


Whistler Ecosystems & Species Monitoring Program – 2023

Prepared for:

Resort Municipality of Whistler

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Karl Ricker provided depth data for Twenty-one Mile Creek he has recorded on a volunteer basis for over 20 years. Temperature data for Nita Lake was supplied by Tom English and Nicholas Collins with the Whistler Lakes Conservation Foundation. Alta Lake ice-on and ice-off dates were again provided by Stephen Vogler from the Point Artists Centre.

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Executive Summary

The Resort Municipality of Whistler (RMOW) is located in the southern Coast Mountains of British Columbia, approximately 100 km north of Vancouver. The RMOW began the Ecosystems and Species Monitoring Program in 2013. The continuing objective of the program has been to identify and monitor indicators of ecosystem health.

The indicators chosen for the 2023 program are mostly consistent with past years of the program and include: beavers, Northern Goshawks, Coastal Tailed Frogs, pond amphibians, benthic invertebrates, stream temperature and water quality, and basic climate indicators.

Overall results show that the status of species and ecosystems monitored in this program is mostly stable as of 2023. Concerns include:

1. A possible downward trend in the tailed frog population in Archibald Creek,
2. High stream temperatures in Jordan Creek that are near temperature thresholds for some fish.
3. A trend to lower water depths in Twenty-one Mile Creek that has resulted in lower minimums and longer periods of low water.

Some positive trends were also noted this year:

1. The detection of a sixth breeding area for Northern Goshawks in Emerald South.
2. An improvement in stream habitat indicators (benthic invertebrates).
3. Improved spawning data provided by the RMOW allowed better interpretation of trends.

The summaries on the following pages describe key results by section. The icons below are used to help convey any trends detected. See Section 1.4 for a list of indicators and preferred trends for them.

Icons used to summarize trends in each section.

Icon	Condition of Indicator (based on available data)
	Good
	No clear evidence of worsening (i.e., incomplete data and/or weak trends)
	Some evidence of worsening
	Clear evidence that the indicator shows diminished species presence and/or habitat value

Indicator	2022 Trend	2023 Trend
Beavers: Active Colonies	Green →	Green →
Beavers: Beaver-affected Wetlands	Green →	Green →
Northern Goshawks	Yellow →	Yellow →
Coastal Tailed Frogs	Green → to Yellow →	Green → to Orange ↘
Western Toads & Red-legged Frogs	Yellow →	Yellow →
Benthic Invertebrates	Yellow →	Green →
Water Temperature	Orange ↘	Orange ↘
Water Quality	Green →	Green →
Fish Populations	Yellow →	Yellow →
Fish Habitat	Yellow →	Orange ↘
Climate: Alta Lake Ice Duration	Orange ↘	Orange ↘
Climate: Twenty-one Mile Creek Depths	Orange ↘	Orange ↘

Beavers

Active Colonies: Stable | **Beaver-affected Wetlands: Stable**

1. Nine more colonies were detected in 2023 compared to 2022, which brings the total to 60. Most of these occupied well-established (i.e., older) lodges that were found for the first time in 2023 due to expanded search effort. That is, they do not represent a real increase in population, but rather a more comprehensive census.
2. The beaver population continues to stable and now totals approximately 348 individuals (+/-).
3. Two-thirds of the active colonies are located in one of two wetland areas: the Millar Wetlands and the ROGD-Rainbow-Wildlife Refuge complex. Such strong, long-established populations no doubt provide the largest source of out-migration that keeps beavers active in less-productive habitats.
4. Almost 90% of wetlands in Whistler Valley were created or modified by beavers. These "beaver-affected wetlands" provide many ecological benefits including: (a) habitat for other species; (b) water storage; (c) carbon storage; and (d) flood mitigation. As of 2023, beaver-affected wetlands covered 110 ha of the valleybottom in Whistler Valley. This number has remained stable since first calculated in 2019.

Northern Goshawks

Stable with Caution (Limited Data)

1. Northern Goshawks are threatened forest predators that require old forest habitat for successful breeding and foraging. Although logging and other urban development have led to a significant decline in the goshawk population throughout BC, recent surveys have shown Whistler is an important breeding area. Their inclusion in this program is meant to (a) identify and protect breeding areas; and (b) provide an indicator of the availability of the low-elevation old forest habitat required by goshawks and other, unsurveyed species.
2. The two highlights from 2023 surveys included: (a) documentation of a successfully fledged juvenile goshawk in the Comfortably Numb area; and (b) the discovery of a recent nest at the south end of Emerald Estates. The latter record brings the total of current or recent nesting areas to six. Areas previously documented include: Comfortably Numb, Lower Blackcomb, Millar's Pond, Lower Sproatt, and Brew Creek.
3. The presence of six breeding areas provides encouraging evidence that: (a) goshawks maintain a strong presence in Whistler in spite of declines elsewhere. As continued surveys contribute more data, it will be possible to make stronger statements about population trends of Northern Goshawks and their old growth habitat in the Whistler area.

Coastal Tailed Frogs

Stable: Whistler, Sproatt, and Van West Creeks

Possibly Declining: Archibald Creek

1. Coastal Tailed Frogs are commonly surveyed for monitoring programs since they require clean, cold streams and are sensitive to disturbances caused by logging and in-stream alterations. The 2023 survey was the 11h year of monitoring in a varying selection of 11 creeks.
2. For the first time, no tadpoles were detected at the lowest-elevation site in Archibald Creek, just upstream of Panorama Drive. Detections at the top of Fitzsimmons Chair, above the main concentration of bike trails, were meanwhile strong. While it is not possible to conclude with certainty that low detections are related to bike park activity or other human-caused impacts, the lack of tadpole detections is concerning. This creek will be included in 2024 surveys with the hope that tadpole detections rebound.
3. Tadpoles were detected for the first time in Blackcomb Creek and Nineteen Mile Creek. This result confirms eDNA results from 2022 and suggests that these creeks: (a) may have a lower density of tailed frogs than other creeks in the area; and, (b) that tailed frogs in them are mostly or entirely restricted to upper reaches.

Western Toads and Red-legged Frogs

Inconclusive (Data deficient)

1. Western Toads and Red-legged Frogs are wetland species of conservation concern, but their breeding sites are not well-known. The only confirmed breeding site for Western Toads within the RMOW is at Lost Lake. In 2022, a second site was confirmed in the Whistler Olympic Park. The only known breeding site for Red-legged Frogs is in the basalt ponds in Brandywine Falls Provincial Park. Finding additional breeding sites is a goal of this program.
2. A total of 10 ponds were surveyed in spring for egg masses, and traps were set in four ponds in July. Western Toad eggs were again found in the Whistler Olympic Park, but no other breeding sites for either Western Toads of Red-legged Frogs were found.
3. It is still likely there are other breeding sites for Western Toads and Red-legged Frogs south of Function Junction and within the RMOW boundary. Until all possible sites are surveyed in that area (ideally by the end of 2026), there is not enough information to detect any trends.

Benthic Invertebrates

Stable (to possible improvement)

1. Taxonomic richness and overall quality of the benthic communities improved at all sites since the 2022 sampling program, which was possibly an outlier year impacted by a relatively cold and wet spring/early summer.
2. Overall Taxonomic Richness is generally declining or stable since 2016, and benthic invertebrate communities are generally Mildly Divergent or in Reference Conditions with some moderate variability year over year.
3. The (upper) River of Golden Dreams has never achieved “Reference Conditions” since 2016 while the (lower) sampling sites almost consistently did (except in 2022). Both sampling sites, however, appear to show a decreasing trend in total taxonomic richness, since 2018 especially. Recreational use of this watercourse may disturb the streambed and associated invertebrate communities.
4. The improvement in benthic invertebrate communities observed on Jordan Creek, as compared with 2020 and 2021 especially, was confirmed again this year.
5. Despite some variability in taxonomic richness, Twenty-one Mile Creek generally remained “Mildly Divergent from Reference Conditions” over the past 6 years, showing some relative stability in the core invertebrate communities (i.e., expected to be present) and a slight, yet consistent, degradation of water and/or habitat quality.
6. Crabapple Creek has typically achieved “Refence Condition”, except in 2020 and 2022 (Mildly Divergent), despite a constant decrease in the total number of families.
7. The taxonomic richness on Whistler Creek showed a substantial increase since 2022 with an additional 15 taxa, resulting in “Reference Conditions” for this site. The 2022 program was, however, a possible outlier year in terms of weather and stream conditions, plus it was the first year Whistler Creek was sampled. likely explaining this difference in benthic communities.
8. Nutrient and fecal coliform analyzes are recommended to be conducted on Crabapple Creek and the two River of Golden Dreams sites to assess potential water quality degradation beyond in situ parameters.
9. The Twenty-one Mile Creek benthic invertebrate sampling site is recommended to be moved outside (upstream) of the powerline right-of-way to eliminate potential impact associated with lower canopy coverage and regular vegetation maintenance in the area.

Water Temperature and Quality

Water Temperature: Probable worsening

Fish Habitat: Stable

1. Temperature records for 2022 and the first half of 2023 were not available due to batteries that failed in late 2021. An analysis of stream records through 2023 generally show stable trends with two exceptions: (i) higher temperatures during the summer of 2023 due to extended drought conditions; and (ii) concerningly high summer temperatures in Jordan Creek. With continued warming, fish habitat in Jordan Creek will deteriorate.
2. All water quality parameters examined were similar to previous years and were within Provincial water quality standards for the protection of aquatic life. Trends in water quality data are generally stable, with no evidence of significant change to WQ in all streams.
3. Temperature loggers need to be maintained on a regular basis. We recommend that the RMOW download the temperature data on a regular schedule (e.g., every three to four months) and replace batteries at scheduled times to prevent loss of data.
4. Two of the original six temperature loggers installed in 2016 are no longer functional, at Alpha Creek and Lower Crabapple Creek. New loggers were installed in August 2023 at four sites that have records going back to 2016, Upper Crabapple, Jordan, ROGD and 21 Mile Creek. Loggers at Lower Crabapple and Alpha were discontinued.

Fish and Fish Habitat

Fish Populations: Inconclusive (Data deficient)

Fish Habitat: Stable to probable worsening

1. With the improvements made to adult data collection for Kokanee it was possible to generate more precise escapement estimates for Kokanee spawners for 2023. Improvements to Rainbow Trout spawner counts also gave greater confidence to survey observations for this species. Continued refinement of and commitment to improved data collection protocols should enable the adult spawner estimates to be robust enough to be used as a yearly index of abundance in the coming years.
2. Analysis of adult Rainbow and Kokanee data did not reveal any population trends. In the coming years, with the improvements in data collection, it is hoped that the adult salmon data collected will be useful for comparing year over year and long-term population trends.
3. Bull Trout are the salmonid species most likely to be impacted by climate change due to their demonstrated sensitivity to elevated stream temperatures. Continued collection of temperature data is a critical part of monitoring fish habitat for Bull Trout. Temperature profile

data from Nita Lake in 2023 confirmed that the lake is deep enough to provide a cold-water refuge for Bull Trout in the summer months.

4. Drought conditions in the Summer of 2023 led to a notable reduction available fish habitat for all creeks examined in 2023. Average water depth and stream velocity were also greatly reduced in 5 of 6 creeks examined. This data will be important to track in future years as the potential impacts of climate change become more apparent.

Climate Indicators

Alta Lake: Trending to a shorter duration of Ice

Twenty-One Mile Creek Depths: Trending to lower minimums of longer duration

1. An incomplete record of dates for ice-on (freezing) and ice-off (thawing) on Alta Lake was analyzed for two periods: early (1942 to 1976) and recent (2001 to 2023).
2. The average duration of ice on Alta Lake has been almost one month (27 days) shorter in recent years than in the mid-1900s.
3. Earlier melting in spring has been the strongest contributor to the shortening the duration of ice, a result consistent with warming summer temperatures caused by climate change.
4. Depths in Twenty-One Mile Creek recorded by Karl Ricker since 2001 show a clear trend towards more prolonged periods of low water that are now below 0 cm on the water gauge for approximately one-third of all readings.
5. The negative impacts of lower flows in the River of Golden Dreams are mitigated by beaver dams downstream of the gauge that raise water levels.
6. The Twenty-one Mile Creek depth gauge should be replaced since it was not designed to measure depths <0 cm.

Table of Contents

1. Introduction

1.1 Overview

This report describes ecosystem monitoring conducted during 2023 in the Resort Municipality of Whistler (RMOW) by Snowline Ecological Research (Snowline). The purpose of the RMOW's Ecosystems and Species Monitoring Program is to monitor the health of ecosystems and species over time through ecological indicators (proxies) that guide conservation and sustainable land use planning in Whistler.

1.2 Background

The Whistler Biodiversity Project (WBP), funded in significant part by the 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, including 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. The report summarizing early results (Brett 2007) 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 proposed a framework for the establishment and application of ecological monitoring in Whistler (Askey *et al*. 2008).

The Ecosystem and Species 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. Results from past year's were published as follows:

- 2013 to 2015 (Cascade 2014-2016);
- 2016 to 2021 (Palmer and Snowline 2017 to 2021; Snowline 2021; Palmer 2022); and
- 2022 to current (Snowline 2022, this report).[1]

1.3 Study Area

The RMOW is located in the southern Coast Mountains of British Columbia, approximately 100 km north of Vancouver. The study area, defined by the extent of the RMOW municipal boundaries (Figure 1-1), contains a range of aquatic and terrestrial ecosystems at montane to alpine elevations. Most development (within the municipal "Development Footprint"[2]) is located in the valley bottom, from Function Junction to Green Lake. The Development Footprint is the main focus of the program, though some efforts go beyond its boundary.

1 *All available at www.whistler.ca/services/environmental-stewardship/ecosystem-monitoring.*
2 *More formally termed the "Whistler Urban Development Containment Area" in the Official Community Plan (*https://www.whistler.ca/ocp*).*

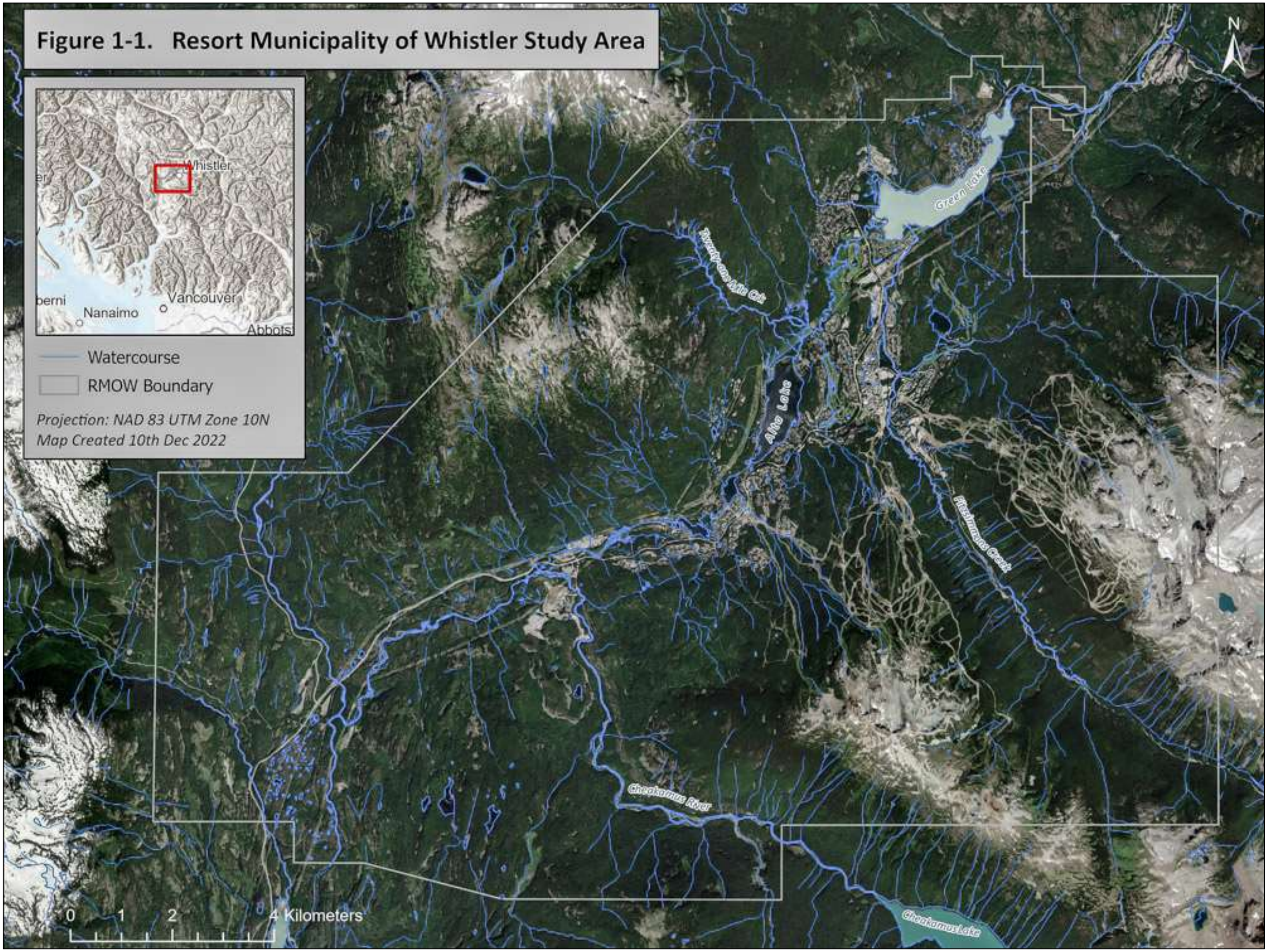

Figure 1-1. Study area. The boundary of the Resort Municipality of Whistler is shown in light grey.

1.4 Indicators in the 2023 Program

Table 1-1. Indicators included in the 2023 program.

Section	Indicator	Ecological Significance	Preferred Trend
2	Active Beaver Colonies	Beavers create and maintain wetland habitat and regulate water flows.	Stable or increasing number of colonies (lodges and burrows).
2	Area of Beaver-affected Wetland	Gives an areal value of the impact of beavers that can be monitored	Stable or increasing area.
3	Northern Goshawks	Old forests at low elevations are necessary for successful breeding of goshawks.	Stable or increasing number of active nests (and/or stable or increasing area of old forest)..
4	Coastal Tailed Frogs – Tadpole Surveys	Tailed frogs require cool, clean mountain streams.	Stable or increasing number of tadpoles in sampled creeks.
5	Pond Amphibians	Western Toads and Red-legged Frogs are local species of interest. Monitoring/confirming breeding sites aids in conservation planning.	Stable or increased number of breeding sites.
6	Benthic Invertebrates	The community composition of benthic invertebrate changes with pollution and other deleterious habitat alterations.	Stable or increased proportion of pollution-sensitive organisms. CABIN results that reflect “Reference” conditions.
7	Stream Temperature	Cool streams are necessary for salmonids but expected to increase with climate change.	Stable or decreasing summer stream temperature (<15° C).
7	Water Quality	Various water quality parameters measure habitat quality for fish and other aquatic life.	Water quality within all provincial and federal guidelines for the protection of aquatic life.
8	Fish Habitat Metrics	Various metrics are used to describe habitat attributes required by fish.	Maintain in “Good” condition.
9	Alta Lake Ice-on/Ice-off	Dates of ice-on and ice-off (freezing and thawing) are indicators of changes in climate.	Stable trend in ice-on and ice-off dates.
9	Low water levels in Twenty-One Mile Creek	Lower water levels and prolonged droughts are predicted by climate change. These in turn affect stream temperature and fish habitat.	Stable number of days with depths lower than 0 cm (i.e., the length of droughts should not increase.

1.5 Graphic Representation of Trends

Icons that summarize trends were first added in the 2022 report and modified for 2023 (Table 1-2). These simplified icons are meant to highlight areas of possible concern, that is, a deviation from preferred trends (Table 1-1). The colour of the icon indicates whether the trend is desirable (green), inconclusive (yellow), potential cause for concern (orange), or a clear indication of a significant diminishment in habitat condition or species status (red).

Table 1-2. Icons used to summarize trends in each section.

Icon	**Condition of Indicator** (based on available data)
	Good
	No clear evidence of worsening (i.e., incomplete data and/or weak trends)
	Some evidence of worsening
	Clear evidence that the indicator shows diminished species presence and/or habitat value

2. Beavers

Key Takeaways

Active Colonies: Stable	Beaver-affected Wetlands: Stable

1. Nine more colonies were detected in 2023 compared to 2022, which brings the total to 60. Most of these occupied well-established (i.e., older) lodges that were found for the first time in 2023 due to expanded search effort. That is, they do not represent a real increase in population, but rather a more comprehensive census.
2. The beaver population continues to stable and now totals approximately 348 individuals (+/-).
3. Two-thirds of the active colonies are located in one of two wetland areas: the Millar Wetlands and the ROGD-Rainbow-Wildlife Refuge complex. Such strong, long-established populations no doubt provide the largest source of out-migration that keeps beavers active in less-productive habitats.
4. Almost 90% of wetlands in Whistler Valley were created or modified by beavers. These "beaver-affected wetlands" provide many ecological benefits including: (a) habitat for other species; (b) water storage; (c) carbon storage; and (d) flood mitigation. As of 2023, beaver-affected wetlands covered 110 ha of the valleybottom in Whistler Valley. This number has remained stable since first calculated in 2019.

2.1 Introduction

Beavers (*Castor canadensis*) are a keystone species that have literally shaped North America's landscapes, especially before European settlers drastically reduced their numbers (Goldfarb 2018). They are commonly referred to as ecosystem and wetlands engineers (e.g., Müller-Schwarze and Sun 2003) in recognition of their immense impact on landscapes that is second only to that of humans. The life history of beavers is predicated on altering landscapes to provide shelter, food, and security which thereby creates the dams, ponds, wetlands, channels, and wetland vegetation that provides critical habitat for countless other species (Morgan 1986; Müller-Schwarze and Sun 2003; Runtz 2015; Goldfarb 2018; Romansic et al. 2020).

Beavers no doubt exerted a vast impact on the Whistler area before the railway opened in 1913. The Whistler Valley contains five lakes in a flat pass that, even now, are connected by creeks and wetlands impacted by beavers. Before European settlement, that habitat would have been much larger and would have stretched north in a mostly continuous swath from what is now Function Junction through Meadow Park and the Nicklaus North Golf Course beside Green Lake. The first, and significant reduction of Whistler's beaver population was caused by so much trapping that Racey and McTaggart-Cowan (1935) noted beavers had already been "completely trapped out in the district for over twenty years" (p. 24), even though their dams and meadows persisted.

Even though development has removed almost three-quarters of Whistler's wetlands (McBlane 2007), beavers still inhabit key wetlands including the Millar Wetlands, the Rainbow Wetlands, the Wildlife Refuge, and the River of Golden Dreams wetland complex. Due to their critical role in creating and maintaining wetland habitats, beavers have the most positive impact on the quantity and quality of those habitats of any species in Whistler. They also play an important role in flood management, erosion control, and water quantity and quality. Their dams raise the water table to keep areas inundated even through dry summer months, and reduce erosion by slowing streamflow (Goldfarb 2018). From an ecological perspective, it would be difficult to have too many beavers on the landscape.

For some land managers, however, beavers are pests to be trapped, killed, or otherwise dissuaded from their normal activities. In Whistler, the conflict between humans and beavers has been concentrated in the valley bottom. Much of the valley bottom habitat that once housed beavers has been transformed into low-lying developments where beavers are not welcome due to their propensity to cut valuable trees, raise water levels, and generally cause trouble for property owners. The ongoing challenge for the RMOW (among other land managers) is to balance the enormous ecological benefit of beavers on the landscape with other priorities such as protecting property and infrastructure.

Beavers are colonial animals. They maintain a family lodge which typically houses the adult parents, two yearlings, and two young-of-the-year (Müller-Schwarze and Sun 2003). Two-year-old beavers generally disperse to form new colonies, except when dispersal is delayed by the lack of suitable habitat and they remain with the family lodge. Some lodges can remain active indefinitely, especially in prime habitats, while others are periodically inactive or abandoned permanently. As a result, many of Whistler's lodges have been occupied for many years or even decades, while others are only active for one or a few years.

Beavers provide a unique situation for field biologists because, given enough effort and accumulation of data, it is possible to document all colonies (overwintering lodges) in a valley the size of Whistler. This information, when combined with an estimated number of beavers per colony, provides a population census that can be monitored without the statistical analysis required in most surveys (i.e., through statistical sampling).

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 program but focussed only on a subset of lodges (Cascade 2014-2016). The 2016 surveys returned to a full census approach where as many active lodges as possible were enumerated (Palmer and Snowline 2017). The greater survey effort and geographic range that began in 2016 increased the number of documented colonies from nine in 2015 to 49 last year (Snowline 2022), and greatly expanded the geographic range of known colonies. Each year since 2015, these surveys have come closer to a full census of all beaver colonies in Whistler.

Field work in 2023 was again led by Bob Brett with assistance from Kristen Jones (River of Golden Dreams), and Birken Metza (Milar Wetlands, Wildlife Refuge, and many others). Anecdotal information from the following people also helped ensure the most comprehensive survey: Kristina Swerhun, Jan Tindle, Eric Crowe, Liz Barrett, Eric Wight (Backroads), Dan Nash (Chateau GC), Andre Arsenault (Whistler GC), and Aaron Mansbridge (Nicklaus North GC). Thanks to Eric and Spencer Wight for supplying a canoe for the River of Golden Dreams survey in late October.

2.2 Methods

2.2.1 Survey Design

Fieldwork towards (re-) building a full census of Whistler's beavers began in 2016, with the recognition that this goal could only be achieved with intensive and cumulative effort. It started with lodges still documented as of 2015 and resurveyed other areas where the Whistler Biodiversity Project had earlier documented them. Surveys were also directed into areas that had anecdotal reports of beaver activity, as well as suitable habitats that could house beavers. This general approach has continued since, and each year benefits from knowledge accumulated in previous years. Consistency and accuracy are further enhanced by having the same surveyors as much as possible (e.g., Bob Brett and Kristen Jones).

The goal of the survey is to enumerate all active, overwintering colonies in Whistler Valley, between Function Junction and the north end of Green Lake. While the vast majority of these colonies overwinter in lodges, a minority are sometimes documented overwintering in bank burrows. The number of active colonies (lodges plus burrows) is then multiplied by an estimated number of beavers per colony to yield an estimate of the total population (Section 2.2.2). Annual fieldwork resurveys sites active in past years, as well as investigates other areas for current activity and potential new colonies. Physical structures (lodges, dams, bank burrows) are mapped, and their activity status is recorded.

In most cases, it is possible to confidently identify whether a lodge, burrow, or dam is active based on the following observations:

- Sightings of beavers, especially if entering and exiting structures (Photo 2-1);
- New construction or repair of lodges, especially in the fall when it shows a colony will overwinter in that lodge (Photo 2-2a);
- Functioning and freshly-maintained dam(s);
- Fresh food caches submerged at the entrance to a lodge or burrow;
- Beaver tracks (Photo 2-2b);
- Well-worn paths (tunnels and slides) through vegetation for feeding (Photo 2-2c) and/or
- Evidence of extensive clippings and cuttings along those paths.

Signs of inactivity include the absence of: beaver sightings, a structurally sound lodge; functioning or freshly-maintained dam(s); and/or other fresh signs.

Photo 2-1. Beaver sightings are the strongest evidence of presence.

Photo 2-2. Other evidence of recent beaver activity: (a) a lodge freshly mudded before winter; (b; beaver tracks; and (c) a runway through adjacent vegetation.

Until 2019, lodges and burrows for which activity status was unclear were recorded as having "Unknown" status. Starting in 2019, this uncertainty has instead been recognized by question marks beside a record, that is, "Active?" or "Inactive?" This change forced surveyors to choose which of the two classifications was most probable. While those designations have typically been correct, any errors are corrected in the subsequent year. For example, a lodge recorded as "Active?" will typically be confirmed active in the subsequent year or, less often, confirmed inactive.

Two new classifications added in 2022 ("Probable" and "Possible") were retained for 2023 surveys: The reason for these additions was to capture information about areas where beaver activity was obvious but the lodge(s) associated with that activity was not detected. The presence of a lodge was deemed to be "Probable" if the level of activity and distance from another lodge provided compelling evidence for an undetected lodge. The expectation for these areas is that a lodge will eventually be located (as happened in 2022 near Meadow Park; Section 2.3.5). The "Possible" category includes similar situations that may or may not be associated with a lodge nearby, that is, the evidence for an undetected lodge is weaker. Both categories are meant to flag areas for further investigation the following year.

2.2.2 Data Analysis

Three factors introduce uncertainty into the reliability of population estimates of Whistler's beavers. First, it is not always possible to conclude whether a colony will overwinter in a given lodge or burrow. Second, not all occupied lodges or burrows are detected each year (though the number of undetected lodges decreases each year due to accumulated knowledge). Third, while it would be ideal to actually count each beaver in Whistler, it is not possible within the scope of this program. As a result, the number of active lodges and burrows is instead used as a proxy for the number of colonies. The total beaver population is then derived by multiplying the number of colonies by an estimated number of individuals per colony.

Among other factors, habitat suitability and beaver density can affect the number of beavers within a colony. The 2008 beaver survey (Mullen 2008) applied a multiplier of 5.8 beavers per lodge from five studies elsewhere and this is the multiplier that has been used since to estimate Whistler's total beaver population. This multiplier continues to be a reasonable estimate because of two reasons:

1. It is consistent with the studies cited by Mullen, and also within the middle of the range of averages from studies in 12 locations reported in; Table 2-1); and,
2. It is consistent with a typical colony that contains two adults, two yearlings, and two young-of- the-year (Section 2.1).

Table 2-1. Number of beavers per colony in various locations (Müller-Schwarze and Sun 2003).

Location	Avg. No. per Colony	Location	Avg. No. per Colony
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

To help describe the possible population range, a low multiplier (4.2 beavers per colony) and high multiplier (6.4 beavers per colony) are also reported. These additional multipliers represent approximate quartiles reported by Müller-Schwarze and Sun (2003; Table 2-1).

2.3 Results and Discussion

2.3.1 Number of Lodges and Burrows

Surveys discovered nine more active colonies than in 2022, including 58 lodges and two burrows (Table 2-2; Figure 2-1; Appendix A). These additions were mostly well-established lodges in the Millar Wetlands and River of Golden Dreams that had not been detected before. Additions in the Milar Wetlands were due to the first survey of its southeast spur which resulted in the discovery of several active and inactive lodges. Additions in the River of Golden Dreams were due to ideal survey conditions (full sun and no leaves on streamside shrubs) and extra search effort. Given that these were already established lodges, the increased total of active colonies reflects improved survey coverage rather than a true population increase.

Table 2-2. Lodges and Burrows by activity status since 2007.

Status	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Lodges - Active(?) + Probable	9	27	16	16	17	10	10	7	13	11	20	29	35	48	49	58
Burrows - Active(?)	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
Total Active	**9**	**27**	**16**	**16**	**17**	**10**	**10**	**7**	**13**	**11**	**20**	**29**	**36**	**49**	**51**	**60**
Lodge - Inactive(?) + Possible	9	12	13	7	21	5	14	18	11	27	38	42	48	57	64	68
Lodges - Summer Only	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0
Lodge - Unknown	1	4	4	4	0	8	1	3	3	8	9	NR	NR	NR	NR	NR
Burrow Inactive(?)	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2
Burrow - Summer Only	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Total Inactive	**10**	**16**	**17**	**11**	**21**	**13**	**15**	**21**	**16**	**39**	**51**	**45**	**51**	**60**	**67**	**71**
Total Surveyed	**19**	**43**	**33**	**27**	**38**	**23**	**25**	**28**	**29**	**50**	**71**	**74**	**87**	**109**	**118**	**131**

Notes: Based on results from other years, 2008 totals are likely over-estimated. No surveys were conducted in 2012.

Totals in Table 2-2 have been updated to include, for the first time, three lodges south of the urbanized part of Whistler. Two active lodges are in the Callaghan North Pond, and one is on a side channel of the Cheakamus River, beside Runaway Train bike trail (Figure 2-1).

It becomes clearer each year that lodges can remain active for many years (Photo 2-3), presumably with the same mating pair and possibly even their descendants. While only four lodges have been deemed active each year since 2017 (Table 2-3), the true number is certainly higher since many well-established lodges now listed as active were first detected since 2017.

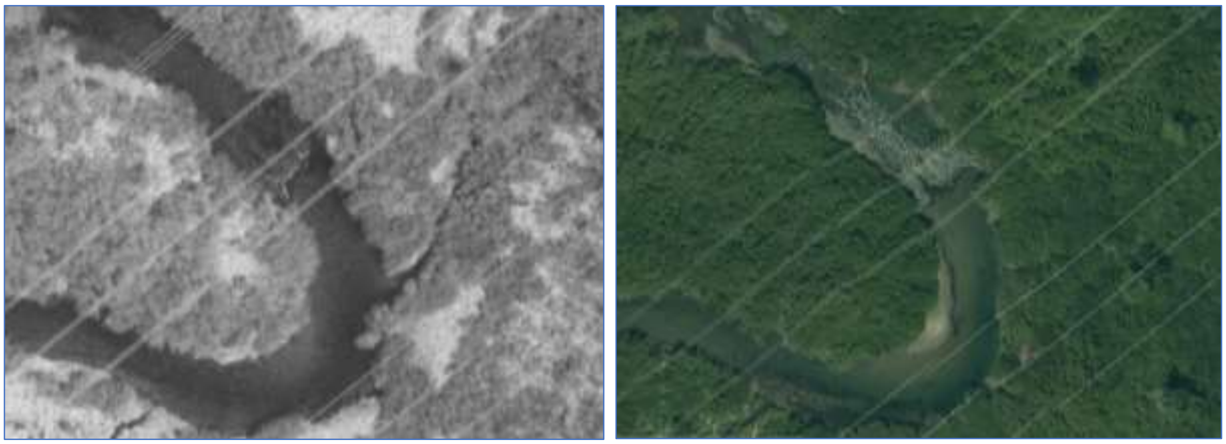

Photo 2-3. RMOW imagery of dam ROGD4-1 in 1995 (left) and 2018 (right). The dam is near the middle of the photo, under the middle power line.

SNOWLINE Ecological Research

Table 2-3. Active and probable colonies, 2017 to 2023.

Map Label	Record	Easting	Northing	New?	2023	2022	2021	2020	2019	2018	2017
Alpha Lk Lodge 1	Lodge	499208	5549034		Active	Active	Active	Active	Active	Active	NR
Alpha Lk Lodge 5	Lodge	499913	5548986		Active?	Active?	Active?	NR	NR	NR	NR
Alta Lake Lodge 2	Lodge	500919	5550750		Active	Active	Active	NR	NR	NR	NR
Alta Vista Lodge 1	Lodge	501458	5550235		Active	Active	Active?	Active	Active	Active	Active
Call North Lodge 1	Lodge	492917	5546177		Active	Active	Active?	NR	NR	NR	NR
Call North Lodge 2	Lodge	492957	5546308		Active	NR	NR	NR	NR	NR	NR
CGC-18 Lodge 1	Lodge	504230	5552246		Active	Active	Active	Active	NR	NR	NR
CGC-18 Lodge 3	Lodge	504188	5552227		Active	Active	Inactive	Inactive	Inactive	Inactive	Inactive
Cheak Cross - Lodge?	Lodge	496833	5547905		Probable	Probable	NR	NR	NR	NR	NR
Cheak River Lodge 1	Lodge	494376	5547052		Active	Active	Active	Active?	Active?	Active?	Active?
Fitz Back Burrow 1	Burrow	504142	5554607		Active	Active	Active	Active	NR	NR	NR
Fitz Fan Lodge 1	Lodge	503847	5554866		Active?	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Fitz Pond Lodge 1	Lodge	503275	5552571		Active	Active	Active	Inactive?	Active	Active	NR
Fitz Pond Lodge 2	Lodge	503300	5552575		Active	Active?	Active	Inactive	Inactive	NR	NR
Fitz Pond Lodge 3	Lodge	503287	5552516		Active	Active	NR	NR	NR	NR	NR
Lost Lake Lodge 1	Lodge	504337	5553160		Active	Inactive?	Active	NR	NR	NR	NR
MW1-1 Lodge	Lodge	497706	5548388		Active	Active	Active	Active	Active	Active	NR
MW1-2 Lodge	Lodge	497737	5548390		Active?	Active	Active	Active	NR	NR	NR
MW1-3 Lodge	Lodge	497796	5548408		Active?	Active	Active?	Active	Active	Active	NR
MW4-1 Lodge	Lodge	498156	5548764		Active	Inactive?	Inactive?	Active?	Active?	NR	NR
MW5-2 Lodge	Lodge	498284	5548908		Active	Active	Active	Active	Active	Inactive?	NR
MW5-3 Lodge	Lodge	498222	5548860	Yes	Active?	NR	NR	NR	NR	NR	NR
MW5-4 Lodge	Lodge	498223	5548877	Yes	Active?	NR	NR	NR	NR	NR	NR
MW6-1 Lodge	Lodge	498321	5548863		Active	Active?	Active?	Active	Active	NR	NR
MW6-2 Lodge	Lodge	498328	5548894		Active	Active	Active	Active	Active	NR	NR
MW6-4 Lodge	Lodge	498341	5548914	Yes	Active?	NR	NR	NR	NR	NR	NR
MW7-1 Lodge	Lodge	498334	5548715	Yes	Active?	NR	NR	NR	NR	NR	NR
ROGD 03-1 Lodge	Lodge	501719	5552450		Active	Active?	NR	NR	NR	NR	NR
ROGD 04-1 Lodge	Lodge	501744	5552517		Active?	Active	Inactive	Inactive?	Active	Active	Active
ROGD 10-1-US Burrow	Burrow	502136	5552980	Yes	Active?	NR	NR	NR	NR	NR	NR
ROGD 10-2 Lodge	Lodge	502126	5553026		Active?	Active?	Active	Active?	Active	NR	NR
ROGD 15-2 Lodge	Lodge	502312	5553204		Active	Active?	Active	Active	Active	NR	NR
ROGD 15-5 Lodge	Lodge	502349	5553202		Active	Active	Active	Active	Active	Active?	NR
ROGD 15-6 Lodge	Lodge	502355	5553222		Active	Active?	Active?	Inactive?	Inactive	Inactive	NR
ROGD 21-1 Lodge	Lodge	502406	5553403		Active	Active	Active	Active	Active	NR	NR
ROGD 25-1 Lodge	Lodge	502311	5553661		Active	Active	Active	Active	Inactive	Inactive	NR
ROGD 25-2 Lodge	Lodge	502308	5553673		Active	Active	Active	Active	Inactive?	Inactive	NR
ROGD 29-1 Lodge	Lodge	502376	5553923	Yes	Active?	NR	NR	NR	NR	NR	NR
ROGD 30-1 Lodge	Lodge	502544	5554067	Yes	Active	NR	NR	NR	NR	NR	NR
ROGD 31-1 Lodge	Lodge	502497	5554158		Active	Probable	NR	NR	NR	NR	NR
ROGD 32-1 Lodge	Lodge	502433	5554240	Yes	Active	NR	NR	NR	NR	NR	NR
ROGD 35-1 Lodge	Lodge	502846	5554565		Active?	Active	Active NR	Active NR	NR	NR	NR
ROGD 40-1 Lodge	Lodge	503202	5554930		Active?	Inactive	Active?	Active?	Inactive?	NR	NR
ROGD 41-1 Lodge	Lodge	503185	5554836		Active	Active	Active	Active	Active	Inactive?	NR
RP Lodge 1	Lodge	501145	5551850		Active	Active	Active?	Active	Inactive	Inactive	Inactive
RW1-1 Lodge	Lodge	501096	5552182		Active?	Active	Active?	NR	NR	NR	NR
RW2-1 Lodge	Lodge	501278	5552385		Active?	Inactive?	Inactive?	NR	NR	NR	NR
RW3-1 Lodge	Lodge	501523	5552527		Probable	Probable	NR	NR	NR	NR	NR
RW4-1 Lodge	Lodge	501702	5552711		Active	Active	Active	NR	NR	NR	NR
RW4-2 Lodge	Lodge	501694	5552718		Active?	Active?	Active	NR	NR	NR	NR
RW5-1 Lodge	Lodge	501848	5552721		Active	Active	Active	NR	NR	NR	NR
RW5-2 Lodge	Lodge	501848	5552727		Active	Active	Active	Active?	Active	Active	Active
RW6-1 Lodge	Lodge	501777	5552792		Active?	Active?	Active?	Active	NR	NR	NR
RW6-2 Lodge	Lodge	501790	5552801		Active?	Active?	Active	NR	NR	NR	NR
Wedge Pond Lodge 2	Lodge	503176	5555733		Active	Inactive	Inactive	Active	Active	Active	Inactive
Wedge Pond Lodge 4	Lodge	503233	5555757		Active	NR	NR	NR	NR	NR	NR
WGC-7 Lodge 2	Lodge	502347	5552127	Yes	Active	NR	NR	NR	NR	NR	NR
WR3-1 Lodge	Lodge	501750	5553298		Active	Active?	Active	Active	NR	NR	NR
WR3-2 Lodge	Lodge	501709	5553226		Active?	Active?	Active	NR	NR	NR	NR

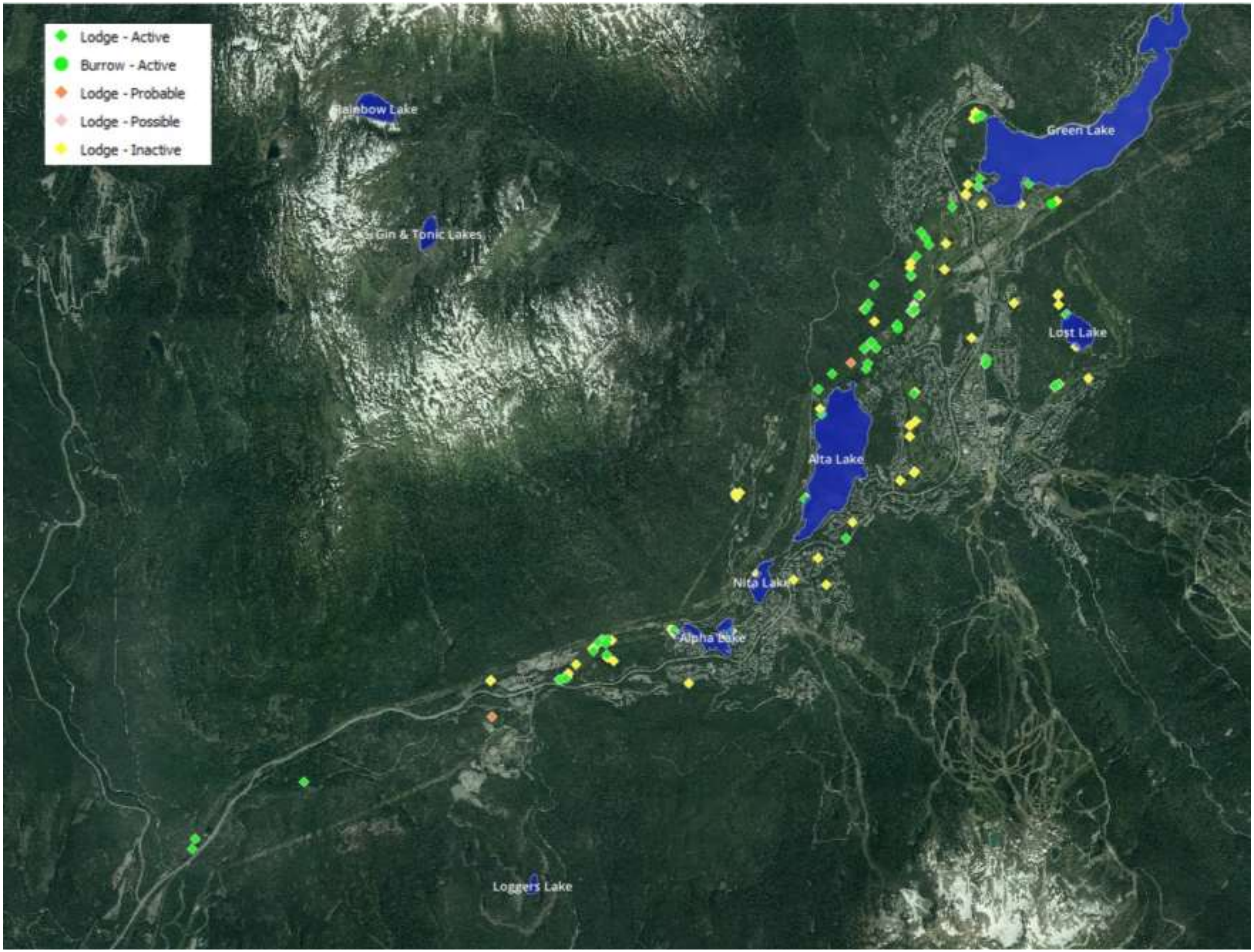

Figure 2-1. Beaver lodges and burrows.

