REPORT

Rascal Stream West Culvert Installation Construction Monitoring Report

B2Gold Back River Project

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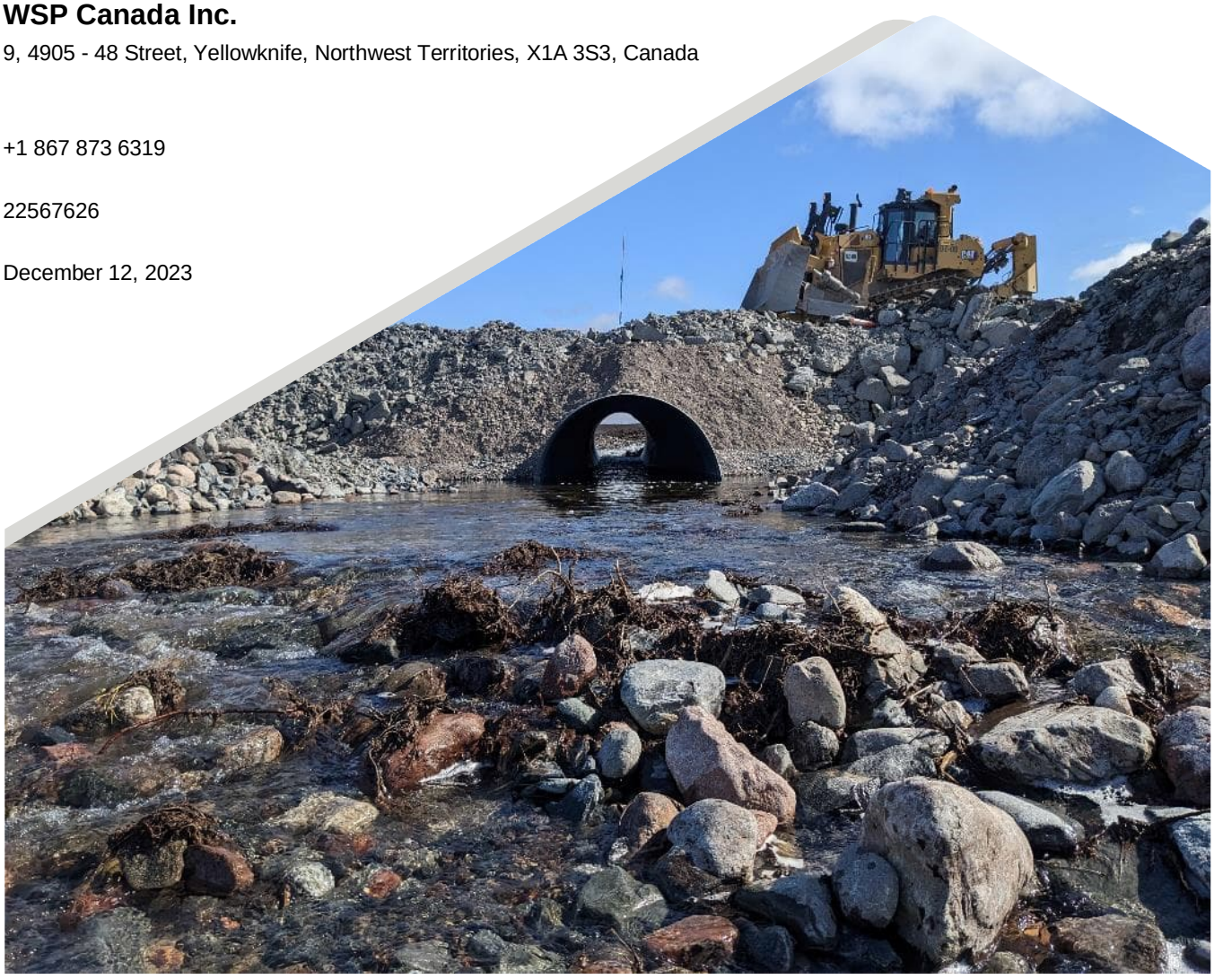

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1.0 INTRODUCTION

1.1 Background

B2Gold Corp. (B2Gold; formerly Sabina Gold & Silver Corp.) operates the Back River Project located in western Nunavut. The Back River Project consists of operations in the Marine Laydown Area and the Goose Lake Property Area. The Goose Lake Property Area is currently being developed for mining operations and is within the construction phase of their approved Water Management Plan. As part of mine development, the Rascal Stream West (RSW) crossing upgrade (the Project) was completed to accommodate haul truck traffic by replacing the bridge crossing on the primary and secondary RSW channels with culvert designs. Design specifications were provided by WSP Canada Inc (WSP; formerly Golder) (Golder 2021), which included twin steel oblong (pipe arch) culverts to be installed at the primary channel crossing and a single steel circular culvert to be installed at the secondary channel of Rascal Stream West.

