon completion of the site survey (BC MELP 2000). Sampling was planned for late-August to early-September when lower streamflow increases the detectability of tadpoles and the proportion of detected tadpoles that will successfully overwinter was presumably higher. Surveys in 2016 were hampered by inclement weather which caused

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[13] *Pierre Friele email to B. Brett and follow-up phone conversation, December 2017.*

a later and more extended survey period than intended (September 14 to 22). This late finishing date meant that the last surveys occurred after streams had cooled significantly, which was the likely cause of low detections (notably at Archibald Creek 1). Sampling in 2017 was approximately two weeks earlier, from August 31 to September 6, to improve tadpole detections (Table 5-1). Similarly, surveys in 2018 were completed by September 6.

5.2.3 *Data Analysis*

The total number of tadpoles per site (reach) were compared among surveys completed from 2015 through 2018. Results were also reported as detections per unit area (per 100 m^2) to permit comparisons between the 2015 area-constrained method and the time-constrained method used for the past three surveys. Additional parameters for analysis and comparison included: captures by stream system, water temperature, air temperature, elevation and age class / developmental stage.

5.2.4 *Quality Assurance/Quality Control*

For consistency, the same two surveyors searched each reach for 15 minutes while a third recorded site, stream and capture data. A trial survey was first used to ensure that measurements were consistent between surveyors. Special care was taken to ensure that cohort classes and developmental stages (see above) were recorded consistently. Photos of representative tadpoles in each class were used as guides to improve consistency between surveyors (e.g. Photo 5-3 and Photo 5-4).

5.3 Results and Discussion

5.3.1 *Tadpole Surveys*

A total of 15 sites on seven creeks were surveyed in 2018 (Figure 5-3; Table 5-3), the highest survey effort since the inception of the RMOW Ecosystem Monitoring Program in 2013. In 2018, surveys focussed for the first time, on the west side of the valley with more sites and creeks surveyed on the west side (nine sites) than on the east side (six sites). A total of 82 tadpoles were detected in 2018, slightly fewer than in 2017 (87 tadpoles) but still more than double the total in 2016 (39) and nine times the total detected in 2015 (nine). Since three more sites were surveyed in 2018 than in 2017, average detections per reach were proportionately lower than total detections. Similar to 2017, no tadpoles were detected in Agnew Creek despite seemingly suitable habitat. Only one tadpole was detected in total at two sites at FJ West Creek, at least partially due to the difficulty of dipnetting at reaches where creek beds are comprised of bedrock and embedded rocks (especially at the higher site). Van West Creek yielded 17 tadpoles from two sites which indicated a strong population in that creek. Likewise, the one site on Sproatt Creek yielded a robust number of tadpoles (11). The new site on Scotia Creek is the fourth and now uppermost site in that system. Two tadpoles were located in spite of non-ideal sampling conditions (low flow and few cobbles to turn over). An adult was found at this site on Scotia Creek and as well as at Sproatt Creek (see Section 5.32).

Table 5-3. Tadpole surveys conducted in the RMOW, 2015-2018.

Survey Year	Valley Side	Site	Number of Sites	Total Survey Area (m²)	Average Survey Area (m²)	Number of Tadpoles Detected	Tadpoles /100m²	Average Water Temp. (°C)
2015	East	Alpha Creek	3	69.6	23.2	4	5.7	7.5
	East	Archibald Creek	3	46.9	15.6	4	8.5	8.7
	West	Scotia Creek	3	45.8	15.3	1	2.2	8.8
	West	19 Mile Creek	3	73.6	24.5	0	0.0	7.9
		All 2015 Sites	**12**	**235.9**	**19.7**	**9**	**3.8**	**8.2**
2016	East	Alpha Creek	3	72.5	24.2	9	12.4	7.0
	East	Archibald Creek	3	45.2	15.1	5	11.1	6.4
	West	Scotia Creek	3	86.7	28.9	3	3.5	10.1
	East	Whistler Creek	4	97.6	24.4	22	22.5	8.8
		All 2016 Sites	**13**	**302.0**	**23.2**	**39**	**12.9**	**8.1**
2017	West	Agnew Creek	3	56.2	18.7	0	0.0	8.8
	East	Archibald Creek	3	88.2	29.4	33	37.4	12.0
	East	Horstman Creek	3	56.2	18.7	6	10.7	9.3
	East	Whistler Creek	3	36.2	12.1	48	132.6	13.0
		All 2017 Sites	**12**	**236.8**	**19.7**	**87**	**36.7**	**10.8**
2018	West	Agnew Creek	3	82.3	18.7	0	0.0	8.1
	East	Archibald Creek	3	55.5	18.7	30	54.1	8.1
	West	FJ West Creek	2	18.0	18.7	1	5.6	9.0
	West	Scotia Creek	1	9.5	18.7	2	21.1	9.0
	West	Sproatt Creek	1	19.5	18.7	11	56.4	9.1
	West	Van West Creek	2	30.0	18.7	17	56.7	10.0
	East	Whistler Creek	3	89.0	18.7	21	23.6	8.1

		All 2018 Sites	**15**	**303.8**	**18.7**	**82**	**27.0**	**8.8**

Several conclusions can be drawn from the summary of Coastal Tailed Frog surveys conducted in the month of September between 2015 and 2018 (Figure 5-2):

- The average area surveyed per site was similar between years;
- Detections by unit area (100m^2) and by site increased dramatically in 2016 and again in 2017 before decreasing slightly in 2018 (compared to 2017 results); and
- The highest average water temperature in 2017 coincided with the highest detections of tadpoles.

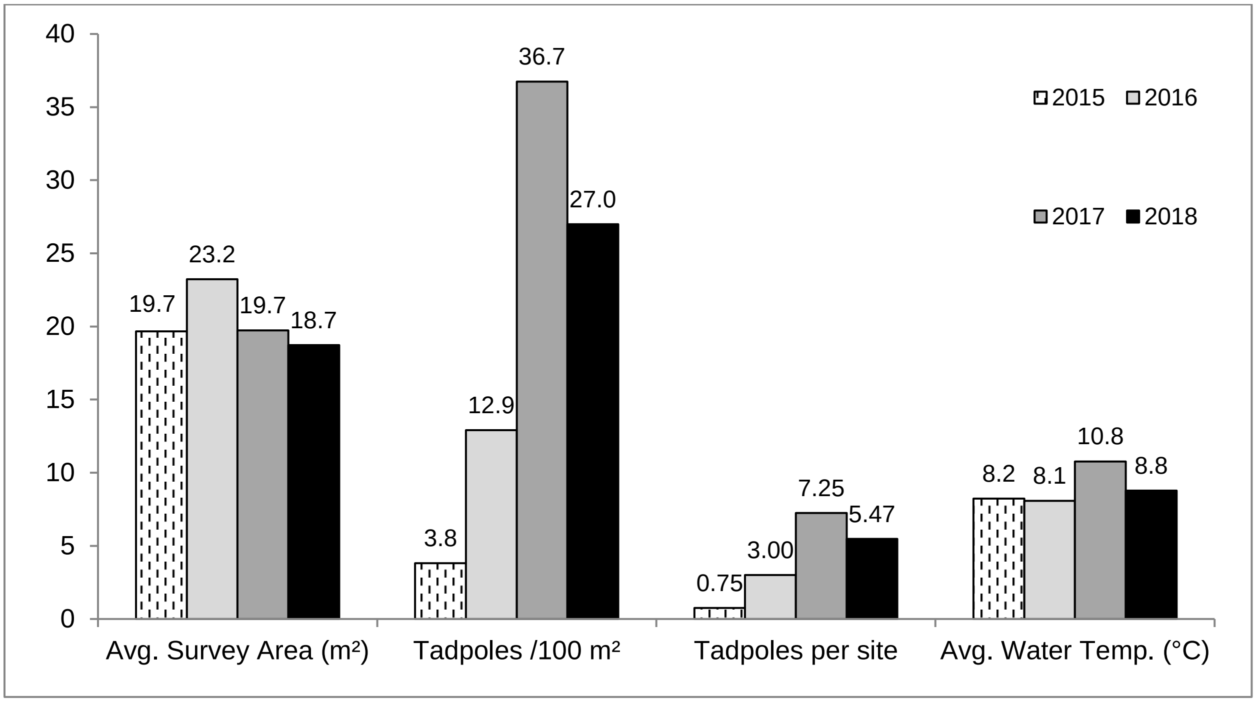

Figure 5-2. Average survey area per site, number of tadpoles per 100 m^2, number of tadpoles per site and average water temperature for September Coastal Tailed Frog surveys, 2015-2018.

The 2018 survey was the third year of using a time- versus area-constrained search. Similar to the previous two years of using this search technique, higher capture rates were observed when compared to the area-constrained search completed in 2015 (Table 5-3; Figure 5-2). As the average area sampled remained very similar between 2015-2018, the average number of tadpoles per unit area also increased after the 2015 survey.

There is a clear signal that higher water temperatures increase tadpole detections in the data and figure above (Figure 5-2; Table 5-3). This trend is evident when comparing sites that have been surveyed three or more times since 2015, namely Archibald Creek and Whistler Creek (Figure 5-3). In general, the improved methods used in 2016 led to a large increase in tadpole detections at all but one creek, Archibald Creek. This discrepancy at Archibald Creek was likely a result of a sudden cooling of the water in mid-September in 2016, a conclusion which is supported by the high number of easily visible tadpoles that were attached to bedrock under flowing water several weeks earlier. A sudden cooling of air temperature that year reduced stream temperature during the 2016 survey to 6.4 °C which presumably drove the tadpoles lower in the stream profile (including into the substrate). Detections at Archibald Creek were much higher in 2017 and 2018 when water temperatures during sampling were higher. A similar relationship between water temperature and detections emerged in Whistler Creek results from 2016 through 2018 where detections and water temperature were closely related.

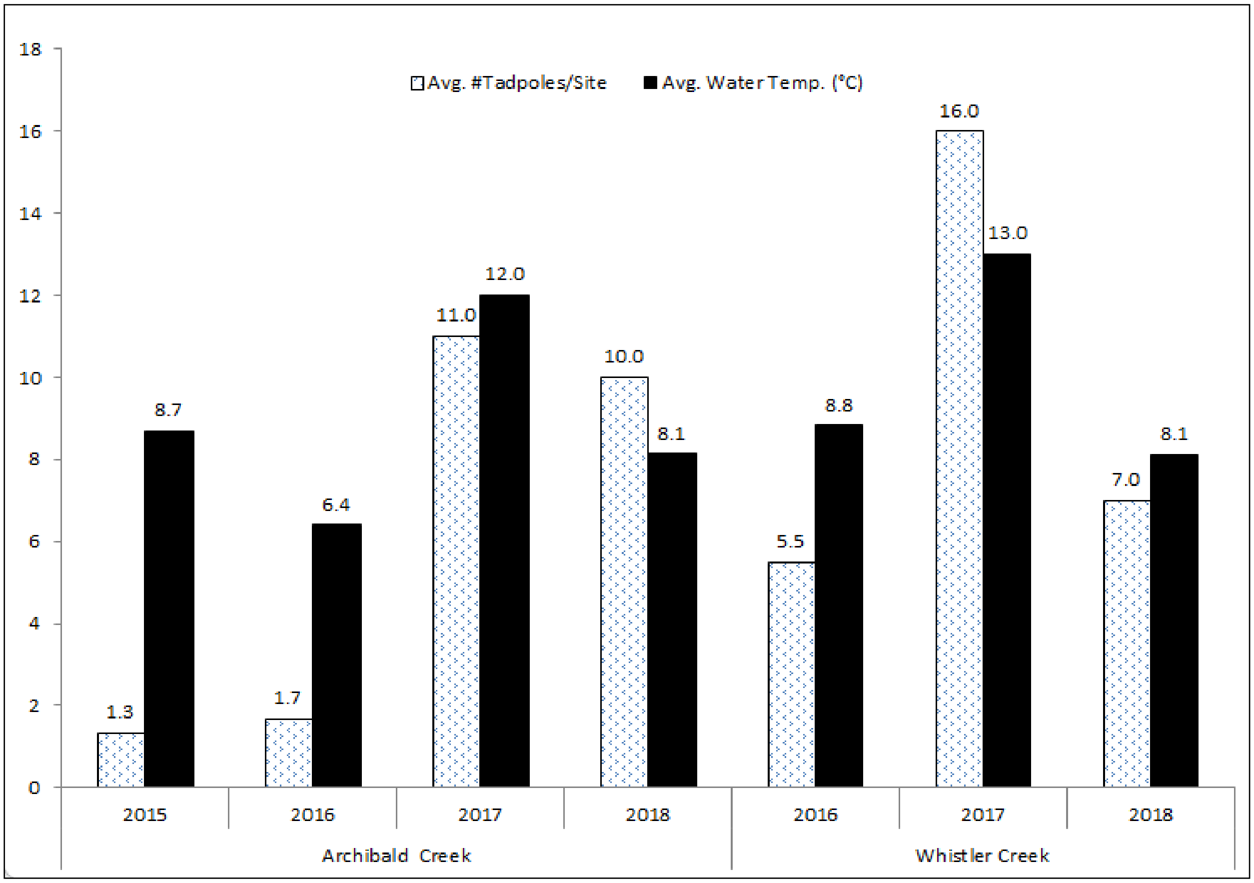

Figure 5-3. Average number of tadpoles detected per site (reach) and average water temperature on Archibald Creek and Whistler Creek, 2015-2018.

While trends can be observed between water temperature and tadpole detections at Archibald and Whistler Creek sites, there was no clear evidence that these busy areas were impacted by the effects of disturbance (Figure 5-3). There were no effects identified from the active bike parks and large ski resort operating in the area.

An increase in the proportion of T1 (early development) compared to T2 (mid-stage development) tadpoles has been observed since 2016 (Table 5-4). T1 tadpoles increased from 63% of all detections in 2016 to 72% in 2017 and 78% in 2018. The proportion of T3 tadpoles remained constant near 20%. Additional data and/or intensity of sampling is required to understand what factors are driving the observed increase in T1 tadpoles, or whether there is truly an increase. Even without that additional data, the relatively constant proportion of T3 (late stage) tadpoles over the three years provides no evidence that survivorship from the

T1 to T3 stage has decreased. There was no observed trend between elevation and tadpole developmental stage from 2016-2018 (Table 5-4).

Table 5-4. Tadpole detections by year, site, elevation and cohort, 2016-2018.

Site	Elevation(m)	Tadpoles 2016				Tadpoles 2017				Tadpoles 2018			
		Total	**T1**	**T2**	**T3**	**Total**	**T1**	**T2**	**T3**	**Total**	**T1**	**T2**	**T3**
Agnew Creek - 1	666	Not Sampled				0	0	0	0	0	0	0	0
Agnew Creek - 2	680					0	0	0	0	0	0	0	0
Agnew Creek - 3	735					0	0	0	0	0	0	0	0
Alpha Creek - 1	684	3	0	1	2	Not Sampled				Not Sampled			
Alpha Creek - 2	714	0	0	0	0								
Alpha Creek - 3	863	6	5	1	0								
Archibald Creek - 1	695	1	0	1	0	11	4	6	1	19	7	0	12
Archibald Creek - 2	835	1	1	0	0	5	2	1	2	5	5	0	0
Archibald Creek - 3	1026	3	3	0	0	17	15	0	2	6	5	0	1
FJ West Creek (South Flank)	648	Not Sampled				Not Sampled				0	0	0	0
FJ West Creek (Into the Mystic)	1119									1	1	0	0
Horstman Creek - 1	687	Not Sampled				1	1	0	0	Not Sampled			
Horstman Creek - 2	736					5	1	2	2				
Horstman Creek - 3	1206					0	0	0	0				
Scotia Creek - 1	661	0	0	0	0	Not Sampled				Not Sampled			
Scotia Creek - 2	773	0	0	0	0								
Scotia Creek - 3	817	3	1	0	2								
Scotia Creek - 4 (Flank Trail)	1000	Not Sampled								2	2	0	0
Sproatt Creek (Flank Trail)	996	Not Sampled				Not Sampled				11	10	1	0
Van West (Flank Trail)	706	Not Sampled				Not Sampled				1	1	0	0
Van West (Into the Mystic)	1036									16	14	1	1
Whistler Creek - 1	693	7	4	2	1	11	9	0	2	7	5	0	2
Whistler Creek - 2	875	9	7	0	2	26	23	0	3	5	5	0	0
Whistler Creek - 3	985	2	2	0	0	11	8	2	1	9	9	0	0
Whistler Creek - 4	1130	4	2	0	2	Not Sampled				Not Sampled			
	Total	**39**	**25**	**4**	**9**	**87**	**63**	**11**	**13**	**82**	**64**	**2**	**16**
	Percent		**63%**	**10%**	**23%**		**72%**	**13%**	**15%**		**78%**	**2%**	**20%**

Similar to results of the previous two years, an overlap between Malt *et al*.'s (2014) age class groupings (cohorts) and detailed developmental stages as described in Section 5.2.2 was observed in 2018 (Table 5-5). While tadpoles at later stages of development (either classified by cohort or by development stage) are generally longer, length is nonetheless an unreliable indicator for either classification. For example, tadpoles in the T1 class share most of their length range with T2 tadpoles with the presence of tadpoles ranging in length from 33 to 45 mm in both classes. Lengths of the T3 cohort (Developmental Stage 5) were more diagnostic and the largest tadpoles tended to be in this cohort/stage. Regardless, there was more similarity between Developmental Stages 4 and 5 than between cohort T2 and T3. This conclusion suggests that T3 should include both of those development stages.

Table 5-5. Length comparisons between Malt et al's (2014a, b) age classes (cohorts) and detailed developmental stages.

Age Class / Cohort	**T1**		**T2**		**T3**	
Developmental Stage	**1** No hind legs	**2** Bulge only, hind legs not defined	**3** Hind legs visible but covered	**4** Hind feet protruding	**5** Hind knees protruding	**All Tadpoles**
Number of Tadpoles	27	37	1	11	6	82
Mean Length (mm)	32	36	33	47	52	37
Median Length (mm)	31	36	33	47	53	35
Smallest (mm)	27	27	33	40	48	27
Largest (mm)	38	45	33	54	55	55
Length Range	27 to 45 mm		33 to 54 mm		48 to 55 mm	27 to 55
Largest to Smallest	1.6x		1.6x		1.1x	2.0x

Notes: No hatchlings <15mm (T0 or development stage 1) have yet been detected in a September survey in Whistler.

As in 2017, the most difficult classifications were for tadpoles demonstrating intermediate stages between cohort 1 and 2 and between cohort 2 and cohort 3 classifications. For cohort 1 and 2, many tadpoles were transitional between having an undefined "bulge" and defined legs contained within that bulge (Photo 5-4). Between cohort 2 and 3, there were some tadpoles whose rear feet but not knees were free of the skin that covered the bulge. They were transitional to cohort 3 but without the exact characteristics described by Malt *et al*. (2014a, 2014b). Therefore, research in the future should be cautious when assuming the age (cohort) of tadpoles is consistently related to developmental stage in RMOW streams.

5.3.2 *Environmental Effects on Tadpole Detections*

Water temperature was the only environmental factor tested that showed any relationship with the number of tadpoles detected from all 40 sites surveyed between 2015 and 2018 (Figure 5-4). This conclusion matches field observations and data discussed above. The calculated coefficient for all sites (1.2 tadpoles per degree of water temperature) predicts two or three more tadpoles would be detected if the water temperature was, for example, 10 °C instead of 8 °C and approximately 5 more would be detected if the water temperatures were 12 °C instead of instead of 8 °C. The effect is slightly higher (1.4 tadpoles per degree of water temperature) when the six Agnew Creek zero-detection surveys are deleted.[14] Both relationships are statistically significant ($p < 0.001$).

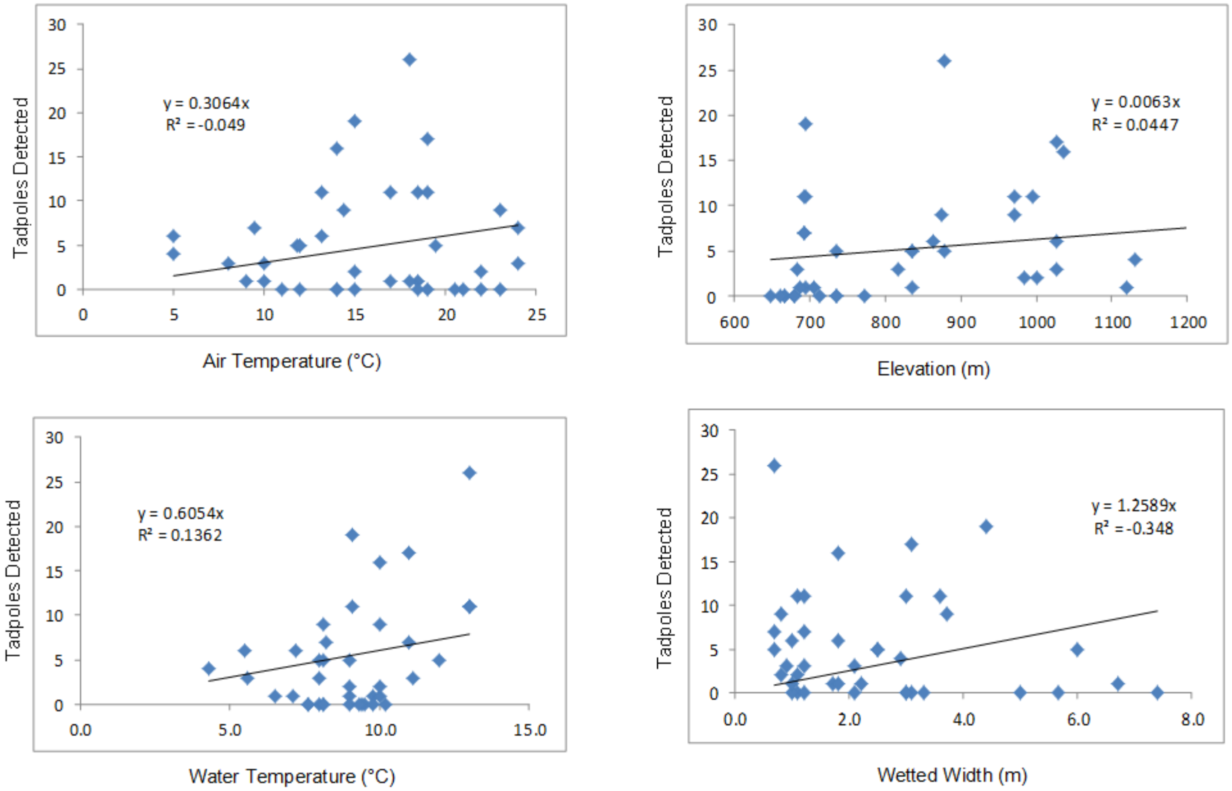

Figure 5-4. Number of tadpoles detected compared to air temperature, elevation, water temperature and wetted width, 2018.

There are two ways to interpret the findings that tadpole detections increase with higher termperatures: (i) warmer streams have more tadpoles; or (ii) more tadpoles will be detected within a stream if it is surveyed when water is warmer. It is the latter interpretation that is supported more strongly by results to date since within-creek temperature variability in Whistler is far higher than between-creek variability. That is, creeks sampled to date have typically been within a very narrow temperature range on the same day, but vary greatly with the weather and season. It is also probable that a general increase in water temperature in Whistler (due to warmer air temperature and/or less glacial runoff due to climate change) might be expected to increase the tailed frog population, but only if those changes were not counteracted by simultaneous negative effects such as lower stream volumes or, less likely, inhospitably high temperatures.

5.3.3 Adults and Incidental Observations

Two adults were captured during the 2018 surveys, a female at Scotia Creek – 4 (Flank Trail) and a male nearby at Sproatt Creek later the same day. Each was discovered under a flat cobble in the stream. Their

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[14] *Sites in which tadpoles were not detected do not provide any information for relationships between environmental variables and detections.*

snout-to-ventral lengths were 40 mm and 38 mm, respectively. The male was at the large end of the range for this species (Photo 5-5; Matsuda et al. 2006). Similar to previous years, it is difficult to derive any significance from such limited observations of adult frogs given the low detection rates.

On August 29, 2018, Hillary Williamson and Jagoda Kozikowska (RMOW Environmental Services) discovered four small male frogs that may have been adults or juveniles (no secondary characteristics were noted). Two were found dead on the bridge over Whistler Creek next to the Legends Hotel and two were found live beside the streambank just upstream of the bridge (Photo 5-6). This is near the location where Amy Romano found an adult male frog in 2015.

Photo 5-5. Adult male tailed frog in Sproatt Creek, upstream of the Flank Trail Bridge.

Photo 5-6. Adult male tailed, one of four (two live, two dead on sidewalk) found incidentally at Whistler Creek near the Legends Hotel (photo credit: Jagoda Kozikowska).

Two tailed frog tadpoles were observed during the electrofishing activities described in Section 4.0 of this report. The first found at the 21 Mile Creek site (21M-DS-AQ21) and the second at the Crabapple Creek site (CRB-DS-AQ01). Similar detections during electrofishing have been made in previous years which have confirmed tadpole presence in creeks that are not ideal or are unsuitable for dipnetting, such as these two creeks.

5.3.4 Stream Disturbances and Tailed Frogs

5.3.4.1 Archibald Creek

In 2016, significant depositions of sand and small gravel occurred in Archibald Creek below the main part of the Whistler Bike Park (Photo 5-7; Photo 5-8). The deposition was especially deep at the lowest reach, Archibald 1, located uphill of Panorama Drive in Brio. This site was downstream of the data logger that became clogged with sand and gravel in 2016. Low detections that year were attributed to two possible causes: (i) the sedimentation; and/or (ii) low water temperatures.

Photo 5-7. Sedimentation in 2016 at Archibald Creek 1 (near Panorama Drive).

Photo 5-8. Sedimentation in 2016 at Archibald Creek 2 (near Crank It Up in the Whistler Bike Park).

In 2017, Archibald Creek was predominantly clear (Photo 5-9; Photo 5-10) and detections of tadpoles were much higher relative to 2016. While it is difficult to interpret cause and effect due to limitations of sample size, the warmer water during the 2017 survey was likely the main explanation for higher detections relative to 2016. If sedimentation caused significant problems in 2016, there presumably wouldn't have been a preponderance of younger/smaller tadpoles comparable to unaffected reaches.

On August 29, 2018, there was a flush of sediments in Archibald Creek after heavy rain occurred following a long dry period (Photo 5-11). One week after the heavy rain event, the water had cleared to reveal an accumulation of sand and small gravel in the streambed. It is not clear whether the previous week's runoff was the cause of the accumulation or whether it was the result of other events. (Photo 5-12) Overall, detections of tadpoles within Archibald Creek were high for a second year in a row and there was no depositional effect observed.

Photo 5-9. Clear water and no significant sedimentation at Archibald Creek 1 in 2017.

Photo 5-10. Sedimentation observed upstream of Photo 5-9 in 2017 was much less than in 2016.

Photo 5-11. Sedimentation at Archibald Creek 1 on August 29, 2019, likely caused by runoff from a heavy rainfall that was the first significant precipitation in many weeks.

Photo 5-12. A photo near the same location as Photo 5-11 on Archibald Creek 1 one week later (September 6, 2019).

5.3.4.2 Whistler Creek

Reach 1 in Whistler Creek was added to the monitoring program in 2016 and at that time showed no recent disturbance. In-stream works that occurred sometime before the 2017 surveys (and were presumably related to the bridge replacement at the site) removed streamside vegetation and channelized the creek (Photo 5-13). The channel was filled with large angular rocks that replaced many of the cobbles that were previously in the stream. The detections of tadpoles in the 2017 survey were higher than those in 2016 despite the apparent degradation of habitat. Between the 2017 and 2018 sampling events, the stream had mostly reverted to its pre-disturbed condition, presumably because the imported rocks had been washed downstream (Photo 5-13; Photo 5-14).

Photo 5-13. Significant in-stream disturbance occurred at the Whistler Creek 1 site before the 2017 surveys.

Photo 5-14. The Whistler Creek 1 streambed had mostly reverted to an undisturbed appearance by early September 2018 when it was surveyed.

5.3.5 eDNA Sampling

Standard sampling techniques used for tailed frog surveys (which include dipnetting) are not effective in some circumstances, especially in large creeks and/or creeks with high flows. Detecting tadpoles with dipnets can also be difficult in creeks with low tadpole abundance or with substrates not suitable for dipnetting (e.g., large boulders, embedded substrates, etc.). Environmental DNA (eDNA) analysis is a new technology that can determine presence (though not relative abundance) in steams that are not suitable for dipnet sampling (Adams and Hobbs 2016). Possible targets for such a test would be creeks in which dipnet sampling has not been able to detect the presence of tadpoles such as in Blackcomb Creek, Agnew Creek and 19 Mile Creek. Using eDNA on Blackcomb Creek may be especially useful as it could test the current assumption that Coastal Tailed Frogs do not inhabit creeks with temperatures <6°C during egg development (BC MOE 2015).[15]

Despite the potential benefits of eDNA sampling, this methodology was not performed in 2018 because of the high cost associated with this new technology. The methodology for properly sampling eDNA has changed rapidly and that the most recent protocols for BC (Hobbs and Goldberg 2017) would require much higher standards and costs than initially anticipated. Most of the additional cost would be the requirement for trained personnel with specialized equipment to ensure the reliability of samples (to prevent false positives or false negatives through contamination). Even then, it is not guaranteed that results would be accurate. While eDNA was not used in the 2018 program, it may still hold potential for use in future sampling as part of the RMOW Environmental Monitoring Program.

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[15] *Blackcomb Creek is the coldest creek sampled in the RMOW since 2004 (4°°C at upper elevations and 6°C at lower elevations).*

5.3.6 Inconsistencies in Stream Mapping

The 2018 work plan included tailed frog sampling for the first time in small creeks accessed by the Flank Trail and new Sproatt Mountain Trails (e.g., Into the Mystic). After extensive reconnaissance, referencing of various maps, and field surveys, it became evident that the location and naming of creeks shown on maps was inconsistent.

5.3.6.1 Scotia ("Nita") Creek

One Flank Trail site was surveyed on a creek signed as "Nita Creek" even though RMOW mapping shows it as a tributary of Scotia Creek (Photo 5-15; Figure 5-5). Meanwhile, a dry creek bed just to the east, signed as "Scotia Creek" and mapped as such by the RMOW, does not appear to have had significant, or at least continuous year-round flow for years. The former location thus appears to be part of the main tributary of Scotia Creek.

Photo 5-15 Left: 2018 survey site Scotia Creek-4, signed as "Nita Creek". Right: The creek bed signed as Scotia Creek (dry during September 2018 surveys).

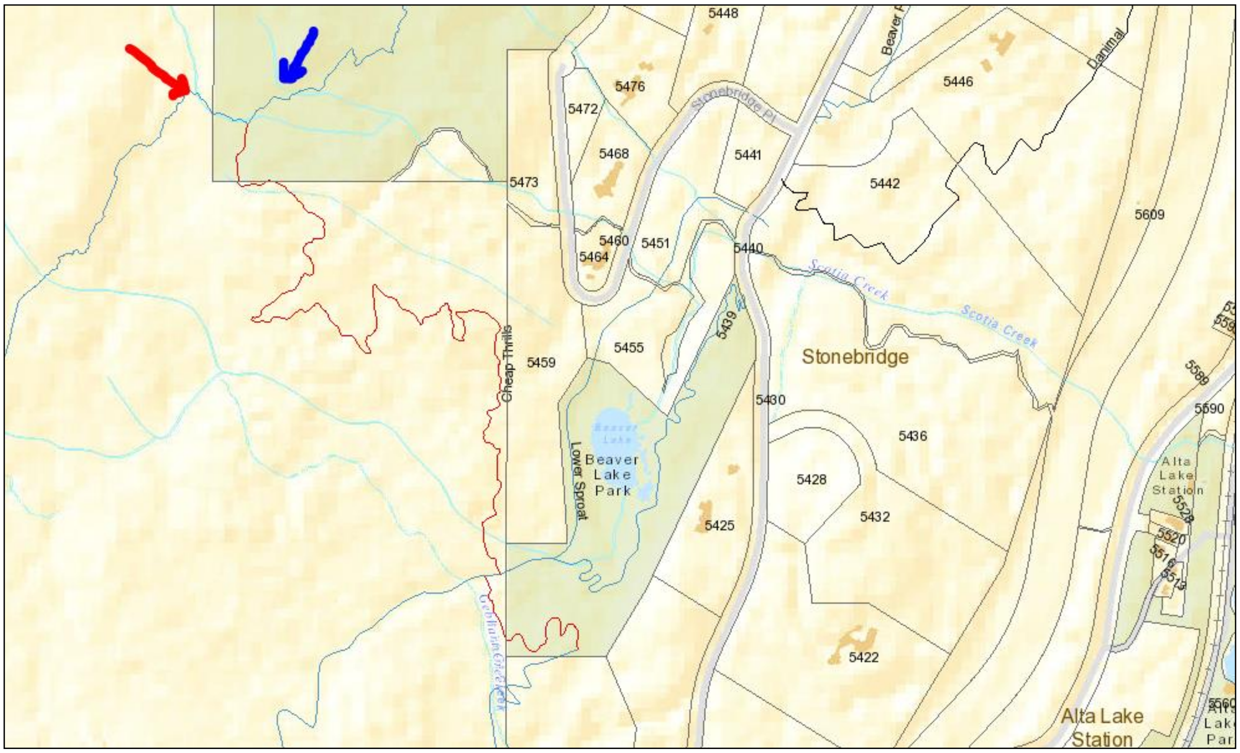

Figure 5-5. Locations of two sites with discrepancies in names. The red arrow depicts the creek signed as "Nita Creek" and the blue arrow depicts the ephemeral creek signed as Scotia Creek.[16]

5.3.6.2 Sproatt Creek and Van West Creek

Sproatt Creek and Van West Creek pose a different kind of mapping challenge as their flow at valley bottom appears to be subsurface. Where both streams cross the Flank Trail, they had low but reasonable volumes in early September which was after a long period of drought. In the valley bottom, there was no observed flow from Sproatt Creek at either of two locations where the creek has been differently mapped (Photo 5-16; Figure 5-6). Similarly, on Van West Creek, stream volume at two locations on the Flank Trail were significantly larger than where the creek crosses Function Junction, suggesting some of the volume is diverted underground (Photo 5-17).

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[16] *RMOW Web Map: https://webmap.whistler.ca/HTML5Viewer/Index.html?viewer=ExternalGIS.*

Photo 5-16. Left: Sproatt Creek (as signed) downstream of the CN Rail tracks and upstream of its junction with Millar Creek (August 30, 2018). Right: Sproatt Creek (as mapped) where the creek bed crosses under Alta Lake Road and towards Alpha Lake (August 30, 2018).

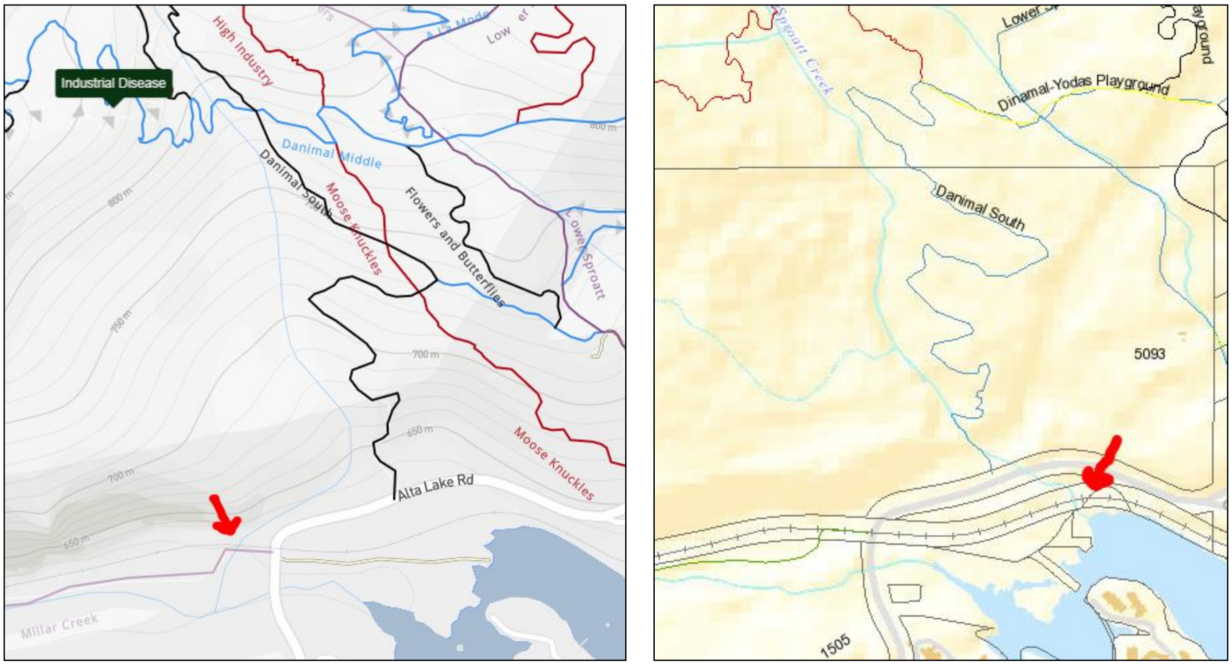

Figure 5-6. Location of Sproatt Creek sampling locations photographed in Photo 5-16.

Photo 5-17. Left: Van West Creek at its junction with the mid Flank Trail at 1036m. Right: Van West Creek where it crosses Function Junction.

6. Beavers

6.1 Introduction

Beavers are a keystone species, second only to humans in their ability to alter Whistler's landscape. The ponds and wetlands created by Whistler's beavers provide important habitat for a wide range of other species including waterfowl, amphibians, snakes, fish, mammals, aquatic plants and insects. Flooding and other damage caused by beavers can bring them into conflict with humans, which is why there is a long history of removing beavers from urban and other habitats.

Beavers provide a unique situation for field biologists in that it is possible to document all colonies (overwintering lodges[17]) in a valley the size of Whistler. This information, when combined with an estimate of number of beavers per colony, provides a population census that can be monitored without statistical analysis as required in most population surveys (statistical sampling). The human equivalent is the Canada census compared to election polling: the former includes the whole population while the latter includes a small subset and uses statistical analysis to estimate figures for the whole population.

Another reason why a census for beavers is beneficial is that beavers are colonial animals. They maintain a family lodge which houses the adult parents and typically two years of offspring, both newborns and yearlings (Müller-Schwarze and Sun 2003). Two-year-old beavers typically disperse to form new colonies, except when quality habitat is already occupied and dispersal is sometimes delayed. A lodge can remain active indefinitely but more often it is periodically inactive or abandoned permanently (as shown by Whistler data). The dispersal of offspring, death and migration of adults indicate that the location of active lodges changes each year within the landscape (here defined as lower elevations in Whistler Valley). A full census of beaver activity will, once fully re-established, provide more complete and accurate information about changes to Whistler's beaver population than would a smaller sample.

The Whistler Biodiversity Project initiated Whistler's first beaver census in 2007 (Brett 2007; Mullen 2008). Surveys continued through 2011, the last two of which were in conjunction with RMOW staff (Mullen 2009; Pevec 2009; Tayless 2010; Tayless and Burrows 2011). The survey was reinitiated in 2013 as part of this Ecosystem Monitoring Program but focussed only on a subset of lodges (Cascade 2014, 2015, 2016). In 2016, the focus of the beaver surveys returned to a full census approach where all possible active beaver locations within Whistler Valley were enumerated. The greater survey effort and geographic range that started in 2016 increased the number of documented lodges from nine in 2015 to 13 in 2016 and 14 in 2017. The documentation of inactive lodges and other activity similarly increased.

The focus of the 2018 census was based on recommendations from 2017 results (PECG and Snowline 2018) and included the following:

- Re-survey all past lodge locations and examine any reports of new activity;
- Conduct a more accurate and extensive survey of the River of Golden Dreams. Results from past surveys were highly variable and potentially suspect. For example, 15 lodges were reported in 2008 and 10 in 2012, while most other years had totals of five or fewer. It was likely the higher

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8 [17] Results from 2018 include for the first time the possibility of colonies overwintering in bank burrows.

numbers that were reported overestimated the number of lodges that were active overwinter (*i.e.*, housed a colony). Active lodges were almost certainly misidentified or overlooked in years with lower totals. Part of the inaccuracy observed in results from previous years was due to the difficulty in determining the status (active or inactive) of lodges. As well, a lack of time allotted to complete the surveys contributed to the inaccuracies observed;

- Confirm the location of lodges and other beaver activity in the wetlands of Millar Creek. Beaver activity was first confirmed in the wetlands of Millar Creek in 2016 but active lodges were not found. Based on extensive activity, two lodges were assumed to be active in the 2017 but locations were not reported;
- Confirm the location of lodges in other areas where activity was detected but lodges were not found. Examples include the Fitzsimmons Creek back channels on the northeast edge of Nicklaus North Golf Course and Wedge Pond;
- Estimate the area of “beaver-affected wetland,” that is, wetland habitats that have been created or altered by beaver activity; and
- Complete surveys earlier in the fall to avoid inaccuracies associated with snow cover.

6.2 Methods

6.2.1 Sampling Design

Sites included in the 2018 census were based on the following sources: (i) locations documented in surveys dating back to 2007; (ii) incidental sightings; and (iii) anecdotal reports. Each beaver survey recorded all past and current beaver activity, e.g., freshly cut branches and trees, tracks, food caches submerged in the water, new twigs and branches on dams, new construction on lodges (fresh mud or branches; Photo 6-1), tunnels through terrestrial vegetation and exit slides from water edges (Photo 6-2).

Photo 6-1. Mud added on top of snow on the Alta Lake Pond lodge (November 28, 2017).

Photo 6-2. Signs of beaver activity from the River of Golden Dreams: a lodge (left); tracks (middle); and a runway through adjacent vegetation (right).

In most cases, it is possible to confidently identify a lodge, burrow, dam, or area as "active" based on observations that include:

- Sightings of beavers, especially if entering and exiting structures;
- New construction or repair, especially in the fall;
- Functioning and freshly-maintained dam(s)
- Fresh food caches submerged at the entrance to a lodge;
- Beaver tracks;
- Well-worn paths (tunnels and slides) through vegetation that links to the lodge's pond; and
- Evidence of extensive clippings and cuttings along those paths.

Signs of inactivity include:

- Absence of any beaver sightings in the area;
- Absence of a structurally sound lodge;
- Absence of functioning or freshly-maintained dam(s); and
- Absence of any other fresh signs (*i.e*., that were obviously not from the survey year).

Such definitive observations are not always possible which is why all beaver surveys to date include a third classification: "Unknown," applied to sites for which there isn't enough evidence to conclude whether they are active or inactive.

Late-fall surveys for beaver are ideal as they can more confidently confirm lodges that are used for overwintering and therefore represent an active colony. Beaver activity after a snowfall clearly confirms an active colony in that area. This activity could include new mud on a snow lodge roof (Photo 6-1) or a freshly cut tree fallen onto the snow. Although such confirmation is welcome waiting to conduct surveys after the middle of October (when snow is possible) may result in not completing the survey. As such, surveys for 2018 were generally planned for late September through late October, with some follow-up in early November, if necessary.

6.2.2 Data Analysis

The surveys updated the status of previously documented beaver activities, added new activities and confirmed the status and location of lodges. Two factors introduce uncertainty into the interpretation of the count of active lodges: (a) lodges for which occupation is unknown; and (b) an incomplete census, that is, an unknown number of lodges that were not assessed. A third uncertainty is that the number of beavers per Whistler colony is not known but determining that number is beyond the present scope of the RMOW Ecosystem Monitoring Program. It is therefore necessary to rely on data published from other areas.

The number of beavers per colony (overwintering lodge or possibly bank burrow) is based on several factors, especially habitat type and beaver density (Müller-Schwarze and Sun 2003). In 2008, data was averaged from five studies to derive an estimate of the total Whistler beaver population based on a multiplier of 5.8 beavers per lodge (Mullen, 2008). This multiplier has been used each year since to derive an estimated total population. Other studies (Müller-Schwarze and Sun 2003) reported the average number of beavers per family from twelve locations that ranged from 4.1 to 8.2 and in which half were 5.1 or below and the average was 5.6 (Table 6-1). This source suggests the multiplier used in Whistler studies to date is reasonable, though may be slightly high.

Table 6-1. Number of beavers per family in various locations (Müller-Schwarze and Sun 2003).

Location	Avg. No. per Family	Location	Avg. No. per Family
Alaska	4.1	**Alleghany**	5.4
Montana	4.1	**Ohio**	5.9
Newfoundland	4.2	**Colorado**	6.3
Adirondacks	4.3	**Isle Royale**	6.4
California	4.8	**Massachusetts**	8.1
Michigan	5.1	**Nevada**	8.2

6.2.3 Quality Assurance and Quality Control

Results from beaver surveys are comparable year to year, with the caveat that the survey effort and reliability has been variable to an unknown degree. As the program has developed over the past three years, the census has become more reliable and the population estimates have become more accurate. In 2018, all possible sites, both recent and historic, were surveyed and photo-documented. All anecdotal reports were recorded and verified with a field visit. Additional effort was focussed on areas where lodge status could not be confirmed in 2017, notably the River of Golden Dreams, Millar Creek Wetlands, the Fitzsimmons Creek back channels and Wedge Pond.

6.3 Results and Discussion

The 2018 beaver survey came closer to a full census of the Whistler population than ever before and achieved several other goals. The 2018 survey:

- Confirmed lodge locations on the River of Golden Dreams in a more intensive survey than has yet been conducted;
- Confirmed lodge locations for the first time at Millar Creek Wetlands, Fitzsimmons Creek back channels and Wedge Pond;
- Mapped the area of beaver-affected wetlands to quantify, for the first time, the impact of beavers in Whistler;
- Visited 67 sites, six more than 2017 and the most of any survey to date; and
- Documented the most lodges (active, inactive and unknown status) since surveys began in 2007.

Since the WBP began beaver surveys in 2007, the overriding goal has been to document all active lodges and other beaver activity in Whistler Valley. Results from such a comprehensive census would document the number of colonies in a given year which could then be extrapolated to derive a reliable estimate of the number of beavers inhabiting Whistler. Survey efforts put forward in 2018 moved as close to this full census as has yet been achieved. Records for the River the Golden Dreams are now more accurate and reliable than they have been in the past. As well, for the first time, active lodges have been located in three areas

(Millar Creek Wetlands, Fitzsimmons Creek back channels and Wedge Pond) where activity has been previously confirmed but no lodges found (Brett 2007; Mullen 2008: Pevec 2009; Tayless and Burrows 2010; Tayless 2011; Cascade 2014, 2015, 2016). Results of the 2018 census provide the means for more accurately monitoring beaver activity in future years.

General observations and lodges: A total of 67 sites were surveyed in 2018 compared to 61 sites in 2017. This is the highest number of individual sites visited in the history of the surveys and resulted in 160 observations of beaver activity. Among those observations, 16 lodges were confirmed active, that is, presumed to house an overwintering colony (Table 6-2; Figure 6-1). This is the highest total since before the initiation of the Ecosystem Monitoring Program in 2013. It is fewer only than in 2008 when structures (especially on the River of Golden Dreams) were likely deemed active incorrectly, at least partially due to inaccurate GPS data. In addition, 2018 surveys documented more inactive lodges (32) and lodges with unknown status (9) than in any survey to date (Table 6-3).

Table 6-2. Summary table of documented lodges from 2007 through 2018 by activity status.

Status	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Lodge - Active	9	27	16	16	17	10	10	7	13	13	16
Burrow - Active	0	0	0	0	0	0	0	0	0	0	2?
Lodge - Inactive	9	12	13	7	21	5	14	18	11	21	32
Summer Only	-	-	-	-	-	-	-	-	2	2	2
Unknown	1	4	4	4	0	8	1	3	3	8	9
Total	**19**	**43**	**33**	**27**	**38**	**23**	**25**	**28**	**29**	**44**	**59**

Notes: Beaver surveys were not conducted in 2012. The status of two lodges at the #18 pond on the Chateau Golf Course remains unclear. In past years it has been considered used only in summer ("Summer Only") and therefore not included in the calculation of overwintering colonies).

Bank Burrows: The 2018 survey is the first to conclude that bank burrows house beaver colonies in Whistler. Past WBP surveys and those conducted in 2016 and 2017 recorded burrows with the assumption that they were intended for temperature control, predator avoidance or other temporary uses (Morgan 1868). While European beavers (*Castor fiber*) are known to use bank burrows often exclusively,[18] beavers in North America (*Castor canadensis*) are typically lodge dwellers. Of the six burrows detected in the vicinity of the Fitzsimmons back channels (Photo 6-3), surveyors concluded at least one likely housed a colony. Similarly, at least one (possibly both) of the unconnected bank burrows on the downstream section of the River of Golden Dreams (ROGD-6; Photo 6-4) was concluded to house a colony. This conclusion is consistent with Karl Ricker's past observations of a bank burrow colony in that area (Karl Ricker, pers. comm., January 2019).