2.3.2 Search Effort and Detections

Surveys in 2023 continued the trend of increased search effort. A total of 131 active and inactive lodges were detected in 2023, which represents an almost linear increase since 2017 (Table 2-2; Figure 2-2). The main reason for the increase in both search effort and detections has been expanded surveys in the hardhack meadows in the Rainbow Wetlands, Wildlife Refuge, and Millar Wetlands, especially since 2019. Hardhack and other tall shrubs in these wetlands can completely hide a lodge, which is why lodges are often hidden even when viewed from only a few metres away. Conducting surveys later in the fall was the other main change, and this also increased the number of detections.

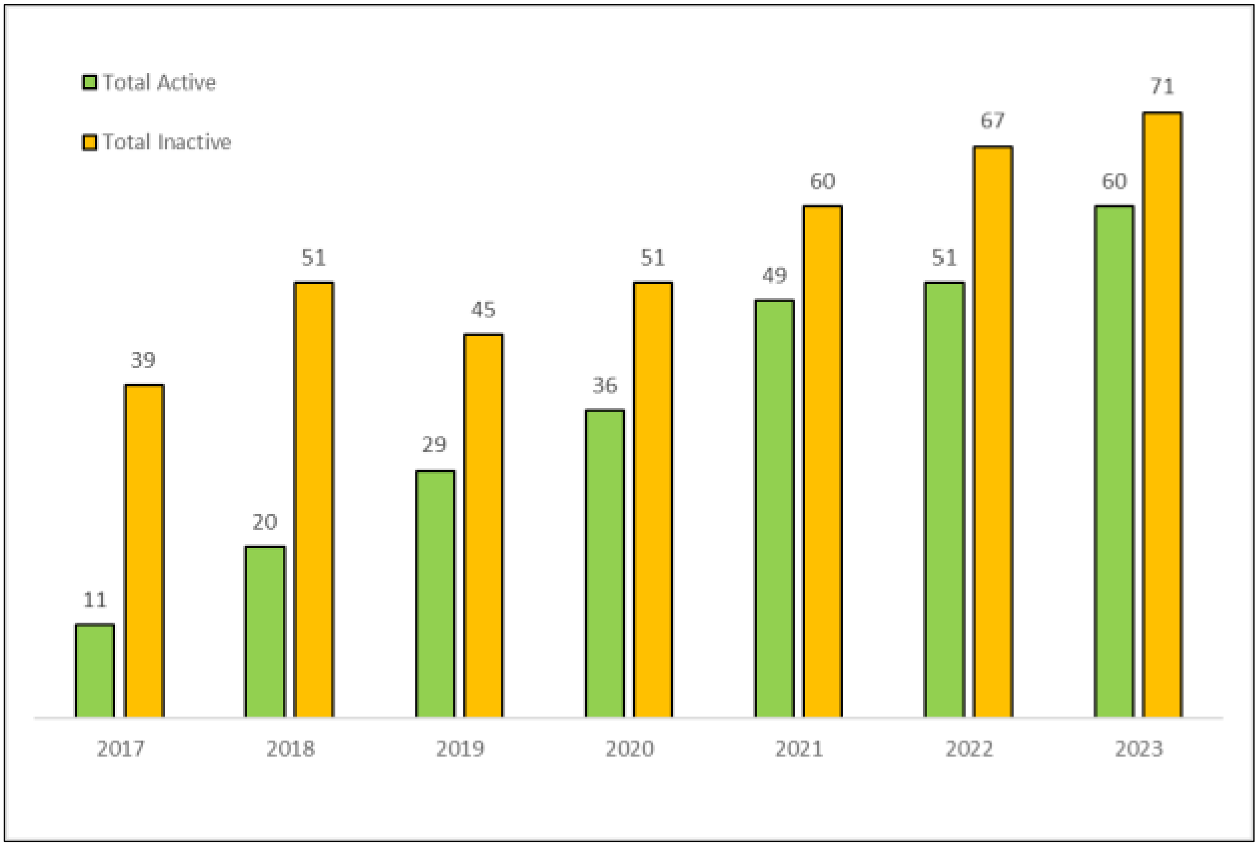

Figure 2-2. Number of active and inactive colonies (lodges and burrows) detected since 2017.

The beaver census continues to benefit from accrued knowledge. In 2023, additional search effort in the Millar Wetlands, especially the southeast spur, revealed yet another beaver activity area. The discovery of six well-established lodges on the River of Golden Dreams is a reminder that beaver lodges can be so cryptic they remain undetected for many years, in spite of extensive search effort.

2.3.3 Estimated Beaver Population

The best estimate of Whistler's beaver population in 2023 is 348 beavers, with a low and high range of 252 to 384 beavers (Table 2-4; Figure 2-3). While it is not possible to determine the number of beavers for previous years, it is possible to project the pre-settlement population based on McBlane's (2007) calculation that almost three-quarters of Whistler's wetlands have been lost to development since the railway opened in 1913. Before European settlement, the fur trade, and the loss of wetlands, it is therefore likely that Whistler's beaver population was well over 1,000.

Table 2-4. Estimated number of beavers in Whistler, 2007-2022. The rational for estimates of the number of beavers per colony is described in Section 2.2.2.

	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Active colonies	9	27	16	16	17	10	10	7	13	11	20	29	36	49	51	60
4.2 beavers/colony	38	113	67	67	71	42	42	29	55	46	84	122	151	206	214	252
5.8 beavers/colony	52	157	93	93	99	58	58	41	75	64	116	168	209	284	296	348
6.4 beavers/colony	58	173	102	102	109	64	64	45	83	70	128	186	230	314	326	384

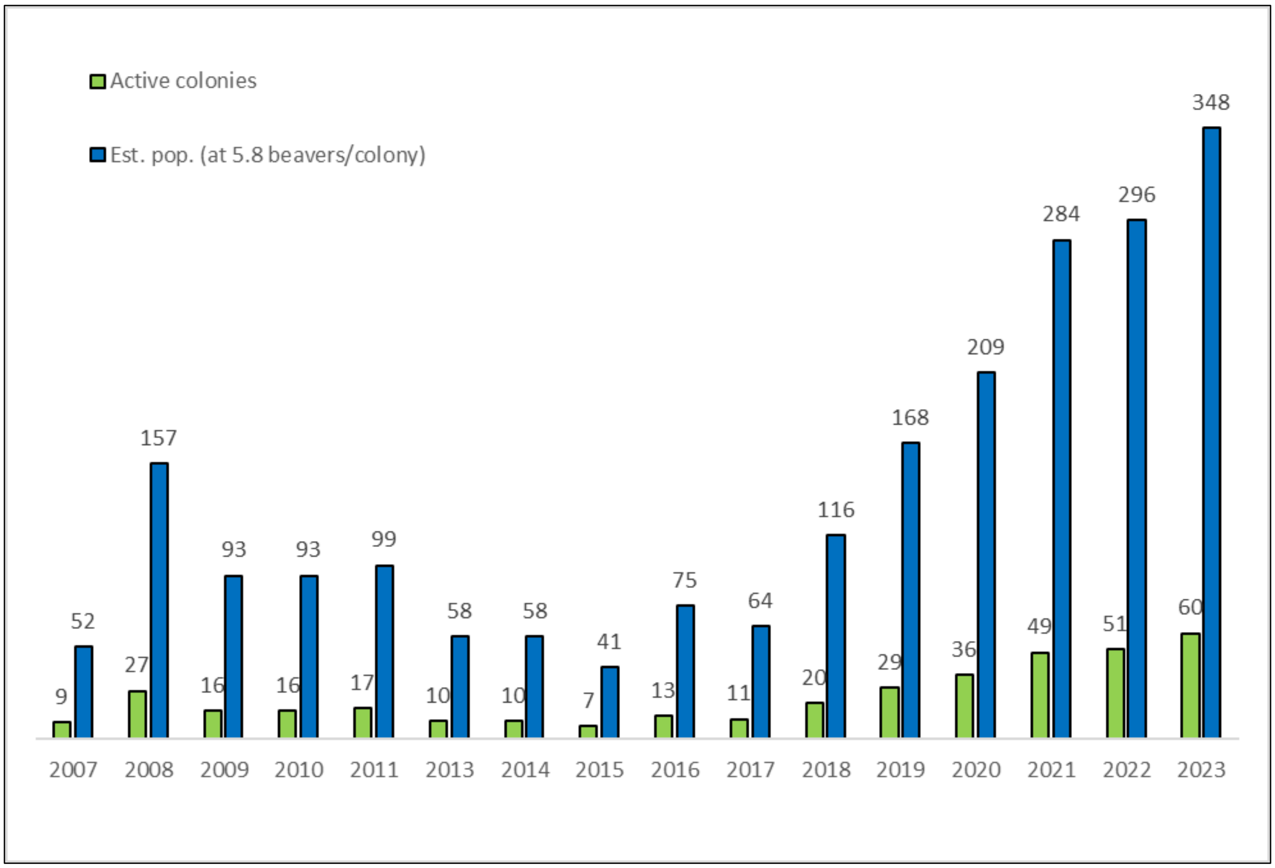

Figure 2-3. Estimated beaver population since 2007.

2.3.4 Importance of ROGD-Rainbow-Wildlife Refuge Complex and Millar Wetlands

The impact and presence of beavers in Whistler was well-known long before annual surveys began (e.g., Racey and McTaggart-Cowan 1935). Before these surveys, perhaps the most obvious habitat was on the River of Golden Dreams (ROGD) where paddlers had to navigate multiple beaver dams. It was therefore not surprising when the first decade of beaver surveys confirmed that at least half of known lodges in Whistler were on the ROGD. While the ROGD still provides important beaver habitat, expanded surveys since 2019 have discovered that other areas provide a similar amount of beaver habitat, notably in the Millar Wetlands, the Rainbow Wetlands, and the Wildlife Refuge.

These three wetland complexes support two-thirds (40 of 60) active colonies in the Whistler Valley (Figure 2-4). Ambitious surveys in 2019 covered the entire Millar Wetland area for the first time, including parts of the hardhack meadows that were very difficult to access. That effort was rewarded with the discovery of seven previously unknown lodges and brought the total for that area to nine active lodges. In 2021, a similar effort discovered an additional five previously unknown lodges in the Rainbow Wetlands and a further two in the Wildlife Refuge. Surveys in 2023 the discovery of yet more colonies in the Millar Wetlands and River of Golden Dreams reinforced the importance of these wetland complexes.

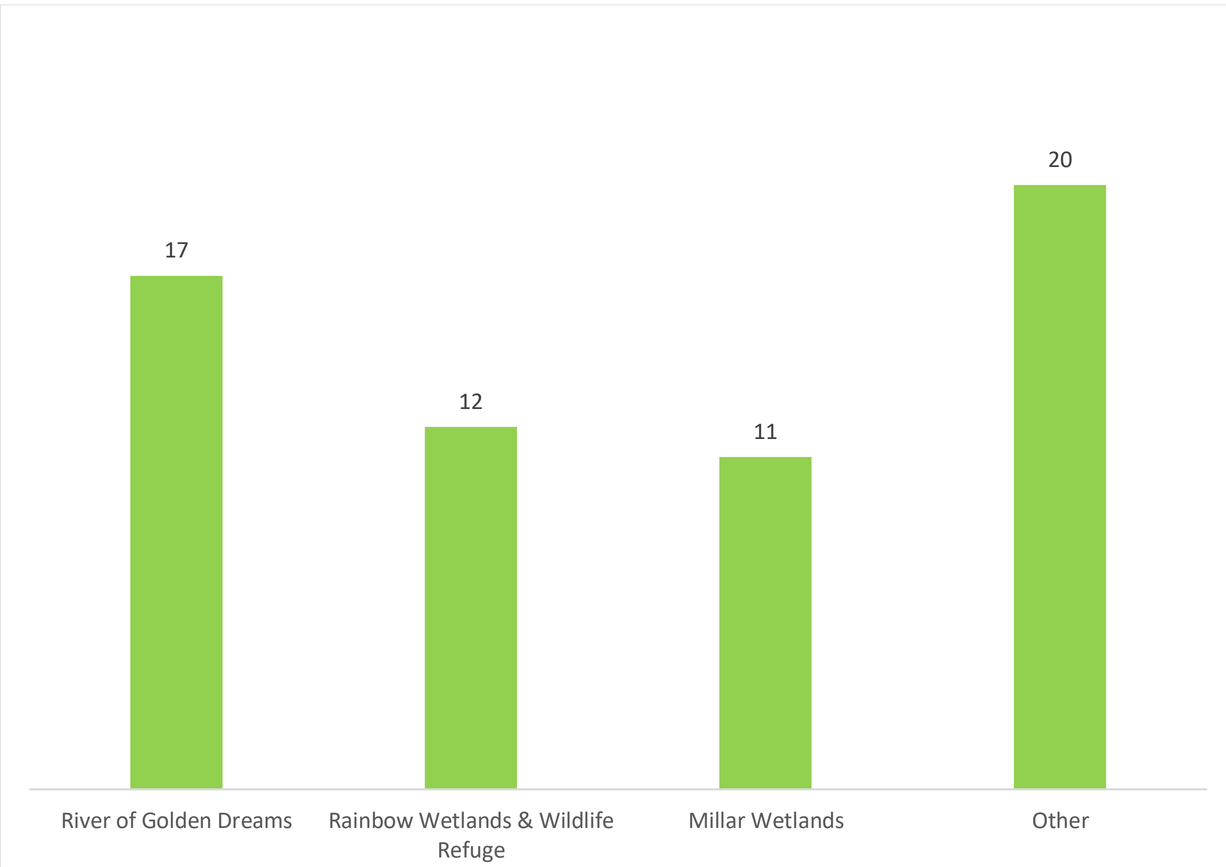

Figure 2-4. Colonies by major activity area.

2.4 Beaver-affected Wetlands

Note: I use the term "Beaver-affected Wetland" with the recognition that a single term cannot capture the entire essence of how beavers create, maintain, and alter wetland habitats. The term is meant to include: (a) wetlands created by beavers; and/or, (b) wetlands that wouldn't continue to exist without continuous beaver activities; and (c) pre-existing wetlands that have been enlarged and/or maintained by beavers. In many cases, the past impacts of beavers persist for many years even without an active colony. Beaver Lake, for example, had four active colonies until about 15 years ago. Even though those colonies were abandoned, the beaver dam that created the lake is still intact.

2.4.1 Introduction

A beaver's life is inextricably involved in creating its own habitat – their incredible ability to alter and saturate landscapes is why they are termed ecosystems engineers. By creating and maintaining wetlands, beavers provide habitat for countless plants and animals, reduce erosion, store water, mitigate floods, and store carbon (Müller-Schwarze and Sun 2003; Goldfarb 2018). The first attempt to quantify this effect of beavers on Whistler's landscape was included in the first mapping of "beaver-affected wetlands[3]" (Palmer and Snowline 2019), a term coined for this project that refers to wetlands that have been created and/or directly affected by beavers within Whistler Valley.

Monitoring the area covered by beaver-affected wetlands is meant to add a spatial complement to the lodge surveys and population estimates described above (Section 2-3). The two measures – number of beavers and areal extent of beaver-affected wetlands – are of course connected. More beavers mean more dams and impounding of water and, hence, more wetland area. Increases or decreases in wetland area likewise reflect the number of beavers present on the landscape.

2.4.2 2023 Update

Most of the wetlands in Whistler Valley, and all large ones, were created or expanded due to beaver activity (Figures 2-2a and 2-2b). As of 2023, beaver-affected wetlands now cover 110.3 hectares (Table 2-5). An additional 6.8 hectares is also affected by beaver activity in Alpha Lake. Beaver dams have created a further 2.2 hectares of wetland in the Callaghan North pond, south of Whistler Valley and near the Callaghan Forest Service Road. Although this total is almost 10 hectares higher than when first calculated in 2019, it is mainly a reflection of: (a) additional documentation of beaver activity in the Millar Wetlands; and (b) improved mapping accuracy. That is, the higher total is mainly a result of mapping that is more accurate.

The three largest wetland complexes not only support two-thirds of all beavers in Whistler Valley (Section 2.3.4), they account for 87% of the total area of beaver-affected wetlands (Table 2-5). The River of Golden Dreams contains almost half (43%) of all beaver-affected wetlands, while the Millar Wetlands (18%), Rainbow Wetlands (14%), and Wildlife Refuge (11%) account for most of the rest.

3 See note at the beginning of Section 2.4. I have replaced all references of "beaver-affected wetlands" even though that is the term used in previous reports.

Table 2-5 Location and area of beaver-affected wetlands in Whistler, 2023.

Wetland (South to North)	2022 Area (ha)	2023 Area (ha)	Change (+/-)
Millar Creek Wetlands	13.2	20.3	7.1
Beaver Lake	1.8	1.9	0.1
Alta Vista Pond	1.3	1.5	0.2
Rainbow Wetlands	15.2	15.8	0.6
Fitzsimmons Wetlands	1.4	1.5	0.1
Chateau GC #18 Pond	0.7	0.8	0.1
Wildlife Refuge	10.4	12.2	1.8
Spruce Grove Wetland	0.3	0.4	0.1
Lost Lake - Saw mill Wetland	1.6	1.6	0.0
Buckhorn Pond	0.5	0.5	0.0
River of Golden Dreams	47.9	47.7	-0.2
Fitzsimmons Creek Outflow Channel	0.9	0.1	-0.8
Wedge Pond	5.5	6	0.5
Total beaver-created wetlands	**100.7**	**110.3**	**9.6**
Alpha Lake (est. flood effect of dam)	7.1	6.8	-0.3
Total beaver effect	**107.8**	**117.1**	**9.3**

One increase of note happened in the past two years in the Fitzsimmons Creek wetland (Photo 2-4; Figures 2-2a and 2-2b), the area bounded by Blackcomb Creek, Nancy Green Drive, and Fitzsimmons Creek. Large dams have resulted in higher water levels, no doubt related to the increase in number of beavers which now maintain three active lodges in that wetland. While there has been a noticeable increase in water level, it had only minimal impact (0.1 ha) in mapped wetland area.

Photo 2-4. Large dam beside the Fitzsimmons Nature Trail that increases water levels in the Fitzsimmons Wetland.

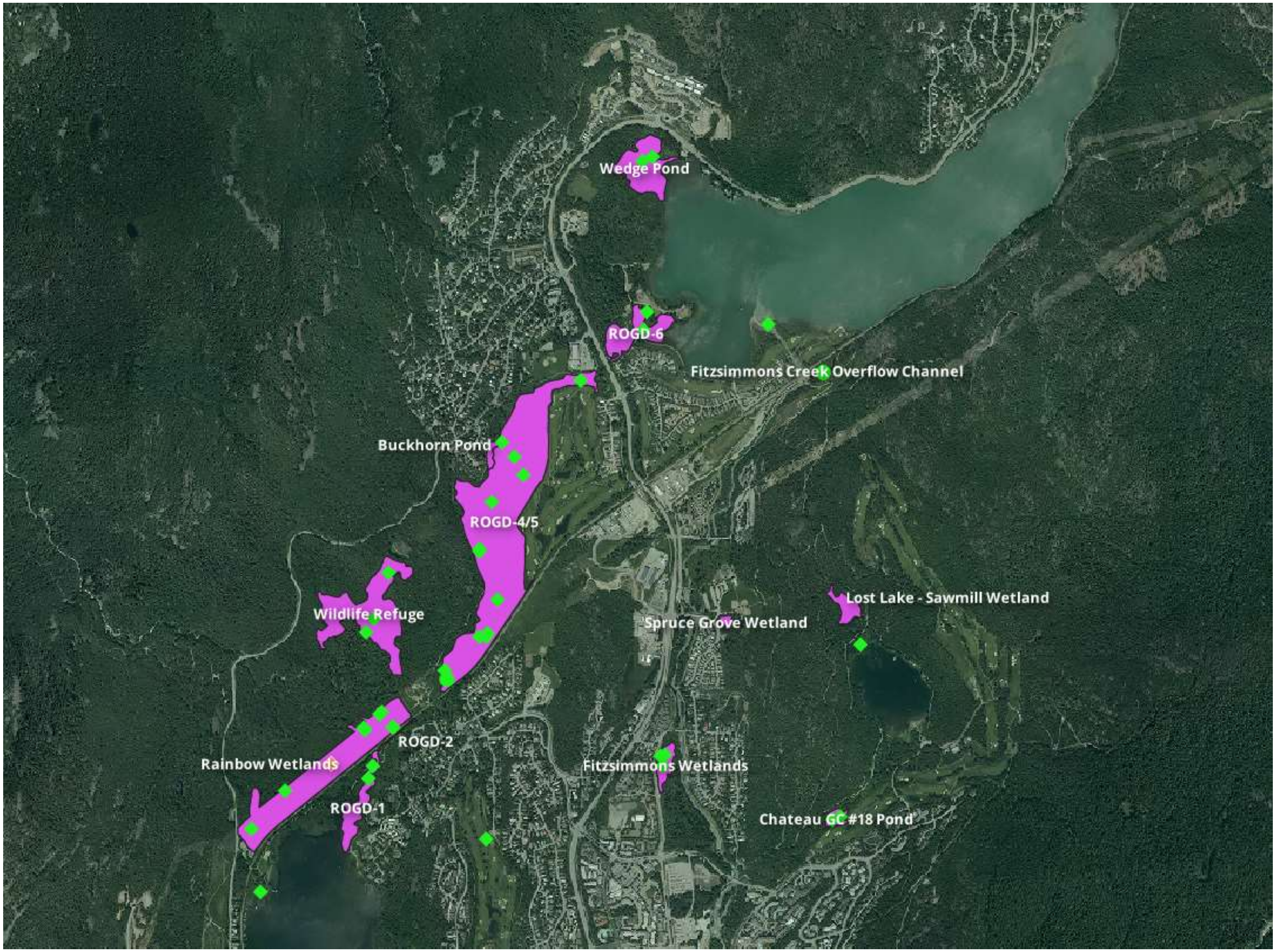

Figure 2-2a. Beaver-affected wetlands, north end of Whistler Valley.

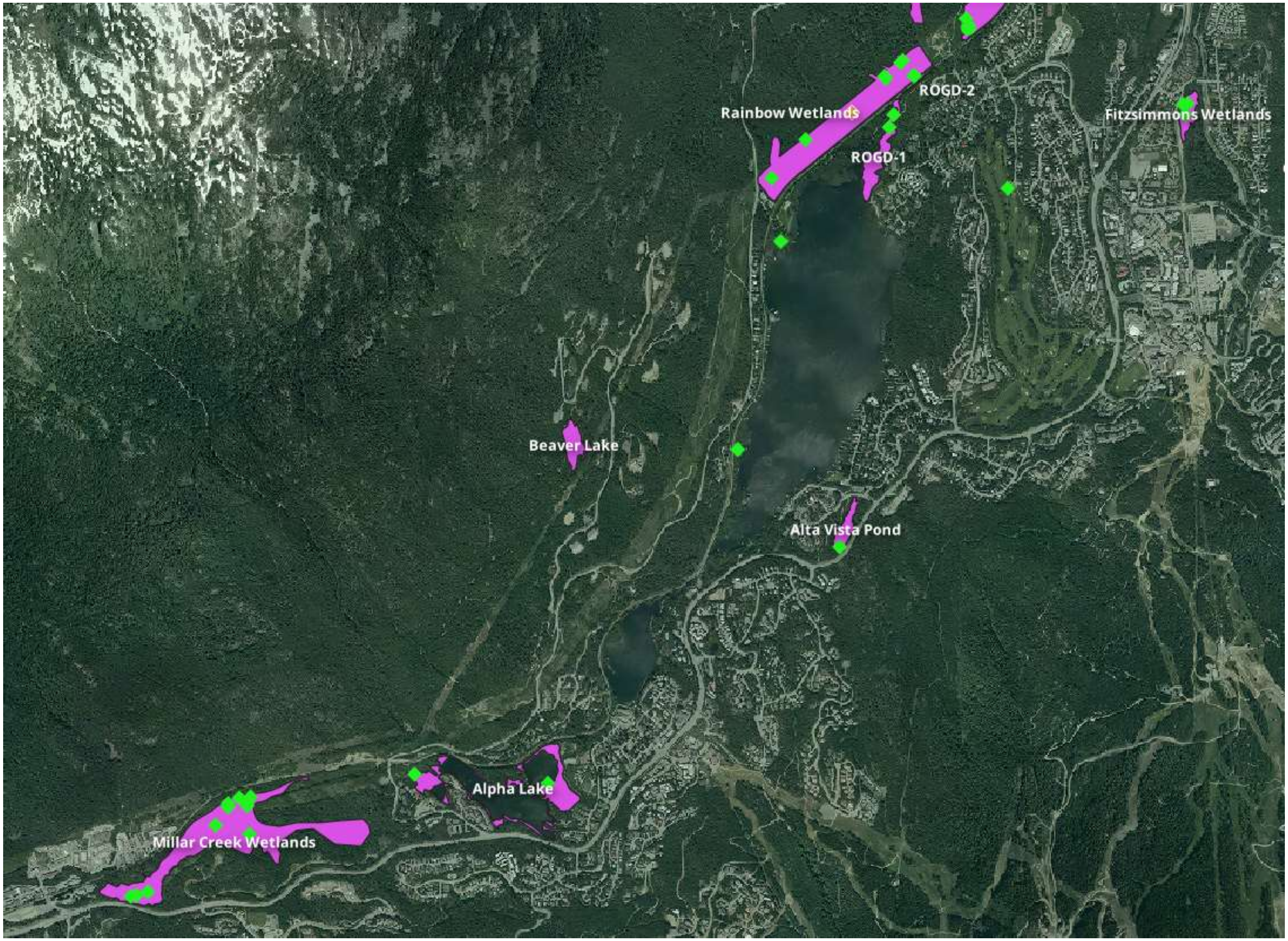

Figure 2-2b. Beaver-affected wetlands, south end of Whistler Valley.

2.4.3 Historic Context

Among other impacts, there were four main changes that that significantly impacted beavers since the railway was built in 1913:

1. The railbed raised water flows in some areas and lowered them elsewhere.
2. The railway facilitated the development of Whistler which brought more people.
3. Beavers were mostly extirpated from the valley within a few years after the railway opened, presumably due to trapping for pelts (Racey and McTaggart-Cowan 1935); and,
4. The expanded development that began with the opening of Whistler Mountain in 1966 and significant loss of beaver habitat since (e.g., McBlane 2007).

The railway bisected the large ROGD-Rainbow-Wildlife Refuge wetland complex which changed the hydrology and reduced the connectivity of that area. As Whistler's population started to grow in the 1960s and 1970s, wetlands were increasingly replaced by subdivisions, golf courses and other urban developments. By 2003, at least 72% of the original area covered by wetlands was lost to development (McBlane 2007; Table 2-6; Figure 2-6).

Table 2-6. Wetland area in the RMOW by year and scope.

Wetland Scope	Area (ha)	Compared to 1946	Compared to 2014	Source
All RMOW (1946)	604.4			McBlane 2007
All RMOW (2003)	169.9	28%		McBlane 2007
<800 m, study area only (2014)	150.7			Palmer and Snowline (2019; unplubl. data)
Beaver-created wetlands (2023)	110.3		73%	This report.

As of 2023, beaver-affected wetlands account for at least 73% of all low-elevation wetlands in Whistler Valley (Table 2-6). This total has remained essentially unchanged since first calculated in 2019. If anything, there may be slight gains due to increased beaver activity in some areas such as the Fitzsimmons Wetlands (Section 2.4.2). New mapping of wetlands (Brett, in prep.) will be available for analysis in 2024, which will provide an opportunity to do a more detailed and accurate analysis of the current extent of wetlands to pre-settlement.

3. Northern Goshawks

Key Takeaways

Stable with Caution (Limited Data)

1. Northern Goshawks are threatened forest predators that require old forest habitat for successful breeding and foraging. Although logging and other urban development have led to a significant decline in the goshawk population throughout BC, recent surveys have shown Whistler is an important breeding area. Their inclusion in this program is meant to (a) identify and protect breeding areas; and (b) provide an indicator of the availability of the low-elevation old forest habitat required by goshawks and other, unsurveyed species.
2. The two highlights from 2023 surveys included: (a) documentation of a successfully fledged juvenile goshawk in the Comfortably Numb area; and (b) the discovery of a recent nest at the south end of Emerald Estates. The latter record brings the total of current or recent nesting areas to six. Areas previously documented include: Comfortably Numb, Lower Blackcomb, Millar's Pond, Lower Sproatt, and Brew Creek.
3. The presence of six breeding areas provides encouraging evidence that: (a) goshawks maintain a strong presence in Whistler in spite of declines elsewhere. As continued surveys contribute more data, it will be possible to make stronger statements about population trends of Northern Goshawks and their old growth habitat in the Whistler area.

3.1 Introduction

The population of BC's Northern Goshawks (*Accipiter gentilis*[4]) has declined precipitously in recent years, mainly due to the loss of old forest habitat (BC MFLNRO 2018). The subspecies resident in Whistler, *A. gentilis laingi* (MFLNRO and Madrone 2014, 2015) is particularly threatened, which is why it is Red-listed in BC (CDC 2023) and ranked as Threatened under the Canadian Species At Risk Act (Government of Canada 2023). Surveys over the past decade have established that Whistler includes some of the most active breeding habitat for goshawks on BC's South Coast (MFLNRO and Madrone 2014, 2015; Brett 2020; Snowline 2021, 2022), presumably due to the availability of old forest habitat in this area.

A total of five nesting areas have been documented to date in Whistler (Figure 3-1):

1. RV Park (Brew Creek. The first public record of goshawk nests in the Whistler area prior was from a 2011 survey for the BC Government that found an active nest uphill and west of the current

[4] *Pending change to American Goshawk (Accipiter atricapillus). https://checklist.americanornithology.org/taxa/15055*

Whistler RV Park.[5] Recent surveys for the BC Government also recorded an active nest in 2022 (and possibly 2023), between the RV Park and Brandywine Creek.[6]

2. Comfortably Numb. Surveys in advance of construction of an Independent Power Project (IPP) on Wedge Creek found active nests near Comfortably Numb Trail in 2014 and 2015 (MFLNRO and Madrone). Surveys since (including in 2023) showed continued breeding in this area (Brett 2020; Snowline 2021).
3. Millar's Pond. A nest near Millar's Pond subdivision, discovered by this program in 2016, produced five fledglings while active in 2016 and 2017 (Palmer and Snowline 2017, 2018).
4. Lower Sproatt. A local resident, Bruce Worden first reported hearing goshawks in 2020. Subsequent surveys in 2021 confirmed presence in the area, but successful breeding was only confirmed in September 2021 when Bruce took photos of two juveniles (Snowline 2021). Bruce also found a nest in 2022 that could have been the one used by those juveniles in the previous year.
5. Lower Blackcomb. This program found an abandoned nest in the Lower Blackcomb area in 2021 (Snowline 2021). Given the number of aerial sightings nearby, it is likely there is another active nest in or nearby this area in at least some years.

The goal for the 2023 survey was to again search for active and inactive goshawk nests. Documenting active nests provides confirmation of continued breeding, while documenting inactive nests extends our knowledge of the Whistler habitats used previously by goshawks which could presumably be reoccupied in the future.

3.2 Methods

Call-playback is an established survey method that is meant to evoke a response from nearby birds. For surveys in the early nesting season, an adult alarm call is played. Goshawks nesting or planning to nest in that area will have a territorial response to that sound, and ideally be detected by sound and/or sight. Detections are meanwhile maximized in the later nesting season by broadcasting juvenile begging calls meant to elicit a response from hungry juveniles begging for food.[7]

Recordings by Erica McLaren (BC Government) of both adult alarm and juvenile begging calls, supplied by Brent Matsuda, were used for all call-playbacks. Formal surveys generally followed established protocols (e.g., MFLNRO and Madrone 2014, 2015; Erica McClaren, undated), though were spaced more closely than the recommended 400m between stations. The closer spacing was meant to take advantage of intensive surveys in a relatively well-studied area.

Calls separated by 30 seconds were repeated six times at each station, and faced downhill on the first calls then turning 90 degrees for each subsequent one. All nests and signs were recorded, including whitewash, plucking posts, and prey remains. Stand conditions and notes about any wildlife responses were also recorded. In addition, the following goshawk habitat conditions were subjectively rated: availability of nesting platforms, presence of flyways, access to the forest floor (for hunting), and overall habitat suitability.

[5] BC Conservation Data Centre (CDC) Species Occurrence Report Shape ID 106601. This area was recorded as Brew Creek.
[6] Emails from Melanie Wilson (then with BC Ministry of Forests) and Laura Kroesen, and Kym Welstead (BC Govt.)..
[7] Trystan Willmott, personal communication to Bob Brett.

3.3 Results and Discussion

A total of 84 stations were surveyed in 2023 using call-playback (Figure3-1; Appendix B). This total exceeds the previous highest search effort of 78 stations in 2022 (Snowline 2022). The main difference in 2023 was the addition of stations in the Emerald South area due to the detection of an inactive goshawk nest during nest surveys conducted for the RMOW's fuel management project east of Rainbow Housing.[8] Surveys were centered on Emerald South and four other areas with known goshawk presence (recent breeding or inactive nests): Lower Sproatt, Comfortably Numb, Millar's Pond, and Lower Blackcomb (Figure 3-1). The main highlights from the 2023 surveys included:

1. Photo-documentation of goshawks in the Lower Sproatt area.
2. Detection of goshawks during nesting season (May 17th) in the Comfortably Numb area.
3. Emerald South nest (June 6th)
4. Emerald South response (June 19th).
5. Photo-documentation of a juvenile goshawk that confirmed successful breeding in the Comfortably Numb area (July 18th).

3.3.1 Lower Sproatt

The first goshawk record from the Lower Sproatt area was from local resident Bruce Worden in 2020 (Palmer and Snowline 2020). A call-playback survey in 2021 elicited a response from an adult goshawk that flew high above the survey station, presumably to check the source of the call. Evidence of breeding in that area was provided in September when Bruce recorded video footage of two juveniles (Snowline 2021). In spring 2022, Bruce found an intact but inactive nest in the area that was structurally sound and could have been used the previous year.

Although call-playback surveys in 2023 did not detect goshawks around Lower Sproatt, local residents Dan Raymond and Craig Kosman took photos of adult birds in April (Photo 3-1). These photos show there is still activity in the area, though are not enough to conclude there was an active nest in 2023.


Photo 3-1. Photos of Northern Goshawks from the Lower Sproatt area taken in April, 2023 by Dan Raymond (left) and Craig Kosman photo (right).

[8] *Bob Brett, 2023 Rainbow Pre-Clearing Nest Surveys, memo to the RMOW, July 2023.*

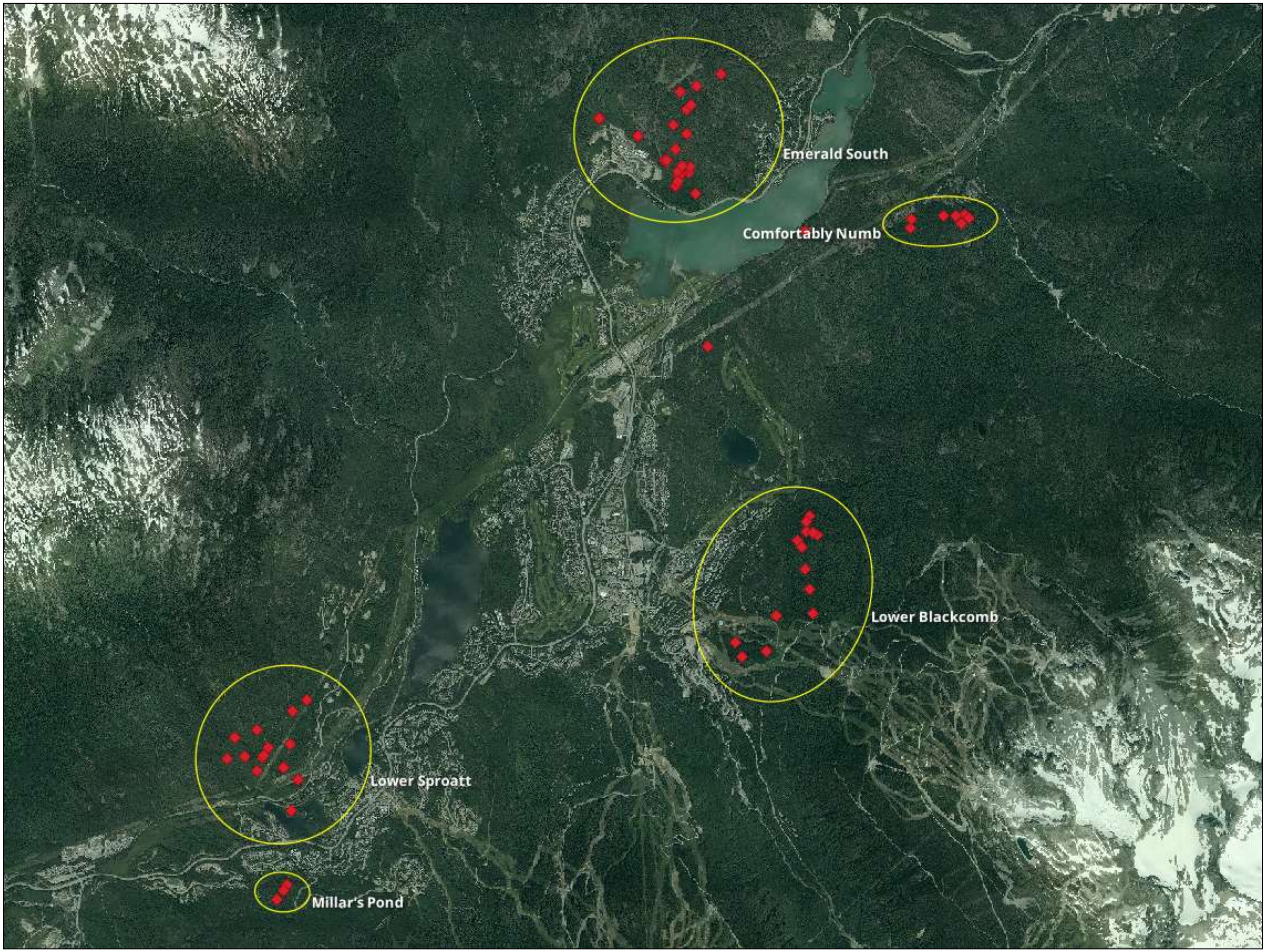

Figure 3-1. Northern Goshawk survey sites.

3.3.2 Comfortably Numb

Based on evidence to date, the Conformably Numb area may be the most important breeding area for goshawks in Whistler. Surveys in mid-May elicited a strong response from an adult goshawk likely defending an active nest nearby. Although the exact nest location was not found, call-playback in July got a response from a juvenile that flew in to examine its source (Photo 3-2). This observation confirmed there was at least one active and successful nest in the area.

Photo 3-1. This juvenile goshawk responded to a juvenile begging call beside the Comfortably Numb trail on July 18, 2023.

3.3.3 Emerald South

An inactive goshawk nest was discovered on June 2, 2023 by Bob Brett during a pre-clearance nest survey for the RMOW fuel management project next to Rainbow Housing (Photo 3-3). Call-playback on subsequent days did not elicit a response until June 19th when a goshawk responded with its own call. Two hours later, a goshawk flew overhead (and was probably the same bird).. Subsequent surveys in late June checked unsuccessfully for goshawk responses to the west (above Rainbow Housing) and north towards One Duck Lake. Further surveys should be conducted in 2024 to check for active nests at times when goshawks are more likely to respond, that is, in May or July.

Photo 3-3. This inactive nest was found near the top of the fuel management (thinning) site in the Emerald South area. It is no longer structurally sound which indicates it has likely been unused for many years.

3.3.4 Lower Blackcomb

Lower Blackcomb includes, along with Comfortably Numb, some of the best apparent habitat for goshawks in the Whistler area. The old forests have abundant flyways and many large trees with suitable branch platforms for nesting. It was therefore not a surprise when surveys in 2021 located an inactive but structurally-sound nest. In spite of surveys since, an active nest or even goshawk response has not yet been recorded. Future surveys should perhaps extend into adjacent areas with old forests farther north.