Although the construction plan was to complete the installation of the crossings during frozen conditions in advance of the spring freshet, an early spring melt created flowing conditions and challenges for the installation, including the potential requirement for an isolation area for work to proceed and environmental monitoring to evaluate risks for fish. B2Gold then secured WSP to provide immediate environmental support, including environmental technicians who arrived at site on 10 May 2023 to monitor turbidity and complete fish rescues at the construction work area, as needed. During which time, the Contractor (Ledcor) and on-site B2Gold staff successful installed the culvert crossing over the secondary channel where there were minimal flows in the watercourse. The culvert crossing for the secondary channel was installed by 14 May 2023. Unfortunately, continued snow and ice melt runoff entered the primary watercourse, flooding the construction area for the twin steel oblong culverts. To redirect water, the Contractor constructed a diversion berm on the primary channel to divert all flow through the secondary channel crossing (such that the work isolation area on the primary channel would be dry). Construction then paused on 17 May 2023 due to water seepage under the diversion berm, subsequent flooding of the isolation area, and the observation of adult Artic Grayling at the secondary channel crossing. It was decided that the Contractor and B2Gold would continue the installation when flow conditions subsided to summer baseflow levels and when dates fall outside the DFO restricted activity window for spring spawning Salmonids in Nunavut (specifically after 15 July). The diversion berm was left in place and surface flow was maintained through the secondary channel until the completion of the primary channel crossing. The primary channel crossing was completed under dry (or nearly dry) watercourse conditions during the second phase of construction in late August / early September 2023.

The objective of this technical memo is to provide a summary of construction monitoring and fish salvage activities that were conducted in spring and summer 2023. Construction monitoring included measurements of turbidity upstream and downstream of the work area during in-water construction, and a qualitative (visual) evaluation of whether fish passage was maintained during any overlap of construction activities with the migration period for Arctic Grayling.

1.2 Event Timeline

An approximate timeline of relevant construction and environmental tasks are provided Figure 1.1. Photos of construction activities and a detailed construction log are provided in Appendix A and B, respectively.

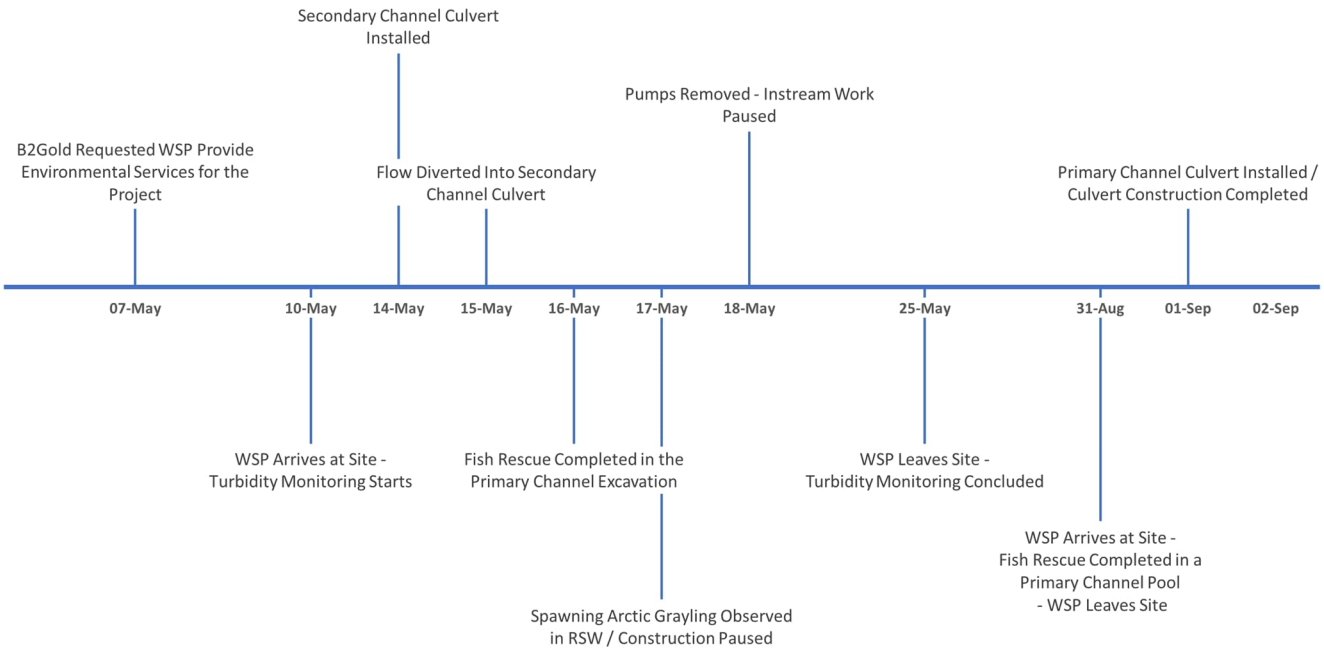


Figure 1-1: Approximate Timeline of Construction Works and Environmental Services Support During the Rascal Stream West Culvert Crossing Construction, 2023