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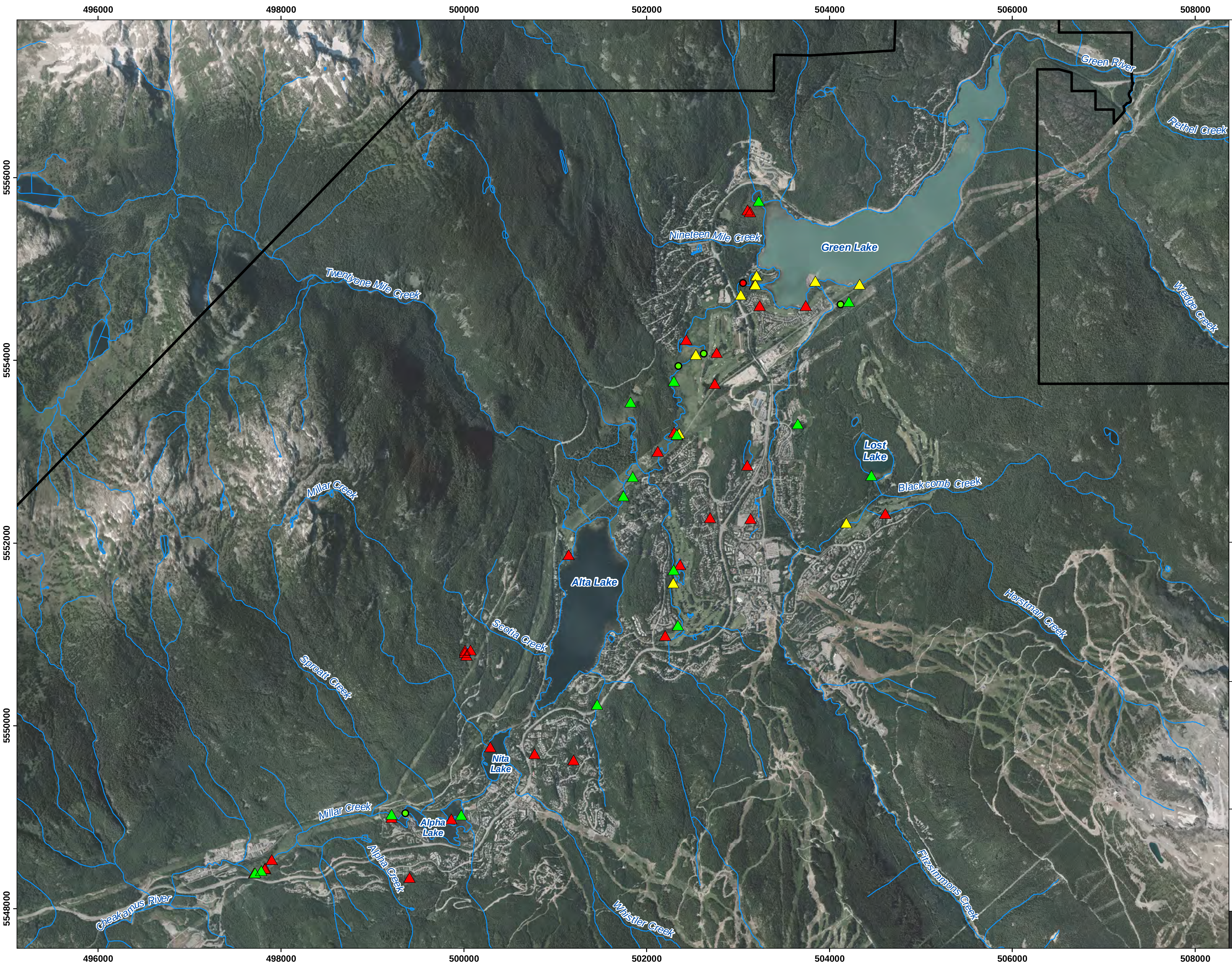
[18] *https://treesforlife.org.uk/forest/european-beaver/*

Photo 6-3. Examples of the burrows detected in the Fitzsimmons Creek back channels. Note the food cache adjacent to the burrow in the left photo.

Photo 6-4. An active burrow identified on a section of the River of Golden Dreams (ROGD-6) between Highway 99 and Green Lake.



Legend

2018 Beaver Census

- ▲ Lodge - Active
- ● Burrow - Active
- ▲ Lodge - Unknown
- ▲ Lodge - Inactive
- ● Burrow - Inactive

- ▭ RMOW Boundary
- — Watercourse

Notes:
(1) Orthoimagery (2014) provided by RMOW.
(2) Watercourse data from BC Freshwater Atlas (accessed 2017).

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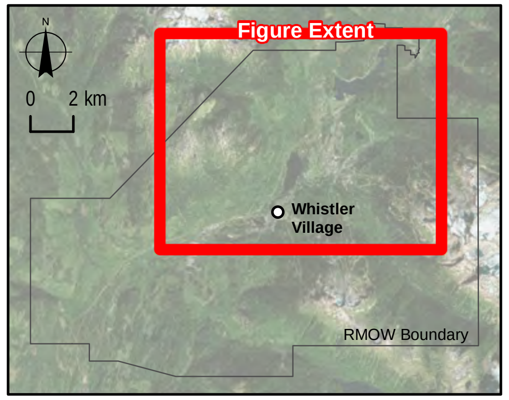

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CONSULTING
GROUP INC.

CLIENT: Resort Municipality of Whistler
PROJECT: Annual Monitoring 2018

Results of 2018 Census of Beaver Lodges in Whistler

DRAFT

FIGURE 6-1

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Table 6-3. Lodges and burrows documented in 2018.

Map Code	Location	No.	2017 Status	Over-Wintering?	Easting	Northing
Burrow - Active	Alpha Lake, south side near old bridge	1	NR	No?	499362	5549041
Burrow - Active	Fitzsimmons Creek, back channels near Old Mill Rd.	6	Active	Yes?	504122	5554611
Burrow - Active	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	1	NR	Yes (1 of 2)	502349	5553936
Burrow - Active	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	1	NR	Yes (1 of 2)	502625	5554071
Burrow - Inactive	ROGD6 - Hwy. 99 bridge to Green Lake	1	NR	No	503057	5554845
Lodge - Active	Alpha Lake, near dog beach	1	Active	Yes	499970	5549027
Lodge - Active	Alpha Lake, outlet at Millar Creek	1	NR	Yes	499208	5549034
Lodge - Active	Alta Vista Pond	1	Active	Yes	501458	5550235
Lodge - Active	Fitzsimmons Creek, back channels near Old Mill Rd.	1	NR	Yes	504212	5554643
Lodge - Active	Lost Lake	1	Unknown	Yes	504458	5552740
Lodge - Active	Millar Creek wetlands - Function Junction	1	Active	Yes	497783	5548416
Lodge - Active	Millar Creek wetlands - Function Junction	1	Active	Yes	497715	5548393
Lodge - Active	Rainbow Wetlands, NE end near 21 Mile Creek	1	Active	Yes	501848	5552727
Lodge - Active	ROGD1 - Alta Lake entrance to fish weir	1	Active	Yes	501744	5552517
Lodge - Active	ROGD4 - RR bridge to bend nearest Valley Tr.	1	Active	Yes	502327	5553188
Lodge - Active	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	1	NR	Yes	502297	5553774
Lodge - Active	Spruce Grove Park, entrance	1	Active	Yes	503652	5553307
Lodge - Active	Wedge Pond	1	Unknown	Yes	503224	5555745
Lodge - Active	Whistler GC, Crabapple Cr. #10 sand trap	1	Active	Yes	502293	5551708
Lodge - Active	Whistler GC, Crabapple Cr. #15 fairway	1	Active	Yes	502341	5551100
Lodge - Active	Wildlife Refuge, middle pond	1	Active	Yes	501825	5553543
Lodge - Inactive	Alpha Lake, northwest side of resident owned island	1	NR	No	499861	5548981
Lodge - Inactive	Alpha Lake, south shore near outlet at Millar Creek	1	NR	No	499208	5548997
Lodge - Inactive	Beaver Lake #1, west side north	1	Inactive	No	500012	5550828
Lodge - Inactive	Beaver Lake #2, west side middle	1	Inactive	No	500012	5550802
Lodge - Inactive	Beaver Lake #3, west side south	1	Inactive	No	500027	5550773
Lodge - Inactive	Beaver Lake #4; northeast side	1	Inactive	No	500072	5550831
Lodge - Inactive	Bottomless Pond	1	Inactive	No	500774	5549695
Lodge - Inactive	Green Lake Lodge e. of float plane base	1	Inactive?	No	503740	5554600
Lodge - Inactive	Millar Creek wetlands - Function Junction	1	NR	No	497705	5548389

Map Code	Location	No.	2017 Status	Over-Wintering?	Easting	Northing
Lodge - Inactive	Millar Creek wetlands - Function Junction	1	NR	No	497822	5548435
Lodge - Inactive	Millar Creek wetlands - Function Junction	1	NR	No	497828	5548443
Lodge - Inactive	Nester's Pond	1	Inactive	No	503099	5552852
Lodge - Inactive	Millar's Pond	1	Inactive	No	499405	5548341
Lodge - Inactive	Nicklaus North GC, #10 pond	1	Inactive	No	502764	5554086
Lodge - Inactive	Nicklaus North GC, #12 pond	1	Inactive	No	502746	5553748
Lodge - Inactive	Nicklaus North GC, #15 pond	1	Inactive	No	503235	5554601
Lodge - Inactive	Nita Lake	1	Inactive?	No	500290	5549772
Lodge - Inactive	Rainbow Park, creek near Alta Lake, west side	1	Inactive	No	501147	5551874
Lodge - Inactive	ROGD4 - RR bridge to bend nearest Valley Tr.	1	NR	No	502120	5553004
Lodge - Inactive	ROGD4 - RR bridge to bend nearest Valley Tr.	1	NR	No	502302	5553215
Lodge - Inactive	ROGD4 - RR bridge to bend nearest Valley Tr.	1	Unknown	No	502334	5553183
Lodge - Inactive	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	1	NR	No	502434	5554227
Lodge - Inactive	ROGD6 - Hwy. 99 bridge to Green Lake	1	NR	No	503185	5554836
Lodge - Inactive	Snowflake Park	1	ND	No	502694	5552281
Lodge - Inactive	Tennis Club Amenity Stream	1	Inactive	No	503139	5552271
Lodge - Inactive	Wedge Pond	1	NR	No	503105	5555646
Lodge - Inactive	Wedge Pond	1	NR	No	503131	5555627
Lodge - Inactive	Whistler GC, #5 tee pond	1	Inactive	No	502367	5551766
Lodge - Inactive	Whistler GC, Crabapple Cr. #15 fairway	1	Inactive	No	502204	5550991
Lodge - Inactive	Wolverine Creek	1	Inactive	No	501201	5549629
Lodge - Inactive	Chateau GC #2 pond lodge	1	Active	No	504612	5552324
Lodge - Inactive	Millar Creek wetlands - bet. hydro tower &Valley Tr. bench	1	NR	No	497900	5548539
Lodge - Inactive						
Lodge - Unknown	Chateau GC #18 lower pond	2	Summer?	No	504184	5552221
Lodge - Unknown	Fitzsimmons Creek Fan, downstream right end	1	Inactive	No	503847	5554866
Lodge - Unknown	Green Lake - Fitz Fan to Parkhurst shoreline	ND	Unknown	No	504330	5554834
Lodge - Unknown	ROGD4 - RR bridge to bend nearest Valley Tr.	1	NR	No	502355	5553202
Lodge - Unknown	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	1	NR	No	502538	5554065
Lodge - Unknown	ROGD6 - Hwy. 99 bridge to Green Lake	1	NR	No	503029	5554719
Lodge - Unknown	ROGD6 - Hwy. 99 bridge to Green Lake	1	NR	No	503187	5554830
Lodge - Unknown	ROGD6 - Hwy. 99 bridge to Green Lake	1	NR	No	503202	5554930

Map Code	Location	No.	2017 Status	Over-Wintering?	Easting	Northing
Lodge - Unknown	Whistler GC, Crabapple Cr. #10 south of green	1	NR	No	502290	5551566
Lodge - Unknown	Whistler GC, Crabapple Cr. #10 south of green	1	NR	No	502335	5551594

Notes: Active lodges are presumed to be overwintering habitats for beaver colonies. It is more difficult to determine whether a burrow houses an overwintering colony.

6.3.1 *Estimated Number of Beavers in 2018*

The estimated numbers of beavers for each year of the survey (based on 5.8 beavers per lodge) is presented in Table 6-4and Figure 6-2. Applying lower and higher estimates of beaver per lodge (4.2 and 6.4 beavers, respectively; which are the 25th and 75th percentiles of the average) gives a range of how many beavers may be in the Whistler Valley.

The variability in the total number of active lodges since 2007 is more likely related to changes in survey methodologies and biologists conducting the surveys over the years rather than to changes in the beaver population.[19] The Whistler Biodiversity Project (WBP) began surveys in 2007 which increased in geographic range and reliability through 2011 (Mullen 2007, 2008; Pevec 2009; Tayless 2010; Tayless and Burrow, unpubl. data[20]). Surveys were not conducted in 2012 then partial surveys re-started in 2013 through 2015 (Cascade 2014, 2015, 2016). That new team apparently did not visit all possible locations and also would not have been familiar with some of the more cryptic lodge locations. Since more extensive surveys were restored in 2016, the number of documented lodges and other beaver activity has rebounded to numbers previously recorded in Whistler between 2009 and 2011.

Based on the assumption of 5.8 beavers per overwintering lodge or burrow, the 2018 total beaver population in Whistler is estimated to be 104 (Table 6-4; Figure 6-2). This total is similar to results observed from 2009 to 2011 when the surveys last approached a complete census. While there was a large increase in estimated population from 2015 to 2016, the total also increased in 2017 and even more in 2018 due to increased survey effort, consistent surveyors and familiarity with active areas. The number and location of active colonies reported in 2018 can confidently be considered an accurate baseline for comparisons with future surveys. Results from 2018 also provide evidence that the Whistler beaver population has been either stable or slightly increasing in the past decade.

Table 6-4. Estimated number of beavers overwintering in Whistler, 2007-2018.

	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018	Avg.
Active lodges/burrows	9	27	16	16	17	10	10	7	13	14	18	14
4.2 beavers/site	38	113	67	67	71	42	42	29	55	59	76	60
5.8 beavers/site	52	157	93	93	99	58	58	41	75	81	104	83
6.4 beavers/site	58	173	102	102	109	64	64	45	83	90	115	91

Notes: Refer to Table 6-1 for sources of estimated multipliers; Beaver surveys were not conducted in 2012.

As mentioned above, the 27 active and 12 inactive lodges recorded in 2008 are anomalous to all other surveys. Based on this year's the 2018 survey, with an almost opposite number and ratio of active to inactive lodges, it is probable that many lodges were inaccurately labelled as active in previous years.

[20] *The 2011 survey was mainly conducted by the RMOW with assistance from the WBP.*

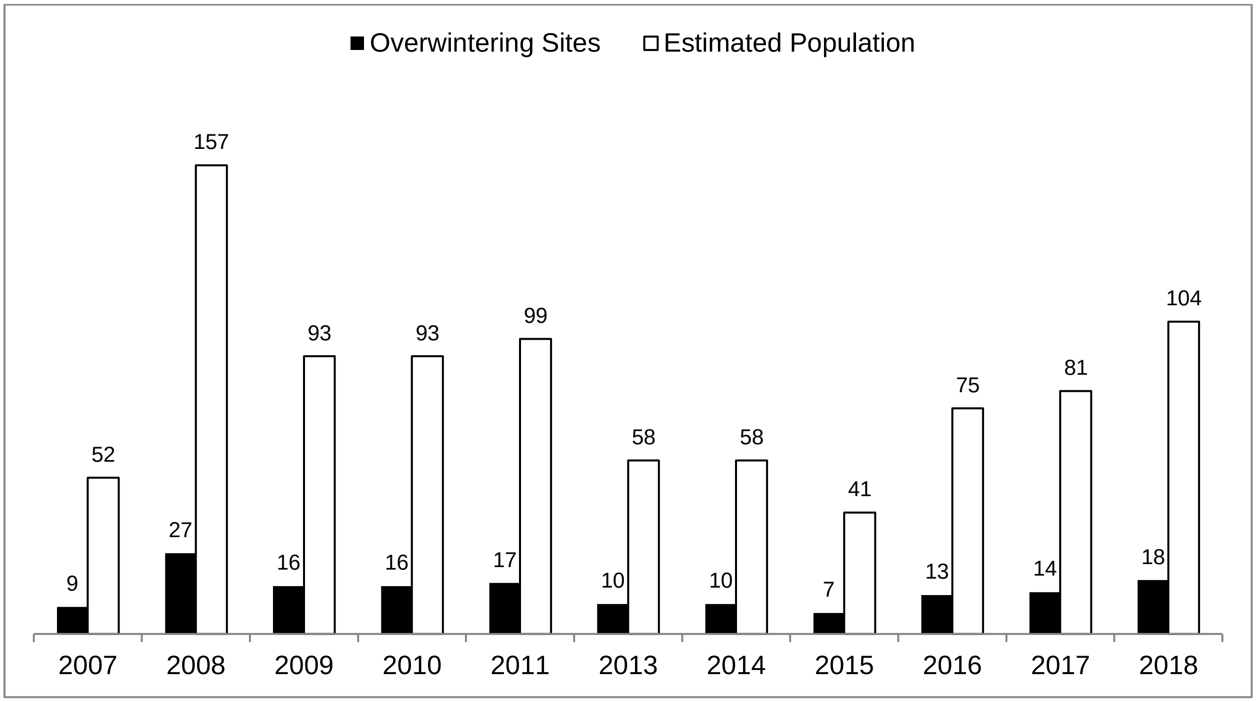

Figure 6-2. Estimated beaver population from 2007-2018 based on a multiplier of 5.8 beavers per overwintering site. Note that surveys were not conducted in 2012.

6.3.2 Beavers on the River of Golden Dreams

The River of Golden Dreams has consistently been the most active habitat for beavers in Whistler Valley since the first attempt at a full census in 2008 (Table 6-5; Mullen 2008), especially in the section between the CN Rail bridge to the outlet of Green Lake. Documenting the presence of active lodges (and overwintering burrows) as well as the number of active colonies has its challenges as they are difficult to detect. Due to the terrain and type of beaver activity, the River of Golden Dreams is a challenging area to survey since it is difficult to: (a) detect lodges and burrows, and (b) determine which are used for overwintering. Therefore, the 2018 survey intensified the survey effort to gain a better understanding of beaver colonies on the River of Golden Dreams.

Three surveyors spent more time surveying in riverside vegetation than scanning the river itself which helped increase detections. These efforts resulted in the confirmation of a previously undetected lodge (Photo 6-5; Table 6-6). The lodge was hidden behind hardhack shrubs and was approximately 3 m inside the edge of the riverbank, making previous detection of the lodge very difficult. The newly identified lodge is believed to have been active for many years as it is made up of many layers of old, grey branches. In addition, surveyors concluded that at least one of two bank burrows in the downstream section of the river (ROGD-6) housed a beaver colony at the time of the survey.

Four colonies are estimated to reside in the River of Golden Dreams area in 2018, more than in the past two years but still fewer than estimated from 2008 to 2014. In contrast, the number of inactive lodges observed in 2018 is the highest recorded to date. This difference may be the result of either some lodges being incorrectly classed as active in previously surveys (thereby overestimating the population) or the

2018 survey not detecting all active lodges (thereby underestimating the population). Nonetheless, the 2018 beaver survey along the River of Golden Dreams found: (a) that four colonies is a reasonable estimate based on the amount of beaver activity observed; and (b) if the 2018 survey did not detect one or more colonies, it is more likely that it would be one (maybe two) than a higher number. As survey knowledge is cumulative, future surveys will be able to further confirm the beaver population in this difficult terrain, especially if surveyors in future years are consistent.

Table 6-5. Active lodges and burrows found on the River of Golden Dreams.

Location	Structure	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018
ROGD	Lodge	1	15	7	7	10	5	5	4	3	2	3
	Burrow	0	0	0	0	0	0	0	0	0	0	1 (2?)
	Total	**1**	**15**	**7**	**7**	**10**	**5**	**5**	**4**	**3**	**2**	**4 (5?)**
Other	Lodge	8	12	9	9	7	5	5	3	10	11	13
	Burrow	0	0	0	0	0	0	0	0	0	1	1
	Total	**8**	**12**	**9**	**9**	**7**	**5**	**5**	**3**	**10**	**12**	**14**
All	Lodge	9	27	16	16	17	10	10	7	13	13	16
	Burrow	0	0	0	0	0	0	0	0	0	1	2
	Total	**9**	**27**	**16**	**16**	**17**	**10**	**10**	**7**	**13**	**14**	**18 (19?)**

Notes: Beaver surveys were not conducted in 2012; Only burrows deemed as possible overwintering locations are listed; Numbers presented in brackets for 2018 depict the uncertain overwintering status of two burrows located in the north-most section of the river (ROGD-6).

Photo 6-5. Left: A lodge on the River of Golden Dreams detected for the first time in 2018. Right: Freshly cut branches cached in the water on the River of Golden Dreams indicate the presence of a lodge nearby.

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Table 6-6. Lodges documented in Whistler during 2018 surveys.

Map Code	Location	2017 Status	2018 Status	Easting	Northing	Notes/Comments 2018
Burrow -	Alpha Lake, south side near old bridge	NR	Active	499362	5549041	First documentation
Active	Fitzsimmons Creek, back channels near Old Mill Rd.	Active	Active	504122	5554611	Extensive activity. No lodge found. Possible overwintering in burrows?
	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	NR	Active	502349	5553936	First documentation
	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	NR	Active	502625	5554071	First documentation
Burrow -	ROGD6 - Hwy. 99 bridge to Green Lake	NR	Inactive	503057	5554845	First documentation
Inactive						
Lodge -	Alpha Lake, near dog beach	Active	Active	499970	5549027	Still active
Active	Alpha Lake, outlet at Millar Creek	NR	Active	499208	5549034	First documentation
	Alta Vista Pond	Active	Active	501458	5550235	Still active
	Fitzsimmons Creek, back channels near Old Mill Rd.	NR	Active	504212	5554643	First documentation
	Lost Lake	Unknown	Active	504458	5552740	Reactivated after 2 years of inactivity
	Millar Creek wetlands - Function Junction	Active	Active	497783	5548416	Confirmed exact locations of 2 lodges estimated in 2017 report.
	Millar Creek wetlands - Function Junction	Active	Active	497715	5548393	Confirmed exact locations of 2 lodges estimated in 2017 report.
	Rainbow Wetlands, NE end near 21 Mile Creek	Active	Active	501848	5552727	Lodge is larger than last year
	ROGD1 - Alta Lake entrance to fish weir	Active	Active	501744	5552517	Still active
	ROGD4 - RR bridge to bend nearest Valley Tr.	Active	Active	502327	5553188	Still active
	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	NR	Active	502297	5553774	First documentation (but possibly UTM error in 2017 data)
	Spruce Grove Park, entrance	Active	Active	503652	5553307	Still active
	Wedge Pond	Unknown	Active	503224	5555745	Confirmed exact location of lodge estimated in 2017 report.
	Whistler GC, Crabapple Cr. #10 sand trap	Active	Active	502293	5551708	Still active. Whistler GC tried unsuccessfully in fall to remove beavers.
	Whistler GC, Crabapple Cr. #15 fairway	Active	Active	502341	5551100	Still active. Whistler GC tried unsuccessfully in fall to remove beavers.
	Wildlife Refuge, middle pond	Active	Active	501825	5553543	Still active. Corrected UTM.
Lodge -	Alpha Lake, northwest side of resident owned island	NR	Inactive	499861	5548981	First documentation

Map Code	Location	2017 Status	2018 Status	Easting	Northing	Notes/Comments 2018
Inactive	Alpha Lake, south shore near outlet at Millar Creek	NR	Inactive	499208	5548997	First documentation
	Beaver Lake #1, west side north	Inactive	Inactive	500012	5550828	Still inactive
	Beaver Lake #2, west side middle	Inactive	Inactive	500012	5550802	Still inactive
	Beaver Lake #3, west side south	Inactive	Inactive	500027	5550773	Still inactive
	Beaver Lake #4; northeast side	Inactive	Inactive	500072	5550831	Still inactive
	Bottomless Pond	Inactive	Inactive	500774	5549695	Still inactive
	Green Lake Lodge e. of float plane base	Inactive?	Inactive	503740	5554600	Confirmed inactive
	Millar Creek wetlands - Function Junction	NR	Inactive	497705	5548389	First documentation
	Millar Creek wetlands - Function Junction	NR	Inactive	497822	5548435	First documentation
	Millar Creek wetlands - Function Junction	NR	Inactive	497828	5548443	First documentation
	Millar's Pond	Inactive	Inactive	499405	5548341	Still inactive
	Nester's Pond	Inactive	Inactive	503099	5552852	Still inactive
	Nicklaus North GC, #10 pond	Inactive	Inactive	502764	5554086	Still inactive
	Nicklaus North GC, #12 pond	Inactive	Inactive	502746	5553748	Lodge still inactive but some fresh gnaw marks in area
	Nicklaus North GC, #15 pond	Inactive	Inactive?	503235	5554601	No lodge found but some freshly cut branches in area
	Nita Lake	Inactive?	Inactive	500290	5549772	Lodge still inactive(?) but some fresh branches near Nita Lake Lodge.
	Rainbow Park, creek near Alta Lake, west side	Inactive	Inactive	501147	5551874	Still inactive
	ROGD4 - RR bridge to bend nearest Valley Tr.	NR	Inactive	502120	5553004	First documentation
	ROGD4 - RR bridge to bend nearest Valley Tr.	NR	Inactive	502302	5553215	First documentation
	ROGD4 - RR bridge to bend nearest Valley Tr.	Unknown	Inactive	502334	5553183	Confirmed inactive
	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	NR	Inactive	502434	5554227	First documentation
	ROGD6 - Hwy. 99 bridge to Green Lake	NR	Inactive	503185	5554836	First documentation
	Snowflake Park	ND	Inactive	502694	5552281	First documentation
	Tennis Club Amenity Stream	Inactive	Inactive	503139	5552271	Still inactive
	Wedge Pond	NR	Inactive	503105	5555646	First documentation
	Wedge Pond	NR	Inactive	503131	5555627	First documentation
	Whistler GC, #5 tee pond	Inactive	Inactive	502367	5551766	Lots of cut branches around pond; Partial structure
	Whistler GC, Crabapple Cr. #15 fairway	Inactive	Inactive	502204	5550991	Still inactive
	Wolverine Creek	Inactive	Inactive	501201	5549629	Still inactive

Map Code	Location	2017 Status	2018 Status	Easting	Northing	Notes/Comments 2018
	Chateau GC #2 pond lodge	Active	Inactive?	504612	5552324	Water levels low, no lodge activity but fresh branches in pond nearby
Lodge-inactive (con't)	Millar Creek wetlands – bet. hydro & Valley Tr. bench	NR	Inactive?	497900	5548539	First documentation
Lodge -	Chateau GC #18 lower pond	Summer?	Summer?	504184	5552221	Dam drained in fall. Structures still prominent.
Unknown	Fitzsimmons Creek Fan, downstream right end	Inactive	Inactive?	503847	5554866	Very active area but couldn't locate active lodge.
	Green Lake - Fitz Fan, Parkhurst area (est. location)	Unknown	Unknown	504330	5554834	Probably location on east side of Green Lake. Need shoreline survey.
	ROGD4 - RR bridge to bend nearest Valley Tr.	NR	Active?	502355	5553202	First documentation
	ROGD5 - bend nearest Valley Tr. to Hwy. 99 bridge	NR	Inactive?	502538	5554065	First documentation
	ROGD6 - Hwy. 99 bridge to Green Lake	NR	Active?	503029	5554719	First documentation
	ROGD6 - Hwy. 99 bridge to Green Lake	NR	Inactive?	503187	5554830	First documentation
	ROGD6 - Hwy. 99 bridge to Green Lake	NR	Active?	503202	5554930	First documentation
	Whistler GC, Crabapple Cr. #10 south of green	NR	Active?	502290	5551566	First documentation

Notes: NR = Not Recorded; GC = Golf Course; Sites where lodge status includes a question mark had enough evidence to suggest they were in the assigned class (e.g., "Active?" lodges were classed as "Active")

6.3.3 Beaver-affected Wetlands

Beavers are well-known keystone species also referred to as “wetlands engineers” for their role in creating and maintaining wetlands (Müller-Schwarze and Sun 2003). One of the goals of the 2018 program was to quantify the number and approximate area of wetlands that have been engineered and/or directly affected by beavers within Whistler Valley. Mapping these areas cannot be precise since the exact edge of beaver activities within these wetlands is often not obvious. The only way to truly determine the role beavers have on these wetlands would be to remove the beavers and compare the wetlands before and many years after removal. With this caveat, Figure 6-3 and more detailed maps below represent the first quantification of the role of beavers in creating, altering and maintaining wetland habitat in Whistler.

Note that this section of the report deals only with where beaver activities have: (a) created or expanded a wetland; and/or (b) where beaver activities are significant enough to obviously alter the habitat. The determination of the latter is more subjective but is meant to include areas that support and are altered by beaver activities, for example, most of the Rainbow Wetlands and River of Golden Dreams wetlands complex.

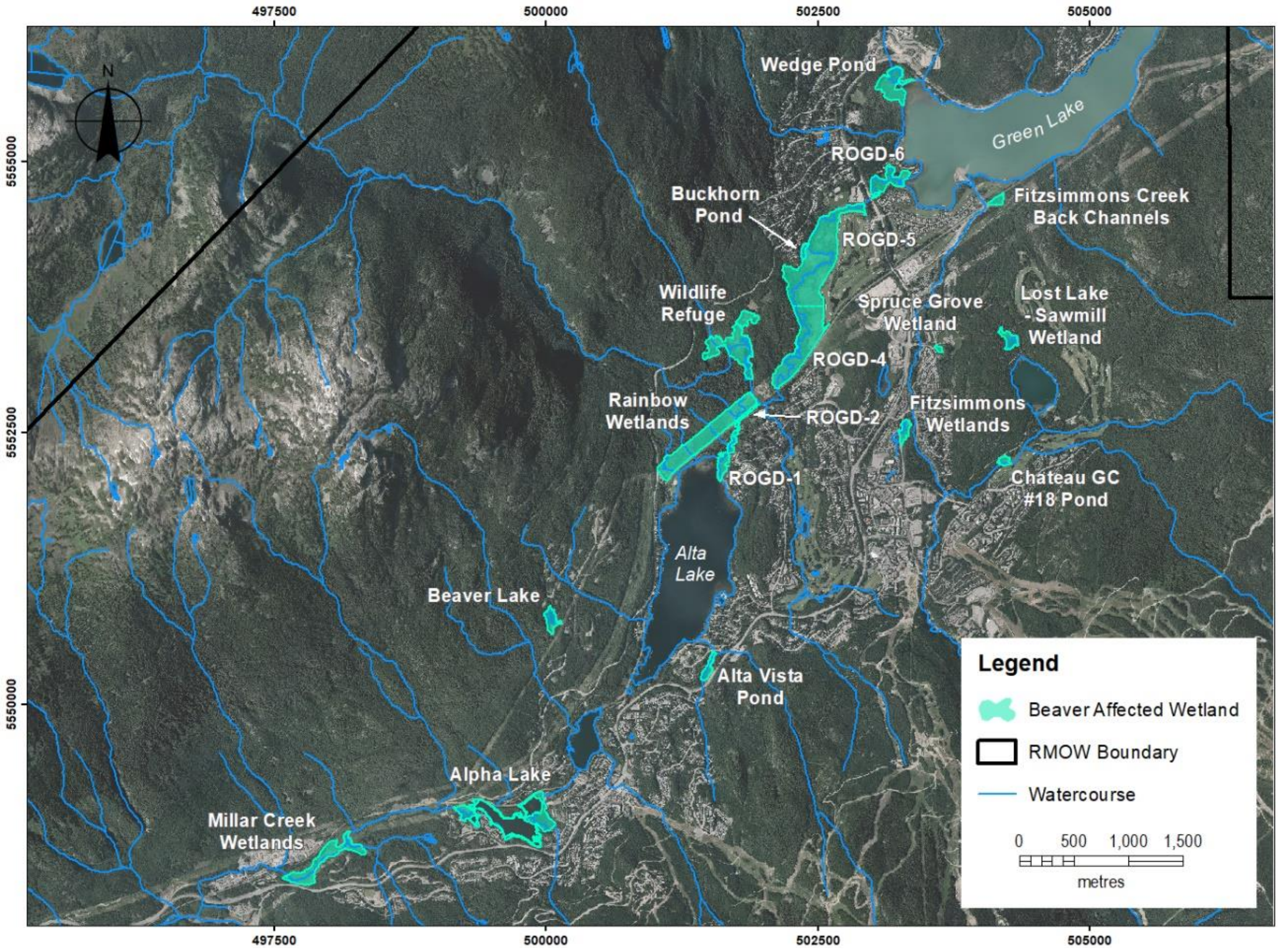

Figure 6-3. Beaver-affected wetlands as mapped in 2018. Alpha Lake is included on this map but not in the calculated area of wetlands in Whistler.

A total of 13 wetlands and one flooded lake (Alpha Lake) were mapped in 2018 (Table 6-7; Figure 6-3). In total, the estimated area of beaver-affected wetlands within Whistler was calculated as 94.7 hectares. In addition, the persistent damming of Alpha Lake by beavers has raised the water level of this lake by approximately 1 m and the lake covers approximately 7.1 ha more area than it would without the beaver dam. Although not a wetland, if the effects of beavers on Alpha Lake were included in the estimate of beaver-created wetlands, the total area of impact by beavers in Whistler would be over 100 ha.

Table 6-7. Location and area of beaver-affected wetlands in Whistler.

Wetland (South to North)	Area (ha)
Millar Creek Wetlands	7.6
Beaver Lake	1.8
Alta Vista Pond	1.3
Rainbow Wetlands	14.7
Fitzsimmons Wetlands	1.4
Chateau GC #18 Pond	0.7
Wildlife Refuge	10.4
Spruce Grove Wetland	0.3
Lost Lake - Sawmill Wetland	1.6
Buckhorn Pond	0.5
River of Golden Dreams	47.9
Fitzsimmons Creek Back Channels	0.9
Wedge Pond	5.5
Total beaver-affected wetlands	**94.7**
Alpha Lake (flood effect of dam)	7.1
Total beaver effect	**101.8**

Notes: The area affected by beavers on Alpha Lake, a non-wetland, is included in the grand total above.

The largest beaver-affected wetland complex mapped in the Whistler study area was the River of Golden Dreams which measured 47.9 hectares (Table 6-7and Table 6-8). By far, the largest part (84%) of this area is the middle section of the river (ROGD-4 and -5; Table 6-8). The next two largest beaver-affected wetlands in Whistler are the Rainbow Wetlands and the Wildlife Refuge (Table 6-7). Before development, these three wetlands areas would have been linked in a complex spanning from Alta Lake to Green Lake on either side of the current railway line, as well as what is now the Whistler Golf Course (McBlane 2007).

Descriptions of all 13 wetlands as well as beaver impacts on Alpha Lake wetland are included below as Section 6.3.3.2.

Table 6-8. Areal extent of beaver-affected wetlands of different sections along the River of Golden Dreams.

ROGD Survey Area	Area (ha)	Area (%)
ROGD-1	3.0	6%
ROGD-2	0.1	0.2%
ROGD-4/5	40.4	84%
ROGD-6	4.4	9%
Total	**47.9**	**100%**

Notes: ROGD = River of Golden Dreams; The names and locations of the survey areas were used for describing the general location of beaver activities on the ROGD over the past three years; ROGD-3 is located between the junction with 21 Mile Creek and railway bridge; this site is not included because no beaver activities have been detected in this section.

6.3.3.1 Historic Context

There were at least two changes that significantly affected beavers since the railway grade was established and operations started in 1913:

1. the railbed for that railway and the ensuing increase in human presence it facilitated; and
2. the increased urban development starting in the 1960s and continuing to the present.

The railway bisected the large wetland complex mentioned above[21] which changed the hydrology and reduced the connectivity of that area. The number of beavers killed for pelts and/or as "pest" control would almost certainly have increased throughout the valley as a result.[22] Once urban development began in earnest in the 1960s, wetlands were increasingly replaced by subdivisions, golf courses and other urban development. As a result, the area covered by wetlands dropped 72% to 170 hectares between 1946[23] and 2003 according to a GIS analysis of air photos (McBlane 2007; Table 6-9). An update of the total area of wetlands in the RMOW (Table 6-9) is complicated by the expansion of municipal boundaries between 2003 (McBlane's latest air photos) and 2014 (the latest imagery upon which the RMOW wetlands layer is based). The municipal expansion would have increased, at least somewhat, from the area of wetlands calculated in 2003.

More importantly for this study, wetland boundaries are defined more liberally in the RMOW wetland mapping layer (updated to 2014) than in this study (Figure 6-3and Figure 6-4). The RMOW layer includes coniferous forests at the edge of some wetlands. Mapping for 2018 excluded coniferous forests and instead drew the outer boundary of wetland polygons where short or sometimes tall shrub vegetation gave way to conifers (Figure 6-3). As a result, the total area calculated from the RMOW data is larger than what would be calculated using the stricter (though not necessarily more accurate) mapping presented here. Those caveats aside, it is still instructive to assess how wetlands have changed over time, the current influence beavers have on habitat, and what this can indicate about the past effect beavers have had in the general area.

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[21] *Rainbow Wetlands, Wildlife Refuge, and River of Golden Dreams.*

[22] *This conjecture could be investigated, at least somewhat, by researching historic and more recent trapping records.*

[23] *The "…first complete available aerial photograph record" (McBlane 2007).*

To reduce some of the concerns mentioned above, calculations were only made for the total wetland area in 2014 that was in the study area (RMOW Development Footprint) and less than 800 m in elevation (below which all beavers inside the study area have been detected). The resulting total area was 150.7 ha (Table 6-9) which indicates that at least 63% of wetlands inside the study area are directly affected by beavers. This number greatly underestimates the impact of beavers due to the mapping differences discussed above. A brief visual comparison of the two maps (Figure 6-3and Figure 6-4) suggests that beavers affect a far higher percentage of Whistler's valley bottom wetlands inside the RMOW's development footprint.

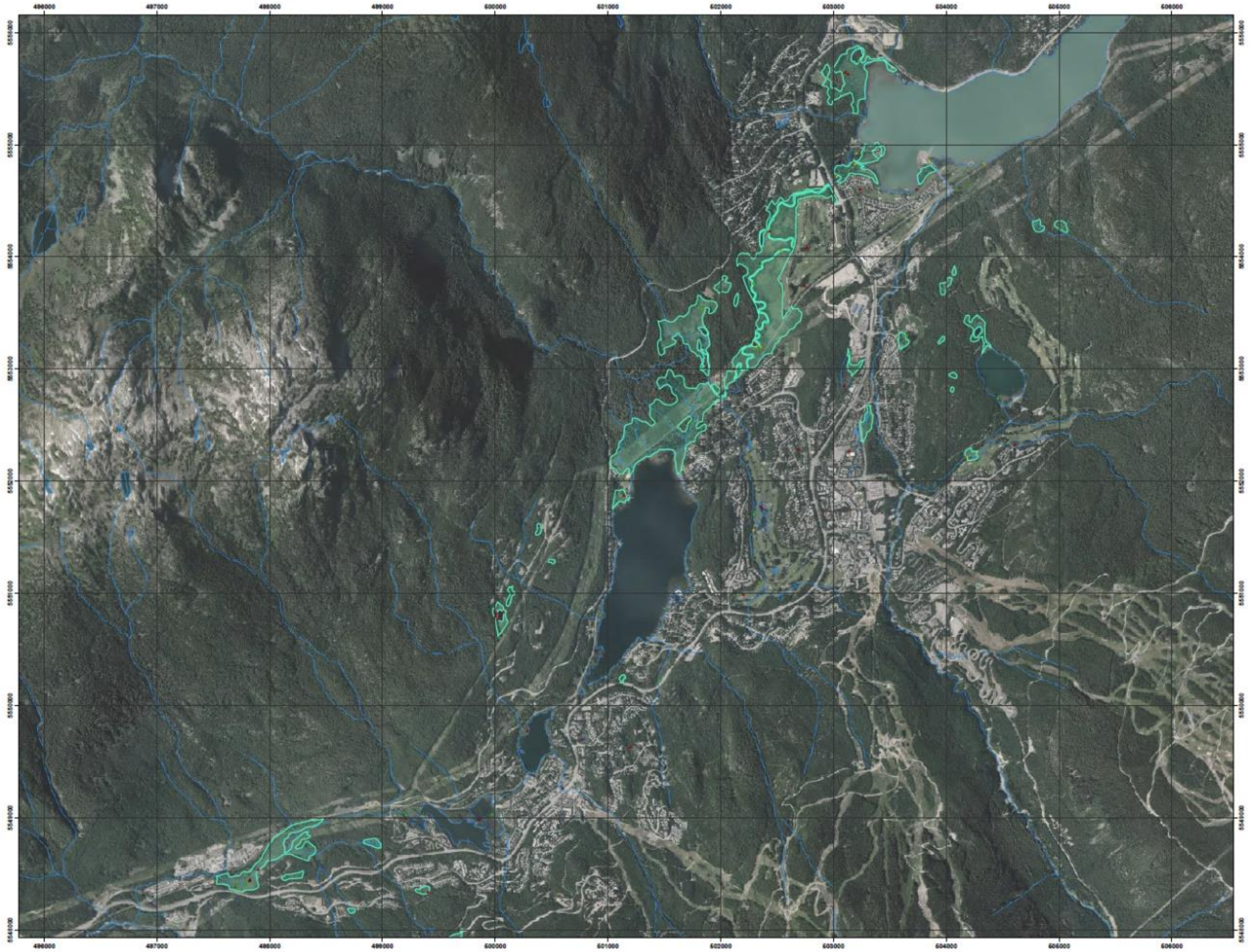

Figure 6-4. RMOW mapping of all wetlands in the Whistler area.

Table 6-9. Wetland area in the RMOW by year and scope.

Year	Wetland Scope	Area (ha)	Source
1946	All RMOW	604.4	McBlane 2007
2003	All RMOW	169.9	McBlane 2007
2014	All RMOW	193.4	PECG (unpubl.)
2014	All RMOW <800 m	169.7	PECG (unpubl.)
2014	<800 m, study area only	150.7	PECG (unpubl.)
2018	Beaver-affected, study area only	**87.2**	This report.

Notes: The study area is equivalent to the RMOW Development Footprint, from Function Junction to the north end of Green Lake. The most recent wetlands layer at the RMOW is based on 2014 imagery.

6.3.3.2 Detailed descriptions of Beaver-affected Wetlands (from South to North)

Millar Creek Wetlands

The Millar Creek Wetlands (Photo 6-6) are a long-standing and important habitat for beavers. Surveys conducted in 2016 and 2017 detected extensive beaver activity and determined that one or two undetected lodges must exist in the area. In 2018, surveys successfully located two lodges in the area. Beaver activities increased in 2018 compared to the previous two years, especially near the new Valley Trail alignment (Photo 6-6, right).

Note that the edge of the wetland delineated from vegetation type (Photo 6-6, left) underestimates the area affected by beavers in the past three years, especially in 2018 (Photo 6-6, right). The damming and impoundment of water near the new Valley Trail alignment is north and not included in the outlined area. In the future, this excluded area should be resurveyed to make the mapped outline more accurate.

Photo 6-6. Beaver activity increased during 2018 in the Millar Creek Wetlands (left) compared to 2016 and 2017. Many active dams are now visible from the new Valley Trail (right); others are present but not easily seen from the trail.

Beaver Lake

In the past, Beaver Lake had four active lodges, but beaver activity has not been detected in the area since 2006. While active lodges are not present, the old lodge structures are still visible, and the related dams still impound water (Photo 6-7).

Photo 6-7*. The beaver-affected wetland at Beaver Lake.*

Alta Vista Pond

The old lodge at Alta Vista Pond was recolonized by beavers in 2016 and has been active since. The main effect since beavers returned to this wetland is that the whole area is now inundated with water due to the construction of a high impoundment at the outlet weir (Photo 6-8).

Photo 6-8. Left: The approximate outline of the beaver-affected area of Alta Vista Pond. Right: Beavers added mud and other material blocking the outflow weir at Alta Vista Pond in 2018. This dam has raised water levels in the past few years enough to inundate the whole wetland.

Rainbow Wetlands

The Rainbow Wetlands complex is a large swath of partially inundated land that has a long history of beaver activity (Photo 6-9). Until recently there was an active lodge at the west end of Rainbow Park and multiple dams upstream that impounded the water in the area nearest to the Rainbow Park lower parking lot (Photo 6-9, right). Most of the current beaver activity is in the northern half of this area (Photo 6-10).

The RMOW’s wetland layer of the Rainbow Wetlands area includes moist, forested areas especially on the upstream side of 21 Mile Creek (Figure 6-3) which means that the area of wetland calculated in this report is conservative.

Photo 6-9. Left: The approximate outline of the beaver-affected area of the Rainbow Wetlands includes the entire hydro corridor. Right: Inactive beaver dams at the southwest end of the wetlands still impounds water, as seen in the foreground of this photo.

Photo 6-10. The old beaver dam in the foreground continues to block water at the northeast end of Rainbow Wetlands, adjacent to and elevated from 21 Mile Creek. An old lodge stands hidden in the centre-background of this photo.

Fitzsimmons Wetland

The Fitzsimmons Wetland (Photo 6-11) is the only remaining remnant of the large wetland that the Village North development replaced in the 1990s. It is at least partially maintained by old dams built by beavers at least several and possibly many years ago. With the change in hydrology and the absence of recent beaver activity, this wetland is being colonized by cattails and other vegetation and will likely have no open water in the future.

Photo 6-11. Left: Beaver-affected wetlands at Fitzsimmons Wetland. Right: Chateau Golf Course #18 Pond.

Chateau Golf Course #18 Pond

The Chateau Golf Course #18 Pond (Photo 6-11, right) is another remnant of a previous, larger wetland. A very large dam (Photo 6-12) has impounded water for many years (at least dating back to the first beaver surveys) and other dams have also changed water flow. There are two lodges below the dam that have appeared active in past years and that surveyors have assumed (based on their observations and those of golf course staff) as likely not used for overwintering. Although there is possible evidence of 2018 beaver activity on Horstman Creek where it crosses #1 fairway, it appears beavers are no longer active in this area (which includes the long-standing lodge on #2 pond). In 2018, the main pond was completely drained at the end of October corroborating inactivity by beavers in the area (compare Photo 6-12 and Photo 6-13). There is no apparent explanation for this occurrence (Dan Nash, Golf Course Superintendent, pers. comm., October 2018) and future surveys (in 2019) will be required to confirm if this area is truly inactive.

Photo 6-12. The beaver-created wetland at the Chateau Golf Course #18 pond in fall 2017. Two lodges, one of which may be active in the summer, are located at the far left of the photo. No beaver activity or maintenance of the two main dams has been noted in the past two years yet the two resulting ponds were still intact into summer 2018.

Photo 6-13. Approximately the same view as the photo above, though slightly shifted to the right from October 23, 2018. There was no apparent breach of the dam and no efforts by golf course staff to drain the pond (D. Nash, pers. comm.), yet the pond was totally drained. Since the beaver lodge in the course's #2 pond has been inactive for at least one year, it is possible no beavers remain to repair the dam.

Wildlife Refuge Wetland

The Wildlife Refuge Wetland (Photo 6-14) has had an active beaver population for at least 20 years[24] and it is almost certain beaver activity predated the railway in 1913. Beaver dams have raised water levels and signs of beaver activities are common in the area. One lodge was again active in 2018.

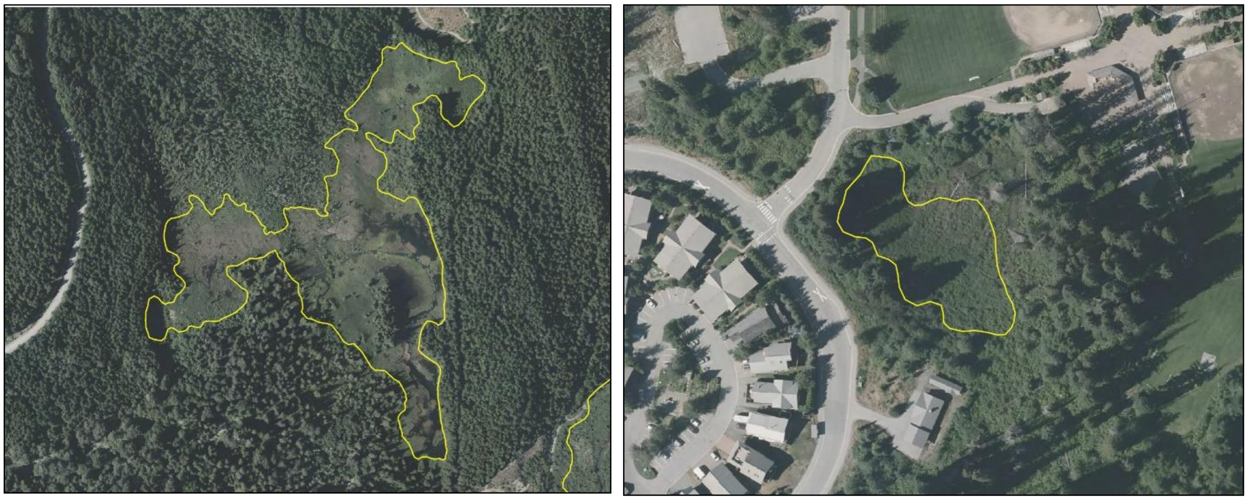

Photo 6-14. Beaver-affected wetlands in the Wildlife Refuge (left) and Spruce Grove Park (right).

Spruce Grove Wetland

There has been beaver activity in Spruce Grove Park for at least the last three years (Photo 6-14). The beavers have blocked the outflow weir to impound water behind it. The active lodge was located for the first time in 2018. This is an area of conflict with RMOW staff who attended a flood caused by the dam in 2018 (discussed in Section 6.3.4 below).

Lost Lake – Sawmill Wetland

The old sawmill site north of Lost Lake (Photo 6-15) supports an active lodge. The small outflow dam(s) maintain the water levels in the open pond.

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[24] *A photo of an old beaver dam at the south end of the wetland dates back to 2000 (B. Brett photo -- https://www.whistler.ca/services/environmental-stewardship/ecosystem-monitoring).*

Photo 6-15. Beaver-affected wetlands at north of Lost Lake at the old sawmill site.

Buckhorn Pond

While Buckhorn Pond is connected to the River of Golden Dreams Wetlands and is the only large pond within the complex (Photo 6-16). The pond is the result of an old beaver dam that blocks water flow into the River of Golden Dreams.

Photo 6-16. Buckhorn Pond, situated between the Valley Trail and the River of Golden Dreams (ROGD), is at least mostly a product of past activity that dams water at the northeast (ROGD) side that is in the mid-background of this photo.