3.3.5 Millar's Pond

Although the Millar's Pond nest has not been active since 2017, it is still structurally sound. Surveys in 2023 again confirmed that nest was inactive, and again found no other evidence of goshawk activity in the area. There are nonetheless enough sightings of goshawks flying overheard in that vicinity each year to suggest there is another nest somewhere near Whistler Creekside, if not in the Millar's Pond forest itself.

3.3.6 Documented and Likely Nesting Areas

Last year's report (Snowline 2022) reported that the emerging pattern of goshawk nests closely matched the regular, 4- to 6-km grid spacing observed by Frank Doyle in the Skeena region.[9] This information, as well as habitat characteristics (mainly old forests) can be used to predict where additional but undetected nests could be found (Doyle et al. 2023).

There are now six activity areas with confirmed or strong evidence of recent activity (Figure 3-2). The newest record in the Emerald South area is slightly closer than predicted from Doyle's observations, since the closest known nest in Comfortably Numb is only three kilometres away. This Emerald South nest was clearly inactive for many years, and may predate nesting in Comfortably Numb, first documented in 2014. If so, then it would still fit Doyle's model. Or perhaps the fact that the two sites are separated by Green Lake reduces the minimum distance required by goshawks.

Based on Doyle's model and other habitat suitability predictors (elevation <1000m and presence of of old forest habitat), six additional areas are prime candidates for future surveys (Figure 3-2):

- Rainbow Falls (an area already surveyed twice; Brett 2020; Snowline 2021).
- Fitzsimmons Valley (which would be difficult but not impossibly to access for surveys).
- Cheakamus Valley.
- Jane Lakes.
- Lower Callaghan.
- The proposed Wildlife Habitat Area in the Callaghan. No records of previous detections in this area were found at the time of writing this report.

[9] *Frank Doyle webinar prepared for BC Government staff, May 10, 2022. Also see Doyle et al. (2023).*

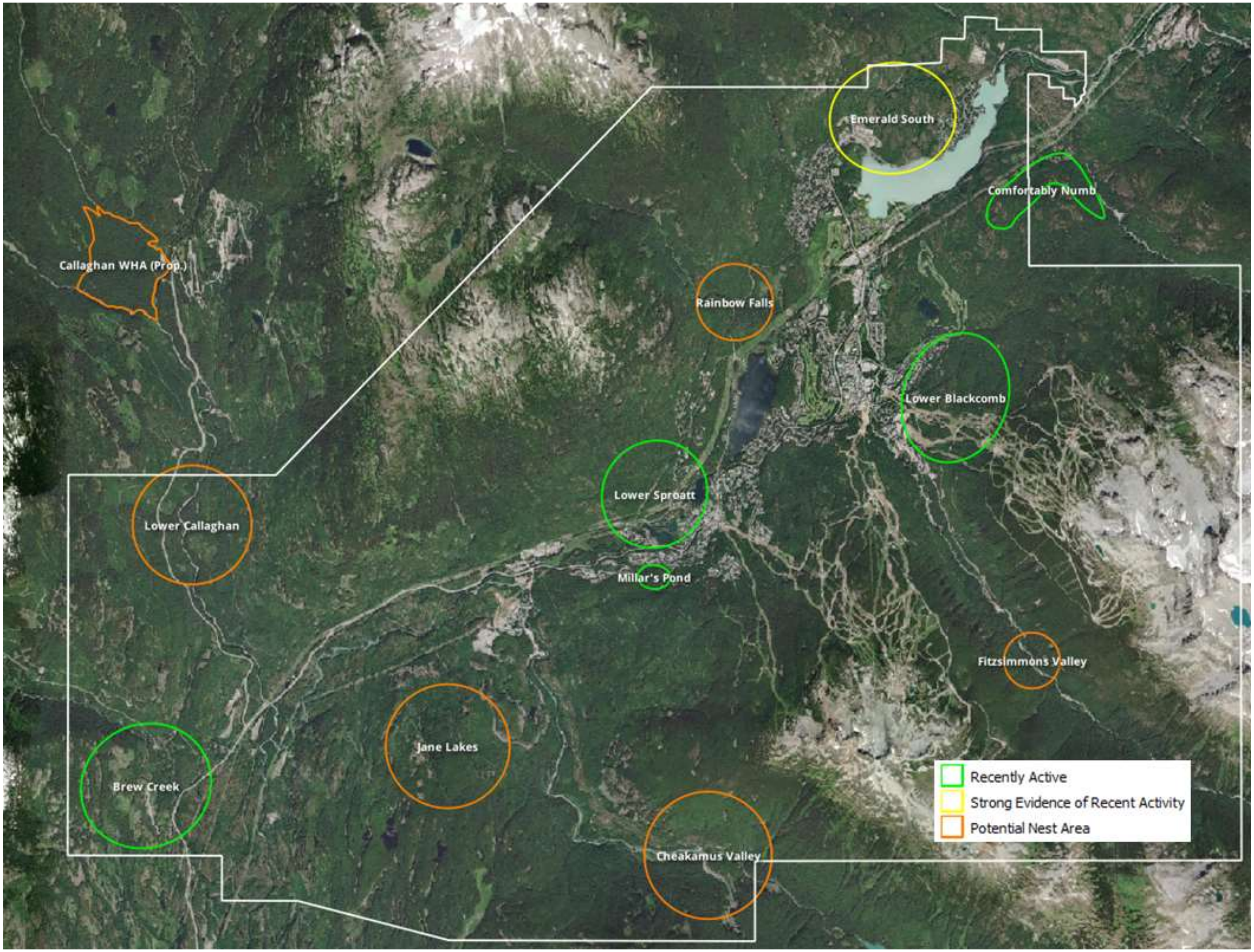

Figure 3-2. Northern Goshawk nesting areas.

4. Coastal Tailed Frogs

Key Takeaways

Stable: Whistler, Sproatt, and Van West Creeks	**Possibly Declining: Archibald Creek**

1. Coastal Tailed Frogs are commonly surveyed for monitoring programs since they require clean, cold streams and are sensitive to disturbances caused by logging and in-stream alterations. The 2023 survey was the 11h year of monitoring in a varying selection of 11 creeks.
2. For the first time, no tadpoles were detected at the lowest-elevation site in Archibald Creek, just upstream of Panorama Drive. Detections at the top of Fitzsimmons Chair, above the main concentration of bike trails, were meanwhile strong. While it is not possible to conclude with certainty that low detections are related to bike park activity or other human-caused impacts, the lack of tadpole detections is concerning. This creek will be included in 2024 surveys with the hope that tadpole detections rebound.
3. Tadpoles were detected for the first time in Blackcomb Creek and Nineteen Mile Creek. This result confirms eDNA results from 2022 and suggests that these creeks: (a) may have a lower density of tailed frogs than other creeks in the area; and, (b) that tailed frogs in them are mostly or entirely restricted to upper reaches.

4.1 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 includes aquatic and terrestrial habitats. These characteristics make them susceptible to perturbations in both habitat types and suitable as indicator species of ecosystem health.

Stream-dwelling amphibians such as 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,[10] long-lived, and maintain relatively stable populations. For these reasons, tailed frogs can be a useful indicator of stream condition (Welsh and Ollivier 1998).

Ideal habitats for tailed frogs are small, steep (usually >10% grade), 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

10 *Adults typically breed in the stream in which they hatched.*

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 so it is unsurprising tadpoles have been detected in most Whistler streams surveyed to date (Wind 2005-2009; Cascade 2014-2016; Palmer and Snowline 2017-2021; Snowline 2021-2022).

Prior to 2004, the only 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 built on that creek. In late 2004, the Whistler Biodiversity Project began the first valley-wide survey Since then, tadpoles have been found in over 40 local creeks (Wind 2005-2009; Brett 2007; Cascade 2013-2015; Palmer and Snowline 2017-2021; Snowline 2021-2022).

In 2017, Coastal Tailed Frogs were down-listed in BC from Blue (Special Concern) to Yellow ("least risk of being lost"), but still has some protection through its classification as Identified Wildlife under the Provincial Forest and Range Practices Act (CDC 2023). It remains a species of Special Concern under the Species at Risk Act (Government of Canada 2023) and was identified as a species of local concern by Brett (2018).

4.2 Methods

4.2.1 Site Selection

The selection of sites for tailed frog survey has been modified each year to maximize the ability to detect changes in stream habitats: (a) between years, and (b) between east and west sides of the valley. Since 2013, a total of 11 creeks have been surveyed for this program (Table 4-1). More sites have been surveyed on the east than west side of the valley for two main reasons: (a) the creeks on the east side of the valley tend to be easier to survey due to higher and more predictable flows; and, (b) they are generally in areas with more development and therefore more potential impacts to monitor.

Since 2016, the three reaches surveyed on each creek are chosen to represent (as much as topography and surveyability allows), three elevations:

1. The toe slope just above the valley bottom;
2. Mid-elevations at ca. 800 m; and
3. At approximately 1000m.

This elevational range is meant to include one site within the development footprint, one at its upper end, and a third above the development footprint (as a control), respectively.

The 2023 tadpole surveys were again led by Bob Brett with helpful assistance from RMOW Environmental Technician Rebecca Merenyi (RMOW), and conducted under BC Government Wildlife Permit SU23-797603.

Table 4-1. Coastal Tailed Frog sampling sites (Cascade 2016 to 2020; Palmer and Snowline 2017 to 2021; Snowline 2021 to 2022).

Creek	Valley Side	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total Sites	Survey Years
Alpha Creek	East	3	3	3	3								12	4
Archibald Creek	East		3	3	3	3	3	3	3	3	3	3	30	10
Blackcomb Creek	East							1	3	2	2	3	11	5
Horstman Creek	East					3							3	1
Whistler Creek	East				4	3	3	3	3	3	3	3	25	8
Agnew Creek	West					3	3						6	2
FJ West Creek	West						2	3	2				7	3
Nineteen Mile Cr.	West		2	2							3	4	11	4
Scotia Creek	West	3	3	3	3		1						13	5
Sproatt Creek	West						1	3	3	3	3	3	16	6
Van West Creek	West						2	2	3	3	2	2	14	6
	Total East	**3**	**6**	**6**	**10**	**9**	**6**	**7**	**9**	**8**	**8**	**9**	**81**	**11**
	Total East	**3**	**5**	**5**	**3**	**3**	**9**	**8**	**8**	**6**	**8**	**9**	**67**	**11**
	Grand Total	**6**	**11**	**11**	**13**	**12**	**15**	**15**	**17**	**14**	**16**	**18**	**148**	**11**

The inclusion of a similar number of east- and west-side creeks increases the geographic range of sampling. At least as importantly, the inclusion of sites on both sides of the valley means creeks with different hydrological regimes are represented -- most east-side creeks are glacier-fed while most west-side creeks are not. Creeks with a glacial source typically have higher and more sustained flows than those relying solely on snowmelt and rainwater. They are also more sensitive to climate change since glacier melt reduces the volume and timing of water flows.

A key goal of the 2023 sampling was to follow up on 2022 eDNA results from Blackcomb Creek and Nineteen Mile Creek (Snowline 2022). Environmental DNA (eDNA) is a method in which water samples are tested for genetic material from one or more target species.[11] It is especially useful when the goal is to determine if a species is present in a system that is difficult to survey and/or has a low population.

No tadpoles had been detected in Blackcomb or Nineteen Mile Creeks by previous surveys for the Whistler Biodiversity Project and this program (Brett 2007; Wind 2005-2009; Cascade 2014-2016; Palmer and Snowline 2016-2020; Snowline 2021-2022). The 2022 eDNA samples, however, provided strong evidence that tailed frogs actually did inhabit both creeks. Results for Blackcomb Creek were especially strong and were interpreted by Jared Hobbs (Snowline 2022) as indicative of near-certain presence. Results from Nineteen Mile Creek were much weaker, but still interpreted as indicative of likely presence by Jared.

The lack of tadpole detections and relatively weak eDNA signal from Blackcomb and Nineteen Mile Creek were consistent with the hypothesis that tailed frogs were farther upstream (thereby diluting eDNA samples). For that reason, 2023 sites on these two creeks were chosen to include higher elevations and tributaries of the main stems.

[11] *See Snowline (2022) for more details about the process.*

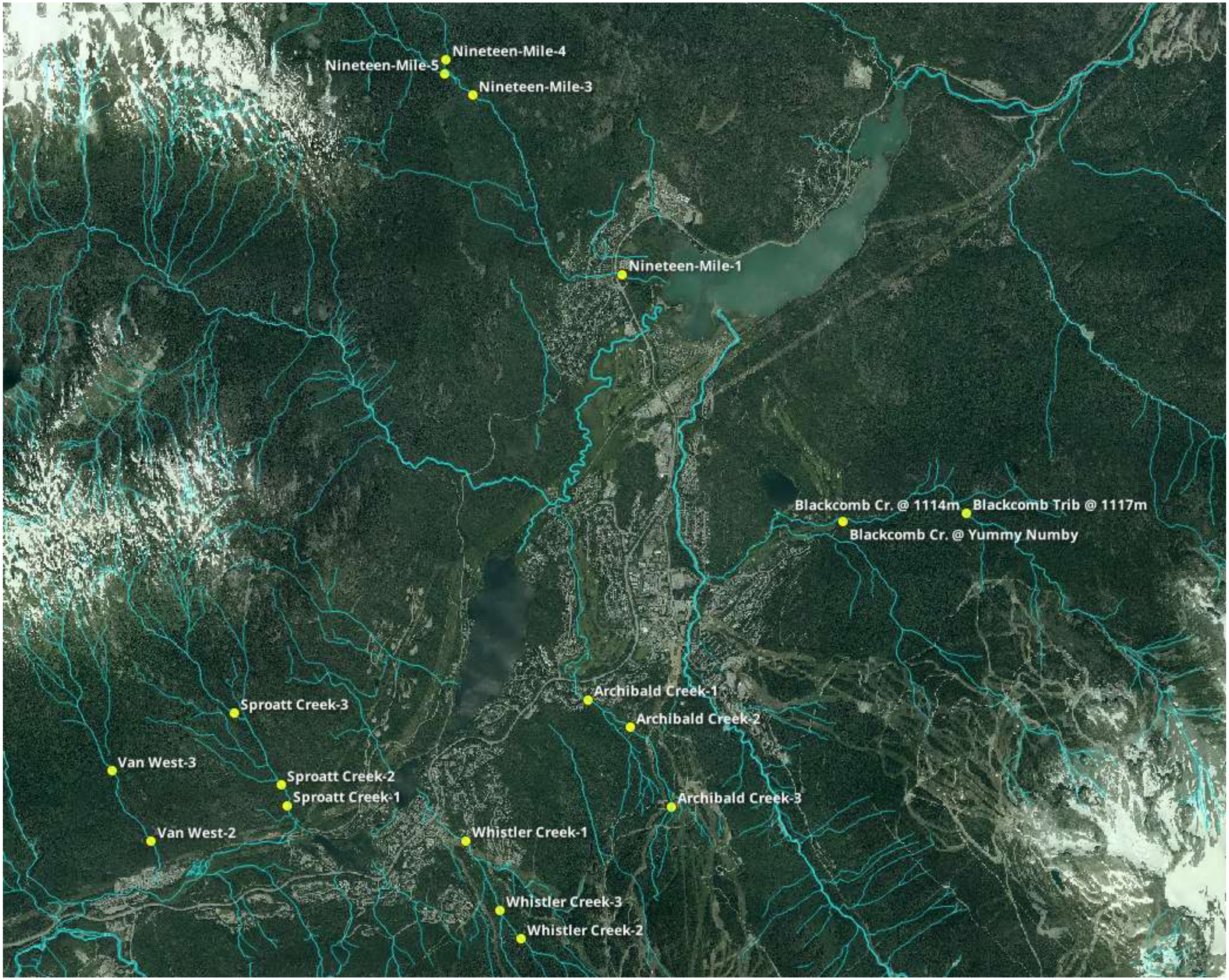

Figure 4-1.Tailed frog survey sites.

4.2.2 Sampling Design

Almost all previous surveys for tailed frog tadpoles in the RMOW study area by the Whistler Biodiversity Project (Brett 2007; Wind 2005-2009;) and this program (Palmer and Snowline 2017-2021; Snowline 2021-2022) have used the same time-constrained method. The only exception occurred in surveys from 2013 to 2015 which used area-constrained surveys (Cascade 2014-2016).

The BC Resource Inventory Committee (BC MELP 2000) originally recommended that area-constrained approach for measuring relative abundance. Based on this guidance, the 2013 to 2015 surveys sampled in fixed 5 m stream lengths for a total of 30 minutes (Cascade 2014-2016). Far fewer tadpoles were detected using this method compared to previous WBP surveys (Wind 2005-2009).[12] The return of surveys since 2016 to a time-constrained approach greatly increased detections (Palmer and Snowline 2017-2021; Snowline 2021-2022) and therefore statistical power (e.g., Malt et al. 2014a, 2014b).

In spite of their names, both methods are actually time-constrained, since both have a sampling time of 30 minutes. As a result, comparisons between years can be made, regardless of sampling method. It is also noteworthy that the total area surveyed at each site has been remarkably similar, regardless of method.

Data collection methods were otherwise the same for all tailed frog surveys since 2004 and followed recommendations of the BC Resource Inventory Committee (BC MELP 2000). The in-stream surveys consisted of overturning rocks and other unembedded cover objects with dipnets held immediately downstream to catch any dislodged animals (Photos 4-1 and 4-2). Rocks were also swept by hand to detect any clinging tailed frog tadpoles before being set back in their original positions, as were large anchored rocks and large woody debris.

Photo 4-1. Hillary Williamson from the RMOW Environmental Stewardship Department dipnetting for tadpoles in Whistler Creek (2019 photo).

Photo 4-2. Captured tadpoles are transferred to a bucket until they are measured, classified to cohort and development stage, then released upstream.

Data collected at each site included:

- Site characteristics including location, weather, overhead cover and stand type;
- Stream characteristics including morphology, substrate size/ shape, slope, and wetted width;

[12] *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.*

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

Data collected for tadpole captures also followed standard methods, including a measurement of total length for tadpoles and snout to ventral length for later stages. From 2013 to 2015[13] and again in 2016, tadpoles were classed into cohorts defined by Malt et al (2014a, b) which served as proxies for age classes (e.g., first year - T1; second year - T2, etc.) as follows:

- T0 (hatchling <15 mm);[14]
- T1 (tadpole, no visible hind legs);
- T2 (tadpole, hind legs with knees not extending beyond the anal fold (Photo 4-3);
- T3 (tadpole, conspicuous hind legs with knees that extend out from body (Photo 4-4); 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).

Doubts about this classification scheme emerged in 2016 regarding how accurately these classes acted as reliable proxies for age cohorts, especially across different streams (Palmer and Snowline 2017). The relationship between length and cohorts (as defined above) was weaker than expected; for example, many longer tadpoles were placed into early cohorts based on morphology, and vice-versa, Pre-survey tests in 2017 again showed overlaps between length and developmental stages within and between streams. These observations intensified questions about whether "cohorts" were reliable proxies for the number of years since hatching, especially between streams that have different growing conditions. This doubt was later strengthened by Pierre Friele[15] who emphasized that the link between developmental stage, length and age is even more tenuous when applied across large geographic gradients in which climate and water temperature regimes differ. As a result, surveys since 2017 measured the length of each tadpole and classified them by more detailed developmental stages as follows:

Table 4-2. Tadpole Developmental Stages and Classifications

Developmental Stage	Cohort (Malt 2014a,b)
DS0 – Hatchling <15 mm	T0
DS1 - No visible hind legs	T1
DS2 - Bulge only, hind legs not defined	
DS3 - Hind legs visible but covered	T2
DS4 - Hind feet protruding	
DS5 -Hind knees protruding outside body	T3

Note: No hatchlings (DS0, T0) have been observed in September surveys in Whistler.

[13] Candace Rose-Taylor, 2016 email to Bob Brett.
[14] No hatchlings have been reported to date in Whistler surveys conducted in late August and September.
[15] Pierre Friele email to B. Brett and follow-up phone conversation, December 2017.

Photo 4-3. Tadpole Cohort 2 (T2). This individual's developmental stage is transitional between developmental stages DS1 and DS2 2 and 3 (hind legs covered but just starting to be defined).

Photo 4-4. This tadpole's hind knees protrude outside its body and its legs are clearly free from previously enclosing skin. It is in Cohort T3 and its equivalent developmental stage DS5.

For consistency with past reports, the classes above were grouped according to Malt et al.'s (2014a, b) cohorts during data analysis. That is, Developmental Stages 1 and 2 (DS1 and DS2) were grouped into Malt's T1 cohort, and Developmental Stages 3 and 4 (DS3 and DS4) were grouped into Malts' T2 cohort. Future analyses may be able to use these detailed classifications to calibrate a reliable relationship between age and developmental stage in Whistler-area creeks. For the purposes of this report, most of the analysis and discussion is based on Malt et al.'s cohorts.

To prevent recaptures, all tadpoles were placed in buckets and released after measurements were complete (Photo 4-2; BC MELP 2000). 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). Surveys were scheduled for early September when low streamflows would increase the detectability of tadpoles.

4.2.3 Data Analysis

The total number of tadpoles detected at each site (reach) was compared to surveys since 2015 (the last year of the area-constrained approach). Results were also reported as detections per unit area (per 100 m^2) to permit comparisons between the 2015 area-constrained method and surveys conducted using the time-constrained method.

4.2.4 Quality Assurance/Quality Control

One challenge in monitoring tailed frog tadpoles is that some surveyors consistently detect more tadpoles than other surveys. If surveyors change, their different detection rates reduce the ability to detect true year-to-year changes in tadpole detections. To minimize this potential for surveyor effect, surveys since 2017 have therefore included at least two surveyors from the previous year. In addition, Special care was taken to ensure that cohort classes and developmental stages (see above) were recorded consistently, for example, through the use of photos of representative tadpoles in each class.

4.3 Results and Discussion

4.3.1 Study Sites

Eighteen sites were surveyed from September 4 to 7, 2023 (Table 4-3; Appendix C). In past years, water in east-side (cool-aspect) creeks was colder by approximately 1°C. In 2023, there was essentially no difference in averages between east- and west-side sites (9.9 and 9.8°C, respectively). The likely reason for this difference compared to past years was the addition of three higher-elevation sites on Nineteen-Mile Creek (Sites 3, 4, and 5).

Table 4-3. Coastal Tailed Frog sampling sites, 2023.

Valley Side	Site	Date	Survey-ors	Easting	Northing	Wea-ther	Elev. (m)	Air Temp. (°C)	Water Temp. (°C)	pH
East	Archibald Creek - 1	2023-09-04	BB, RM	502387	5550606	Sun	695	14.0	11.0	7.2
	Archibald Creek - 2	2023-09-04	BB, RM	502854	5550298	Mixed	835	11.0	10.0	6.8
	Archibald Creek - 3	2023-09-04	BB, RM	503310	5549422	Cloud	1026	11.0	10.0	6.8
	Blackcomb Cr. @ Yummy Numby	2023-09-04	BB, RM	505211	5552576	Cloud	762	15.0	10.0	6.8
	Blackcomb Cr. @ 1114m	2023-09-09	BB	506565	5552659	Sun	1114	17.0	8.5	6.8
	Blackcomb Trib @ 1117m	2023-09-09	BB	506565	5552659	Sun	1117	17.0	9.5	6.8
	Whistler Creek - 1	2023-09-04	BB, RM	501041	5549045	Sun	692	15.0	12.0	7.0
	Whistler Creek - 2	2023-09-06	BB, RM	501649	5547961	Rain	879	11.0	9.0	6.8
	Whistler Creek - 3	2023-09-06	BB, RM	501417	5548276	Cloud	972	10.0	9.0	6.8
West	Nineteen-Mile Creek-1	2023-09-07	BB, RM	502764	5555303	Mixed	648	13.0	10.0	6.8
	Nineteen-Mile Creek-3	2023-09-06	BB, RM	501114	5557282	Cloud	1095	11.0	8.0	6.8
	Nineteen-Mile Creek-4	2023-09-06	BB, RM	500822	5557676	Cloud	1115	10.0	8.0	6.8
	Nineteen-Mile Creek-5	2023-09-06	BB, RM	500808	5557519	Cloud	1111	13.9	9.0	6.8
	Sproatt Creek - 1 (Danimal South)	2023-09-05	BB, RM	499063	5549434	Mixed	692	15.0	11.0	6.5
	Sproatt Creek - 2 (Don't Look Back)	2023-09-05	BB, RM	498996	5549662	Cloud	790	15.0	11.0	6.8
	Sproatt Creek - 3 (Flank Trail)	2023-09-05	BB, RM	498483	5550455	Cloud	996	12.0	10.0	7.0
	Van West-2 (Flank Trail)	2023-09-05	BB, RM	497563	5549038	Cloud	706	12.0	11.0	6.8
	Van West-3 (Into the Mystic)	2023-09-05	BB, RM	497125	5549816	Cloud	1036	11.0	10.0	7.0
						East-side Average	899	13.4	9.9	6.9
						West-side Average	910	12.5	9.8	6.8
						Average (All Sites)	**905**	**13.0**	**9.8**	**6.8**

4.3.2 Tailed Frog Detections

Tadpole detections in 2023 were within the general range of surveys since 2016, with a total of 52 tadpoles detected at the 18 sites (Table 4-4; Appendix C). Although it may be reassuring that this total is similar to previous years (Figure 4-2), the aggregated data is not directly comparable since it comes from a different assemblage of creeks each year. Direct comparisons are therefore discussed by individual creeks below (Section 4.3.5).

There were two notable differences in survey results in 2023: (a) much greater presence of tailed frogs in the open in Scotia Creek; and (b) a high number of froglets on Whistler Creek. The two higher-elevation sites on Sproatt Creek (Sites 2 and 3) both had many tadpoles on top of rocks, and easily visible from streamside (Photos 4-5 and 4-6). Although this is not unprecedented, the typical behaviour of tadpoles is to forage on the undersurface of rocks where they are not visible to potential predators. The presence of so many tadpoles is probably indicative that the actual density of tailed frogs is higher (potentially much higher) than revealed by surveys using dipnets.

Photo 4-5. One of the many tailed frog tadpoles grazing in the open at Sproatt Creek Sites 2 and 3.

Photo 4-6. Close=up of one of the tadpoles in the open.

Another unusual observation in 2023 was the abundance of tiny tailed frog froglets at the two higher-elevation sites in Whistler Creek (Sites 2 and 3). It was not possible to count them within the constraints of the survey and because they were so cryptic, but it was clear there were many tailed frogs in that area that recently metamorphized.

Table 4-4. Tadpoles detected in 2023 by creek and cohort.

Valley Side	Site	Cohort T1	Cohort T2	Cohort T3	Total tadpoles	Meta-morphs /adults
East	Archibald Creek - 1	2	1	1	4	0
East	Archibald Creek - 2	1	0	2	3	0
East	Archibald Creek - 3	5	0	1	6	0
East	Blackcomb Cr. @ Lost Lake Rd.	0	0	0	0	0
East	Blackcomb Cr. @ Yummy Numby	0	0	0	0	0
East	Nineteen-Mile Creek-1	0	0	0	0	0
East	Nineteen-Mile Creek-2	0	0	0	0	0
East	Nineteen-Mile Creek-3	0	0	0	0	0
West	Sproatt Creek - 1 (Danimal South)	0	1	0	1	0
West	Sproatt Creek - 2 (Don't Look Back)	0	1	0	1	0
West	Sproatt Creek - 3 (Flank Trail)	1	6	1	8	0
West	Van West-2 (Flank Trail)	1	0	0	1	0
West	Van West-3 (Into the Mystic)	0	3	3	6	0
East	Whistler Creek - 1	0	5	1	6	0
East	Whistler Creek - 2	7	1	0	8	0
East	Whistler Creek - 3	5	3	0	8	0
	Total tadpoles	22	21	9	52	0
		42%	40%	17%	100%	

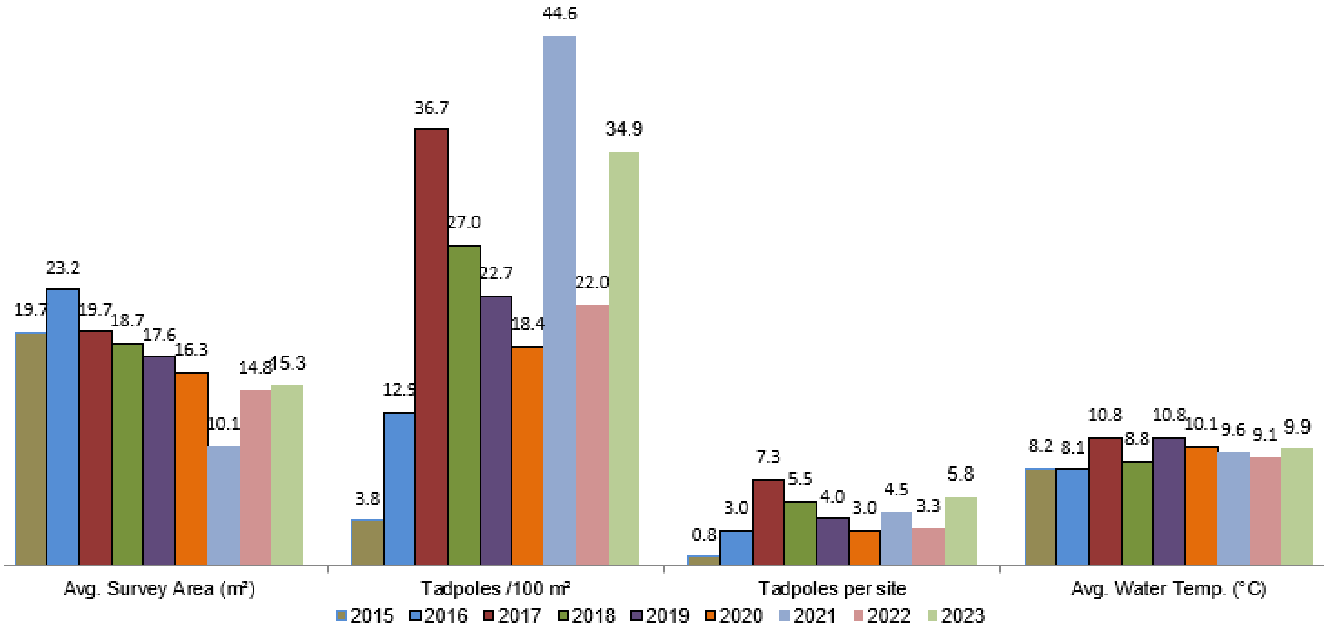

Figure 4-2. Average area, tadpoles per 100 m2, tadpoles per site, and average water temperature of Coastal Tailed Frog Surveys, 2015 to 2023.

4.3.3 Detections by Valley Side (East and West)

From 2016-2022, more than twice as many tadpoles have been detected per site on the east-side than on the west-side of Whistler Valley (Table 4-5). Glacier-fed creeks are predominantly on the east side of Whistler Valley where glacial run-off increases overall volume and provides more mid-summer flow than in creeks reliant solely on rainwater. Creeks on the east side of the valley are therefore more likely to be larger and, as found in these surveys, apparently have better habitat characteristics such as more cobbles, less embeddedness, and more riffles. These are preliminary conclusions that need to be further tested, especially since the predominance of detections from two creeks (Whistler and Archibald; Section 4.3.5) affect the totals so much.

Table 4-5. Tadpoles detected in east-side versus west-side creeks, 2016 to 2023.

Year(s)	Valley Side	T1/Site	T2/Site	T3/Site	Tadp. per Site	T1 (%)	Water Temp. (°C)
2023	East	3.1	1.0	0.1	4.2	74%	9.9
	West	5.0	1.4	1.0	7.4	67%	9.8
	East to West	62%	69%	11%	57%	110%	+0.1
2016 to 2022	East	3.8	1.1	1.1	6.0	63%	9.3
	West	1.3	0.9	0.6	2.7	47%	10.2
	East to West Ratio	296%	122%	202%	220%	135%	-0.9

Results from 2023, however, reversed the detection ratio seen from 2016-2022, with detections in west-side creeks almost double those in east-side creeks. It is important to note, however, that totals across all sites are not directly comparable given that sites are not consistent each year. See Section 4.3.5 for a discussion of individual creeks.

4.3.4 Detections by Cohort

Survivorship curves for all animal populations lead to the expectation that there will be fewer individuals at later ages/stages, and this has generally been the case for tailed frog surveys (Figures 4-3 and 4-4). Although any interpretations of these results must be tempered by the fact that detectability is not constant (that is, that weather and other contingencies are involved), it is reassuring that younger stage tadpoles continue to enter the population. In addition, a strong proportion of T3 tadpoles ensures a higher likelihood of new individuals surviving until metamorphosis and breeding ages.

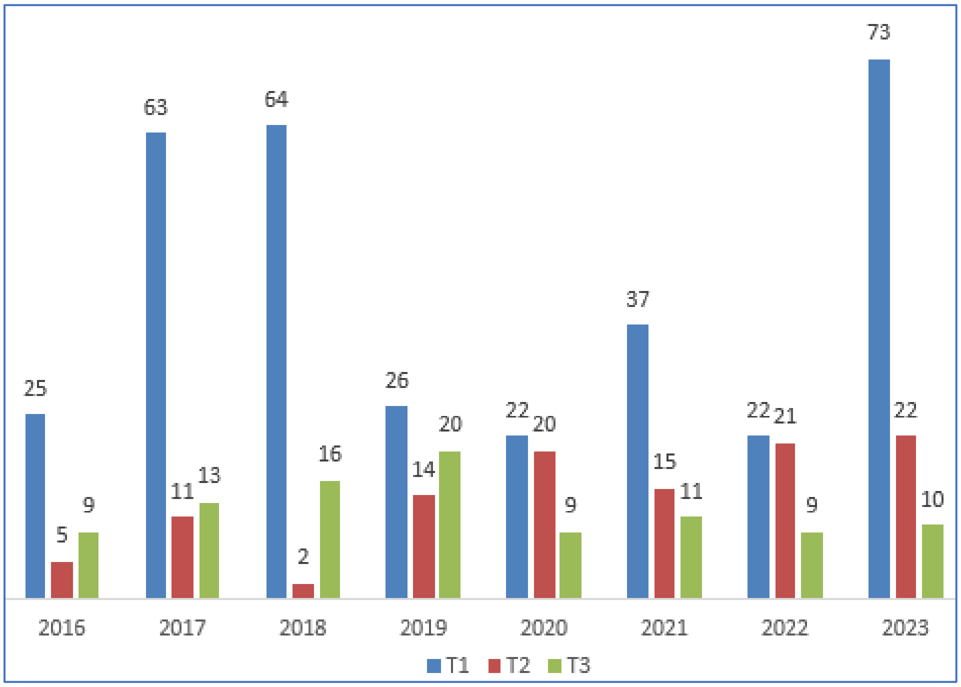

Figure 4-3. Number of tadpoles by cohort and year.

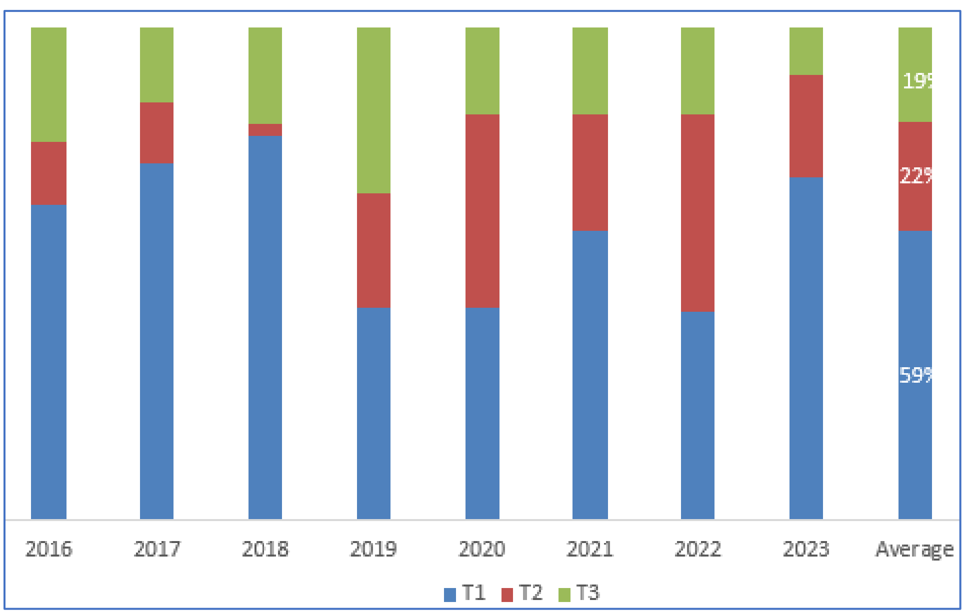

Figure 4-4. Percentage of tadpoles by cohort and year.

4.3.5 Tadpole Detections by Creek

Archibald Creek

Possibly Decreasing

Archibald Creek is one of only two systems surveyed in all six years since 2016 (Whistler Creek is the other). it is also one of two creeks, again with Whistler Creek, affected most directly by human activities since both are adjacent to the Whistler Bike Park. Results from Archibald Creek have been the most variable of any creek in the program, especially in 2016 and 2020 when detections were notably low (Figure 4-5). Although years of low detections are notable, the high variability across years has made it difficult to conclude any real changes to the population. Results from 2023 nonetheless again raise concerns that this population is not stable.

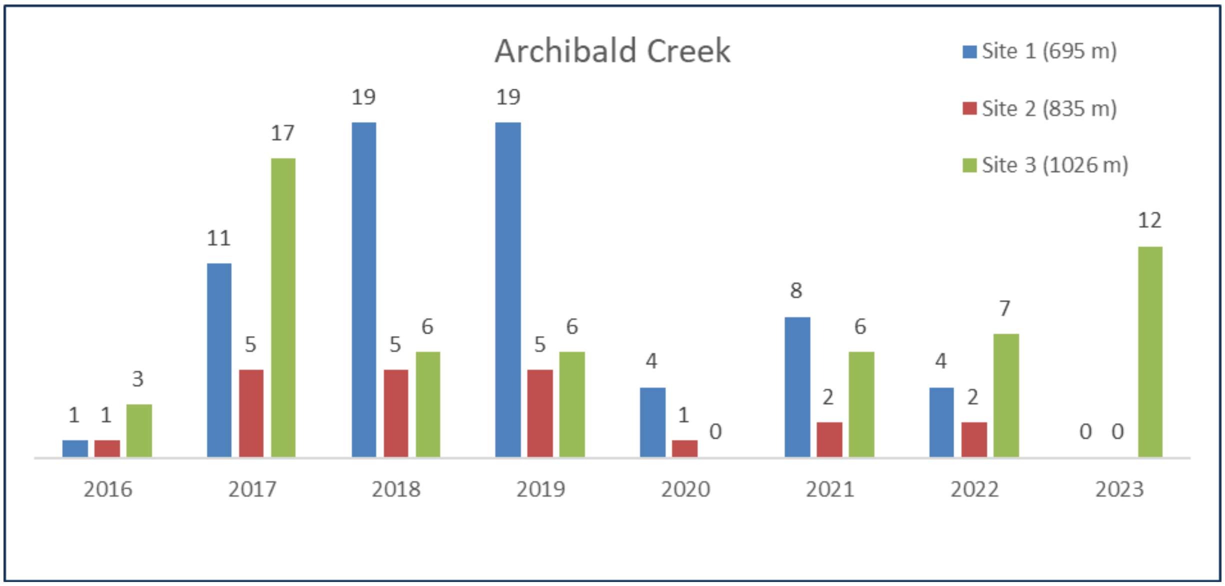

Figure 4-5. Tadpole detections in Archibald Creek by site, 2016-2023.

For the first time, no tadpoles were detected in 2023 at either of the lower-elevation sites (Sites 1 and 2). Given that some of the highest detections of all sites have been recorded in past years at Archibald Creek Site 1, the absence of any detections in 2023 is notable. In contrast, 2023 detections at Site 3 were the second highest on record. Site 3 is at the top of Fitzsimmons Chair and therefore above the main concentration of trails in the Whistler Bike Park. It could therefore be assumed that it is impacted the least by biking activities, e.g., deposition of fines due to erosion.

These divergent results may indicate that: (a) there is a stable population of tailed frogs above the main concentration of bike trails; and (b) tailed frogs may be negatively impacted by the Bike Park within the main concentration of bike trails. If results in 2024 show a similar lack of detections at Sites 1 and 2, it will strengthen this hypothesis.

Blackcomb Creek

Inconclusive (Data deficient)

Blackcomb Creek is a cold, turbid steam that drains the shrinking Blackcomb Glacier. No tadpoles had been detected in multiple surveys since 2006. To help assess the potential of a tailed frog population in this creek, eDNA sampling was conducted in 2022 (Section 4.2.1; Snowline 2022), Results from the eDNA sampling showed that tailed frogs were almost certainly present, in spite of the lack of tadpole detections.

In 2023, two high-elevation sites near 1114 m were added, one in the main stem of Blackcomb Creek (Photo 4-7) and one in an adjacent, very small tributary (Figure 4-8). In spite of the apparent lack of habitat in that tributary (due to low water), a total of seven tadpoles were detected. An eight tadpole was detected while sampling the stie in the main stem, but since it was within approximately one metre of the junction with that tributary, it was almost certainly part of that sub-population.

These detections confirm 2022 eDNA sampling results. They also demonstrate that very small creeks can be important to tailed frogs and, for Blackcomb Creek, may be the main locations for them. Given the difficulty in detecting tailed frogs in Blackcomb Creek, it is not possible to comment on population trends.

Photo 4-7. Blackcomb Creek @ 1114 m. This is the main stem of the creek.

Photo 4-8. Blackcomb Tributary @ 1117. This is a small tributary of Blackcomb Creek.

Nineteen Mile Creek

Inconclusive (Data deficient)

Similar to Blackcomb Creek, no tadpoles had been detected in many previous surveys on Nineteen-Mile Creek. It was also sampled for eDNA in 2022, but returned a much less conclusive result. In spite of a very weak signal, Jared Hobbs was confident enough in the methodology (particularly related to the distinct DNA of tailed frogs relative to many other amphibians) that he concluded tailed frogs were indeed present in Nineteen Mile Creek (Snowline 2022). Surveys in 2023 proved Jared correct.