1.3 Regulatory Overview

Section 34.4(1) and 35(1) of the *Fisheries Act* prohibits the death of fish and the harmful alteration, disruption, or destruction of fish habitat (HADD), respectively (GOC 1985). Section 36.3 of the *Fisheries Act* prohibits the deposition of a deleterious substance in any waterway frequented by fish. Since the Project constitutes works in and around fish bearing waters, a Request for Review application was submitted to DFO for approval to proceed with planned culvert construction works. The application included fish and fish habitat protection measures to reduce risk of residual effects to fish and fish habitat. DFO subsequently reviewed the construction activities and mitigation measures provided in the application and determined that the culvert crossing construction works could proceed under a Letter of Advice (LOA) dated 15 July 2022 (file # 18-HCAA-00185). DFO was subsequently notified during a meeting on 31 January 2023 between DFO and B2Gold that the installation was delayed until April 2023. DFO was then notified on 19 April 2023 by email from WSP that construction activities were to begin immediately under frozen conditions in advance of the spring freshet.

1.4 Water Quality Guidelines

Instream construction works has the potential to introduce sediment and/or foreign materials into the waterbody and cause harm to aquatic organisms (Canadian Council of Ministers of the Environment (CCME 2002), triggering *Section 36.3* of the Fisheries Act. Possible direct and indirect effects of introduced sediment include changes in substrate composition, habitat degradation for macroinvertebrates and fish, smothering of benthic communities and fish eggs, and abrasion to the respiratory surfaces of macroinvertebrates and fish (CCME 2002). As a best management practise, B2Gold requested that WSP monitor turbidity and/or total suspended sediment (TSS) during construction activities if and when such activities would be completed under flowing conditions.

The turbidity guidelines described under the *Canadian Water Quality Guidelines for the Protection of Aquatic Life – Total Particulate Matter* (CCME 2002) were applied to the Project (Table 1-1). According to the guidelines for when background turbidity levels are less than 80 nephelometric turbidity units (NTU), a short-term exceedance occurs when turbidity has increased by at least 8 NTU above background levels over a 24-hour period. A long-term exceedance occurs when turbidity has increased by at least 2 NTU above background levels over a multi-day period. When background levels are greater than 80 NTU, an exceedance occurs when a maximum increase of 10% is observed at any time. The CCME definitions were used as guidelines to determine if an increase in instream sedimentation resulting from construction works constituted a potential residual impact on fish habitat, potentially requiring follow-up with regulators (e.g., DFO).

Table 1-1: Water Quality Guidelines for Construction Monitoring

Parameter	CCME Guideline[(a)] (relative to background level)		
	Background is < 8 NTU	*Background is 8 to 80 NTU*	*Background is > 80 NTU*
Turbidity (NTU)	Maximum increase of 8 NTU for a short-term exposure (e.g., 24-hour period) Maximum average increase of 2 NTU for a long-term exposure (e.g., 30 days)	Maximum increase of 8 NTU	Maximum increase of 10%

(a) Source: CCME 2002.

2.0 METHODS

Environmental monitoring was conducted for the Project from 10 to 25 May 2023. Monitoring activities included the collection of data to determine the effectiveness of mitigation measures to meet requirements under *Fisheries Act* policies, including Codes of Practices (COPs; DFO 2020a and 2020b), and in accordance with conditions of the DFO LOA (file # 18-HCAA-00185). The WSP environmental monitor conducted the following on-site tasks:

- provided technical assistance and recommendations to improve or modify environmental mitigation
- prepared daily environmental monitoring reports summarizing the activities on site
- monitored water quality (i.e., turbidity) and compared against CCME guidelines
- conducted fish rescue activities, where and when required to reduce risks of fish mortality during construction

Instream work was paused on 17 May 2023 due a combination of excessive seepage into the primary channel and the observation of adult Arctic Grayling in Rascal Stream West. As such, the environmental monitors stayed on-site until 25 May 2023 to collect additional fish and fish habitat information from RSW. This consisted of the following:

- continuation of turbidity monitoring
- fish habitat and watercourse crossing surveys to evaluate fish passage downstream and upstream of the newly installed culvert on the secondary channel, including the temporary diversion channel from the secondary channel to the confluence with the natural primary channel above the work area
- fish presence visual surveys along the shoreline of the entire watercourse length and fish egg presence surveys using in-water kick-net methods to better understand the distribution of fish and whether fish were migrating and/or spawning above the diversion