River of Golden Dreams Wetlands

The River of Golden Dreams wetland complex comprises approximately 40% of all wetland area in Whistler (Table 6-7 and Table 6-8). To assist in locating features along the river, surveyors segmented the river into six sections:

- ROGD-1 (Alta Lake entrance to fish weir);
- ROGD-2 (fish weir to junction with 21 Mile Creek);
- ROGD-3 (21 Mile Creek to railway bridge);
- ROGD-4 (railway bridge to closest approach to Valley Trail – about midway through this section);
- ROGD-5 (closest approach to Valley Trail to Highway 99 bridge); and
- ROGD-6. (Highway 99 bridge to Green Lake).

All except for the ROGD-3 segment have been affected by beaver activities.

ROGD-1 (Alta Lake entrance to fish weir)

The first segment of the River of Golden Dreams (Photo 6-17; left) includes one large, long-standing lodge upstream of the Valley Trail bridge. While there are not many obvious alterations on land from this lodge, there is a small dam (frequently breached by boaters) that raises the water level.

ROGD-2 (fish weir to junction with 21 Mile Creek)

The second segment of the River of Golden Dreams (Photo 6-17, right) is a narrow, constructed channel that is defined by the CN railbed adjacent to it. Beavers have long-used this area, most notably in recent years, with bank burrows that are presumably unoccupied in winter. Active lodges have been previously observed in this area (e.g., Tayless 2010).

Photo 6-17. The southern most segment of the River of Golden Dreams (ROGD) wetland. Left: ROGD-1; Right: ; ROGD-2 (just north), shown as the elongated polygon enclosing that part of the creek.

ROGD-4 and ROGD-5 (railway bridge to Highway 99 bridge)

This segment is by far the largest wetland through which the River of Golden Dreams flows (Photo 6-18). Yearly evidence of beaver activity is apparent throughout the area and includes: lodges, bank burrows, food caches, gnawed trees and branches, tracks, scent mounds, slides, tunnels through vegetation and when fortunate, direct sightings of beavers.

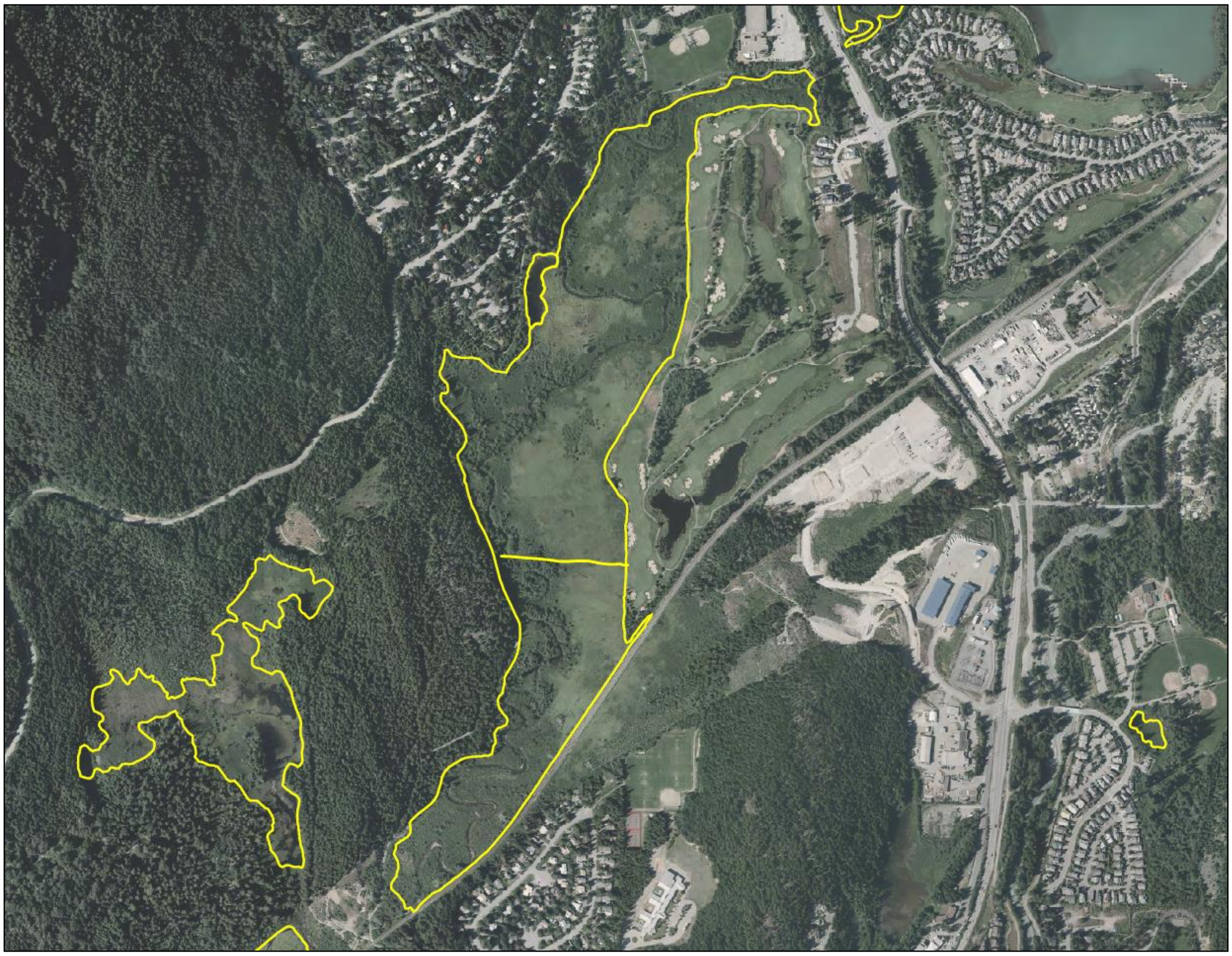

Photo 6-18. The largest contingous wetland that the River of Golden Dreams passes between the railway bridge to the south and bridge over Highway 99 to the north. This area is coded as ROGD-4 (south end of the polygon) and ROGD-5 (north end of the polygon). The Wildlife Refuge Wetland is shown to the southwest (bottom left).

ROGD-6. (Highway 99 bridge to Green Lake)

Beavers are also active each year in the downstream segment of the River of Golden Dreams (Photo 6-19). Small dams are usually maintained, though they don't tend to impound much water. There are abundant signs of activity in the river and on the adjacent shore. One key finding from the extensive 2018 surveys is that there is likely one colony (possible even two) that inhabits a bank burrow in this area.

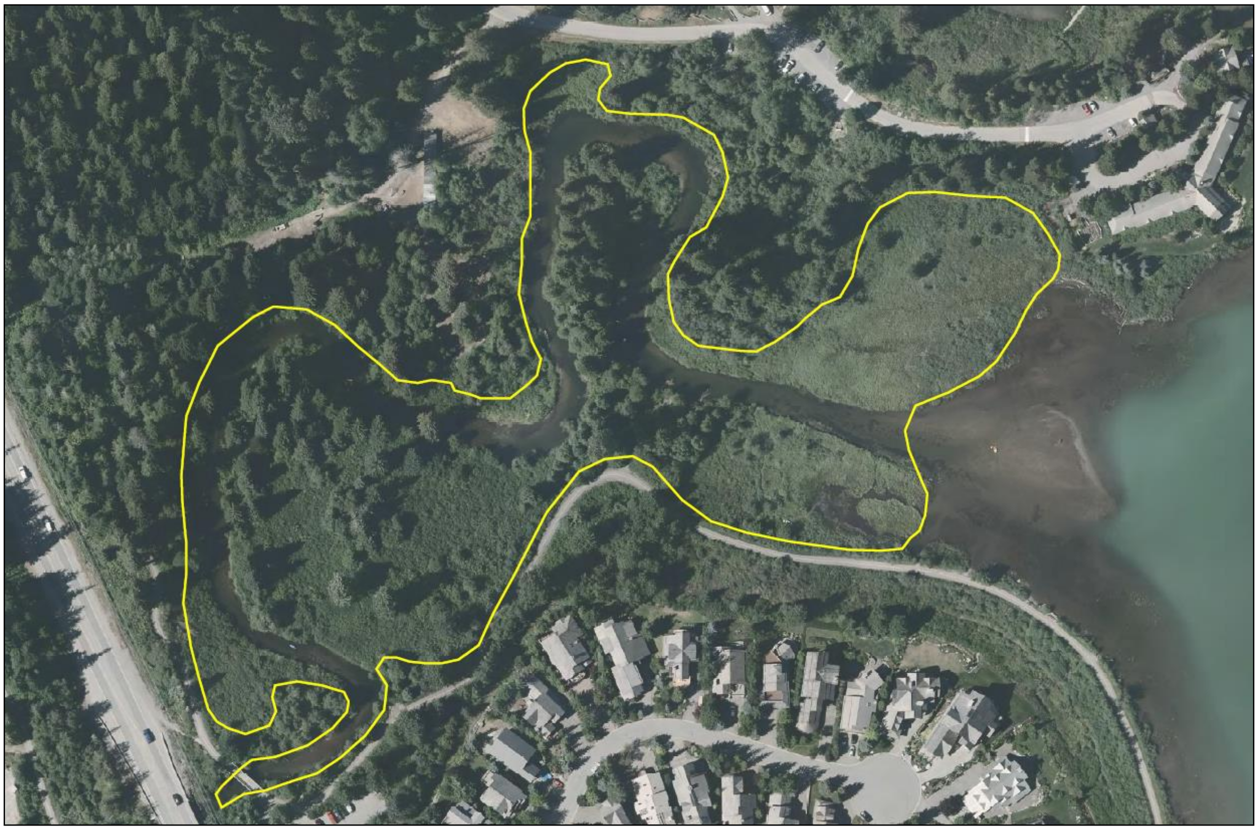

Photo 6-19. The northmost section of the River of Golden Dreams wetland is between the Highway 99 bridge and Green Lake. It is coded as ROGD-6.

Fitzsimmons Creek Back Channels

The Fitzsimmons Creek back channels (Photo 6-20) are on the uphill (southeast) side of the railway tracks, east of and adjacent to the Fitzsimmons Creek main channel at Nicklaus North Golf Course. Extensive beaver activity was first documented in this location in 2016 but no active structures were detected until surveys conducted in 2018. One lodge and six burrows were found during surveys of the Fitzsimmons Creek back channels in 2018. Based on observations from 2018, there is one colony in the lodge and possibly another in burrow habitat.

Photo 6-20. The approximate area influenced by beavers at the Fitzsimmons Creek back channels.

Wedge Pond

An active lodge at Wedge Pond (Photo 6-21) was re-located in 2018 after many years of non-detections in the area. Beaver activity in this wetland has nonetheless persisted for at least one decade (likely far longer), as evidenced by the numerous channels, dams, structures and other signs.

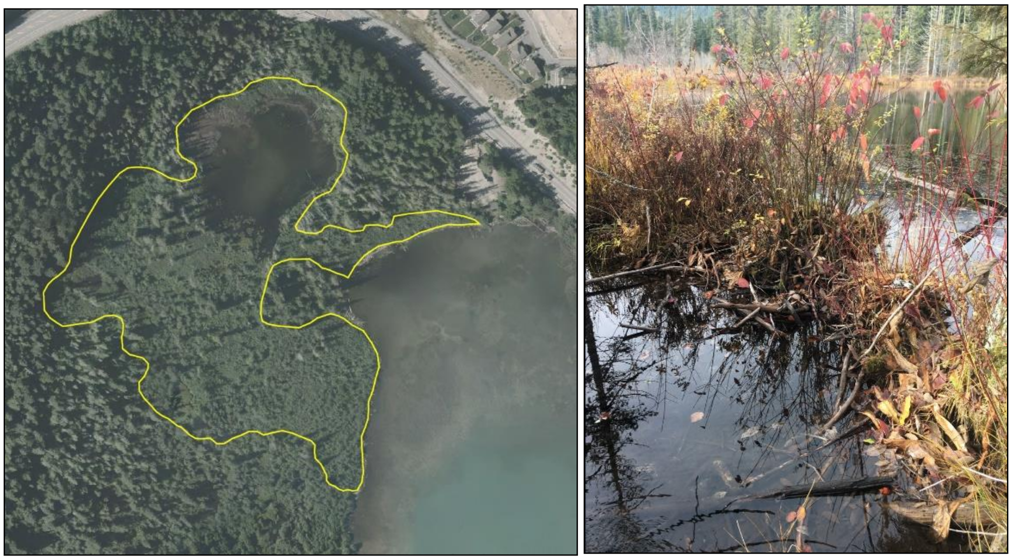

Photo 6-21. Beaver-affected wetlands at Wedge Pond (left) and Buckhorn Place (right)

Alpha Lake (non-wetland)

Alpha Lake is the only non-wetland area included in the discussion of beaver-affected habitats (Photo 6-22). The beaver dam at the outlet of the lake has been maintained for at least 30 years. The dam maintains water levels within the lake approximately 1 m higher than if the dam was not present. Given the large amount of area that is covered by shallow water, it is apparent that the beaver dam greatly increases the lake's surface area. At least some of these shallow areas, especially on the west and east edges, have wetland characteristics.

Photo 6-22. The outlet dam created by beavers on Alpha Lake (top left). The outer yellow line shows the approximate extent of the beavers' influence (e.g., wetland vegetation). The inner line attempts to delineate how much the open lake surface would diminish without the dam. The estimated impact of beavers is the area within the two lines.

6.3.4 Conflict Areas in 2018

Beavers have a long history of conflict with humans, especially when urban development occurs in valley bottoms, as is the case in Whistler. Beaver conflicts are seldom made public, thus limiting the ability to report on them. All known information about 2018 conflicts is discussed below.

Millar Creek Wetlands: Line maintenance in 2018 by Fortis Gas included the new Valley Trail alignment between Alta Lake Road and Function Junction that passed through beaver-dammed parts of this wetland. Fortis BC applied for a trapping permit but was able to achieve their goals instead by breaching some of the dams.[25] This situation exemplifies an opportunity to design new developments to avoid beaver conflicts, especially when the developer is the RMOW. As of fall 2018, the RMOW plans to build the trail to accommodate flooding.[26]

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[25] *Hillary Williamson (RMOW) email to B. Brett, September 2018.*

[26] *Heather Beresford email to B. Brett, September 2018.*

Alta Vista Pond: Blocking of the outflow weir by beavers continues to trouble the RMOW Roads Department. Given that the elevation of the flooded beaver pond is well below the road surface, there may be an opportunity to continue to allow beavers to flood to a certain level that does not threaten the integrity of the roadbed while also providing beavers with their preferred pond depth. Otherwise, the RMOW could investigate ways to waterproof the roadbed to allow beavers to maintain the pond to the desired depth.

Rainbow Wetlands: CN Rail continues to breach dams each year along the section of tracks in the Rainbow Wetlands area. Dam breaches over the past three years do not appear to have negatively affected the beaver population in that area.

River of Golden Dreams. The main concern for beaver conservation within this important habitat is human use of the river. On most sunny days in the summer, large numbers of people boat on the river by canoe and kayak (primarily customers of outdoor recreation companies) or by inflatable boats. Dams are routinely breached by the passage of these vessels (possibly unintentional). Without this human activity, dams would impound more water, beavers could likely remain active more hours in a day (as they would not have to avoid humans), colonies would likely be more plentiful and more area in the wetland complex would likely to be inundated.

Whistler Golf Course: The golf course is built on a previous wetland which has a creek passing through the course to the west (the creek is named Archibald Creek above the course and Crabapple Creek inside the course). Since the level of the creek is not far below the level of the course, damming by beavers can flood the course and cause damage. The Whistler Golf Course has a long, unquantified history of trapping beavers, but recently has made some efforts to co-exist with them. The lodge at the #10 sand trap was trapped out and re-colonized at least once during the time beaver surveys have been conducted (2007-2018). This lodge is in a relatively benign location since it is far below the golf course and therefore some damming and beaver activity can be tolerated. The other frequent site for beavers to recolonize after being trapped out is adjacent to the #15 fairway. The elevation of the creek at that point is very close to the elevation of the golf course which means that it is less tolerable for golf course operations. Golf course staff breached dams and hired a trapper in the fall of 2018 who was unsuccessful in eliminating the beavers in the two lodges.

Spruce Grove Park: RMOW road crews responded to flooding at this site in fall 2018. Unverified reports note that staff removed at least some of the material beavers had built up to block the outlet weir. It is unclear if those actions caused any issues for the beavers inhabiting the wetland. Also unclear is if the raised water level required by that colony is consistent with RMOW requirements. This may be another opportunity for the RMOW to set a standard that allows beavers to persist in this area.

Chateau Golf Course #2 and #18 Ponds: Beaver activity appears to have ceased in this area since sometime in 2017. In late 2017, the lodge in #2 pond appeared to be inactive while the dam on Horstman Creek (where it crosses #1 fairway) was active. Observations made in spring 2018 indicated that the large dam on #18 pond was in good shape, maintaining water depths similar to previous years (Photo 6-12b). By the end of October 2018, impounded water was completely drained even though there didn’t appear to be any damage to the dam. Golf course staff stated they did not attempt to alter the dam since: (a) that level of that pond has been low enough below the course to avoid flooding; and (b) the pond is an attractive feature on the course.

Nicklaus North Golf Course: Whistler's third golf course has a long history with beavers, understandably given its location used to be a major portion of the historic Alta Lake to Green Lake wetland complex. The course is very close to the River of Golden Dreams (Photo 6-18). Beavers have used golf course ponds to forage and, less frequently, to build lodges (most recently on #10 pond, now inactive for two years).

7. Additional Species

7.1 Black Cottonwoods

Black cottonwoods (*Populus trichocarpa*), especially when large and old, provide important habitat for a wide range of organisms in Whistler. Mapping for a conservation ranking of species and habitats (Brett 2018) showed cottonwood forests are relatively uncommon in Whistler and generally concentrated in areas associated with valley bottom wetlands and riparian areas between Alta and Green Lakes. The Working Group assembled for this report prioritized black cottonwood as a priority species which should be considered for inclusion in future years of the RMOW Ecosystems Monitoring Program. The first step towards that goal was the initial analysis of the extent and distribution of cottonwood forests presented below.

The cottonwood map layer in Brett (2018) included all ecosystem polygons that contained cottonwoods (regardless of percent cover) and showed the age of trees within (<100 years, 100-250 years and >250 years). The map shown here (Figure 7-1) has been revised to add percent cover of cottonwoods within each polygon.

The conclusions from the 2018 map (Brett 2018) and the revised map are that:

1. The largest contiguous area mapped as containing cottonwoods (between Spruce Grove and Nicklaus North) appears to have been mostly developed since that mapping. Updated orthophotography and mapping and/or field-truthing may be required to determine the current extent of cottonwoods in that area.
2. The main areas with old (>250-years) cottonwoods are the Edgewater forest, Rebagliati Park north on the west edge of Fitzsimmons Creek to the wetlands south of Nancy Greene Drive (Photo 7-1) and in riparian areas of the Cheakamus River upstream near the park entrance.
3. Significant components of younger cottonwoods occur in the River Runs Through It area (Photo 7-1and Photo 7-2), edges of both the River of Golden Dreams wetlands (Photo 7-3), Millar Creek Wetlands and south of the development footprint in the riparian edges of Cheakamus River near the Sugar Cubes (across from the entrance to the Callaghan Forestry Service Road).

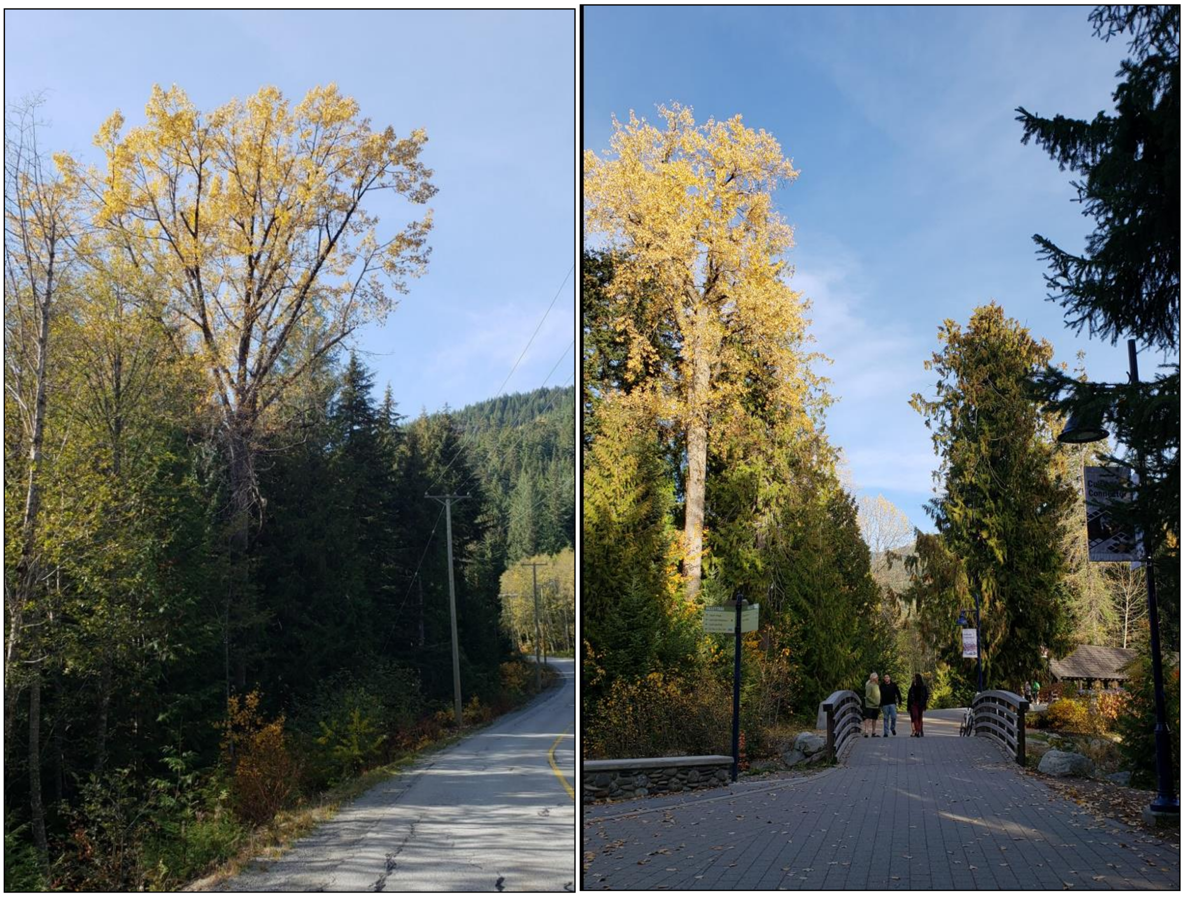
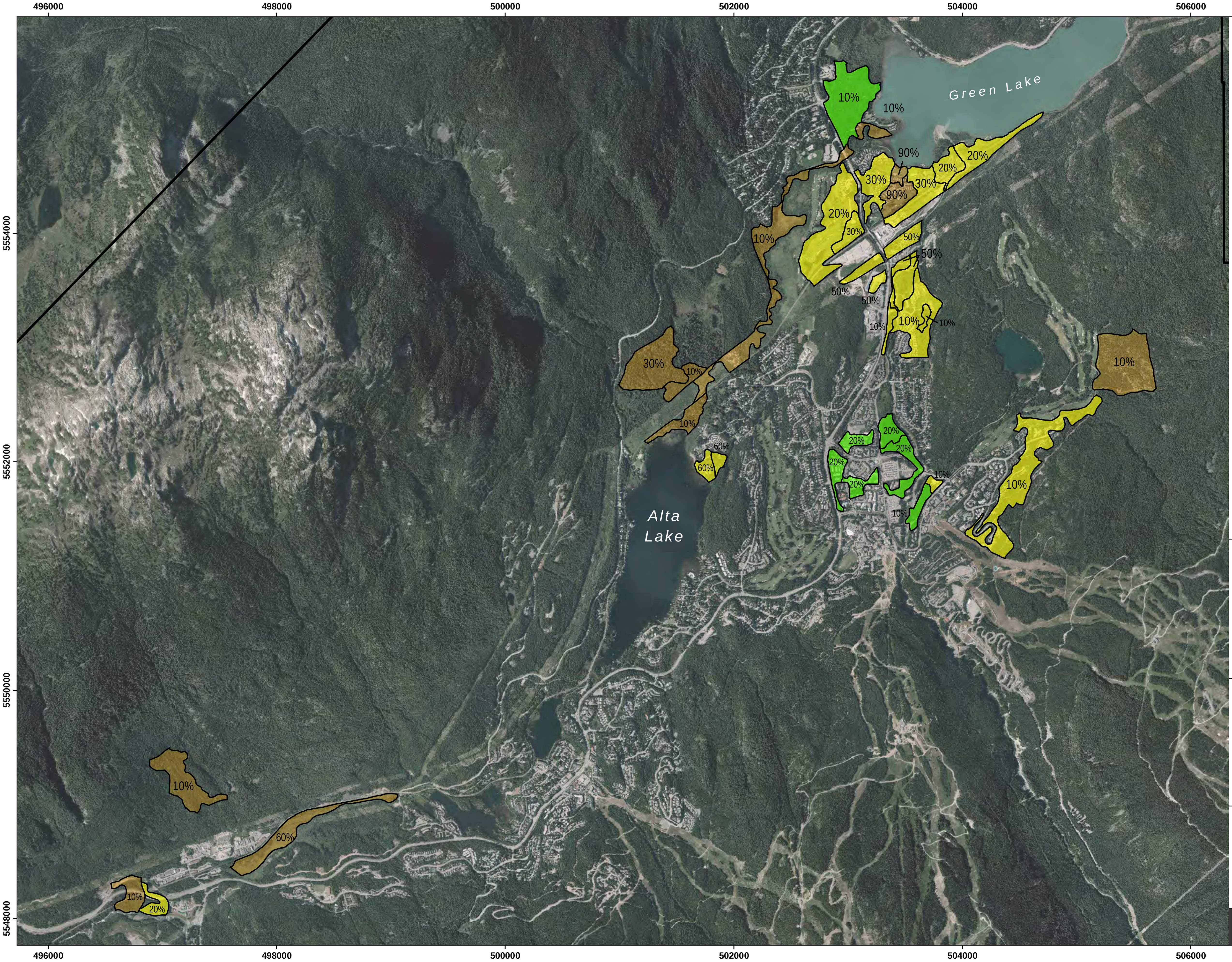


Photo 7-1. Large cottonwoods near the River Runs Through It (left) and Rebagliati Park (right). The tree on the right is approximately 300 years old (Brett and Ruddy, In Prep). The tree on the left has not been cored but based on the age of other trees in the area, it is likely in the range of 100 years-old. Older trees are larger, have more complex branching and provide more habitat for more organisms, especially those that benefit from tree cavities.



Legend

▭ RMOW Boundary

Age Class (Stand)

🟩 Original Forest (>250 years)

🟨 Original Forest (100-249 years)

🟧 Second Growth (<100 years)

*Percent value displayed represents percentage of polygon area covered by cottonwood.

Notes:
(1) Orthoimagery (2014) provided by RMOW.
(2) Cottonwood polygons provided by the Vegetation Resources Inventory (2017) - Ministry of Forests, Lands, Natural Resource Operations and Rural Development

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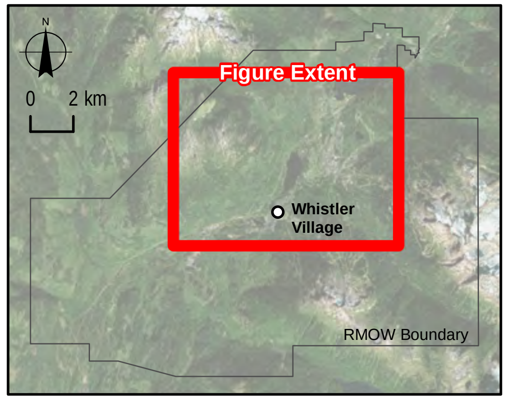

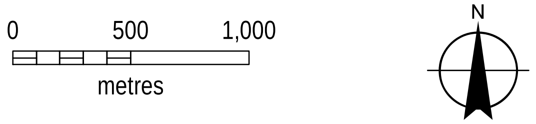

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Percent cover and age class of polygons containing black cottonwood within the RMOW Development Footprint

FIGURE 7-1

Photo 7-2. A cottonwood-dominated forest in the River Runs Through It area adjacent to 21 Mile Creek.

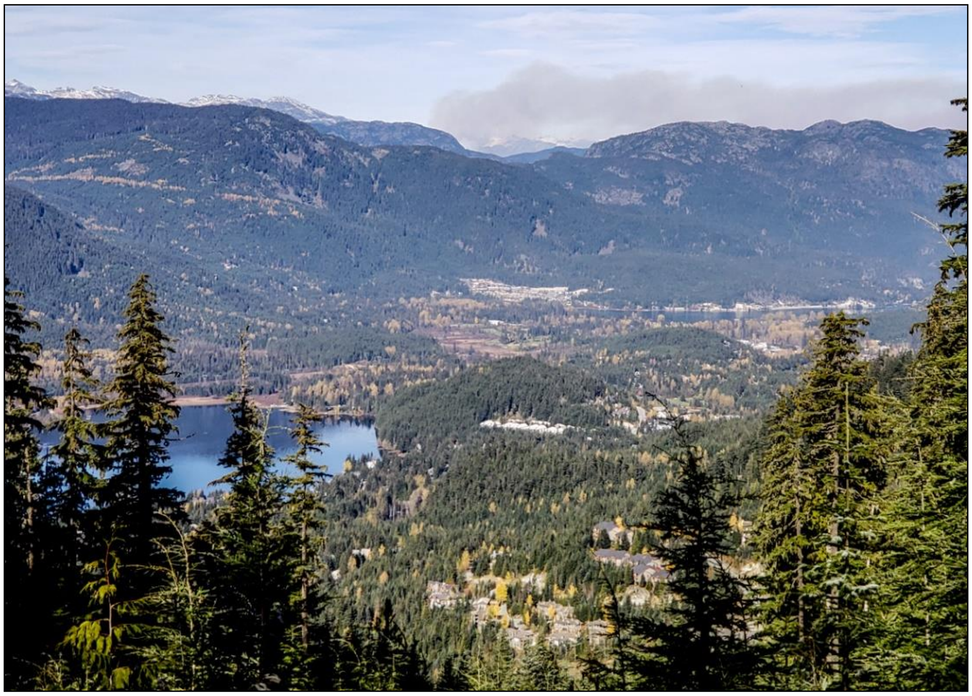


Photo 7-3. Cottonwoods are most visible after turning yellow in fall. This photo shows the view northward across Whistler Valley and highlights cottonwoods interspersed in developed areas, especially at low elevations of the wetland corridor in the mid background.

7.2 Northern Goshawks

The population of BC's Northern Goshawks (*Accipiter gentilis*) has declined precipitously in recent years, at least partly due to the loss of old forest habitat (BC MFLNRO 2018)[27]. Two subspecies occur in British Columbia. Provincial biologists to date identify the subspecies in the Whistler area as the Queen Charlotte Goshawk (*A. gentilis laingi*; MFLNRO and Madrone 2014, 2015; CDC 2019). The other subspecies, *A. gentilis atricapillus*, occurs throughout the rest of BC and other parts of North America. Both subspecies of the Northern Goshawk are listed as species at risk. The *A.* laingi subspecies is Red-listed in BC (CDC 2019) and Threatened under the Canadian Species At Risk Act (Government of Canada 2019). The *A. atricapillus* subspecies is Blue-listed in BC but is considered Not At Risk by the Canadian Government (CDC 2019).[28]

Northern Goshawks were prioritized by the Working Group (Brett 2018) for consideration as indicators within the RMOW Ecosystems Monitoring Program. The results presented here are an initial effort towards compiling and updating current knowledge about goshawks within the RMOW which will help assess how or whether they can be cost-effective indicators within the program.

A total of 32 records of Northern Goshawk (*A. gentilis*) observed in Whistler since 2001 have been compiled to date (Brett, in prep.; Figure 7-2; Table 7-1). This list includes two recently-active nesting areas: (a) at two nearby locations adjacent to Comfortably Numb in 2014 and 2015; and (b) a nest uphill of Millars Pond in 2016 and 2017 that was initially found as part of the Ecosystems Monitoring Program. BC Government surveys did not continue after 2015 at the Comfortably Numb sites so their current status is unknown. Repeated surveys at the Millars Pond nest by project biologists revealed it was not active in 2018.

One 2018 sighting and another two previous records were from Callaghan Valley (Figure 7-2; Table 7-1). One juvenile and another individual (possibly a juvenile) observed beside Alta Lake Road in the spring (Photo 7-4and Photo 7-5) may have been offspring from the 2017 nest at Millars Pond. Another two sightings were observed uphill of Millars Pond in the 2018 Kadenwood FireSmart tree thinning site, again indicating a possible relationship with the previously active nest in that area.

Based on recent records, it is likely that at least one goshawk nest was active in the Whistler area in 2018, The most probable location(s) for future nesting activity in the future are Comfortably Numb and Millars Pond, both of which have recently had active nests. Sightings have been recorded a number of times near Lower Sproatt and the Callaghan Valley which may indicate the possibility of nesting in that area as well.

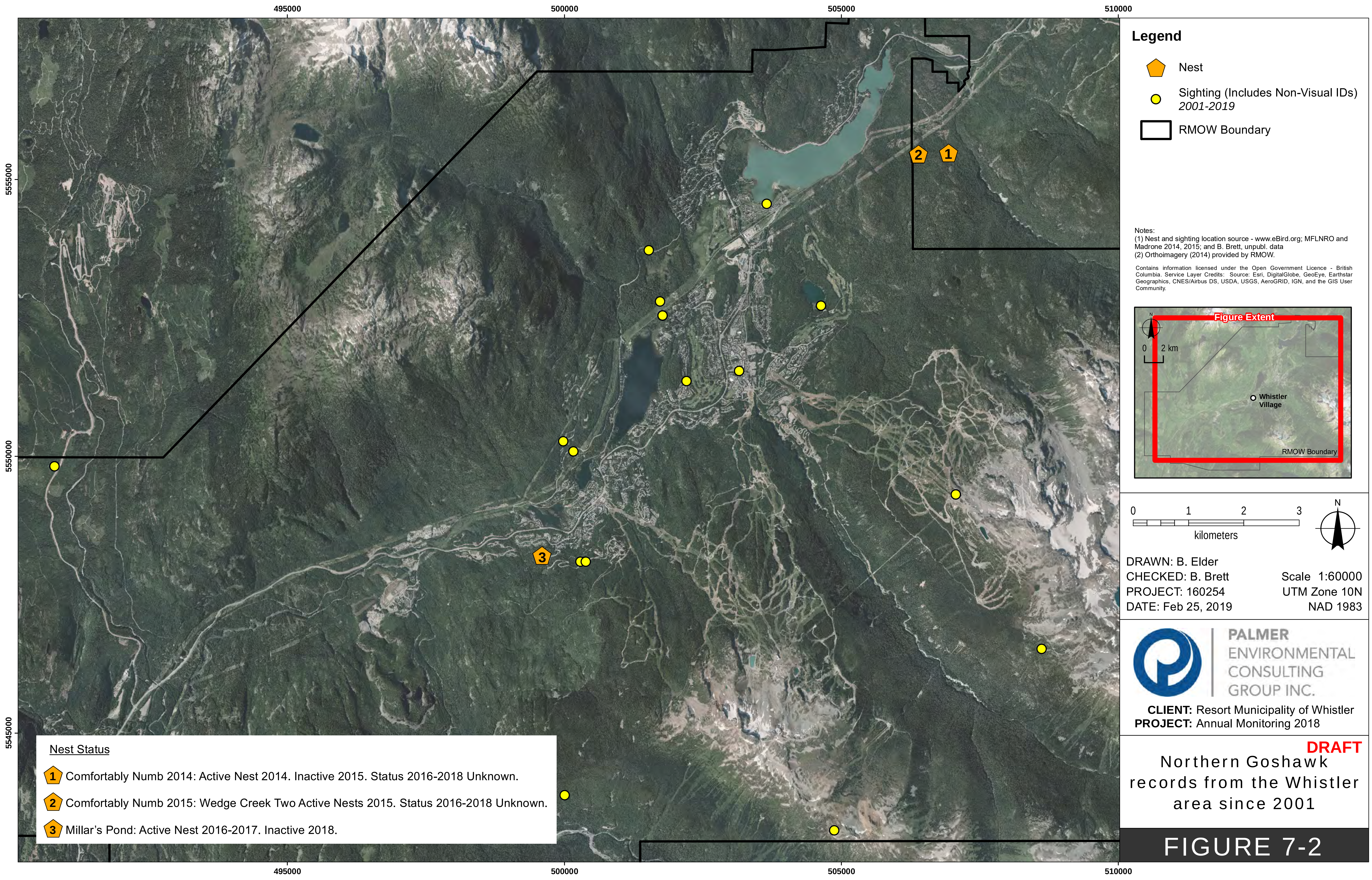
---

[27] *Much of the information in the introductory part of this section are based on Brett (In prep.).*

[28] *See Brett (In prep.) for an update and discussion of the taxonomic and conservation status of Northern Goshawk.*

Photo 7-4. Photo of an immature Northern Goshawk taken on April 14, 2018 near Alta Lake Road (Christa Vandeberg photo).

Photo 7-5. Indistinct photo of a Northern Goshawk taken on May 1, 2018 on Alta Lake Road north of the Wildlife Refuge (Bob Brett photo)



Legend

⬟ Nest

● Sighting (Includes Non-Visual IDs) *2001-2019*

▭ RMOW Boundary

Notes:
(1) Nest and sighting location source - www.eBird.org; MFLNRO and Madrone 2014, 2015; and B. Brett, unpubl. data
(2) Orthoimagery (2014) provided by RMOW.

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Nest Status

1 Comfortably Numb 2014: Active Nest 2014. Inactive 2015. Status 2016-2018 Unknown.

2 Comfortably Numb 2015: Wedge Creek Two Active Nests 2015. Status 2016-2018 Unknown.

3 Millar's Pond: Active Nest 2016-2017. Inactive 2018.

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PROJECT: Annual Monitoring 2018

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Northern Goshawk records from the Whistler area since 2001

FIGURE 7-2

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Table 7-1. Northern Goshawk records from the Whistler area since 2001. (Sources: www.eBird.org; MFLNRO and Madrone 2014, 2015; and B. Brett, unpubl. data).

Location	Affiliation	Date	No.	Observer(s)
Blackcomb Alpine	Personal	2000-03-14	1	B Max Götz
Valley Trail to Rainbow Beach	Naturalists' bird count	2001-03-03	1	B Max Götz
Valley Trail to Rainbow Beach	Naturalists' bird count	2007-06-02	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2008-02-02	1	Chris Dale, Heather Baines & others
Blackcomb Alpine	Personal	2009-02-14	1	Peter Dunwiddie
Whistler Village and vicinity	Personal	2009-08-22	1	Daniel Airola
Whistler Golf Club	Whistler BioBlitz	2011-08-06	1	Christopher Di Corrado
Valley Trail to Rainbow Beach	Naturalists' bird count	2011-08-15	1	Chris Dale, Heather Baines & others
Fitzsimmons Fan & Nicklaus North GC	Personal	2011-11-02	1	Chris Dale
Valley Trail to Rainbow Beach	Naturalists' bird count	2011-11-05	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2012-02-13	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2012-05-05	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2013-03-02	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2013-03-14	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2013-05-04	1	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2014-08-02	2	Chris Dale, Heather Baines & others
Valley Trail to Rainbow Beach	Naturalists' bird count	2014-12-06	1	Chris Dale, Heather Baines & others
Lost Lake and vicinity	Personal	2015-03-15	1	Cole Gaerber
Valley Trail to Rainbow Beach	Naturalists' bird count	2015-07-04	1	Chris Dale, Heather Baines & others
Blackcomb Alpine	Personal	2016-03-12	1	Nina Rach
Valley Trail to Rainbow Beach	Naturalists' bird count	2016-05-07	1	Chris Dale, Heather Baines & others
Callaghan Valley Road	Breeding Bird Survey	2016-06-10	1	BBS Team
Valley Trail to Rainbow Beach	Naturalists' bird count	2016-07-02	1	Chris Dale, Heather Baines & others
Whistler Village and vicinity	Personal	2016-11-30	1	Daniel Tinoco
5302 Alta Lake Rd.	Personal	2017-06-21	1	C Palmer
Lost Lake and vicinity	Personal	2018-06-09	1	Mike Farnworth
Callaghan Valley Road	Breeding Bird Survey	2018-06-15	1	BBS Team
Alta Lake Road n. of Wildlife Refuge	Personal	2018-05-01	1	Bob Brett

Location	Affiliation	Date	No.	Observer(s)
Kadenwood 2018 FireSmart site	RMOW project	2018-10-02	1	Bob Brett
Callaghan Valley A01 Fuel Mgt. Site	RMOW field tour	2018-10-03	1	FWAC field tour via Claire Ruddy
Kadenwood 2018 FireSmart site	RMOW project	2018-10-10	1	Leo Coudrau
Near Emerald Forest south gravel pit	Naturalists' bird count	2019-01-05	1	Chris Dale, Heather Baines & others

7.3 Western Toads

The RMOW Environmental Stewardship department has monitored amphibian populations at the south end of Whistler over the past decade, especially near the Cheakamus Crossing neighbourhood. In that time, annual breeding sites for Western Toads have not been confirmed (other than farther north, at Lost Lake). Given the number of anecdotal reports of juvenile and adult toads at the south end of Whistler, it seems reasonable to assume there would be one or more annually-used breeding sites within the RMOW study area. One site was chosen by the RMOW to survey in 2018 as part of the effort to test this hypothesis. The area selected was a pond on the northwest corner of the entrance from Highway 99 to the Callaghan Forest Service Road (UTM 493120E 5546435N, elevation 512m; **Error! Reference source not found.**, Figure 7-3).

The pond was surveyed twice and included a shore survey of the southeastern half of the pond on July 4, 2018 and a full, kayak-based survey completed on July 11, 2018. No Western Toads or other amphibians were detected during these surveys. Even though the survey date was later than planned, it was presumably early enough to detect toads if they inhabited the pond, even if they'd already metamorphosed. That said, the low elevation and warm summer could possibly have meant toads had already migrated away. Future surveys, especially in this lowest-elevation part of Whistler should be completed earlier in the season. In addition, egg surveys could be incorporated into the program to increase detection success.

Photo 7-6. Pond selected for Western Toad surveys, 2018.

Legend

★ Western Toad

― Watercourse

Notes:
(1) Orthoimagery (2014) provided by RMOW.
(2) Watercourse data from BC Freshwater Atlas (accessed 2017).

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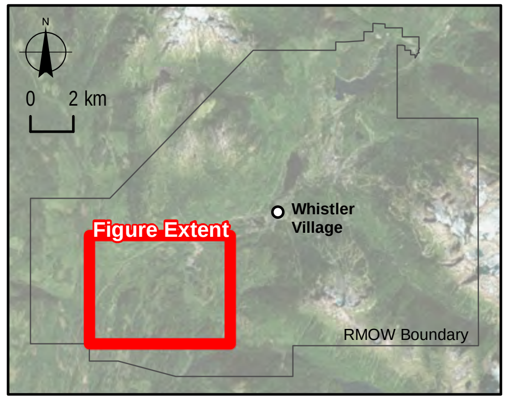

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PROJECT: 160254
DATE: Feb 07, 2019

Scale 1:20000
UTM Zone 10N
NAD 1983

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Western Toad

FIGURE **7-3**

8. Climate Indicators

The timing and duration of ice on Alta Lake has been used as a climate indicator since the inception of the Ecosystems Monitoring Program. Cascade (2013) compiled data from two reporting periods: 1942 to 1975, and from spring 2002 to present. No data is known to have been recorded between those two periods. The current dataset is derived from the Alta Lake Ice Break Up Raffle, a fundraiser for The Point Artist-Run Centre.[29] The purpose of presenting and analyzing this data is to document how the timing and duration of ice on Alta Lake has changed over time to predict how it may change in the future.

Data from 49 years from 1942 through spring 2018 are presented as Appendix I. There has been a noticeable reduction in the duration of ice on Alta Lake between the early records and records since 2002 (Figure 8-1; Table 8-1). Nine of 10 of the winters with the longest duration of ice on Alta Lake were from the earlier dataset, and six of 10 of the winters with the shortest duration were from the current dataset (Appendix I). The median reduction in number of days the lake was frozen between those two reporting periods was 21 days (average 27 days; Table 8-1). There has been less change in the date that Alta Lake freezes over (ice-on) than the date it thaws (ice-off). The median ice-on date is six days later in the recent dataset compared to earlier dataset: December 18th compared to December 12th. The median ice-off date for the recent dataset is April 10th compared to April 23rd for the earlier dataset, which represents a reduction of 13 days.

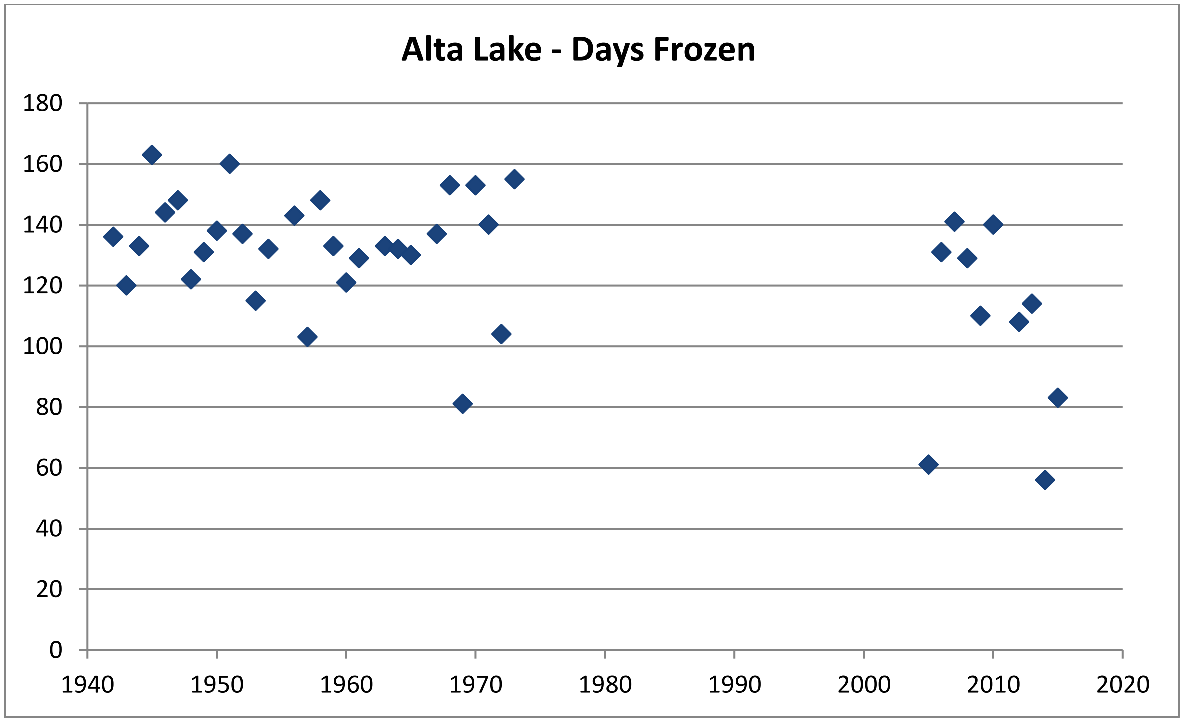

Figure 8-1. Ice records from Alta Lake from two datasets, 1942-1975 and 2002-2018. No data was recorded between those two periods.

---

[29] *Date of thaw from The Point's event has been supplied by Stephen Vogler. The 2018 date was emailed by him on March 8, 2019.*

Table 8-1 Ice records from Alta Lake from two datasets, 1942-1975 and 2002-2018. No data was recorded between these two periods. Inconsistent recording, especially of ice-on dates, is the reason the number of records varies.

		Dataset				Recent vs. Early Records
		1942-1975		**2002-2018**		
		Date	**Day Count**	**Date**	**Day Count**	
Ice-On	Records	n/a	31	n/a	10	21 records fewer
	Earliest	8-Nov-45	312	30-Nov-06	334	22 days later
	Latest	15-Jan-70	380	6-Jan-06	371	9 days earlier
	Median	Dec. 12th	346	Dec. 18th	353	7 days later
	Average	Dec. 12th	346	Dec. 16th	351	5 days later
Ice-Off						
	Records	n/a	31	n/a	16	15 records fewer
	Earliest	23-Mar-63	82	20-Feb-15	51	31 days earlier
	Latest	21-May-52	142	29-Apr-08	120	22 days earlier
	Median	April 23rd	113	April 10th	100	13 days earlier
	Average	April 23rd	113	April 5th	95	18 days earlier
Days Frozen						
	Records	n/a	29	n/a	10	19 records fewer
	Median	n/a	133	n/a	112	21 days shorter
	Average	n/a	134	n/a	107	27 days shorter

These two datasets provide convincing evidence of a changing climate that is consistent with other observations, for example, glacial recession within that same time. The conclusions would be stronger with more complete data, especially from 1976 to 2001 and if more ice-on dates had been recorded since 2002.

9. Conclusions and Recommendations

In the future, it is recommended that the main basis for determining what to monitor and sampling procedures for the annual Ecosystems Monitoring Program will be using prioritized species and habitats most important to conserving biodiversity within the RMOW's development footprint. Recommendations for the 2019 work plan will build on the findings resulting from studies completed, most recently, by Brett (2018) and PECG and Snowline, (2017, 2018, 2019 in prep). Locations and methods will be assessed to effectively monitor priority species and habitats within the RMOW.

9.1 State of Monitoring Sites

Six streams sites were assessed for benthic invertebrates in 2018 including sites Crabapple Creek, Jordan Creek, 21 Mile Creek, Millar Creek and two sites on the River of Golden Dreams. Of these, two streams sites demonstrated potentially compromised aquatic system health (Jordan Creek and Millar Creek). At these sites, EPT taxa abundance was low relative to overall abundance. The remaining four stream sites assessed did not show any signs of being compromised.