Nineteen Mile Creek is difficult to survey due steep cascades and ravines on most of its middle sections. The first site above Alpine Meadows subdivision that is easily accessible is at the Flank Trail bridge at an elevation of 1095 m (Site 3). It was sampled in 2022 and no tadpoles were detected in spite of excellent habitat (Photo 4-9). Resampling in 2023 detected the first tadpole in Blackcomb Creek. Two more tadpoles were then found in one of the two new sites just uphill (Site 4; Photo 4-10).

These results lead to similar conclusions as for Blackcomb Creek. That is, that a population of tailed frogs can exist throughout a stream system or, in the case of Nineteen Mile and Blackcomb Creeks, possibly only in upper reaches. Given that possibility, these creeks are not high priorities for future monitoring since (a) tadpole detectability is low, at least partially due to low population density; and (b) the majority of their tailed frog populations appears to be uphill of the development footprint.

Photo 4-9. Nineteen Mile Site 3. Note the Flank Trail bridge in the mid background.

Photo 4-10. Nineteen Mile Site 4.

Sproatt Creek

Stable [possible increase]

Sproatt Creek was added to the program in 2018, the first year after major scouring occurred on this and many neighbouring creeks during a fall 2017 flood. Only one site was surveyed that year, near Into the Mystery bike trail (996 m). Two lower-elevation sites were added in 2019. Detections remained mostly consistent through last year, but increased markedly in 2023 (Figure 4-6).

Detections in 2023 were the highest yet (Figure 4-6), mainly due to all the tadpoles visible from streamside (Photos 4-5 and 4-6). It was also the only creek in which a juvenile frog was detected. It is difficult to interpret these results and whether or not they indicate a true increase in tadpoles at the two sites. That is, were there actually more tadpoles, or were there just more visible in the open instead of hidden under rocks (as more usual)? For now, it is safe to conclude the population is at least stable, and is possibly increasing.

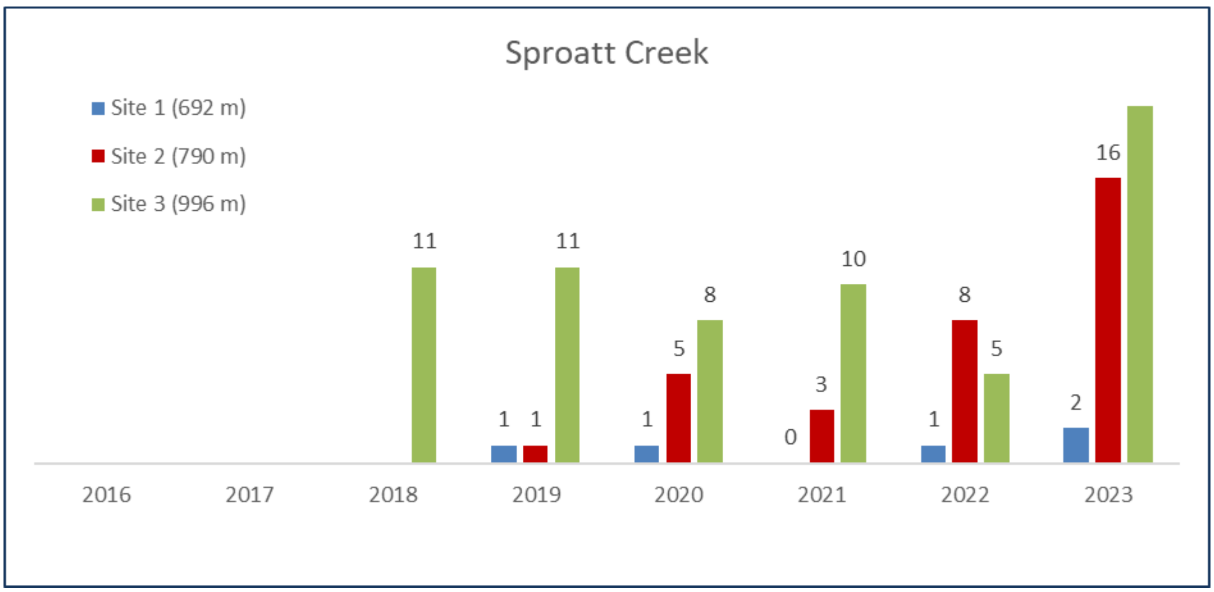

Figure 4-6 Tadpole detections in Sproatt Creek by site, 2018-2023 (only Site 3 surveyed in 2018).

Van West Creek

Stable

Like many other creeks in the program, the uppermost site on Van West Creek is surrounded by old forest, while the lower, logged sites have varying levels of in-stream disturbance. The highest site (Site 3) on Van West provides ideal habitat for tailed frogs (Photo 4-11), so it is not surprising detections are consistently high (Figure 4-7). Site 2, meanwhile, includes poor habitat conditions for tailed frogs as a result of extensive logging disturbance (Photo 4-12). Only four tadpoles have been detected at Site 2 since 2018. Site 3 is in Function Junction and not surveyable since 2021 due to low water. No tadpoles have yet been detected in the disturbed habitat at Site 1, though small salmonids have been found (Snowline 2021).

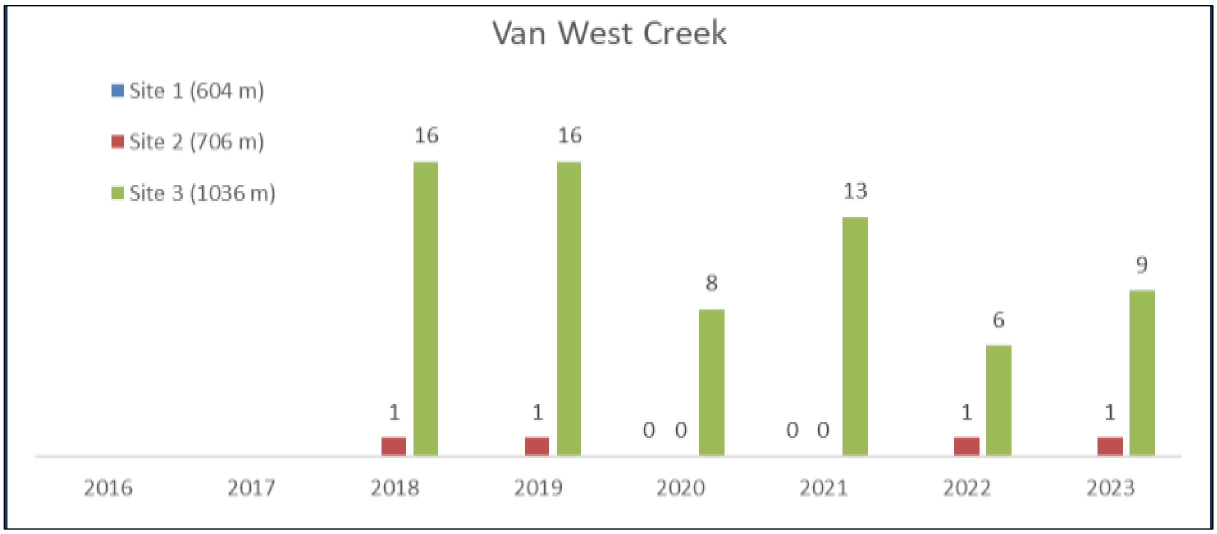

Figure 4-7. Tadpole detections in Van West Creek by site since 2018.

Photo 4-11. Van West Creek-3 is below the bridge near Into the Mystic trail (2021 photo).

Photo 4-12. Logging debris in Van West Creek-2 (2020 photo).

Whistler Creek

Stable

Since being added to the program in 2016, more tadpoles have been detected in Whistler Creek than any other, and year-to-year variability has been lowest (Figure 4-8). Habitat on this creek and its tributaries is mostly unaltered and the watershed probably supports a higher tailed frog population than any other sampled in the greater Whistler area. One of the main reasons to resurvey Whistler Creek in 2016 was to measure possible impacts of the Whistler Bike Park, which started expanding into the watershed at that time. With the exception of unusually high detections at Site 2 in 2017, detections have remained consistent for the eight years of surveys.

As mentioned above (Section 4.3.2), numerous froglets were observed at the stream edge at Sites 2 and 3. Given their size (<2 cm), they had only recently metamorphized. Froglets have only rarely been reported in past surveys so it is not possible to draw conclusions about their significance other than that they are a positive sign that tailed frogs at these sites are surviving into later life stages and, hopefully, eventually contribute to the breeding population.

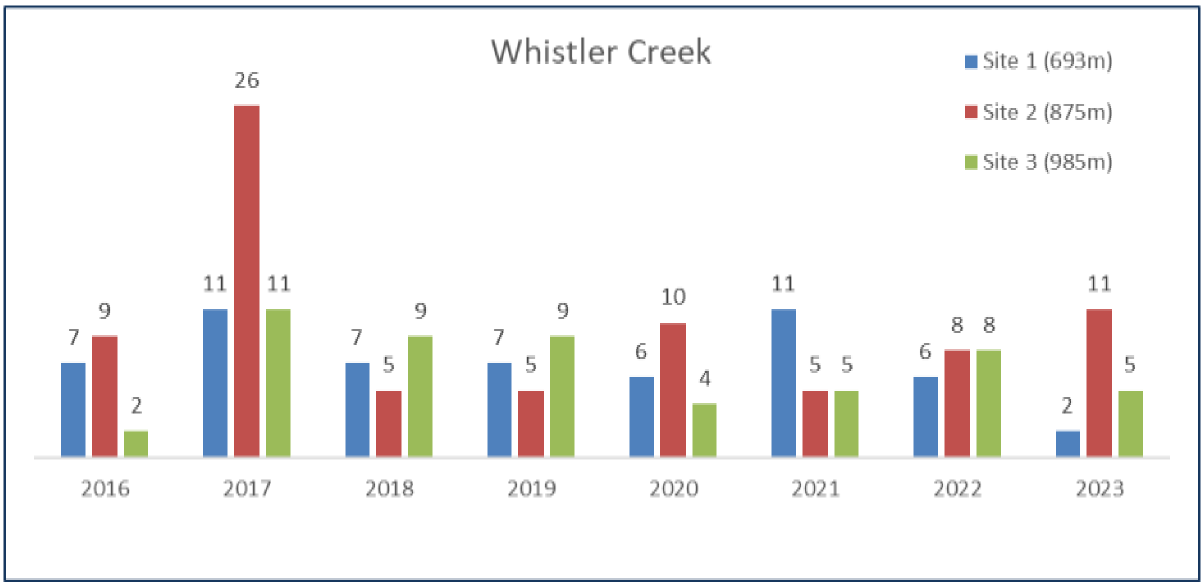

Figure 4-8. Tadpole detections in Whistler Creek by site since 2016.

5. Western Toads and Red-legged Frogs

Key Takeaways

Inconclusive (Data deficient)

1. Western Toads and Red-legged Frogs are wetland species of conservation concern, but their breeding sites are not well-known. The only confirmed breeding site for Western Toads within the RMOW is at Lost Lake. In 2022, a second site was confirmed in the Whistler Olympic Park. The only known breeding site for Red-legged Frogs is in the basalt ponds in Brandywine Falls Provincial Park. Finding additional breeding sites is a goal of this program.
2. A total of 10 ponds were surveyed in spring for egg masses, and traps were set in four ponds in July. Western Toad eggs were again found in the Whistler Olympic Park, but no other breeding sites for either Western Toads of Red-legged Frogs were found.
3. It is still likely there are other breeding sites for Western Toads and Red-legged Frogs south of Function Junction and within the RMOW boundary. Until all possible sites are surveyed in that area (ideally by the end of 2026), there is not enough information to detect any trends.

5.1 Introduction

In spite of occasional sightings in most parts of the RMOW, the only known annual breeding site for Western Toads (*Anaxyrus boreas*) within Whistler is at Lost Lake. A second site was confirmed in 2022 in the Whistler Olympic Park in Callaghan Valley but outside RMOW boundaries (Snowline 2022). Past surveys by the Whistler Biodiversity Project (Brett 2007; Wind 2005-2009) recorded breeding sites at Cheakamus Crossing, Eva Lake, and the Brandywine snowmobile parking area. Breeding since then has not been recorded since at any of these sites. Western Toads are ranked as Special Concern by the Federal Government (Government of Canada 2023), though no longer considered at-risk in BC (CDC 2023). The main threats to Western Toads is urbanization which causes the loss of breeding and non-breeding habitat.

Red-legged Frogs are ranked as Blue-listed and Identified Wildlife in BC (CDC 2023), and ranked as Special Concern by the Federal Government (Government of Canada 2023). The Whistler Biodiversity Project first found a breeding site in 2006 (Brett 2007), inside what became the northward expansion of Brandywine Falls Provincial Park. Although they have been recorded in the lower Callaghan Valley by BioBlitz scientists, Leslie Anthony, and Elizabeth Barrett since then,[16] no other breeding sites have yet been documented.

The goal for the current three-year cycle of this program (2022-2024) is to look for breeding sites of either species south of Function Junction, a large and mostly unexplored area includes suitable habitat for both species.

[16] *Personal communication on various dates with Bob Brett.*

5.2 Methods

Pond surveys consisted of egg mass surveys in spring and trapping in early July. Egg mass surveys were conducted at nine lower-elevation sites on May 14 and 15, 2023 and at the higher-elevation site in the Callaghan on June 4 (Figures 5-1 and 5-2; Table 5-1). Kristina Swerhun, who first observed toad breeding at the Callaghan site in 2022 assisted the egg survey at that site. Trapping included four sites where traps were placed in the evening on July 2 and retrieved in the morning of July 3. Trapping was conducted by Bob Brett under BC Government Wildlife Permit SU23-797603.

Egg surveys consisted of shoreline searches for egg masses. July trapping used standard minnow traps (Photo 5-1) that were placed at the edge of target ponds in the evening and retrieved the next morning (Photo 5-2). Care was taken to ensure a part of the trap was out of the water in case air-breathing animals were trapped. Once retrieved, amphibians were identified and measured, and aquatic invertebrates were recorded to the lowest possible taxonomic level. To prevent contamination between ponds, traps were sterilized in mild bleach and left to dry in the sun before and after trapping.

Table 5-1. Pond amphibian survey sites.

Location	Date	Easting	Northing	Elev (m)	Water (°C)	Air (°C)	Survey	#traps	Detect-ions?
Callaghan FSR Pond 3	2023-05-14	492857	5546552	527	NR	30	egg mass	n/a	AMMA
Callaghan FSR Pond 2	2023-05-14	492798	5546507	527	NR	30			No
Hwy 99 Callaghan North Pond	2023-05-14	492947	5546215	508	NR	30			No
Hwy 99 Callaghan South Pond	2023-05-14	492818	5546057	508	NR	30			No
Callaghan Road Pond 2	2023-05-14	492258	5546198	533	NR	30			No
Callaghan Road Pond 1	2023-05-14	492274	5545819	519	NR	30			n/a
Hwy 99 Brandywine Pond	2023-05-14	492046	5545222	499	NR	30			No
McGuire Pond	2023-05-15	492188	5545136	497	NR	29			No
Train Wreck South Pond	2023-05-15	495081	5547516	554	NR	29			No
Callaghan Valley, W. Olympic Park	2023-06-04	491266	5555826	900	NR	NR			ANBO, PSRE
Callaghan FSR Pond 2	2023-07-02	492798	5546507	527	14	14	tadpole	4	AMGR
Hwy 99 Callaghan South Pond	2023-07-02	492818	5546057	508	16	20		4	AMGR
Hwy 99 Brandywine Pond	2023-07-02	492046	5545222	499	18	17		4	AMGR
McGuire Pond	2023-07-02	492188	5545136	497	20	24		2	No

Photo 5-1. A minnow trap set at the Hwy 99 Brandywine Pond.

Photo 5-2. Retrieving and checking an amphibian trap.

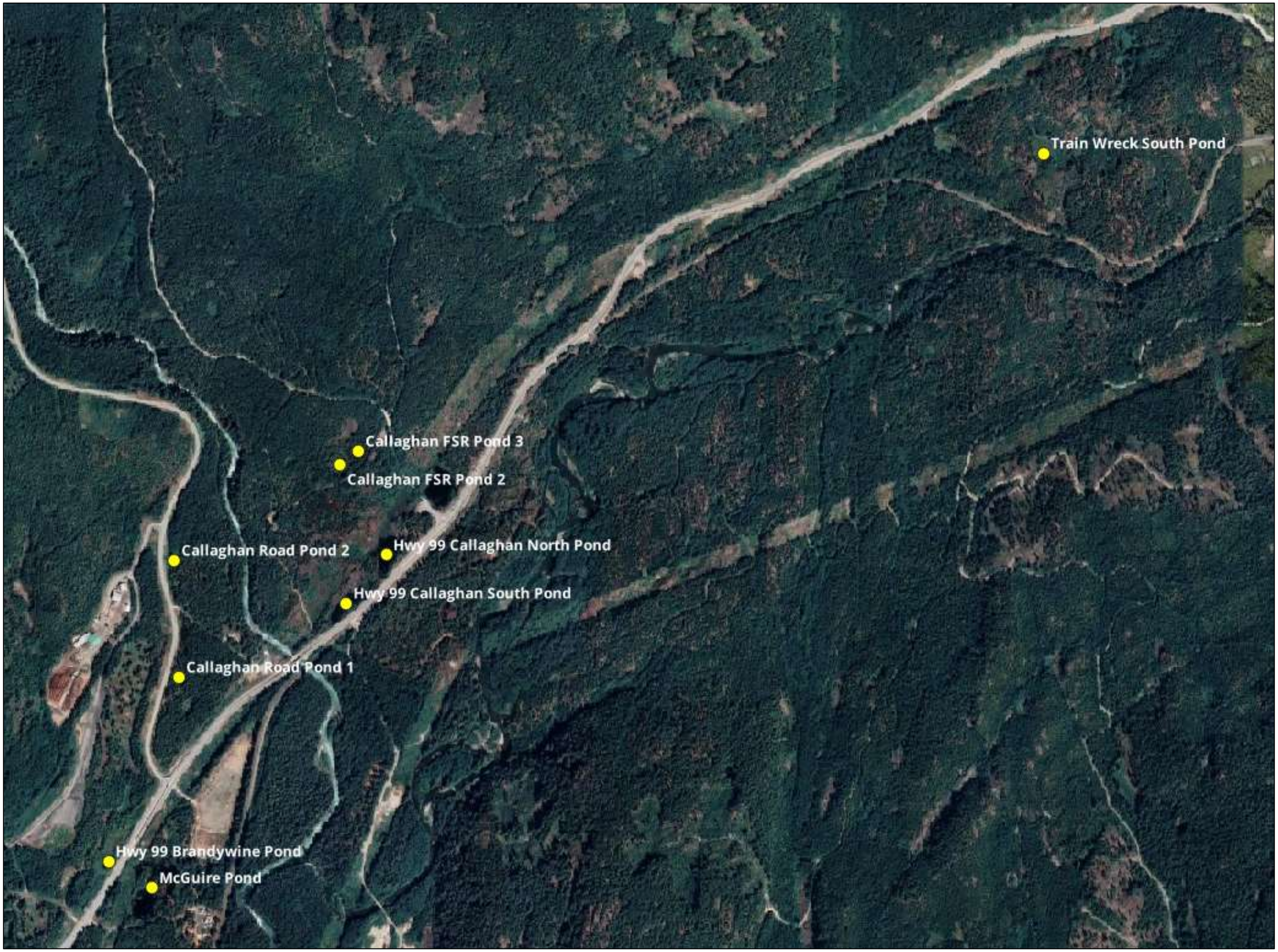

Figure 5-1. Pond amphibian survey sites (low elevation).

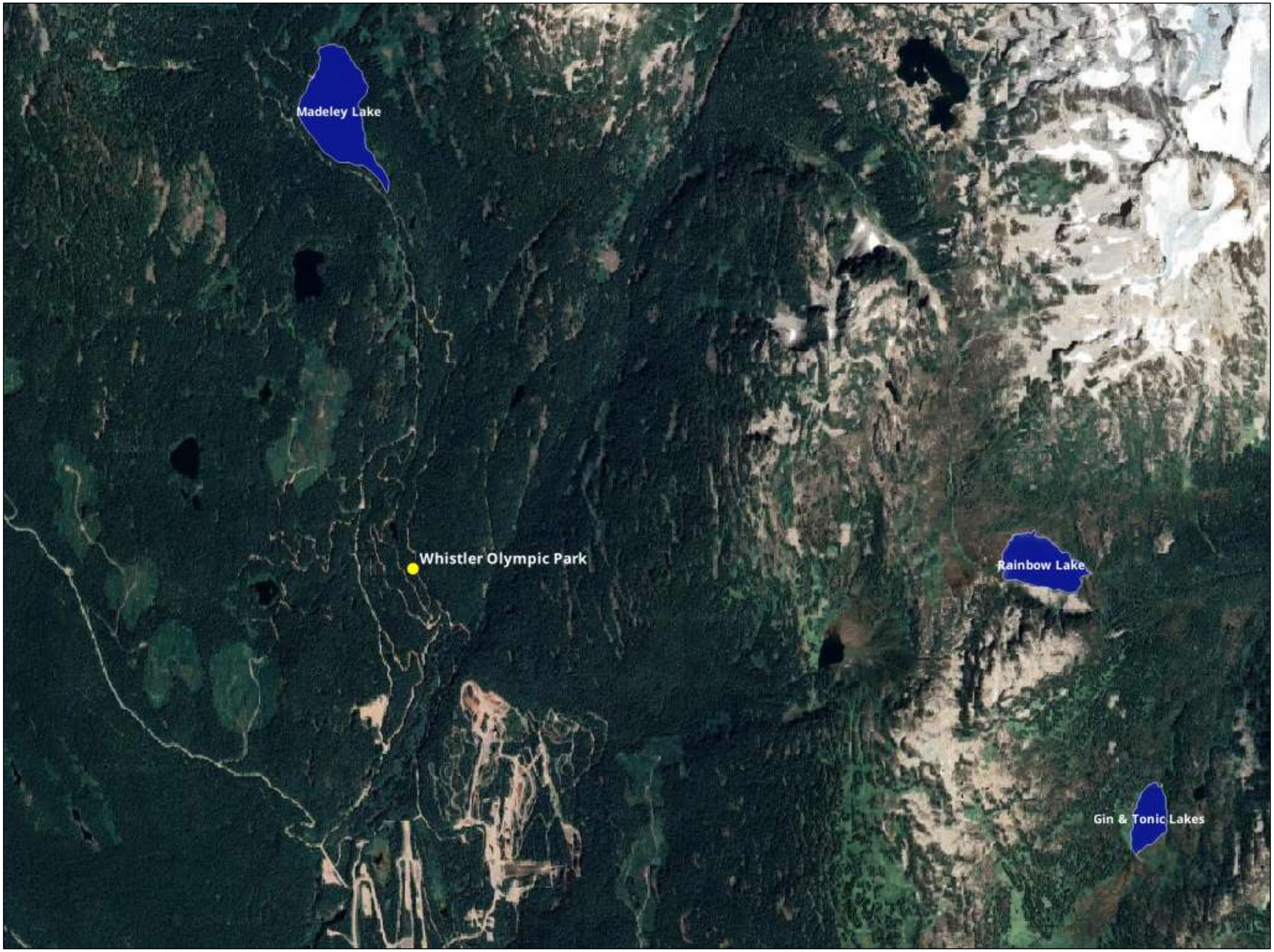

Figure 5-2. Pond amphibian survey site in Whistler Olympic Park, Callaghan Valley.

5.3 Results and Discussion

5.3.1 Egg Mass Surveys (Spring)

Egg masses were detected at two of nine sites (Table 5-1). There were at least four aggregations of Long-toed Salamander (*Ambystoma macrodactylum*) egg masses at Callaghan FSR Pond 3, most of which were hatched out. At the Whistler Olympic Park site (Photo 5-3), there were many egg masses of both Western Toads (Photo 5-4) and Pacific Treefrog (*Pseudacris regilla*).

Photo 5-3. Western Toad breeding pond in the Whistler Olympic Park, Callaghan Valley. This pond is south of Lunch Lake.

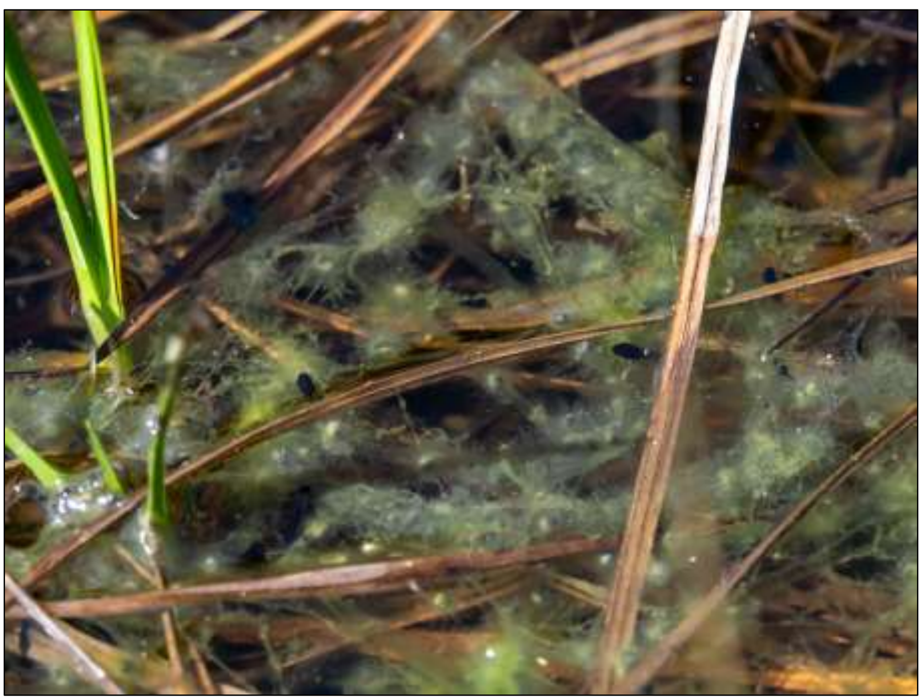

Photo 5-4. Western Toad egg masses with tadpoles at the Whistler Olympic Park pond.

5.3.2 Pond Trapping (July)

No Western Toads or Red-legged Frogs were detected during July trapping (Table 5-2). Consistent with results from pond surveys during the Whistler Biodiversity Project, Northwestern Salamanders (*Ambystoma gracile*) were the most common species and were recorded in 8 of 14 ponds. Pacific treefrogs, found in two ponds, were the only other species found in the traps. The Callaghan FSR Pond 2 had the most amphibians (Photo 5-5). No amphibians were trapped at McGuire Pond (Photo 5-6).

Table 5-2: Pond trapping results.

	Callaghan FSR Pond 2				Hwy 99 Callaghan South Pond				Hwy 99 Brandywine Pond				McGuire Pond	
Amphibian Species	**Trap 1**	**Trap 2**	**Trap 3**	**Trap 4**	**Trap 1**	**Trap 2**	**Trap 3**	**Trap 4**	**Trap 1**	**Trap 2**	**Trap 3**	**Trap 4**	**Trap 1**	**Trap 2**
NW Salamander		2	1	2	1	1	2		1			5		
Pacific Treefrog			1	1										
Long-toed Salamander														
Ambystoma sp.														
Western Toad														
Rough-skinned Newt														
Red-legged Frog														
	0	**2**	**2**	**3**	**1**	**1**	**2**	**0**	**1**	**0**	**0**	**5**	**0**	**0**
<u>Total Length (mm)</u>														
NW Salamander		115	160	150	78	95	75		73			75		
		95		150			130					75		
												75		
												75		
												75		

Photo 5-5. Callaghan FSR Pond 2.

Photo 5-6. McGuire Pond.

6. Benthic Invertebrates

Key Takeaways

Stable (to possible improvement)

1. Taxonomic richness and overall quality of the benthic communities improved at all sites since the 2022 sampling program, which was possibly an outlier year impacted by a relatively cold and wet spring/early summer.
2. Overall Taxonomic Richness is generally declining or stable since 2016, and benthic invertebrate communities are generally Mildly Divergent or in Reference Conditions with some moderate variability year over year.
3. The (upper) River of Golden Dreams has never achieved "Reference Conditions" since 2016 while the (lower) sampling sites almost consistently did (except in 2022). Both sampling sites, however, appear to show a decreasing trend in total taxonomic richness, since 2018 especially. Recreational use of this watercourse may disturb the streambed and associated invertebrate communities.
4. The improvement in benthic invertebrate communities observed on Jordan Creek, as compared with 2020 and 2021 especially, was confirmed again this year.
5. Despite some variability in taxonomic richness, Twenty-one Mile Creek generally remained "Mildly Divergent from Reference Conditions" over the past 6 years, showing some relative stability in the core invertebrate communities (i.e., expected to be present) and a slight, yet consistent, degradation of water and/or habitat quality.
6. Crabapple Creek has typically achieved "Refence Condition", except in 2020 and 2022 (Mildly Divergent), despite a constant decrease in the total number of families.
7. The taxonomic richness on Whistler Creek showed a substantial increase since 2022 with an additional 15 taxa, resulting in "Reference Conditions" for this site. The 2022 program was, however, a possible outlier year in terms of weather and stream conditions, plus it was the first year Whistler Creek was sampled. likely explaining this difference in benthic communities.
8. Nutrient and fecal coliform analyzes are recommended to be conducted on Crabapple Creek and the two River of Golden Dreams sites to assess potential water quality degradation beyond in situ parameters.
9. The Twenty-one Mile Creek benthic invertebrate sampling site is recommended to be moved outside (upstream) of the powerline right-of-way to eliminate potential impact associated with lower canopy coverage and regular vegetation maintenance in the area.

6.1 Introduction

Benthic invertebrates are an important component of freshwater ecosystems. They are a food source for fish, amphibians, and birds. They play a major role in the decomposition of organic material and, therefore, affect nutrient availability and plant productivity in the water. Aquatic insects have a wide range of water quality tolerances and requirements, and exist within a wide variety of environments. Aquatic invertebrates have long been used as an indicator of water quality and aquatic health. Their benefits as bioindicators include their relatively restricted range during the aquatic lifetime, the short length of their life span (from a few months to several years) and their varied requirements for water quality. Undisturbed aquatic systems generally have high insect species richness with elevated densities of species sensitive to habitat and water quality alterations from anthropogenic disturbance. Conversely, disturbed streams generally have comparatively lower species richness with elevated densities of species more tolerant to pollution and/or low habitat complexity and quality. Cold, fast flowing watercourses may have limited species richness, but a higher proportion of species sensitive to disturbance of habitat or water quality, including changes in water temperature (stenothermic species).

In BC, benthic invertebrate samples are typically analyzed with set protocols, such as the Canadian Aquatic Biomonitoring Network (CABIN) or the Benthic Index of Biotic Integrity (B-IBI), in conjunction with water quality results. The health of benthic invertebrate communities has been monitored by this program since 2016 using the CABIN protocol with taxonomic identification to the family level in 2016-17 and to the lowest possible taxonomic level thereafter.

6.2 Methods

6.2.1 The CABIN Protocol

The Canadian Aquatic Biomonitoring Network (CABIN) is an aquatic biological monitoring program for assessing the health of freshwater ecosystems in Canada. CABIN is based on the network of networks approach that promotes inter-agency collaboration and data sharing to achieve consistent and comparable reporting on freshwater quality and aquatic ecosystem conditions in Canada. The program is maintained by Environment Canada to support the collection, assessment, reporting and distribution of biological monitoring information. CABIN allows partners to take their observations and make a formalized scientific assessment using nationally comparable standards.

The CABIN program primarily uses the Reference Condition Approach (RCA; Bailey et al., 2004) for evaluating whether a test site is in Reference Condition, and if not, then determine how divergent it is from Reference Condition. Reference sites are considered to be minimally affected by human activity. These sites provide the basis on which to compare the health of any given test sites. This approach relies on the establishment of a large database of biological and habitat data from a wide range of reference sites. The wide range of reference sites provides the data to develop empirical models that explain the variability among the different benthic communities based on environmental characteristics (e.g., location, hydrology, substrate, bedrock geology, and climate).

An empirical Model (see Section 6.2.5), typically at a watershed scale (e.g., Fraser River, Skagit River, etc.), subsequently predicts the benthic community that should be observed at a test site if that site was in '*Reference Condition.*' The further the test site is from the predicted group of reference sites, the more different it is. The assumption of RCA is that if a site is different from what is expected, there must be some anthropogenic stress exerted on the benthic community.

6.2.2 Benthic Invertebrate Sample Collection

The macro-invertebrate sample collection was performed at 6 sites over a two-day period between July 28th and 29th (Table 6 1 and Figure 6 1), in accordance with the CABIN Field Manual (Environment Canada, 2012) by Jason Macnair, CABIN-certified for field sampling, and assisted by Bob Brett (Snowline) and Rebecca Merenyi (RMOW).

Table 6-1. 2023 Benthic Invertebrate Sampling Locations and Dates.

Site	UTM Location (Zone 10)		Aquatic Site ID	Access (Bridge Crossing)	Date Sampled
	Easting	Northing			
Twenty-one Mile Creek	501910	5552856	21M-DS-AQ21	Lorimer Road	July 28, 2023
Crabapple Creek	502030	5552670	CRB-DS-AQ01	Lorimer Road	July 28, 2023
Jordan Creek	500242	5549278	JOR-DS-AQ31	Lake Placid Road	July 29, 2023
River of Golden Dreams (Upper)	502066	5552829	RGD-US-AQ11	Lorimer Road	July 28, 2023
River of Golden Dreams (Lower)	503035	5554687	RGD-DS-AQ12	Via Golden Bear Place	July 28, 2023
Whistler Creek	500534	5549592	WHI-DS-AQ01	Lake Placid Road	July 29, 2023

Samples were collected using a 400µm kick-net over a period of exactly three minutes to standardize the level of effort. Sampling was initiated at the downstream end of the study area and moved upstream to avoid potential contamination of the lower sites when invertebrates are dislodged during sampling. A zigzag sampling pattern across the stream is used to integrate benthic macro-invertebrates from various stream microhabitats within the erosional zone in proportion to their occurrence in a sample reach. Sampling also included stream habitats directly adjacent to the stream bank to include microhabitats such as leaf litter that support a unique fauna. Each sampling kick area and path was pre-defined before entering the creek, and targeted riffle habitats with cobble/gravel substrate.

The content of the kicknet was emptied into a 400µm sieve before being transferred into a 500mL plastic jar. Each sample was preserved in the field by addition of an 85% ethyl alcohol solution. Care was taken to remove as much creek water as possible to avoid preservative dilution. In some cases, the 'bucket-swirling' method, as described in the CABIN Field Manual, was used to remove excess sand from the sample before preservation. Bucket swirling, or elutriation, is a common method used by to remove large amounts of inorganic material (sand/gravel) from a sample. During elutriation the sample is agitated or swirled in a bucket with water to create a vortex. Swirling causes lighter organic material and macroinvertebrates to float in the water column while the heavier inorganic sand and gravel remains at the bottom of the bucket. This process also reduces the risk of damage to specimens during transport to the taxonomy lab, since the larger substrate is removed. As recommended in the CABIN Field Manual, the removed substrate was kept for QA/QC purposes and to check that no organisms were left behind.

Photo 6 1. Invertebrate sampling in Twenty-One Mile Creek.

Photo 6 2. Invertebrate sampling in Whistler Creek.

6.2.3 *In Situ* Habitat Data Collection

Habitat data was collected in situ at each of the six sampling sites following the CABIN field sheets.

- **Primary Site Data**: Basin name, estimate of site location coordinates, ecoregion, and stream order are all recorded.
- **Site Description**: a broad characterization of the site. It includes a site drawing and written description, site coordinates, and surrounding land use classification.
- **Reach characteristics**: a description of aquatic habitat types, canopy coverage, macrophyte coverage, streamside vegetation and canopy coverage in a defined sampling reach (site).
- **Water chemistry**: measurement of certain physical-chemical water quality parameters which are required by CABIN such as dissolved oxygen and saturation, pH, water temperature and conductivity. Most can be collected with in-situ field meters.
- **Substrate characteristics**: a 100-pebble count is used to characterize the substrate. The degree of embeddedness of substrate and the size of surrounding material are also determined.
- **Channel measurements**: characterization of the stream channel at current flow and estimate of peak flow conditions. This includes measurements of channel width (bankfull and wetted), depth, velocity and slope. Velocity measurements were collected using a Swoffer unit.

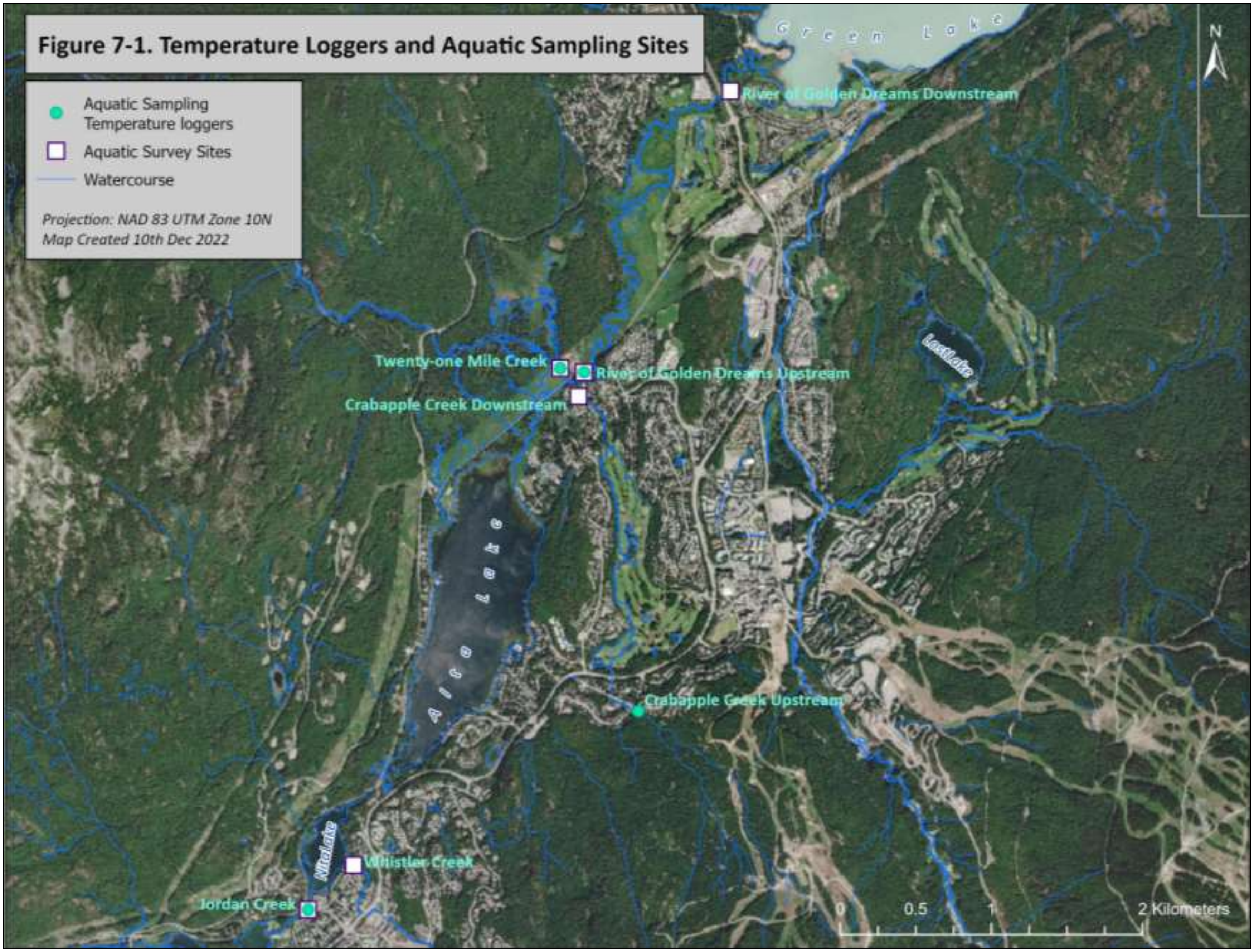

Figure 6-1. Temperature loggers and aquatic sampling sites.

6.2.4 Sample Sorting and Taxonomic Analysis

Benthic invertebrate sample sorting and taxonomic analysis was conducted by Thibault Doix (Roe Environmental Inc.), Certified Taxonomist with the Society for Freshwater Science. The sample sorting process consists of removing all the benthic invertebrates from the sample matrix prior to taxonomic identification. Each sample was processed as follow:

- The whole sample (i.e., all the jars constituting one sample) was washed with water into a 320µm sieve (smaller than the kicknet mesh size) to remove preservative.
- Large materials, rocks, twigs, and macrophytes were gently and thoroughly washed over. Washed large material was placed in a white tray for further examination and to make that sure no organisms were left behind.
- The sieve content was transferred into a white tray for a first sorting under a hands-free magnifier to remove large and conspicuous specimens.
- The tray content was subsequently split into smaller fractions and progressively transferred into a Petri dish for fine sorting under a dissecting microscope. Sorted debris was set aside and preserved in 85% ethanol.
- Removed specimens were separated into coarse family groupings in multi-well plates.
- All organisms removed from the white tray were identified, tallied and recorded on a bench sheet.
- The specimen vial and sorted debris jars were labeled, preserved in 85% ethanol and retained for Quality Assurance/Quality Control (QA/QC) audits of sorting and identification efficiency, as required.
- Each organism was identified using dissecting (10x-90x magnification) or compound microscopes (40x-1000x magnification) and appropriate taxonomic identification keys. The taxonomic identification was performed to the lowest level possible (generally genus/species level for insect taxa and family/genus for non-insects). Different life stages (e.g., larvae, nymphs) were identified and enumerated separately. If the condition of a specimen did not allow for a correct identification, it was discarded.

6.2.5 CABIN Database and Data Analysis

The CABIN database analysis uses the Reference Condition Approach (RCA) to assess anthropogenic disturbances. A large database of benthic macroinvertebrate communities was established by Environment Canada from a wide range of minimally disturbed sites (‘Reference Sites’) throughout various watersheds (e.g., Fraser River, Skagit River, etc.). Reference Sites were subsequently grouped based on their habitat characteristics, biogeoclimatic zones, etc. Using multivariate statistical techniques, empirical Models were developed from the information collected to predict the ‘expected’ invertebrate assemblage using the habitat characteristics at a particular site (Sylvestre et al., 2005). The assumption is that if the observed community at a given test site was not what was expected, then the stream must experience some level of anthropogenic stress.