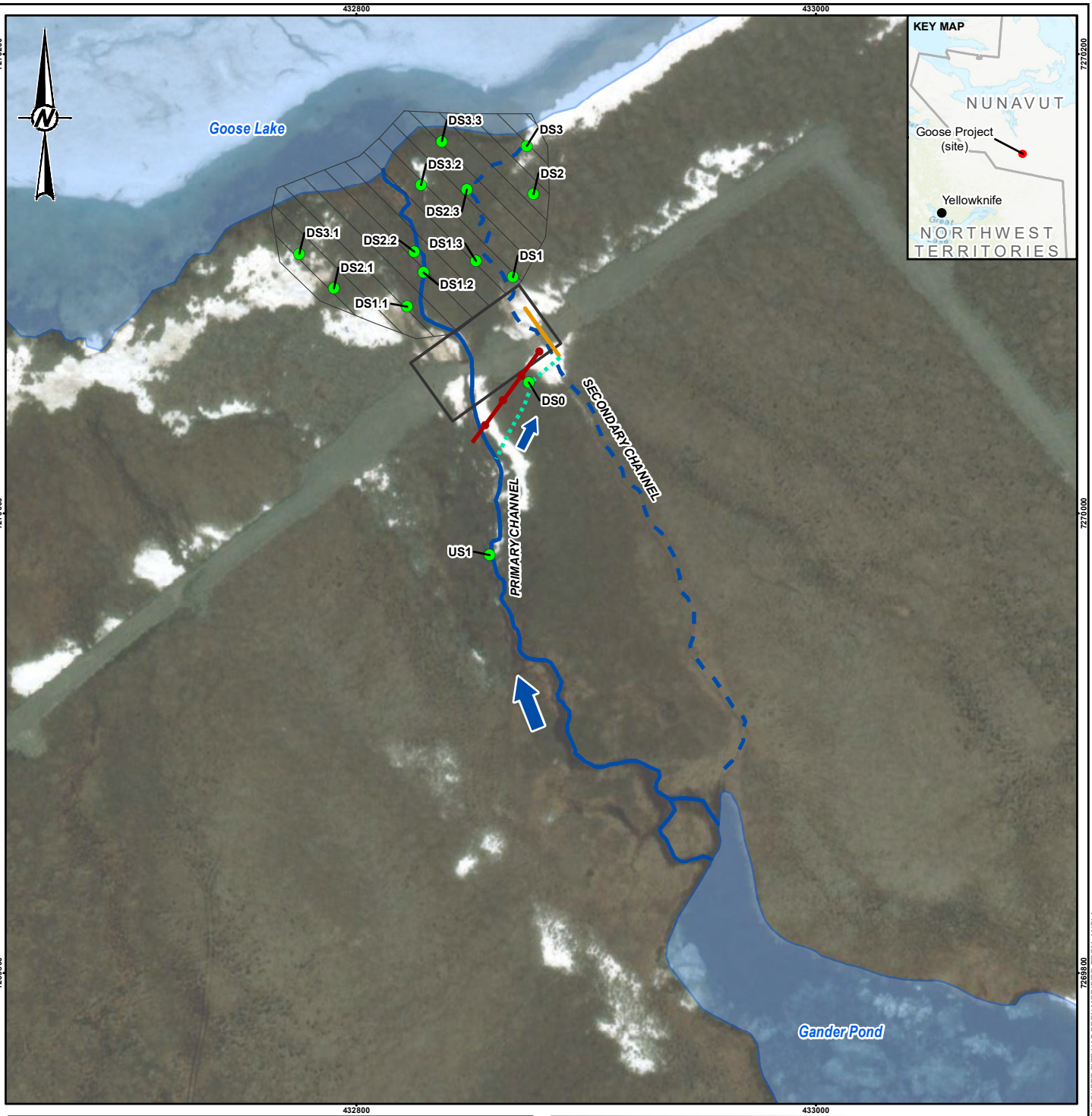
2.1 Turbidity Monitoring

Turbidity monitoring was conducted during in-channel construction (10 to 17 May 2023) and after construction (17 to 25 May 2023). The turbidity (NTU) parameter was used during this program as NTU measurements can be calculated in the field using portable instrumentation, providing measurements for comparisons to guidelines made in real time. Sampling was conducted upstream and downstream from the crossing construction area in the primary and secondary channels of RSW (Figure 2-1).

A background (US - upstream) station was established approximately 50 m above of the crossing construction instream work. Sampling stations downstream of instream work were located approximately 20 m and 50 m downstream of the work, and at the Goose Lake confluence, where the shoreline of Goose Lake was approximately 100 m downstream of the work area. Downstream sampling was conducted at stations in both the primary and secondary channels of Rascal Stream West. Sampling stations were adjusted throughout the program based on flow rate and water level. Photos of each monitoring station are provided in Appendix A.