Fishing was also completed at all sites where benthic invertebrate sampling was conducted, with the exception of Millar Creek. Mean relative condition of trout captured from each site was calculated. No trout were captured at the upstream site on the River of Golden Dreams (RGD-US-AQ11), however all trout sampled within the RMOW in 2018 were considered healthy based on the relative condition index. Within the four sites where trout were captured, all showed similar condition values for 2018. Within Jordan Creek and Crabapple Creek, there was a decline in condition from 2016 to 2017 and 2018, which may potentially indicate that these fish are living in an impaired habitat. Despite the decreases in mean relative condition in trout caught in Jordan Creek and Crabapple Creek relative to previous years, the values still imply that these fish are healthy, indicating that any changes in the benthic invertebrate communities at Jordan Creek in particular are not reflected in the higher aquatic trophic levels (i.e. fish).

In the past three years of monitoring Coastal Tailed Frogs, no evidence was detected that linked environmental changes (whether caused by human activities or not) and negative impacts on frog populations. In 2016, sediments were transported downstream of the Whistler Bike Park in Archibald Creek. Low detections of tadpoles in that year were hypothesized to be more a result of a sudden cooling of air and water temperatures (and therefore lower detections) rather than sedimentation. A rebound in the 2017 survey to higher detections consistent with previous years supported that conclusion. In 2017, the installation of a pedestrian bridge across Whistler Creek left large, angular boulders and a channelized stream, both of which could negatively impact tailed frogs. Tadpole detections in 2017 were nonetheless high and apparently unaffected. Tadpole detections in 2018 at both of these reaches remained relatively high and consistent with 2017 which provided further evidence that in-stream disturbances had not affected tadpole abundance. Results from all streams to date suggest habitat conditions for tailed frogs have remained consistent, or at least that any impacts have not been strong enough to be detectable with current methods.

Now that the extent of beaver-affected wetlands has been calculated (Section 6.3.3), it is possible to more accurately detect changes in the amount of that critical habitat. Even without mapping, the locations and number of beavers appeared relatively stable in the past three years. By extension, the areal extent of wetland they created or maintained was therefore also mostly stable. One exception to this conclusion are the expected changes in lodge status due to natural fluctuations in the distribution of this colonial animal. That is, some areas will provide higher quality habitat and higher year-to-year success. Another exception, beaver control efforts, have likely affected beavers and their wetlands more than natural fluctuations. Beaver removals and/or destruction of dams and lodges have occurred at various locations in Whistler, notably at the golf courses, beside the CN Rail right-of-way, and in areas that conflict with RMOW infrastructure. The conclusion from these observations is that beavers will maintain or even expand their population as long as enough habitat is set aside for them.

Two preliminary analyses of terrestrial indicators are presented in this report: black cottonwoods and Northern Goshawks. The analysis of the extent of old and/or large cottonwoods in Whistler – most centered on the area between the Village, Alta Lake, and Green Lake – shows a loss of some of this critical habitat since ecosystem mapping was last conducted. This conclusion needs to be investigated in future years of the program.

The initial analysis of the current state of knowledge about local Northern Goshawks (Section 6.2) emphasizes the conclusion that the Whistler area provides critical habitat for this threatened species. It showed that Millar's Pond area and Comfortably Numb areas likely continue to support goshawk nesting (even though undetected since 2017). It also suggested that the goshawks' affinity to those areas is likely to be more related to habitat type (old forest) rather than specific sites since only one nest was re-used, and only for one year.

9.2 Recommendations for Future Monitoring

Recommendations for future monitoring in the RMOW include the following:

- Water Quality:
    - Continue in situ water quality monitoring during benthic invertebrate, fish and coastal tailed frog tadpole surveys;
    - Maintain the use of water temperature loggers at seven sites (Alpha Creek, Jordan Creek, Scotia Creek, Crabapple Creek (2), River of Golden Dreams and 21 Mile Creek); and
    - It is recommended that the RMOW continue their water quality and sediment quality sampling programs at established sites with more emphasis at Jordan Creek and Millar Creek where benthic invertebrate communities have been determined to be compromised relative to other sites in the RMOW, or where other exceedances of water quality and sediment quality guidelines have been observed.

- Benthic Invertebrates:
    - Continue benthic invertebrate community monitoring at all sites using the CABIN method;
    - Continue to monitor the condition of benthic invertebrate EPT in Jordan Creek and Millar Creek to determine whether the sensitive taxa may recover over time; and
    - Investigate a potential reference site for Jordan Creek and Millar Creek; as these sites were identified as potentially compromised during the 2018 field program.

- Fisheries:
    - Continue monitoring fish communities at up to 8 sites within the RMOW, including those sampled as a component of the 2016-2018 Ecosystem Monitoring Program as well as three additional sites including Millar Creek, Fitzsimmons Creek and Blackcomb Creek;
    - Conduct detailed fish habitat assessments using methods based on the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory procedure (RISC 2001) at all stream sites. In addition, three sites, including those on Fitzsimmons Creek, Blackcomb Creek and a reference creek, should be surveyed based on the Fish Habitat Assessment Procedures (Johnston and Slaney 1996) to further characterize Bull Trout habitat, which will compliment current enumeration work conducted in support of the gravel removal program; and
    - Identify potential differences between cutthroat and rainbow trout with the use of genetic testing. At present, trout collected could represent either cutthroat or rainbow trout and therefore future studies may include the collection of fin clips to conduct genetic analysis.

- Coastal Tailed Frogs
    - Continue to expand the number and extent of creeks on the west side of Whistler Valley. Establish three sites at each of the new 2018 creeks and/or add new creeks to the north (North Flank) and south (South Flank);
    - Continue multi-year sampling on Whistler and Blackcomb Mountains which have the most heavily-used mountainside streams that support tailed frogs and are potentially at greatest risk of disturbance. Consider switching out Whistler or Crabapple Creek for one or more years to allow sampling of another east-side creek;
    - Remap small creeks on the west side of the valley where current mapping is inaccurate including Sproatt Creek, Van West Creek, and possibly Scotia Creek. Accurate mapping of small creeks which tailed frogs may inhabit is important for monitoring and even more to reliably assess potential development within those areas. This effort could potentially be more cost-effective if it used a combination of LIDAR mapping and, where effective, field truthing. Though not directly related to ecosystem monitoring, it may also be worthwhile to replace the current sign on the Flank Trail that inaccurately identifies Scotia Creek as Nita Creek; and
    - Re-assess the use of Environmental DNA (eDNA) sampling techniques to determine if it would be useful within future years of the program. There are many possible benefits of employing eDNA including a quicker and potentially more reliable way of determining presence/absence within stream systems that are difficult to survey due to low temperatures, substrate, flow, and/or access. As of 2018, eDNA sampling methods are still being standardized and refined to prevent false positives and false negatives in a cost-effective way. As more progress is made towards this goal, it is likely eDNA sampling could become another useful option within the program. Two creeks where no detections have been made to date have emerged as good candidates for future eDNA surveys: Blackcomb Creek (where water temperatures are below 6° C – near the documented minimum for egg development and also a temperature at which detections are very difficult); and Agnew Creek (which appears to be good habitat but where no detections have been made in two survey years).

- Beavers
    - Build on 2018 results to further clarify the presence/activity of colonies on the River of Golden Dreams, Millar Creek Wetlands, and Fitzsimmons Creek back channels. It should be possible to achieve this goal with the same, expanded search effort employed in 2018. The goal, as in 2018, is to complete a full census of beavers in Whistler Valley;
    - Obtain and tabulate historic and recent trapping records. Correlate those trapping records where possible to past and current beaver locations;
    - Work with RMOW staff to convey information about beavers to avoid/mitigate conflicts, especially where the new Valley Trail is being built in Function Junction;
    - Continue to communicate with local golf courses about beaver activities and possible ways to coexist better with beavers; and
    - Field truth beaver-affected wetlands to reconcile the discrepancy between the RMOW wetlands layer and what was mapped for this report. The eventual goals are to be able to:

    (a) accurately monitor the extent of beaver-affected wetland; and ideally (b) provide a better historic baseline to which that extent can be compared.

- Western Toads
    - Survey one or more potential breeding sites in the south end of Whistler Valley with the goal of establishing, for the first time, annual breeding site(s) south of Lost Lake;
    - Survey earlier in the summer to increase the probability of detection; and
    - Coordinate toad breeding surveys with the RMOW Environmental Stewardship team to improve efficiencies and reliability. Red-legged Frogs surveys may also further increase cost efficiency and survey extent.

- Black Cottonwoods
    - Use air photos, field surveys, and possibly LIDAR to delineate and describe areas containing older and/or larger cottonwoods. Stand characteristics should be described and measured to better classify sites by current or potential habitat value; and
    - Identify areas that could be planted with black cottonwoods, for example, denuded areas and appropriate (warm aspect and/or open FireSmart sites).

- Northern Goshawks
    - Coordinate efforts with BC Government biologists, the RMOW, Cheakamus Community Forest, and possibly local ENGOs to ensure potential nesting areas are monitored in 2019 and beyond. Part of the goal would be to provide the best possible local data to identify possible Wildlife Habitat Areas;
    - Use documented habitat requirements to further delineate potential habitat within the RMOW; and
    - Continue to compile local records.

- Climate Indicators
    - Continue to compile and analyze Alta Lake ice-off dates provided by The Point Artist Run Centre; and
    - Explore ways to re-establish annual monitoring of ice-on dates.

10. Certification

This report was prepared, reviewed and approved by the undersigned:

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11. References

Adams, Ian and J. Hobbs. 2016. Rocky Mountain environmental DNA inventory – year three (2016). Vast Resource Solutions, Cranbrook BC, and Hemmera Envirochem Inc., Vancouver BC. Contract report for BC Min. For., Lands, and Nat. Res. Ops., Victoria, BC. 19pp + app.

Askey, Ethan, Bob Brett, and Linda Dupuis. 2008. A proposed framework for the use of ecological data in monitoring and promoting the conservation of biodiversity in Whistler. Golder Associates Ltd., Squamish, BC. Contract report prepared for the Resort Municipality of Whistler. 36 pp. plus appendices.

Baumsteiger, J., D. Hankin, and E. J. Loudenslager. 2005. Genetic analyses of juvenile steelhead, coastal cutthroat trout, and their hybrids differ substantially from field identifications. Transactions of the American Fisheries Society 134:829–840.

BC Ministry of Environment (BC MOE). 1997. UTM: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/dissolvedoxygen-or.pdf. Accessed January 23, 2019.

BC Ministry of Environment (BC MOE). 2015. Management plan for the Coastal Tailed Frog (*Ascaphus truei*) in British Columbia. B.C. Ministry of Environment, Victoria, BC. 49 pp. URL: http://a100.gov.bc.ca/pub/eirs/finishDownloadDocument.do?subdocumentId=10303.

BC Ministry of Environment, Lands and Parks Resources Inventory Branch (BC MELP). 2000. Inventory Methods for Tailed Frog and Pacific Giant Salamander. Standards for Components of British Columbia's Biodiversity No. 39. Version 2. Ministry of Environment, Lands and Parks. Victoria, BC.

BC Ministry of Forests, Lands, and Natural Resource Operations. 2017a. Sport Fish of BC – Coastal Cutthroat Trout. URL: http://www.env.gov.bc.ca/fw/fish/sport_fish/#CoastalCutthroatTrout. Accessed January 23, 2019.

BC Ministry of Forests, Lands, and Natural Resource Operations. 2017b. Bull Trout (*Salvelinus confluentus*). URL: http://www.env.gov.bc.ca/omineca/esd/faw/bulltrout/. Accessed January 23, 2019.

British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (BCMFLNRO). 2018. Implementation plan for Northern Goshawk, *laingi* subspecies in British Columbia. Victoria, BC. 23 pp.

Brett, Bob. 2007. Whistler Biodiversity Project -- Progress report and provisional checklists. Whistler Biodiversity Project, Whistler, BC. 101 pp.

Brett, Bob. 2015. Whistler Biodiversity Project – progress report. Whistler Biodiversity Project, Whistler, BC. 7 pp.

Brett, Bob. 2018. Species and Habitat Priorities for Biodiversity Conservation in the Resort Municipality of Whistler. Snowline Ecological Research, Whistler BC, and Palmer Environmental Consulting Group, Vancouver, BC. Contract report prepared for the Resort Municipality of Whistler.

Brett, Bob. In prep. Species and Ecosystems at Risk in the Resort Municipality –2018 Update. Whistler Biodiversity Project, Whistler, BC. Contract report prepared for the Resort Municipality.

Brett, Bob and Claire Ruddy. In prep. Old and Ancient Trees in Whistler. Snowline Ecological Research and Association of Whistler-Area Residents for the Environment (AWARE), Whistler, BC. Double-sided map.

BC Ministry of Environment, Lands and Parks Resources Inventory Branch (BC MELP). 2000. Inventory Methods for Tailed Frog and Pacific Giant Salamander. Standards for Components of British Columbia's Biodiversity No. 39. Version 2. Ministry of Environment, Lands and Parks. Victoria, BC.

Canadian Council of Ministers of the Environment (CCME). 2014. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Environment Canada. Ottawa Ontario. https://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/ Accessed January 20, 2019.

Cascade Environmental Resource Group (Cascade). 2014. RMOW Ecosystem Monitoring Program 2013. Contract report for the Resort Municipality of Whistler, Whistler, BC. 78 pp. plus appendices.

Cascade Environmental Resource Group (Cascade). 2015. RMOW Ecosystem Monitoring Program 2014. Contract report for the Resort Municipality of Whistler, Whistler, BC. 75 pp. plus appendices.

Cascade Environmental Resource Group (Cascade). 2016. RMOW Ecosystem Monitoring Program 2015. Contract report for the Resort Municipality of Whistler, Whistler, BC. 65 pp. plus appendices.

Conservation Data Centre (CDC). 2019. B.C. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria B.C. Accessed January 29, 2019. URL: http://a100.gov.bc.ca/pub/eswp/.

Corkran, C.C. and C. Thoms. 1996. Amphibians of Oregon, Washington and British Columbia. Lone Pine Publishing, Vancouver, B.C. 175 pp.

Environment and Climate Change Canada (ECCC). 2011. Canadian aquatic biomonitoring network: wadable streams field manual.

Government of Canada. 2019. Species at Risk Public Registry. Government of Canada, Ottawa, ON. URL: https://wildlife-species.canada.ca/species-risk-registry/sar/index/default_e.cfm. Accessed February 7, 2019.

Hobbs, Jared and Caren Goldberg. 2017. Environmental DNA protocol for freshwater aquatic systems. Hemmera Envirochem Inc., Vancouver, BC. Contract report prepared for the BC Ministry of Environment, Victoria, BC. 32 pp.

Invasive Species Council of BC (ISCBC) 2017. URL: https://bcinvasives.ca/ Accessed on February 15, 2019.

Johnson, D. H., B. M. Shrier, J. S. O’Neal, J. A. Knutzen, X. Augerot, T. A. O’Neil, and T. N. Pearsons. 2007. Salmonid field protocols handbook: Techniques for assessing status and trends in salmon and trout populations. Maryland: American Fisheries Society.

Johnston, N. T., and P. A. Slaney. 1996. Fish habitat assessment procedures. Watershed Restoration Technical Circular No. 8. Ministry of Environment, Lands and Parks and Ministry of Forests. Vancouver, BC.

Jones, Lawrence L.D., William P. Leonard and Deanna H. Olson (eds.). 2005. Amphibians of the Pacific Northwest. Seattle Audubon Society, Seattle, WA. 227 pp.

Leigh-Spencer, Sally. 2004. Wildlife species in the Resort Municipality of Whistler. Contract report prepared for BA Blackwell and Associates, North Vancouver, BC. 21 pp.

Malt, Josh, Danielle Courcelles, and Sarah Nathan. 2014a. Study Design and Field Methods: Guidance on Coastal Tailed Frog monitoring of run-of-river hydropower projects. Version 1.2, May 2014. Ministry of Forests, Lands, and Natural Resource Operations. 22 pp.

Malt, Josh, Danielle Courcelles, and Sarah Nathan. 2014b. Study Design and Field Methods: Guidance on Coastal Tailed Frog monitoring of run-of-river hydropower projects. Version 1.3, December 2014. Ministry of Forests, Lands, and Natural Resource Operations. 22 pp.

McBlane, Lindsay. 2007. Connectivity changes in wetland ecosystems from 1946 to 2003 in the Resort Municipality of Whistler, British Columbia. Masters thesis, Simon Fraser University, Vancouver, BC. 77 pp.

Matsuda, Brent M., David M. Green and Patrick T. Gregory. 2006. Amphibians and reptiles of British Columbia. Royal BC Museum, Victoria, BC. 266 pp.

Ministry of Forests, Lands, and Natural Resources Operations and Madrone Environmental Services Ltd. (MFLNRO and Madrone). 2014. Northern Goshawk laingi inventory in the South Coast: 2014 field survey results. Victoria, BC. 12 pp.

Ministry of Forests, Lands, and Natural Resources Operations and Madrone Environmental Services Ltd. (MFLNRO and Madrone). 2015. Northern Goshawk laingi inventory in the South Coast: 2015 field survey results. Victoria, BC. 11 pp.

Morgan, Lewis H. 1868. The American beaver. Reprinted 1986 by Dover Publications Inc., New York, NY. 330 pp.

Mullen, Jory. 2008. Whistler Biodiversity Project preliminary beaver census – 2007. Whistler Biodiversity Project, Whistler, BC.

Mullen, Jory. 2009. Whistler Biodiversity Project beaver census – 2008. Whistler Biodiversity Project, Whistler, BC.

Müller-Schwarze, Dietland and Lixing Sun. 2003. The beaver: natural history of a wetlands engineer. Cornell University Press, Ithaca, NY. 190 pp.

Palmer Environmental Consulting Group and Snowline Ecological Research (PECG and Snowline). 2017**.** Whistler Ecosystems Monitoring Program 2016. Palmer Environmental Consulting Group, Vancouver, BC, and Snowline Ecological Research, Whistler, BC. Contract report for the Resort Municipality of Whistler.

Palmer Environmental Consulting Group and Snowline Ecological Research (PECG and Snowline). 2018**.** Whistler Ecosystems Monitoring Program 2017. Palmer Environmental Consulting Group, Vancouver, BC, and Snowline Ecological Research, Whistler, BC. Contract report for the Resort Municipality of Whistler.

Perrin, C. J., S.A. Bennett, S. Linke, A.J. Downie, G. Tamblyn,B. Ells, I. Sharpe, and R.C. Bailey. 2007. Bioassessment of streams in north-central British Columbia using the reference condition approach. Final report v.2a. March 31, 2007.

Pevec, Zuleika. 2009. Whistler Biodiversity Project beaver census – 2009. Whistler Biodiversity Project, Whistler, BC.

Resource Information Standards Committee (RISC). 2001. Reconnaissance (1:20 000) fish and fish habitat inventory: Standards and procedures. Victoria, B.C.

Sylvestre, Stephanie, Monique Fluegel and Taina Tuominen. 2005. Benthic invertebrate assessment of streams in the Georgia Basin using the reference condition approach: Expansions of the Fraser River invertebrate monitoring program 1998-2002. Environment Canada, Vancouver BC. EC/GB/o4/81 Tayless, Emma. 2010. Whistler Biodiversity Project beaver census – 2009. Whistler Biodiversity Project, Whistler, BC.

Tayless, Emma and Julie Burrows. 2011. Whistler Biodiversity Project beaver census – 2009. Whistler Biodiversity Project and Resort Municipality of Whistler, Whistler, BC. Unpublished data.

Welsh, H.H., Jr. and L.M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: A case study from California's redwoods. Ecological Applications 8(4): 1118–1132.

Wind, E. 2005-2009. Whistler Biodiversity Project amphibian survey. Annual reports for the Whistler Biodiversity Project. Whistler, BC

Appendix A

Daily Stream Temperature Data

Alpha Creek			
Date	Minimum Temperature (°C)	Average Temperature (°C)	Maximum Temperature (°C)
27-07-2017	10.79	11.33	11.81
28-07-2017	9.95	10.84	11.54
29-07-2017	10.10	10.94	11.64
30-07-2017	10.47	11.12	11.71
31-07-2017	10.22	11.11	11.90
01-08-2017	10.91	11.62	12.44
02-08-2017	11.42	12.05	12.75
03-08-2017	11.54	12.29	13.14
04-08-2017	11.93	12.49	13.02
05-08-2017	11.71	12.26	12.80
06-08-2017	11.47	12.25	13.02
07-08-2017	11.73	12.52	13.31
08-08-2017	12.34	12.94	13.59
09-08-2017	12.53	13.18	13.88
10-08-2017	12.61	13.35	14.05
11-08-2017	12.87	13.56	14.15
12-08-2017	12.90	13.32	13.76
13-08-2017	11.76	12.51	13.11
14-08-2017	10.81	11.15	11.59
15-08-2017	9.53	10.41	11.10
16-08-2017	10.52	11.01	11.52
17-08-2017	10.32	11.04	11.61
18-08-2017	11.20	11.40	11.59
19-08-2017	10.22	10.73	11.10
20-08-2017	10.32	10.77	11.30
21-08-2017	10.20	10.90	11.59
22-08-2017	10.79	11.51	12.17
23-08-2017	11.83	12.17	12.56
24-08-2017	10.91	11.66	12.27
25-08-2017	9.68	10.21	10.74
26-08-2017	9.26	10.08	10.86
27-08-2017	10.30	11.10	12.03
28-08-2017	11.27	11.88	12.53
29-08-2017	11.25	11.99	12.58
30-08-2017	11.37	11.76	12.24
31-08-2017	11.20	11.55	11.86
01-09-2017	11.03	11.50	11.90
02-09-2017	11.15	11.86	12.58
03-09-2017	11.76	12.35	12.90
04-09-2017	12.27	12.78	13.38
05-09-2017	13.02	13.28	13.59
06-09-2017	12.99	13.28	13.57
07-09-2017	12.68	13.06	13.31

08-09-2017	12.82	13.05	13.16
09-09-2017	10.96	11.81	12.78
10-09-2017	10.61	10.88	11.10
11-09-2017	10.81	11.22	11.69
12-09-2017	11.37	11.66	11.95
13-09-2017	9.63	10.45	11.35
14-09-2017	8.39	8.91	9.46
15-09-2017	7.80	8.41	8.84
16-09-2017	7.80	8.36	8.87
17-09-2017	7.92	8.20	8.44
18-09-2017	7.22	7.55	7.85
19-09-2017	6.54	6.94	7.29
20-09-2017	6.51	6.93	7.34
21-09-2017	6.81	7.14	7.52
22-09-2017	6.03	6.70	7.27
23-09-2017	7.09	7.51	7.92
24-09-2017	7.54	7.93	8.34
25-09-2017	8.30	8.57	8.89
26-09-2017	8.89	9.16	9.51
27-09-2017	8.94	9.32	9.76
28-09-2017	8.99	9.39	9.81
29-09-2017	9.31	9.45	9.58
30-09-2017	7.85	8.48	9.19
01-10-2017	7.07	7.39	7.80
02-10-2017	6.33	6.58	6.91
03-10-2017	5.85	6.15	6.46
04-10-2017	5.59	5.95	6.28
05-10-2017	5.15	5.68	6.13
06-10-2017	5.72	6.00	6.31
07-10-2017	5.72	5.90	6.20
08-10-2017	5.18	5.54	5.77
09-10-2017	4.87	5.24	5.54
10-10-2017	4.95	5.19	5.39
11-10-2017	4.61	4.78	4.95
12-10-2017	4.38	4.54	4.66
13-10-2017	3.43	3.84	4.51
14-10-2017	3.35	3.68	4.04
15-10-2017	4.04	4.49	5.05
16-10-2017	5.10	5.54	5.92
17-10-2017	4.77	5.81	6.36
18-10-2017	1.70	3.14	4.64
19-10-2017	2.42	3.58	4.17
20-10-2017	3.91	4.26	4.53
21-10-2017	3.12	3.69	3.99
22-10-2017	3.27	4.05	4.58
23-10-2017	4.06	4.48	4.90
24-10-2017	4.12	4.57	4.84

25-10-2017	4.64	5.30	5.72
26-10-2017	4.43	4.80	5.31
27-10-2017	4.56	4.97	5.44
28-10-2017	5.00	5.37	5.77
29-10-2017	5.10	5.50	5.64
30-10-2017	3.41	4.14	5.00
31-10-2017	2.85	3.39	3.85
01-11-2017	3.88	4.10	4.32
02-11-2017	0.36	2.16	4.32
03-11-2017	0.05	0.12	0.30
04-11-2017	0.05	0.10	0.19
05-11-2017	0.05	0.13	0.22
06-11-2017	0.05	0.13	0.22
07-11-2017	0.14	0.26	0.36
08-11-2017	0.36	0.47	0.61
09-11-2017	0.61	0.76	0.96
10-11-2017	0.96	1.20	1.37
11-11-2017	1.37	1.51	1.62
12-11-2017	1.32	1.47	1.62
13-11-2017	0.88	1.32	1.62
14-11-2017	0.58	1.49	1.97
15-11-2017	0.50	0.86	1.13
16-11-2017	1.07	1.44	1.64
17-11-2017	1.70	1.83	1.91
18-11-2017	1.78	1.86	1.91
19-11-2017	0.08	1.13	1.97
20-11-2017	0.74	1.37	1.64
21-11-2017	1.51	1.67	1.86
22-11-2017	0.66	1.09	1.64
23-11-2017	0.72	1.53	2.34
24-11-2017	2.37	2.57	2.72
25-11-2017	2.42	2.76	2.96
26-11-2017	2.48	2.70	2.93
27-11-2017	2.56	2.69	2.85
28-11-2017	2.26	2.50	2.64
29-11-2017	2.48	2.54	2.61
30-11-2017	2.37	2.50	2.58
01-12-2017	2.07	2.32	2.58
02-12-2017	2.10	2.25	2.32
03-12-2017	0.52	1.36	2.02
04-12-2017	0.30	0.63	0.99
05-12-2017	0.36	0.63	1.02
06-12-2017	1.04	1.24	1.43
07-12-2017	1.15	1.26	1.37
08-12-2017	0.93	1.04	1.15
09-12-2017	0.63	0.88	1.02
10-12-2017	0.85	1.45	1.72

11-12-2017	1.48	1.67	1.75
12-12-2017	1.53	1.78	1.94
13-12-2017	1.78	1.91	1.99
14-12-2017	1.67	1.78	1.94
15-12-2017	1.83	2.02	2.16
16-12-2017	1.10	1.42	1.81
17-12-2017	1.24	1.46	1.62
18-12-2017	1.48	1.71	1.83
19-12-2017	0.41	1.11	1.83
20-12-2017	0.02	0.08	0.33
21-12-2017	0.05	0.08	0.16
22-12-2017	0.05	0.07	0.14
23-12-2017	0.05	0.05	0.05
24-12-2017	0.05	0.05	0.05
25-12-2017	0.05	0.05	0.05
26-12-2017	0.05	0.06	0.08
27-12-2017	0.08	0.09	0.11
28-12-2017	0.11	0.12	0.16
29-12-2017	0.08	0.19	0.22
30-12-2017	0.16	0.29	0.36
31-12-2017	0.36	0.40	0.44
01-01-2018	0.44	0.48	0.55
02-01-2018	0.55	0.60	0.69
03-01-2018	0.69	0.75	0.83
04-01-2018	0.83	0.88	0.96
05-01-2018	0.08	0.65	0.96
06-01-2018	0.14	0.59	1.04
07-01-2018	1.04	1.11	1.21
08-01-2018	1.18	1.21	1.29
09-01-2018	1.21	1.29	1.37
10-01-2018	1.26	1.38	1.43
11-01-2018	0.05	0.41	1.15
12-01-2018	0.05	0.07	0.14
13-01-2018	0.05	0.66	1.15
14-01-2018	1.15	1.23	1.34
15-01-2018	1.34	1.37	1.40
16-01-2018	1.02	1.33	1.51
17-01-2018	1.43	1.54	1.62
18-01-2018	1.29	1.57	1.75
19-01-2018	1.72	1.79	1.86
20-01-2018	1.29	1.72	1.83
21-01-2018	0.58	0.94	1.34
22-01-2018	1.29	1.48	1.62
23-01-2018	1.34	1.49	1.62
24-01-2018	0.83	1.23	1.51
25-01-2018	0.96	1.26	1.37
26-01-2018	0.50	0.97	1.29

27-01-2018	0.52	0.82	1.13
28-01-2018	0.05	0.50	1.18
29-01-2018	0.08	0.33	1.18
30-01-2018	1.29	1.62	1.75
31-01-2018	1.51	1.63	1.81
01-02-2018	1.53	1.73	1.83
02-02-2018	1.45	1.78	1.91
03-02-2018	1.91	2.01	2.07
04-02-2018	1.94	2.03	2.13
05-02-2018	2.05	2.14	2.21
06-02-2018	2.07	2.16	2.26
07-02-2018	2.18	2.24	2.34
08-02-2018	2.05	2.22	2.34
09-02-2018	0.85	1.34	1.97
10-02-2018	0.22	0.64	1.07
11-02-2018	0.44	0.86	1.10
12-02-2018	0.05	0.13	0.36
13-02-2018	0.11	0.46	0.91
14-02-2018	0.69	0.93	1.15
15-02-2018	0.14	0.58	0.91
16-02-2018	0.85	1.10	1.40
17-02-2018	0.36	0.78	1.29
18-02-2018	0.05	0.06	0.22
19-02-2018	0.05	0.05	0.05
20-02-2018	0.05	0.05	0.05
21-02-2018	0.05	0.07	0.08
22-02-2018	0.08	0.09	0.11
23-02-2018	0.11	0.14	0.19
24-02-2018	0.19	0.26	0.38
25-02-2018	0.27	0.47	0.58
26-02-2018	0.33	0.47	0.63
27-02-2018	0.63	0.76	0.88
28-02-2018	0.88	0.94	0.99
01-03-2018	0.58	0.77	0.91
02-03-2018	0.85	0.96	1.07
03-03-2018	0.88	0.96	1.04
04-03-2018	0.85	0.95	1.04
05-03-2018	0.96	1.06	1.13
06-03-2018	1.02	1.08	1.15
07-03-2018	0.69	0.84	0.99
08-03-2018	0.99	1.09	1.18
09-03-2018	1.04	1.14	1.24
10-03-2018	0.58	0.80	1.02
11-03-2018	0.77	0.90	1.02
12-03-2018	1.02	1.13	1.21
13-03-2018	1.13	1.27	1.34
14-03-2018	1.07	1.32	1.45

15-03-2018	1.13	1.25	1.34
16-03-2018	0.96	1.18	1.37
17-03-2018	1.24	1.37	1.48
18-03-2018	0.85	1.15	1.37
19-03-2018	1.34	1.48	1.62
20-03-2018	1.48	1.58	1.72
21-03-2018	1.18	1.46	1.62
22-03-2018	1.21	1.43	1.56
23-03-2018	0.91	1.10	1.21
24-03-2018	0.83	1.05	1.18
25-03-2018	0.72	1.07	1.29
26-03-2018	1.13	1.26	1.40
27-03-2018	1.24	1.43	1.70
28-03-2018	1.48	1.64	1.83
29-03-2018	1.56	1.68	1.83
30-03-2018	1.67	1.85	2.05
31-03-2018	1.32	1.62	1.86
01-04-2018	1.24	1.61	1.72
02-04-2018	0.44	0.95	1.29
03-04-2018	1.13	1.35	1.67
04-04-2018	1.37	1.60	1.83
05-04-2018	1.56	1.72	1.89
06-04-2018	1.81	1.99	2.24
07-04-2018	1.97	2.05	2.13
08-04-2018	1.94	2.15	2.42
09-04-2018	2.13	2.27	2.53
10-04-2018	2.10	2.24	2.48
11-04-2018	2.05	2.26	2.48
12-04-2018	1.97	2.23	2.50
13-04-2018	1.83	2.02	2.18
14-04-2018	2.07	2.30	2.58
15-04-2018	2.07	2.36	2.66
16-04-2018	2.32	2.48	2.80
17-04-2018	2.26	2.44	2.77
18-04-2018	2.07	2.33	2.61
19-04-2018	1.62	2.22	2.80
20-04-2018	2.24	2.48	2.77
21-04-2018	2.16	2.47	2.85
22-04-2018	1.62	2.19	2.82
23-04-2018	1.78	2.31	3.01
24-04-2018	1.97	2.55	3.22
25-04-2018	2.24	2.69	3.41
26-04-2018	2.29	2.71	3.49
27-04-2018	2.29	2.73	3.43
28-04-2018	2.48	2.60	2.77
29-04-2018	2.34	2.58	2.90
30-04-2018	2.50	2.82	3.30

01-05-2018	2.58	2.98	3.64
02-05-2018	2.34	2.99	3.85
03-05-2018	2.50	3.04	3.78
04-05-2018	2.66	2.97	3.46
05-05-2018	2.45	3.04	3.88
06-05-2018	2.74	3.14	3.83
07-05-2018	2.64	3.19	4.12
08-05-2018	2.61	3.25	4.19
09-05-2018	2.82	3.16	3.67
10-05-2018	2.74	3.31	4.14
11-05-2018	2.58	3.49	4.64
12-05-2018	2.85	3.70	4.95
13-05-2018	2.96	3.74	4.97
14-05-2018	2.96	3.84	5.15
15-05-2018	3.12	4.00	5.28
16-05-2018	3.22	4.21	5.64
17-05-2018	3.62	4.49	6.00
18-05-2018	3.46	4.34	5.21
19-05-2018	3.78	4.45	5.28
20-05-2018	3.99	4.37	4.92
21-05-2018	3.96	4.97	6.41
22-05-2018	3.99	5.27	6.89
23-05-2018	4.22	5.58	7.22
24-05-2018	4.69	5.78	7.09
25-05-2018	4.71	5.64	6.74
26-05-2018	4.12	5.34	6.54
27-05-2018	5.08	6.02	7.27
28-05-2018	5.02	6.03	7.04
29-05-2018	4.97	5.69	6.41
30-05-2018	3.78	5.04	6.13
31-05-2018	4.27	5.45	6.59
01-06-2018	4.48	5.20	5.62
02-06-2018	5.08	5.84	6.84
03-06-2018	5.39	5.96	6.54
04-06-2018	5.26	5.74	6.28
05-06-2018	4.35	5.11	5.67
06-06-2018	5.13	6.20	7.49
07-06-2018	5.44	6.46	7.34
08-06-2018	5.69	6.27	6.59
09-06-2018	5.36	5.83	6.41
10-06-2018	4.97	5.45	5.92
11-06-2018	4.74	5.45	6.23
12-06-2018	4.04	5.21	6.08
13-06-2018	5.49	5.78	6.18
14-06-2018	5.64	6.49	7.42
15-06-2018	5.85	7.06	8.37
16-06-2018	6.36	7.78	9.16

17-06-2018	7.12	8.45	9.76
18-06-2018	7.80	9.25	10.71
19-06-2018	8.72	10.05	11.42
20-06-2018	9.29	10.54	11.73
21-06-2018	9.73	10.62	11.54
22-06-2018	9.21	9.67	10.30
23-06-2018	8.69	9.33	10.15
24-06-2018	8.87	9.48	10.15
25-06-2018	7.92	8.52	9.16
26-06-2018	7.24	7.93	8.62
27-06-2018	6.89	7.92	8.84
28-06-2018	8.00	8.28	8.62
29-06-2018	7.85	8.25	8.74
30-06-2018	8.34	8.49	8.62
01-07-2018	8.32	8.73	9.36
02-07-2018	7.52	8.26	8.87
03-07-2018	7.19	8.28	9.26
04-07-2018	8.12	9.13	10.25
05-07-2018	9.68	10.48	11.42
06-07-2018	10.12	10.54	10.98
07-07-2018	9.56	9.88	10.17
08-07-2018	8.42	9.56	10.61
09-07-2018	9.06	9.89	10.57
10-07-2018	9.76	10.03	10.30
11-07-2018	9.66	10.53	11.54
12-07-2018	10.03	11.09	12.03
13-07-2018	10.47	11.41	12.20
14-07-2018	10.57	11.19	11.78
15-07-2018	9.83	10.94	11.90
16-07-2018	10.37	11.47	12.49
17-07-2018	11.13	12.06	12.87
18-07-2018	11.49	12.15	12.73
19-07-2018	11.54	11.88	12.22
20-07-2018	10.49	11.01	11.54
21-07-2018	8.82	9.82	10.64
22-07-2018	9.61	10.58	11.66
23-07-2018	10.57	11.44	12.27
24-07-2018	11.20	11.95	12.75
25-07-2018	11.44	12.25	13.02
26-07-2018	12.22	12.88	13.59
27-07-2018	12.29	12.90	13.47
28-07-2018	12.12	12.99	13.86
29-07-2018	12.51	13.37	14.17
30-07-2018	12.75	13.64	14.43
31-07-2018	13.21	13.86	14.43
01-08-2018	13.14	13.58	14.00
02-08-2018	12.63	12.92	13.38

Crabapple Creek (aka Blackwater)			
Date	Minimum Temperature (°C)	Average Temperature (°C)	Maximum Temperature (°C)
27-07-2017	10.66	11.24	11.93
28-07-2017	9.85	10.77	11.73
29-07-2017	10.08	10.91	11.81
30-07-2017	10.22	10.95	11.83
31-07-2017	10.12	11.04	12.07
01-08-2017	10.69	11.51	12.44
02-08-2017	11.27	11.95	12.80
03-08-2017	11.30	12.18	13.26
04-08-2017	11.86	12.38	12.97
05-08-2017	11.47	12.05	12.68
06-08-2017	11.30	12.12	13.02
07-08-2017	11.54	12.41	13.35
08-08-2017	12.00	12.80	13.67
09-08-2017	12.24	13.08	14.03
10-08-2017	12.46	13.33	14.27
11-08-2017	12.80	13.59	14.36
12-08-2017	12.58	13.15	13.71
13-08-2017	11.20	11.88	12.68
14-08-2017	9.76	10.34	11.03
15-08-2017	8.74	9.88	11.18
16-08-2017	10.08	10.73	11.71
17-08-2017	9.98	10.90	11.93
18-08-2017	10.91	11.15	11.42
19-08-2017	9.53	10.27	10.88
20-08-2017	9.71	10.32	11.22
21-08-2017	9.73	10.61	11.66
22-08-2017	10.61	11.45	12.46
23-08-2017	11.69	12.04	12.61
24-08-2017	10.15	11.03	11.90
25-08-2017	8.64	9.46	10.25
26-08-2017	8.67	9.75	11.03
27-08-2017	10.17	11.14	12.51
28-08-2017	10.98	11.87	12.94
29-08-2017	11.13	12.75	17.08
30-08-2017	11.52	13.67	17.34
31-08-2017	11.47	13.47	18.99
01-09-2017	11.22	13.63	20.22
02-09-2017	11.66	14.26	21.68
03-09-2017	12.51	14.90	23.64
04-09-2017	13.21	15.32	23.52
05-09-2017	14.05	15.08	16.23
06-09-2017	13.86	15.01	17.68
07-09-2017	13.09	14.75	16.82

08-09-2017	13.43	13.99	14.41
09-09-2017	9.85	11.20	13.38
10-09-2017	9.71	10.89	12.61
11-09-2017	10.39	11.99	14.48
12-09-2017	11.37	13.39	25.26
13-09-2017	9.26	11.02	23.55
14-09-2017	6.89	9.49	21.96
15-09-2017	6.31	8.84	16.18
16-09-2017	7.04	9.71	20.87
17-09-2017	6.46	8.15	9.93
18-09-2017	5.21	6.40	7.37
19-09-2017	3.88	5.74	7.62
20-09-2017	5.02	6.21	7.77
21-09-2017	5.28	6.68	8.30
22-09-2017	3.91	6.21	8.77
23-09-2017	6.51	8.42	15.15
24-09-2017	7.47	8.90	12.36
25-09-2017	8.57	9.45	10.98
26-09-2017	9.26	10.10	14.19
27-09-2017	8.57	10.02	13.40
28-09-2017	8.92	10.38	13.43
29-09-2017	9.36	10.19	10.66
30-09-2017	6.38	7.83	8.94
01-10-2017	5.82	6.60	7.47
02-10-2017	5.21	6.18	7.52
03-10-2017	2.96	4.71	6.56
04-10-2017	2.66	4.54	6.79
05-10-2017	3.78	5.67	8.22
06-10-2017	5.08	6.19	6.84
07-10-2017	4.17	5.47	6.48
08-10-2017	2.85	4.71	6.51
09-10-2017	3.46	4.95	6.79
10-10-2017	3.22	4.46	5.44
11-10-2017	3.14	3.67	4.51
12-10-2017	2.80	3.48	4.48
13-10-2017	0.88	1.72	3.27
14-10-2017	0.93	2.64	3.83
15-10-2017	3.49	4.52	5.69
16-10-2017	5.49	6.05	6.36
17-10-2017	3.67	5.52	6.46
18-10-2017	0.11	1.86	3.46
19-10-2017	3.09	3.86	4.35
20-10-2017	3.59	4.17	4.35
21-10-2017	2.10	3.23	3.64
22-10-2017	2.82	4.19	4.69
23-10-2017	4.12	4.72	5.28
24-10-2017	3.99	4.93	5.67

25-10-2017	5.59	6.15	6.56
26-10-2017	3.83	4.66	5.85
27-10-2017	3.64	4.78	6.03
28-10-2017	5.08	6.02	7.27
29-10-2017	4.97	6.03	6.89
30-10-2017	1.70	2.93	4.64
31-10-2017	1.29	2.93	4.95
01-11-2017	2.24	3.76	4.69
02-11-2017	-3.81	-0.45	4.09
03-11-2017	-5.57	-4.66	-3.66
04-11-2017	-5.48	-2.06	-0.40
05-11-2017	-2.60	-2.14	-1.56
06-11-2017	-3.87	-3.15	-2.57
07-11-2017	-3.33	-2.06	-1.07
08-11-2017	-1.61	-0.87	-0.20
09-11-2017	-0.48	-0.21	-0.03
10-11-2017	0.00	0.07	0.14
11-11-2017	0.11	0.28	0.50
12-11-2017	0.11	0.25	0.52
13-11-2017	0.00	0.38	0.88
14-11-2017	0.02	0.77	1.26
15-11-2017	0.02	0.07	0.14
16-11-2017	0.16	0.50	1.04
17-11-2017	0.50	0.73	1.21
18-11-2017	0.47	0.89	1.26
19-11-2017	0.00	0.52	1.18
20-11-2017	0.00	0.32	0.66
21-11-2017	0.33	0.63	0.96
22-11-2017	0.58	0.98	1.64
23-11-2017	1.43	2.23	2.61
24-11-2017	2.50	2.58	2.64
25-11-2017	2.18	2.66	2.93
26-11-2017	2.07	2.50	2.90
27-11-2017	2.18	2.30	2.45
28-11-2017	1.81	2.07	2.18
29-11-2017	1.89	2.02	2.13
30-11-2017	1.86	2.03	2.18
01-12-2017	1.45	1.79	2.05
02-12-2017	1.37	1.65	1.81
03-12-2017	-0.26	0.42	1.21
04-12-2017	-0.34	-0.09	0.11
05-12-2017	-0.42	-0.23	-0.12
06-12-2017	-0.14	0.04	0.25
07-12-2017	0.00	0.08	0.22
08-12-2017	0.05	0.15	0.27
09-12-2017	-0.40	-0.12	0.14
10-12-2017	-0.40	0.20	0.55

11-12-2017	0.25	0.55	0.99
12-12-2017	0.72	1.12	1.48
13-12-2017	0.41	0.93	1.21
14-12-2017	0.41	0.70	1.04
15-12-2017	0.80	1.41	1.86
16-12-2017	0.05	0.47	0.85
17-12-2017	0.55	0.72	0.93
18-12-2017	0.88	1.10	1.56
19-12-2017	-0.82	0.11	0.93
20-12-2017	-2.19	-0.98	0.00
21-12-2017	0.00	0.00	0.00
22-12-2017	-0.68	-0.31	0.00
23-12-2017	-0.48	-0.23	-0.20
24-12-2017	-0.48	-0.27	-0.20
25-12-2017	-0.93	-0.66	-0.51
26-12-2017	-1.07	-1.02	-0.96
27-12-2017	-1.04	-0.95	-0.82
28-12-2017	-0.82	-0.69	-0.54
29-12-2017	-0.51	-0.31	-0.17
30-12-2017	-0.14	-0.11	-0.09
31-12-2017	-0.09	-0.06	-0.06
01-01-2018	-0.06	-0.06	-0.06
02-01-2018	-0.06	-0.05	-0.03
03-01-2018	-0.03	-0.03	-0.03
04-01-2018	-0.03	-0.03	-0.03
05-01-2018	-0.03	-0.03	0.00
06-01-2018	-0.03	-0.01	0.00
07-01-2018	0.00	0.00	0.00
08-01-2018	0.00	0.00	0.00
09-01-2018	0.00	0.01	0.02
10-01-2018	0.02	0.04	0.05
11-01-2018	0.00	0.00	0.02
12-01-2018	0.00	0.00	0.00
13-01-2018	0.00	0.01	0.02
14-01-2018	0.02	0.05	0.08
15-01-2018	0.08	0.11	0.14
16-01-2018	0.14	0.37	0.83
17-01-2018	0.72	0.84	0.91
18-01-2018	0.83	1.32	1.56
19-01-2018	1.10	1.28	1.37
20-01-2018	0.52	0.90	1.07
21-01-2018	0.22	0.40	0.66
22-01-2018	0.38	0.63	0.85
23-01-2018	0.25	0.42	0.66
24-01-2018	0.02	0.23	0.38
25-01-2018	0.02	0.18	0.44
26-01-2018	-0.31	-0.03	0.08

27-01-2018	-0.73	-0.33	-0.06
28-01-2018	-0.06	-0.03	0.00
29-01-2018	0.00	0.01	0.38
30-01-2018	0.61	1.31	1.51
31-01-2018	0.88	1.13	1.34
01-02-2018	0.85	1.13	1.40
02-02-2018	0.85	1.24	1.43
03-02-2018	1.40	1.64	1.81
04-02-2018	1.56	1.81	2.02
05-02-2018	1.94	2.06	2.18
06-02-2018	1.78	1.97	2.10
07-02-2018	1.97	2.10	2.24
08-02-2018	1.91	2.16	2.29
09-02-2018	0.16	0.86	1.81
10-02-2018	-0.06	0.01	0.11
11-02-2018	-0.12	0.05	0.11
12-02-2018	-0.17	-0.02	0.00
13-02-2018	0.00	0.00	0.00
14-02-2018	0.00	0.02	0.05
15-02-2018	-0.06	0.00	0.05
16-02-2018	0.05	0.09	0.16
17-02-2018	-0.03	0.08	0.16
18-02-2018	-0.48	-0.05	0.00
19-02-2018	0.00	0.00	0.00
20-02-2018	-0.06	-0.01	0.00
21-02-2018	-0.62	-0.47	-0.12
22-02-2018	-0.68	-0.58	-0.45
23-02-2018	-0.62	-0.50	-0.28
24-02-2018	-0.26	-0.18	-0.09
25-02-2018	-0.09	-0.05	-0.03
26-02-2018	-0.03	-0.01	0.00
27-02-2018	0.00	0.02	0.05
28-02-2018	0.05	0.09	0.11
01-03-2018	0.05	0.09	0.11
02-03-2018	0.11	0.13	0.16
03-03-2018	0.14	0.15	0.16
04-03-2018	0.14	0.16	0.19
05-03-2018	0.16	0.19	0.22
06-03-2018	0.16	0.19	0.22
07-03-2018	0.11	0.14	0.19
08-03-2018	0.19	0.20	0.22
09-03-2018	0.16	0.17	0.19
10-03-2018	0.05	0.10	0.14
11-03-2018	0.08	0.10	0.14
12-03-2018	0.14	0.14	0.14
13-03-2018	0.14	0.16	0.16
14-03-2018	0.11	0.16	0.19

15-03-2018	0.08	0.12	0.16
16-03-2018	0.08	0.11	0.14
17-03-2018	0.14	0.16	0.19
18-03-2018	0.11	0.17	0.25
19-03-2018	0.25	0.29	0.36
20-03-2018	0.33	0.38	0.47
21-03-2018	0.19	0.35	0.50
22-03-2018	0.19	0.34	0.41
23-03-2018	0.05	0.13	0.16
24-03-2018	-0.03	0.11	0.25
25-03-2018	-0.03	0.17	0.36
26-03-2018	0.14	0.26	0.38
27-03-2018	0.36	1.35	7.39
28-03-2018	0.72	1.56	3.41
29-03-2018	0.88	1.64	2.96
30-03-2018	0.83	2.40	11.22
31-03-2018	-0.42	1.13	3.22
01-04-2018	-0.14	1.20	3.56
02-04-2018	-2.77	-0.41	2.77
03-04-2018	-0.03	1.04	5.69
04-04-2018	0.19	1.24	2.98
05-04-2018	0.66	1.23	1.94
06-04-2018	1.07	1.58	2.45
07-04-2018	1.21	1.67	1.97
08-04-2018	1.70	1.98	2.50
09-04-2018	1.94	2.13	2.40
10-04-2018	1.91	2.03	2.29
11-04-2018	1.94	2.10	2.34
12-04-2018	1.78	1.98	2.34
13-04-2018	1.53	1.78	2.05
14-04-2018	1.89	2.08	2.42
15-04-2018	1.70	2.05	2.53
16-04-2018	1.94	2.25	2.88
17-04-2018	1.94	2.23	2.69
18-04-2018	1.75	2.13	3.54
19-04-2018	0.96	1.96	3.17
20-04-2018	1.94	2.33	3.06
21-04-2018	1.94	2.21	2.56
22-04-2018	1.10	1.79	3.09
23-04-2018	0.96	1.77	3.06
24-04-2018	1.67	2.20	2.77
25-04-2018	2.02	2.35	2.82
26-04-2018	2.16	2.43	2.90
27-04-2018	2.21	2.59	3.09
28-04-2018	2.45	2.58	2.85
29-04-2018	2.24	2.50	2.90
30-04-2018	2.40	2.75	3.33