These Models comprise five to six different reference site groups that the benthic invertebrate communities of each test site can be compared to. Test sites are plotted with the appropriate group of reference sites on two or three axes, each axis representing a group of benthic community attributes. Each test site is assigned to the farthest band to which it resides in the three plots. The CABIN database assessment is summarized based on where the test site fell within the confidence ellipses (Figure 6 2):

- A site falling within the 90% confidence ellipse is designated 'Similar to Reference'.
- A site falling within the 90% and 99% confidence ellipses is designated 'Mildly Divergent'.
- A site falling within the 99% and 99.9% confidence ellipses is designated 'Divergent'.

- A site that falls outside of the 99.9% confidence ellipses is designated 'Highly Divergent'.

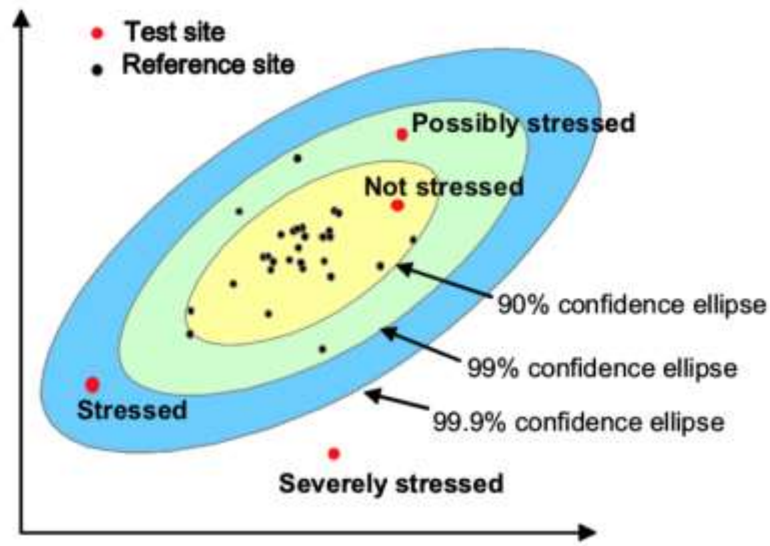

Figure 6 2. Ordination of invertebrate communities at reference sites and test sites. Different bands surrounding the cloud of reference sites represent the assessment criteria for a test site based on the distance the test site falls away from the cloud of reference sites (Source: Sylvestre et al., 2005).

The multivariate ordination used in the RCA was developed using Bray-Curtis Index (BCI) data calculated for the RCA as a complete data matrix. For the test sites, the BCI was calculated based on the expected relative abundance of the taxa present for that reference group. These BCI data were then used to locate each site on the ordination. For the BCI, a value of 0 indicates that a site is identical in community structure to the Reference Condition and a value of 1 indicates a site is entirely different from the Reference Condition with no species in common. Within that range, between site variability is considered low if BCI values are less than 0.40, moderate if BCI values are between 0.40 and 0.80, and high if BCI values are greater than 0.80. The latter category is also problematic because the correlation between BCI values and ecological 'distance' becomes sharply non- linear above approximately 0.80 (Beals 1984). Site comparisons with BCI values greater than 0.80 should therefore be interpreted with caution. For the reference sites, the mean BCI values ranged from 0.41 to 0.55 and were therefore considered, on average, moderately variable (Table 6 2).

The CABIN database assessment was further developed through comparison of test sites with reference sites using the River Invertebrate Prediction and Classification System (RIVPACS). The RIVPACS compares the observed taxonomic richness at each test site, to the expected taxonomic richness from the group of Reference sites predicted from the reference model, which is then reported as an Observed:Expected (O:E) ratio. O:E ratios are calculated to assess the potential loss of highly expected taxa that have more than a 70% chance of occurrence (O:E p>0.7) at the Reference sites. A low O:E (p<0.7) score indicates taxa loss as compared with expected benthic communities at Reference sites and is indicative of some form of anthropogenic stress.

The expected taxa richness is calculated from the sum of all taxon probabilities of occurrence in comparison with the average of the Reference sites of a given group. O:E ratios are examined to investigate the loss of highly expected taxa that have more than with more than a 70% chance of occurrence (O:E p>0.7). Ratios were calculated by summing up the total number of observed taxa (taxa present with probabilities of occurrence greater than 70%) and divided by the expected number of taxa from the group of reference sites (with sum of probabilities greater than 70%). A ratio <1 indicates fewer of the taxa with high probability of presence than expected at a site in Reference Condition (i.e., sign of potential alteration) and a ratio >1 indicates a greater taxonomic richness.

Each taxon found at the Reference sites is attributed a probability of occurrence based on the results of the various assessments conducted at these sites. A taxon with a high probability of presence at the group of reference sites that is not found at a test site can substantially affect the results of the CABIN assessment, same as the presence of a higher number of pollution tolerant taxa (i.e., not present at the reference sites).

6.3 Results and Discussion

6.3.1 Reference Model and Reference Group Assignment

The probability of the test site belonging to each of the reference site group is calculated using the habitat variables for the specific Model being used. The Fraser River 2014 Reference Model was used for the River of Golden Dreams (2 sites), Crabapple Creek, and Twenty-Mile Creek as they are part of the Lillooet River drainage (tributary to the Fraser River), while Whistler Creek and Jordan Creek were assessed using the Fraser River Georgia Basin 2005 Model (Sylvestre et al., 2005) as they ultimately drain into Howe Sound. A summary of the Reference Model Group assignment probability is summarized in Appendix D.

An updated Fraser River Model (Reynoldson 2021) does exist, but it requires a complete re-analysis of the predictive habitat metrics and the calculation of some new ones. Thus, it is proposed to be included in next year's analysis as it cannot be included in the present report.

6.3.2 Taxonomic Identification and CABIN Database Analysis

The results of the CABIN database analysis shows that the benthic communities at the assessed sites were Mildly Divergent or Similar to Reference Condition (Table 6 2). Most sites improved from the 2022 sampling season, which was affected by an unseasonably cold and wet spring/early summer that year. Twenty-one-Mile Creek remained within similar quality levels as 2022, despite gaining 9 additional invertebrate taxa. The taxonomic richness also improved at most sites since the previous sampling program, except on Crabapple Creek. Regardless of having the lowest taxonomic richness of the 2023 program, Crabapple Creek achieved a quality of benthic communities in Reference Condition. This improvement is likely due, in part, to the addition of two families with a probability of presence >50% according to the CABIN analysis, which were not found in 2022.

It is noted that some inconsistencies in the CABIN database identified during the previous monitoring program were addressed and the CABIN analysis was performed once again for all the sites. Table 6 2 below shows the updated results.

Detailed results of the taxonomic analysis and CABIN database analysis will be provided to RMOW under a separate cover.

Table 6-1. Summary of CABIN Database Output and Site Assessment Results since 2016.

Site	Reference Model	Year	Reference Group #	Test Site BCI	Reference BCI (Mean ± SD)	RIVPACS O:E (p>0.7)	CABIN Assessment Results
Twenty-one Mile Creek	Fraser River 2014	2016	3	0.74	0.41 ±0.17	1.16	Mildly Divergent
		2017	3	0.78	0.41 ±0.17	0.93	Divergent
		2018	5	0.87	0.55 ±0.22	1.20	Mildly Divergent
		2019	3	0.75	0.41 ±0.17	1.16	Mildly Divergent
		2020	3	0.64	0.41 ±0.17	1.20	Mildly Divergent
		2021	3	0.85	0.41 ±0.17	1.16	Mildly Divergent
		2022	3	0.67	0.41 ±0.17	0.93	Mildly Divergent
		2023	3	0.64	0.41 ±0.17	1.16	Mildly Divergent
Crabapple Creek	Fraser River 2014	2016	1	0.71	0.48 ± 0.15	0.96	Mildly Divergent
		2017	1	0.37	0.48 ± 0.15	0.96	Reference
		2018	1	0.43	0.48 ± 0.15	1.15	Reference
		2019	1	0.32	0.48 ± 0.15	1.15	Reference
		2020	5	0.74	0.55 ±0.22	1.25	Mildly Divergent
		2021	1	0.61	0.48 ± 0.15	0.88	Reference
		2022	5	0.81	0.55 ±0.22	0.94	Mildly Divergent
		2023	5	0.77	0.55 ±0.22	0.56	Reference
River of Golden Dreams (Upper)	Fraser River 2014	2016	3	0.70	0.41 ±0.17	1.16	Mildly Divergent
		2017	3	0.70	0.41 ±0.17	1.16	Mildly Divergent
		2018	5	0.94	0.55 ±0.22	1.20	Divergent
		2019	3	0.71	0.41 ±0.17	1.16	Mildly Divergent
		2020	3	0.61	0.41 ±0.17	1.16	Mildly Divergent
		2021	5	0.86	0.55 ±0.22	0.91	Mildly Divergent
		2022	5	0.96	0.55 ±0.22	0.90	Divergent
		2023	5	0.94	0.55 ±0.22	1.21	Mildly Divergent
River of Golden Dreams (Lower)	Fraser River 2014	2016	4	0.57	0.53 ± 0.14	1.18	Reference
		2017	5	0.72	0.55 ±0.22	1.22	Reference
		2018	5	0.59	0.55 ±0.22	1.18	Reference
		2019	5	0.39	0.55 ±0.22	1.22	Reference
		2020	5	0.58	0.55 ±0.22	1.22	Reference
		2021	4	0.59	0.53 ± 0.14	1.18	Reference
		2022	5	0.89	0.55 ±0.22	0.55	Mildly Divergent
		2023	5	0.82	0.55 ±0.22	1.22	Reference
Jordan Creek	Fraser River – Georgia Basin 2005	2016	1	0.86	0.53 ± 0.14	0.91	Divergent
		2017	1	0.87	0.53 ± 0.14	0.90	Mildly Divergent
		2018	1	0.85	0.53 ± 0.14	0.91	Mildly Divergent
		2019	1	0.72	0.53 ± 0.14	0.91	Reference
		2020	1	0.86	0.53 ± 0.14	0.54	Divergent
		2021	1	0.93	0.53 ± 0.14	0.96	Divergent
		2022	1	0.61	0.53 ± 0.14	0.90	Mildly Divergent
		2023	1	0.63	0.53 ± 0.14	0.95	Mildly Divergent
Whistler Creek	Fraser River – Georgia Basin 2005	2022	4	0.94	0.50 ± 0.2	1.18	Mildly Divergent
		2023	1	0.58	0.53 ± 0.14	1.11	Reference

6.3.3 Taxonomic Richness

Analysis of macroinvertebrate taxonomic richness together with analyses of community composition and the functional traits of benthic organisms are important in the assessment of freshwater ecosystem health. Numerous ecological factors influence the number and diversity of taxa in a macroinvertebrate assemblage, including water chemistry (e.g., water temperatures, dissolved oxygen, amount of nutrients, etc.), the variety and type of micro-habitats present at the sampling site (e.g., gravel, fine and coarse organic debris, etc.), but also larger scale ecological factors such as geography, geology, and climate. Beyond site conditions, taxonomic richness can also be influenced by sampling effort and the presence/absence of rare taxa represented by only one of two specimens, which can easily be undetected during some sampling years despite being present.

Although the assessment of ecosystem degradation (or recovery) also requires consideration of community composition and functional traits (e.g., feeding mode, living habits, position in the sediments, etc.), the overall taxonomic richness found at each site since 2016 is summarized in Table 6 3 below for discussion purposes. This Table displays both the number of families (taxonomic level used in the CABIN analysis and comparison with reference conditions) and the total number of taxa identified to the lowest taxonomic level possible, generally the to the genus level. A list of all taxa found at each sampling site (identified to the lowest taxonomic level possible) is available as Appendix D.

Both sites on the River of Golden Dreams display the highest taxonomic richness. Conversely, Jordan Creek is substantially lower than the other sites, which is likely due to its unique characteristics as a short (approximately 350 metres in length) reach between its headwaters in Nita Lake and its confluence in Alpha Lake. This creek also displays warmer temperatures than any other of the creeks assessed (Section 7).

Crabapple Creek shows a consistently decreasing trend in taxonomic richness despite displaying benthic invertebrate communities either similar to reference condition or mildly divergent. This trend may be indicative of increasing stress in the smallest of the watercourses in terms of channel widths and flows assessed as part of the monitoring program, and which also flows through residential areas and a golf course.

The taxonomic richness results show that typically less than half of the taxa potentially present at any given sampling site are found during a given sampling year. This variability can be explained, in part, by the low abundance of some taxa represented by fewer than three specimens. These specimens may affect the results of the CABIN analysis, especially when they are expected at a high percentage value but not found in a sample.

Table 6-2. Summary of Taxonomic Richness per Site since 2016.

Site	Year	# of Families	# of Taxa	Total Unique # of Taxa
Twenty-one Mile Creek	2016	13	13*	70
	2017	12	12*	
	2018	23	34	
	2019	24	41	
	2020	22	35	
	2021	22	35	
	2022	13	20	
	2023	19	29	
Crabapple Creek	2016	15	15*	71
	2017	10	10*	
	2018	20	33	
	2019	15	32	
	2020	19	31	
	2021	17	31	
	2022	16	27	
	2023	14	31	
River of Golden Dreams (Upper)	2016	13	13*	78
	2017	13	13*	
	2018	25	53	
	2019	19	37	
	2020	25	47	
	2021	20	42	
	2022	13	23	
	2023	19	33	
River of Golden Dreams (Lower)	2016	16	16*	75
	2017	12	12*	
	2018	23	51	
	2019	20	43	
	2020	24	41	
	2021	27	48	
	2022	14	31	
	2023	17	34	
Jordan Creek	2016	12	12*	61
	2017	14	14*	
	2018	15	24	
	2019	18	35	
	2020	12	22	
	2021	15	33	
	2022	17	28	
	2023	20	33	
Whistler Creek	2022	17	27	45

Notes:

*Taxonomic identification to family only in 2016 and 2017.

Numbers in **orange** show lowest value and numbers in **green** show highest value observed since 2016.

Number of taxa as entered the CABIN database.

6.4 Discussion and Recommendations

Taxonomic richness and overall quality of the benthic communities improved at all sites since the 2022 sampling program, which was possibly an outlier year impacted by a relatively cold and wet spring/early summer. An overview of the updated CABIN database outputs and taxonomic richness since the onset of the monitoring program yielded the following findings:

- Despite some variability in taxonomic richness, Twenty-one Mile Creek generally remained "Mildly Divergent from Reference Conditions over the past 6 years, showing some relative stability in the core invertebrate communities (i.e., expected to be present) and a slight, yet consistent, degradation of water and/or habitat quality. In the absence of any substantial human development within the watershed, the sampling site location, below a routinely maintained powerline right-of-way, could potentially affect the local benthic invertebrate communities at the site (e.g., lower canopy coverage, increased temperature variations throughout the day, etc.). Thus, it is recommended that in 2024 the sampling site be moved upstream, outside of the powerline right-of-way.
- Crabapple Creek has typically achieved "Refence Condition", except in 2020 and 2022 (Mildly Divergent), despite a constant decrease in the total number of families. This decrease appears offset by a relatively stable total number of taxa as identified at the lowest possible taxonomic level (i.e., genus or species level). The analysis of nutrients and fecal coliforms is recommended to detect any potential anthropogenic impacts on the water quality and benthic communities.
- The (upper) River of Golden Dreams has never achieved "Reference Conditions" since 2016 while the (lower) sampling sites almost consistently did (except in 2022). Both sampling sites, however, appear to show a decreasing trend in total taxonomic richness, since 2018 especially. Despite some benthic communities being "Divergent" to "Mildly Divergent" from Reference Conditions quality levels, the (upper) River of Golden Dreams sampling site achieved the highest cumulative taxonomic richness since 2016. The recreational use of the River of Golden Dreams by watercrafts could potentially have an impact on the water and habitat quality of the watercourse through regular disturbance of the substrate, nutrients and fecal bacteria inputs. Since the assessment of the recreational users' disturbance of stream substrate may not be practical and beyond the scope of the monitoring program, the analysis of nutrients and fecal coliforms is recommended to detect any potential impacts from recreational users on the water quality and benthic communities.
- The improvement in benthic invertebrate communities observed on Jordan Creek, as compared with 2020 and 2021 especially, was confirmed this year, with the highest number of families (n=20) ever observed since the beginning of the monitoring program. Due to its unique characteristics (i.e., short reach between two lakes), Jordan Creek possesses the lowest overall taxonomic richness (n=61) of the five historical sampling sites before the addition of Whistler Creek to the Program in 2022.
- The taxonomic richness on Whistler Creek showed a substantial increase in taxonomic richness since 2022 (first year of sampling) with an additional 15 taxa, resulting in "Reference Conditions" for this site.

The integration of the results from the additional invertebrate samples collected from micro-habitats not easily sampled during kicknet sampling as described in the CABIN field sampling protocol (e.g., areas with nil velocities or surface of coarse woody debris) remains outstanding due to time constraints in 2023 and will be included in next year's report. Similarly, we plan to include: (a) re-evaluation of sites using the updated Fraser Model (2021); and (b) calculation and analysis of the Hilsenhoff Biotic Tolerance Index, which integrates the known pollution tolerance levels of each taxon found during a sampling event.

7. Water Temperature and Quality

Key Takeaways

Water Temperature: Probable worsening	Fish Habitat: Stable

1. Temperature records for 2022 and the first half of 2023 were not available due to batteries that failed in late 2021. An analysis of stream records through 2023 generally show stable trends with two exceptions: (i) higher temperatures during the summer of 2023 due to extended drought conditions; and (ii) concerningly high summer temperatures in Jordan Creek. With continued warming, fish habitat in Jordan Creek will deteriorate.
2. All water quality parameters examined were similar to previous years and were within Provincial water quality standards for the protection of aquatic life. Trends in water quality data are generally stable, with no evidence of significant change to WQ in all streams.
3. Temperature loggers need to be maintained on a regular basis. We recommend that the RMOW download the temperature data on a regular schedule (e.g., every three to four months) and replace batteries at scheduled times to prevent loss of data.
4. Two of the original six temperature loggers installed in 2016 are no longer functional, at Alpha Creek and Lower Crabapple Creek. New loggers were installed in August 2023 at four sites that have records going back to 2016, Upper Crabapple, Jordan, ROGD and 21 Mile Creek. Loggers at Lower Crabapple and Alpha were discontinued.

7.1 Introduction

The ongoing objective of monitoring water quality and fish habitat within this program is to collect meaningful long-term data that can be used to assess the overall health of aquatic biological communities within the RMOW. In addition, this data will inform other components of the program as well as assist in charting long term climatic changes within the local area.

7.2 Methods

The 2022-2023 stream water temperature monitoring program provided data from four sites (Figure 6.1 & Table 7.1) using Onset® HOBO® MX2201 Pendant wireless loggers set to record stream temperature at hourly intervals. Due to issues with batteries, logger damage, and improper maintenance, no temperature data is available for all sites for the entirety of 2022 and for the first half of 2023. This means that the most recent data available covers only a two and half month period from August 10, 2023 to the end of October 2023. Data for previous years dating back to 2016 is also included but is only available for the Jordan Creek, Upper Crabapple Creek and the ROGD US site. Sampling locations and most recent period of record is shown in Table 7-1.

Additional in situ water quality measurements including dissolved oxygen (DO), pH, and conductivity were measured in 2023 using a hand-held YSI Pro plus meter. Measurements were taken as part of fish habitat surveys conducted alongside CABIN benthic invertebrate sampling. In addition, a new benthic/fish habitat site on Whistler Creek was selected for 2022 monitoring (Figure 6-1).

Fish habitat data was collected according to BC Resource Information Standards Committee Criteria (RIC 2008) for fish habitat sampling. Fish habitat data was collected by lead surveyor Jason Macnair and field assistants: Bob Brett (Snowline) and Rebecca Merenyi (RMOW)

Table 7-1. Temperature logger location and data range for the monitoring period.

Site	Easting	Northing	Data Range
Crabapple Creek Downstream	502030	5552670	n/a
Crabapple Creek Upstream	502426	5550589	August-October 2023
Jordan Creek	500258	5549255	August-October 2023
River of Golden Dreams	502066	5552829	August-October 2023
Scotia Creek	499199	5548227	n/a
Twenty-one Mile Creek	501910	5552856	August-October 2023

7.3 Results and Discussion

7.3.1 Stream Temperatures

Mean monthly temperatures ranged from a low of 6.0°C in October 2023 in Crabapple Creek to a high of 18.8 °C at Jordan Creek for the month of August 2023. Daily maximum temperature was 21.7 °C on August 17, 2023, in Jordan Creek and the daily minimum temperature was 0.1 °C on October 29, 2023, at Crabapple Creek U/S. For the 2016-2023 period of record the average monthly stream temperatures varied from a low of -0.21°C in January 2017 at Crabapple Creek D/S to 18.8 °C at Jordan Creek in August 2023 (Appendix E).

The lack of available stream temperature data for 2022 and 2023 means that there is little additional information that can be useful in analyzing long term trends for this period. However, data that was collected from August to October 2023 captured the warmest period of the year, and provided important information on a potential trend of increasing water temperatures for a few of the creeks under consideration. As noted in the opening paragraph, the highest temperatures recorded were, as expected, in Jordan Creek downstream of Nita Lake. The temperatures experienced in August 2023 were in fact he highest yet recorded for this site during the period of record, warmer even than those recorded during the “heat dome” event in 2021 (Table 7-2). For the first time, temperatures above 21°C were recorded in Jordan Creek, and there was a period of 6 consecutive days where the temperature exceeded 20°C, which was also a record. The 21.7°C recorded on August 17, 2023 is the highest yet on record for any site since records began in 2016.

Temperatures in this range are above provincial guidelines for all age classes of salmonid species known to inhabit the RMOW watershed, and can lead to undue stress in juvenile and adult salmonids that can cause increased mortality under extended exposure periods of as little as two weeks (Crossin et al. 2008, Dill 2011). Resident Cutthroat and Rainbow Trout are more than likely able to tolerate these temperatures, but more heat-sensitive fish such as Kokanee and Bull Trout could see their productivity impacted (Verhille, 2016, Decker 2011).

All four sites where stream temperature data is collected had record high mean monthly and maximum temperatures recorded for the August - September 2023 period (Table7-2). As with the record temperatures recorded in the region due to the "heat dome" of 2021, the summer of 2023 had an extended drought that ran from July -September which likely impacted stream temperatures in the RMOW area. According to the British Columbia Drought Information Portal, the Lower Mainland and Howe Sound region was under a stage 4-5 drought from the beginning of July to the end of September in 2023, with the majority of August and September in Stage 5 drought (defined as exceptionally dry, with adverse impacts to socio-economic or ecosystem values are almost certain).

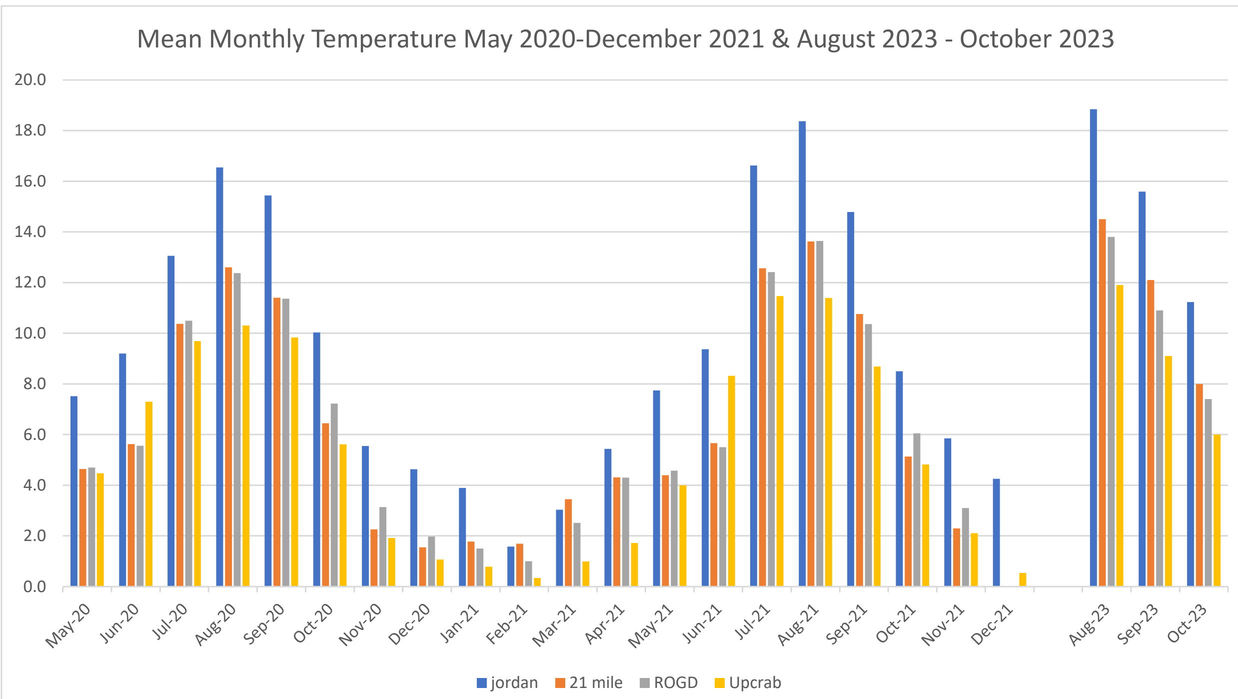

***Figure 7-1*. Mean monthly stream temperature (°C) for May 2020 to December 2021 and Aug-Oct 2023. Note the consistently higher temperatures in Jordan Creek compared to the other sites.**

With the exception of Jordan Creek, water temperature in the streams examined were all within approved British Columbia Water Quality Guidelines (BC WQGS) with respect to supporting aquatic life. Jordan Creek has been the warmest creek throughout the study period, likely due to the fact that it is immediately downstream of a lake – Nita Lake – which receives strong solar radiation in the summer months and then feeds Jordan Creek from this warm surface water (Figure 6-1; Figure 7-1).

Surface water temperature data from Nita Lake has been collected by Whistler Lakes Conservation Foundation (WLCF) volunteers over recent years.[17] This effort is also affiliated with the British Columbia Lake Stewardship Society (BCLSS). WCLF volunteers perform weekly spot measurements of the surface temperature on Nita Lake during the spring to late summer. Data made available by the WCLF for 2021 and 2023 provides evidence of the direct influence that the warm lake surface water has on Jordan Creek.

We took daily mean stream temperature data from the installed logger in Jordan Creek and compared it to the weekly Nita Lake surface temperature, and the results show a clear pattern that closely matches lake and stream temperatures (Figure 7-2). There is ample evidence elsewhere for this lake heat influence on downstream temperatures (e.g., Mellina 2002, Moore 2006, Dripps 2013). Continued summer temperature monitoring in Nita Lake would be useful to gain more information on it's influence on Jordan Creek water temperature.

Despite the limited scope of the stream temperature data presented for 2023, it does again demonstrate that stream temperatures may continue to increase in the coming years due to extreme climatic events which are only predicted to become more frequent and with increased intensity due to climate change (Falke 2015).

Table 7-2. Mean August-September temperature 2016-2023 showing evidence of impact of the Stage 5 drought conditions on local stream temperatures.

Year	Jordan	21 Mile	ROGD	Upper Crabapple
2023	**17.2**	**13.3**	**12.4**	**10.5**
2021	16.6	12.2	12.0	10.0
2020	16.0	12.0	11.9	10.1
2019	16.0	No data	11.3	No data
2018	14.3	No data	9.8	No data
2017	16.7	12.5	12.0	10.5
2016	16.4	No data	11.7	9.7

[17] Thanks to Tom English and Nicholas Collins with the Whistler Lakes Conservation Foundation for generously sharing this data.

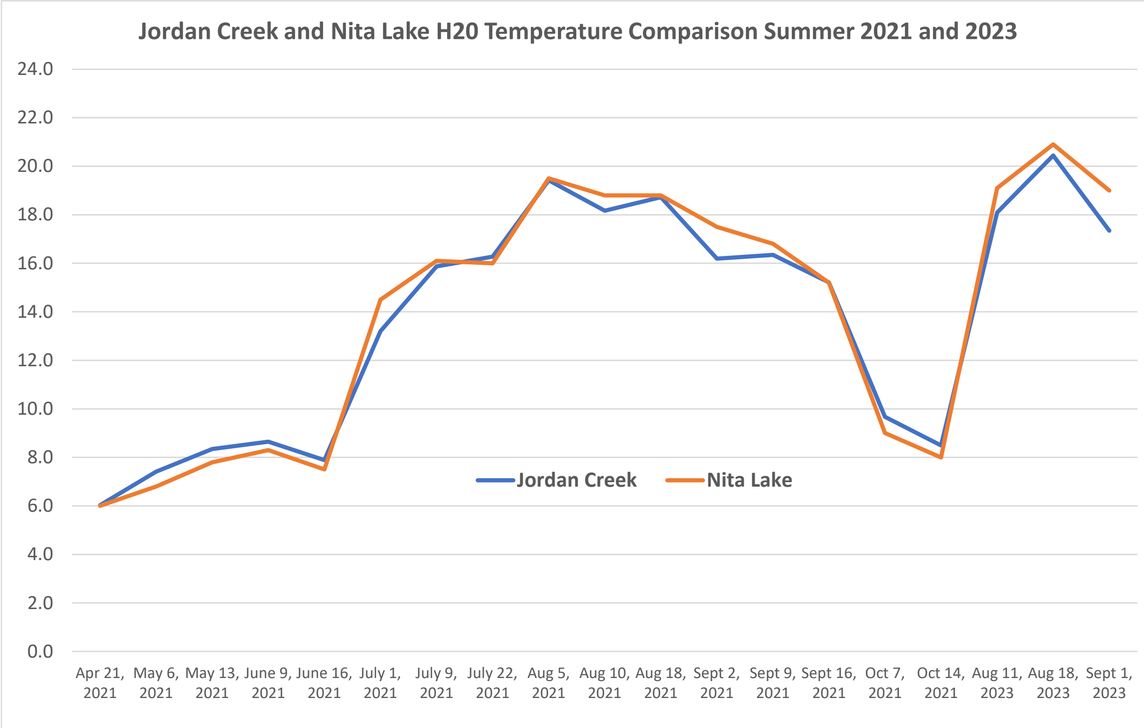

Figure 7-2. Mean daily Jordan Creek stream temperature matched against spot temperature measurements taken on the same date from Nita Lake BCLSS data (°C). April – October 2021 data and August-September 1, 2023 data. Source: Tom English and Nicholas Collins, Whistler Lakes Conservation Foundation.

7.3.2 Water Quality

All in situ, instantaneous water quality data collected in 2023 was within all Provincial and Federal guidelines for the protection of aquatic life (BC WQG MOE 1997; Table 7-3). Potential incorrect measurements are marked with an asterisk in Table 8-3, as these results are likely a result of operator or instrument error and are therefore not included in any discussion of the results. Results that are outside of provincial WQGS are in italics.

Dissolved oxygen (DO) varied from 8.7 mg/L to 10.0 mg/L across all sites in 2023, and saturation ranged from 92.3 to 101.5 percent. Across all years DO has been between 7.5 mg/L to 11.7 mg/L. Dissolved oxygen at all sites in all years was above the BC WQG instantaneous minimum of 5 mg/L (BC MOE, 1997) for all fish life stages. In some years a number of measurements were below the BC WQG instantaneous minimum guideline of 9 mg/L for buried embryo/alevin life stages (Table 7-3).

Stream pH varied from 6.8 to 7.6 across all sites in 2023 (Table 7-3). All results conformed to the pH guidelines for the support of aquatic life. Across all sites and years and the stream pH has varied from 6.2 to 7.8. These estimates align with expected values of pH for streams along the coast of British Columbia.

Conductivity, which represents the ability of water to conduct electricity by measuring dissolved salts and is therefore an indirect way to measure how saline water may be, is represented in Table 7-3 as Specific Conductance (SC) in microsiemens per centimetre, (µS/cm). In 2023 the SC ranged from 32.0 µS/cm to 84.4 µS/cm for all sites with the exception of Crabapple Creek which was measured at 209 µS/cm.

Instantaneous estimates of SC on Crabapple Creek have been well above that of all other creeks sampled since 2016 and have ranged from 190 µS/cm to 336 µS/cm (Table 7-3). There is no confirmation of the reason for the elevated SC on Crabapple Creek, though an anthropogenic source is possible as the creek passes through residential areas as well as a golf course. There are no provincial or federal standards for SC with respect to the protection of aquatic life, as each lake and stream tends to have a relatively constant range of conductivity that may vary from others but is suitable for the local environment. However, most literature recommends that in our region a SC of over 1000 µS/cm might be cause for concern, and under 200 µS/cm is generally considered to be excellent conditions.

***Table 7-3.* In situ water quality results taken during benthic sampling 2016-2023.**

Site ID	Date	Oxygen (mg/L)	Dissolved Oxygen (%)	pH	Specific Conductance (µS/cm)	Temperature (°C)
Jordan Creek	03-08-16	9.3	94	7.1	64	15.8
	26-07-17	*8.9*	88	7.1	105	14.9
	01-08-18	*7.7*	83	7.1	65	18.8
	30-07-19	9.4	98	7.7	78	17.4
	05-08-20	*8.1*	83	7.7	63	16.7
	27-07-21	9.2	105	7.2	55	18.3
	23-07-22	10.2	104	7.0	51	13.0
	29-07-23	8.7	99	7.6	73	18.2
Crabapple D/S	02-08-16	9.4	89	7.6	218	12.7
	25-07-17	11.6	108	7.4	336	12.0
	01-08-18	*7.5*	76	7.5	194	16.0
	30-07-19	10.0	97	7.6	235	13.9
	04-08-20	9.1	87	9.0*	218	13.3
	28-07-21	10.8	99	6.9	200	18.6
	22-07-22	9.3	97	6.4	190	14.0
	28-07-23	9.3	96	7.6	209	13.4
Twenty One Mile	03-08-16	9.4	87	*6.3*	40	12.0
	25-07-17	11.3	104	7.1	40	11.6
	31-07-18	14.6*	160*	*6.2*	38	19.9
	30-07-19	9.8	94	7.0	52	13.3
	04-08-20	*8.0*	77	9.4*	47	13.9
	28-07-21	11.7	113	7.0	55	14.2
	22-07-22	11.6	98.5	7.3	15	8.0
	28-07-23	9.1	92.3	7.4	39	12.6
ROGD US	03-08-16	*8.3*	76	7.3	64	11.7
	25-07-17	11.0	99	7.1	50	10.5
	31-07-18	*7.5*	75	7.2	36	15.5
	30-07-19	9.8	92	6.8	33	12.8
	05-08-20	*8.2*	79	7.7	42	13.6
	28-07-21	10.6	100	7.1	46	13.1
	22-07-22	10.8	99	7.0	20	11.5
	28-07-23	9.1	92.9	6.8	48	12.9
ROGD DS	05-08-16	9.9	99	7.8	69	15.2
	25-07-17	9.8	93	7.0	73	13.0
	01-08-18	*8.2*	86	6.7	48	17.8
	31-07-19	9.9	94	7.6	61	13.1
	05-08-20	9.1	93	7.5	71	16.3
	27-07-21	11.5	118	7.3	74	16.6
	22-07-22	10.4	100.2	7.1	29	10.5
	28-07-23	9.5	101.5	6.8	79	15.2
Whistler Creek	23-Jul-22	10.9	99.6	6.8	37	8.4
	29-07-23	10.0	99.7	7.3	84	12

The Canadian Water Quality Guidelines for the Protection of Aquatic Life state the lowest acceptable dissolved oxygen concentration, for a cold-water aquatic ecosystem, as 9.0 mg/L for early life stages, and 6.5 mg/L for other life stages. The Canadian Water Quality Guidelines for the Protection of Aquatic Life, state the guideline range for pH as 6.5 to 9.0. Numbers printed in italics indicate a value below provincial or federal guidelines.

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8. Fish and Fish Habitat

Key Takeaways

Fish Populations: Inconclusive (Data deficient)	Fish Habitat: Stable to probable worsening

1. With the improvements made to adult data collection for Kokanee it was possible to generate more precise escapement estimates for Kokanee spawners for 2023. Improvements to Rainbow Trout spawner counts also gave greater confidence to survey observations for this species. Continued refinement of and commitment to improved data collection protocols should enable the adult spawner estimates to be robust enough to be used as a yearly index of abundance in the coming years.
2. Analysis of adult Rainbow and Kokanee data did not reveal any population trends. In the coming years, with the improvements in data collection, it is hoped that the adult salmon data collected will be useful for comparing year over year and long-term population trends.
3. Bull Trout are the salmonid species most likely to be impacted by climate change due to their demonstrated sensitivity to elevated stream temperatures. Continued collection of temperature data is a critical part of monitoring fish habitat for Bull Trout. Temperature profile data from Nita Lake in 2023 confirmed that the lake is deep enough to provide a cold-water refuge for Bull Trout in the summer months.
4. Drought conditions in the Summer of 2023 led to a notable reduction in available fish habitat for all creeks examined in 2023. Average water depth and stream velocity were also greatly reduced in 5 of 6 creeks examined. This data will be important to track in future years as the potential impacts of climate change become more apparent.

8.1 Introduction

Fish habitat and water quality data were collected during fish habitat surveys in order to provide baseline information on fish and fish habitat in the RMOW study area. Streams were assessed using methods based on the Reconnaissance 1:20,000 Fish and Fish Habitat Inventory Protocol (RIC 2001) and the Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Site Card Field Guide (RISC 1999b). This involved characterizing fish habitat over a section of stream by measuring physical attributes such as: gradient, channel width, temperature and water quality, describing cover types, cover abundance and substrate quality and describing stream morphology. Based on the attributes collected at the monitoring sites, professional judgement was used to rate habitat suitability for all fish life history stages (spawning, incubation and rearing). All fish habitat data along with site photos are found in Appendix E.

8.1.1 Stream Temperature and Fish Habitat

A crucial step in tracking the impact of climate change in the RMOW is the long-term collection of local stream temperature regimes. Stream temperature changes resulting from modifications to the natural landscape and climate change can potentially have a negative impact on aquatic ecosystems, particularly for cold-water species such as salmonids (Beschta et al. 1987; Eaton and Scheller 1996). In recent years there has been increasing attention in the Pacific Northwest and elsewhere to identify "temperature-sensitive streams" (Ruesch2012; Porter and Nelitz 2009).

For example, research across the entire range of Bull Trout habitat in British Columbia increasingly shows that stream temperature should be treated as the primary indicator of habitat suitability, and that stream temperatures >15°C likely indicate poor or marginal suitability (Haas 2001; Decker and Hagen 2007). Furthermore, climate change, because of its direct and potentially wide-ranging impact on stream temperature regimes, should be regarded as the most important future threat to Bull Trout across the province as a whole, although other threats may be more important at a local level (Falke et al. 2015, Hagen and Decker 2011).

Bull Trout are a Blue listed species in BC (CDC 2023). This species is particularly vulnerable to habitat and climate shifts due to its sensitivity to changes in water temperature and habitat loss. Climate and landscape change might isolate small patches of Bull Trout habitat, often in the headwaters of watersheds, and precisely where the RMOW is situated (Falke 2015).

Stream temperatures in excess of 15° C are most likely to impact local Kokanee and Bull Trout populations as their sensitivity to elevated water temperature is much greater than Rainbow or Cutthroat Trout (Verhille 2016, Bear et al. 2011). More stringent temperature guidelines have been recommended for streams and rivers inhabited by Bull Trout, as Bull Trout are known to have the highest thermal sensitivity of salmonids native to British Columbia (Hagen and Decker 2011).

Stream temperature data collected over the past several years shows that all creeks, with the exception of Jordan Creek, currently have a suitable year-round temperature regime for all species of salmonid in the local area. However, the mean July-August temperatures in Jordan Creek in 2021 and 2023 were both well above what Bull Trout are known to tolerate (Table 7-2; Figure 7-1). Furthermore, in 2021 and 2023 Jordan Creek also reached temperatures that would be considered dangerous to Kokanee Salmon (Verhille 2016, Bear 2011).

Temperature profile data for Nita Lake provided by the Whistler Lake Conservation Foundation was useful in determining if the deeper water in the lake is cool enough to provide a potential thermal refuge for resident Bull Trout or Kokanee. The profile was collected using a buoy stationed at one of the deepest points in the lake, and spot measurements were recorded every metre up to 21 metres in depth. A total of 6 days of data were collected with survey points 1 – 2 weeks apart. The data recorded for July-August 2023 shows a clear thermocline with sufficiently cool temperature from below 6 metres in depth (Figure 8- 1). This information seems to support the idea that warm surface lake water feeding directly into Jordan Creek results in high temperatures, however a clear cool water refuge area is available to salmonids in Nita Lake throughout the summer months.

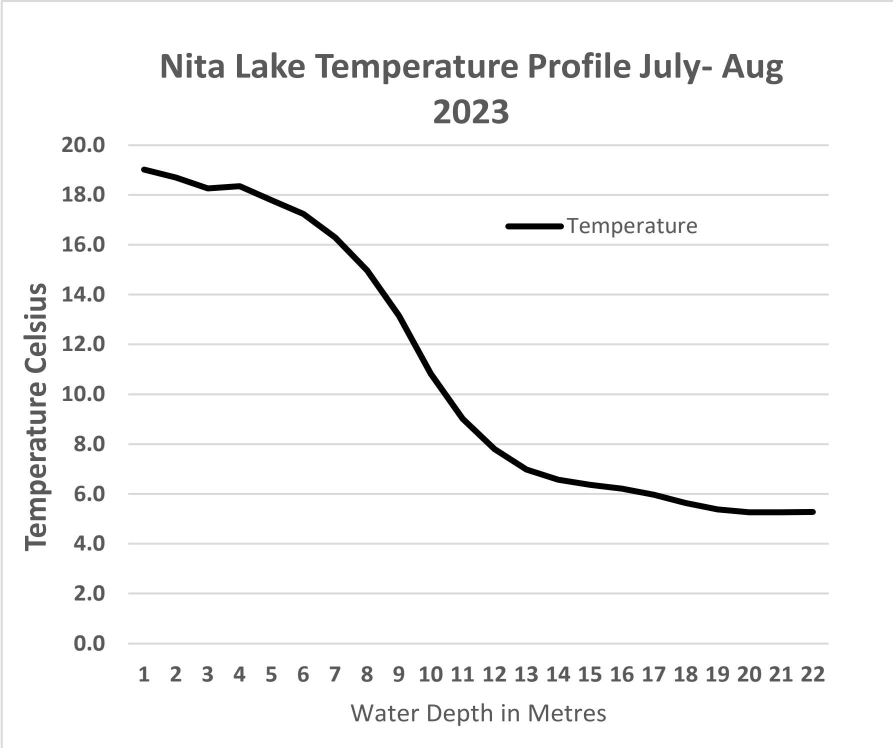

Figure 8-1 Nita Lake temperature profile for July-August 2023. Temperature data presented is the average of all days surveyed. Days surveyed n=6. Source: Tom English and Nicholas Collins, Whistler Lakes Conservation Foundation.