During instream construction works, turbidity water quality grab-samples were collected at, approximately, two-hour intervals at well-mixed centre point transect locations from upstream and downstream sampling stations. Sampling was completed once per day after instream construction work concluded and downstream turbidity conditions returned to background. Turbidity samples were collected in 1.2 L plastic bottles at 60% stream depth from a well-mixed, representative location at the sampling station. A 20 mL subsample was decanted from each sample bottle and transferred into a test vial. Turbidity measurements were taken in triplicate from each test vial using a LaMotte 2020TI portable turbidity meter. Please see Appendix C for turbidity monitoring quality assurance and quality control (QAQC) procedures and results.

In the event of a downstream measurement that was elevated above guidelines (e.g., downstream turbidity conditions were over 8 NTU greater than upstream conditions), sampling frequency was increased, and the B2Gold Site Supervisor was notified so the construction crew could be instructed to implement mitigation. The field crew provided recommended mitigation measures when necessary. If turbidity conditions at a downstream station was over 10-times larger than the upstream station, the B2Gold Site Supervisor was notified, and it was recommended to stop work until suitable mitigation can be applied.



LEGEND

- FLOW DIRECTION
- CULVERT
- DIVERSION CHANNEL
- DIVERSION BERM
- GANDER POND OUTFLOW SIDE CHANNEL
- WATERCOURSE
- CONSTRUCTION FOOTPRINT AREA
- BRAIDED CHANNEL AREA
- WATERBODY

0 50 100

1:2,500 METRES

REFERENCE(S)

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PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
B2GOLD

PROJECT
BACK RIVER PROJECT - RASCAL STREAM WEST CROSSING UPGRADE

TITLE
TURBIDITY MONITORING SAMPLING STATIONS ON RASCAL STREAM WEST

CONSULTANT

wsp

YYYY-MM-DD	2023-09-13
DESIGNED	TD
PREPARED	SP
REVIEWED	CC
APPROVED	CS

PROJECT NO.	PHASE	REV.	FIGURE
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2.2 Fish Rescues

Three emergency fish rescues were completed in RSW. DFO granted authorization for WSP to proceed with fishing effort on RSW on 16 March 2023, via email communication. Prior to conducting any fishing effort, the section of channel that required a fish rescue was isolated by installing block nets (5 mm mesh) positioned upstream and downstream, if required. Fishing rescues were completed on the following dates:

- 6 May 2023 – a fish rescue was completed, using a beach seine, in the primary channel culvert excavation pond.
- 17 May 2023 – a fish rescue was initiated, using backpack electrofishing, in the primary channel between the diversion berm and Gander Pond.
- 31 August 2023 – a fish rescue was completed, using backpack electrofishing, in an isolated pool located in the primary channel and just above the diversion berm.

Fish sampling followed standard methods for inventories for small watercourses (Golder 1999; Bonar 2009). To the extent practical, fishing effort was conducted until all fish from the isolated area had been rescued. The following information was recorded for each fishing effort:

- UTM coordinates for sampling location boundaries
- dates
- gear type and electrofishing settings
- effort
- species and fork length of each fish captured

2.3 Fish Passage Assessment

After construction paused on 17 May 2023, the field crew remained on site to assess and document fish passage from Goose Lake to Gander Pond, specifically for Arctic Grayling. This assessment included a fish habitat and crossing assessment (including discharge measurements), daily visual surveys, and kick net surveys.

A fish habitat assessment was conducted on 20 May 2023 to document watercourse habitat features of the secondary channel from the confluence of Goose Lake to the secondary culvert, the diversion channel from the secondary culvert to the primary channel upstream of the construction area, and the primary channel upstream of the construction area to Gander Pond. The section of RSW downstream from the road crossing and culvert had dispersed flow with multiple braided channels before entering Goose Lake. The habitat assessment for this section was completed in the deepest and most defined channel.

Fish habitat survey methods were consistent with habitat mapping procedures for Watercourse Crossings in Alberta (Government of Alberta 2009), as well as internal technical procedures (Golder 2005). In addition, the field crew collected daily depth and current velocity measurements to calculate discharge from 20 to 25 May 2023. The measurement was collected at a suitable location where flows were confined and within the vicinity of the crossing location. Discharge was calculated using the velocity-area method. A tape measure was extended across the length of the cross-section during the measurement event. Streamflow velocities and corresponding water depths were collected at varying intervals along the cross section depending on the width of the channel. Current velocities were recorded with a Hach meter at 60% of the total water depth.

2.3.1 Visual Surveys

Systematic visual surveys for spawning fish were conducted daily from 17 May to 25 May 2023. Stationary visual surveys were conducted by remaining in one location along the stream bank and documenting the presence and passage of any fish. Walking visual surveys were conducted by walking the length of the stream segment and documenting any fish observations.