01-05-2018	2.45	2.86	3.41
02-05-2018	2.37	2.97	3.91
03-05-2018	2.56	3.03	3.85
04-05-2018	2.85	3.20	3.72
05-05-2018	2.58	3.16	4.06
06-05-2018	2.90	3.28	3.88
07-05-2018	2.93	3.51	4.40
08-05-2018	3.01	3.58	4.51
09-05-2018	3.27	3.62	4.04
10-05-2018	3.06	3.70	4.51
11-05-2018	2.98	3.96	5.13
12-05-2018	3.43	4.34	5.59
13-05-2018	3.78	4.62	5.77
14-05-2018	3.93	4.89	6.18
15-05-2018	4.27	5.26	6.51
16-05-2018	4.51	5.62	7.12
17-05-2018	4.97	5.94	7.39
18-05-2018	5.02	5.96	7.12
19-05-2018	5.46	6.14	7.19
20-05-2018	5.54	6.03	6.76
21-05-2018	5.36	6.33	7.72
22-05-2018	5.49	6.71	8.22
23-05-2018	5.80	7.05	8.52
24-05-2018	6.31	7.28	8.39
25-05-2018	6.10	6.91	7.77
26-05-2018	5.13	6.25	7.32
27-05-2018	6.03	6.81	7.90
28-05-2018	5.98	6.72	7.57
29-05-2018	5.59	6.19	6.71
30-05-2018	4.38	5.44	6.59
31-05-2018	4.66	5.80	6.97
01-06-2018	5.39	5.82	6.18
02-06-2018	5.46	6.36	7.59
03-06-2018	6.10	6.61	7.14
04-06-2018	5.59	6.01	6.59
05-06-2018	4.53	5.31	5.95
06-06-2018	5.44	6.50	7.82
07-06-2018	6.00	7.13	8.39
08-06-2018	6.00	6.69	7.07
09-06-2018	5.54	5.88	6.36
10-06-2018	4.92	5.48	6.41
11-06-2018	4.74	5.55	6.66
12-06-2018	4.17	5.51	6.46
13-06-2018	5.75	6.07	6.56
14-06-2018	5.92	6.78	7.95
15-06-2018	6.15	7.44	8.99
16-06-2018	6.59	8.12	9.71

17-06-2018	7.85	9.28	10.93
18-06-2018	8.72	10.25	12.07
19-06-2018	9.81	11.28	13.45
20-06-2018	10.49	11.83	13.38
21-06-2018	10.91	12.09	14.34
22-06-2018	9.95	10.71	11.37
23-06-2018	9.31	10.42	13.28
24-06-2018	9.41	10.20	11.42
25-06-2018	7.92	8.70	9.66
26-06-2018	7.29	8.15	10.32
27-06-2018	6.89	8.20	9.56
28-06-2018	8.15	8.60	9.24
29-06-2018	8.02	8.76	10.12
30-06-2018	8.77	8.94	9.19
01-07-2018	8.52	9.16	11.61
02-07-2018	7.22	8.34	9.85
03-07-2018	7.14	8.90	11.64
04-07-2018	8.30	10.22	12.49
05-07-2018	10.03	11.64	14.75
06-07-2018	10.35	11.31	12.58
07-07-2018	9.63	10.15	11.54
08-07-2018	8.17	10.36	13.33
09-07-2018	9.16	10.70	12.41
10-07-2018	10.05	10.72	11.86
11-07-2018	9.85	11.77	15.94
12-07-2018	10.54	12.86	18.03
13-07-2018	10.91	13.20	18.01
14-07-2018	10.93	12.57	16.94
15-07-2018	9.68	12.50	17.77
16-07-2018	10.64	13.39	18.41
17-07-2018	11.61	14.15	19.34
18-07-2018	12.12	14.10	18.68
19-07-2018	11.66	12.80	14.05
20-07-2018	10.15	11.23	13.93
21-07-2018	7.47	10.10	13.50
22-07-2018	9.39	12.05	18.30
23-07-2018	10.83	13.31	18.84
24-07-2018	11.54	13.61	17.61
25-07-2018	11.66	14.06	19.34
26-07-2018	12.53	14.62	18.60
27-07-2018	12.41	14.62	19.01
28-07-2018	12.32	14.73	19.18
29-07-2018	12.70	14.91	19.41
30-07-2018	12.87	15.40	19.94
31-07-2018	13.40	15.77	20.96
01-08-2018	13.57	15.36	20.46
02-08-2018	12.63	13.80	17.06

Jordan Creek			
Date	Minimum Temperature	Average Temperature	Maximum Temperature
27-07-2017	14.27	15.35	16.70
28-07-2017	14.84	15.60	16.87
29-07-2017	15.01	15.86	16.56
30-07-2017	14.91	15.90	16.96
31-07-2017	15.82	16.61	17.34
01-08-2017	16.53	17.20	18.41
02-08-2017	16.37	17.01	18.06
03-08-2017	16.25	16.70	17.39
04-08-2017	16.42	17.01	18.01
05-08-2017	15.87	16.47	16.87
06-08-2017	15.94	16.40	17.25
07-08-2017	16.34	16.76	17.37
08-08-2017	16.68	17.17	17.96
09-08-2017	16.89	17.33	18.20
10-08-2017	17.13	17.56	18.11
11-08-2017	17.53	17.99	18.77
12-08-2017	17.46	17.89	18.49
13-08-2017	16.84	17.15	17.82
14-08-2017	16.65	16.86	17.11
15-08-2017	16.25	16.78	17.42
16-08-2017	16.51	16.76	17.18
17-08-2017	16.39	16.97	17.89
18-08-2017	16.63	16.82	17.08
19-08-2017	16.30	16.77	17.32
20-08-2017	16.39	16.75	17.30
21-08-2017	16.46	17.10	18.08
22-08-2017	16.92	17.52	18.01
23-08-2017	17.18	17.51	17.84
24-08-2017	16.77	17.11	17.42
25-08-2017	16.46	16.80	17.25
26-08-2017	16.25	16.96	17.61
27-08-2017	16.70	17.56	18.51
28-08-2017	17.27	18.12	19.06
29-08-2017	17.58	18.25	19.06
30-08-2017	17.51	17.83	18.20
31-08-2017	17.25	17.71	18.56
01-09-2017	17.25	17.79	18.51
02-09-2017	17.42	18.05	18.68
03-09-2017	17.84	18.50	19.06
04-09-2017	18.27	18.98	19.77
05-09-2017	18.58	18.85	19.18
06-09-2017	18.27	18.56	18.99
07-09-2017	17.99	18.22	18.49

08-09-2017	17.80	17.95	18.06
09-09-2017	17.08	17.39	17.77
10-09-2017	16.89	17.02	17.23
11-09-2017	16.65	16.93	17.25
12-09-2017	16.80	17.13	17.72
13-09-2017	16.49	16.75	17.03
14-09-2017	15.96	16.37	16.73
15-09-2017	15.70	16.18	16.80
16-09-2017	15.58	15.89	16.30
17-09-2017	15.10	15.46	15.65
18-09-2017	14.75	14.98	15.13
19-09-2017	14.43	14.66	14.98
20-09-2017	14.24	14.65	15.25
21-09-2017	14.17	14.41	14.67
22-09-2017	13.79	14.22	14.75
23-09-2017	13.93	14.21	14.55
24-09-2017	13.98	14.22	14.55
25-09-2017	14.07	14.29	14.63
26-09-2017	14.22	14.67	15.56
27-09-2017	14.24	14.80	15.34
28-09-2017	14.27	14.87	15.56
29-09-2017	14.24	14.54	14.82
30-09-2017	13.64	13.88	14.17
01-10-2017	13.47	13.70	13.98
02-10-2017	13.19	13.36	13.52
03-10-2017	12.80	13.11	13.50
04-10-2017	12.51	12.92	13.35
05-10-2017	12.51	12.97	13.55
06-10-2017	12.68	12.87	12.97
07-10-2017	12.39	12.64	12.85
08-10-2017	12.15	12.55	13.06
09-10-2017	12.15	12.46	12.85
10-10-2017	11.98	12.26	12.39
11-10-2017	11.76	11.89	12.00
12-10-2017	11.64	11.76	11.93
13-10-2017	11.01	11.27	11.66
14-10-2017	11.03	11.21	11.39
15-10-2017	11.22	11.42	11.69
16-10-2017	10.66	11.28	11.49
17-10-2017	10.05	10.21	10.57
18-10-2017	9.14	9.58	10.03
19-10-2017	8.74	9.06	9.26
20-10-2017	8.34	8.55	8.72
21-10-2017	8.05	8.22	8.34
22-10-2017	7.85	7.95	8.05
23-10-2017	7.77	7.84	7.95
24-10-2017	7.80	8.02	8.42

25-10-2017	7.75	7.88	8.07
26-10-2017	7.72	7.87	8.02
27-10-2017	7.52	7.72	7.85
28-10-2017	7.49	7.80	8.17
29-10-2017	7.52	7.70	7.87
30-10-2017	7.24	7.38	7.49
31-10-2017	7.14	7.23	7.34
01-11-2017	7.07	7.28	7.65
02-11-2017	6.41	6.77	7.19
03-11-2017	5.95	6.20	6.38
04-11-2017	5.46	5.73	5.87
05-11-2017	5.23	5.36	5.46
06-11-2017	4.82	5.02	5.26
07-11-2017	4.69	4.80	4.87
08-11-2017	4.64	4.74	4.84
09-11-2017	4.56	4.70	4.77
10-11-2017	4.77	4.84	4.97
11-11-2017	4.79	4.89	5.00
12-11-2017	4.35	4.58	4.79
13-11-2017	3.96	4.12	4.35
14-11-2017	4.01	4.18	4.27
15-11-2017	4.09	4.15	4.19
16-11-2017	4.12	4.15	4.19
17-11-2017	4.12	4.14	4.19
18-11-2017	4.14	4.17	4.22
19-11-2017	4.01	4.12	4.17
20-11-2017	4.12	4.20	4.25
21-11-2017	4.14	4.19	4.25
22-11-2017	3.51	3.87	4.17
23-11-2017	3.30	3.46	3.62
24-11-2017	3.30	3.34	3.35
25-11-2017	3.35	3.41	3.49
26-11-2017	3.27	3.35	3.41
27-11-2017	3.38	3.41	3.46
28-11-2017	3.33	3.39	3.46
29-11-2017	3.25	3.28	3.33
30-11-2017	3.20	3.26	3.30
01-12-2017	3.09	3.21	3.27
02-12-2017	2.85	3.04	3.17
03-12-2017	2.10	2.40	2.77
04-12-2017	2.16	2.31	2.40
05-12-2017	2.29	2.36	2.42
06-12-2017	2.37	2.43	2.48
07-12-2017	2.40	2.46	2.50
08-12-2017	2.45	2.50	2.56
09-12-2017	2.45	2.49	2.56
10-12-2017	2.45	2.52	2.58

11-12-2017	2.48	2.53	2.61
12-12-2017	2.48	2.54	2.61
13-12-2017	2.45	2.56	2.64
14-12-2017	2.53	2.60	2.66
15-12-2017	2.64	2.66	2.72
16-12-2017	2.48	2.54	2.61
17-12-2017	2.42	2.47	2.50
18-12-2017	2.40	2.46	2.50
19-12-2017	2.26	2.36	2.45
20-12-2017	2.05	2.11	2.26
21-12-2017	1.94	2.01	2.05
22-12-2017	1.78	1.88	2.02
23-12-2017	1.64	1.72	1.81
24-12-2017	1.70	1.78	1.83
25-12-2017	1.62	1.70	1.78
26-12-2017	1.53	1.63	1.81
27-12-2017	1.48	1.53	1.59
28-12-2017	1.21	1.35	1.48
29-12-2017	0.83	1.20	1.34
30-12-2017	1.04	1.20	1.26
31-12-2017	1.04	1.10	1.18
01-01-2018	1.02	1.04	1.10
02-01-2018	0.77	1.04	1.13
03-01-2018	1.02	1.09	1.15
04-01-2018	1.07	1.13	1.21
05-01-2018	1.15	1.22	1.29
06-01-2018	1.18	1.29	1.40
07-01-2018	1.26	1.32	1.34
08-01-2018	1.32	1.37	1.43
09-01-2018	1.37	1.43	1.48
10-01-2018	1.45	1.48	1.53
11-01-2018	1.21	1.34	1.45
12-01-2018	1.07	1.15	1.18
13-01-2018	0.99	1.20	1.29
14-01-2018	1.24	1.28	1.32
15-01-2018	1.32	1.36	1.43
16-01-2018	1.37	1.48	1.53
17-01-2018	1.48	1.56	1.62
18-01-2018	1.62	1.67	1.72
19-01-2018	1.75	1.80	1.86
20-01-2018	1.86	1.89	1.94
21-01-2018	1.91	1.93	1.97
22-01-2018	1.91	1.95	1.99
23-01-2018	1.91	1.95	1.97
24-01-2018	1.72	1.91	1.97
25-01-2018	1.83	1.90	1.97
26-01-2018	1.72	1.83	1.89

27-01-2018	1.67	1.73	1.78
28-01-2018	1.34	1.55	1.70
29-01-2018	1.51	1.60	1.70
30-01-2018	1.53	1.61	1.67
31-01-2018	1.64	1.67	1.70
01-02-2018	1.67	1.69	1.72
02-02-2018	1.67	1.75	1.81
03-02-2018	1.78	1.82	1.89
04-02-2018	1.86	1.90	1.94
05-02-2018	1.91	1.99	2.05
06-02-2018	2.05	2.15	2.21
07-02-2018	2.21	2.27	2.32
08-02-2018	2.32	2.37	2.45
09-02-2018	2.42	2.48	2.53
10-02-2018	2.16	2.23	2.40
11-02-2018	1.97	2.09	2.18
12-02-2018	1.78	1.86	1.97
13-02-2018	1.70	1.77	1.83
14-02-2018	1.67	1.74	1.81
15-02-2018	1.56	1.61	1.67
16-02-2018	1.56	1.62	1.70
17-02-2018	1.40	1.54	1.64
18-02-2018	1.10	1.26	1.40
19-02-2018	1.02	1.09	1.15
20-02-2018	0.88	0.95	1.04
21-02-2018	0.83	0.92	1.04
22-02-2018	0.80	0.89	1.07
23-02-2018	0.80	0.88	0.96
24-02-2018	0.77	0.88	1.04
25-02-2018	0.83	0.95	1.13
26-02-2018	0.77	0.88	1.07
27-02-2018	0.91	0.98	1.10
28-02-2018	1.02	1.07	1.15
01-03-2018	0.85	1.08	1.21
02-03-2018	0.99	1.12	1.34
03-03-2018	0.96	1.12	1.43
04-03-2018	1.02	1.13	1.32
05-03-2018	0.83	1.16	1.32
06-03-2018	1.10	1.27	1.70
07-03-2018	0.96	1.15	1.51
08-03-2018	1.10	1.24	1.37
09-03-2018	1.10	1.25	1.40
10-03-2018	1.02	1.20	1.62
11-03-2018	1.02	1.25	1.72
12-03-2018	1.10	1.34	1.83
13-03-2018	1.21	1.40	1.64
14-03-2018	1.40	1.46	1.62

15-03-2018	1.34	1.52	1.89
16-03-2018	1.45	1.65	2.05
17-03-2018	1.67	1.78	1.94
18-03-2018	1.67	1.93	2.32
19-03-2018	1.94	2.07	2.21
20-03-2018	2.07	2.16	2.32
21-03-2018	2.07	2.23	2.45
22-03-2018	2.24	2.30	2.34
23-03-2018	2.21	2.28	2.48
24-03-2018	2.16	2.28	2.58
25-03-2018	2.16	2.30	2.50
26-03-2018	2.24	2.33	2.48
27-03-2018	2.26	2.43	2.72
28-03-2018	2.50	2.66	2.88
29-03-2018	2.69	2.75	2.82
30-03-2018	2.74	2.86	3.09
31-03-2018	2.85	3.01	3.27
01-04-2018	3.01	3.11	3.30
02-04-2018	3.04	3.22	3.49
03-04-2018	3.17	3.26	3.43
04-04-2018	3.20	3.30	3.46
05-04-2018	3.25	3.32	3.46
06-04-2018	3.27	3.37	3.54
07-04-2018	3.33	3.40	3.49
08-04-2018	3.43	3.55	3.62
09-04-2018	3.59	3.73	3.85
10-04-2018	3.72	3.84	3.88
11-04-2018	3.64	3.74	3.85
12-04-2018	3.59	3.78	3.93
13-04-2018	3.64	3.76	3.83
14-04-2018	3.62	3.81	4.06
15-04-2018	3.41	4.13	4.95
16-04-2018	3.93	4.53	5.00
17-04-2018	3.83	4.12	4.51
18-04-2018	4.48	4.89	5.39
19-04-2018	4.71	5.01	5.28
20-04-2018	5.05	5.31	5.62
21-04-2018	4.82	5.19	5.57
22-04-2018	5.28	6.06	6.86
23-04-2018	6.05	6.93	8.05
24-04-2018	6.56	7.24	7.90
25-04-2018	7.12	7.95	9.16
26-04-2018	7.32	7.98	8.99
27-04-2018	5.82	7.23	8.15
28-04-2018	5.95	6.24	6.74
29-04-2018	5.67	5.82	6.00
30-04-2018	5.75	5.96	6.28

01-05-2018	6.03	6.67	7.62
02-05-2018	6.43	7.09	7.57
03-05-2018	6.74	7.35	8.00
04-05-2018	6.08	6.65	7.19
05-05-2018	6.79	7.82	9.14
06-05-2018	6.81	7.51	7.90
07-05-2018	6.28	6.72	7.54
08-05-2018	6.54	7.16	8.20
09-05-2018	5.67	6.10	6.94
10-05-2018	5.67	6.20	6.91
11-05-2018	6.71	7.53	8.99
12-05-2018	7.27	8.12	9.56
13-05-2018	7.19	7.78	8.92
14-05-2018	6.79	7.19	8.05
15-05-2018	6.46	7.09	8.10
16-05-2018	6.20	6.77	7.27
17-05-2018	6.61	7.05	7.62
18-05-2018	6.81	8.17	9.51
19-05-2018	6.81	7.60	8.30
20-05-2018	6.71	7.11	7.57
21-05-2018	6.89	7.53	8.94
22-05-2018	7.67	8.71	9.44
23-05-2018	8.22	8.78	9.63
24-05-2018	7.52	8.54	10.10
25-05-2018	7.65	8.48	9.09
26-05-2018	7.85	8.50	8.99
27-05-2018	8.27	8.99	10.32
28-05-2018	8.47	9.33	10.64
29-05-2018	8.57	9.24	10.25
30-05-2018	8.77	9.53	10.44
31-05-2018	9.21	9.78	10.54
01-06-2018	8.87	9.17	9.71
02-06-2018	8.92	9.42	10.54
03-06-2018	9.06	9.57	10.22
04-06-2018	8.74	9.12	9.71
05-06-2018	8.69	9.34	9.85
06-06-2018	8.67	9.43	10.59
07-06-2018	9.19	9.87	10.69
08-06-2018	8.89	9.47	10.37
09-06-2018	8.52	9.06	9.90
10-06-2018	8.74	9.21	9.78
11-06-2018	8.94	9.42	10.15
12-06-2018	8.89	9.46	9.88
13-06-2018	8.89	9.26	9.53
14-06-2018	8.87	9.42	10.12
15-06-2018	10.10	10.91	12.32
16-06-2018	11.08	12.19	13.59

17-06-2018	10.91	11.93	13.50
18-06-2018	10.86	12.03	14.24
19-06-2018	10.59	11.36	12.32
20-06-2018	11.25	11.79	12.75
21-06-2018	10.39	11.36	11.98
22-06-2018	10.74	11.07	11.71
23-06-2018	10.66	11.12	11.95
24-06-2018	11.32	11.70	12.00
25-06-2018	10.74	11.05	11.98
26-06-2018	10.54	11.11	12.22
27-06-2018	11.10	11.48	12.27
28-06-2018	10.83	11.15	11.54
29-06-2018	10.79	11.05	11.44
30-06-2018	10.93	11.17	11.47
01-07-2018	10.66	11.24	12.36
02-07-2018	11.37	11.83	12.78
03-07-2018	11.52	11.97	12.70
04-07-2018	12.07	13.00	14.34
05-07-2018	12.61	13.81	15.44
06-07-2018	12.70	13.37	14.60
07-07-2018	12.36	12.92	13.45
08-07-2018	12.85	13.44	14.10
09-07-2018	12.85	13.56	14.15
10-07-2018	12.82	13.16	13.88
11-07-2018	13.79	14.36	15.20
12-07-2018	14.03	15.08	16.39
13-07-2018	14.27	15.54	16.63
14-07-2018	15.53	16.23	17.70
15-07-2018	15.34	15.99	16.84
16-07-2018	15.82	16.43	17.32
17-07-2018	15.72	16.75	17.58
18-07-2018	15.58	16.55	17.15
19-07-2018	15.92	16.63	17.56
20-07-2018	15.96	16.39	16.73
21-07-2018	15.77	16.26	16.94
22-07-2018	15.80	16.71	17.68
23-07-2018	16.75	17.52	18.58
24-07-2018	17.27	18.00	19.44
25-07-2018	17.44	18.17	19.06
26-07-2018	18.15	18.74	20.06
27-07-2018	18.32	19.05	20.15
28-07-2018	18.34	18.90	19.53
29-07-2018	18.72	19.47	20.15
30-07-2018	19.08	19.82	20.58
31-07-2018	19.01	19.52	20.17
01-08-2018	18.84	19.23	19.60

River of Golden Dreams			
Date	Minimum Temperature	Average Temperature	Maximum Temperature
27-07-2017	10.96	12.21	13.74
28-07-2017	10.52	12.10	13.64
29-07-2017	10.98	12.50	14.03
30-07-2017	11.35	12.67	14.05
31-07-2017	11.20	12.71	14.22
01-08-2017	11.76	13.08	14.34
02-08-2017	12.00	13.04	14.19
03-08-2017	11.83	13.17	14.55
04-08-2017	12.32	13.28	14.15
05-08-2017	11.86	12.81	13.76
06-08-2017	11.90	13.00	14.03
07-08-2017	12.22	13.36	14.41
08-08-2017	12.61	13.66	14.60
09-08-2017	12.75	13.89	14.94
10-08-2017	13.09	14.31	15.39
11-08-2017	13.76	14.80	15.80
12-08-2017	13.83	14.68	15.53
13-08-2017	12.99	13.86	14.53
14-08-2017	11.49	12.28	12.97
15-08-2017	11.08	12.24	13.47
16-08-2017	11.98	12.71	13.59
17-08-2017	11.76	12.88	14.05
18-08-2017	12.58	13.04	13.64
19-08-2017	11.27	12.29	13.19
20-08-2017	11.61	12.39	13.33
21-08-2017	11.57	12.52	13.52
22-08-2017	11.90	13.00	14.19
23-08-2017	12.75	13.43	14.12
24-08-2017	12.03	12.81	13.40
25-08-2017	10.66	11.58	12.46
26-08-2017	10.66	11.85	13.02
27-08-2017	11.49	12.58	13.79
28-08-2017	11.98	13.00	14.12
29-08-2017	12.03	13.09	14.15
30-08-2017	11.81	12.77	13.57
31-08-2017	11.90	12.72	13.55
01-09-2017	12.03	12.92	13.79
02-09-2017	12.12	13.22	14.31
03-09-2017	12.51	13.44	14.22
04-09-2017	12.51	13.47	14.36
05-09-2017	12.85	13.34	13.79
06-09-2017	12.51	13.11	13.67
07-09-2017	12.39	12.99	13.43

08-09-2017	12.87	13.06	13.35
09-09-2017	11.57	12.23	12.87
10-09-2017	11.15	11.81	12.58
11-09-2017	11.37	12.19	12.97
12-09-2017	11.93	12.61	13.40
13-09-2017	11.18	11.83	12.41
14-09-2017	9.68	10.69	11.57
15-09-2017	8.97	10.09	11.03
16-09-2017	8.97	9.97	10.81
17-09-2017	8.79	9.27	9.95
18-09-2017	8.30	8.78	9.36
19-09-2017	8.15	8.87	9.56
20-09-2017	7.82	8.70	9.26
21-09-2017	8.49	9.09	9.71
22-09-2017	7.85	8.81	9.58
23-09-2017	8.72	9.40	10.10
24-09-2017	8.89	9.52	10.15
25-09-2017	9.51	9.92	10.39
26-09-2017	9.98	10.56	11.37
27-09-2017	9.39	10.28	11.05
28-09-2017	9.24	10.11	10.88
29-09-2017	9.41	9.94	10.22
30-09-2017	8.59	9.02	9.39
01-10-2017	8.00	8.44	8.87
02-10-2017	7.75	8.15	8.54
03-10-2017	6.94	7.59	8.15
04-10-2017	6.51	7.20	7.77
05-10-2017	6.33	7.15	7.87
06-10-2017	6.97	7.26	7.67
07-10-2017	6.71	7.10	7.57
08-10-2017	6.59	7.22	7.80
09-10-2017	6.51	7.18	7.85
10-10-2017	6.79	7.05	7.34
11-10-2017	6.38	6.62	6.94
12-10-2017	6.15	6.45	6.81
13-10-2017	5.28	5.82	6.38
14-10-2017	5.13	5.63	6.10
15-10-2017	5.87	6.22	6.71
16-10-2017	6.10	6.23	6.56
17-10-2017	5.41	6.12	6.46
18-10-2017	1.81	3.71	5.28
19-10-2017	3.14	3.89	4.30
20-10-2017	4.32	4.74	5.26
21-10-2017	3.88	4.44	4.82
22-10-2017	3.54	4.29	4.90
23-10-2017	4.64	5.13	5.72
24-10-2017	4.79	5.20	5.62

25-10-2017	4.84	5.22	5.49
26-10-2017	4.27	4.82	5.33
27-10-2017	4.58	5.09	5.72
28-10-2017	4.90	5.43	6.13
29-10-2017	4.77	5.34	5.72
30-10-2017	3.64	4.10	4.61
31-10-2017	3.54	4.12	4.74
01-11-2017	4.43	4.79	5.23
02-11-2017	1.97	3.29	5.00
03-11-2017	1.43	1.63	1.86
04-11-2017	1.51	1.61	1.72
05-11-2017	1.32	1.42	1.51
06-11-2017	1.21	1.57	2.24
07-11-2017	1.51	1.67	1.91
08-11-2017	1.67	1.87	2.32
09-11-2017	1.81	2.14	2.66
10-11-2017	2.58	2.84	3.14
11-11-2017	2.82	3.13	3.41
12-11-2017	2.16	2.58	3.09
13-11-2017	1.72	2.16	2.34
14-11-2017	1.04	2.06	2.56
15-11-2017	1.10	1.58	2.16
16-11-2017	1.81	2.23	2.61
17-11-2017	2.34	2.48	2.69
18-11-2017	2.34	2.60	2.85
19-11-2017	1.07	2.07	2.72
20-11-2017	1.40	2.17	2.66
21-11-2017	2.05	2.38	2.61
22-11-2017	0.14	0.90	1.94
23-11-2017	0.25	1.83	2.61
24-11-2017	2.64	2.75	2.90
25-11-2017	2.69	2.97	3.22
26-11-2017	2.48	2.62	2.74
27-11-2017	2.37	2.57	2.85
28-11-2017	2.16	2.45	2.61
29-11-2017	2.48	2.59	2.77
30-11-2017	2.48	2.69	2.96
01-12-2017	2.16	2.47	2.72
02-12-2017	2.18	2.35	2.53
03-12-2017	1.62	1.99	2.29
04-12-2017	1.51	1.68	1.94
05-12-2017	1.40	1.57	1.86
06-12-2017	1.45	1.66	1.99
07-12-2017	1.51	1.68	1.91
08-12-2017	1.62	1.73	1.91
09-12-2017	1.48	1.61	1.72
10-12-2017	1.48	1.73	2.05

11-12-2017	1.64	1.78	1.99
12-12-2017	1.59	1.77	2.05
13-12-2017	1.51	1.77	1.99
14-12-2017	1.56	1.73	1.91
15-12-2017	1.78	2.05	2.32
16-12-2017	1.70	1.81	1.89
17-12-2017	1.56	1.68	1.75
18-12-2017	1.64	1.89	2.02
19-12-2017	1.26	1.63	1.99
20-12-2017	0.66	0.87	1.18
21-12-2017	0.58	0.74	0.96
22-12-2017	0.50	0.76	0.96
23-12-2017	0.36	0.44	0.55
24-12-2017	0.30	0.40	0.52
25-12-2017	0.38	0.46	0.55
26-12-2017	0.41	0.51	0.66
27-12-2017	0.47	0.54	0.63
28-12-2017	0.14	0.35	0.52
29-12-2017	0.02	0.37	0.52
30-12-2017	0.08	0.34	0.52
31-12-2017	0.33	0.43	0.52
01-01-2018	0.36	0.45	0.61
02-01-2018	0.41	0.55	0.74
03-01-2018	0.47	0.60	0.74
04-01-2018	0.52	0.69	0.85
05-01-2018	0.36	0.79	1.02
06-01-2018	0.25	0.37	0.47
07-01-2018	0.47	0.78	1.04
08-01-2018	0.88	1.09	1.24
09-01-2018	0.91	1.15	1.34
10-01-2018	1.18	1.28	1.45
11-01-2018	0.25	0.61	1.13
12-01-2018	0.19	0.34	0.47
13-01-2018	0.22	0.71	1.04
14-01-2018	0.80	1.20	1.62
15-01-2018	1.24	1.30	1.40
16-01-2018	1.21	1.29	1.32
17-01-2018	1.13	1.26	1.32
18-01-2018	1.18	1.31	1.51
19-01-2018	1.34	1.49	1.67
20-01-2018	1.18	1.45	1.72
21-01-2018	1.13	1.26	1.43
22-01-2018	1.21	1.36	1.53
23-01-2018	1.24	1.37	1.45
24-01-2018	0.72	1.10	1.34
25-01-2018	0.99	1.30	1.62
26-01-2018	0.99	1.14	1.40

27-01-2018	0.99	1.10	1.18
28-01-2018	0.30	0.70	1.21
29-01-2018	0.44	0.54	0.69
30-01-2018	0.77	1.20	1.48
31-01-2018	1.18	1.31	1.56
01-02-2018	1.18	1.37	1.62
02-02-2018	1.07	1.49	1.72
03-02-2018	1.70	1.86	2.16
04-02-2018	1.56	1.78	2.05
05-02-2018	1.70	1.93	2.32
06-02-2018	1.75	1.96	2.18
07-02-2018	1.97	2.13	2.40
08-02-2018	1.78	2.04	2.32
09-02-2018	1.18	1.51	1.78
10-02-2018	0.80	1.17	1.62
11-02-2018	1.07	1.42	1.86
12-02-2018	0.83	1.11	1.48
13-02-2018	1.02	1.26	1.75
14-02-2018	1.13	1.51	2.21
15-02-2018	0.80	1.21	1.62
16-02-2018	1.21	1.55	2.10
17-02-2018	0.61	1.06	1.64
18-02-2018	0.30	0.53	0.88
19-02-2018	0.30	0.53	0.96
20-02-2018	0.27	0.51	0.93
21-02-2018	0.25	0.44	0.72
22-02-2018	0.19	0.45	0.91
23-02-2018	0.27	0.42	0.58
24-02-2018	0.30	0.56	0.96
25-02-2018	0.19	0.58	0.96
26-02-2018	0.16	0.57	1.15
27-02-2018	0.74	1.13	1.75
28-02-2018	0.99	1.11	1.29
01-03-2018	0.44	1.09	1.72
02-03-2018	0.77	1.27	1.83
03-03-2018	0.80	1.32	2.13
04-03-2018	0.99	1.36	1.86
05-03-2018	1.10	1.41	1.72
06-03-2018	1.07	1.64	2.48
07-03-2018	0.58	1.35	2.10
08-03-2018	1.29	1.65	2.02
09-03-2018	1.21	1.73	2.64
10-03-2018	0.74	1.51	2.64
11-03-2018	0.77	1.64	2.88
12-03-2018	0.99	1.86	3.09
13-03-2018	1.40	1.79	2.18
14-03-2018	1.62	2.02	2.66

15-03-2018	1.34	2.17	3.43
16-03-2018	1.29	2.28	3.67
17-03-2018	1.94	2.61	3.75
18-03-2018	1.48	2.57	4.04
19-03-2018	2.29	2.71	3.14
20-03-2018	2.32	2.75	3.17
21-03-2018	1.94	2.79	3.78
22-03-2018	2.16	2.65	3.12
23-03-2018	1.83	2.51	3.54
24-03-2018	2.07	3.17	4.82
25-03-2018	2.40	3.15	4.12
26-03-2018	2.29	2.85	3.59
27-03-2018	2.58	3.37	4.79
28-03-2018	2.82	3.71	5.15
29-03-2018	3.14	3.70	4.51
30-03-2018	3.06	3.99	5.46
31-03-2018	2.85	3.96	5.26
01-04-2018	3.41	3.75	4.22
02-04-2018	2.48	3.73	5.28
03-04-2018	3.01	3.72	4.77
04-04-2018	3.06	3.84	4.74
05-04-2018	3.46	3.89	4.40
06-04-2018	3.35	4.02	4.95
07-04-2018	3.35	3.71	4.22
08-04-2018	3.35	4.55	6.13
09-04-2018	4.27	4.89	5.64
10-04-2018	3.49	3.93	4.45
11-04-2018	3.30	3.78	4.32
12-04-2018	3.30	4.19	5.36
13-04-2018	3.49	3.73	4.14
14-04-2018	3.22	3.95	4.87
15-04-2018	3.67	4.68	6.03
16-04-2018	4.01	4.62	5.44
17-04-2018	4.06	5.05	6.43
18-04-2018	4.35	5.24	6.56
19-04-2018	3.93	5.28	6.86
20-04-2018	4.95	5.44	6.08
21-04-2018	4.22	4.98	5.90
22-04-2018	3.62	5.13	6.81
23-04-2018	3.78	5.37	7.34
24-04-2018	3.80	5.34	7.19
25-04-2018	3.85	5.03	6.86
26-04-2018	3.06	4.21	6.36
27-04-2018	2.82	3.77	5.64
28-04-2018	3.12	3.58	4.09
29-04-2018	3.59	4.16	4.92
30-04-2018	4.14	4.79	5.87

01-05-2018	4.19	5.23	6.84
02-05-2018	3.93	4.97	6.91
03-05-2018	3.64	4.49	6.10
04-05-2018	3.54	4.17	5.05
05-05-2018	3.49	4.43	6.38
06-05-2018	3.46	4.14	5.46
07-05-2018	3.43	4.32	6.05
08-05-2018	3.62	4.52	6.15
09-05-2018	3.64	3.96	4.30
10-05-2018	3.64	4.49	5.67
11-05-2018	3.85	5.02	6.81
12-05-2018	3.99	4.96	6.97
13-05-2018	3.83	4.67	6.51
14-05-2018	3.80	4.73	6.54
15-05-2018	3.96	4.82	6.48
16-05-2018	3.99	4.94	6.81
17-05-2018	4.14	5.12	7.17
18-05-2018	4.14	4.89	6.26
19-05-2018	4.22	4.78	5.77
20-05-2018	3.75	4.30	5.26
21-05-2018	4.01	5.21	7.27
22-05-2018	4.27	5.32	7.37
23-05-2018	4.19	5.23	7.27
24-05-2018	4.27	5.17	6.91
25-05-2018	4.27	5.06	6.54
26-05-2018	3.91	5.08	6.48
27-05-2018	4.61	5.47	7.12
28-05-2018	4.30	5.30	7.17
29-05-2018	4.32	5.29	7.17
30-05-2018	3.88	5.23	7.07
31-05-2018	4.32	5.42	7.04
01-06-2018	4.45	5.29	6.26
02-06-2018	4.58	5.41	6.76
03-06-2018	4.51	5.09	5.87
04-06-2018	4.30	5.24	6.76
05-06-2018	4.19	4.86	5.59
06-06-2018	4.58	5.57	7.32
07-06-2018	4.53	5.63	7.62
08-06-2018	3.64	4.31	4.90
09-06-2018	3.64	4.52	5.59
10-06-2018	4.17	5.11	6.33
11-06-2018	4.27	5.39	6.79
12-06-2018	4.01	5.11	6.13
13-06-2018	4.66	5.17	6.00
14-06-2018	4.66	5.65	7.09
15-06-2018	4.53	5.93	8.05
16-06-2018	4.32	5.61	7.90

17-06-2018	4.53	5.76	7.70
18-06-2018	4.82	6.05	8.27
19-06-2018	5.05	6.26	8.39
20-06-2018	5.36	6.39	8.32
21-06-2018	5.44	6.70	8.82
22-06-2018	5.69	6.22	7.27
23-06-2018	5.51	6.77	9.11
24-06-2018	5.69	6.76	8.69
25-06-2018	5.59	6.08	6.71
26-06-2018	5.51	6.58	8.17
27-06-2018	5.62	6.95	8.67
28-06-2018	6.46	7.00	7.70
29-06-2018	6.26	6.99	8.05
30-06-2018	6.61	7.02	7.80
01-07-2018	6.23	6.86	8.49
02-07-2018	5.57	6.82	8.25
03-07-2018	6.08	7.50	9.04
04-07-2018	6.61	8.24	10.37
05-07-2018	7.44	8.93	11.05
06-07-2018	7.82	8.78	10.10
07-07-2018	7.52	8.59	10.25
08-07-2018	7.37	9.17	11.08
09-07-2018	8.44	9.65	10.96
10-07-2018	9.04	9.68	10.44
11-07-2018	8.74	10.59	12.85
12-07-2018	9.83	11.69	13.79
13-07-2018	10.49	12.22	14.15
14-07-2018	10.69	12.08	13.62
15-07-2018	10.49	12.25	14.05
16-07-2018	11.32	13.02	14.72
17-07-2018	12.05	13.65	15.32
18-07-2018	12.41	13.86	15.39
19-07-2018	12.56	13.34	14.10
20-07-2018	11.52	12.36	13.14
21-07-2018	10.39	11.46	12.24
22-07-2018	10.79	12.24	13.86
23-07-2018	11.73	13.10	14.70
24-07-2018	12.07	13.38	14.72
25-07-2018	12.10	13.57	15.06
26-07-2018	12.73	14.03	15.32
27-07-2018	12.65	13.89	15.13
28-07-2018	12.58	13.91	15.29
29-07-2018	12.99	14.20	15.49
30-07-2018	13.23	14.46	15.77
31-07-2018	13.57	14.79	16.23
01-08-2018	13.71	14.75	15.82

Scotia Creek			
Date	Minimum Temperature (°C)	Average Temperature (°C)	Maximum Temperature (°C)
27-07-2017	11.37	11.91	12.53
28-07-2017	10.76	11.64	12.27
29-07-2017	11.10	11.89	12.56
30-07-2017	11.25	11.97	12.61
31-07-2017	11.27	12.12	12.75
01-08-2017	11.78	12.46	13.11
02-08-2017	12.22	12.80	13.35
03-08-2017	12.41	13.10	13.81
04-08-2017	12.85	13.31	13.71
05-08-2017	12.61	13.09	13.57
06-08-2017	12.56	13.17	13.74
07-08-2017	12.82	13.48	14.10
08-08-2017	13.40	13.92	14.48
09-08-2017	13.59	14.18	14.77
10-08-2017	13.79	14.42	15.01
11-08-2017	14.10	14.69	15.25
12-08-2017	14.07	14.46	14.86
13-08-2017	12.73	13.33	14.05
14-08-2017	11.73	12.06	12.58
15-08-2017	10.79	11.55	12.20
16-08-2017	11.59	11.99	12.41
17-08-2017	11.54	12.18	12.78
18-08-2017	12.15	12.37	12.53
19-08-2017	11.22	11.75	12.12
20-08-2017	11.39	11.77	12.17
21-08-2017	11.30	11.88	12.49
22-08-2017	11.90	12.58	13.31
23-08-2017	12.75	13.12	13.52
24-08-2017	11.27	12.45	13.14
25-08-2017	10.42	11.18	11.90
26-08-2017	10.10	11.49	12.82
27-08-2017	11.52	12.91	14.58
28-08-2017	12.51	13.97	15.75
29-08-2017	12.75	14.50	16.39
30-08-2017	12.56	13.92	15.44
31-08-2017	12.17	13.51	15.22
01-09-2017	11.98	13.59	14.91
02-09-2017	12.46	14.13	16.06
03-09-2017	13.14	14.69	16.49
04-09-2017	13.67	15.41	17.39
05-09-2017	14.96	15.53	16.37
06-09-2017	14.39	15.25	16.58
07-09-2017	13.83	14.61	15.37

08-09-2017	13.71	14.31	14.63
09-09-2017	10.32	11.72	13.50
10-09-2017	10.69	11.55	12.53
11-09-2017	11.37	12.65	14.17
12-09-2017	11.83	13.04	14.65
13-09-2017	9.95	11.19	12.46
14-09-2017	8.32	10.14	11.81
15-09-2017	7.75	10.05	11.86
16-09-2017	8.30	10.28	12.46
17-09-2017	8.59	9.09	10.71
18-09-2017	7.34	8.36	8.99
19-09-2017	6.51	7.55	8.77
20-09-2017	6.99	7.69	8.37
21-09-2017	7.14	7.94	8.84
22-09-2017	5.77	7.73	9.21
23-09-2017	7.59	8.91	10.44
24-09-2017	8.17	9.27	10.47
25-09-2017	9.26	9.74	10.57
26-09-2017	9.81	10.38	11.39
27-09-2017	9.76	10.72	12.17
28-09-2017	9.53	11.05	12.75
29-09-2017	10.12	10.59	10.93
30-09-2017	8.27	9.04	9.95
01-10-2017	7.32	8.05	8.49
02-10-2017	6.61	7.41	8.15
03-10-2017	5.82	6.78	8.00
04-10-2017	5.64	6.88	8.15
05-10-2017	5.49	7.08	8.74
06-10-2017	6.64	7.11	7.57
07-10-2017	5.67	6.54	7.02
08-10-2017	5.02	6.28	7.29
09-10-2017	5.18	6.21	7.72
10-10-2017	4.95	5.54	6.13
11-10-2017	2.18	4.62	5.59
12-10-2017	4.25	4.63	4.97
13-10-2017	3.78	4.23	4.92
14-10-2017	3.80	4.27	4.71
15-10-2017	4.64	5.34	6.05
16-10-2017	5.87	6.14	6.26
17-10-2017	5.26	6.04	6.59
18-10-2017	2.21	3.78	5.18
19-10-2017	4.04	4.86	5.26
20-10-2017	5.10	5.42	5.67
21-10-2017	4.53	5.08	5.33
22-10-2017	4.40	5.12	5.51
23-10-2017	5.33	5.66	6.00
24-10-2017	5.36	5.82	6.23

25-10-2017	5.64	6.05	6.26
26-10-2017	4.97	5.39	5.64
27-10-2017	5.31	5.82	6.38
28-10-2017	6.08	6.54	7.09
29-10-2017	5.33	6.19	6.76
30-10-2017	4.27	4.60	5.21
31-10-2017	4.09	4.44	4.77
01-11-2017	4.51	4.79	5.08
02-11-2017	1.43	2.86	4.92
03-11-2017	0.80	1.00	1.37
04-11-2017	0.72	0.81	0.93
05-11-2017	0.77	0.87	0.99
06-11-2017	0.69	0.81	0.96
07-11-2017	0.77	1.00	1.21
08-11-2017	1.21	1.34	1.51
09-11-2017	1.51	1.67	1.83
10-11-2017	1.86	2.01	2.10
11-11-2017	2.07	2.25	2.40
12-11-2017	1.89	2.12	2.26
13-11-2017	1.56	2.12	2.66
14-11-2017	1.89	2.64	2.96
15-11-2017	2.05	2.44	2.80
16-11-2017	2.61	2.91	3.06
17-11-2017	3.06	3.16	3.25
18-11-2017	2.93	3.08	3.20
19-11-2017	1.51	2.59	3.33
20-11-2017	2.37	2.76	3.06
21-11-2017	2.45	2.91	3.17
22-11-2017	1.67	1.93	2.29
23-11-2017	1.78	2.73	3.27
24-11-2017	3.27	3.34	3.43
25-11-2017	3.25	3.61	3.78
26-11-2017	3.22	3.40	3.70
27-11-2017	2.16	3.07	3.22
28-11-2017	1.51	2.21	3.01
29-11-2017	1.32	1.66	1.86
30-11-2017	1.34	1.70	2.24
01-12-2017	0.52	1.19	1.70
02-12-2017	0.08	0.79	1.18
03-12-2017	-2.77	-0.64	0.02
04-12-2017	-2.83	-1.41	-0.34
05-12-2017	-2.28	-0.84	-0.06
06-12-2017	-0.06	0.03	0.08
07-12-2017	0.02	0.11	0.25
08-12-2017	-0.54	-0.28	0.00
09-12-2017	-1.93	-1.01	-0.23
10-12-2017	-1.13	-0.17	0.16

11-12-2017	0.00	0.31	0.66
12-12-2017	0.11	0.46	0.83
13-12-2017	-0.03	0.94	1.64
14-12-2017	0.08	0.74	1.26
15-12-2017	0.02	1.29	1.75
16-12-2017	-0.06	0.08	0.25
17-12-2017	0.19	0.42	0.69
18-12-2017	0.44	0.76	1.10
19-12-2017	-1.24	0.02	0.77
20-12-2017	-4.50	-2.95	-1.67
21-12-2017	-4.90	-2.96	-1.81
22-12-2017	-5.39	-3.46	-2.45
23-12-2017	-7.06	-6.36	-5.45
24-12-2017	-7.48	-6.57	-5.51
25-12-2017	-7.12	-6.07	-5.02
26-12-2017	-7.28	-6.56	-5.73
27-12-2017	-6.61	-5.86	-4.93
28-12-2017	-5.61	-2.92	-0.65
29-12-2017	-0.70	-0.57	-0.54
30-12-2017	-0.79	-0.61	-0.42
31-12-2017	-0.42	-0.33	-0.31
01-01-2018	-0.31	-0.29	-0.26
02-01-2018	-0.26	-0.20	-0.14
03-01-2018	-0.14	-0.11	-0.06
04-01-2018	-0.06	-0.02	0.02
05-01-2018	0.02	0.05	0.08
06-01-2018	0.05	0.06	0.08
07-01-2018	0.08	0.11	0.14
08-01-2018	0.14	0.16	0.22
09-01-2018	0.19	0.20	0.22
10-01-2018	0.00	0.18	0.22
11-01-2018	-1.81	-0.83	0.00
12-01-2018	-2.07	-1.63	-0.82
13-01-2018	-0.73	-0.22	0.02
14-01-2018	0.02	0.07	0.14
15-01-2018	0.16	0.24	0.30
16-01-2018	0.30	0.33	0.38
17-01-2018	0.36	0.48	0.91
18-01-2018	0.77	0.92	1.13
19-01-2018	0.63	0.90	1.15
20-01-2018	0.55	0.75	1.02
21-01-2018	0.55	0.79	1.24
22-01-2018	0.22	0.50	0.83
23-01-2018	0.16	0.24	0.41
24-01-2018	0.02	0.22	0.41
25-01-2018	-0.09	0.09	0.33
26-01-2018	-1.41	-0.24	0.05

27-01-2018	-0.96	-0.27	0.00
28-01-2018	0.02	0.02	0.02
29-01-2018	0.02	0.29	1.32
30-01-2018	0.66	1.59	1.91
31-01-2018	0.02	0.26	0.74
01-02-2018	0.05	0.37	0.69
02-02-2018	0.41	0.73	1.29
03-02-2018	1.32	1.44	1.62
04-02-2018	1.07	1.75	2.32
05-02-2018	2.10	2.38	2.53
06-02-2018	1.83	2.06	2.48
07-02-2018	1.83	2.17	2.69
08-02-2018	2.34	2.54	2.69
09-02-2018	0.14	1.60	2.32
10-02-2018	-1.99	-0.73	0.05
11-02-2018	-2.10	-1.00	-0.26
12-02-2018	-3.96	-2.39	-0.79
13-02-2018	-1.70	-1.21	-0.42
14-02-2018	-0.37	-0.15	0.00
15-02-2018	-1.33	-0.60	-0.20
16-02-2018	-0.82	-0.25	0.02
17-02-2018	0.02	0.02	0.02
18-02-2018	-0.73	-0.36	0.02
19-02-2018	-0.96	-0.77	-0.48
20-02-2018	-0.96	-0.74	-0.54
21-02-2018	-0.96	-0.63	-0.31
22-02-2018	-0.82	-0.58	-0.37
23-02-2018	-0.82	-0.68	-0.37
24-02-2018	-0.37	-0.21	-0.06
25-02-2018	-0.03	-0.01	0.02
26-02-2018	-0.03	0.00	0.02
27-02-2018	0.02	0.03	0.05
28-02-2018	0.08	0.09	0.11
01-03-2018	0.08	0.13	0.19
02-03-2018	0.19	0.25	0.33
03-03-2018	0.27	0.31	0.36
04-03-2018	0.30	0.33	0.36
05-03-2018	0.36	0.40	0.44
06-03-2018	0.41	0.46	0.52
07-03-2018	0.33	0.42	0.52
08-03-2018	0.27	0.45	0.55
09-03-2018	0.36	0.40	0.44
10-03-2018	0.16	0.32	0.44
11-03-2018	0.36	0.44	0.52
12-03-2018	0.41	0.52	0.80
13-03-2018	0.44	0.59	0.77
14-03-2018	0.36	0.71	1.15