We could find no record of Bull Trout in Jordan Creek or Nita Lake, but populations of Bull Trout are confirmed in the Daisy Lake Reservoir and Cheakamus River 14km downstream (Hagen and Decker 2011).The possibility exists that Bull Trout are seasonally excluded from this area of the headwaters due to the warmer summer temperature regime. In addition, the warmer temperatures could also impact Kokanee, which are known to inhabit Nita Lake and spawn in Whistler Creek, which is the main tributary to Nita Lake. It is entirely possible that the elevated temperatures in Jordan Creek are localized and do not extend any further downstream than Alpha Lake, which is the outlet for Jordan Creek. Jordan Creek is a short stretch of creek – approximately 350 metres in length – and its discharge is small enough that the warmer temperatures from it would likely be reduced by downstream watercourses fed directly from glacier and snow melt.

8.1.2 Fish Habitat Surveys

All fish habitat data collected in 2023 confirmed that monitoring sites were in Good to Fair condition for all life stages of fish inhabiting the RMOW area. Table 8-1 shows the ranking criteria and how each ranking is determined. Habitat characterises are grouped into five broad categories for evaluation: (i) water quality, (ii) site area and substrate, (iii) water depth and velocity, (iv) stream morphology, and (v) instream cover. Professional judgement was used to assess the habitat criteria at each site. All fish habitat data collected with accompanying rating is shown in Appendix E.

With respect to the criteria outlined in Table 8-1, two sites had a Fair rating under the habitat category of instream cover and substrate. Twenty-one Mile Creek had a "Fair" rating under instream cover as a result of the monitoring site location being directly underneath a powerline right of way. Due to this proximity, vegetation along the right-of-way must be constantly pruned to keep it clear of the overhead transmission cables. This situation means that this site will not be able to be adequately shaded due to constant pruning of larger trees and shrubs. Lack of this type of larger vegetation may also reduce the amount of woody debris that enters the stream. The ROGD D/S site also received a “Fair” rating in the substrate category as the streambed had a dominant cover of fines and organic material which is unsuitable for spawning salmonids and provides little cover for rearing juveniles. Jordan Creek received a “Fair” rating in the water quality category due to ongoing issues with high summer stream temperatures.

Data collected during habitat surveys detected a decrease in available fish habitat at all sites in 2023 compared to 2022, likely due to drought conditions during the late spring and summer of 2023. The wetted area data collected at each site (using the site length multiplied by the average width) showed a decrease in the estimate of the surface area of wetted stream at each site (Table 8-2). In some sites the reduction in available habitat compared to the previous year was quite dramatic, with as much as a 41% decrease in wetted surface area habitat at the River of Golden Dream upstream site (Table 8-2). In addition to the wetted area data - site photos, survey notes, as well as maximum depth and average width and stream velocity all provide evidence of a clear decrease in available fish habitat compared to 2022 (Tables 8-2 and 8-3; Appendix E). Whether or not this is in fact an unusually low year remains to be seen as this data has only been consistently collected for the past two years.

Table 8-1. Ranking criteria for fish habitat monitoring

Overall Fish Habitat Quality	
Rank	**Criteria**
Poor	The necessary physical/biological components for healthy fish habitat at all life stages are missing or severely defficient
Fair	Some of the necessary physical/biological components for healthy fish habitat are present, but some important components are missing or defficient
Good	All of the necessary physical/biological components for healthy fish habitat are present at the monitoring site.

Table 8-2. Changes in wetted surface area of stream by site 2022 vs 2023.

Stream	2022 Wetted area m2	2023 Wetted area m2	% Reduction
21 Mile Creek	1124	768	32%
Jordan Creek	212	200	5%
River of Golden Dreams U/S	945	560	41%
River of Golden Dreams D/S	1359	945	30%
Crabapple Ck	92	87	5%
Whistler Ck	295	232	21%
Total All Sites	**4027**	**2793**	**31%**

Table 8-3. Changes in average stream depth and average stream velocity by site 2022 vs 2023.

Stream	2022 Avg depth (m)	2023 Avg depth (m)	Reduction (m)	2022 Avg vel m/sec.	2023 Avg vel m/sec.	Reduction (m)
21 Mile Creek	0.31	0.18	-0.13	0.85	0.24	-0.61
Jordan Creek	0.55	0.37	-0.19	0.21	0.16	-0.05
ROGD U/S	0.32	0.26	-0.06	0.90	0.27	-0.64
ROGD D/S	0.73	0.39	-0.33	0.44	0.10	-0.34
Crabapple Ck	0.15	0.17	0.02	0.14	0.20	0.06
Whistler Ck	0.24	0.20	-0.05	0.67	0.29	-0.37

8.2 Population Estimates for Adult Rainbow Trout and Kokanee

8.2.1 Introduction

In 2022 adult escapement observations for Rainbow Trout for the years 2011-2021 and Kokanee data for 2017 was provided by the RMOW. The intent of examining this data was to determine if it could be realistically applied to a standard estimator of escapement (defined in this case as the number of adult fish that enter local rivers to spawn), with the goal of providing accurate year-over-year estimates of Rainbow and Kokanee populations. A number of recommendations were made with respect to how the data is collected in order for it to be useful in comparing year over year estimates and to potentially track population trends. Adult spawner surveys in 2023 incorporated a number of the recommendations made in the 2022 report which improved the data and should be able to provide better estimates of adult populations.

8.2.2 Methods adult salmon escapement surveys

In order to assess adult spawning populations in the RMOW area, weekly counts of spawning adult Kokanee salmon were undertaken from August 15, 2023 to October 15, 2023.Counts of adult Rainbow Trout were performed from May 1, 2023 to June 15, 2023. In 2023 surveys were performed on the following streams:

- Kokanee Salmon: ROGD, Crabapple Creek, Whistler Creek, 19 Mile Creek, Blackcomb Creek, 21 Mile and Scotia Creek.
- Rainbow Trout: Crabapple Creek, Whistler Creek, Blackcomb Creek, 21 Mile Creek, Scotia Creek, Write-off Creek, Lakeside Creek Jordan Creek and Millars Creek.

Due to time and budget constraints as well as fish presence, or lack thereof, not all creeks were given the same level of survey effort. For Kokanee adult surveys, only ROGD, Whistler and Crabapple Creek received full, detailed surveys, as they are the creeks with a known and consistent presence of Kokanee spawners which makes it possible to apply these counts to the escapement model. The remaining 5 creeks were surveyed with the intent of only gathering presence/absence information. For Rainbow Trout all streams were surveyed for presence/absence only as Rainbow populations are not able to be analyzed using the escapement model we employed.

Crew members were on opposite sides of the creek and remained in continuous communication with each other to ensure: (a) as many fish as possible were observed, and (b) that duplicate counts of individual fish were avoided. Fish were identified to species and live fish were counted as either holding or actively spawning. Any carcasses observed were identified to species, enumerated and placed above the high-water mark to avoid counting more than once. Surveyors used appropriate gear including a wide brim hat, polarized sunglasses, chest waders, and wading staff. Surveyors noted the date and the start and end time of the survey. The weather conditions were recorded and any rain was noted at the time of the survey.

Beginning in 2023, the survey crew also began collecting more quantitative water visibility data. To index water visibility for each section during each survey, a wading staff, clearly marked at 5cm intervals, is placed in the water column, and the depth at which the tip of the staff is no longer visible is recorded. Measurements can be taken at permanently marked locations in each section. Collecting water visibility data each year allows for the option of incorporating this variable as a predictor of observer efficiency in future escapement models if a significant correlation is found.

An observer efficiency was estimated for each of the stream surveys using this data. The observer efficiency is a qualitative assessment based on flow conditions and water clarity and provides an estimated efficiency for the days count. For example, an observer efficiency of 75% estimates that 75 % of the fish present on that day are counted and the count is expanded by that fraction in the AUC method described in Section 8.2.3.

To account for spawners that are present within the survey area, but not in the main survey section, the spawner survey is extended on at least one occasion each year to include the entire fish accessible length of the stream area; this is termed a “calibration” survey. Data from the complete surveys can then be used to expand counts for surveys that included only the main survey section.

8.2.3 Kokanee Data Analysis and Escapement Estimates

Kokanee adult counts from ROGD, Whistler Creek and Crabapple Creek were applied to an area-under-the-curve analysis (AUC) used to estimate adult escapement for anadromous salmon in small to medium streams. This method is commonly used in surveys of this kind, and is most simply defined as:

Equation 1

$$N = {AUC}/{r \bullet v}$$

Where:
N = total estimated number of individuals in the system
AUC = the “area under the curve”: $A_1 + A_2 + A_3 + \ldots + A_n$
A_n = number of spawners counted for visit n * time between visits
r = estimate of stream residence time or “survey life” during spawning. Defined as the number of days a fish is in the river to spawn, from the moment of entry to death.
v = visibility, an estimate of observer efficiency using a maximum value of 1.0

Results of the escapement estimates are seen in Table 8-3. These estimates were generated using a modified version of the method shown in Equation 1 where r is represented as “survey life” (SL) and follows a slope corresponding to date of entry of spawning fish rather than a fixed value throughout the run. (Korman 2002; Decker and Macnair 2003). This model incorporates research indicating that stream residence times for spawning salmon are not uniform throughout the escapement period. This trend has been noted by a number of studies that demonstrate a pattern of longer residence times for adults entering early in the run, and shorter residence times for those that enter later (Perrin and Irvine 1990, English et al. 1992, Korman et al. 2002). This equation is as follows:

Equation 2

$$S_t = S_{max}\left\{1 - \frac{t}{S_{half} + t}\right\}$$

Where:

S_t = survey life in days for fish entering on day t
S_{max} = maximum survey life possible
S_{half} = the day at which the survey life is half the maximum
S_l = the slope of the relationship

For the example used here, all values input into the model, with the exception of start and end of run timing, and observer efficiency "*v*" are considered to be a "best guess" as there is no local empirical data to use for any of the parameters. For 2023 the value for "*v*" was standardized and collected in the field therefore this data was able to be included in the model. We chose the following values to input into the model, shown below and in Table 9-2:

- "SL" was set at 15 days
- "v" was the observer efficiency, a value between 0.05 and 0.95
- Start of run timing was set at August 15
- End of run timing was set at October 1st

For Equation 2, S_{max} was set as 15 days, S_{half} was set at 30 days (in this case the mid-point in the escapement curve), and the $S_l$was set at 1.0.

8.3 Results and Discussion

For the 2023 Kokanee spawner estimates survey start timing and end of run timing were well defined as there is a confirmed "0" date prior to fish entering the system and a clear "0" end date. As noted, the incorporation of a more rigorous collection of observer efficiency data allowed that value to be used with confidence in the escapement estimate model. Without the ability to collect proper stream specific spawner or survey life data, the value for survey life "SL" was set at 15 days. This length of time was chosen using Kokanee survey life data from other systems where Kokanee spawn in rivers and lakes (Plate and Zimmer 2018, McCarrel 2020). Also provided in Table8-2 are alternate escapement estimates using a different value for SL which demonstrates how sensitive the model is to alterations in the values for SL, though in our examples the escapement estimate was not greatly altered.

Table 8-4. Summary of escapement estimates for Kokanee. Final estimate is the sum of all dAUC values.

Stream	Spawner Estimate	Est. SL 12 Days	Est. SL 18 Days	Peak Count	Peak Count Date	#Days Kokanee Obs. in System
Crabapple Creek	56	47	70	22	2023-09-15	6
Whistler Creek	43	36	54	30	2023-08-22	20
ROGD	51	43	64	37	2023-09-19	2

Using a standard or modified AUC method it was possible to generate an estimate of escapement for Kokanee; however, due to the demonstrated data gaps and missing information, the estimates it generates do lack some precision. As discussed, the predominant issues with the data were addressed with the exception of stream residence time. Variations in run timing, survey timing interval, and stream residence times from year to year can seriously reduce accuracy and consistency of the resulting estimates (Thomas 1982; Perrin and Irvine 1990).

Despite these challenges, and now with better defined end of run timing and a more accurate representation of visibility, the use of this model should make valid year-over-year escapement estimates feasible. Using Kokanee residence time data from other streams to estimate the survey life, “SL” for AUC models is not uncommon, as few program are able to afford the effort and budget required to collect yearly residence time data. We feel the values we are using are at least a reasonable reflection of residence time for Kokanee Salmon in the creeks surveyed.

Though these improvements have made the AUC model more viable, they could not replace a mark-recapture program that could much more precisely estimate critical variables of survey life and observer efficiency. However, depending on a programs goal, an exact population value might be unnecessary, as trend monitoring using indexes of abundance are usually more logistically feasible with limited resources (Caughly 1977).

9.3.1 Rainbow Trout

Adult Rainbow Trout escapement data was provided by the RMOW for the years 2011-2023. Data included weekly – twice monthly counts of spawning Rainbow Trout for 9 creeks: Write-off, Jordan, Lakeside, Scotia, Millar, Crabapple, Gonzales, Whistler, and Blackcomb. Rainbow Trout spawner stream counts by RMOW staff provided information on the cumulative number of spawners observed, number of surveys, as well as the yearly peak count and Catch Per Unit Effort (CPUE) determination (Table 8-3).

Unfortunately, it is not possible to calculate a population estimate from the data provided. AUC estimates are not appropriate for resident Rainbow Trout as they do not have the die-off associated with Kokanee or other sea-run Pacific salmon. Accurate annual estimates of resident Rainbow Trout populations require some form of extensive, annual mark-recapture program, or more intensive options such as electronic stream counters or fish fences (Cousens et al. 1982). Current survey methods using peak counts, a CPUE or possibly adults per stream kilometre are suitable for representing a yearly index of abundance. Changes made in 2023 to the adult Rainbow survey protocol based on recommendations in last year’s report should enable rainbow spawner data to be used as a yearly index of abundance.

The Rainbow Trout spawner counts presented in Table 8-4 have a few inefficiencies that should be noted when considering the data. The main issue is the fact that the number of surveys completed each year for each creek are wildly inconsistent. For example, Jordan Creek, the only site that has data for the entire 2011-2021 period, has yearly survey efforts ranging from 1 to 22 days. With the collection of data using more rigorous and consistent methods since 2022, there can be improved confidence in annual comparisons of Rainbow Trout spawners. Although we cannot use quantitative population modelling on indices, it may be that an index of abundance is sufficient for the goals of the monitoring program.

Table 8-5 Showing peak count, data for Rainbow Trout spawner surveys 2011-2023

	Write-off Creek	Jordan Creek	Whistler Creek	Crabapple Creek	River of Golden Dreams	Blackcomb Creek	Scotia Creek	Millars Creek	Lakeside Creek
2023	**9**	**20**	**0**	**52**	**NS**	**6**	**31**	**7**	**106**
2022									
2021	8	2	0	20	NS	NS	NS	NS	21
2020	14	4	0	34	6	9	0	2	18
2019	0	4	NS	36	0	NS	NS	4	NS
2018	0	11	0	15	0	0	0	0	15
2017	0	5	0	28	0	2	1	0	43
2016	NA	14	NS	NS	15	NA	6	NA	5
2015	0	21	0	20	0	2	5	NS	8
2014	0	21	0	20	0	0	5	NS	46
2013	NS	8	0	9	NS	NS	NS	NS	NS
2012	0	7	0	NS	NS	NS	NS	0	NS
2011	0	15	0	13	2	NS	NS	NS	NS
Average	**3.1**	**11.0**	**0.0**	**24.7**	**2.9**	**3.2**	**6.9**	**2.2**	**32.8**

8.4 Recommendations

1. Continue with stream temperature data collection on as many creeks as possible. Consider expanding temperature monitoring to include Whistler Creek and others, as well as supporting collecting more temperature profile data on Nita Lake. This information should be considered critical with respect to monitoring Bull Trout and Kokanee habitat. Bull Trout population vulnerability may depend on the extent to which climate effects can be at least partially offset by managing factors such as reproductive habitat protection and maintenance of suitable stream and lake temperatures.
2. Rainbow Trout populations are likely the most well-adapted to any landscape and climate changes in the Whistler area, plus they are regularly stocked in local lakes and streams, therefore if resources are put into monitoring adult or spawning populations, it is recommended that Kokanee and Bull Trout be the focus. These species are the most sensitive to shifts in climate and landscape change in the area and there is a lack of good information about the distribution of Bull Trout within the RMOW. Available information on spawning, distribution, age class and Bull Trout type is spotty and very little is available, particularly for the last 10 years.
3. Continue to collect and refine data on observer efficiency and water clarity in order to increase reliability and consistency of Kokanee spawner surveys. Clearly define what portion of the stream is being surveyed and establish a well-defined survey length for each creek. Collect Kokanee data so that it can continue to be used in the AUC model in order to be able to track any trends.
4. Aside from the Jordan Creek temperature issue, all water quality characteristics examined continue to be in a healthy range for coastal streams in respect to the protection of aquatic life. Continued annual monitoring to track water quality is recommended. Continue to collect yearly baseline fish habitat data as it has proved valuable for tracking changes in available fish habitat as well as support ongoing monitoring of landscape and climate change impacts on aquatic habitat within the RMOW area.

9. Climate Indicators

Key Takeaways

Alta Lake: Trending to a shorter duration of Ice

Twenty-One Mile Creek Depths: Trending to lower minimums of longer duration

1. An incomplete record of dates for ice-on (freezing) and ice-off (thawing) on Alta Lake was analyzed for two periods: early (1942 to 1976) and recent (2001 to 2023).
2. The average duration of ice on Alta Lake has been almost one month (27 days) shorter in recent years than in the mid-1900s.
3. Earlier melting in spring has been the strongest contributor to the shortening the duration of ice, a result consistent with warming summer temperatures caused by climate change.
4. Depths in Twenty-One Mile Creek recorded by Karl Ricker since 2001 show a clear trend towards more prolonged periods of low water that are now below 0 cm on the water gauge for approximately one-third of all readings.
5. The negative impacts of lower flows in the River of Golden Dreams are mitigated by beaver dams downstream of the gauge that raise water levels.
6. The Twenty-one Mile Creek depth gauge should be replaced since it was not designed to measure depths <0 cm.

9.1 Alta Lake Ice-On and Ice-Off Dates

Data Source: Stephen Vogler, The Point Artist-Run Centre[18]

The timing and duration of ice on Alta Lake was introduced as a climate indicator in this program in 2013 (Cascade 2014). The discontinuous dataset includes at least one record (ice on and/or ice-off) for a total of 33 winters between 1942-43 and 1975-76 ("early years"), and 21 winters since 2001 ("recent years"). Although the data is incomplete, some trends can be seen (Table 9-1):

1. There is a clear trend in recent years towards a shorter duration of ice on Alta Lake.
2. On average, Alta Lake freezes seven days later in recent years (averaging December 19th versus December 12th in the early years).
3. The lake thaws an average of 17 days earlier for the corresponding periods (April 5th vs. April 22nd).
4. The resulting duration of ice on Alta Lake has shortened by 27 days in recent years.
5. The minimum duration of ice in recent years is 30 days shorter than in the early years, while the maximum duration is 22 days shorter.

All five of these trends lead to the same conclusions – that in recent years, Alta Lake usually freezes later and melts earlier than during the years from 1942 to 1976.

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[18] *Annual data has been supplied by Stephen Vogler, most recently via email to Bob Brett on February 27, 2024.*

Table 9-1. Summary of available ice records from Alta Lake.

		Early (1942-1976)		Recent (2001-2023)		Recent vs. Early
		Date	Day Count	Date	Day Count	Records
Ice-On	No. of Records	n/a	31	n/a	16	19 records fewer
	Earliest	1945-11-08	312	2006-11-30	334	22 days later
	Latest	1970-01-15	380	2006-01-06	371	9 days earlier
	Median	Dec. 12th	346	Dec. 21st	353	9 days later
	Average	Dec. 12th	346	Dec. 19th	353	7 days later
Ice-Off	No. of Records	n/a	31	n/a	21	13 records fewer
	Earliest	1963-03-23	82	2015-02-20	51	31 days earlier
	Latest	1952-05-21	142	2008-04-29	120	22 days earlier
	Median	April 22nd	113	April 10th	100	12 days earlier
	Average	April 22nd	113	April 5th	97	17 days earlier
Days Frozen	No. of Records	29		15		17 records fewer
	Median	133		110		24 days shorter
	Average	134		110		27 days shorter
	Minimum	81		51		30 days shorter
	Maximum	163		141		22 days shorter

Notes: No records are available for winters from 1976/77 through 2000/01. Ice-on and ice-off dates were not recorded for all years; days frozen was calculated only for those years in which both were recorded.

These observations should be considered within the context of the incomplete and noisy data, especially since 2001 (Figure 9-1). The duration of freezing was relatively consistent in the early years – ice on Alta Lake lasted from 120 to 160 in all but five of the 29 years. While the average duration in the recent period is clearly shorter (Table 9-1), it is also much more variable. Combined with the lack of records for years in the intervening period, this variability precludes the meaningful use of statistical analysis (e.g., regression) to detect trends.

Even taking this variability into account, a scatterplot of ice duration (Figure 9-1) nonetheless shows the clear trend towards a shorter duration of ice on Alta Lake. Consistent with this observation, nine of 11 years in which Alta Lake remained frozen for more than 140 days occurred in the early years, and all but three of the years with the shortest duration of ice occurred in recent years.

Digging deeper into this data, it turns out that earlier thawing (in spring) is much more of a factor than later freezing (in fall) when explaining why ice duration has shortened in recent years (Figure 9-2). Ice-on (freezing) dates have remained comparatively stable in recent years compared to early years. Meanwhile, ice-off (thawing dates) are noticeably earlier. And while the ice-on date has been relatively stable and within a similar range in the two reporting periods (usually occurring in December or early January), the ice-off date in recent years is clearly earlier. These records indicate that the main change in Whistler's winters has been earlier (warmer) springs rather than late winters, at least in the valleybottom.

Although Alta Lake records are not on their own enough to conclude with certainty that Whistler's climate has warmed since the mid-1900s, the warming trends they reveal are consistent with other local observations, notably the rapid retreat of local glaciers in that period. In addition, the fact that Alta Lake appears to be melting earlier in the spring may be related to the overall trend towards a longer, warmer summer which has resulted in more evidence of climate change in summer months than in winter months.[19]

[19] For example, Arthur DeJong's analysis of glacier data and temperatures on Whistler Mountain showed that rising overnight temperatures in the summer were the main cause of glacial recession (personal communication with B. Brett).

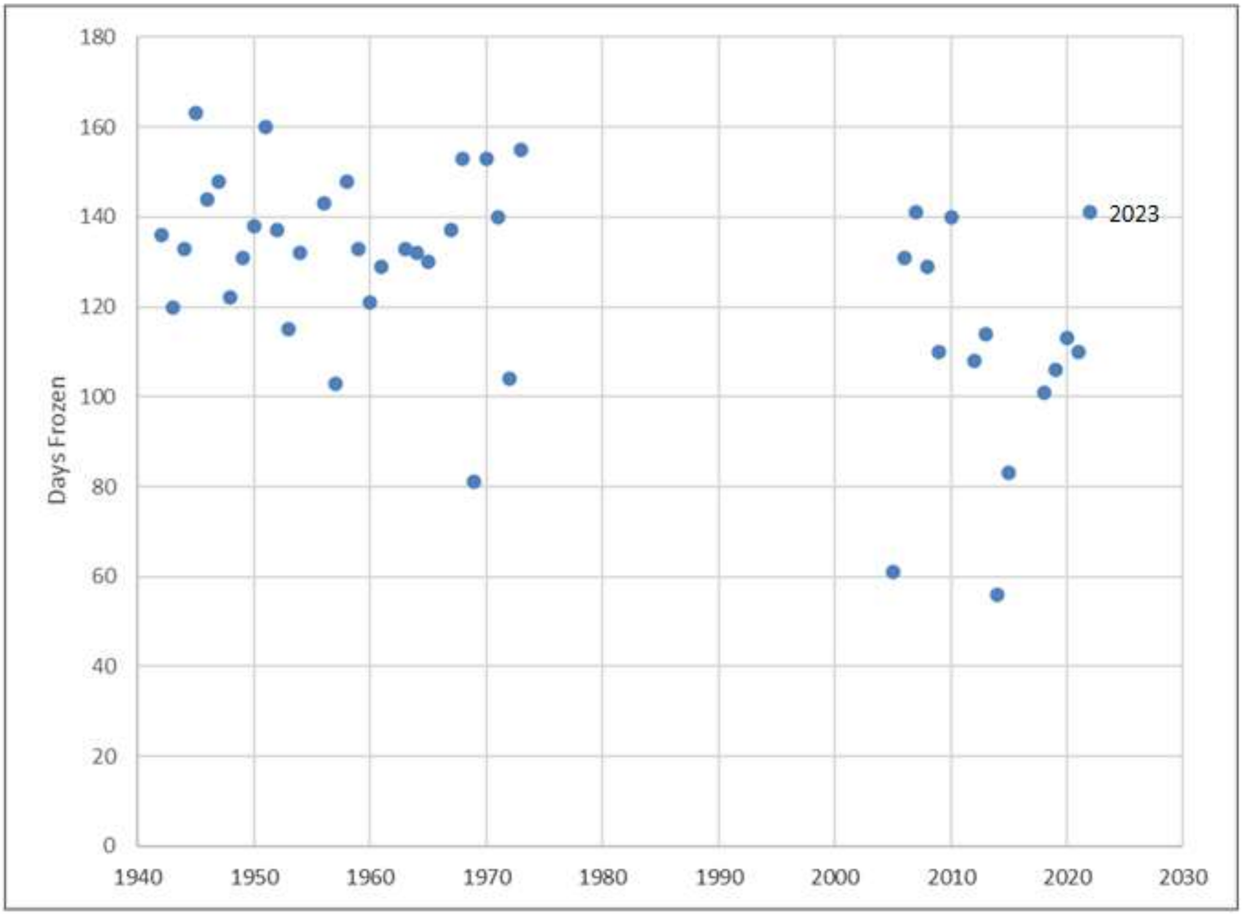

Figure 9-1. Number of days Alta Lake was frozen, 1942/43 to 1975/76 and 2000/01 to 2021/22.

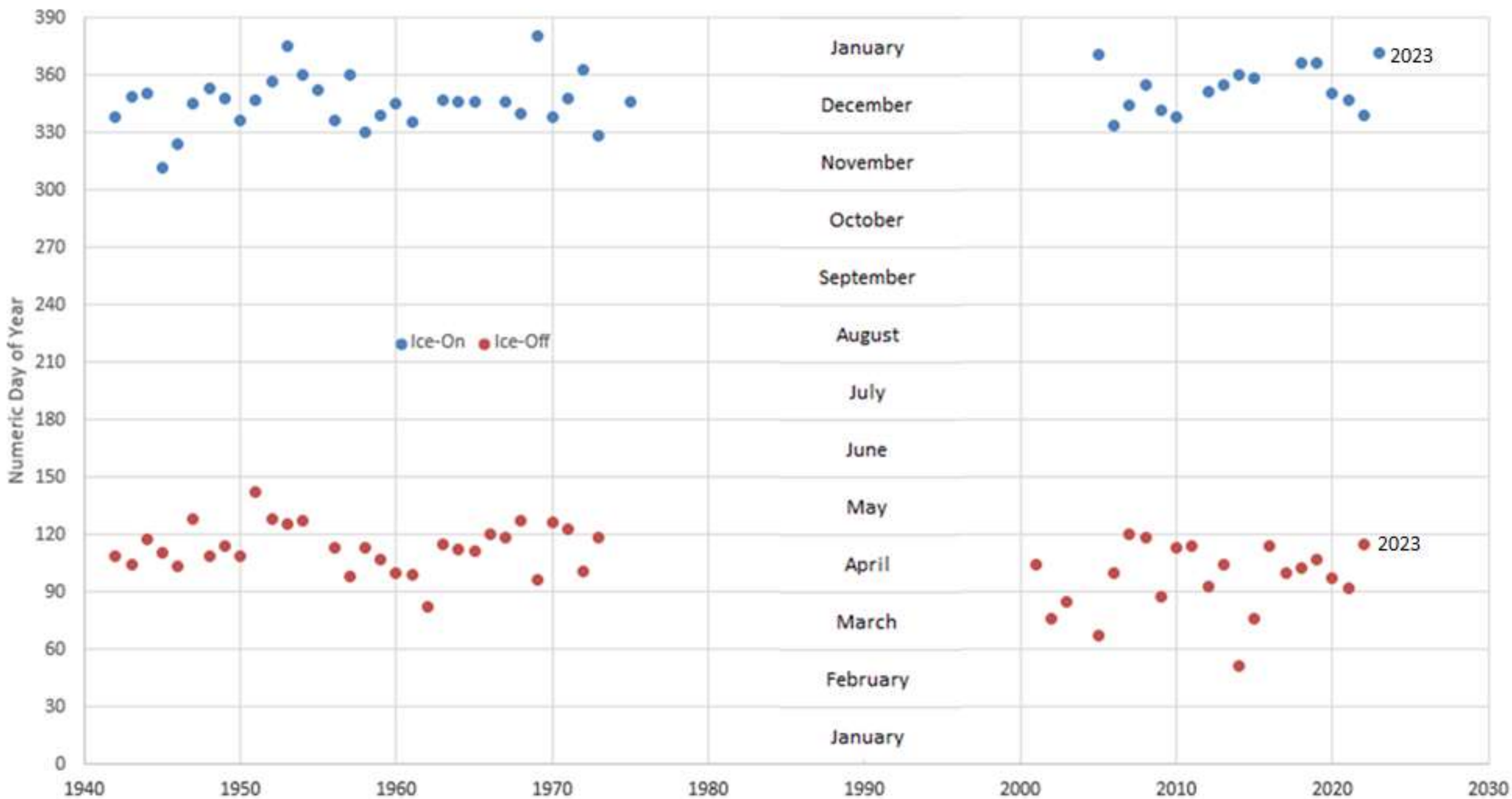

Figure 9-2. Alta Lake Ice-on (top) and ice-off (bottom) by numeric day of year.

9.2 Twenty-one Mile Creek Depths

9.2.1 Introduction

Karl Ricker has recorded depths on the Twenty-One Mile Creek gauge intermittently since December 1, 2001 (Photo 9-1). In fall 2022, he first provided his hand-written notes for data entry and analysis. The dataset now includes 1,554 records spanning 23 years from December 1, 2001 to November 30, 2023 (Table 9-2). While the number of records per year and their timing is inconsistent, there are generally more records for ice-free months and for more recent years. The main goal in analyzing this dataset for the 2022 report was to investigate whether the prolonged drought from July to October 2022 caused unusually low water levels.

Photo 9-1. Since December 2001, Karl Ricker has been recording the depth of Twenty-One Mile Creek just upstream of its confluence with the outflow from Alta Lake.

Table 9-2. Number of records per year.

Year	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Records	4	84	78	62	65	57	54	34	27	43	53	42	26	36	20	30	36	28	52	163	183	183	194

9.2.3 Results and Discussion

A simple scatterplot of depths (Figure 9-2) shows:

1. No clear trend in data between 2001 and 2019.
2. An emerging and strengthening trend towards lower minimum depths and more prolonged depths near or below 0 cm (e.g., the negative readings at the gauge shown in Photo 9-1).
3. This is the second year in a row with a record minimum depth (-0.18 m on September 9th).

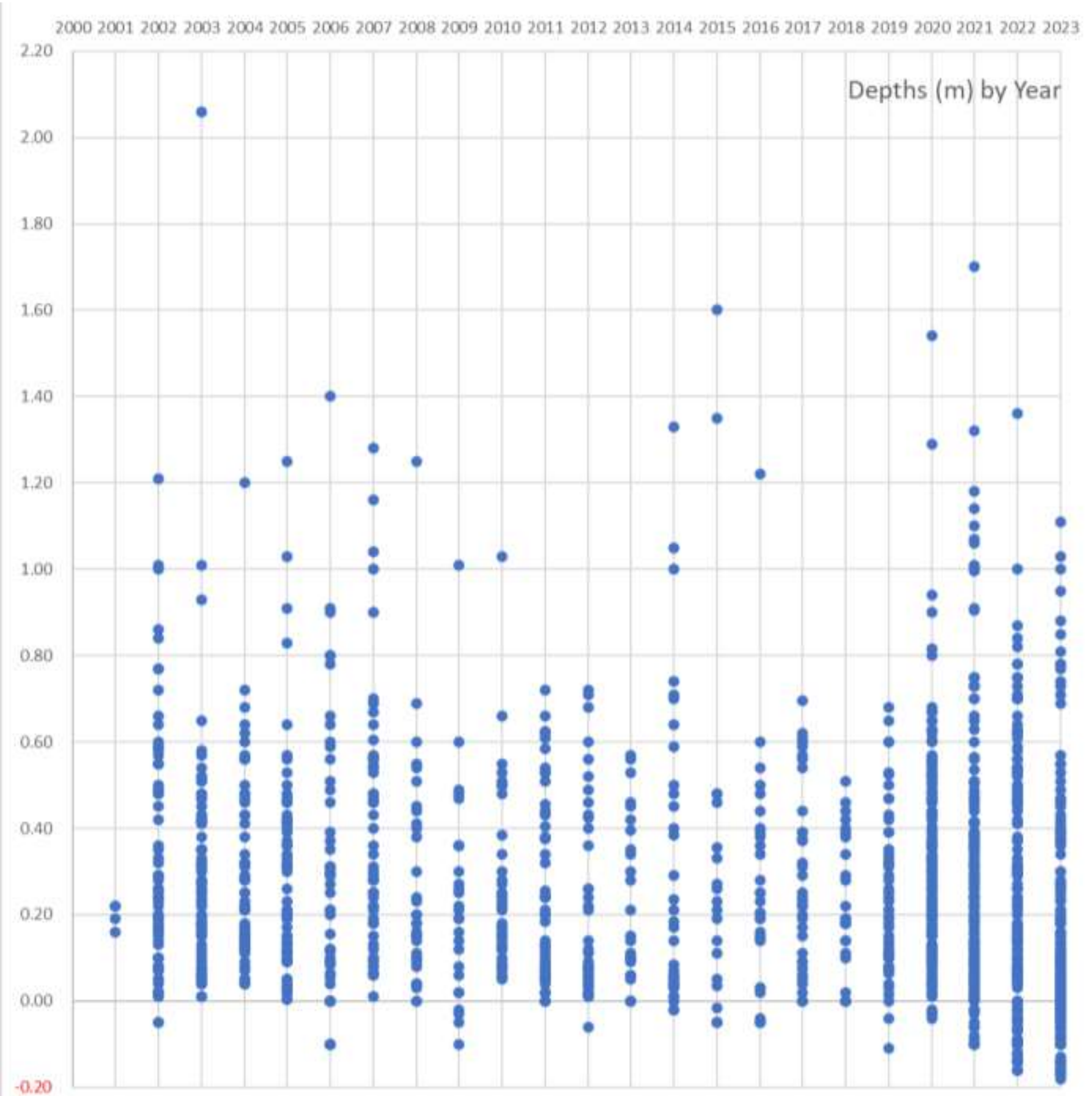

Figure 9-3.` Twenty-One Mile Creek depths (m) since December 1, 2001. The 2001 data is not included in this analysis since there are only four records. Source: Karl Ricker.

The observations above are corroborated by a summary of the dataset by year (Table 9-3): While the dataset is not consistent due to fewer records in the past, it reveals a number of clear trends:

1. It is only in the past two years that readings below 0 cm have become common. In 2023, 34% of readings were below 0 cm, with the most readings and highest percentage of records below zero. The number and percentage (62%) of days below 10 cm was also the highest on record.
2. The longest consecutive periods with negative depths were in 2023 (59 days), 2022 (53 days), and 2021 (39 days).
3. The lowest maximum depth yet recorded was -0.18 m (September 9, 2023).
4. Negative depths were recorded in only half (11 out 22) of the years in the dataset.
5. The lowest depths mostly occur between late August and early October, which coincides with some fish spawning windows.

Table 9-3. Summary of lowest depths in Twenty-One Mile Creek since 2001.

		Consecutive Days <0 cm			Mininum Depth					
Year	Rec-ords	Start Date of <0 cm	End Date of <0 cm	No. Days	Depth (cm)	Date(s)	Days <0cm	%Days <0cm	Days <10cm	%Days <10cm
2001	4	n/a		0	0.16	10-Dec-01	0	0%	0	0%
2002	84	20-Oct-02	05-Nov-02	17	-0.05	Oct 30 - Nov 5	2	2%	2	31%
2003	78	n/a		0	0.04	Sept 24 - Sept 25	0	0%	0	17%
2004	62	n/a		0	0.04	Oct 4	0	0%	0	13%
2005	65	n/a		0	0.01	Aug 23 - Aug 29	0	0%	0	17%
2006	57	18-Aug-06	13-Sep-06	26	-0.10	Aug 18 - Sept 13	6	11%	12	39%
2007	54	25-Sep-07	25-Sep-07	1	0.01	25-Sep-07	0	0%	0	13%
2008	34	26-Sep-08	26-Sep-08	1	0.04	26-Sep-08	0	0%	0	24%
2009	27	22-Aug-09	25-Sep-09	35	-0.10	10-Oct-09	4	15%	5	30%
2010	43	n/a		0	0.05	20-Oct-10	0	0%	0	19%
2011	53	n/a		0	0.07	08-Sep-11	0	0%	0	40%
2012	42	06-Oct-12	06-Oct-12	1	-0.06	06-Oct-12	1	2%	1	52%
2013	26	n/a		0	0.06	Sept 3 and Oct 26	0	0%	0	31%
2014	36	11-Sep-14	22-Sep-14	12	-0.02	Sept 11 - Sept 22	2	6%	2	47%
2015	20	01-Aug-15	21-Aug-15	21	-0.05	Aug 1 - Aug 15	4	20%	4	30%
2016	30	26-Aug-16	06-Oct-16	42	-0.05	Aug 26 - Oct 6	4	13%	4	23%
2017	36	n/a		0	0.00	Sept 5 - Oct 7	0	0%	0	28%
2018	28	n/a		0	0.00	Oct 20 - Oct 23	0	0%	0	25%
2019	52	07-Sep-19	10-Sep-19	4	-0.11	10-Sep-19	2	4%	3	21%
2020	163	10-Sep-20	18-Sep-20	9	-0.04	Sept 10 - Sept 18	4	2%	4	16%
2021	183	05-Aug-21	12-Sep-21	39	-0.10	Sept 4 - Sept 9	14	8%	18	31%
2022	183	06-Sep-22	28-Oct-22	53	-0.16	Sept 23 - Sept 25	46	25%	74	43%
2023	194	28-Jul-23	25-Sep-23	59	-0.18	09-Sep-23	65	34%	88	62%

Average and median depths also tell the same story, that is, that 2023 continued the trend of less water on average at the Twenty-one Mile Creek gauge. (Table 9-4).

Table 9-4. Average and median depths in Twenty-One Mile Creek since 2001.

Year	Records	Avg (m)	Median (m)
2001	4	0.20	0.20
2002	84	0.29	0.07
2003	78	0.31	0.26
2004	62	0.29	0.21
2005	65	0.29	0.21
2006	57	0.26	0.16
2007	54	0.40	0.30
2008	34	0.27	0.18
2009	27	0.24	0.21
2010	43	0.26	0.18
2011	53	0.24	0.13
2012	42	0.21	0.08
2013	26	0.22	0.14
2014	36	0.30	0.14
2015	20	0.32	0.21
2016	30	0.26	0.21
2017	36	0.28	0.23
2018	28	0.21	0.18
2019	52	0.25	0.21
2020	163	0.31	0.29
2021	183	0.29	0.22
2022	183	0.21	0.10
2023	194	0.13	0.05

9.2.4 Stream Depths, Beavers, and Fish Habitat

The section of the River of Golden Dreams downstream of the depth gauge in Photo 9-1 is probably the shallowest part of that system. The reason why water levels are generally higher downstream is due to beaver dams (Section 2).

Overall, the trends described in this report and elsewhere show that climate change is impacting Whistler's habitats in various ways, including a reduction in summer stream flow and a consequent warmer of water. Observations in 2022 (Snowline 2022) showed that beaver dams more than offset the negative impacts of the drought conditions that appear to be more common and last longer.

There is a clear interaction between beavers, climate change, stream depth and warming, fish habitat, recreation, and water storage. The simple depth measurements done on a volunteer basis by Karl Ricker for more than 20 years provide valuable information that helps highlight and quantify the issue of lower water levels. His measurements have been hampered somewhat by a depth gauge that was not designed for negative water levels. It would therefore be helpful if the depth gauge were replaced.