Visual surveys were conducted in the following downstream locations:

- along the Goose Lake shoreline between the primary and secondary channel outflows
- along the primary channel confluence with Goose Lake to the road
- along the secondary channel confluence with Goose Lake to the newly installed culvert

Visual surveys were also conducted in the following upstream locations:

- along the diversion channel from the secondary culvert to the primary channel upstream of the construction area
- along the primary channel from the construction area to Gander Pond

Arctic Grayling age was estimated based on the following size classes (McPherson et al. 2022).

- Young-of-Year: 0 to 80 mm
- Juvenile: 80 to 170 mm
- Adult: >170 mm

2.3.2 Kick Net Surveys

Kick net surveys were completed on 24 May 2023 using a D-shaped kick net (305 mm by 254 mm net opening and a 500 µm mesh size) to determine the presence or absence of Arctic Grayling eggs. Kick netting was completed at locations with suitable spawning habitat (i.e., patches of gravel in a riffle or run habitat, or run-riffle transition area); the net was placed downstream of the area to be kicked (1 m^2), so that when substrate was disturbed, any eggs that were deposited in the substrate would drift downstream into the net. The number of sampling plots kicked per location of spawning gravels reflected the size of that area (one to five plots per area, spaced at least 1 m apart). As soon as eggs were documented in an area, no more kicks were conducted so impact to eggs was minimized.

Arctic Grayling eggs are small, ranging from 2 to 3 mm in diameter prior to fertilization, 2.7 mm on average when water hardened, and swell for 3 to 4 days to reach 3.5 to 4 mm in diameter (Northcote 1993).

The following information was recorded for each sampling effort:

- UTM coordinates for sampling locations
- dates
- start and end time
- net dimensions

- water depth
- general habitat description and dominant substrate types
- area sampled
- number and diameter of eggs captured

3.0 RESULTS

3.1 Construction Monitoring

Construction monitoring began on 10 May 2023 after rapid snow and ice melt caused flooding of the construction zone. Upon WSP's arrival at the Site, the twin culvert excavation for the primary channel crossing had paused because the work area filled with water. However, the single culvert excavation in the secondary channel was progressing, with extents completed on 10 May 2023. Upon the final stages of the installation of the secondary channel crossing on 15 May 2023, a temporary earth dam was constructed in the primary channel of Rascal Stream West to divert flows from the primary channel into the new corrugated steel culvert in the secondary channel. Site photos and a log of construction activities are provided in Appendix A and B, respectively.

Turbidity monitoring in RSW was conducted during instream construction activities from 10 to 18 May 2023, and continued for approximately one week after construction. Table 3-1 provides an overview of which sites were sampled on specific dates of the monitoring program. A total of 313 samples (i.e., not including QA/QC samples) were collected among downstream and upstream sampling sites (Appendix D).

Table 3-1: Overview of Where and When Turbidity Samples were Collected on RSW

Site ID	Date (May 2023)															
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Primary Channel																
US1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS1.1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-
DS1.2	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS2.1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-
DS2.2	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS3.1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-
DS3.2	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS3.3	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diversion Channel																
DS0	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Secondary Channel																
DS1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS1.3	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DS2.3	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ = turbidity sampling completed; - = no turbidity sampling completed.

Turbidity conditions at downstream sites were elevated, relative to the guidelines (CCME 2002), during the following events:

- 10 May: in the afternoon, the turbidity level at downstream site DS2 was 10.0 NTU, which was elevated above the upstream turbidity level by more than 8 NTU. The DS2 turbidity level returned to background levels by the next morning, within 24 hours of the elevated reading. This short-term elevation was attributed to water flowing through the secondary channel excavation area.
- 11 May: in the afternoon, turbidity levels at downstream sites DS1, DS2, DS3, and DS1.1 ranged from 15.5 to 78.1 NTU and were elevated above the upstream turbidity level by greater than 8 NTU. This elevation was attributed to flow from pumps in the excavation work area, which was recently disturbed. The pump inlets were relocated upstream of the temporary earth dam to decrease turbidity levels downstream; downstream turbidity level returned to background levels by the next morning (i.e., within 24 hours).
- 12 May: in the afternoon, turbidity levels at downstream sites DS1.2, DS2.2, and DS3.2 ranged from 23.9 to 67.1 NTU and were elevated above the upstream turbidity levels by greater than 8 NTU. The turbidity level returned to background levels by the next morning. This short-term elevation was attributed to downstream flow seeping through the temporary road.
- 13 May: in the afternoon, the turbidity level at site DS2 and DS2.2 was 9.0 and 9.2, respectively, and elevated above the upstream turbidity level by greater than 8 NTU. The DS2 turbidity level returned to background levels later that afternoon and the DS2.2 turbidity level returned to background levels by the next morning. The elevation at DS2.2 was attributed to downstream flow seeping through the temporary road.
- 15 May: in the morning, turbidity levels at downstream sites DS1.2, DS2.2, and DS3.2 ranged from 27.1 to 117 NTU and were elevated above the upstream turbidity levels by greater than 8 NTU. Turbidity levels at sites DS1.2 and DS2.2 continued to be elevated above guideline until the morning of 19 May. Turbidity levels at site DS3.2 returned to background levels on the morning of 17 May, but were elevated again by 18 May, before returning to background on 19 May.
- During the afternoon of 15 May, turbidity levels at other downstream sites DS3, DS3.1, and DS1.1 ranged from 10.3 to 50.7 NTU and were elevated above the upstream turbidity levels by greater than 8 NTU. DS3 turbidity levels returned to background by the next morning; however, DS3.1 and DS1.1 remained elevated until the morning of 17 May.