15-03-2018	-0.12	0.26	0.88
16-03-2018	-0.68	0.14	0.85
17-03-2018	-0.09	0.65	1.18
18-03-2018	-0.93	0.26	1.24
19-03-2018	0.16	0.93	1.45
20-03-2018	0.33	1.12	1.64
21-03-2018	-0.23	0.63	1.70
22-03-2018	0.02	0.77	1.29
23-03-2018	-0.20	0.00	0.14
24-03-2018	-0.82	0.07	0.74
25-03-2018	-0.93	-0.01	0.44
26-03-2018	0.02	0.42	0.85
27-03-2018	0.88	1.56	2.74
28-03-2018	1.13	1.59	2.24
29-03-2018	1.15	1.64	2.34
30-03-2018	0.63	1.98	2.88
31-03-2018	-0.31	1.12	2.29
01-04-2018	-0.03	0.94	1.64
02-04-2018	-2.31	-0.44	0.27
03-04-2018	0.02	0.47	1.15
04-04-2018	0.44	1.39	2.24
05-04-2018	0.99	1.61	2.24
06-04-2018	1.40	2.00	2.74
07-04-2018	1.78	2.14	2.50
08-04-2018	1.70	2.49	3.64
09-04-2018	2.21	2.78	3.43
10-04-2018	2.21	2.58	3.51
11-04-2018	1.72	2.43	2.96
12-04-2018	1.32	1.95	3.09
13-04-2018	1.18	1.84	2.72
14-04-2018	1.67	2.32	3.12
15-04-2018	1.34	2.46	3.46
16-04-2018	2.16	2.71	3.54
17-04-2018	1.86	2.55	3.38
18-04-2018	1.04	2.25	3.41
19-04-2018	-0.09	2.21	4.22
20-04-2018	2.32	2.95	3.85
21-04-2018	1.24	2.66	3.62
22-04-2018	0.00	1.90	4.06
23-04-2018	0.11	2.56	4.95
24-04-2018	1.81	3.57	5.64
25-04-2018	2.32	3.84	5.92
26-04-2018	3.14	3.76	5.28
27-04-2018	2.90	3.65	4.58
28-04-2018	3.25	3.42	3.70
29-04-2018	3.14	3.50	3.99
30-04-2018	3.41	4.05	5.02

01-05-2018	3.51	4.49	5.98
02-05-2018	3.01	4.25	6.26
03-05-2018	3.25	3.98	4.97
04-05-2018	3.30	3.88	4.48
05-05-2018	3.12	4.00	5.44
06-05-2018	3.51	4.13	5.21
07-05-2018	3.51	4.29	5.90
08-05-2018	3.51	4.37	5.69
09-05-2018	3.59	4.14	4.69
10-05-2018	3.46	4.19	5.21
11-05-2018	3.27	4.86	7.14
12-05-2018	3.80	5.05	7.12
13-05-2018	4.04	4.89	6.64
14-05-2018	3.96	4.98	6.79
15-05-2018	4.17	5.25	7.19
16-05-2018	4.32	5.41	7.39
17-05-2018	4.48	5.53	7.49
18-05-2018	4.45	5.42	6.74
19-05-2018	4.64	5.33	6.46
20-05-2018	4.51	5.06	5.95
21-05-2018	4.45	5.64	7.42
22-05-2018	4.74	5.96	7.80
23-05-2018	4.90	6.09	7.92
24-05-2018	5.28	6.19	7.82
25-05-2018	4.95	5.80	7.07
26-05-2018	4.40	5.50	6.66
27-05-2018	5.41	6.24	7.67
28-05-2018	5.15	6.27	8.02
29-05-2018	4.95	5.97	7.59
30-05-2018	2.98	5.30	7.12
31-05-2018	3.72	5.88	7.65
01-06-2018	5.02	5.95	6.99
02-06-2018	5.26	6.59	8.05
03-06-2018	5.80	6.51	7.54
04-06-2018	4.04	5.87	6.99
05-06-2018	3.72	4.98	6.03
06-06-2018	5.05	6.69	8.44
07-06-2018	5.57	7.28	9.56
08-06-2018	4.74	5.87	6.66
09-06-2018	4.64	5.62	7.09
10-06-2018	4.40	5.24	6.26
11-06-2018	4.17	5.51	6.64
12-06-2018	3.22	5.35	6.66
13-06-2018	5.49	6.03	7.07
14-06-2018	5.75	7.07	8.92
15-06-2018	5.51	7.35	9.98
16-06-2018	5.72	7.02	9.11

17-06-2018	6.26	7.53	9.44
18-06-2018	6.76	7.96	9.26
19-06-2018	7.07	8.34	9.95
20-06-2018	7.67	8.59	10.17
21-06-2018	7.72	8.72	10.27
22-06-2018	7.62	7.95	8.49
23-06-2018	7.59	8.53	10.42
24-06-2018	7.70	8.85	10.98
25-06-2018	6.64	7.08	7.42
26-06-2018	6.48	7.51	8.79
27-06-2018	6.13	7.78	9.39
28-06-2018	7.67	8.24	9.16
29-06-2018	7.49	8.51	9.76
30-06-2018	8.54	8.96	9.53
01-07-2018	8.07	8.88	10.15
02-07-2018	6.79	7.97	9.26
03-07-2018	6.64	8.47	10.32
04-07-2018	8.17	10.17	11.83
05-07-2018	10.08	11.45	12.85
06-07-2018	9.51	11.13	12.56
07-07-2018	9.29	10.02	11.08
08-07-2018	8.02	10.19	12.07
09-07-2018	9.41	10.77	12.10
10-07-2018	10.32	10.92	11.64
11-07-2018	9.95	11.72	13.67
12-07-2018	10.93	12.78	14.53
13-07-2018	11.37	13.10	15.18
14-07-2018	11.35	12.43	13.64
15-07-2018	10.08	12.27	14.07
16-07-2018	11.35	13.23	15.13
17-07-2018	12.27	14.13	16.23
18-07-2018	12.82	14.29	16.03
19-07-2018	11.83	13.18	14.36
20-07-2018	10.35	11.37	12.22
21-07-2018	8.27	10.51	12.20
22-07-2018	10.05	12.15	14.17
23-07-2018	11.44	13.43	15.70
24-07-2018	12.36	14.11	15.72
25-07-2018	12.65	14.74	16.77
26-07-2018	13.64	15.56	17.92
27-07-2018	13.76	15.72	17.70
28-07-2018	13.76	16.00	18.65
29-07-2018	14.27	16.68	19.18
30-07-2018	14.67	17.24	20.17
31-07-2018	15.13	17.58	20.96
01-08-2018	14.53	16.98	20.08
02-08-2018	13.62	14.93	16.99

Twentyone Mile Creek

Date	Minimum Temperature (°C)	Average Temperature (°C)	Maximum Temperature (°C)
03-08-2017	11.61	12.98	14.41
04-08-2017	12.20	13.18	14.07
05-08-2017	11.81	12.75	13.69
06-08-2017	11.83	12.97	14.15
07-08-2017	12.20	13.39	14.51
08-08-2017	12.73	13.83	14.89
09-08-2017	12.90	14.09	15.27
10-08-2017	13.26	14.37	15.39
11-08-2017	13.67	14.75	15.96
12-08-2017	13.74	14.65	15.77
13-08-2017	13.14	13.91	14.58
14-08-2017	11.49	12.41	13.64
15-08-2017	11.01	12.57	14.82
16-08-2017	12.00	13.07	15.01
17-08-2017	11.73	13.25	15.46
18-08-2017	12.58	13.22	14.17
19-08-2017	11.39	12.62	14.17
20-08-2017	11.90	12.92	14.70
21-08-2017	11.47	12.82	14.60
22-08-2017	11.83	13.09	14.75
23-08-2017	12.92	13.78	15.44
24-08-2017	12.34	13.09	13.81
25-08-2017	11.01	12.32	14.51
26-08-2017	10.57	12.19	14.19
27-08-2017	11.54	12.88	14.60
28-08-2017	12.00	13.28	14.98
29-08-2017	12.20	13.53	15.03
30-08-2017	12.12	13.22	14.24
31-08-2017	12.20	13.42	15.22
01-09-2017	12.46	13.53	15.13
02-09-2017	12.49	13.71	15.44
03-09-2017	12.78	13.92	15.44
04-09-2017	12.82	13.94	15.39
05-09-2017	13.28	13.57	14.10
06-09-2017	12.94	13.31	13.76
07-09-2017	12.80	13.22	13.55
08-09-2017	12.97	13.12	13.28
09-09-2017	12.10	12.72	13.06
10-09-2017	11.71	12.73	14.41
11-09-2017	12.20	13.04	14.12
12-09-2017	12.68	13.55	15.08
13-09-2017	11.76	13.08	14.65
14-09-2017	10.57	12.17	13.81

15-09-2017	10.25	11.76	13.26
16-09-2017	10.71	11.85	13.06
17-09-2017	9.58	10.85	12.15
18-09-2017	8.82	9.46	10.37
19-09-2017	8.42	9.55	10.88
20-09-2017	8.57	9.73	10.69
21-09-2017	8.82	9.61	10.54
22-09-2017	8.02	9.24	10.39
23-09-2017	9.26	10.43	12.10
24-09-2017	9.78	10.60	11.64
25-09-2017	10.44	10.89	11.44
26-09-2017	10.64	11.75	13.81
27-09-2017	10.37	11.77	14.03
28-09-2017	10.12	11.31	12.44
29-09-2017	9.56	10.83	11.73
30-09-2017	8.59	9.03	9.51
01-10-2017	8.02	8.62	9.81
02-10-2017	7.57	8.63	10.39
03-10-2017	6.59	7.93	9.46
04-10-2017	6.31	7.68	9.21
05-10-2017	6.41	7.76	9.19
06-10-2017	7.49	7.83	8.37
07-10-2017	6.76	7.63	8.97
08-10-2017	6.74	8.00	9.78
09-10-2017	6.69	7.97	9.49
10-10-2017	7.12	7.62	8.32
11-10-2017	6.69	7.23	8.25
12-10-2017	6.48	7.06	7.87
13-10-2017	5.59	6.74	8.34
14-10-2017	5.69	6.39	7.22
15-10-2017	6.41	7.08	8.32
16-10-2017	6.05	6.77	7.42
17-10-2017	5.39	6.28	6.76
18-10-2017	1.53	3.67	5.26
19-10-2017	3.12	3.73	4.12
20-10-2017	4.01	4.31	4.77
21-10-2017	2.80	3.64	4.12
22-10-2017	2.82	3.64	4.27
23-10-2017	3.93	4.33	4.90
24-10-2017	4.01	4.48	4.87
25-10-2017	4.40	4.93	5.33
26-10-2017	3.67	4.18	4.53
27-10-2017	3.88	4.46	5.31
28-10-2017	4.53	5.06	5.80
29-10-2017	4.32	4.94	5.28
30-10-2017	2.96	3.44	4.14
31-10-2017	2.90	3.42	4.09

01-11-2017	3.75	4.03	4.38
02-11-2017	1.13	2.47	4.19
03-11-2017	0.72	0.88	1.21
04-11-2017	0.77	0.88	1.10
05-11-2017	0.77	0.95	1.48
06-11-2017	0.61	1.06	2.50
07-11-2017	0.77	0.98	1.21
08-11-2017	0.99	1.13	1.81
09-11-2017	1.04	1.37	1.75
10-11-2017	1.83	2.34	4.01
11-11-2017	2.18	2.71	3.27
12-11-2017	1.53	2.03	3.04
13-11-2017	0.91	1.45	1.67
14-11-2017	0.44	1.27	1.67
15-11-2017	0.44	0.72	1.15
16-11-2017	0.72	1.08	1.37
17-11-2017	1.21	1.45	1.75
18-11-2017	1.51	1.73	1.99
19-11-2017	0.44	1.28	1.78
20-11-2017	0.61	1.11	1.48
21-11-2017	1.15	1.36	1.48
22-11-2017	0.05	0.39	1.04
23-11-2017	0.25	1.33	2.16
24-11-2017	2.05	2.20	2.32
25-11-2017	2.02	2.36	2.64
26-11-2017	2.10	2.30	2.56
27-11-2017	1.89	2.10	2.32
28-11-2017	1.43	1.83	2.05
29-11-2017	1.94	2.04	2.21
30-11-2017	1.89	2.15	2.40
01-12-2017	1.59	1.97	2.37
02-12-2017	1.67	1.79	1.91
03-12-2017	0.96	1.36	1.75
04-12-2017	0.77	0.89	1.04
05-12-2017	0.66	0.83	1.04
06-12-2017	0.88	1.02	1.32
07-12-2017	0.93	1.08	1.37
08-12-2017	1.04	1.14	1.34
09-12-2017	0.96	1.08	1.29
10-12-2017	0.96	1.24	1.56
11-12-2017	1.34	1.45	1.86
12-12-2017	1.34	1.51	1.83
13-12-2017	1.37	1.58	1.81
14-12-2017	1.37	1.51	1.75
15-12-2017	1.53	1.79	2.02
16-12-2017	1.43	1.56	1.75
17-12-2017	1.26	1.44	1.51

18-12-2017	1.37	1.56	1.70
19-12-2017	1.02	1.36	1.64
20-12-2017	0.36	0.63	1.15
21-12-2017	0.30	0.41	0.58
22-12-2017	0.14	0.46	1.13
23-12-2017	0.08	0.40	1.15
24-12-2017	0.11	0.25	0.38
25-12-2017	0.11	0.32	0.69
26-12-2017	0.63	0.72	0.83
27-12-2017	0.52	0.63	0.77
28-12-2017	0.63	0.75	0.85
29-12-2017	0.30	0.52	0.69
30-12-2017	0.19	0.38	0.69
31-12-2017	0.58	0.73	0.88
01-01-2018	0.88	0.91	0.96
02-01-2018	0.91	0.97	0.99
03-01-2018	0.88	0.96	0.99
04-01-2018	0.69	0.77	0.85
05-01-2018	0.08	0.54	0.83
06-01-2018	0.02	0.10	0.16
07-01-2018	0.19	0.48	0.74
08-01-2018	0.66	0.82	0.93
09-01-2018	0.69	0.87	1.02
10-01-2018	0.91	1.04	1.81
11-01-2018	0.11	0.42	0.88
12-01-2018	0.05	0.22	0.55
13-01-2018	0.38	0.63	0.77
14-01-2018	0.74	1.00	1.48
15-01-2018	0.69	0.83	1.02
16-01-2018	0.93	1.00	1.07
17-01-2018	0.91	1.03	1.10
18-01-2018	0.85	0.99	1.10
19-01-2018	1.02	1.16	1.32
20-01-2018	0.99	1.16	1.40
21-01-2018	0.83	0.91	0.99
22-01-2018	0.77	0.91	1.07
23-01-2018	0.74	0.91	1.02
24-01-2018	0.30	0.66	0.91
25-01-2018	0.44	0.75	1.07
26-01-2018	0.50	0.67	0.99
27-01-2018	0.44	0.54	0.69
28-01-2018	0.08	0.38	0.74
29-01-2018	0.02	0.13	0.41
30-01-2018	0.47	0.82	0.99
31-01-2018	0.72	0.84	1.02
01-02-2018	0.74	0.89	1.10
02-02-2018	0.58	0.94	1.13

03-02-2018	1.15	1.35	1.59
04-02-2018	1.15	1.36	1.56
05-02-2018	1.34	1.55	1.83
06-02-2018	1.43	1.63	1.81
07-02-2018	1.64	1.80	1.99
08-02-2018	1.40	1.72	1.94
09-02-2018	0.85	1.15	1.59
10-02-2018	0.16	0.50	0.77
11-02-2018	0.50	0.71	1.04
12-02-2018	0.05	0.28	0.50
13-02-2018	0.14	0.37	0.72
14-02-2018	0.44	0.76	1.59
15-02-2018	0.16	0.52	0.72
16-02-2018	0.61	0.93	1.94
17-02-2018	0.19	0.61	1.15
18-02-2018	0.02	0.18	0.63
19-02-2018	0.05	0.18	0.72
20-02-2018	0.02	0.17	0.55
21-02-2018	0.05	0.11	0.22
22-02-2018	0.05	0.21	0.69
23-02-2018	0.08	0.11	0.16
24-02-2018	0.08	0.12	0.22
25-02-2018	0.11	0.17	0.25
26-02-2018	0.08	0.23	0.61
27-02-2018	0.47	0.79	0.93
28-02-2018	0.44	0.76	0.93
01-03-2018	0.72	0.87	0.93
02-03-2018	0.80	0.95	1.07
03-03-2018	0.91	1.05	1.26
04-03-2018	1.04	1.14	1.24
05-03-2018	0.93	1.10	1.15
06-03-2018	1.10	1.23	1.48
07-03-2018	1.24	1.32	1.45
08-03-2018	1.26	1.31	1.37
09-03-2018	1.24	1.39	1.83
10-03-2018	1.32	1.55	2.05
11-03-2018	1.43	1.78	2.48
12-03-2018	1.59	2.06	3.01
13-03-2018	1.34	1.78	1.97
14-03-2018	0.74	1.73	2.69
15-03-2018	1.81	2.77	5.08
16-03-2018	2.26	3.23	5.28
17-03-2018	2.72	3.60	5.13
18-03-2018	2.90	4.01	5.72
19-03-2018	3.46	4.01	4.45
20-03-2018	3.22	3.70	4.40
21-03-2018	3.09	4.02	5.57

22-03-2018	2.34	3.64	4.35
23-03-2018	2.50	3.62	5.36
24-03-2018	3.04	4.21	6.38
25-03-2018	3.56	4.35	5.85
26-03-2018	2.72	3.41	4.19
27-03-2018	2.66	3.83	6.38
28-03-2018	2.74	4.18	6.71
29-03-2018	3.56	4.23	5.59
30-03-2018	3.17	4.33	6.69
31-03-2018	2.50	3.98	6.33
01-04-2018	3.01	3.93	5.92
02-04-2018	3.04	4.09	6.26
03-04-2018	3.59	4.31	6.15
04-04-2018	3.33	4.15	5.18
05-04-2018	3.56	4.14	4.87
06-04-2018	3.43	4.14	5.36
07-04-2018	2.98	3.32	3.78
08-04-2018	2.82	3.89	5.49
09-04-2018	4.01	4.48	5.02
10-04-2018	3.06	3.62	4.17
11-04-2018	2.72	3.11	3.51
12-04-2018	2.82	3.53	4.51
13-04-2018	2.90	3.18	3.72
14-04-2018	2.53	3.16	3.88
15-04-2018	3.14	4.07	5.28
16-04-2018	4.01	4.44	4.90
17-04-2018	3.80	4.58	5.92
18-04-2018	4.14	4.96	6.56
19-04-2018	3.75	4.86	6.69
20-04-2018	4.43	4.90	6.15
21-04-2018	3.83	4.36	5.28
22-04-2018	3.20	4.49	6.15
23-04-2018	3.59	4.98	7.22
24-04-2018	3.56	4.70	6.05
25-04-2018	3.22	4.28	6.10
26-04-2018	2.37	3.63	5.54
27-04-2018	2.21	2.97	4.51
28-04-2018	2.72	2.86	3.20
29-04-2018	2.64	3.08	3.70
30-04-2018	3.17	3.67	4.61
01-05-2018	3.20	3.95	5.36
02-05-2018	2.88	3.73	5.49
03-05-2018	2.82	3.62	4.84
04-05-2018	3.46	3.86	4.53
05-05-2018	2.90	3.94	5.36
06-05-2018	3.62	4.36	5.10
07-05-2018	3.72	4.93	5.90

08-05-2018	3.80	4.99	5.75
09-05-2018	4.79	5.25	5.64
10-05-2018	3.59	4.21	5.00
11-05-2018	3.09	4.35	5.75
12-05-2018	3.80	5.03	6.43
13-05-2018	4.12	5.62	7.04
14-05-2018	4.12	5.70	7.22
15-05-2018	4.25	5.84	7.34
16-05-2018	4.25	5.91	7.37
17-05-2018	4.53	6.04	7.39
18-05-2018	4.38	5.55	6.54
19-05-2018	4.51	5.26	5.82
20-05-2018	4.82	5.28	5.85
21-05-2018	4.14	5.35	6.94
22-05-2018	4.40	5.85	7.27
23-05-2018	4.56	6.13	7.65
24-05-2018	4.77	6.30	7.77
25-05-2018	4.79	5.97	7.02
26-05-2018	4.17	5.33	6.26
27-05-2018	4.58	5.68	7.17
28-05-2018	4.69	5.63	7.12
29-05-2018	4.25	5.34	6.69
30-05-2018	3.30	4.77	6.41
31-05-2018	3.49	4.76	6.41
01-06-2018	3.78	4.70	5.67
02-06-2018	3.93	4.98	6.38
03-06-2018	4.09	4.81	5.39
04-06-2018	3.99	4.95	6.28
05-06-2018	3.51	4.19	4.84
06-06-2018	3.88	5.02	6.76
07-06-2018	3.91	5.26	7.09
08-06-2018	4.87	5.25	5.82
09-06-2018	4.04	4.86	5.72
10-06-2018	3.83	4.70	5.75
11-06-2018	3.54	4.63	6.03
12-06-2018	3.30	4.35	5.33
13-06-2018	4.01	4.61	5.49
14-06-2018	3.99	5.15	6.66
15-06-2018	3.96	5.73	7.97
16-06-2018	5.18	6.82	8.74
17-06-2018	5.36	6.84	8.27
18-06-2018	5.62	7.36	9.24
19-06-2018	6.03	7.74	9.71
20-06-2018	6.31	7.81	9.61
21-06-2018	6.33	8.06	10.05
22-06-2018	6.64	7.14	8.15
23-06-2018	5.87	7.37	9.53

24-06-2018	6.36	7.45	8.87
25-06-2018	6.28	6.90	8.22
26-06-2018	5.33	6.44	7.90
27-06-2018	4.90	6.37	8.12
28-06-2018	5.77	6.46	7.19
29-06-2018	5.59	6.39	7.59
30-06-2018	6.05	6.84	7.75
01-07-2018	6.69	7.37	8.84
02-07-2018	5.57	6.83	7.95
03-07-2018	5.44	6.94	8.62
04-07-2018	6.05	7.97	10.39
05-07-2018	7.59	9.25	11.49
06-07-2018	7.82	9.19	10.25
07-07-2018	8.15	9.08	10.44
08-07-2018	6.94	8.80	10.69
09-07-2018	7.95	9.17	10.52
10-07-2018	8.64	9.31	10.20
11-07-2018	8.27	10.12	12.58
12-07-2018	9.39	11.28	13.45
13-07-2018	10.08	11.86	13.88
14-07-2018	10.37	11.70	13.21
15-07-2018	10.17	11.89	13.76
16-07-2018	11.13	12.77	14.48
17-07-2018	11.93	13.48	15.22
18-07-2018	12.41	13.79	15.32
19-07-2018	12.58	13.38	14.19
20-07-2018	11.64	12.50	13.31
21-07-2018	10.49	11.56	12.41
22-07-2018	10.86	12.26	14.07
23-07-2018	11.69	13.04	14.77
24-07-2018	12.05	13.35	14.84
25-07-2018	12.44	13.76	15.32
26-07-2018	13.06	14.29	15.68
27-07-2018	13.06	14.27	15.70
28-07-2018	13.06	14.39	15.96
29-07-2018	13.52	14.82	16.44
30-07-2018	13.83	15.14	16.84

Crabapple Creek 2			
Date	Minimum Temperature (°C)	Average Temperature (°C)	Maximum Temperature (°C)
03-08-2017	13.55	14.51	15.34
04-08-2017	14.19	14.83	15.39
05-08-2017	13.86	14.39	14.94
06-08-2017	13.40	14.16	14.79
07-08-2017	13.98	14.69	15.37
08-08-2017	14.51	15.14	15.56
09-08-2017	14.67	15.40	15.99
10-08-2017	15.13	15.80	16.32
11-08-2017	15.46	16.11	16.70
12-08-2017	15.56	16.12	16.73
13-08-2017	14.22	15.03	15.80
14-08-2017	12.85	13.46	14.05
15-08-2017	11.93	12.96	13.74
16-08-2017	12.99	13.51	14.22
17-08-2017	12.80	13.74	14.75
18-08-2017	13.67	14.22	14.43
19-08-2017	12.29	13.15	13.88
20-08-2017	13.02	13.39	13.98
21-08-2017	12.63	13.35	14.10
22-08-2017	13.02	13.94	14.91
23-08-2017	14.36	14.68	15.18
24-08-2017	13.40	14.08	14.65
25-08-2017	11.81	12.50	13.21
26-08-2017	11.27	12.27	13.06
27-08-2017	12.15	13.00	13.93
28-08-2017	12.82	13.69	14.60
29-08-2017	13.11	13.98	14.82
30-08-2017	13.14	13.86	14.48
31-08-2017	13.11	13.75	14.43
01-09-2017	13.33	13.93	14.65
02-09-2017	13.16	14.04	14.98
03-09-2017	13.55	14.39	15.32
04-09-2017	13.74	14.63	15.61
05-09-2017	14.46	14.81	15.18
06-09-2017	14.17	14.55	15.01
07-09-2017	13.88	14.34	14.63
08-09-2017	14.22	14.51	14.60
09-09-2017	12.36	13.31	14.17
10-09-2017	11.98	12.36	12.92
11-09-2017	12.15	12.71	13.35
12-09-2017	12.85	13.25	13.83
13-09-2017	11.54	12.27	13.04
14-09-2017	9.73	10.59	11.32

15-09-2017	8.89	9.73	10.37
16-09-2017	8.97	9.76	10.42
17-09-2017	8.92	9.25	9.83
18-09-2017	8.47	8.72	8.97
19-09-2017	7.54	8.10	8.49
20-09-2017	7.49	8.04	8.39
21-09-2017	7.70	8.17	8.52
22-09-2017	6.86	7.70	8.27
23-09-2017	8.10	8.56	9.16
24-09-2017	8.59	9.04	9.61
25-09-2017	9.39	9.65	10.05
26-09-2017	10.03	10.40	10.96
27-09-2017	9.66	10.29	10.76
28-09-2017	9.53	10.26	10.88
29-09-2017	10.20	10.43	10.64
30-09-2017	9.06	9.79	10.49
01-10-2017	8.42	8.73	8.99
02-10-2017	7.65	7.97	8.44
03-10-2017	6.33	7.02	7.72
04-10-2017	5.46	6.18	6.79
05-10-2017	5.33	6.14	6.94
06-10-2017	6.26	6.59	6.99
07-10-2017	6.41	6.74	7.04
08-10-2017	5.92	6.41	6.81
09-10-2017	5.62	6.23	6.76
10-10-2017	5.80	6.12	6.51
11-10-2017	5.41	5.60	5.80
12-10-2017	5.18	5.33	5.54
13-10-2017	4.19	4.60	5.21
14-10-2017	3.93	4.28	4.69
15-10-2017	4.69	5.11	5.64
16-10-2017	5.67	6.20	6.61
17-10-2017	6.10	6.81	7.24
18-10-2017	1.72	3.78	5.95
19-10-2017	2.24	4.00	4.77
20-10-2017	4.77	5.04	5.41
21-10-2017	4.30	4.77	5.02
22-10-2017	4.14	5.03	5.72
23-10-2017	5.26	5.67	6.15
24-10-2017	5.59	6.00	6.31
25-10-2017	6.00	6.77	7.24
26-10-2017	5.49	5.99	6.81
27-10-2017	5.15	5.63	6.15
28-10-2017	5.49	6.05	6.66
29-10-2017	5.85	6.32	6.71
30-10-2017	4.35	4.98	6.03
31-10-2017	3.33	3.95	4.53

01-11-2017	4.51	4.87	5.28
02-11-2017	1.59	3.49	5.13
03-11-2017	0.16	0.51	1.45
04-11-2017	0.00	0.21	0.47
05-11-2017	0.00	0.11	0.25
06-11-2017	-0.03	0.05	0.14
07-11-2017	0.00	0.22	0.55
08-11-2017	0.55	0.83	1.15
09-11-2017	1.13	1.29	1.48
10-11-2017	1.48	1.80	2.18
11-11-2017	1.94	2.21	2.53
12-11-2017	2.02	2.18	2.37
13-11-2017	1.48	2.00	2.34
14-11-2017	0.96	2.32	2.80
15-11-2017	0.77	1.33	1.91
16-11-2017	1.75	2.32	2.88
17-11-2017	2.56	2.87	3.09
18-11-2017	2.77	3.00	3.20
19-11-2017	1.29	2.50	3.20
20-11-2017	1.72	2.81	3.35
21-11-2017	2.74	3.03	3.25
22-11-2017	1.78	2.34	2.85
23-11-2017	1.94	2.99	3.64
24-11-2017	3.67	3.80	3.93
25-11-2017	3.72	3.94	4.19
26-11-2017	3.12	3.44	3.70
27-11-2017	3.33	3.53	3.78
28-11-2017	3.25	3.45	3.59
29-11-2017	3.46	3.54	3.67
30-11-2017	3.46	3.62	3.91
01-12-2017	3.20	3.49	3.67
02-12-2017	3.09	3.26	3.46
03-12-2017	1.83	2.47	3.06
04-12-2017	1.51	1.75	2.07
05-12-2017	1.32	1.50	1.75
06-12-2017	1.29	1.60	1.99
07-12-2017	1.59	1.77	1.94
08-12-2017	1.78	1.96	2.16
09-12-2017	1.56	1.76	1.99
10-12-2017	1.48	1.89	2.37
11-12-2017	1.81	1.96	2.13
12-12-2017	1.78	2.06	2.45
13-12-2017	1.81	2.12	2.32
14-12-2017	1.86	2.06	2.26
15-12-2017	2.13	2.56	2.96
16-12-2017	2.02	2.24	2.58
17-12-2017	1.99	2.05	2.16

18-12-2017	2.10	2.42	2.58
19-12-2017	1.18	1.91	2.48
20-12-2017	0.02	0.39	1.10
21-12-2017	-0.03	0.23	0.58
22-12-2017	-0.03	0.26	0.55
23-12-2017	0.00	0.00	0.02
24-12-2017	0.00	0.00	0.00
25-12-2017	0.00	0.00	0.02
26-12-2017	0.00	0.01	0.02
27-12-2017	0.00	0.02	0.02
28-12-2017	0.00	0.01	0.02
29-12-2017	0.00	0.02	0.02
30-12-2017	0.00	0.00	0.00
31-12-2017	0.00	0.00	0.00
01-01-2018	0.00	0.01	0.02
02-01-2018	0.00	0.01	0.02
03-01-2018	0.02	0.02	0.02
04-01-2018	0.02	0.05	0.11
05-01-2018	0.11	0.24	0.44
06-01-2018	0.22	0.87	1.40
07-01-2018	1.34	1.46	1.59
08-01-2018	1.32	1.52	1.67
09-01-2018	1.29	1.59	1.83
10-01-2018	1.70	1.78	1.86
11-01-2018	0.00	0.69	1.67
12-01-2018	-0.03	-0.01	0.00
13-01-2018	0.00	0.22	0.74
14-01-2018	0.69	1.15	1.53
15-01-2018	1.21	1.47	1.78
16-01-2018	1.21	1.41	1.53
17-01-2018	1.32	1.53	1.64
18-01-2018	1.18	1.68	2.10
19-01-2018	1.97	2.16	2.40
20-01-2018	1.86	2.13	2.40
21-01-2018	1.56	1.76	1.97
22-01-2018	1.94	2.16	2.37
23-01-2018	1.81	2.12	2.32
24-01-2018	0.83	1.58	2.10
25-01-2018	1.29	1.73	2.07
26-01-2018	0.99	1.37	1.89
27-01-2018	1.04	1.18	1.40
28-01-2018	0.00	0.63	1.53
29-01-2018	0.00	0.33	0.69
30-01-2018	0.74	1.65	2.13
31-01-2018	1.72	1.97	2.26
01-02-2018	1.86	2.07	2.40
02-02-2018	1.91	2.35	2.66

03-02-2018	2.66	2.91	3.22
04-02-2018	2.50	2.75	2.98
05-02-2018	2.72	2.95	3.35
06-02-2018	2.66	2.93	3.20
07-02-2018	2.96	3.08	3.33
08-02-2018	2.82	3.00	3.27
09-02-2018	1.62	2.15	2.74
10-02-2018	0.93	1.35	1.72
11-02-2018	1.13	1.57	1.83
12-02-2018	0.36	0.83	1.24
13-02-2018	0.77	1.09	1.62
14-02-2018	0.85	1.33	1.81
15-02-2018	0.33	1.03	1.51
16-02-2018	1.29	1.66	2.18
17-02-2018	0.02	1.02	1.97
18-02-2018	-0.03	0.09	0.52
19-02-2018	0.00	0.00	0.02
20-02-2018	0.00	0.00	0.02
21-02-2018	0.00	0.00	0.02
22-02-2018	0.00	0.01	0.05
23-02-2018	0.00	0.01	0.02
24-02-2018	0.02	0.06	0.14
25-02-2018	0.08	0.31	0.58
26-02-2018	0.00	0.22	0.66
27-02-2018	0.63	0.96	1.34
28-02-2018	1.10	1.24	1.51
01-03-2018	0.14	0.85	1.37
02-03-2018	0.74	1.17	1.70
03-03-2018	0.66	1.24	1.72
04-03-2018	0.96	1.31	1.64
05-03-2018	1.10	1.50	1.94
06-03-2018	1.15	1.69	2.29
07-03-2018	0.05	1.03	1.81
08-03-2018	1.26	1.69	2.07
09-03-2018	1.53	1.85	2.40
10-03-2018	0.30	1.24	2.10
11-03-2018	0.36	1.39	2.42
12-03-2018	0.61	1.71	2.66
13-03-2018	1.37	1.99	2.48
14-03-2018	2.07	2.39	2.98
15-03-2018	1.51	2.35	3.33
16-03-2018	1.04	2.25	3.41
17-03-2018	2.02	2.77	3.78
18-03-2018	1.26	2.48	3.62
19-03-2018	2.42	2.91	3.27
20-03-2018	2.56	3.06	3.56
21-03-2018	1.91	2.77	3.64

22-03-2018	2.29	2.75	3.35
23-03-2018	1.75	2.40	3.06
24-03-2018	1.83	2.94	4.35
25-03-2018	2.05	2.82	3.51
26-03-2018	1.94	2.61	3.20
27-03-2018	2.45	3.33	4.64
28-03-2018	2.64	3.53	4.84
29-03-2018	2.88	3.46	4.19
30-03-2018	3.25	4.11	5.57
31-03-2018	2.64	3.83	5.23
01-04-2018	3.22	3.67	4.27
02-04-2018	1.83	3.18	4.61
03-04-2018	2.61	3.36	4.30
04-04-2018	2.82	3.64	4.61
05-04-2018	3.17	3.80	4.53
06-04-2018	3.56	4.26	5.28
07-04-2018	3.70	4.03	4.64
08-04-2018	3.20	4.18	5.57
09-04-2018	3.75	4.29	5.13
10-04-2018	3.14	3.56	4.22
11-04-2018	2.98	3.46	4.09
12-04-2018	3.04	3.75	4.77
13-04-2018	2.98	3.38	3.67
14-04-2018	3.09	3.77	4.66
15-04-2018	3.17	4.19	5.54
16-04-2018	3.64	4.28	5.18
17-04-2018	3.51	4.36	5.69
18-04-2018	3.27	4.28	5.57
19-04-2018	2.48	4.08	5.77
20-04-2018	3.67	4.32	5.31
21-04-2018	3.51	4.17	5.10
22-04-2018	2.29	3.77	5.72
23-04-2018	2.24	4.12	6.48
24-04-2018	2.77	4.51	6.76
25-04-2018	2.88	4.33	6.33
26-04-2018	2.88	4.19	5.95
27-04-2018	2.74	4.31	6.46
28-04-2018	3.54	3.84	4.32
29-04-2018	3.17	3.72	4.51
30-04-2018	3.38	4.12	5.28
01-05-2018	3.64	4.71	6.28
02-05-2018	3.25	4.77	6.51
03-05-2018	3.33	4.56	6.15
04-05-2018	3.67	4.53	5.59
05-05-2018	3.17	4.70	6.61
06-05-2018	3.78	4.63	6.20
07-05-2018	3.56	4.88	6.71

08-05-2018	3.62	4.90	6.71
09-05-2018	4.27	4.72	5.39
10-05-2018	3.88	4.92	6.23
11-05-2018	3.72	5.44	7.29
12-05-2018	4.14	5.85	7.85
13-05-2018	4.43	5.95	7.97
14-05-2018	4.58	6.18	8.27
15-05-2018	4.92	6.53	8.42
16-05-2018	5.23	6.95	9.06
17-05-2018	6.00	7.41	9.19
18-05-2018	5.90	7.27	8.57
19-05-2018	6.48	7.39	8.30
20-05-2018	6.61	7.27	8.15
21-05-2018	6.48	7.80	9.49
22-05-2018	6.59	8.20	9.95
23-05-2018	6.79	8.54	10.42
24-05-2018	7.44	8.79	10.27
25-05-2018	7.37	8.53	9.78
26-05-2018	6.46	7.90	9.16
27-05-2018	7.39	8.54	9.88
28-05-2018	7.17	8.45	9.76
29-05-2018	7.24	8.12	9.14
30-05-2018	5.90	7.39	8.84
31-05-2018	6.26	7.40	8.54
01-06-2018	6.66	7.36	7.87
02-06-2018	6.61	7.55	8.69
03-06-2018	7.14	7.82	8.34
04-06-2018	6.99	7.76	8.62
05-06-2018	6.00	6.72	7.47
06-06-2018	6.41	7.66	9.26
07-06-2018	7.19	8.38	9.95
08-06-2018	7.57	8.15	8.89
09-06-2018	6.71	7.51	8.44
10-06-2018	6.41	7.24	8.10
11-06-2018	6.23	7.14	8.02
12-06-2018	5.67	6.76	7.57
13-06-2018	7.02	7.42	8.05
14-06-2018	7.14	8.21	9.71
15-06-2018	7.42	9.08	10.76
16-06-2018	8.37	9.97	11.71
17-06-2018	9.09	10.75	12.51
18-06-2018	9.98	11.75	13.74
19-06-2018	11.18	12.80	14.55
20-06-2018	12.07	13.40	14.89
21-06-2018	12.58	13.90	15.25
22-06-2018	12.29	12.76	14.12
23-06-2018	11.08	12.11	13.38

24-06-2018	11.35	12.20	13.02
25-06-2018	10.44	10.96	11.93
26-06-2018	9.14	10.22	11.47
27-06-2018	8.94	10.13	11.37
28-06-2018	9.85	10.27	10.88
29-06-2018	9.46	9.98	10.76
30-06-2018	10.08	10.47	10.86
01-07-2018	9.98	10.62	11.44
02-07-2018	9.39	10.53	11.64
03-07-2018	9.36	10.60	11.88
04-07-2018	9.81	11.45	13.50
05-07-2018	11.83	13.09	14.60
06-07-2018	12.56	13.33	14.55
07-07-2018	11.59	12.24	13.14
08-07-2018	10.64	12.08	13.55
09-07-2018	11.22	12.27	13.33
10-07-2018	11.64	12.21	12.78
11-07-2018	11.71	13.04	14.94
12-07-2018	12.49	14.09	15.63
13-07-2018	13.21	14.77	15.96
14-07-2018	13.14	14.55	15.72
15-07-2018	12.41	14.12	15.56
16-07-2018	12.87	14.61	16.27
17-07-2018	13.83	15.36	16.63
18-07-2018	14.41	15.65	16.56
19-07-2018	14.48	15.28	16.49
20-07-2018	13.31	14.01	15.22
21-07-2018	11.66	12.59	13.76
22-07-2018	11.42	12.94	14.96
23-07-2018	12.94	14.38	15.72
24-07-2018	13.59	14.83	15.89
25-07-2018	13.91	15.21	16.44
26-07-2018	14.79	15.90	16.84
27-07-2018	14.96	16.04	16.84
28-07-2018	14.77	15.98	16.94
29-07-2018	15.20	16.34	17.18
30-07-2018	15.37	16.56	17.37
31-07-2018	15.87	16.85	17.44

Appendix B

Benthic Invertebrate Taxonomy Results

Cordillera Consulting

Project: 16025 Whistler 2018

Palmer Environmental Group, Alyssa Murdoch, May Mason Irene Mencke,

Taxonomist: Scott Finlayson

scottfinlayson@cordilleraconsulting.ca

250-494-7553

Site:	2018	2018	2018	2018	2018	2018	2018	2018
Sample:	21M-DS-AAQ21	21M-DS-AAQ21-QA/QC	JOR-DS-AQ31	MIL-DS-001	CRB-DS-AQ01	RGD-AQ11	RDG-DS-AQ12	RGD-DS-AQ12-QA/QC
Sample Collection Date:	31-Jul-18	31-Jul-18	01-Aug-18	01-Aug-18	01-Aug-18	31-Jul-18	01-Aug-18	01-Aug-18
CC#:	CC191659	CC191660	CC191661	CC191662	CC191663	CC191664	CC191665	CC191666
Phylum: Arthropoda	0	0	0	0	0	0	0	0
| Order: Collembola	0	0	0	0	0	0	0	0
| Family: Sminthuridae	0	0	0	0	0	2	0	0
Subphylum: Hexapoda	0	0	0	0	0	0	0	0
| Class: Insecta	0	0	0	0	0	0	0	0
| Order: Ephemeroptera	0	0	0	0	0	0	0	0
| Family: Ameletidae	0	0	0	0	0	0	0	0
Ameletus	28	1	6	0	0	31	14	0
| Family: Baetidae	217	0	12	20	380	23	11	0
Baetis	128	1	35	90	680	58	32	0
Baetis rhodani group	17	0	94	50	100	81	34	0
Baetis bicaudatus	0	0	0	0	0	2	5	0
Centroptilum	0	0	0	0	0	0	0	0
Anafroptilum	0	0	0	0	0	0	14	0
Diphetor hageni	0	0	0	15	0	0	0	0
| Family: Ephemerellidae	6	0	6	5	0	3	18	0
Caudatella	0	0	0	10	0	0	0	0
Drunella	0	0	0	0	0	0	0	0
Drunella grandis group	0	0	0	0	0	0	16	0
Drunella doddsii	33	0	0	10	0	9	5	0
Drunella spinifera	11	0	0	0	10	1	57	0
Serratella	0	0	18	0	0	1	0	0
| Family: Heptageniidae	28	0	0	25	40	20	0	0
Cinygmula	117	0	0	0	0	30	0	0
Epeorus	239	0	0	20	0	46	0	0
Rhithrogena	28	0	0	5	0	23	0	0
| Family: Leptophlebiidae	6	0	53	5	240	12	34	0
| Order: Plecoptera	0	0	0	0	0	0	0	0
| Family: Capniidae	6	0	0	0	0	4	0	0
| Family: Chloroperlidae	0	0	0	0	10	7	2	0
Neaviperla	0	0	0	0	0	1	0	0
Paraperla	0	0	0	0	0	5	0	0

Site:	2018	2018	2018	2018	2018	2018	2018	2018
Sample:	21M-DS-AAQ21	21M-DS-AAQ21-QA/QC	JOR-DS-AQ31	MIL-DS-001	CRB-DS-AQ01	RGD-AQ11	RDG-DS-AQ12	RGD-DS-AQ12-QA/QC
Sample Collection Date:	31-Jul-18	31-Jul-18	01-Aug-18	01-Aug-18	01-Aug-18	31-Jul-18	01-Aug-18	01-Aug-18
CC#:	CC191659	CC191660	CC191661	CC191662	CC191663	CC191664	CC191665	CC191666
Suwallia	0	0	0	0	0	5	2	0
Sweltsa	128	0	6	0	90	62	11	0
| Family: Leuctridae	0	0	0	0	0	1	0	0
Paraleuctra	6	0	0	0	0	0	0	0
| Family: Nemouridae	0	0	0	0	0	0	0	0
Malenka	0	0	0	0	10	1	5	0
Zapada	6	0	153	15	630	4	30	0
Zapada oregonensis group	0	0	0	0	10	0	0	0
Zapada cinctipes	6	0	82	55	130	0	5	0
Zapada columbiana	11	0	0	0	0	2	0	0
| Family: Perlidae	78	0	12	25	0	47	0	0
Doroneuria	17	0	0	0	0	3	0	0
Hesperoperla	0	0	18	20	0	1	0	0
| Family: Perlodidae	28	0	0	0	10	3	0	0
Megarcys	11	0	0	0	0	8	0	0
| Order: Trichoptera	0	1	0	0	0	0	0	0
| Family: Brachycentridae	0	0	0	0	0	0	0	0
Micrasema	0	0	0	5	0	1	0	0
| Family: Hydropsychidae	0	0	12	40	0	0	0	0
Arctopsyche	0	0	0	20	0	0	0	0
| Family: Hydroptilidae	0	0	0	0	0	0	0	0
Oxyethira	6	0	0	0	0	0	0	0
| Family: Lepidostomatidae	0	0	0	0	0	0	0	0
Lepidostoma	0	0	12	0	0	0	2	0
| Family: Limnephilidae	0	0	0	0	0	0	0	0
Dicosmoecus	0	0	0	0	0	0	2	0
Onocosmoecus	0	0	0	0	50	0	2	0
| Family: Rhyacophilidae	0	0	0	0	0	0	0	0
Rhyacophila	22	1	18	0	10	3	5	0
Rhyacophila angelita group	0	0	6	0	10	0	0	0
Rhyacophila betteni group	0	0	0	0	0	1	0	0
Rhyacophila brunnea/vemna group	17	0	0	15	0	1	0	0
Rhyacophila hyalinata group	0	0	0	5	0	0	0	0
Rhyacophila vagrita group	6	0	0	0	0	1	0	0
Rhyacophila arnaudi	0	0	0	0	30	0	0	0
| Order: Coleoptera	0	0	0	0	0	0	0	0
| Family: Dytiscidae	0	0	0	0	0	0	0	0
Oreodytes	0	0	0	0	0	0	39	0
| Subfamily: Hydroporinae	0	0	0	0	0	0	39	0
| Order: Diptera	0	0	0	5	0	0	0	0
| Family: Ceratopogonidae	0	0	0	0	0	0	0	0
Bezzia/ Palpomyia	39	0	0	15	0	0	2	0

Site:	2018	2018	2018	2018	2018	2018	2018	2018
Sample:	21M-DS-AAQ21	21M-DS-AAQ21-QA/QC	JOR-DS-AQ31	MIL-DS-001	CRB-DS-AQ01	RGD-AQ11	RDG-DS-AQ12	RGD-DS-AQ12-QA/QC
Sample Collection Date:	31-Jul-18	31-Jul-18	01-Aug-18	01-Aug-18	01-Aug-18	31-Jul-18	01-Aug-18	01-Aug-18
CC#:	CC191659	CC191660	CC191661	CC191662	CC191663	CC191664	CC191665	CC191666
Mallochohelea	6	0	0	0	0	0	0	0
| Family: Chironomidae	17	0	24	5	30	6	43	3
| Subfamily: Chironominae	0	0	0	0	0	0	0	0
| Tribe: Chironomini	0	0	0	0	0	0	0	0
Polypedilum	17	0	0	5	0	1	2	0
Saetheria	0	0	0	0	0	0	20	1
| Tribe: Tanytarsini	17	0	0	0	0	0	0	0
Micropsectra	22	0	59	265	30	6	14	0
Rheotanytarsus	0	0	0	5	0	0	0	0
Stempellinella	0	0	0	20	0	0	2	0
| Subfamily: Orthocladiinae	6	0	6	0	20	0	0	1
Brillia	0	0	29	0	20	0	0	0
Eukiefferiella	22	0	53	20	150	3	0	0
Heterotrissocladius	0	0	0	0	0	0	2	0
Hydrobaenus	6	0	0	0	0	0	0	0
Metriocnemus	0	0	0	0	0	1	0	0
Orthocladius complex	0	0	0	5	30	2	5	0
Parakiefferiella	0	0	0	0	0	0	9	0
Parametriocnemus	11	0	0	0	0	2	2	0
Psectrocladius	0	0	0	0	0	0	2	0
Rheocricotopus	0	0	0	0	0	0	9	0
Thienemanniella	0	0	0	0	30	0	7	0
Tvetenia	0	0	100	35	130	1	30	1
| Subfamily: Tanypodinae	0	0	0	0	0	0	0	0
Zavrelimyia	0	0	0	0	0	2	0	0
| Tribe: Pentaneurini	0	0	0	0	0	0	0	0
Thienemannimyia group	28	0	0	15	0	3	41	0
| Family: Deuterophlebiidae	0	0	0	0	0	0	0	0
Deuterophlebia	6	0	0	0	0	0	0	0
| Family: Empididae	0	0	0	0	10	0	0	0
Chelifera/ Metachela	0	0	0	0	30	0	2	0
Oreogeton	0	0	0	5	0	0	0	0
| Family: Simuliidae	11	0	41	10	20	5	0	1
Prosimulium	0	0	0	0	0	1	0	0
Prosimulium/Helodon	0	1	0	0	0	1	0	0
Simulium	478	3	1271	645	120	275	14	0
| Family: Tipulidae	0	0	0	0	0	0	2	0
Dicranota	0	1	0	5	0	1	2	0
Erioptera	0	0	0	0	20	0	0	0
Hexatoma	0	0	6	0	20	0	0	0
| Order: Lepidoptera	0	0	0	0	0	1	0	0
| Order: Megaloptera	0	0	0	0	0	0	0	0
| Family: Sialidae	0	0	0	0	0	0	0	0
Sialis	0	0	0	0	0	0	2	0

Site:	2018	2018	2018	2018	2018	2018	2018	2018
Sample:	21M-DS-AAQ21	21M-DS-AAQ21-QA/QC	JOR-DS-AQ31	MIL-DS-001	CRB-DS-AQ01	RGD-AQ11	RDG-DS-AQ12	RGD-DS-AQ12-QA/QC
Sample Collection Date:	31-Jul-18	31-Jul-18	01-Aug-18	01-Aug-18	01-Aug-18	31-Jul-18	01-Aug-18	01-Aug-18
CC#:	CC191659	CC191660	CC191661	CC191662	CC191663	CC191664	CC191665	CC191666
Subphylum: Chelicerata	0	0	0	0	0	0	0	0
| Class: Arachnida	0	0	0	0	0	0	0	0
| Order: Trombidiformes	0	0	0	5	0	2	2	0
| Family: Aturidae	0	0	0	0	0	0	0	0
Aturus	0	0	0	0	10	0	0	0
| Family: Hydryphantidae	0	0	0	0	0	0	0	0
Protzia	0	0	0	15	10	1	0	0
| Family: Hygrobatidae	0	0	0	0	0	0	0	0
Atractides	33	0	0	0	10	8	2	0
Hygrobates	0	0	0	0	20	0	20	0
| Family: Lebertiidae	0	0	0	0	0	0	0	0
Lebertia	11	0	0	0	10	2	9	0
| Family: Sperchontidae	0	0	0	0	0	0	0	0
Sperchon	22	0	0	0	10	8	5	0
Sperchonopsis	0	0	6	0	0	0	0	0
| Family: Torrenticolidae	0	0	0	0	0	0	0	0
Testudacarus	6	0	0	15	10	1	0	0
Torrenticola	0	0	0	10	0	0	0	0
| Order: Sarcoptiformes	0	0	0	0	0	0	0	0
| Order: Oribatida	0	0	0	0	0	2	0	0
| Class: Malacostraca	0	0	0	0	0	0	0	0
| Order: Amphipoda	0	0	0	0	0	0	2	0
| Family: Crangonyctidae	0	0	0	0	0	0	0	0
Crangonyx	0	0	0	0	0	1	2	0
Phylum: Mollusca	0	0	0	0	0	0	0	0
| Class: Bivalvia	0	0	0	0	0	0	0	0
| Order: Veneroida	0	0	0	0	0	0	0	0
| Family: Pisidiidae	0	0	6	0	0	0	2	1
Pisidium	0	0	6	0	0	0	5	2
| Class: Gastropoda	0	0	0	0	0	0	0	0
| Order: Basommatophora	0	0	0	0	0	0	0	0
| Family: Planorbidae	0	0	0	0	0	1	0	0
Phylum: Annelida	0	0	0	0	0	0	0	0
Subphylum: Clitellata	0	0	0	0	0	0	0	0
| Class: Oligochaeta	0	0	0	0	0	0	0	0
| Order: Lumbriculida	0	0	0	0	0	0	0	0
| Family: Lumbriculidae	22	0	0	0	0	0	0	0
Lumbriculus	6	0	0	0	0	6	9	0

Site:	2018	2018	2018	2018	2018	2018	2018	2018
Sample:	21M-DS-AAQ21	21M-DS-AAQ21-QA/QC	JOR-DS-AQ31	MIL-DS-001	CRB-DS-AQ01	RGD-AQ11	RDG-DS-AQ12	RGD-DS-AQ12-QA/QC
Sample Collection Date:	31-Jul-18	31-Jul-18	01-Aug-18	01-Aug-18	01-Aug-18	31-Jul-18	01-Aug-18	01-Aug-18
CC#:	CC191659	CC191660	CC191661	CC191662	CC191663	CC191664	CC191665	CC191666
| Order: Tubificida	0	0	0	0	0	0	0	0
| Family: Naididae	0	0	0	0	0	0	0	0
Nais	0	0	0	0	10	0	0	0
| Subfamily: Tubificinae with hair chaet	0	0	0	0	0	0	161	0
Totals:	**1992**	**9**	**2150**	**1560**	**3190**	**846**	**815**	**10**

Taxa present but not included:

Terrestrials	0	0	0	0	0	0	2	0
Phylum: Arthropoda	0	0	0	0	0	0	0	0
Subphylum: Hexapoda	0	0	0	0	0	0	0	0
| Class: Insecta	0	0	0	0	0	0	0	0
| Order: Psocodea	0	0	0	0	0	1	0	0
Subphylum: Crustacea	0	0	0	0	0	0	0	0
| Class: Ostracoda	0	0	0	0	0	1	0	0
| Class: Maxillipoda	0	0	0	0	0	0	0	0
| Class: Copepoda	0	0	0	0	10	0	0	0
Phylum: Nemata	0	0	6	0	0	1	2	1
Phylum: Platyhelminthes	0	0	0	0	0	0	0	0
| Class: Turbellaria	0	0	6	0	0	1	0	0
Totals:	**0**	**0**	**12**	**0**	**10**	**4**	**4**	**1**

Appendix C

Benthic Invertebrate (CABIN) Sampling Datasheets

21M-DS-AQ21

Field Crew: MS, AC, AB, JK   Site Code: ~~R-01-01~~

Sampling Date: (DD/MM/YYYY) 31/07/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: RMOW Ecosyst. Monitoring   Local Basin Name: River of Golden Dreams

River/Stream Name: Twentyone Mile   Stream Order: (map scale 1:50,000) ______

Select one: ☐ Test Site ☒ ? Potential Reference Site (upstream of RGD)

Geographical Description/Notes:

Lorimer Rd parking/church.