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Appendix A: Beaver Surveys, 2017 to 2023

Map Label	Easting	Northing	2023 Status	2022 Status	2021 Status	2020 Status	2019 Status	2018 Status	2017 Status
Alpha Lk Dam 1	499157	5549046	Inactive	Active	Active	Active	Active	Active	NR
Alpha Lk Lodge 1	499208	5549034	Active	Active	Active	Active	Active	Active	NR
Alpha Lk Lodge 2	499970	5549027	Inactive?	Inactive?	Inactive?	Active	Active	Active	Active
Alpha Lk Lodge 3	499214	5548991	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	NR
Alpha Lk Lodge 4	499172	5549048	Inactive	Inactive	Inactive	Active	Active	Active	NR
Alpha Lk Lodge 5	499913	5548986	Active?	Active?	Active?	NR	NR	NR	NR
Alpha Lk Lodge 6	499861	5548981	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	NR
Alta Lake Lodge 1	500934	5550767	Inactive?	Active?	Active	NR	NR	NR	NR
Alta Lake Lodge 2	500919	5550750	Active	Active	Active	NR	NR	NR	NR
Alta Lake Lodge 3	500906	5550670	ND	Inactive	Active?	NR	NR	NR	NR
Alta Lake Lodge 4	500954	5550790	ND	Inactive	Inactive?	NR	NR	NR	NR
Alta Vista Dam 1	501471	5550344	Active?	Active?	Active	Active	Active	Active	Active
Alta Vista Dam 2	501495	5550399	Active?	Active?	Active	Active	Active	NR	NR
Alta Vista Lodge 1	501458	5550235	Active	Active	Active?	Active	Active	Active	Active
Alta Vista Lodge 2	501544	5550444	Inactive	Inactive?	Inactive?	Inactive	NR	NR	NR
Alta Vista Lodge 3	501552	5550477	ND	Inactive	Inactive	Inactive	NR	NR	NR
Beaver Lk Lodge 1	500012	5550828	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Beaver Lk Lodge 2	500012	5550802	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Beaver Lk Lodge 3	500027	5550773	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Beaver Lk Lodge 4	500072	5550831	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Bottomless Lodge 1	500774	5549695	Inactive	Inactive	Inactive	Inactive	Inactive?	Inactive	Inactive
Buckhorn Dam 1	502412	5554235	Active	Active?	Active?	Active?	Active?	Active	NR
Call North Lodge 1	492923	5546160	Active	Active	Active?	NR	NR	NR	NR
Call North Lodge 2	492974	5546193	Active	Active	NR	NR	NR	NR	NR
CGC-02 Dam 1	504575	5552349	Active	Active?	Active	Inactive	Inactive	Inactive	Active
CGC-02 Lodge 1	504612	5552324	Inactive	Inactive?	Inactive	Inactive	Inactive?	Inactive?	Active
CGC-18 Dam 1	504205	5552210	Active	Active	Active	Active	Active	Inactive	Inactive?
CGC-18 Dam 2	504199	5552217	Active	Active	Inactive	NR	NR	NR	NR
CGC-18 Lodge 1	504228	5552240	Active	Active	Active	Active	NR	NR	NR
CGC-18 Lodge 2	504181	5552219	Inactive?	Inactive	Active?	Inactive	Inactive	Summer?	Summer?
CGC-18 Lodge 3	504184	5552221	Active	Active	Inactive	Inactive	Inactive	Inactive	Inactive
CGC-18 Lodge 4	504245	5552249	Inactive	Inactive	Inactive	Inactive	Inactive?	NR	NR
Cheak Cross - Lodge?	496833	5547905	Probable	Probable	NR	NR	NR	NR	NR
Cheak River Dam 1	494378	5547059	Active	Active	Active	Active?	Active?	Active?	Active?
Cheak River Lodge 1	494378	5547059	Active	Active	Active	Active?	Active?	Active?	Active?
Eva Lake	501094	5549975	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Fitz Back Burrow 1	504142	5554607	Active	Active	Active	Active	NR	NR	NR
Fitz Back Dam 1	504144	5554608	Active	Active	Active	Active	NR	NR	NR
Fitz Back Lodge 1	504212	5554643	Inactive	Inactive	Inactive	Inactive	Inactive?	Active	NR
Fitz Fan Lodge 1	503847	5554866	Active?	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Fitz Pond Dam 1	503354	5552674	Active	Active	Active	Active	Active	NR	NR
Fitz Pond Dam 2	503354	5552674	Active	Active	Active	Active	NR	NR	NR
Fitz Pond Lodge 1	503275	5552571	Active	Active	Active	Inactive?	Active	Active	NR
Fitz Pond Lodge 2	503300	5552575	Active	Active?	Active	Inactive	Inactive	NR	NR
Fitz Pond Lodge 3	503287	5552516	Active	Active	NR	NR	NR	NR	NR
Fitz Pond Lodge 4	503274	5552521	Inactive?	ND	ND	ND	ND	ND	ND
Green Lake Lodge 1	503740	5554600	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Active
Lost Lake Lodge 1	504337	5553160	Active	Inactive?	Active	NR	NR	NR	NR
Lost Lake Lodge 2	504333	5553154	Inactive	Inactive	Inactive?	NR	NR	NR	NR
Lost Lake Lodge 3	504458	5552740	Inactive?	Inactive?	Inactive?	Active	Active	Active	Unknown
Millar Cr Dam 1	496855	5548395	Active	Inactive?	Active	Active	NR	NR	NR
Millar Cr Dam 2	496809	5548372	Inactive?	Active?	Active	Active	Active	NR	NR

Millar Cr Lodge 1	496821	5548379	Inactive?	Active	Active	Active	NR	NR	NR
Millar Cr Lodge 2	496812	5548373	Inactive	Inactive?	Active	Active?	NR	NR	NR
Millar Cr Lodge 3	496888	5548391	ND	Inactive	Inactive	Inactive	NR	NR	NR
Millars Pond	499405	5548341	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
MW1-1 Dam	497622	5548431	Active	Active?	Active?	Active	NR	NR	NR
MW1-1 Lodge	497706	5548388	Active	Active	Active	Active	Active	Active	NR
MW1-2 Dam	497649	5548401	Active	Active	Active?	Active	NR	NR	NR
MW1-2 Lodge	497737	5548390	Active?	Active	Active	Active	NR	NR	NR
MW1-3 Dam	497674	5548378	Active?	Active	NR	NR	NR	NR	NR
MW1-3 Lodge	497796	5548408	Active?	Active	Active?	Active	Active	Active	NR
MW1-4 Lodge	497818	5548447	Inactive	Inactive?	Inactive?	Inactive	Active	Inactive	NR
MW1-5 Dam	497778	5548405	Active?	Active	Active	Active	NR	NR	NR
MW1-5 Lodge	497816	5548424	Inactive?	NR	NR	NR	NR	NR	NR
MW1-6 Dam	497839	5548459	Active?	Active	Active	Active	NR	NR	NR
MW1-6 Lodge	497830	5548471	Inactive?	NR	NR	NR	NR	NR	NR
MW2-1 Burrow	497803	5548350	Inactive?	Inactive?	NR	NR	NR	NR	NR
MW2-1 Dam	497758	5548358	Active	Active	NR	NR	NR	NR	NR
MW2-2 Dam	497759	5548384	Active	Active	NR	NR	NR	NR	NR
MW3-1 Lodge	497931	5548588	Inactive?	Active	Active?	Active	Inactive	NR	NR
MW4-1 Dam	498156	5548703	Active	ND	ND	Inactive	NR	NR	NR
MW4-1 Lodge	498156	5548764	Active	Inactive?	Inactive?	Active?	Active?	NR	NR
MW4-2 Dam	498169	5548719	Active	ND	ND	Inactive	NR	NR	NR
MW4-2 Lodge	498146	5548795	Inactive?	Inactive?	Inactive	Inactive	Inactive	NR	NR
MW4-3 Dam	498168	5548759	Active	ND	flooded	Active	NR	NR	NR
MW5-1 Dam	498083	5548812	Active?	Active	NR	NR	NR	NR	NR
MW5-1 Lodge	498270	5548912	Inactive?	Active?	Active	NR	NR	NR	NR
MW5-2 Dam	498143	5548844	Active	Active	NR	NR	NR	NR	NR
MW5-2 Lodge	498284	5548908	Active	Active	Active	Active	Active	Inactive?	NR
MW5-3 Dam	498201	5548886	Active	Active	NR	NR	NR	NR	NR
MW5-3 Lodge	498222	5548860	Active?	NR	NR	NR	NR	NR	NR
MW5-4 Lodge	498223	5548877	Active?	NR	NR	NR	NR	NR	NR
MW6-1 Dam	498371	5548896	Inactive	Inactive	Inactive	Active	Active	NR	NR
MW6-1 Lodge	498321	5548863	Active	Active?	Active?	Active	Active	NR	NR
MW6-2 Lodge	498328	5548894	Active	Active	Active	Active	Active	NR	NR
MW6-3 Lodge	498398	5548903	Inactive	Active	Active	Active	Active	NR	NR
MW6-4 Lodge	498341	5548914	Active?	NR	NR	NR	NR	NR	NR
MW7-1 Lodge	498334	5548715	Active?	NR	NR	NR	NR	NR	NR
MW7-2 Lodge	498341	5548676	Inactive?	NR	NR	NR	NR	NR	NR
MW7-3 Lodge	498422	5548632	Inactive	NR	NR	NR	NR	NR	NR
Nesters Pond	503099	5552852	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Nita Lake Lodge 1	500290	5549772	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
NNCG-15 Lodge	503235	5554601	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
NNGC-10 Lodge	502764	5554086	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
NNGC-12 Lodge	502746	5553748	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Old Mill Dam 1	504321	5553311	Active?	Active	Active	Active	Active	Active	NR
Old Mill Dam 2	504340	5553261	Inactive?	Inactive?	Inactive	Inactive	NR	NR	NR
Old Mill Lodge 1	504223	5553409	Inactive	Inactive	Inactive	NR	NR	NR	NR
Old Mill Lodge 2	504232	5553421	Inactive	Inactive	Inactive	NR	NR	NR	NR
Old Mill Lodge 3?	504238	5553287	Inactive	Possible	NR	NR	NR	NR	NR
ROGD 03-1 Lodge	501719	5552450	Active	Active?	NR	NR	NR	NR	NR
ROGD 04-1 Dam	501758	5552522	Inactive	Active	Inactive	Inactive?	Active	Active	Active
ROGD 04-1 Lodge	501744	5552517	Active?	Active	Inactive	Inactive?	Active	Active	Active
ROGD 06-1 Burrow	501840	5552670	Inactive?	Active	Summer?	Summer?	NR	NR	NR
ROGD 10-1 Dam	502144	5553021	Active	NR	NR	NR	NR	NR	NR
ROGD 10-1 Lodge	502120	5553004	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
ROGD 10-1-DS Burrow	502135	5552995	Secondary	NR	NR	NR	NR	NR	NR

ROGD 10-1-US Burrow	502136	5552980	Active?	NR	NR	NR	NR	NR	NR
ROGD 10-2 Lodge	502126	5553026	Active?	Active?	Active	Active?	Active	NR	NR
ROGD 12-1 Dam	502230	5553001	Active	NR	NR	NR	NR	NR	NR
ROGD 14-1 Dam	502226	5553199	Active	NR	NR	NR	NR	NR	NR
ROGD 15-1 Dam	502340	5553225	Active	Active	flooded	Active	Active	NR	NR
ROGD 15-1 Lodge	502302	5553208	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
ROGD 15-2 Lodge	502312	5553204	Active	Active?	Active	Active	Active	NR	NR
ROGD 15-3 Lodge	502327	5553188	Inactive?	Active?	Active	Active	Active	Active	NR
ROGD 15-4 Lodge	502334	5553183	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
ROGD 15-5 Lodge	502349	5553202	Active	Active	Active	Active	Active	Active?	NR
ROGD 15-6 Lodge	502355	5553222	Active	Active?	Active?	Inactive?	Inactive	Inactive	NR
ROGD 17-1 Dam	502340	5553309	Active	Active	flooded	Active	Active	NR	NR
ROGD 17-1 Lodge?	502347	5553288	Possible	Possible	NR	NR	NR	NR	NR
ROGD 21-1 Lodge	502406	5553403	Active	Active	Active	Active	Active	NR	NR
ROGD 21-1-Dam	502421	5553430	Active	Active	flooded	Active	Active	NR	NR
ROGD 21-2 Lodge	502422	5553411	Inactive	NR	NR	NR	NR	NR	NR
ROGD 21-3 Lodge	502428	5553414	Inactive	NR	NR	NR	NR	NR	NR
ROGD 23-1 Dam	502377	5553591	Active	Active	flooded	Active	Active	NR	NR
ROGD 25-1 Dam	502291	5553684	Active	Active	flooded	Active	Active	NR	NR
ROGD 25-1 Lodge	502311	5553661	Active	Active	Active	Active	Inactive	Inactive	NR
ROGD 25-2 Lodge	502308	5553673	Active	Active	Active	Active	Inactive?	Inactive	NR
ROGD 27-1 Dam	502283	5553770	Active	Active	flooded	Active	Active	NR	NR
ROGD 27-1 Lodge	502294	5553771	Inactive	Active?	Active	Active	NR	NR	NR
ROGD 28-1 Dam	502280	5553830	Active	NR	NR	NR	NR	NR	NR
ROGD 28-1 Lodge	502304	5553839	Inactive?	Inactive?	Inactive?	Inactive?	Inactive?	Inactive	NR
ROGD 29-1 Lodge	502376	5553923	Active?	NR	NR	NR	NR	NR	NR
ROGD 30-1 Dam	502429	5553974	Inactive	Inactive?	flooded	Active	Active	NR	NR
ROGD 30-1 Lodge	502544	5554067	Active	NR	NR	NR	NR	NR	NR
ROGD 31-1 Dam	502621	5554167	Inactive	Active?	flooded	Active	Active	NR	NR
ROGD 31-1 Lodge	502497	5554158	Active	Probable	NR	NR	NR	NR	NR
ROGD 32-1 Dam	502439	5554305	Active	Active?	flooded	Active	Active	NR	NR
ROGD 32-1 Lodge	502433	5554240	Active	NR	NR	NR	NR	NR	NR
ROGD 32-2 Dam	502488	5554382	Active	NR	NR	NR	NR	NR	NR
ROGD 35-1 Dam	502898	5554585	Inactive	Active	NR	NR	NR	NR	NR
ROGD 35-1 Lodge	502846	5554565	Active?	Active	Active NR	Active NR	NR	NR	NR
ROGD 37-1 Dam	503032	5554681	Inactive	Inactive	flooded	Active	Active	NR	NR
ROGD 37-1 Lodge	503029	5554719	Inactive	Inactive	Inactive	Inactive	NR	NR	NR
ROGD 37-2 Lodge	503023	5554736	Inactive?	NR	NR	NR	NR	NR	NR
ROGD 38-1 Dam	502996	5554792	Inactive	Inactive	flooded	Active	Active	NR	NR
ROGD 38-1 Lodge	503050	5554860	Inactive	Inactive	Inactive?	Inactive	Inactive	Inactive	NR
ROGD 40-1 Dam	503127	5554905	Inactive	Inactive	flooded	Active	Active	NR	NR
ROGD 40-1 Lodge	503202	5554930	Active?	Inactive	Active?	Active?	Inactive?	NR	NR
ROGD 40-2 Dam	503125	5554906	Inactive	Inactive	flooded	Active	Active	NR	NR
ROGD 41-1 Lodge	503185	5554836	Active	Active	Active	Active	Active	Inactive?	NR
ROGD 41-2 Lodge	503187	5554830	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
RP Lodge 1	501145	5551850	Active	Active	Active?	Active	Inactive	Inactive	Inactive
RP Lodge 2	501118	5551927	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
RW1-1 Dam	501096	5551929	Inactive?	Active?	Active	NR	NR	NR	NR
RW1-1 Lodge	501096	5552182	Active?	Active	Active?	NR	NR	NR	NR
RW2-1 Lodge	501278	5552385	Active?	Inactive?	Inactive?	NR	NR	NR	NR
RW3-1 Lodge	501523	5552527	Probable	Probable	NR	NR	NR	NR	NR
RW4-1 Dam	501718	5552677	Active	Active	NR	NR	NR	NR	NR
RW4-1 Lodge	501702	5552711	Active	Active	Active	NR	NR	NR	NR
RW4-2 Lodge	501694	5552718	Active?	Active?	Active	NR	NR	NR	NR
RW4-Ditch-1 Dam	501780	5552643	Active	Active	Active	NR	NR	NR	NR
RW5-1 Lodge	501848	5552721	Active	Active	Active	NR	NR	NR	NR

RW5-2 Lodge	501848	5552727	Active	Active	Active	Active?	Active	Active	Active
RW5-Ditch-1? Dam	501848	5552696	Active	Active	Active	NR	NR	NR	NR
RW5-Ditch-2? Dam	501898	5552741	Active	Active	Active	Active	Active	Active	Active
RW6-1 Lodge	501777	5552792	Active?	Active?	Active?	Active	NR	NR	NR
RW6-2 Lodge	501790	5552801	Active?	Active?	Active	NR	NR	NR	NR
Spruce Grove Lodge 1	503652	5553307	Inactive	Inactive	Active?	Active	Active	Active	Active
Tennis Club Dam 1	503101	5552253	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Tennis Club Dam 2	503127	5552267	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Tennis Club Lodge 1	503139	5552271	ND	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Wedge Pond Dam 1	503258	5555777	Active	Active?	Inactive?	Active?	Active?	Active?	Active?
Wedge Pond Lodge 1	503156	5555770	Inactive	Inactive	Inactive	NR	NR	NR	NR
Wedge Pond Lodge 2	503176	5555733	Active	Inactive	Inactive	Active	Active	Active	Inactive
Wedge Pond Lodge 3	503121	5555719	Inactive	Inactive	Inactive	NR	NR	NR	NR
Wedge Pond Lodge 4	503233	5555757	Active	NR	NR	NR	NR	NR	NR
Wedge Pond Lodge 5	503150	5555803	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
WGC-10 Lodge 1	502293	5551708	Inactive	Inactive	Inactive	Inactive	Active?	Active	Active
WGC-10 Lodge 2	502290	5551566	Inactive	Inactive	Inactive	Inactive	Inactive?	Active	NR
WGC-15 Lodge 1	502167	5550989	Inactive	Inactive	Inactive	Inactive	Inactive?	Inactive	Inactive
WGC-15 Lodge 2	502346	5551092	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
WGC-15 Lodge 3	502356	5551107	Inactive	Inactive?	Inactive	Inactive	Active?	Active	Active
WGC-5 Lodge 1	502367	5551766	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
WGC-7 Dam 1	502361	5552148	Active	Inactive	Inactive	Inactive?	Active	NR	NR
WGC-7 Lodge 1	502361	5552148	Inactive	Inactive	Inactive	Inactive?	Active	NR	NR
WGC-7 Lodge 2	502347	5552127	Active	NR	NR	NR	NR	NR	NR
Wolverine Lodge 1	501201	5549629	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
WR1-1 Dam	501887	5553000	Inactive	Active	Active?	Active	Active	Active	Active
WR1-1 Lodge	501830	5553068	Inactive	Inactive?	Active?	NR	NR	NR	NR
WR1-2 Dam	501884	5552978	Inactive?	Active?	Active?	Active?	NR	NR	NR
WR3-1 Dam	501713	5553278	Active	Active?	Active	Active	NR	NR	NR
WR3-1 Lodge	501750	5553298	Active	Active?	Active	Active	NR	NR	NR
WR3-2 Lodge	501709	5553226	Active?	Active?	Active	NR	NR	NR	NR
WR3-3 Lodge	501693	5553232	Inactive	Inactive	Inactive	NR	NR	NR	NR
WR4 1-Lodge	501825	5553543	Active	Active?	Active	Active	Active	Active	Active

Appendix B: Northern Goshawk Site Data

Date	Site Location	Site Code	Survey-ors	Tree Species	CWHms1 Unit	Struct. Stage	Tree Ht. (m)	Avg. DBH (cm)	Canopy Closure (%)	Slope Position	Slope (%)	Nesting Plat-forms	Flyways	Under-storey	Habitat Rating
2023-05-16	Danimal Mid	23-DM-01	B.Brett	Hw (FdCwBa)	03	7 (2)	20-26	45	80	Lower	25	2	3	3	2+
2023-05-16	Danimal Mid	23-DM-02	B.Brett	FdHw (Cw)	03	7(6)	20-26	50	60	Middle	30	3+	3	3+	3
2023-05-16	Danimal Mid	23-DM-03	B.Brett	FdHw (Pl)	03 (02)	7	14-20	30	50	Crest	0	1+	2+	3	2
2023-05-16	Danimal Mid	23-DM-04	B.Brett	Hw (FdCw)	01	7	>26	55	80	Middle	10	2+	3	3+	3
2023-05-16	Danimal Mid	23-DM-05	B.Brett	Hw (FdCw)	03	7	20-26	45	80	Middle	50	2	3	2+	2+
2023-05-16	Millar's Pond	MP-1	B.Brett	Fd (Hw)	01(03)	7	20-26	55	60	Middle	20	2.5	3+	3+	3+
2023-05-16	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-05-16	Emerald South	RT-02	B.Brett	Fd (PlPwBl)	03	7	14-20	45	30	Upper	30	2	4	4	2
2023-05-16	Emerald South	RT-03	B.Brett	Fd (HwCwPlBl)	03	3 (7)	14-20	25	25	Upper	10	2	4	3	2
2023-05-16	Emerald South	RT-04	B.Brett	Fd (CwMdHw)	03	4 (5)	14-20	25	50	Middle	30	1+	2+	2+	2
2023-05-17	Comf. Numb - North	23M-CNN-01	B.Brett	HwFd (Cw,Ba)	01	7	>26	55	60	Middle	25	3+	3+	3+	3+
2023-05-17	Comf. Numb - North	23M-CNN-02	B.Brett	HwFd (Cw)	01	7	>26	45	50	Upper	40	3-	3-	3	3-
2023-05-17	Comf. Numb - North	23M-CNN-03	B.Brett	HwFd (Cw,Ba)	01	7	>26	60	50	Middle	15	3	3	3	3
2023-05-18	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-05-25	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-05-25	Emerald South	RT-02	B.Brett	Fd (PlPwBl)	03	7	14-20	45	30	Upper	30	2	4	4	2
2023-05-25	Emerald South	RT-03	B.Brett	Fd (HwCwPlBl)	03	3 (7)	14-20	25	25	Upper	10	2	4	3	2
2023-05-25	Emerald South	RT-04	B.Brett	Fd (CwMdHw)	03	4 (5)	14-20	25	50	Middle	30	1+	2+	2+	2
2023-06-02	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-03	Lower Blackcomb	LB-Ju23-01	B.Brett	HwFd (Ba,Cw)	01	7	>26	NR	NR	Middle	NR	3	3+	3+	3+
2023-06-03	Lower Blackcomb	LB-Ju23-02	B.Brett	HwFd (Ba,Cw)	01	7	>26	NR	NR	Middle	NR	3	3+	3+	3+
2023-06-03	Lower Blackcomb	LB-Ju23-03	B.Brett	HwFd (Ba,Cw)	01	7	>26	NR	NR	Middle	NR	3	3+	3+	3+
2023-06-03	Lower Blackcomb	LB-Ju23-04	B.Brett	HwFd (Ba,Cw)	01	7	>26	55	50	Middle	25	3	4	3+	3+
2023-06-06	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-06	Emerald South	RT-02	B.Brett	Fd (PlPwBl)	03	7	14-20	45	30	Upper	30	2	4	4	2
2023-06-06	Emerald South	RT-03	B.Brett	Fd (HwCwPlBl)	03	3 (7)	14-20	25	25	Upper	10	2	4	3	2
2023-06-06	Emerald South	RT-04	B.Brett	Fd (CwMdHw)	03	4 (5)	14-20	25	50	Middle	30	1+	2+	2+	2
2023-06-12	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-19	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-19	Emerald South	RT-05	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-19	Emerald South	RT-06	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-19	Emerald South	RT-07	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-19	Emerald South	RT-08	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-19	Emerald South	RT-09	B.Brett	Fd (HwPwPlCw)	NR	NR	NR	NR	NR	NR	NR	2+	3+	3+	3
2023-06-20	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-20	Emerald South	RT-10	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-20	Emerald South	RT-11	B.Brett	FdPl	03/02	NR	NR	NR	NR	NR	NR	1+	3+	3+	1+
2023-06-20	Emerald South	RT-12	B.Brett	Fd (PlPw)	03/02	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-20	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+
2023-06-20	Emerald South	RT-07	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-06-27	Emerald South	RT-01	B.Brett	Fd (HwPwPlCw)	03	4 (7)	14-20	20	30	Upper	30	1+	1+	1+	1+

Date	Site Location	Site Code	Survey-ors	Tree Species	CWHms1 Unit	Struct. Stage	Tree Ht. (m)	Avg. DBH (cm)	Canopy Closure (%)	Slope Position	Slope (%)	Nesting Plat-forms	Flyways	Under-storey	Habitat Rating
2023-06-27	Emerald South	RT-13	B.Brett	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2023-07-16	Lower Sproatt	23J-LS-01	B.Brett	Hw (FdCwBa)	03	7 (2)	20-26	45	80	Lower	25	2	3	3	2+
2023-07-16	Lower Sproatt	23J-LS-02	B.Brett	Hw (FdCw)	03	7 (6)	20-26	35	80	Middle	50	2	3	2+	2+
2023-07-16	Lower Sproatt	23J-LS-03	B.Brett	HwFd (Cw)	03	7	>26	45	70	Middle	25	2+	3	3+	3
2023-07-16	Lower Sproatt	23J-LS-04	B.Brett	Hw (FdCw)	03	7 (6)	>26	55	50	Upper	25	2+	3+	3+	3
2023-07-16	Lower Sproatt	23J-LS-05	B.Brett	Fd (CwHw)	01/05	5 (4)	20-26	35	80	Middle	35	1+	1+	2	1+
2023-07-16	Lower Sproatt	23J-LS-06	B.Brett	HwFd (CwBa)	01	7	20-26	45	75	Upper	0	2+	2+	3	2+
2023-07-16	Lower Sproatt	23J-LS-07	B.Brett	HwFd (Cw)	03	7	20-26	50	60	Upper	20	2+	3	3	3
2023-07-16	Lower Sproatt	23J-LS-08	B.Brett	Hw (BaFdCw)	01	7	20-26	40	60	Level	0	2+	3	2+	2+
2023-07-16	Lower Sproatt	23J-LS-09	B.Brett	Fd (HwCwBa)	03/01	7	>26	55	75	Middle	25	3	3+	3+	3
2023-07-16	Lower Sproatt	23J-LS-10	B.Brett	Hw (FdCw)	03	7	>26	50	80	Middle	15	2+	2+	3	2+
2023-07-18	Comf. Numb - North	23J-CNN-01	B.Brett	HwFd (Cw,Ba)	01	7	>26	60	60	Middle	30	3+	3-	3	3+
2023-07-18	Comf. Numb - North	23J-CNN-02	B.Brett	FdHw (CwBa)	01	7	>26	65	40	Upper	50	3	3+	3	3
2023-07-18	Comf. Numb - North	23J-CNN-03	B.Brett	FdHw (CwBa)	01	7	>26	65	60	Middle	25	3+	3+	3	3+
2023-07-18	Comf. Numb - North	23J-CNN-04	B.Brett	FdHw (BaCwPw)	01	7	>26	55	50	Middle	15	2+	2+	2+	2+
2023-07-18	Comf. Numb - South	23J-CNS-01	B.Brett	HwFd (Cw)	03 (01)	7 (6)	20-26	40	60	Level	0	2	2+	2+	2+
2023-07-18	Comf. Numb - South	23J-CNS-02	B.Brett	broadcast only											
2023-07-20	LSD	LSD-01	B.Brett	Hw (FdBaYc)	01 (05)	7	20-26	65	50	Middle	15	3	2+	2+	3-
2023-07-22	Emerald	EM-01	B.Brett	Fd (CwPlHw)	03	5 (7)	<14	25	20	Upper	10	2	4	4	2
2023-07-22	Emerald	EM-02	B.Brett	Fd (PlHwPw)	02	7	14-20	40	25	Crest	10	3-	4	4	2+
2023-07-22	Emerald	EM-03	B.Brett	Fd (PlHw)	02	7 (6)	<14	25	15	Crest	0	2-	3	3	2-
2023-07-22	Emerald	EM-04	B.Brett	Fd (PlCw)	02	7 (6)	14-20	35	15	Crest	0	2+	3	3	2+
2023-07-22	Emerald	EM-05	B.Brett	FdHw (BaPl)	03	7 (6)	14-20	45	30	Crest	0	2+	2+	2+	2+
2023-07-22	Emerald	EM-06	B.Brett	Fd (HwBa)	03	7	14-20	45	45	Crest	0	3	3	3	3
2023-07-22	Emerald	EM-07	B.Brett	HwFdCw(Ba)	01	7	20-26	55	60	Lower	10	3	3	3	3
2023-07-22	Emerald	EM-08	B.Brett	Hw (FdCwBa)	01	7	>26	55	70	Level	0	3	3	3	3
2023-07-22	Emerald	EM-09	B.Brett	broadcast only											
2023-07-22	Emerald	EM-10	B.Brett	FdCwHw	05	7	>26	60	75	Upper	15	3	3	3	3
2023-07-22	Emerald	EM-11	B.Brett	Fd (PlHw)	02	7	20-26	60	20	Upper	35	2+	4	4	2+
2023-07-23	Lower Blackcomb	23J-LB-01	B.Brett	HwFd (BaYcPw)	01	7	20-26	55	75	Middle	25	3+	3+	3+	3
2023-07-23	Lower Blackcomb	23J-LB-02	B.Brett	FdHw (Ba)	01	7	20-26	55	60	Middle	25	3	3	3	3
2023-07-23	Lower Blackcomb	23J-LB-03	B.Brett	HwFdCw (Ba)	01	7	20-26	50	80	Middle	30	3+	3+	3+	3
2023-07-23	Lower Blackcomb	23J-LB-04	B.Brett	HwFdCw (Ba)	01	7	>26	60	75	Middle	30	3+	3	3	3
2023-07-23	Lower Blackcomb	23J-LB-05	B.Brett	HwCwBa	05 (01)	7	20-26	65	60	Middle	20	3	3	3	3
2023-07-23	Lower Blackcomb	23J-LB-06	B.Brett	HwCwBa	01	7	20-26	65	60	Middle	35	2+	3	3	3
2023-07-23	Lower Blackcomb	23J-LB-07	B.Brett	Hw (FdYcBa)	01	7	14-20	40	50	Level	0	2+	3	3	2+
2023-07-23	Lower Blackcomb	23J-LB-08	B.Brett	Hw (FdCwBaYc)	01	7	20-26	55	60	Middle	25	3	3+	3+	3
2023-07-23	Lower Blackcomb	23J-LB-09	B.Brett	HwFd	01	7	>26	50	70	Middle	20	3+	3+	3+	3+
2023-07-23	Lower Blackcomb	23J-LB-10	B.Brett	HwFdCw (Ba)	01	7	>26	55	50	Middle	20	3+	3+	2	3
2023-07-25	Millar's Pond	MP-1	B.Brett	Fd (Hw)	01(03)	7	20-26	55	60	Middle	20	2.5	3+	3+	3+
2023-07-25	Millar's Pond	23J-MP-02	B.Brett	FdHw(Cw,Ba)	01(03)	7	>26	45	70	Upper	20	2	4	4	3
2023-07-25	Millar's Pond	23-MP-03	B.Brett	HwFdBa	01	5	14-20	30	40	Middle	10	1+	4	4	2
2023-07-31	Pine Point Park	PP-01	B.Brett	Hw (FdCwPl)	03	6	20-26	40	70	Upper	10	2	2	2	2

Appendix C: Tailed Frog Site and Capture Data

Valley Side	Site	Date	Easting	Northing	Elev. (m)	Slope (%)	Channel Width (m)	Wetted Width (m)	pH	Flow (rel.)	Stream Disturb-ance	Mean Depth (cm)	Embedd-edness	Survey-ability	Subj. Hab. Rating
East	Archibald Creek - 1	2022-09-07	502387	5550606	695	17	4.0	2.2	7.0	Low	Med.	12	4	3	3
East	Archibald Creek - 2	2022-09-07	502854	5550298	835	18	2.7	1.9	6.9	Low	High	11	3	3	3
East	Archibald Creek - 3	2022-09-07	503310	5549422	1026	12	2.2	2.4	6.8	Low	Low	12	2	4	3
East	Blackcomb Cr. @ Lost Lake Rd.	2022-09-06	504641	5552586	692	25	10.0	4.0	6.8	Low	Low	17	2	4	3
East	Blackcomb Cr. @ Yummy Numby	2022-09-06	505211	5552576	762	15	8.4	6.8	6.8	Low	Med.	19	3	3	4
East	Whistler Creek - 1	2022-09-06	501041	5549045	692	14	6.2	5.2	7.5	Low	High	12	3	3	4
East	Whistler Creek - 2	2022-09-06	501649	5547961	879	14	5.1	5.3	6.8	Low	Low	11	1	5	5
East	Whistler Creek - 3	2022-09-06	501417	5548276	972	25	4.1	6.1	6.8	Low	Low	14	3	3	4
West	Nineteen-Mile Creek-1	2022-09-07	502764	5555303	648	4	NR	3.9	7.0	Low	Low	12	2	4	4
West	Nineteen-Mile Creek-2	2022-09-07	502121	5555246	692	8	NR	5.1	7.0	Low	Low	16	3	2	4
West	Nineteen-Mile Creek-3	2022-09-09	501114	5557282	1095	3	NR	4.3	7.0	Med	Low	20	1	5	5
West	Sproatt Creek - 1 (Danimal South)	2022-09-08	499063	5549434	692	25	6.6	2.1	6.5	Low	Low	11	3	3	4
West	Sproatt Creek - 2 (Don't Look Back)	2022-09-08	498996	5549662	790	32	7.8	4.2	6.5	Low	High	8	3	3	5
West	Sproatt Creek - 3 (Flank Trail)	2022-09-08	498483	5550455	996	24	5.0	2.2	6.2	Low	High	9	3	3	4
West	Van West-2 (Flank Trail)	2022-09-08	497563	5549038	706	18	5.1	2.6	6.5	Low	High	11	4	2	2
West	Van West-3 (Into the Mystic)	2022-09-08	497125	5549816	1036	25	4.2	1.5	6.8	Low	Low	10	1	5	5

Valley Side	Site	Date	Surveyors	Easting	Northing	Elev. (m)	Wea-ther	Water Temp. (°C)	Air Temp. (°C)	T1	T2	T3	Tad-poles	Tad-poles /100m2	Meta+ Adults
East	Archibald Creek - 1	2022-09-07	BB, RM	502387	5550606	695	Sun	10.4	16.0	2	1	1	4	28.6	0
East	Archibald Creek - 2	2022-09-07	BB, RM	502854	5550298	835	Sun	9.2	13.4	1	0	2	3	30.0	0
East	Archibald Creek - 3	2022-09-07	BB, RM	503310	5549422	1026	Sun	8.2	12.8	5	0	1	6	44.4	0
East	Blackcomb Cr. @ Lost Lake Rd.	2022-09-06	BB, HW, RM	504641	5552586	692	Sun	8.0	19.0	0	0	0	0	0.0	0
East	Blackcomb Cr. @ Yummy Numby	2022-09-06	BB, HW, RM	505211	5552576	762	Sun	6.8	11.0	0	0	0	0	0.0	0
East	Whistler Creek - 1	2022-09-06	BB, HW, RM	501041	5549045	692	Sun	10.0	20.0	0	4	2	6	42.9	0
East	Whistler Creek - 2	2022-09-06	BB, HW, RM	501649	5547961	879	Sun	8.0	10.0	7	1	0	8	53.3	0
East	Whistler Creek - 3	2022-09-06	BB, HW, RM	501417	5548276	972	Sun	7.0	8.0	5	3	0	8	57.1	0
West	Nineteen-Mile Creek-1	2022-09-07	BB, RM	502764	5555303	648	Sun	9.7	11.0	0	0	0	0	0.0	0
West	Nineteen-Mile Creek-2	2022-09-07	BB, RM	502121	5555246	692	Sun	9.5	12.3	0	0	0	0	0.0	0
West	Nineteen-Mile Creek-3	2022-09-09	BB	501114	5557282	1095	Sun	8.0	14.0	0	0	0	0	0.0	0
West	Sproatt Creek - 1 (Danimal South)	2022-09-08	BB, RM	499063	5549434	692	Sun	11.0	17.0	0	1	0	1	9.5	0
West	Sproatt Creek - 2 (Don't Look Back)	2022-09-08	BB, RM	498996	5549662	790	Sun	11.0	15.0	0	0	1	1	10.5	0
West	Sproatt Creek - 3 (Flank Trail)	2022-09-08	BB, RM	498483	5550455	996	Sun	10.0	12.0	1	0	7	8	55.2	1
West	Van West-2 (Flank Trail)	2022-09-08	BB, RM	497563	5549038	706	Sun	10.0	12.0	1	0	0	1	11.1	0
West	Van West-3 (Into the Mystic)	2022-09-08	BB, RM	497125	5549816	1036	Sun	9.5	14.0	0	1	5	6	80.0	0

Surveyors: BB (Bob Brett); HW (Hillary Williamson; RM (Rebecca Merenyi)

Appendix D: Benthic Invertebrates / CABIN

Fraser River 2014 Reference Model Group Assignment Probability (%)

Site	Year	Assigned Reference Group #	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Twenty-one Mile Creek	2016	3	10%	5%	***33%***	24%	17%	10%
	2017	3	10%	5%	***33%***	24%	17%	10%
	2018	5	10%	5%	22%	17%	***39%***	6%
	2019	3	10%	5%	***33%***	24%	17%	10%
	2020	3	10%	5%	***33%***	24%	17%	10%
	2021	3	10%	5%	***33%***	24%	17%	10%
	2022	3	9%	4%	***40%***	21%	16%	10%
	2023	3	9%	5%	***37%***	22%	17%	10%
Crabapple Creek	2016	1	***45%***	26%	0%	18%	8%	2%
	2017	1	***45%***	26%	0%	18%	8%	2%
	2018	1	***45%***	26%	0%	18%	8%	2%
	2019	1	***45%***	26%	0%	18%	8%	2%
	2020	5	27%	11%	0%	4%	***58%***	0%
	2021	1	***38%***	18%	0%	8%	36%	1%
	2022	5	27%	11%	0%	4%	***58%***	0%
	2023	5	8%	3%	0%	1%	***88%***	0%
River of Golden Dreams (Upper)	2016	3	9%	5%	***38%***	22%	17%	10%
	2017	3	8%	4%	***41%***	20%	16%	10%
	2018	5	9%	4%	27%	15%	***38%***	7%
	2019	3	9%	5%	***39%***	21%	17%	10%
	2020	3	9%	4%	***40%***	21%	17%	10%
	2021	5	9%	4%	21%	18%	***41%***	7%
	2022	5	9%	4%	25%	16%	***39%***	7%
	2023	5	9%	4%	27%	15%	***38%***	7%
River of Golden Dreams (Lower)	2016	4	15%	8%	15%	***28%***	24%	10%
	2017	5	13%	6%	9%	17%	***48%***	6%
	2018	5	9%	4%	4%	8%	***73%***	2%
	2019	5	13%	6%	9%	17%	***48%***	6%
	2020	5	13%	6%	9%	18%	***48%***	6%
	2021	4	15%	8%	16%	***27%***	24%	10%
	2022	5	2%	1%	0%	1%	***95%***	0%
	2023	5	14%	6%	10%	17%	***48%***	6%

Fraser River – Georgia Basin 2005 Reference Model Group Assignment Probability (%)

Site	Year	Assigned Reference Group #	Group 1	Group 2	Group 3	Group 4	Group 5
Jordan Creek	2016	1	***71%***	0.3%	21%	0.3%	7%
	2017	1	***95%***	0.2%	4%	0.0%	1%
	2018	1	***93%***	0.2%	6%	0.3%	1%
	2019	1	***91%***	0.1%	8%	0.0%	1%
	2020	1	***87%***	0.1%	11%	0.1%	2%
	2021	1	***50%***	0.4%	30%	10%	10%
	2022	1	***48%***	0.1%	8%	42%	2%
	2023	1	***69.4***%	0.1%	17.2%	11.0%	2.4%
Whistler Creek	2022	4	27.8%	0.6%	19.8%	***35.3%***	16.5%
	2023	1	***70.8%***	0.7%	16.3%	2.5%	9.8%

Results of the 2023 Taxonomic Analysis

ROE Assessment Planning Compliance

Project Name: RMOW Ecosystem Monitoring, 2023 Program
Report Date: December 06, 2023
Taxonomist: Thibault Doix, Certified Taxonomist thibault@roe-env.ca

				Stream Name	**River of Golden Drea**	**River of Golden Drea**	**21 Mile Creek**	**Whistler Creek**	**Jordan Creek**	**Crabapple Creek**
				Site Code	**RGD-US-AQ11**	**RGD-DS-AQ12**	**21M-DS-AQ21**	**WHS-CK**	**JOR-DS-AQ31**	**CRB-DS-AQ01**
				Sampling Date	**29-Jul-23**	**29-Jul-23**	**28-Jul-23**	**29-Jul-23**	**29-Jul-23**	**28-Jul-23**
				Sorting Date	**18-Oct-23**	**16-Oct-23**	**15-Oct-23**	**17-Oct-23**	**13-Oct-23**	**14-Oct-23**
				Sorted Fraction	100%	100%	37%	100%	100%	32%
Phylum	**Class**	**Order**	**Family**	**Genus/Species**						
P. ANNELIDA	**Cl. CLITELLATA**	**O. Opisthopora**	**F. Lumbricidae**	*Eiseniella tetraedra*				1		
		O. Lumbriculida	**F. Enchytraeidae**	(unidentified)		1	1	1		
			F. Lumbriculidae	(unidentified)	13	7	22	10	2	1
P. MOLLUSCA	**Cl. BIVALVIA**	**O. Veneroida**	**F. Pisidiidae**	*Pisidium sp.*	2	5			29	3
	Cl. GASTROPODA	**O. Basommatophor**	**F. Planorbidae**	*Gyraulus sp.*		1			4	
			F. Ancylidae	*Ferrissia sp.*					10	
			F. Physidae	*Physella sp.*					9	
P. ARTHROPODA	**Cl. ARACHNIDA**	**O. Trombidiformes**	**F. Hygrobatidae**	*Hygrobates sp.*			1			
			F. Lebertiidae	*Lebertia sp.*	1	2	1		1	1
			F. Stygothrombiida	*Stygothrombium sp.*						2
	Cl. INSECTA	**O. Ephemeroptera**	**F. Ameletidae**	*Ameletus sp.*	71		59	17		
			F. Baetidae	*Baetis sp.*	51	11	28	26	32	58
				Baetis bicaudatus				3		
				Baetis rhodani group				3		
				Diphetor hageni				5	1	
				Procloeon sp.		34				
			F. Ephemerellidae	(Immature)		60				1
				Drunella sp.	2	2			1	
				Drunella coloradensis			1	15		
				Drunella doddsii			1	6		
				Drunella spinifera	1					
				Serratella sp.	12	7	4	143	1	2
			F. Heptageniidae	*Cinygma sp.*		1				
				Cinygmula sp.	29	3	83	9		2
				Epeorus sp.	45	1	38	3		
				Rhithrogena sp.	13		1	1		
			F. Leptophlebiidae	*Paraleptophlebia sp.*	5	2	4	1	93	73
		O. Plecoptera	**F. Chloroperlidae**	*Suwallia sp.*	14		5	14		
				Sweltsa sp.		9	1	3	7	53
			F. Leuctridae	(Early instar)				1		
			F. Nemouridae	*Visoka cataractae*	1			1		
				Zapada sp.					6	2
				Zapada cinctipes				2		
				Zapada columbiana				10		1
				Malenka sp.		2				5
			F. Perlidae	(Early instar)					3	
				Calineuria sp.	2		1	2		
				Hesperoperla pacifica				1	3	
			F. Perlodidae	(Immature)	11	2				
				Kogotus sp.	1	1	1	12		
				Megarcys sp.	19		2			
		O. Trichoptera	**F. Hydropsychidae**	(early instar)					1	
				Arctopsyche sp.				1		
				Hydropsyche sp.				1		
			F. Lepidostomatida	*Lepidostoma sp.*				1	11	4
			F. Limnephilidae	*Onocosmoescus sp.*	3				1	3
			F. Rhyacophilidae	*Rhyacophila sp.*	2	3	2	2		10
				Rhyacophila angelita group	1		3	13	1	1
				Rhyacophila betteni group	1		1	2		1
		O. Coleoptera	**F. Dytiscidae**	*Oreodytes sp.*	9	33	1			
			F. Elmidae	*Narpus sp.*			2	3		
		O. Megaloptera	**F. Sialidae**	*Sialis sp.*					1	
		O. Diptera	**F. Ceratopogonida**	*Mallochohelea sp.*			3			1
			F. Chironomidae	Pupa		1	1	1	1	
				Orthocladiinae (Early instar)	3	5		3	13	
				Brillia sp.	2	3		1	1	6
				Chrironomus sp.						
				Corynoneura sp.						2
				Cricotopus sp./Orthocladius s	1	4		9	2	
				Diamesa sp.						
				Eukiefferiella sp.				1	1	
				Heterotrissocladius sp.		2			1	
				Macropelopia sp		2				2
				Micropsectra sp./Tanytarsus	3	21	22		9	51
				Pagastia sp.				1		
				Parametriocnemus sp.		6	1			
				Polypedilum sp.		1	4			1
				Pseudodiamesa sp.						
				Rheocricotopus sp.		2	1			
				Thienemannimyia group	2	18	7	5	31	1
				Tevtenia sp.	2	26	1	2	23	4
				Zavrelimyia sp.						1
			F. Empididae	*Chelifera sp./ Metachela sp.*				1		
			F. Simuliidae	*Simulium sp.*	25	13	8	3	8	12
			F. Tipulidae	*Dicranota sp.*	1		5	3	2	1
				Hexatoma sp.	1				2	9
				Limnophila sp.						1
P. CRUSTACEA	**Cl. MALCOSTRACA**	**O. Amphipoda**	**F. Crangonyctidae**	*Crangonyx sp.*	18	11			1	
				Total Number of Organisms	367	302	316	343	312	315
				Total Number of Taxa	33	34	33	42	33	31