The elevated NTU levels from 15 to 19 May were attributed to the following construction activities:

- 15 May: excavation work downstream of the secondary culvert and the construction of the diversion dam
- 16 May: excavator working in excavation pond during pump-out, resulting in very high turbidity levels downstream. Pump outlets were then moved to a position further upstream, to allow sediment to settle prior to reaching Goose Lake. The excavator was also moved out of the lower pond.
- 17 to 19 May: seepage through road. On 18 May, a silt fence was installed to mitigate downstream transfer of sediment.

The elevated turbidity levels were reported to the B2Gold Site Supervisor to discuss the implementation of mitigation solutions. Mitigations included attempting to speed up the pace of construction, re-positioning pump outlets to allow sediment to settle prior to Goose Lake, the installation of additional silt fences, and re-positioning the excavator to reduce in-water disturbances.

3.1.1 Fish Rescues

A summary of the fishing effort is provided in Table 3-1. Six seine net efforts were conducted in the excavation pond on 16 May 2023, no fish were captured, and as such, the pond was considered unlikely to support fish at the time of monitoring. One pass of backpack electrofishing was conducted in the primary channel of Rascal Stream West on 17 May 2023 between the installed block nets (i.e., from upstream of the installed diversion berm to Gander Pond) (Table 3-1). Three adult Arctic Grayling with a fork length and weight ranging between 240 and 290 mm and 156 to 272 g, respectively, were captured and released in Gander Pond. Additional fish rescue efforts were not conducted after the first electrofishing pass, as B2Gold, in consultation with WSP and DFO, made the decision to pause construction until later in the season to minimize disruption to spawning Arctic Grayling in RSW.

In advance of construction that was re-initiated in late August, a fish rescue was conducted within a pool of water that refilled the area above the berm following late summer precipitation events. A total of eleven passes were conducted over the wetted area (i.e., within the small pond or pool) immediately above the diversion berm. Total catch was 336 fish (202 young-of-year Arctic Grayling, and 134 Ninespine Stickleback). The first past yielded the highest catch of 84 young of year Arctic Grayling and 10 Ninespine Stickleback, with the catch consistently declining through subsequent passes and the final pass yielding no fish. Length of captured Arctic Grayling ranged from 55 to 95 mm, and Ninespine Stickleback ranged from 22 to 40 mm. All fish were released immediately upon capture downstream of the work area near the confluence with Goose Lake.

Table 3-1: Summary of Project Fish Rescue Effort Completed in the Lower Reach of RSW, 2023

Date (2023)	Location	Method	UTM Coordinates (Zone 13W, UTM NAD83)				Total Distance (m)	# of Passes	Total Effort
			Start Location		End Location				
			Easting	Northing	Easting	Northing			
16-May	Excavation Isolation Pond	Seining[(a)]	432844	7270078	432829	7270069	15	6	405 m^2
17-May	Primary Channel Upstream	E-fishing[(b)]	432870	7270014	432957	7279858	150	1	1,244 seconds
31-Aug.	Primary Channel Upstream Pool	E-fishing[(c)]	432860	7270009	432854	7270028	21	11	5,587 seconds

(a) Seine dimensions = 4.6 x 1.5 m with a mesh size of 5 mm.

(b) Backpack electrofishing settings = 30 hertz (frequency), 830 volts (output voltage), 3.6 ampere (current), 12 milliseconds (pulse width).

(c) Backpack electrofishing settings = 60 hertz (frequency), 500 volts (output voltage), 3.6 ampere (current), 15 milliseconds (pulse width).

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; E-fishing = backpack electrofishing.