- use trail to NE (right hand side) - cross bridge - cross rail tracks

go ~50m b/f cut off trail @ sand pit - aligned w/ 1st line tower

Surrounding Land Use: (check those present)   Information Source: onsite

☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other recreational (trail/dogwalkers)

Dominant Surrounding Land Use: (check one)   Information Source: ______

☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ______

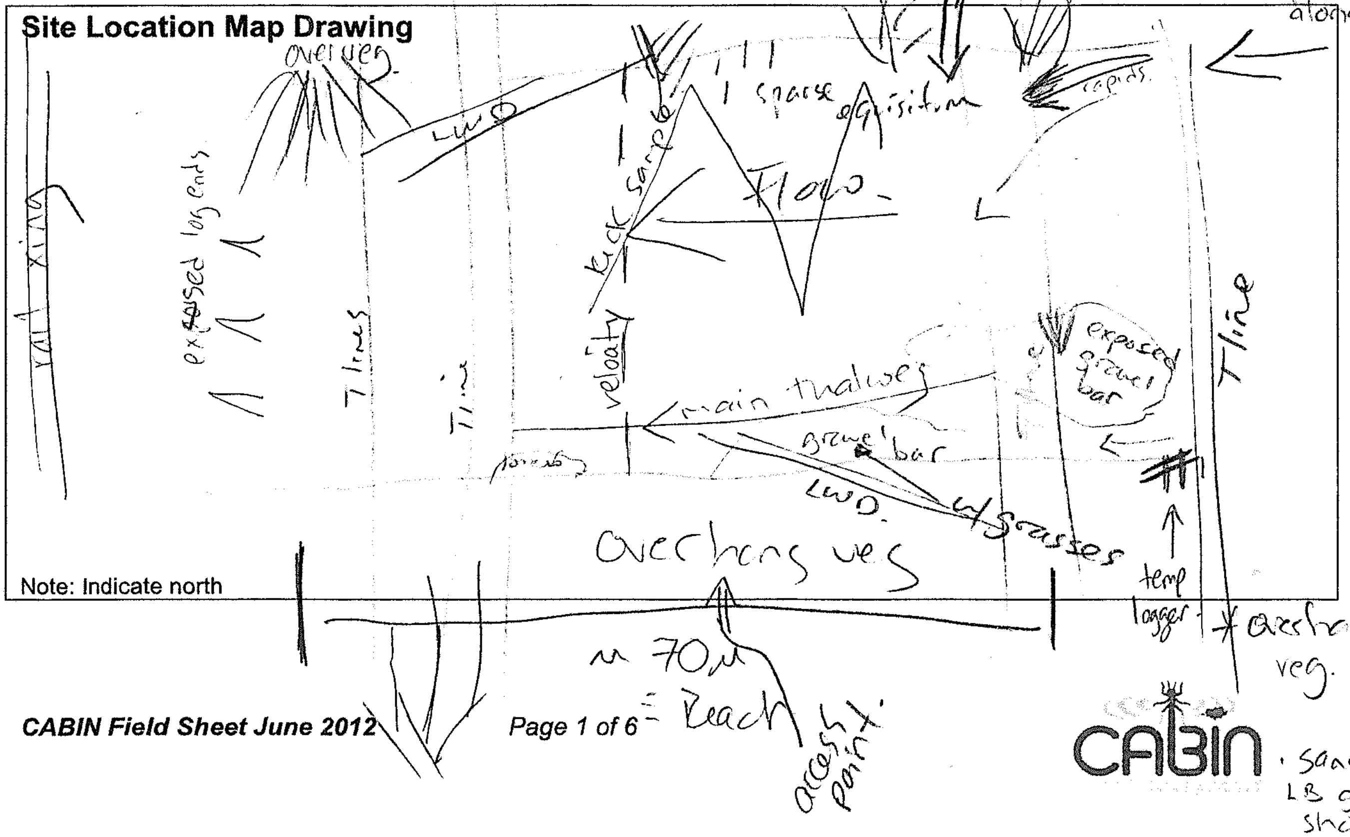
Location Data 0501931 E, 5552826 N

Latitude: ______ N Longitude: - ______ W (DMS or DD)

Elevation: 645 (fasl *or* masl)   GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ______

iron inflows. see pic #6.
- rocks red-toned (esp. underside) along RB where iron chan comes in

Site Location Map Drawing



Note: Indicate north

* overhang veg. throughout

. sand on LB gravel shore.

CABIN Field Sheet June 2012   Page 1 of 6

Field Crew: MS, AC, AB, J.K Site Code: 21M-DS-AQ21

Sampling Date: (DD/MM/YYYY) 31/07/2018

Photos
☑ Field Sheet #1 ☑ Upstream #2 ☑ Downstream #3 ☑ Across Site #4 ☐ Aerial View
☐ Substrate (exposed) ☑ Substrate (aquatic) #5 ☐ Other

PIC 6-7-8 od iron inflow @ waypoint 239

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
☑ Riffle ~~☑ Rapids~~ ☑ Straight run ☑ Pool/Back Eddy

PIC 9 looking U/S - gravel bars @ temp logger

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
☐ 0 % ☑ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

PIC 10 lookin d/s - @ temp logger

3. Macrophyte Coverage: *(not algae or moss, check one)*
☐ 0 % ☑ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

very little on RB @ kick area

4. Streamside Vegetation: (*check those present)*
☑ ferns/grasses ☑ shrubs ☑ deciduous trees ☐ coniferous trees

5. Dominant Streamside Vegetation: *(check one)*
☐ ferns/grasses ☑ shrubs ☐ deciduous trees ☐ coniferous trees

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one)*

— random rocks w/ chunks od thick algae

☑ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
☐ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
☐ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☑ riffle ☐ rapids ☐ straight run

400 µm mesh Kick Net	✓
Person sampling	Maria S.
Sampling time (i.e. 3 min.)	3 min
No. of sample jars	2 + 2QA/QC
Typical depth in kick area (cm)	10cm

Preservative used: Ethanol 1:1

Sampled sieved on site using "Bucket Swirling Method":
☑ YES ☐ NO
If YES, debris collected for QAQC ☑

+ 3 sculpin found.

+ River otter d/s od site

Note: Indicate if a sampling method other than the recommended 400 µm mesh kick net is used.

Field Crew: MS, AC, AB, JK Site Code: 21M-DS-AQ21

Sampling Date: (DD/MM/YYYY) 31/07/2018

WATER CHEMISTRY DATA **Time:** 12:08 (24 hr clock) **Time zone:** PST

Air Temp: ______ (°C) Water Temp: 19.9 (°C) pH: 6.19

Specific Conductance: 38.1 (µs/cm) DO: 14.6 (mg/L) Turbidity: ______ (NTU)

140.3%

Check if water samples were collected for the following analyses:

☐ TSS (Total Suspended Solids)

☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)

☐ Phosphorus (Total, Ortho, and/or Dissolved)

☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate) ☐ Other ______

— n/a done by EMOW.

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

— Temp logger downloaded @ 2pm (no waterflow holes/ wrong placement) - in pool area.

Slope - Indicate how slope was measured: (check one)

☐ **Calculated from map**

Scale: ______ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).

contour interval (vertical distance) ______ (m),

distance between contour intervals (horizontal distance) ______ (m)

slope = vertical distance/horizontal distance = ______

OR

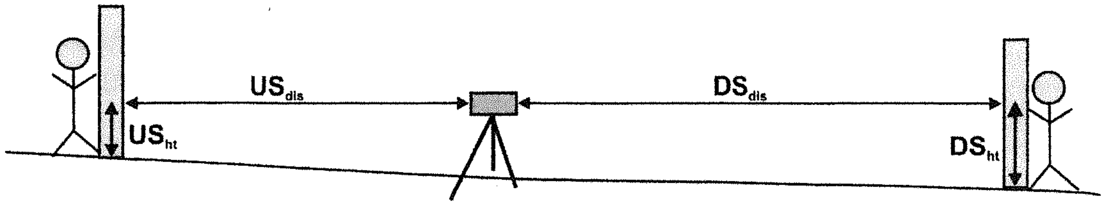
☑ **Measured in field**

Circle device used and fill out table according to device:

a. Survey Equipment b. Hand Level & Measuring Tape

Clinometer = <1 ° over 30m

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
ᵃTop Hairline (T)			
ᵃMid Hairline (ht) OR ᵇHeight of rod			
ᵃBottom Hairline (B)			
ᵇDistance (dis) OR ᵃT-B x 100	ᵃUS_{dis}=T-B	ᵃDS_{dis}=T-B	US_{dis}+DS_{dis}=
Change in height (Δht)			DS_{ht}-US_{ht}=
Slope (Δht/total dis)			



Field Crew: MS, AC, AB, JK Site Code: 21M-DS-AQ21

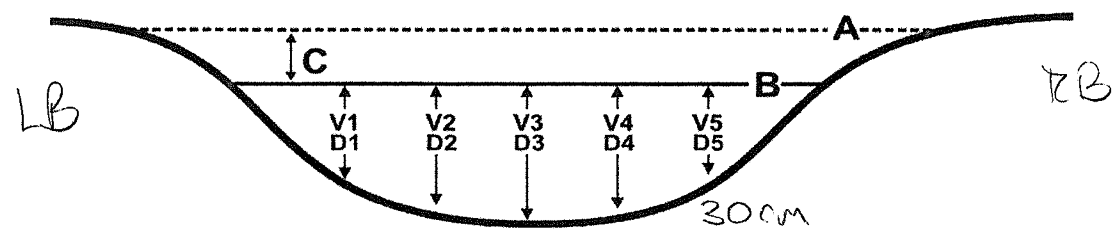
Sampling Date: (DD/MM/YYYY) 31/07/2018

Widths and Depth

Location at site: In u/s zone of kick sample location (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 11.7 (m) B - Wetted Stream Width: 10.9 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 30cm (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☑ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = √ [2(ΔD/100) * 9.81]

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other

	RB		middle			LB	
	1	2	3	4	5	6	AVG
Distance from Shore (m) RB →	2.0	3.5	6.0	7.5	9.0	10.5	
Depth (D) (cm)	8.0						
Velocity Head Rod (ruler)							
Flowing water Depth (D_1) (cm)	8.0	15.5	19.0	18.0	24.5	25.5	
Depth of Stagnation (D_2) (cm)	8.8	18.2	22.0	19.5	27.3	26.5	
Change in depth ($\Delta D = D_2 - D_1$) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (V) (m/s)							

Field Crew: MS, AC, AB, JK Site Code: 21M-DS-A021

Sampling Date: (DD/MM/YYYY) 31/07/2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	2
0.2-1.6 cm (gravel)	[✓ 3]
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embededness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	40.		26	2.2		51	1.5		76	1.5	
2	4.2		27	3.2		52	1.8	0	77	3.4	
3	3.4		28	5.1		53	3.0		78	2.0	
4	3.9		29	5.4		54	1.7		79	2.6	
5	3.0		30	3.4		55	1.3		80	2.4	1/2
6	5.7		31	3.2		56	6.9		81	1.6	
7	5.8		32	2.5		57	3.0		82	1.1	
8	5.4		33	3.2	0	58	2.4		83	1.6	
9	3.9		34	3.0		59	2.0		84	1.8	
10	8.0		35	2.5		60	39		85	1.0	
11	4.5		36	3.4		61	2.0	1/4	86	2.0	
12	5.4	0	37	2.9		62	1.9		87	2.0	
13	4.0		38	3.8		63	3.0		88	2.3	
14	3.0		39	3.0		64	2.3		89	1.0	
15	2.7		40	3.7		65	1.1		90	2.1	
16	2.5		41	5.5	1/4	66	1.4		91	3.6	1/2
17	6.0		42	3.8		67	2.8		92	3.6	
18	2.6		43	2.6		68	2.6		93	1.7	
19	6.5		44	4.3		69	1.4		94	2.2	
20	4.0		45	3.0		70	4.8	1/2	95	2.0	
21	3.9	1/2	46	5.1		71	1.5		96	2.0	
22	3.0		47	3.8		72	2.7		97	1.6	
23	3.5		48	3.9		73	1.6		98	0.5	
24	3.2		49	3.6		74	0.6		99	2.6	
25	3.0		50	4.9		75	2.5		100	2.3	1/4

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: Maria S, Andrea B., Alex C. Jagoda K. Kozikowska. Site Code: 21M-DS-AQ21

Sampling Date: (DD/MM/YYYY) 31/07/2018

SITE INSPECTION

Site Inspected by: Maria S.

Communication Information

☑ Itinerary left with contact person (include contact numbers)

Contact Person: ____________ Time checked-in: ________

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: ( ) ________

Vehicle Safety

☑ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☑ Equipment and chemicals safely secured for transport

☑ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Field Crew: MS AC AB Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: RMCW Ecosystem Monitoring Local Basin Name: RGD - AQ11

River/Stream Name: ________ Stream Order: (map scale 1:50,000) ________

Select one: ☑ Test Site ☐ Potential Reference Site

Geographical Description/Notes: Lorimer Rd - parking - take 1st path to Left - follow ~20m and. opening on right that leads you to gravel bar / site.

Surrounding Land Use: (check those present) Information Source: ________

☑ Forest ☐ Field/Pasture ☐ Agriculture ☑ Residential/Urban /recreation

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ________

Dominant Surrounding Land Use: (check one) Information Source: ________

☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

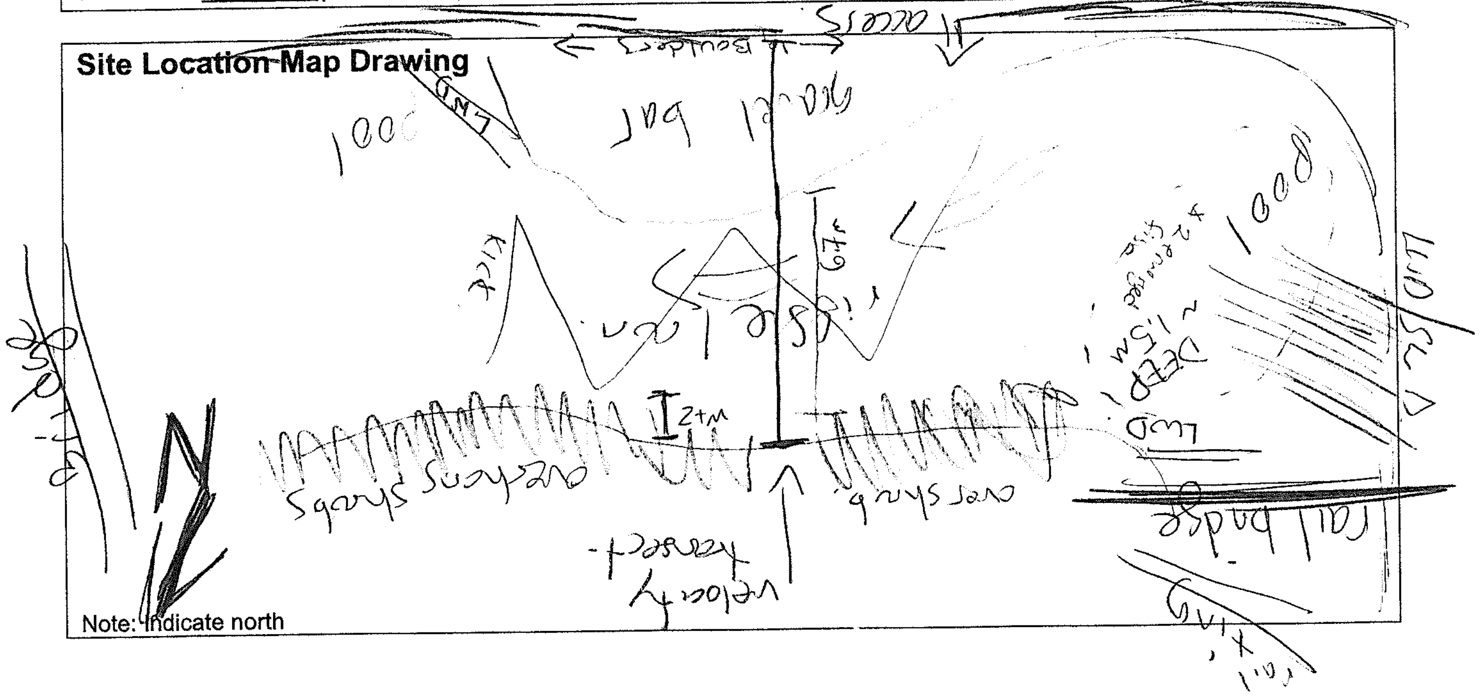
☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ________

Location Data UTM 10U 0502000 5552767 WPT: 240

Latitude: ________N Longitude: - ________W (DMS or DD)

Elevation: ________(fasl *or* masl) GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ________

Site Location Map Drawing



Note: Indicate north

temp logger 241 (under bridge rr LB)

Field Crew: MS, AC, AB
Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

Photos

Railbridge around bend

☑ Field Sheet #1 ☑ Upstream #2 ☑ Downstream #3 ☑ Across Site #4 ☐ Aerial View
☐ Substrate (exposed) ☑ Substrate (aquatic) #5 ☐ Other ______

#6 - Kayers

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
☑ Riffle ☐ Rapids ☑ Straight run ☑ Pool/Back Eddy

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
☐ 0 % ☑ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

3. Macrophyte Coverage: *(not algae or moss, check one)*
☑ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

4. Streamside Vegetation: (*check those present)*
☐ ferns/grasses ☑ shrubs ☑ deciduous trees ☐ coniferous trees

5. Dominant Streamside Vegetation: *(check one)*
☐ ferns/grasses ☑ shrubs ☐ deciduous trees ☐ coniferous trees

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one)*

☑ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
☐ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
☐ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

Note: 1 through 5 represent categories entered into the CABIN database.

- rail/ped bridge
- dogs
- kyakers
- tubers
- walkers in stm

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☐ riffle ☐ rapids ☐ straight run

400 µm mesh Kick Net	✓
Person sampling	Maria
Sampling time (i.e. 3 min.)	3min
No. of sample jars	1 jar.
Typical depth in kick area (cm)	25

Preservative used: 1:1 Ethanol.

Sampled sieved on site using "Bucket Swirling Method":
☐ YES ☒ NO
If YES, debris collected for QAQC ☐

Note: Indicate if a sampling method other than the recommended 400 µm mesh kick net is used.

Field Crew: MS AC AB Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

WATER CHEMISTRY DATA **Time:** 1514 (24 hr clock) **Time zone:** PST

Air Temp: 34.0 (°C) Water Temp: 15.5 (°C) pH: 7.23

Specific Conductance: 35.6 (µs/cm) DO: 7.50 (mg/L) 75.1% Turbidity: 19 ppm (NTU)

Check if water samples were collected for the following analyses:

N/A

- ☐ TSS (Total Suspended Solids)
- ☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)
- ☐ Phosphorus (Total, Ortho, and/or Dissolved)
- ☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate) ☐ Other

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - Indicate how slope was measured: (check one)

☐ **Calculated from map**

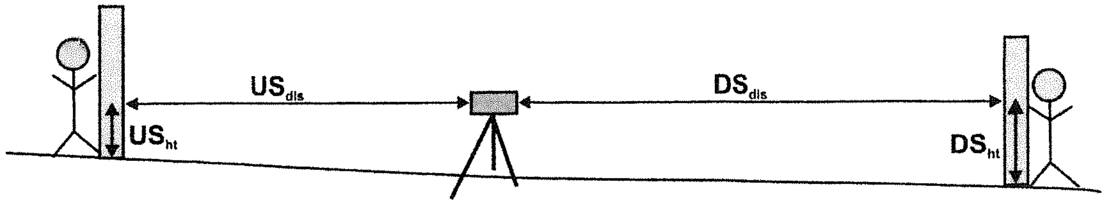
Scale: (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) (m),
distance between contour intervals (horizontal distance) (m)
slope = vertical distance/horizontal distance =

OR

☑ **Measured in field**

Circle device used and fill out table according to device: Clino 1% over 20m.
a. Survey Equipment b. Hand Level & Measuring Tape

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
^{a}Top Hairline (T)			
^{a}Mid Hairline (ht) OR ^{b}Height of rod			
^{a}Bottom Hairline (B)			
^{b}Distance (dis) OR ^{a}T-B x 100	$^{a}US_{dis}$=T-B	$^{a}DS_{dis}$=T-B	$US_{dis}+DS_{dis}$=
Change in height (Δht)			$DS_{ht}-US_{ht}$=
Slope (Δht/total dis)			



Field Crew: MS, AC, AB Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

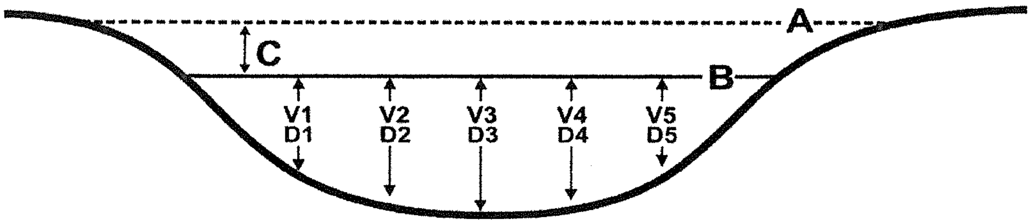
Widths and Depth

Location at site: d/s of kick area (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 18.1 (m)

B - Wetted Stream Width: 6.7 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 35 cm. (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☐ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = $\sqrt{[2(\Delta D/100) * 9.81]}$

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other

	1	2	3	4	5	6	AVG
Distance from Shore (m)							
Depth (**D**) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (**D₁**) (cm)	12.2	22.5	38.5	34.5	24.0	6.5	
Depth of Stagnation (**D₂**) (cm)	12.8	23.0	450	38.5	27.0	6.9	
Change in depth (**ΔD=D₂-D₁**) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (**V**) (m/s)							

Field Crew: M.S. AC AB

Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	2
0.2-1.6 cm (gravel)	[✓ 3]
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embedderness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	1.0		26	2.6		51	3.7		76	4.1	
2	3.0		27	2.7		52	5.2		77	2.6	0
3	1.9		28	1.1		53	3.2		78	3.5	
4	2.2		29	3.7		54	3.6		79	1.8	
5	1.8		30	3.2		55	0.4		80	2.3	
6	2.5		31	3.7	0	56	2.9		81	3.7	1/2
7	3.5		32	15.2		57	2.4		82	2.5	
8	1.1		33	3.4		58	6.5		83	2.3	
9	3.4		34	3.0		59	1.1	0	84	0.9	
10	3.7		35	3.6		60	1.0		85	2.6	
11	1.8		36	1.6		61	2.8		86	1.9	
12	3.7	0	37	1.6		62	2.9		87	2.3	
13	3.2		38	0.9		63	3.5		88	3.1	
14	3.6		39	1.9		64	1.4		89	2.4	0
15	3.2		40	2.7		65	3.3		90	2.9	
16	3.4		41	1.6		66	3.7		91	2.3	
17	2.2		42	1.7		67	2.1		92	4.5	1/4
18	1.7		43	3.3		68	3.1		93	3.8	
19	2.5		44	1.4		69	2.2		94	1.2	
20	4.0		45	2.7		70	2.9		95	3.3	
21	2.9	0	46	2.0	0	71	2.8	0	96	2.2	
22	2.1		47	3.3		72	2.6		97	2.7	
23	4.1		48	3.0		73	2.5		98	5.3	
24	3.8		49	1.1		74	3.0		99	1.7	
25	4.9		50	1.9		75	3.8		100	3.7	

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: Maria S., Alex C. Andrea B. Site Code: RGD-AQ11

Sampling Date: (DD/MM/YYYY) 31/07/2018

SITE INSPECTION

Site Inspected by: Maria S.

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: ____________________ Time checked-in: ________

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: (   ) ____________

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Field Crew: MS, JK, A.C.   Site Code: CRB-DS-AP01

Sampling Date: (DD/MM/YYYY) 01/08/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: ____________ Local Basin Name: ____________

River/Stream Name: ____________ Stream Order: (map scale 1:50,000) ____________

Select one: ☐ Test Site ☐ Potential Reference Site

Geographical Description/Notes:
Pack at Lonnier Rd parking lot - take SE trail ~15m till hit unmarked path in woods to L; walk 30m to stream.

Surrounding Land Use: (check those present)   Information Source: ____________

☑ Forest ☐ Field/Pasture ☐ Agriculture ☑ Residential/Urban /rec.
☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ____________

Dominant Surrounding Land Use: (check one)   Information Source: ____________

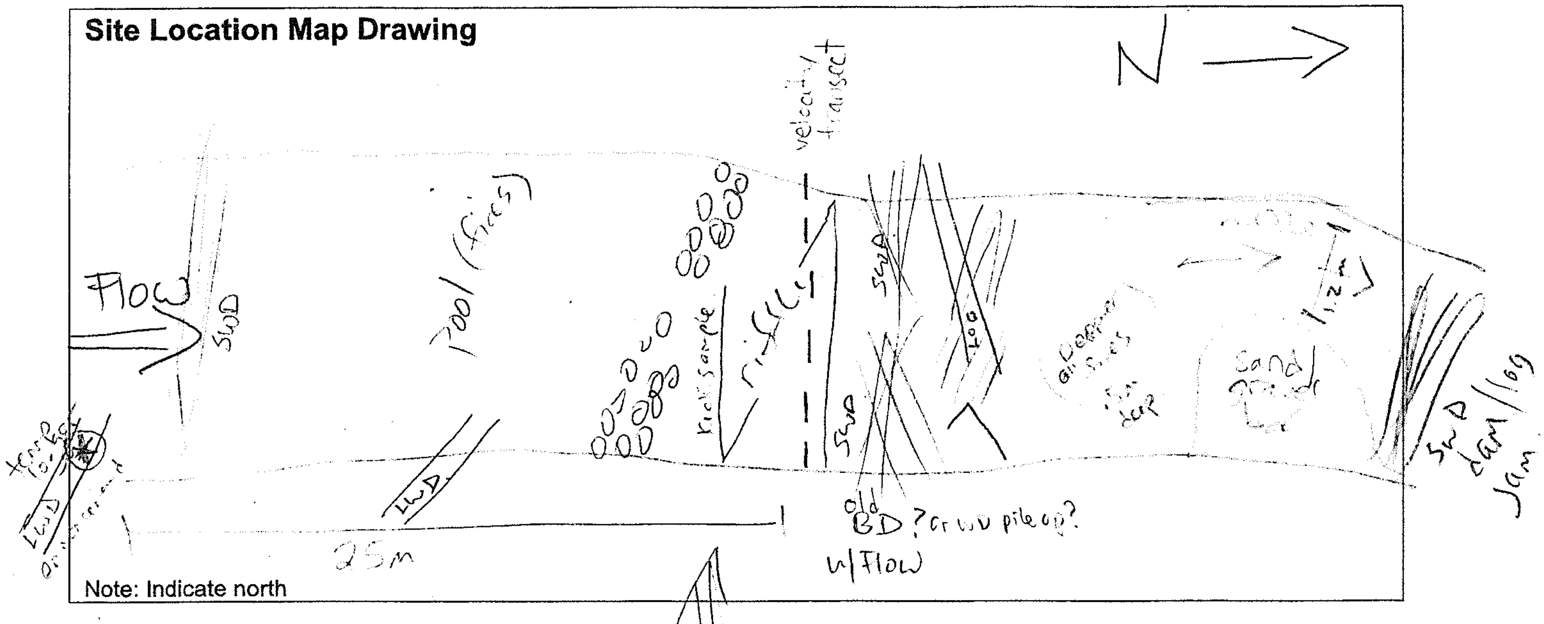
☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban
☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ____________

Location Data 10 U 0502022 5552694 waypt. 242

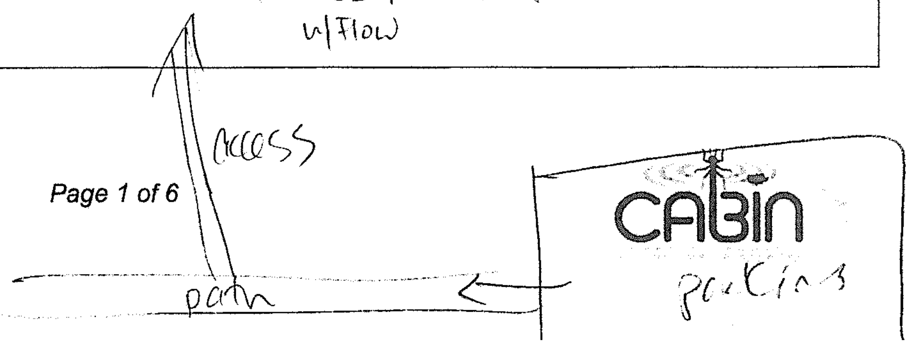
Latitude: ____________N Longitude: - ____________W (DMS or DD)

Elevation: 645 (fasl *or* masl) GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ____________

Site Location Map Drawing



Note: Indicate north



u/s temp logger ~25m u/s of site on [illegible] anchored LWD

Field Crew: MS, JK, AC   Site Code: CEB-DS-AQ01

Sampling Date: (DD/MM/YYYY) 01/08/2018

Photos
1 ☑ Field Sheet   2 ☑ Upstream   3 ☑ Downstream   4 ☑ Across Site   ☐ Aerial View
☐ Substrate (exposed)   5,6,7 ☑ Substrate (aquatic)   ☐ Other ____________

Pics of u/s temp logger + us in action

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
   ☑ Riffle   ☐ Rapids   ☐ Straight run   ☑ Pool/Back Eddy

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
   ☐ 0 %   ☐ 1-25 %   ☐ 26-50 %   ☑ 51-75 %   ☐ 76-100 %

3. Macrophyte Coverage: *(not algae or moss, check one)*
   ☑ 0 %   ☐ 1-25 %   ☐ 26-50 %   ☐ 51-75 %   ☐ 76-100 %

4. Streamside Vegetation: *(check those present)*
   ☑ ferns/grasses   ☑ shrubs   ☑ deciduous trees   ☐ coniferous trees

5. Dominant Streamside Vegetation: *(check one)*
   ☐ ferns/grasses   ☑ shrubs   ☐ deciduous trees   ☐ coniferous trees

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one)*

   ☐ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
   ☑ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick) – majority had algae build up like this [illegible]
   ☑ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick) (random – 50% of rocks have mossy clumps) see pic
   ☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
   ☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☑ riffle ☐ rapids ☐ straight run

400 μm mesh Kick Net	✓
Person sampling	Maria S.
Sampling time (i.e. 3 min.)	3 min
No. of sample jars	1 jar
Typical depth in kick area (cm)	10cm.

Preservative used: 1:1 Ethanol

Sampled sieved on site using "Bucket Swirling Method":
☐ YES ☒ NO
If YES, debris collected for QAQC ☐

Note: Indicate if a sampling method other than the recommended 400 μm mesh kick net is used.

Field Crew: MY, JK, AC. Site Code: CRB-DS-AQ01

Sampling Date: (DD/MM/YYYY) 01/08/2018

WATER CHEMISTRY DATA

Time: 0911 (24 hr clock) Time zone: ______

Air Temp: 19'C (°C) Water Temp: 16.0 (°C) pH: 7.51

Specific Conductance: 194.4 (µs/cm) DO: 7.53 (mg/L) 76.3% Turbidity: 115(ppm) (NTU)

Check if water samples were collected for the following analyses: n/a

- ☐ TSS (Total Suspended Solids)
- ☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)
- ☐ Phosphorus (Total, Ortho, and/or Dissolved)
- ☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate)
- ☐ Other______

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - Indicate how slope was measured: (check one)

☐ **Calculated from map**

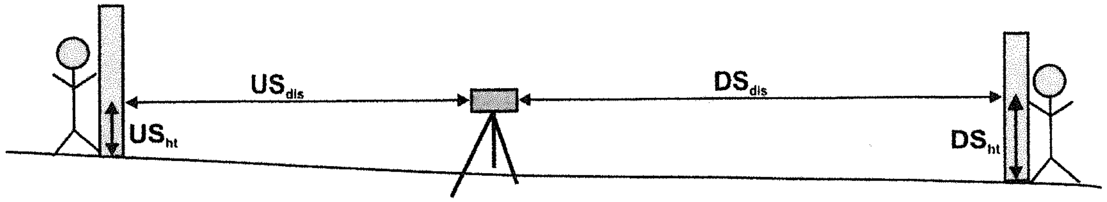
Scale: ______ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) ______ (m),
distance between contour intervals (horizontal distance) ______ (m)
slope = vertical distance/horizontal distance = ______

OR

☒ **Measured in field**

Circle device used and fill out table according to device: clinometer, 2'@10m
a. Survey Equipment b. Hand Level & Measuring Tape

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
^{a}Top Hairline (T)			
^{a}Mid Hairline (ht) OR ^{b}Height of rod			
^{a}Bottom Hairline (B)			
^{b}Distance (dis) OR ^{a}T-B x 100	$^{a}US_{dis}$=T-B	$^{a}DS_{dis}$=T-B	$US_{dis}+DS_{dis}$=
Change in height (Δht)			$DS_{ht}-US_{ht}$=
Slope (Δht/total dis)			



Field Crew: MG, JK, AC Site Code: CRB-DS-AQ01

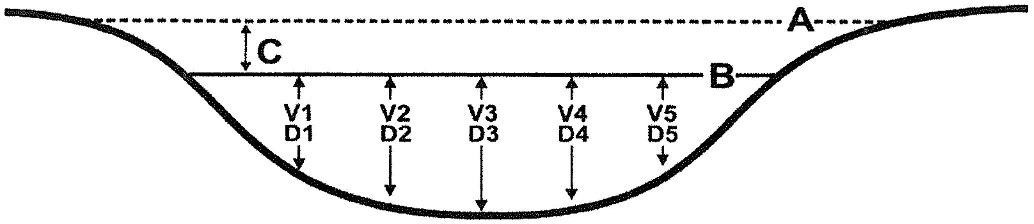
Sampling Date: (DD/MM/YYYY) 01/08/2018

Widths and Depth

Location at site: w/in kick sample line (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 4.5 (m) B - Wetted Stream Width: 3.1 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 37 (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☒ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = $\sqrt{[2(\Delta D/100) * 9.81]}$

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other

wetted RB .5 1.0 1.5 2.0 2.5 LB.

	1	2	3	4	5	6	AVG
Distance from Shore (m)	10.5						
Depth (**D**) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (**D$_1$**) (cm)	10.5	13.5	18.5	15.0	13.5		
Depth of Stagnation (**D$_2$**) (cm)	11.0	14.5	19.0	15.5	14.0		
Change in depth (**ΔD=D$_2$-D$_1$**) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (**V**) (m/s)							

Field Crew: MS, JK, AC

Site Code: CRB-DS-AQ01

Sampling Date: (DD/MM/YYYY) 01/08/2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	[✓ 2]
0.2-1.6 cm (gravel)	3
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embededness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	7.2		26	3.0		51	10.0		76	S	
2	5.0		27	10.0		52	15.1		77	10.5	
3	16.8		28	1.5		53	7.7		78	9.0	
4	2.1		29	11.6		54	3.0		79	3.0	
5	10.6		30 *	9.0	3/4	55	0.7		80 *	0.6	
6	1.6		31	0.9		56	10.4		81	6.8	
7	5.5		32	2.6		57	12.0		82	7.0	1/2
8	3.6		33	4.7		58	0.7		83	6.1	
9	12.0		34	25.5		59	29.7		84	0.8	
* 10	6.8	1/2	35	7.0		60 *	4.5	3/4	85	9.5	
11	13.0		36	13.0		61	11.0		86	6.2	
12	16.8		37	0.5		62	6.3		87	S	
13	11.0		38	0.9		63	13.0		88	11.4	
14	1.1		39	11.0		64	S		89	5.1	
15	13.2		40 *	2.2		65	13.0		90 *	4.8	1/2
16	2.3		41	10.0	1/2	66	20.0		91	4.5	
17	7.1		42	0.3		67	0.2		92	0.5	
18	8.4		43	S		68	1.7		93	9.0	
19	12.5		44	1.5		69	23.0		94	12.0	
* 20	14.0	1/2	45	5.3		70 *	5.0		95	12.2	
21	5.0		46	9.0		71	2.1		96	16.0	
22	10.8		47	16.4		72	2.8		97	0.5	
23	14.2		48	12.0		73	11.0	3/4	98	1.3	
24	4.4		49	S		74	0.4		99	10.0	
25	5.2		50 *	15.4	1/4	75	1.5		100 *	7.2	1/2

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

* Done within kick-sample area but was in an enhancement site. ie: fixes US + DS

Field Crew: ______________________________ Site Code: ____________

Sampling Date: (DD/MM/YYYY) ____________________

SITE INSPECTION

Site Inspected by: __________________________

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: ______________________ Time checked-in: ________

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: (   ) __________

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Field Crew: M Sotiropoulos, Alex C & J K Site Code: MIL-DS-001

Sampling Date: (DD/MM/YYYY) 01/08/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: RMOW Ecosyst. Monitoring Local Basin Name: ______

River/Stream Name: Miller Creek (DS of Olives) Stream Order: (map scale 1:50,000) ______

Select one: ☑ Test Site ☐ Potential Reference Site

Geographical Description/Notes: turn off Hwy @ Function Junction - Park @ 'Olives' store, take path off parking lot in front of Olives turn R - Follow path — m over wood bridge/walk - turn L - walk past 2 picnic tables (~35m) - take L trail to 'beach/beach' * riffle u/s *

(✱) circle secondary path @ back of Olives takes you to wood bridge/walk [illegible].

Surrounding Land Use: (check those present) Information Source: ______

☑ Forest ☐ Field/Pasture ☐ Agriculture ☑ Residential/Urban
☐ Logging ☐ Mining ☑ Commercial/Industrial ☐ Other ______

Dominant Surrounding Land Use: (check one) Information Source: ______

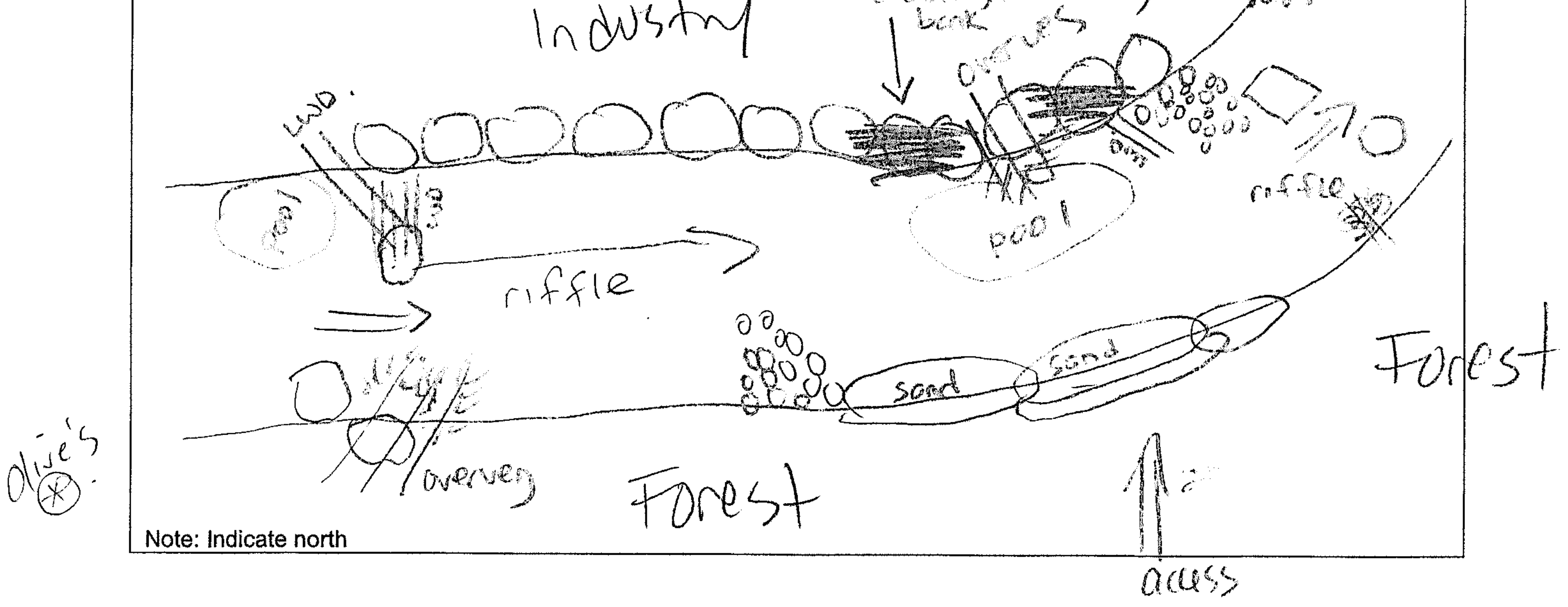
☑ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban
☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ______

Location Data 10U04970995540450 WD: 247

Latitude: ______N Longitude: - ______W (DMS or DD)

Elevation: 614 (fasl *or* masl) GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ______

Site Location Map Drawing



Note: Indicate north

CABIN Field Sheet June 2012 *Page 1 of 6*

Field Crew: MS AC, JK Site Code: MIL-DS-001

Sampling Date: (DD/MM/YYYY) 01/08/2018

Photos
☐ Field Sheet 1 ☐ Upstream 2 ☐ Downstream 3 ☐ Across Site 4 ☐ Aerial View
☐ Substrate (exposed) ☐ Substrate (aquatic) 5 & 6 ☐ Other

PIC 7 looking u/s from d/s end of riffle / kick (alex in pic)

PIC 8 @ RB shoreline (diff from altered/boulder LB)

PIC 9 looking u/s from top of riffle kick area (where boulder/WD instream)

PIC 10 - looking d/s from PIC 9 location @ kick/riffle area

PIC 11 - looking d/s from sand bar on

PIC 12 - looking d/s from access p

PIC 13 - looking u/s from access pt,

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
☑ Riffle ☐ Rapids ☑ Straight run ☑ Pool/Back Eddy

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
☐ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☑ 76-100 %

3. Macrophyte Coverage: *(not algae or moss, check one)*
☑ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

4. Streamside Vegetation: (*check those present)*
☐ ferns/grasses ☑ shrubs ☑ deciduous trees ☑ coniferous trees

5. Dominant Streamside Vegetation: *(check one)*
☐ ferns/grasses ☐ shrubs ☑ deciduous trees ☐ coniferous trees

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one*)

☐ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
☑ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
☐ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

filamentous

(*) random algae but not major like garden

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☑ riffle ☐ rapids ☐ straight run

400 µm mesh Kick Net	✓
Person sampling	Mona S
Sampling time (i.e. 3 min.)	3 min
No. of sample jars	1 of 1
Typical depth in kick area (cm)	20

Preservative used: 1:1 Ethanol

Sampled sieved on site using "Bucket Swirling Method":
☐ YES ☒ NO
If YES, debris collected for QAQC ☐

Note: Indicate if a sampling method other than the recommended 400 µm mesh kick net is used.

Field Crew: MS, AC, AK Site Code: MIL-DS-001

Sampling Date: (DD/MM/YYYY) 01/08/2018

WATER CHEMISTRY DATA **Time:**________ (24 hr clock) **Time zone:** ________

Air Temp: 24°C (°C) Water Temp: 21.0 (°C) pH: 6.83

Specific Conductance: 81.2 (µs/cm) DO: 6.75 (mg/L) Turbidity: 45 (NTU)

DO% 75.6

Check if water samples were collected for the following analyses:

N/A

- ☐ TSS (Total Suspended Solids)
- ☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)
- ☐ Phosphorus (Total, Ortho, and/or Dissolved)
- ☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate)
- ☐ Other________

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - Indicate how slope was measured: (check one)

☐ **Calculated from map**

Scale: ________ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) ______ (m),
distance between contour intervals (horizontal distance) ______ (m)
slope = vertical distance/horizontal distance =________

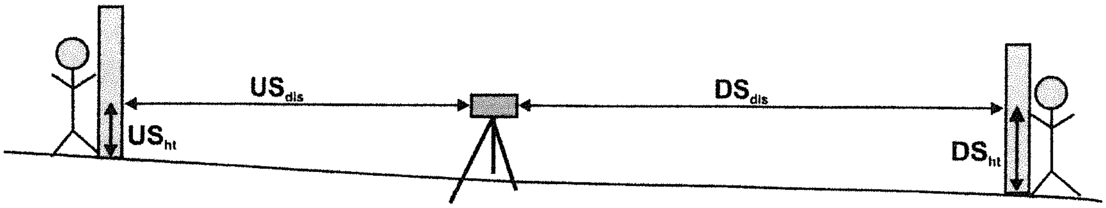
OR

☒ **Measured in field**

Circle device used and fill out table according to device:
a. Survey Equipment b. Hand Level & Measuring Tape

Clino 4% @ 18.4m.