Twenty-one Mile Creek Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculus*
Clitellata	*Tubificida*	*Enchytraeidae*	*Enchytraeidae*
Clitellata	*Tubificida*	*Naididae*	*Naididae*
Arachnida	*Trombidiformes*	*Hydryphantidae*	*Protzia*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Atractides*
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchon*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Testudacarus*
Insecta	*Coleoptera*	*Dytiscidae*	*Oreodytes*
Insecta	*Coleoptera*	*Elmidae*	*Narpus*
Insecta	*Diptera*	*Ceratopogonidae*	*Bezzia/ Palpomyia*
Insecta	*Diptera*	*Ceratopogonidae*	*Mallochohelea*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Corynoneura*
Insecta	*Diptera*	*Chironomidae*	*Diamesa*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Hydrobaenus*
Insecta	*Diptera*	*Chironomidae*	*Micropsectra/Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Microtendipes*
Insecta	*Diptera*	*Chironomidae*	*Orthocladius complex*
Insecta	*Diptera*	*Chironomidae*	*Parametriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Parorthocladius*
Insecta	*Diptera*	*Chironomidae*	*Polypedilum*
Insecta	*Diptera*	*Chironomidae*	*Rheocricotopus*
Insecta	*Diptera*	*Chironomidae*	*Rheosmittia*
Insecta	*Diptera*	*Chironomidae*	*Stempellinella*
Insecta	*Diptera*	*Chironomidae*	*Thienemanniella*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Deuterophlebiidae*	*Deuterophlebia*
Insecta	*Diptera*	*Empididae*	*Oreogeton*
Insecta	*Diptera*	*Simuliidae*	*Helodon*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Diptera*	*Tipulidae*	*Hexatoma*
Insecta	*Diptera*	*Tipulidae*	*Limnophila*
Insecta	*Ephemeroptera*	*Ameletidae*	*Ameletus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis bicaudatus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis rhodani group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella coloradensis*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella doddsii*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella spinifera*

Class	Order	Family	Genus/Species
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygmula*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Epeorus*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Rhithrogena*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Plecoptera*	*Capniidae*	*Capniidae*
Insecta	*Plecoptera*	*Chloroperlidae*	*Haploperla*
Insecta	*Plecoptera*	*Chloroperlidae*	*Suwallia*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Paraleuctra*
Insecta	*Plecoptera*	*Nemouridae*	*Malenka*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada columbiana*
Insecta	*Plecoptera*	*Perlidae*	*Calineuria californica*
Insecta	*Plecoptera*	*Perlidae*	*Doroneuria*
Insecta	*Plecoptera*	*Perlodidae*	*Kogotus*
Insecta	*Plecoptera*	*Perlodidae*	*Megarcys*
Insecta	*Plecoptera*	*Pteronarcyidae*	*Pteronarcys*
Insecta	*Trichoptera*	*Glossosomatidae*	*Glossosoma*
Insecta	*Trichoptera*	*Hydropsychidae*	*Hydropsychidae*
Insecta	*Trichoptera*	*Hydropsychidae*	*Parapsyche*
Insecta	*Trichoptera*	*Hydroptilidae*	*Oxyethira*
Insecta	*Trichoptera*	*Limnephilidae*	*Ecclisomyia*
Insecta	*Trichoptera*	*Limnephilidae*	*Lenarchus*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila angelita group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila betteni group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila brunnea/vemna*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila vagrita group*

Crabapple Creek Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculidae*
Clitellata	*Tubificida*	*Naididae*	*Naididae*
Clitellata	*Tubificida*	*Naididae*	*Nais*
Arachnida	*Trombidiformes*	*Aturidae*	*Aturus*
Arachnida	*Trombidiformes*	*Aturidae*	*Ljania*
Arachnida	*Trombidiformes*	*Hydryphantidae*	*Protzia*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Atractides*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Hygrobates*
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchon*
Arachnida	*Trombidiformes*	*Stygothrombiidae*	*Stygothrombium*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Testudacarus*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Torrenticola*
Collembola	*Collembola*	*Collembola*	*Collembola*
Insecta	*Coleoptera*	*Dytiscidae*	*Oreodytes*
Insecta	*Coleoptera*	*Elmidae*	*Narpus*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Cardiocladius*
Insecta	*Diptera*	*Chironomidae*	*Corynoneura*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Krenosmittia*
Insecta	*Diptera*	*Chironomidae*	*Macropelopia*
Insecta	*Diptera*	*Chironomidae*	*Micropsectra/Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Microtendipes*
Insecta	*Diptera*	*Chironomidae*	*Orthocladius complex*
Insecta	*Diptera*	*Chironomidae*	*Parametriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Polypedilum*
Insecta	*Diptera*	*Chironomidae*	*Procladius*
Insecta	*Diptera*	*Chironomidae*	*Pseudodiamesa*
Insecta	*Diptera*	*Chironomidae*	*Rheocricotopus*
Insecta	*Diptera*	*Chironomidae*	*Saetheria*
Insecta	*Diptera*	*Chironomidae*	*Stempellinella*
Insecta	*Diptera*	*Chironomidae*	*Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Thienemanniella*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Chironomidae*	*Zavrelimyia*
Insecta	*Diptera*	*Empididae*	*Chelifera/ Metachela*
Insecta	*Diptera*	*Empididae*	*Neoplasta*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Diptera*	*Tipulidae*	*Eloeophila*

Class	Order	Family	Genus/Species
Insecta	*Diptera*	*Tipulidae*	*Erioptera*
Insecta	*Diptera*	*Tipulidae*	*Hexatoma*
Insecta	*Diptera*	*Tipulidae*	*Limnophila*
Insecta	*Diptera*	*Tipulidae*	*Tipula*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis rhodani group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella grandis group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella spinifera*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygma*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygmula*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Epeorus*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Megaloptera*	*Sialidae*	*Sialidae*
Insecta	*Plecoptera*	*Chloroperlidae*	*Haploperla*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Leuctridae*
Insecta	*Plecoptera*	*Nemouridae*	*Malenka*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada columbiana*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada oregonensis group*
Insecta	*Plecoptera*	*Taeniopterygidae*	*Taeniopterygidae*
Insecta	*Trichoptera*	*Brachycentridae*	*Micrasema*
Insecta	*Trichoptera*	*Lepidostomatidae*	*Lepidostoma*
Insecta	*Trichoptera*	*Limnephilidae*	*Onocosmoecus*
Insecta	*Trichoptera*	*Limnephilidae*	*Psychoglypha*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila angelita group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila arnaudi*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila betteni group*
Bivalvia	*Veneroida*	*Pisidiidae*	*Pisidium*

(Upper) River of Golden Dreams Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Hirudinida*	*Glossiphoniidae*	*Helobdella stagnalis*
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculus*
Clitellata	*Tubificida*	*Naididae*	*Nais*
Clitellata	*Tubificida*	*Enchytraeidae*	
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Atractides*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Hygrobates*
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchon*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Testudacarus*
Insecta	*Coleoptera*	*Dytiscidae*	*Oreodytes*
Insecta	*Diptera*	*Ceratopogonidae*	*Mallochohelea*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Cricotopus/Orthocladius*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Heterotanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Heterotrissocladius*
Insecta	*Diptera*	*Chironomidae*	*Macropelopia*
Insecta	*Diptera*	*Chironomidae*	*Micropsectra/Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Nilotanypus*
Insecta	*Diptera*	*Chironomidae*	*Odontomesa*
Insecta	*Diptera*	*Chironomidae*	*Orthocladius complex*
Insecta	*Diptera*	*Chironomidae*	*Paracladopelma*
Insecta	*Diptera*	*Chironomidae*	*Parakiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Parametriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Parorthocladius*
Insecta	*Diptera*	*Chironomidae*	*Polypedilum*
Insecta	*Diptera*	*Chironomidae*	*Psectrocladius*
Insecta	*Diptera*	*Chironomidae*	*Rheocricotopus*
Insecta	*Diptera*	*Chironomidae*	*Saetheria*
Insecta	*Diptera*	*Chironomidae*	*Stempellinella*
Insecta	*Diptera*	*Chironomidae*	*Synorthocladius*
Insecta	*Diptera*	*Chironomidae*	*Thienemanniella*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Empididae*	*Chelifera/ Metachela*
Insecta	*Diptera*	*Empididae*	*Hemerodromia*
Insecta	*Diptera*	*Empididae*	*Neoplasta*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tabanidae*	*Tabanus*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Ephemeroptera*	*Ameletidae*	*Ameletus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis bicaudatus*

Class	Order	Family	Genus/Species
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis rhodani group*
Insecta	*Ephemeroptera*	*Baetidae*	*Centroptilum*
Insecta	*Ephemeroptera*	*Baetidae*	*Procloeon*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella doddsii*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella grandis group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella spinifera*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Ephemerella*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygma*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygmula*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Epeorus*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Rhithrogena*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Megaloptera*	*Sialidae*	*Sialis*
Insecta	*Plecoptera*	*Capniidae*	
Insecta	*Plecoptera*	*Chloroperlidae*	*Suwallia*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Leuctridae*
Insecta	*Plecoptera*	*Nemouridae*	*Malenka*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Perlidae*	*Perlidae*
Insecta	*Plecoptera*	*Perlodidae*	*Kogotus*
Insecta	*Plecoptera*	*Perlodidae*	*Megarcys*
Insecta	*Trichoptera*	*Brachycentridae*	*Micrasema*
Insecta	*Trichoptera*	*Glossosomatidae*	*Glossosoma*
Insecta	*Trichoptera*	*Hydropsychidae*	*Hydropsychidae*
Insecta	*Trichoptera*	*Lepidostomatidae*	*Lepidostoma*
Insecta	*Trichoptera*	*Limnephilidae*	*Dicosmoecus*
Insecta	*Trichoptera*	*Limnephilidae*	*Lenarchus*
Insecta	*Trichoptera*	*Limnephilidae*	*Onocosmoecus*
Insecta	*Trichoptera*	*Limnephilidae*	*Psychoglypha*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila*
Malacostraca	*Amphipoda*	*Crangonyctidae*	*Crangonyx*
Bivalvia	*Veneroida*	*Pisidiidae*	*Pisidium*
Gastropoda	*Basommatophora*	*Planorbidae*	*Gyraulus*

(Lower) River of Golden Dreams Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculus*
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Stylodrilus heringianus*
Clitellata	*Tubificida*	*Naididae*	*Naididae*
Arachnida	*Trombidiformes*	*Hydryphantidae*	*Protzia*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Atractides*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Hygrobates*
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Arachnida	*Trombidiformes*	*Mideopsidae*	*Mideopsis*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchon*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Testudacarus*
Collembola	*Collembola*	*Sminthuridae*	
Insecta	*Coleoptera*	*Dytiscidae*	*Oreodytes*
Insecta	*Diptera*	*Ceratopogonidae*	*Mallochohelea*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Cladotanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Corynoneura*
Insecta	*Diptera*	*Chironomidae*	*Cricotopus/Orthocladius*
Insecta	*Diptera*	*Chironomidae*	*Diamesa*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Metriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Micropsectra/Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Microtendipes*
Insecta	*Diptera*	*Chironomidae*	*Parametriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Paratanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Polypedilum*
Insecta	*Diptera*	*Chironomidae*	*Rheocricotopus*
Insecta	*Diptera*	*Chironomidae*	*Rheosmittia*
Insecta	*Diptera*	*Chironomidae*	*Stempellinella*
Insecta	*Diptera*	*Chironomidae*	*Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Chironomidae*	*Zavrelimyia*
Insecta	*Diptera*	*Empididae*	*Empididae*
Insecta	*Diptera*	*Simuliidae*	*Prosimulium*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Diptera*	*Tipulidae*	*Hexatoma*
Insecta	*Ephemeroptera*	*Ameletidae*	*Ameletus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis bicaudatus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis rhodani group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella doddsii*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella grandis group*

Class	Order	Family	Genus/Species
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella spinifera*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Ephemerella*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygmula*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Epeorus*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Rhithrogena*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Plecoptera*	*Capniidae*	*Capniidae*
Insecta	*Plecoptera*	*Chloroperlidae*	*Haploperla*
Insecta	*Plecoptera*	*Chloroperlidae*	*Paraperla*
Insecta	*Plecoptera*	*Chloroperlidae*	*Suwallia*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Paraleuctra*
Insecta	*Plecoptera*	*Nemouridae*	*Malenka*
Insecta	*Plecoptera*	*Nemouridae*	*Visoka cataractae*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada columbiana*
Insecta	*Plecoptera*	*Perlidae*	*Calineuria californica*
Insecta	*Plecoptera*	*Perlidae*	*Doroneuria*
Insecta	*Plecoptera*	*Perlidae*	*Hesperoperla*
Insecta	*Plecoptera*	*Perlodidae*	*Kogotus*
Insecta	*Plecoptera*	*Perlodidae*	*Megarcys*
Insecta	*Trichoptera*	*Brachycentridae*	*Micrasema*
Insecta	*Trichoptera*	*Hydropsychidae*	
Insecta	*Trichoptera*	*Limnephilidae*	*Lenarchus*
Insecta	*Trichoptera*	*Limnephilidae*	*Onocosmoecus*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila angelita group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila betteni group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila brunnea/vemna group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila vagrita group*
Malacostraca	*Amphipoda*	*Crangonyctidae*	*Crangonyx*
Bivalvia	*Veneroida*	*Pisidiidae*	*Pisidium*
Gastropoda	*Basommatophora*	*Planorbidae*	

Jordan Creek Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculidae*
Clitellata	*Tubificida*	*Naididae*	*Naididae*
Arachnida	*Trombidiformes*	*Hygrobatidae*	*Atractides*
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchon*
Arachnida	*Trombidiformes*	*Sperchontidae*	*Sperchonopsis*
Arachnida	*Trombidiformes*	*Torrenticolidae*	*Torrenticola*
Collembola	*Collembola*	*Collembola*	*Collembola*
Insecta	*Diptera*	*Ceratopogonidae*	*Ceratopogonidae*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Corynoneura*
Insecta	*Diptera*	*Chironomidae*	*Cricotopus/Orthocladius*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Heterotrissocladius*
Insecta	*Diptera*	*Chironomidae*	*Limnophyes*
Insecta	*Diptera*	*Chironomidae*	*Micropsectra/Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Nilotanypus*
Insecta	*Diptera*	*Chironomidae*	*Orthocladius*
Insecta	*Diptera*	*Chironomidae*	*Parakiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Polypedilum*
Insecta	*Diptera*	*Chironomidae*	*Rheotanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Stempellinella*
Insecta	*Diptera*	*Chironomidae*	*Synorthocladius*
Insecta	*Diptera*	*Chironomidae*	*Tanytarsus*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Empididae*	*Neoplasta*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Diptera*	*Tipulidae*	*Hexatoma*
Insecta	*Ephemeroptera*	*Ameletidae*	*Ameletus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis rhodani group*
Insecta	*Ephemeroptera*	*Baetidae*	*Diphetor*
Insecta	*Ephemeroptera*	*Baetidae*	*Diphetor hageni*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella grandis group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Ephemerella*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Megaloptera*	*Sialidae*	*Sialis*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Leuctridae*

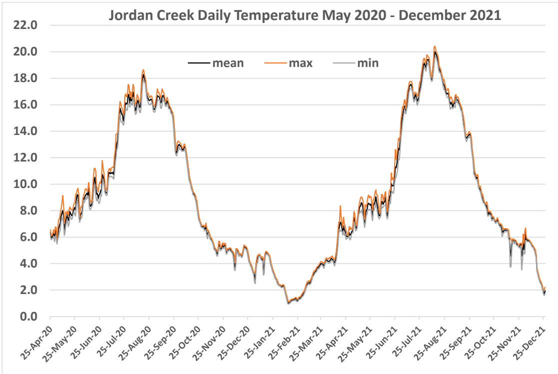
Class	Order	Family	Genus/Species
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Perlidae*	*Hesperoperla pacifica*
Insecta	*Plecoptera*	*Perlidae*	
Insecta	*Plecoptera*	*Perlodidae*	*Kogotus*
Insecta	*Trichoptera*	*Glossosomatidae*	*Glossosoma*
Insecta	*Trichoptera*	*Hydropsychidae*	*Hydropsyche*
Insecta	*Trichoptera*	*Lepidostomatidae*	*Lepidostoma*
Insecta	*Trichoptera*	*Leptoceridae*	*Mystacides*
Insecta	*Trichoptera*	*Limnephilidae*	*Clostoeca disjuncta*
Insecta	*Trichoptera*	*Limnephilidae*	*Onocosmoecus*
Insecta	*Trichoptera*	*Limnephilidae*	*Psychoglypha*
Insecta	*Trichoptera*	*Philopotamidae*	*Wormaldia*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila angelita group*
Malacostraca	*Amphipoda*	*Crangonyctidae*	*Crangonyx*
Hydrozoa	*Anthoathecatae*	*Hydridae*	*Hydra*
Bivalvia	*Veneroida*	*Pisidiidae*	*Pisidium*
Gastropoda	*Basommatophora*	*Physidae*	*Physella*
Gastropoda	*Basommatophora*	*Planorbidae*	*Ferrissia*
Gastropoda	*Basommatophora*	*Planorbidae*	*Gyraulus*

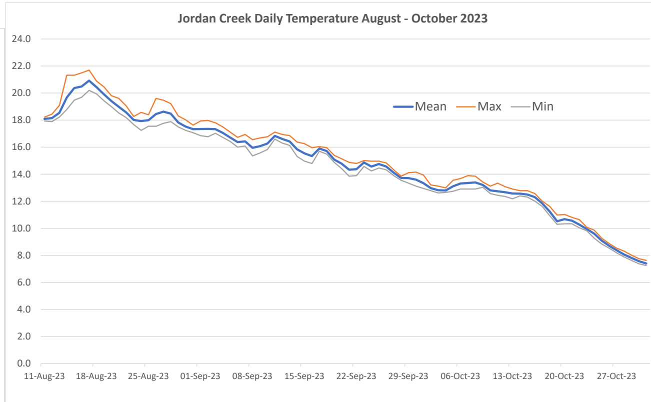
Whistler Creek Cumulative Taxonomic List

Class	Order	Family	Genus/Species
Clitellata	*Lumbriculida*	*Lumbriculidae*	*Lumbriculidae*
Clitellata	*Opisthopora*	*Lumbricidae*	*Eiseniella tetraedra*
Clitellata	*Tubificida*	*Enchytraeidae*	
Arachnida	*Trombidiformes*	*Lebertiidae*	*Lebertia*
Insecta	*Coleoptera*	*Elmidae*	*Narpus*
Insecta	*Diptera*	*Ceratopogonidae*	*Mallochohelea*
Insecta	*Diptera*	*Chironomidae*	*Brillia*
Insecta	*Diptera*	*Chironomidae*	*Cricotopus/Orthocladius*
Insecta	*Diptera*	*Chironomidae*	*Eukiefferiella*
Insecta	*Diptera*	*Chironomidae*	*Pagastia*
Insecta	*Diptera*	*Chironomidae*	*Parametriocnemus*
Insecta	*Diptera*	*Chironomidae*	*Thienemannimyia group*
Insecta	*Diptera*	*Chironomidae*	*Tvetenia*
Insecta	*Diptera*	*Empididae*	*Chelifera/Metachela*
Insecta	*Diptera*	*Empididae*	*Clinocera*
Insecta	*Diptera*	*Simuliidae*	*Simulium*
Insecta	*Diptera*	*Tipulidae*	*Dicranota*
Insecta	*Ephemeroptera*	*Ameletidae*	*Ameletus*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis*
Insecta	*Ephemeroptera*	*Baetidae*	*Baetis bicaudatus*
Insecta	*Ephemeroptera*	*Baetidae*	*Diphetor hageni*
Insecta	*Ephemeroptera*	*Baetidae*	*Rhodani group*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella coloradensis*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella doddsii*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Drunella spinifera*
Insecta	*Ephemeroptera*	*Ephemerellidae*	*Serratella*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Cinygmula*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Epeorus*
Insecta	*Ephemeroptera*	*Heptageniidae*	*Rhithrogena*
Insecta	*Ephemeroptera*	*Leptophlebiidae*	*Paraleptophlebia*
Insecta	*Plecoptera*	*Chloroperlidae*	*Suwallia*
Insecta	*Plecoptera*	*Chloroperlidae*	*Sweltsa*
Insecta	*Plecoptera*	*Leuctridae*	*Despaxia augusta*
Insecta	*Plecoptera*	*Nemouridae*	*Visoka cataractae*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada columbiana*
Insecta	*Plecoptera*	*Nemouridae*	*Zapada cinctipes*
Insecta	*Plecoptera*	*Perlidae*	*Calineuria*
Insecta	*Plecoptera*	*Perlidae*	*Hesperoperla pacifica*
Insecta	*Plecoptera*	*Perlodidae*	*Kogotus*
Insecta	*Trichoptera*	*Hydropsychidae*	*Arctopsyche*
Insecta	*Trichoptera*	*Hydropsychidae*	*Hydropsyche*
Insecta	*Trichoptera*	*Lepidostomatidae*	*Lepidostoma*

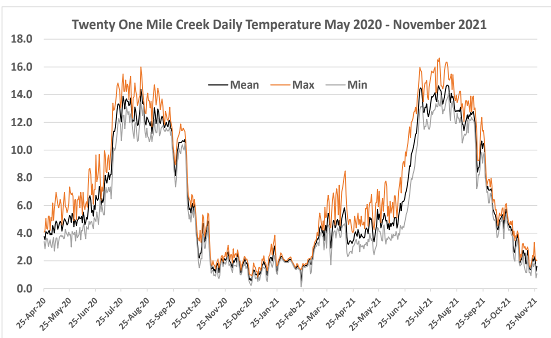
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila Angelita group*
Insecta	*Trichoptera*	*Rhyacophilidae*	*Rhyacophila Betteni group*
Malacostraca	*Amphipoda*	*Crangonyctidae*	*Crangonyx*

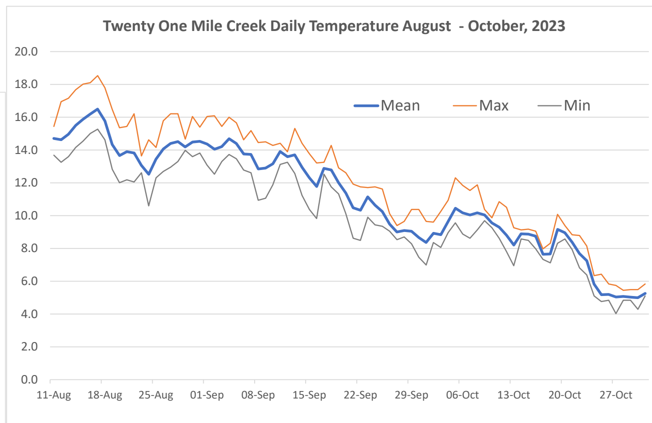
Appendix E: Water Temperatures and Fish Habitat

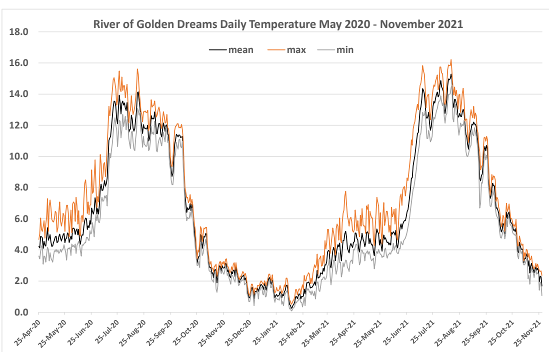


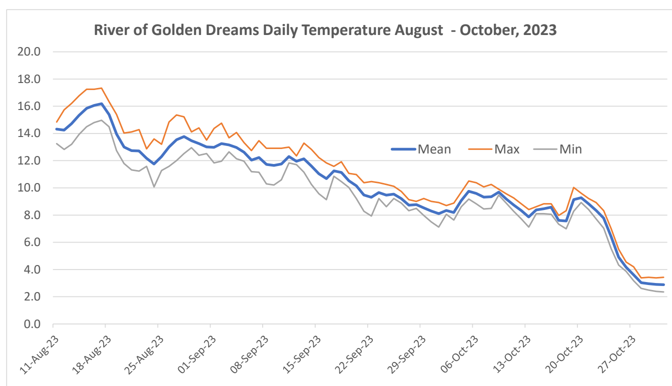


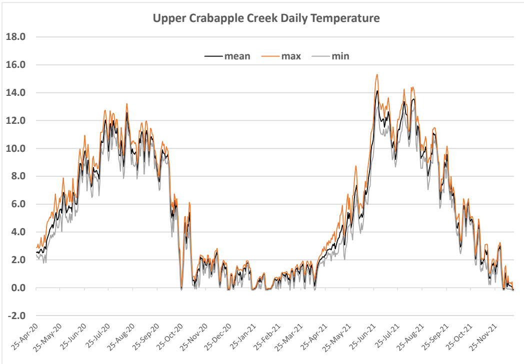
Graph going back to 2016, or three years? Side by side showing 2023 higher.

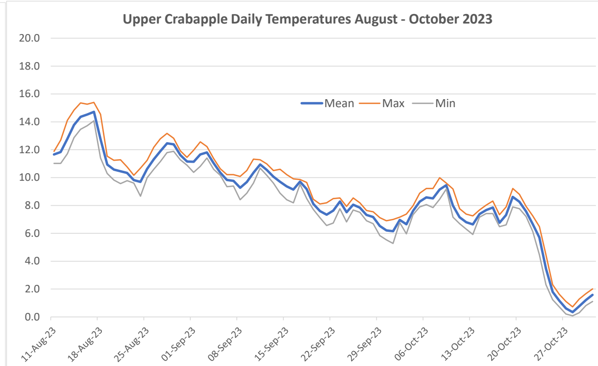




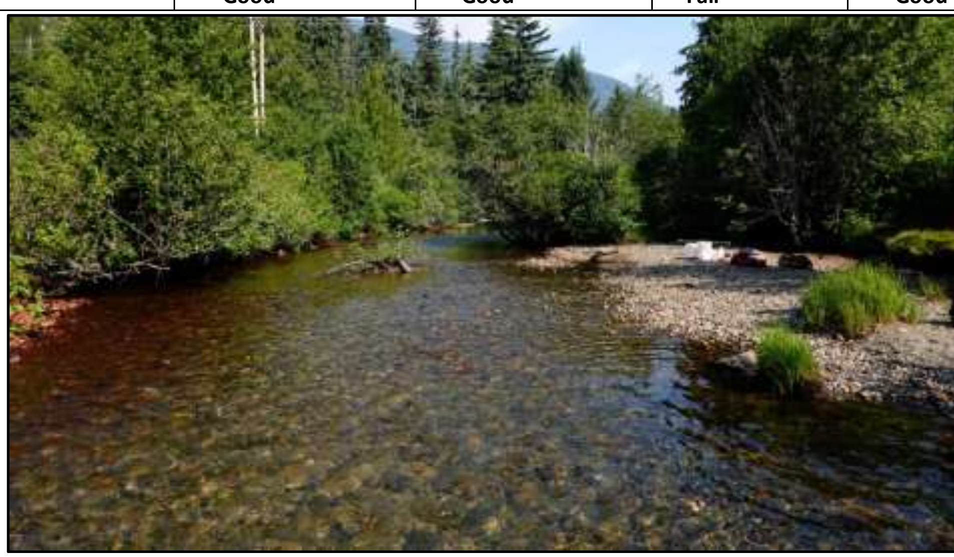








Date	Stream								
28-Jul-23	**21 Mile Creek**								
Water quality		**Area and Substrate**		**Depth and velocity (m)**		**Site Cover**		**Vegetation and Channel**	
Habitat type	Riffle-Run	Gradient	1%	Avg Dep	0.18	OH%	1-25%	Grass	Y
Site type	Full x-sec	Width 1 (m)	8	Avg Vel	0.24	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/a	Width 2 (m)	8.1	Depth 1	0.72	Deep%	1-25%	Decidiuous	Y
do%	92.3	Width 3 (m)	12	Depth 2	0.45	Bol%	0%	Conifer	n
do mg/l	9.14	Length (m)	66	Depth 3	0.26	UC%	76-100%	Dom Veg	S
TDS	32	Wet area m2	616	Depth 4	0.01	Macro%	1-25%	Sub Veg	D
Conductivity	20.2	max depth(m)	0.76	Depth 5	0.09	LWD m2	2	Channel Pat	S
SC/cm	32	%bol	5	Depth 6	0.09	SWD m2	2	Islands	O
ph	7.4	%cob	15	Vel 1	0.02	Dmax(m)	0.55	Bars	N
Stream Temp ^{0}C	12.6	%grv	65	Vel 2	0.01	D90 (m)	0.06	Riparian Stg	SHR
		%fines	15	Vel 3	0.30				
		%Org	0	Vel 4	0.11				
				Vel 5	0.33				
				Vel 6	0.43				
Good		**Good**		**Good**		**Fair**		**Good**	



Twenty-One Mile Ck U/S View

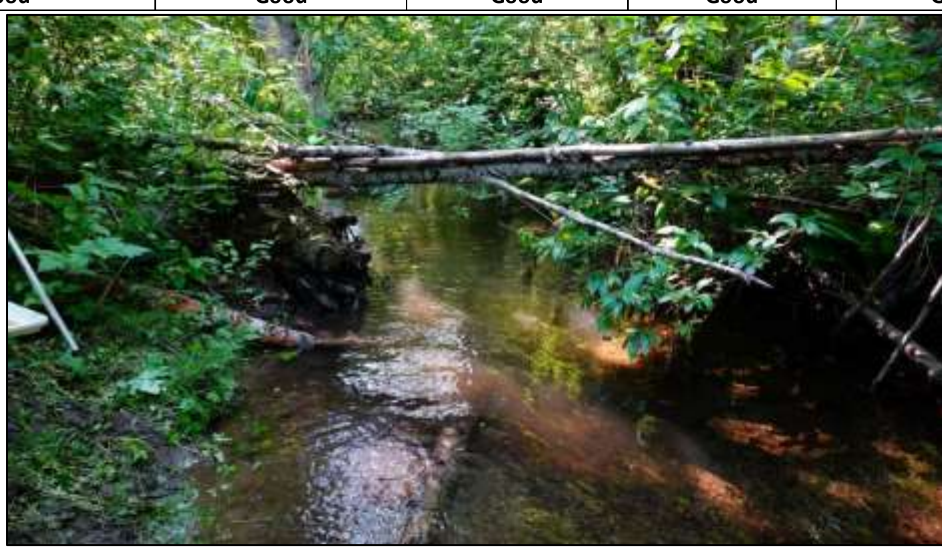
Twenty-One Mile Ck D/S View

Date	Stream								
28-Jul-23	ROGD U/S								
Water quality		Area and Substrate		Depth and velocity (m)		Site Cover		Vegetation and Channel	
Habitat type	Pool-Riffle	Gradient	<1%	Avg Dep	0.26	OH%	1-25%	Grass	Y
Site type	Full x-sec	Width 1 (m)	10.8	Avg Vel	0.27	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/s	Width 2 (m)	4.7	Depth 1	0.14	Deep%	1-25%	Decidiuous	Y
do%	92.9	Width 3 (m)	6.9	Depth 2	0.22	Bol%	0%	Conifer	Y
do mg/l	9.1	Length (m)	45	Depth 3	0.20	UC%	26-50%	Dom Veg	S
TDS	31	Wet area m2	336	Depth 4	0.29	Macro%	1-25%	Sub Veg	D
Conductivity	35.6	max depth(m)	1.06	Depth 5	0.24	LWD m2	6	Channel Pat	IM
SC/cm	47.8	%bol	5	Depth 6	0.17	SWD m2	8	Islands	N
ph	6.8	%cob	15	Vel 1	0.28	Dmax(m)	0.80	Bars	S
Stream Temp ^{0}C	12.9	%grv	60	Vel 2	0.64	D90 (m)	0.1	Riparian Stg	YF
		%fines	20	Vel 3	0.80				
		%Org		Vel 4	0.11				
				Vel 5	0.05				
				Vel 6	0.00				
Good		Good		Good		Good		Good	

ROGD US site U/S View

ROGD US Site D/S View

Date	Stream								
28-Jul-23	Crabapple Ck								
Water quality		Area and Substrate		Depth and velocity (m)		Site Cover		Vegetation and Channel	
Habitat type	riffle-run	Gradient	1%	Avg Dep	0.17	OH%	76-100%	Grass	Y
Site type	Full x-sec	Width 1 (m)	3.1	Avg Vel	0.2	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/s	Width 2 (m)	4.4	Depth 1	0.1	Deep%	0%	Decidiuous	Y
do%	95.5	Width 3 (m)	3.9	Depth 2	0.14	Bol%	1-25%	Conifer	Y
do mg/l	9.3	Length (m)	23	Depth 3	0.13	UC%	51-75%	Dom Veg	C
TDS	136	Wet area m2	87	Depth 4	0.13	Macro%	1-25%	Sub Veg	S
Conductivity	108.8	max depth(m)	0.43	Depth 5	0.11	LWD m2	2	Channel Pat	S
SC/cm	209	%bol	5	Depth 6	0.08	SWD m2	4	Islands	N
ph	7.2	%cob	10	Vel 1	0.12	Dmax(m)	0.75	Bars	N
Stream Temp ^{0}C	13.4	%grv	35	Vel 2	0.23	D90 (m)	0.15	Riparian Stg	YF
		%fines	35	Vel 3	0.35				
		%Org	15	Vel 4	0.42				
				Vel 5	0.16				
				Vel 6	0.2				
Good		Good		Good		Good		Good	



Crabapple Creek U/S View

Crabapple Creek D/S View

Date	Stream								
28-Jul-23	ROGD DS								
Water quality		Area and Substrate		Depth and velocity (m)		Site Cover		Vegetation and Channel	
Habitat type	Pool-Riffle	Gradient	<1%	Avg Dep	0.39	OH%	1-25%	Grass	n
Site type	Full x-sec	Width 1 (m)	12.6	Avg Vel	0.10	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/s	Width 2 (m)	7.8	Depth 1	0.34	Deep%	1-25%	Decidiuous	Y
do%	101.5	Width 3 (m)	11.1	Depth 2	0.52	Bol%	0%	Conifer	Y
do mg/l	9.5	Length (m)	63	Depth 3	0.63	UC%	76-100%	Dom Veg	S
TDS	51	Wet area m2	662	Depth 4	0.08	Macro%	1-25%	Sub Veg	D
Conductivity	41.2	max depth(m)	0.93	Depth 5	0.72	LWD m2	4	Channel Pat	IM
SC/cm	78.7	%bol	0	Depth 6	0.41	SWD m2	10	Islands	N
ph	6.8	%cob	5	Vel 1	0.00	Dmax(m)	0.30	Bars	S
Stream Temp ^{0}C	15.2	%grv	55	Vel 2	0.00	D90 (m)	0.15	Riparian Stg	YF
		%fines	35	Vel 3	0.03				
		%Org	5	Vel 4	0.07				
				Vel 5	0.09				
				Vel 6	0.03				
Good		Fair		Good		Good		Good	

ROGD DS Site U/S View

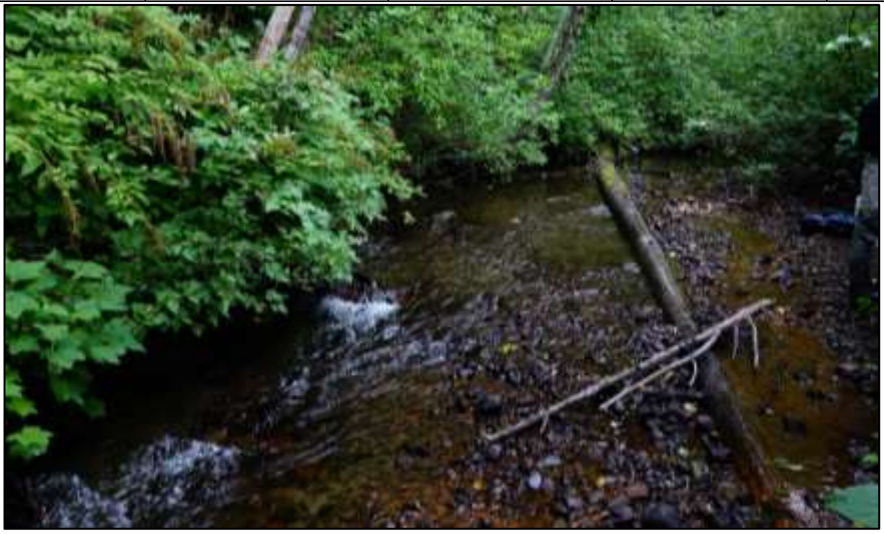
ROGD DS Site U/S View

Date	Stream								
29-Jul-23	Jordan Creek								
Water quality		**Area and Substrate**		**Depth and velocity (m)**		**Site Cover**		**Vegetation and Channel**	
Habitat type	Pool-Run	Gradient	1%	Avg Dep	0.37	OH%	76-100%	Grass	Y
Site type	Full x-sec	Width 1 (m)	5.7	Avg Vel	0.16	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/s	Width 2 (m)	5.8	Depth 1	0.17	Deep%	26-50%	Decidiuous	Y
do%	98.9	Width 3 (m)	5.2	Depth 2	0.26	Bol%	1-25%	Conifer	Y
do mg/l	8.68	Length (m)	34	Depth 3	0.29	UC%	76-100%	Dom Veg	D
TDS	48	Wet area m2	190	Depth 4	0.32	Macro%	1-25%	Sub Veg	C
Conductivity	55	max depth(m)	1.28	Depth 5	0.26	LWD m2	2	Channel Pat	S
SC/cm	73.2	%bol	25	Depth 6	0.18	SWD m2	5	Islands	N
ph	7.6	%cob	40	Vel 1	0.05	Dmax(m)	1.80	Bars	N
Stream Temp ^{0}C	18.2	%grv	25	Vel 2	0.08	D90 (m)	0.35	Riparian Stg	YF
		%fines	10	Vel 3	0.15				
		%Org	0	Vel 4	0.11				
				Vel 5	0.02				
				Vel 6	0.00				
Fair		**Good**		**Good**		**Good**		**Good**	

Jordan Creek U/S View

Jordan Creek D/S View

Date	Stream								
29-Jul-23	Whistler Creek								
Water quality		Area and Substrate		Depth and velocity (m)		Site Cover		Vegetation and Channel	
Habitat type	Pool-Run	Gradient	1%	Avg Dep	0.20	OH%	51-75%	Grass	Y
Site type	Full x-sec	Width 1 (m)	4.7	Avg Vel	0.29	Turb%	1-25%	Shrub	Y
Turbidity NTU	n/s	Width 2 (m)	6.1	Depth 1	0.23	Deep%	1-25%	Decidiuous	Y
do%	99.7	Width 3 (m)	5.8	Depth 2	0.22	Bol%	1-25%	Conifer	Y
do mg/l	10	Length (m)	33	Depth 3	0.2	UC%	76-100%	Dom Veg	C
TDS	56	Wet area m2	184	Depth 4	0.12	Macro%	0%	Sub Veg	S
Conductivity	57.6	max depth(m)	0.57	Depth 5	0.12	LWD m2	4	Channel Pat	S
SC/cm	84.4	%bol	5	Depth 6	0.04	SWD m2	6	Islands	N
ph	6.8	%cob	15	Vel 1	0.08	Dmax(m)	1.20	Bars	N
Stream Temp ^{0}C	12.0	%grv	55	Vel 2	0.2	D90 (m)	0.25	Riparian Stg	YF
		%fines	15	Vel 3	0.51				
		%Org	10	Vel 4	0.31				
				Vel 5	0.31				
				Vel 6	0.11				
Good		Good		Good		Good		Good	



Whistler Creek U/S View

Whistler Creek D/S View