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
^{a}Top Hairline (T)			
^{a}Mid Hairline (ht) OR ^{b}Height of rod			
^{a}Bottom Hairline (B)			
^{b}Distance (dis) OR ^{a}T-B x 100	$^a US_{dis}$=T-B	$^a DS_{dis}$=T-B	$US_{dis}+DS_{dis}$=
Change in height (Δht)			$DS_{ht}-US_{ht}$=
Slope (Δht/total dis)			



Field Crew: MS, AC, DK Site Code: MIL-DS-001

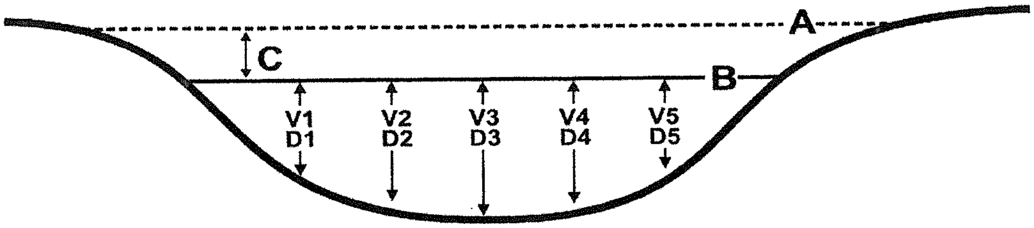
Sampling Date: (DD/MM/YYYY) 01/09/2018

Widths and Depth

Location at site: middle of riffle @ kick zone (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 10.17 (m) B - Wetted Stream Width: 8.55 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 25.5 (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☐ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = √ [2(ΔD/100) * 9.81]

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other__________

LB → RB, - adjusted to avoid boulders

	1	2	3	4	5	6	AVG
Distance from Shore (m)	1.0	2.0	3.0	4.0	5.0	6.0	
Depth (**D**) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (**D₁**) (cm)	31.5	21.5	21.5	20.5	13.0	17.5	
Depth of Stagnation (**D₂**) (cm)	33.0	23.5	22.5	21.0	13.5	18.5	
Change in depth (**ΔD=D₂-D₁**) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (**V**) (m/s)							

Field Crew: MS, AC, KR

Site Code: MIL-DS-001

Sampling Date: (DD/MM/YYYY) 01/08/2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	2
0.2-1.6 cm (gravel)	[✓ 3]
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embededness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	6.8		26	6.0		51	11.5		76	9.0	
2	4.4		27	9.5		52	15.5		77	3.9	
3	19.5		28	5.3		53	15.0		78	11.4	
4	12.5		29	29.0		54	5.4		79	17.0	
5	6.0		30	24.0	3/4	55	13.0		80	7.0	1/4
6	10.0		31	5.3		56	5.3		81	9.0	
7	9.5		32	5.7		57	11.5		82	17.0	
8	13.0		33	6.0		58	6.5		83	5.2	
9	4.6		34	2.2		59	5.5		84	6.0	
10	6.6	0	35	9.1		60	23.0	1/2	85	12.5	
11	28.5		36	4.0		61	9.5		86	7.3	
12	5.5		37	4.2		62	6.3		87	7.0	
13	2.3		38	16.5		63	3.0		88	1.8	
14	11.5		39	13.7		64	4.3		89	29	
15	6.2		40	12.5	1/4	65	10.8		90	6.5	1/4
16	20.2		41	6.6		66	11.0		91	9.8	
17	7.0		42	6.5		67	13.4		92	1.5	
18	8.3		43	5.9		68	4.5	1/2	93	2.3	
19	5.4		44	1.7		69	16.0		94	7.8	
20	9.2	0	45	18.5		70	6.4	1/4	95	11.5	
21	7.3		46	8.0		71	2.5		96	30	
22	7.7		47	3.6		72	3.2		97	26.2	
23	5.4		48	4.3		73	5.0		98	3.0	
24	23.5		49	17.0		74	6.8		99	2.7	
25	6.0		50	13.5		75	10.2		100	2.0	0

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: ______________________ Site Code: MIL-DS-001

Sampling Date: (DD/MM/YYYY) 01/08/2018

SITE INSPECTION

Site Inspected by: ______________________

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: ______________________ Time checked-in: ________

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: ( ) ____________

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Field Crew: MS, JK, AC.　　Site Code: JOR-DS-AQ31

Sampling Date: (DD/MM/YYYY) 01/08/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: RMOW Ecosystem Monitor'g　Local Basin Name: ZGD

River/Stream Name: Jordan Creek　Stream Order: (map scale 1:50,000) ____________

Select one: ☐ Test Site ☐ Potential Reference Site

Geographical Description/Notes:
Alta Lake Park - Parking lot.
parking lot - take path to E - follow to pump house - go over fence.

Surrounding Land Use: (check those present)　Information Source: ____________

☑ Forest　☐ Field/Pasture　☐ Agriculture　☑ Residential/Urban
☐ Logging　☐ Mining　☐ Commercial/Industrial　☐ Other ____________

Dominant Surrounding Land Use: (check one)　Information Source: ____________

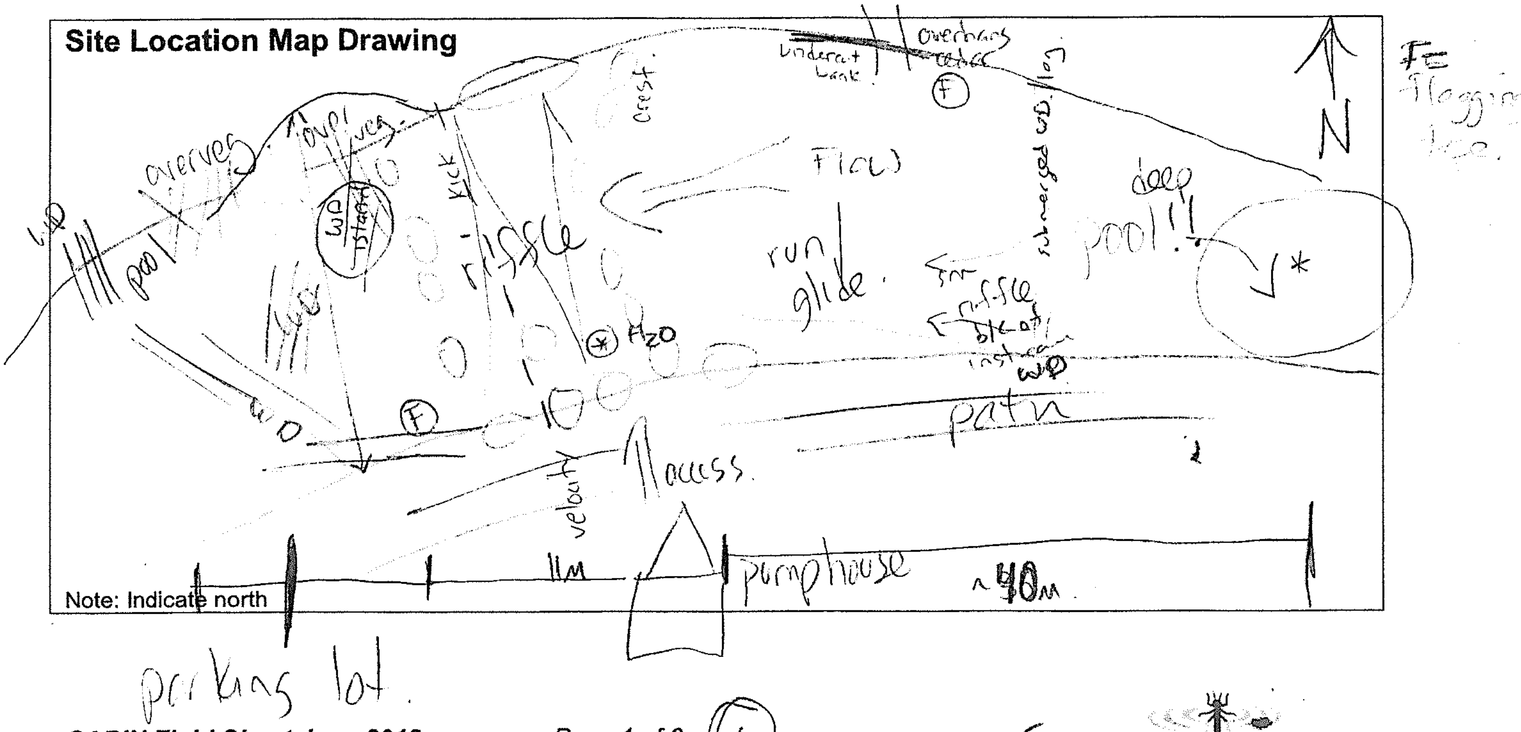
☐ Forest　☐ Field/Pasture　☐ Agriculture　☑ Residential/Urban
☐ Logging　☐ Mining　☐ Commercial/Industrial　☐ Other ____________

Location Data　WP: 246

Latitude: 0500183 N　Longitude: - 5549261 W　(DMS or DD)

Elevation: 644 (fasl *or* masl)　GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ________

Site Location Map Drawing



Note: Indicate north

(F) temp logger
u/s of side - u/s of bridge xing on LB.
- use RB bridge access

CABIN Field Sheet June 2012　*Page 1 of 6*

Field Crew: MS, JK, AC

Site Code: JOR-DS-AQ31

Sampling Date: (DD/MM/YYYY) 01/08/2018

Photos #1 2 from centre / from centre

☑ Field Sheet ☑ Upstream ☑ Downstream ☑ Across Site ☐ Aerial View

☐ Substrate (exposed) ☑ Substrate (aquatic) ☐ Other ________________

PIC 6 - u/s of sampled riffle habitat showing run/sm riffle + pool

PIC 7 - downstream +PIC 8 - from u/s end showing entire riffle sampled by kick net

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
   ☑ Riffle ☐ Rapids ☑ Straight run ☑ Pool/Back Eddy

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
   ☐ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☑ 76-100 %

3. Macrophyte Coverage: *(not algae or moss, check one)*
   ☑ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %

4. Streamside Vegetation: (*check those present)*
   ☑ ferns/grasses ☑ shrubs ☑ deciduous trees ☑ coniferous trees 3 cedars !.

5. Dominant Streamside Vegetation: *(check one)*
   ☐ ferns/grasses ☐ shrubs ☑ deciduous trees ☐ coniferous trees

PIC 9. - hand showing chironomids after touching rock for 2 sec.

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one)*

   ☐ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
   ☐ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
   ☐ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
   ☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
   ☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

PIC 10-11 stonefly under one rock lifted

PIC 12-13 silt on underside of rocks. more in u/s of kick location

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☑ riffle ☐ rapids ☐ straight run

400 μm mesh Kick Net	✓
Person sampling	Maria S
Sampling time (i.e. 3 min.)	3 min
No. of sample jars	1 jar
Typical depth in kick area (cm)	22 cm

Preservative used: 1:1 Ethanol

Sampled sieved on site using "Bucket Swirling Method":
☐ YES ☒ NO
If YES, debris collected for QAQC ☐

* note you touch your hand to rocks w/in kick zone and w/in 2-3sec your hand has 10-30 chironomids on it. PIC 9

Note: Indicate if a sampling method other than the recommended 400 μm mesh kick net is used.

Field Crew: MS, JK, AC Site Code: JOR-DS-AQ31

Sampling Date: (DD/MM/YYYY) 9/08/2018

WATER CHEMISTRY DATA **Time:** 1135 (24 hr clock) **Time zone:** ________

Air Temp: 23.5°C (°C) Water Temp: 18.8 (°C) pH: 7.14

Specific Conductance: 65.4 (µs/cm) DO: 7.74 (mg/L) 82.9% Turbidity: 36 (NTU) w/ Hanna

Check if water samples were collected for the following analyses:

☐ TSS (Total Suspended Solids)
☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia) n/a
☐ Phosphorus (Total, Ortho, and/or Dissolved)
☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate) ☐ Other________

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - Indicate how slope was measured: (check one)

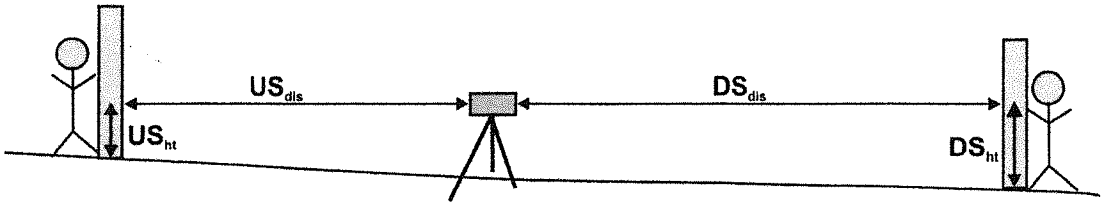
☐ **Calculated from map**
Scale: ________ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) ______ (m),
distance between contour intervals (horizontal distance) ______ (m)
slope = vertical distance/horizontal distance = ________

OR

☒ **Measured in field**
Circle device used and fill out table according to device:
a. Survey Equipment b. Hand Level & Measuring Tape

Clino 5% @ 11 m

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
^{a}Top Hairline (T)			
^{a}Mid Hairline (ht) OR ^{b}Height of rod			
^{a}Bottom Hairline (B)			
^{b}Distance (dis) OR ^{a}T-B x 100	^{a}US$_{dis}$=T-B	^{a}DS$_{dis}$=T-B	US$_{dis}$+DS$_{dis}$=
Change in height (Δht)			DS$_{ht}$-US$_{ht}$=
Slope (Δht/total dis)			



Field Crew: MS, JK, AC

Site Code: JOR-DS-AQ31

Sampling Date: (DD/MM/YYYY) 01|08|2018

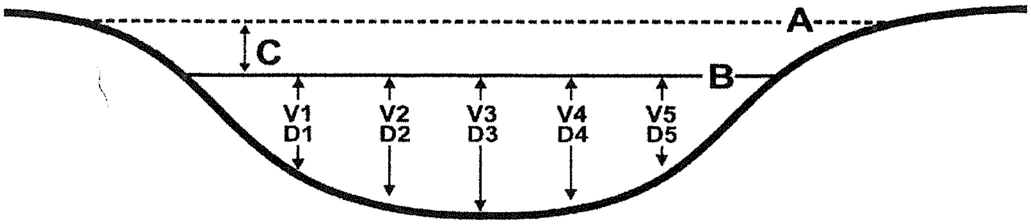
Widths and Depth

Location at site: middle of kick location (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 4.35 (m)

B - Wetted Stream Width: 4.2 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 11.5 (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☐ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = √ [2(ΔD/100) * 9.81]

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other__________

RB → .5 1.0 1.5 2.0 2.5 3.0 LB.

	1	2	3	4	5	6	AVG
Distance from Shore (m)							
Depth (**D**) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (D_1) (cm)	29.5	41.5	24.0	23.5	33.0		
Depth of Stagnation (D_2) (cm)	31.0	43.0	27.5	25.0	33.5		
Change in depth ($\Delta D = D_2 - D_1$) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (**V**) (m/s)							

Field Crew: ms, JK, AC

Site Code: JOR-05-AQ31

Sampling Date: (DD/MM/YYYY) 01/08/2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	2
0.2-1.6 cm (gravel)	[✓ 3]
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embededness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	8.5		26	6.5		51	4.0	1/2	76	15.5	
2	10.0		27	8.5		52	2.3		77	9.0	
3	8.0		28	9.0		53	2.6		78	9.7	
4	5.5		29	13.4		54	4.0		79	14.0	
5	9.0		*30	2.0	1/2	55	10.0		*80	5.5	1/4
6	8.5		31	10.5		56	6.0		81	3.7	
7	12.0		32	3.3		57	20.0		82	22.0	
8	10.5		33	8.5		58	5.6		83	7.0	
9	7.0		34	19 0		59	13.5		84	0.4	
*10	7.5	1/4	35	18.0		*60	8.5	3/4	85	7.0	
11	3.8		36	31.0		61	4.0		86	2.6	
12	10.4		37	22.0		62	17.7		87	13.8	
13	5.5		38	3.3		63	10.0		88	10.3	
14	3.5		39	2.0		64	6.4		89	5.2	
15	7.0		*40	18.0	1/4	65	17.0		*90	4.0	1/2
16	11 0		41	1.9		66	5.1		91	1.4	
17	21.0		42	17.0		67	3.0		92	5.0	
18	4.5		43	10.0		68	2.4		93	5.0	
19	9.5		44	18.0		69	22.0		94	25.5	
*20	18.5	1/4	45	1.5		*70	10.0	1/2	95	2.8	
21	2.3		46	15.5		71	5.0		96	0.6	
22	10.5		47	33.0		72	8.0		97	sand	
23	4.8		48	3.4		73	6.8		98	15.5	
24	11.5		49	2 0		74	6.2		99	13.0	
25	9.0		*50	.6		75	13.0		*100	6.8	1/4

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: ______________________________ Site Code: ____________

Sampling Date: (DD/MM/YYYY) ____________________

SITE INSPECTION

Site Inspected by: ____________________________

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: ______________________ Time checked-in: ________

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: (   ) __________

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Field Crew: MS DK

Site Code: RGD-05-A012

Sampling Date: (DD/MM/YYYY) 01/08/2018

☐ **Occupational Health & Safety: Site Inspection Sheet completed**

PRIMARY SITE DATA

CABIN Study Name: RMCW Ecosystem Monitoring

Local Basin Name: River of Golden Dreams

River/Stream Name: River of Golden Dreams

Stream Order: (map scale 1:50,000) ______

Select one: ☐ Test Site ☐ Potential Reference Site

Geographical Description/Notes: Pull off Hwy to R into "Nichlaus North Golf Course" Golf course

- go N past public works yard.
- go L @ 1st side street 'Golden Bear Place' Rd — take left at fork.
- park and follow open trail to R of red bridge

Surrounding Land Use: (check those present)

Information Source: ______

☐ Forest ☐ Field/Pasture ☐ Agriculture ☑ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other Golf course / Hwy / residential

Dominant Surrounding Land Use: (check one)

Information Source: ______

☐ Forest ☐ Field/Pasture ☐ Agriculture ☑ Residential/Urban

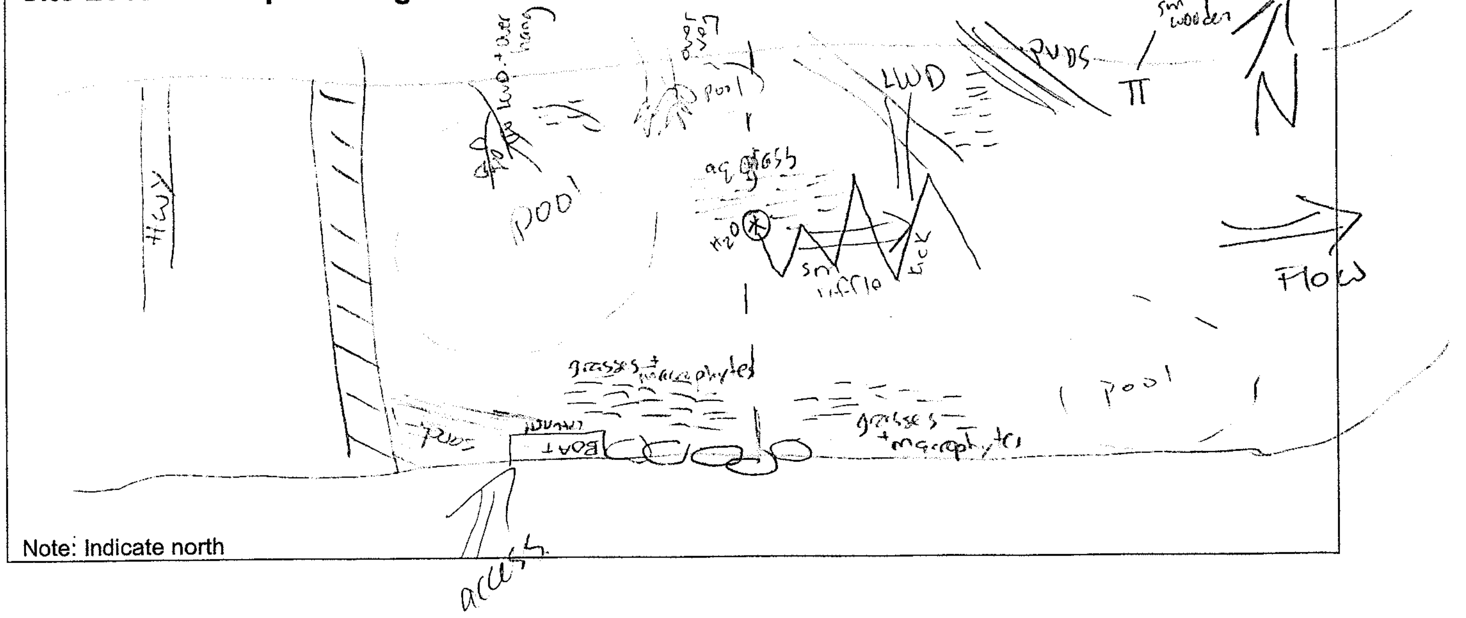
☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other ______

Location Data 10 U 0503035 5554687 @ u/s end of kick. Waypt #249

Latitude: ______N Longitude: - ______W (DMS or DD)

Elevation: 641 (fasl *or* masl) GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: ______

Site Location Map Drawing



Note: Indicate north

>> kyak + paddle boarders

Field Crew: MS DK

Site Code: Z6D-DS- AQ12

Sampling Date: (DD/MM/YYYY) 01/08/2018

Photos

1 ☐ Field Sheet   2 ☐ Upstream   3 ☐ Downstream   4 ☐ Across Site   ☐ Aerial View
☐ Substrate (exposed)   5 ☐ Substrate (aquatic)   ☐ Other ____________

REACH DATA *(represents 6 times bankfull width)*

PIC 6-8 caddis fly from kick sample

1. Habitat Types: *(check those present)*
   ☑ Riffle   ☐ Rapids   ☐ Straight run   ☑ Pool/Back Eddy

PIC 7 looking d/s from bridge riprap (looking @ kick site)

2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
   ☐ 0 %   ☐ 1-25 %   ☐ 26-50 %   ☐ 51-75 %   ☐ 76-100 %

3. Macrophyte Coverage: *(not algae or moss, check one)*
   ☐ 0 %   ☑ 1-25 %   ☐ 26-50 %   ☐ 51-75 %   ☐ 76-100 %

PIC 8 sub. macro + ag grasses along reach

4. Streamside Vegetation: (*check those present)*
   ☑ ferns/grasses   ☑ shrubs   ☑ deciduous trees   ☐ coniferous trees

PIC 9 looking u/s @ kick location

5. Dominant Streamside Vegetation: *(check one)*
   ☐ ferns/grasses   ☑ shrubs   ☐ deciduous trees   ☐ coniferous trees

PIC 10-11 aerial @ site from ped Bridge - looking d/s

6. Periphyton Coverage on Substrate: *(benthic algae, not moss, check one*)
   ☑ **1** - Rocks are not slippery, no obvious colour (thin layer < 0.5 mm thick)
   ☐ **2** - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
   ☐ **3** - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
   ☐ **4** - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
   ☐ **5** - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

PIC 12 - looking u/s from ped bridge on-to Hwy bridge (deep pool) to LB

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: (*check one*) ☑ riffle ☐ rapids ☐ straight run

400 µm mesh Kick Net	✓
Person sampling	Mana S
Sampling time (i.e. 3 min.)	3 min
No. of sample jars	1 of 1
Typical depth in kick area (cm)	25 cm

Preservative used: 1:1 Ethanol

Sampled sieved on site using "Bucket Swirling Method":
☒ YES ☐ NO
If YES, debris collected for QAQC ☒   +4 sculpin

Note: Indicate if a sampling method other than the recommended 400 µm mesh kick net is used.

Field Crew: MS, JK

Site Code: PGD-DS-A012

Sampling Date: (DD/MM/YYYY) 01|08|208

WATER CHEMISTRY DATA **Time:** 1551 (24 hr clock) **Time zone:** ______

Air Temp: 29 (°C) Water Temp: 17.8 (°C) pH: 6.67

Specific Conductance: 48.3 (µs/cm) DO: 8.16 (mg/L) 86.1 % Turbidity: 31 (NTU) Hanna

Check if water samples were collected for the following analyses:

N/A

☐ TSS (Total Suspended Solids)
☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)
☐ Phosphorus (Total, Ortho, and/or Dissolved)
☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate) ☐ Other ______

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - Indicate how slope was measured: (check one)

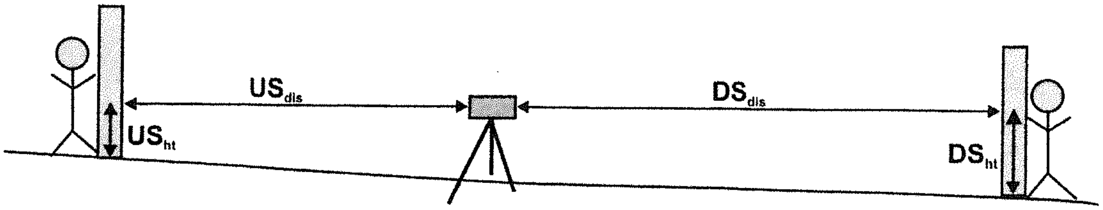
☐ **Calculated from map**
Scale: ______ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) ______ (m),
distance between contour intervals (horizontal distance) ______ (m)
slope = vertical distance/horizontal distance = ______

OR

☒ **Measured in field**
Circle device used and fill out table according to device:
a. Survey Equipment b. Hand Level & Measuring Tape

Clino 0% @ 28m.

Measurements	Upstream (U/S)	Downstream(D/S)	Calculation
^{a}Top Hairline (T)			
^{a}Mid Hairline (ht) OR ^{b}Height of rod			
^{a}Bottom Hairline (B)			
^{b}Distance (dis) OR ^{a}T-B x 100	$^a US_{dis}$=T-B	$^a DS_{dis}$=T-B	$US_{dis}+DS_{dis}$=
Change in height (Δht)			$DS_{ht}-US_{ht}$=
Slope (Δht/total dis)			



Field Crew: MS, DK

Site Code: RBD-DS-AQ12

Sampling Date: (DD/MM/YYYY) 01/08/2018

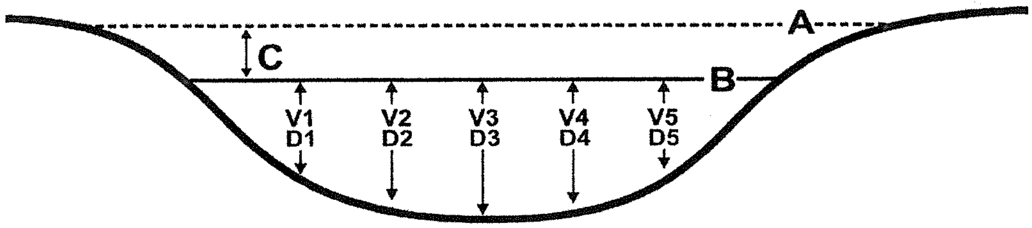
Widths and Depth

Location at site: Thru centre of kick area. (Indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: 16.6 (m)

B - Wetted Stream Width: 16.4 (m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): 17 (cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations;
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☒ **Velocity Head Rod (or ruler)**: Velocity Equation (m/s) = √ [2(ΔD/100) * 9.81]

☐ **Rotary meters**: Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements**: ☐ Marsh-McBirney ☐ Sontek or ☐ Other

LB →

RB

	1	2	3	4	5	6	AVG
Distance from Shore (m)	2.5m	5.0	7.5	10.0	12.5	15.0	
Depth (D) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (D_1) (cm)	30.5	23.5	26.0	31.0	40.0	22.5	
Depth of Stagnation (D_2) (cm)	30.5	24.0	26.5	31.5	40.5	23.0	
Change in depth ($\Delta D = D_2 - D_1$) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement or calculation							
Velocity (V) (m/s)							

Field Crew: MS AK

Site Code: EGD-DS-AQ12

Sampling Date: (DD/MM/YYYY) 01|08|2018

SUBSTRATE DATA

Surrounding/Interstitial Material

Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	[✓ 2]
0.2-1.6 cm (gravel)	3
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embededness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E		Diameter (cm)	E
1	3.8		26	2.4		51	S		76	1.9	
2	2.9		27	S		52	1,2		77	2.3	1/2
3	4 6		28	1.3		53	S		78	2.8	
4	2.8		29	2.2		54	0.5		79	0.2	
5	0.6		*30	3.2	1/2	55	0,4		80	3.8	1/2
6	2.3		31	0,3		56	3,2		81	0.2	
7	S		32	2.1		57	3.2		82	0.2	
8	3.2		33	6.0		58	3,0		83	S	
9	S		34	0.2		59	3,1	3/4	84	1.1	
*10	2,8	1/4	35	S		*60	0.9		85	0.7	
11	3,3		36	2.7		61	S		86	1,2	
12	2,8		37	2,3		62	0.9		87	S	
13	1,6		38	3.3		63	0,9		88	0.8	
14	2.5		39	1,3		64	1.9		89	2.7	
15	1.3		40	1.8		65	S		90	0.8	1/2
16	S		41	0.7		66	0.5		91	3.5	
17	0,3		42	1.3	1/2	67	S		92	2.6	
18	1.0		43	2.6		68	S		93	1.0	
19	3.7		44	3.2		69	0.9		94	0.6	
*20	2.6	1/4	45	0.7		70	4.7	3/4	95	0.4	
21	6.5		46	S		71	3.2		96	2.5	
22	4.2		47	0.6		72	1.8		97	0.5	
23	2 0		48	2.8		73	2.3		98	0.3	
24	1.1		49	1.0		74	2.0		99	S	
25	1.4		50	2.5	3/4	75	2.5		100	S	

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: ______________________________ Site Code: ____________

Sampling Date: (DD/MM/YYYY) ____________________

SITE INSPECTION

Site Inspected by: __________________________

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: ______________________ Time checked-in: ______

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: (   ) __________

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes:

Appendix D

Fish Biological Data

Fish Biological Characteristics

Site	Watershed	Creek	Gear Type	Sampling Date / Set Date	Retrieval Date	Fish ID	Species	Fork Length (mm)	Weight (g)	Comments
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	16	CC	90	8.8	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	17	CC	78	4.4	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	18	TSB	60	2.4	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	19	CC	41	1	Mortality
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	20	CC	43	0.8	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	21	CC	63	2.6	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	22	CC	59	2.3	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	23	CC	52	1.4	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	24	CC	49	1.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	25	CC	48	0.9	No pigmentation on body
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	26	CC	68	3.7	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	27	CC	48	0.9	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	28	CC	60	2.5	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	29	CC	47	1.3	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	30	CC	47	0.9	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	31	CC	47	0.9	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	32	TSB	57	2	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	33	TSB	55	1.7	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	34	CC	42	0.6	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	35	RB	85	6.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	36	RB	94	8.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	37	RB	41	0.6	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	38	RB	40	0.7	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Electrofisher	02-Aug-18	n/a	39	RB	37	0.5	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	76	TSB	54	1.5	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	77	TSB	52	1.3	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	78	TSB	53	1.5	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	79	TSB	52	1.3	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	80	TSB	58	1.9	Slight red anterior belly
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	81	TSB	59	1.9	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	82	TSB	59	2.1	Slight red anterior belly
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	83	TSB	59	2.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	84	TSB	55	1.6	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	85	TSB	50	1.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	86	TSB	58	1.9	Slight red anterior belly
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	87	TSB	60	2.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	88	TSB	54	1.7	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	89	TSB	53	1.4	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	90	TSB	50	1.4	

CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	91	TSB	50	1.4	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	92	TSB	55	1.8	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	93	TSB	49	1.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	94	CC	54	1.5	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	95	RB	66	3.3	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	96	RB	87	7.1	
CRB-DS-AQ01	River of Golden Dreams	Crabapple Creek	Minnow Trap	02-Aug-18	03-Aug-18	97	RB	105	13.4	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	40	CC	70	3.7	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	41	CC	55	1.6	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	42	CC	74	5.9	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	43	CC	76	5.6	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	44	CC	72	4.8	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	45	CC	55	1.7	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	46	RB	32	0.2	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	47	RB	44	0.8	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Electrofisher	02-Aug-18	n/a	48	RB	74	4.2	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	98	TSB	54	1.5	Light red anterior belly
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	99	TSB	45	0.7	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	100	TSB	53	1.4	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	101	TSB	48	1.1	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	102	TSB	54	1.7	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	103	TSB	54	1.5	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	104	TSB	55	1.9	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	105	RB	54	1.7	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	106	RB	91	8.6	
JOR-DS-AQ31	Jordan Creek	Jordan Creek	Minnow Trap	02-Aug-18	03-Aug-18	107	RB	115	15.7	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	1	CC	44	1.2	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	2	CC	61	2.5	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	3	CC	86	7.1	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	4	CC	93	9.1	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	5	CC	60	2.3	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	6	CC	75	4.9	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	7	CC	44	1	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	8	CC	68	3.3	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	9	CC	73	4.4	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	10	CC	62	2.9	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	11	CC	46	1.2	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	12	CC	63	2.7	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	13	CC	49	1.5	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	14	CC	48	1.3	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Electrofisher	02-Aug-18	n/a	15	CC	50	1.1	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	67	CC	48	1.1	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	68	CC	85	6.4	

21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	69	CC	75	5	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	70	TSB	50	1.3	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	71	TSB	55	1.5	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	72	TSB	55	1.4	Notable red anterior belly
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	73	TSB	53	1.7	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	74	RB	94	8.2	
21M-DS-AQ21	River of Golden Dreams	21-Mile Creek	Minnow Trap	02-Aug-18	03-Aug-18	75	RB	70	3.6	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	49	CC	52	1.2	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	50	CC	68	4.3	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	51	TSB	52	1.4	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	52	TSB	62	2.6	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	53	TSB	52	1.9	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	54	TSB	57	1.7	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	55	TSB	59	2.1	Notable red anterior belly; fungus on dorsal fin
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	56	TSB	56	1.7	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	57	TSB	55	1.8	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	58	TSB	57	1.8	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	59	TSB	57	2.2	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	60	TSB	54	1.6	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	61	TSB	5.5	1.8	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	62	TSB	54	1.3	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	63	TSB	50	1.5	Slight red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	64	TSB	40	0.6	
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	65	TSB	55	1.8	Notable red anterior belly
RGD-AQ11	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	66	TSB	51	1.6	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	108	TSB	48	1.2	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	109	TSB	45	0.9	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	110	TSB	49	1.1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	111	TSB	49	1.3	Slight red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	112	TSB	44	0.9	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	113	TSB	48	1	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	114	TSB	51	1.6	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	115	TSB	47	0.9	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	116	TSB	50	1.2	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	117	TSB	56	1.8	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	118	TSB	42	1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	119	TSB	49	1.1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	120	TSB	42	0.8	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	121	TSB	39	0.6	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	122	TSB	45	0.8	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	123	TSB	40	0.6	Slight red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	124	TSB	55	2.2	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	125	TSB	44	1.1	Notable red anterior belly

RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	126	TSB	42	1.1	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	127	TSB	43	0.8	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	128	TSB	43	0.8	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	129	TSB	40	0.5	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	130	TSB	50	1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	131	TSB	50	1.3	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	132	TSB	59	3	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	133	TSB	45	0.9	Red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	134	TSB	38	0.7	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	135	TSB	42	0.8	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	136	TSB	50	1.6	Notable red anterior belly
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	137	TSB	43	0.7	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	138	CC	49	0.9	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	139	CC	52	1.5	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	140	CC	63	2.5	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	141	CC	51	1.6	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	142	CC	53	1.4	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	143	CC	50	1.4	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	144	CC	61	2.3	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	145	CC	45	0.7	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	146	CC	57	1.8	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	147	CC	54	1.5	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	148	CC	52	1.5	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	149	RB	70	3.1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	150	RB	74	4.1	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	151	RB	101	11	
RGD-DS-AQ12	River of Golden Dreams	River of Golden Dreams	Minnow Trap	02-Aug-18	03-Aug-18	152	RB	123	19.4	

Table Notes: RB = Rainbow Trout, TSB = Threespine Stickleback, CC = Sculpin (General)

Appendix E

Site Data for Coastal Tailed Frog Surveys

Valley Side	Creek and Reach	Date	Easting	Northing	Elev. (m)	Survey Area (m2)	Air Temp. (°C)	Water Temp. (°C)	Wetted Width (m)	Slope (%)	Mean Depth (cm)	Crown Closure	Tree Comp.	Struct. Stage	Stream Disturbance	Stream Morph.	Substrate	Rock Shape
West	Agnew Creek - 1	2018-09-06	502069	5554207	666	23.3	12	8.0	0.9	10	4	80	Conif.	MF	Low	Step Pool	Cobble	Subangular
West	Agnew Creek - 2	2018-09-04	501982	5554360	680	37.0	14	8.1	1.1	7	8	50	Mixed	YF	Low	Riffle	Stone (Cobble)	Subangular
West	Agnew Creek - 3	2018-09-04	501848	5554666	735	22.0	14	8.1	1.1	19	6	85	Mixed	MF	Med.	Step Pool (Riffle)	Stone (Cobble)	Subangular
East	Archibald Creek - 1	2018-09-06	502387	5550606	695	21.0	15	9.1	1.8	17	7	75	Decid.	PS	Med.	Step Pool	Bedrock (Boulder)	Subrounded
East	Archibald Creek - 2	2018-09-06	502854	5550298	835	18.0	12	8.1	1.8	18	13	80	Mixed	YF	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Archibald Creek - 3	2018-09-06	503310	5549422	1026	16.5	13	7.2	1.2	12	7	95	Conif.	YF	Low	Step Pool (Riffle)	Cobble (Boulder)	Subangular
West	FJ West Creek (Into the Mystic)	2018-09-05	496022	5549522	1119	16.5	19	9.0	1.2	14	7	80	Mixed	YF	Med.	Step Pool	Cobble (Bedrock)	Subangular
West	FJ West Creek (South Flank)	2018-09-06	496383	5548374	648	18.0	23	10.2	0.7	14	5	30	Conif.	OF	Low	Cascade (Step Pool)	Bedrock (Cobble)	Subrounded
West	Scotia Creek - 4 (Flank Trail)	2018-09-05	499477	5551280	1000	9.5	15	9.0	0.8	8	4	90	Decid.	YF	Med.	Step Pool (Riffle)	Stone (Cobble)	Subangular
West	Sproatt Creek (Flank Trail)	2018-09-05	498483	5550455	996	19.5	13	9.1	0.7	24	4	40	Conif.	MF	High	Step Pool	Boulder (Bedrock)	Subrounded
West	Van West (Flank Trail)	2018-09-05	497563	5549038	706	15.5	18	10.0	0.7	18	4	95	Conif.	YF	High	Step Pool	Boulder (Bedrock)	Subangular
West	Van West (Into the Mystic)	2018-09-05	497125	5549816	1036	14.5	14	10.0	0.8	25	5	50	Conif.	OF	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Whistler Creek - 1	2018-09-04	501041	5549045	692	30.0	10	8.2	3.0	14	24	5	Decid.	Shrub	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Whistler Creek - 2	2018-09-04	501417	5548276	879	28.5	12	8.0	3.7	14	10	10	Conif.	OF	Low	Riffle (Step Pool)	Cobble (Boulder)	Subangular
East	Whistler Creek - 3	2018-09-04	501649	5547961	972	30.5	14	8.1	2.9	25	14	40	Conif.	OF	Low	Step Pool	Cobble (Bedrock)	Subangular
				Average	**846**	**21**	**15**	**8.7**	1.5	16	8	60						

Table Notes: Surveyors for all sites were Bob Brett, Jagoda Kozikowsk, and Luke Harrison..

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Appendix F

Capture Data for Coastal Tailed Frog Surveys

Age Class / Cohort	T1		T2		T3		
	1	2	3	4	5		
Developmental Stage	No hind legs	Bulge only, hind legs not defined	Hind legs visible but covered	Hind feet protruding	Hind knees protruding	All Tadpoles	Adults
Agnew Creek - 1						0	
Agnew Creek - 2						0	
Agnew Creek - 3						0	
Archibald Creek - 1		40		48	52	19	
		37		40	55		
		38		50	50		
		45		45	53		
		40		50			
		35		47			
		35		44			
				50			
Archibald Creek - 2		38				5	
		35					
		33					
		38					
		38					
Archibald Creek - 3	27	35			55	6	
	27						
	35						
	35						
FJ West Creek (South Flank)						0	
FJ West Creek (Into the Mystic)	31					1	
Scotia Creek - 4 (Flank Trail)	35					2	40 (F)
	31						
Sproatt Creek (Flank Trail)		35		54		11	38 (M)
		35					
		37					
		36					
		35					
		35					
		35					
		36					
		36					
		36					
Van West (Flank Trail)	31					1	
Van West (Into the Mystic)	30	40	33	46		16	
	32	37					
	32	38					
	38	37					
	38	27					
		43					
		35					
		35					
		35					
Whistler Creek - 1	33	33		45	48	7	
	34	35					
		35					
Whistler Creek - 2	33	35				5	
	30						
	28						
	30						
Whistler Creek - 3	30	40				9	
	33						
	31						
	30						
	37						
	30						

Table Notes:

1. Figures reported by Age Class (Malt et al. 20141, b) and Developmental Stage (Section 5.2.2) are total tadpole lengths (in mm), snout to ventral length for adults.

2. Figures reported by Age Class (Malt et al. 20141, b) and Developmental Stage (Section 5.2.2) are total tadpole lengths (in mm), snout to ventral length for adults.

3. Numbers in red show tadpoles that escaped or were visual only. Lengths are estimated.

Appendix G

Site Data for Coastal Tailed Frog Surveys

Valley Side	Creek and Reach	Date	Easting	Northing	Elev. (m)	Survey Area (m2)	Air Temp. (°C)	Water Temp. (°C)	Wetted Width (m)	Slope (%)	Mean Depth (cm)	Crown Closure	Tree Comp.	Struct. Stage	Stream Disturb-ance	Stream Morph.	Substrate	Rock Shape
West	Agnew Creek - 1	2018-09-06	502069	5554207	666	23.3	12	8.0	0.9	10	4	80	Conif.	MF	Low	Step Pool	Cobble	Subangular
West	Agnew Creek - 2	2018-09-04	501982	5554360	680	37.0	14	8.1	1.1	7	8	50	Mixed	YF	Low	Riffle	Stone (Cobble)	Subangular
West	Agnew Creek - 3	2018-09-04	501848	5554666	735	22.0	14	8.1	1.1	19	6	85	Mixed	MF	Med.	Step Pool (Riffle)	Stone (Cobble)	Subangular
East	Archibald Creek - 1	2018-09-06	502387	5550606	695	21.0	15	9.1	1.8	17	7	75	Decid.	PS	Med.	Step Pool	Bedrock (Boulder)	Subrounded
East	Archibald Creek - 2	2018-09-06	502854	5550298	835	18.0	12	8.1	1.8	18	13	80	Mixed	YF	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Archibald Creek - 3	2018-09-06	503310	5549422	1026	16.5	13	7.2	1.2	12	7	95	Conif.	YF	Low	Step Pool (Riffle)	Cobble (Boulder)	Subangular
West	FJ West Creek (Into the Mystic)	2018-09-05	496022	5549522	1119	16.5	19	9.0	1.2	14	7	80	Mixed	YF	Med.	Step Pool	Cobble (Bedrock)	Subangular
West	FJ West Creek (South Flank)	2018-09-06	496383	5548374	648	18.0	23	10.2	0.7	14	5	30	Conif.	OF	Low	Cascade (Step Pool)	Bedrock (Cobble)	Subrounded
West	Scotia Creek - 4 (Flank Trail)	2018-09-05	499477	5551280	1000	9.5	15	9.0	0.8	8	4	90	Decid.	YF	Med.	Step Pool (Riffle)	Stone (Cobble)	Subangular
West	Sproatt Creek (Flank Trail)	2018-09-05	498483	5550455	996	19.5	13	9.1	0.7	24	4	40	Conif.	MF	High	Step Pool	Boulder (Bedrock)	Subrounded
West	Van West (Flank Trail)	2018-09-05	497563	5549038	706	15.5	18	10.0	0.7	18	4	95	Conif.	YF	High	Step Pool	Boulder (Bedrock)	Subangular
West	Van West (Into the Mystic)	2018-09-05	497125	5549816	1036	14.5	14	10.0	0.8	25	5	50	Conif.	OF	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Whistler Creek - 1	2018-09-04	501041	5549045	692	30.0	10	8.2	3.0	14	24	5	Decid.	Shrub	Med.	Step Pool	Cobble (Boulder)	Subangular
East	Whistler Creek - 2	2018-09-04	501417	5548276	879	28.5	12	8.0	3.7	14	10	10	Conif.	OF	Low	Riffle (Step Pool)	Cobble (Boulder)	Subangular
East	Whistler Creek - 3	2018-09-04	501649	5547961	972	30.5	14	8.1	2.9	25	14	40	Conif.	OF	Low	Step Pool	Cobble (Bedrock)	Subangular
				Average	**846**	**21**	**15**	**8.7**	1.5	16	8	60						

Table Notes: Surveyors for all sites were Bob Brett, Jagoda Kozikowsk, and Luke Harrison..

Appendix H

Capture Data for Coastal Tailed Frog Surveys

Age Class / Cohort	T1		T2		T3		
Developmental Stage	1	2	3	4	5		
	No hind legs	Bulge only, hind legs not defined	Hind legs visible but covered	Hind feet protruding	Hind knees protruding	All Tadpoles	Adults
Agnew Creek - 1						0	
Agnew Creek - 2						0	
Agnew Creek - 3						0	
Archibald Creek - 1		40 37 38 45 40 35 35		48 40 50 45 50 47 44 50	52 55 50 53	19	
Archibald Creek - 2		38 35 33 38 38				5	
Archibald Creek - 3	27 27 35 35	35			55	6	
FJ West Creek (South Flank)						0	
FJ West Creek (Into the Mystic)	31					1	
Scotia Creek - 4 (Flank Trail)	35 31					2	40 (F)
Sproatt Creek (Flank Trail)		35 35 37 36 35 35 35 36 36 36		54		11	38 (M)
Van West (Flank Trail)	31					1	
Van West (Into the Mystic)	30 32 32 38 38	40 37 38 37 27 43 35 35 35	33	46		16	
Whistler Creek - 1	33 34	33 35 35		45	48	7	
Whistler Creek - 2	33 30 28 30	35				5	
Whistler Creek - 3	30 33 31 30 37 30	40				9	

Table Notes:

1. Figures reported by Age Class (Malt et al. 20141, b) and Developmental Stage (Section 5.2.2) are total tadpole lengths (in mm), snout to ventral length for adults.

2. Figures reported by Age Class (Malt et al. 20141, b) and Developmental Stage (Section 5.2.2) are total tadpole lengths (in mm), snout to ventral length for adults.

3. Numbers in red show tadpoles that escaped or were visual only. Lengths are estimated.

Appendix I

Timing and Duration of Ice on Alta Lake, 1942-1976 and 2002-2018

Alta Lake Ice Records: 1942-1976 and 2002-2018

	Ice-On		Ice-Off		
Winter	**Date**	**Day Count**	**Date**	**Day Count**	**Days Frozen**
1942/43	4-Dec-42	338	19-Apr-43	109	136
1943/44	15-Dec-43	349	13-Apr-44	104	120
1944/45	15-Dec-44	350	27-Apr-45	117	133
1945/46	**8-Nov-45**	**312**	20-Apr-46	110	**163**
1946/47	20-Nov-46	324	13-Apr-47	103	144
1947/48	11-Dec-47	345	7-May-48	128	148
1948/49	18-Dec-48	353	19-Apr-49	109	122
1949/50	14-Dec-49	348	24-Apr-50	114	131
1950/51	2-Dec-50	336	19-Apr-51	109	138
1951/52	13-Dec-51	347	**21-May-52**	**142**	160
1952/53	22-Dec-52	357	8-May-53	128	137
1953/54	10-Jan-54	375	5-May-54	125	115
1954/55	26-Dec-54	360	7-May-55	127	132
1955/56	18-Dec-55	352	No Data	N/A	N/A
1956/57	1-Dec-56	336	23-Apr-57	113	143
1957/58	26-Dec-57	360	8-Apr-58	98	103
1958/59	26-Nov-58	330	23-Apr-59	113	148
1959/60	5-Dec-59	339	16-Apr-60	107	133
1960/61	10-Dec-60	345	10-Apr-61	100	121
1961/62	1-Dec-61	335	9-Apr-62	99	129
1962/63	No Data	N/A	**23-Mar-63**	**82**	N/A
1963/64	13-Dec-63	347	24-Apr-64	115	133
1964/65	11-Dec-64	346	22-Apr-65	112	132
1965/66	12-Dec-65	346	21-Apr-66	111	130
1966/67	No Data	N/A	30-Apr-67	120	N/A
1967/68	12-Dec-67	346	27-Apr-68	118	137
1968/69	5-Dec-68	340	7-May-69	127	153
1969/70	**15-Jan-70**	**380**	6-Apr-70	96	**81**
1970/71	4-Dec-70	338	6-May-71	126	153
1971/72	14-Dec-71	348	2-May-72	123	140
1972/73	28-Dec-72	363	11-Apr-73	101	104
1973/74	24-Nov-73	328	28-Apr-74	118	155
1974/75	No Data	N/A	No Data	N/A	N/A
1975/76	12-Dec-75	346	No Data	N/A	N/A
Data was not recorded between the fall 1975 freeze-up and the spring 2002 thaw.					
2001/02	No Data	N/A	14-Apr-02	104	N/A
2002/03	No Data	N/A	17-Mar-03	76	N/A
2003/04	No Data	N/A	25-Mar-04	85	N/A
2004/05	No Data	N/A	No Data	N/A	N/A
2005/06	**6-Jan-06**	**371**	8-Mar-06	67	61
2006/07	**30-Nov-06**	**334**	10-Apr-07	100	131
2007/08	10-Dec-07	344	**29-Apr-08**	**120**	**141**
2008/09	20-Dec-08	355	28-Apr-09	118	129
2009/10	8-Dec-09	342	28-Mar-10	87	110
2010/11	4-Dec-10	338	23-Apr-11	113	140
2011/12	No Data	N/A	23-Apr-12	114	N/A
2012/13	16-Dec-12	351	3-Apr-13	93	108

2013/14	21-Dec-13	355	14-Apr-14	104	114
2014/15	26-Dec-14	360	**20-Feb-15**	**51**	**56**
2015/16	24-Dec-15	358	16-Mar-16	76	83
2016/17	No Data	N/A	24-Apr-17	114	N/A
2017/18	No Data	N/A	10-Apr-18	100	N/A
2018/19	No Data	N/A	No Data	N/A	N/A

Sources: Modified and updated from Cascade (Appendix H; 2015) with data contributed by Stephen Vogler (via email, text, and phone conversations).