3.2 Fish Passage Assessment

Discharge measurements were collected daily from 20 to 25 May 2023. Mean discharge over this period was 0.129 m^3/s. Flow discharge in RSW was highest on 22 May (0.162 m^3/s) before decreasing gradually during subsequent days. Discharge on 25 May was 0.099 m^3/s. Water temperature was recorded in the secondary channel just downstream of the culvert on 24 May, measuring 7.2°C.

A fish habitat assessment of the entire stream section from the secondary channel outflow at Goose Lake to Gander Pond was conducted on 20 May 2023 (Table 3-2). Detailed results are provided in Appendix E.

Table 3-2: Summary of Fish Habitat Assessment, 20 May 2023

Location	Channel Unit #	Length (m)	Habitat Type[a]	Maximum Water Depth (m)	Average Wetted Width (m)	Average Bankfull Width (m)	Substrate [b]	
							Dominant	Subdominant
Secondary Channel	1	78	Run 3	0.6	15	1.3	Sa	Or, Si
	2	10	Riffle	0.3	15	1.2	Bo	Co
	3	10	Run 3	1.0	5.5	5.5	Gr	Si, Sa, Co, Bo
Diversion Channel	4	40	Run 3	0.6	1.4	1.8	Bo	Co, Gr
Primary Channel	5	30	Pool	>1.5	22	22	Or	Si
	6	50	Riffle	0.5	1.2	1.4	Bo	Co, Gr
	7	50	Run 3	0.7	3.0	3.5	Or	Bo, Si, Sa
	8	50	Run 2	2.0	3.0	3.4	Bo, Or	Si, Sa
	9	50	Run 3	0.8	2.5	3.0	Or	Si, Sa

(a) As defined by O'Neil and Hildebrand (1986). Run 3 is a shallow (<0.75 m deep) moderate velocity area with low instream cover; Riffle is a shallow (<0.5 m deep), high velocity and gradient area dominated by coarse substrate; Pool is a discrete portion of channel with increased depth and reduced velocity compared to run habitat; Run 2 is a 0.75 to 1.0 m deep, moderate to high velocity area with moderate to high instream cover.

(b) Or = Organics; Si = Silt (<0.06 mm); Sa = Sand (0.06-2 mm); Gr = Gravel (2-64 mm); Co = Cobble (64-256 mm); Bo = Boulder (>256 mm).

Under the diverted flow condition, the secondary channel was primarily shallow run habitat, with a short riffle section over a ledge of cobble and boulders. This section was largely flooded, with a wetted and bankfull width ranging from 5.5 to 15 m and 1.2 to 5.5 m, respectively. The dominant substrate in the downstream portion (closest to Goose Lake) was sand and the dominant substrate upstream from the crossing was gravel. The diversion channel was shallow run habitat, with boulder, cobble, and gravel substrate. A deep pool (greater than 1.5 m depth) formed in the primary channel just above the diversion berm, the substrate in this pool consisted of fines (i.e., silt and organics). The section of habitat in the primary channel extending from the pool to Gander Pond consisted of riffle and run habitat. The wetted and bankfull width ranged from 1.2 to 3 m and 1.4 to 3.5 m, respectively. The dominate substrate was boulder in the riffle habitat and organic material in the run habitat.

A qualitative assessment of fish passage was conducted to determine whether Arctic Grayling were able to move up through the secondary culvert, through the diversion channel, and into the natural primary channel for spawning. The main concern was a natural ledge of boulder and cobble substrate just downstream of the secondary culvert that may create a fish barrier during lower flows. On 21 May, the field crew rearranged boulders and cobble to create a deeper channel over the rock ledge, decreasing the chance of a fish barrier in the future. The field crew did not identify any barriers when departing from site on 25 May. Spot velocity measurements were taken along the secondary channel, in the culvert, and in the diversion channel (Table 3-3).

Table 3-3: Spot Velocity Measurements in Secondary Channel and Diversion Channel, 23 May 2023

Location	UTM Coordinates (Zone 13W, UTM NAD83)		Habitat Type[(a)]	1/4 Width		1/2 Width		3/4 Width	
	Easting	Northing		Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)
Secondary Channel	432853	7270125	Run 3	0.25	0.541	0.24	0.451	0.18	0.693
Secondary Channel	432863	7270105	Riffle	0.08	1.307	0.06	1.090	0.06	1.017
Secondary Channel	432864	7270101	Run 3	0.12	0.054	0.10	0.063	0.20	0.112
Culvert	432880	7270074	Run 3	0.12	0.233	0.10	0.338	0.11	0.463
Diversion Channel	432884	7270060	Run 3	0.12	0.550	0.25	0.247	0.25	0.927

(a) As defined by O'Neil and Hildebrand (1986). Run 3 is a shallow (<0.75 m deep) moderate velocity area with low instream cover; Riffle is a shallow (<0.5 m deep), high velocity and gradient area dominated by coarse substrate.

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983.

3.2.1 Visual Surveys

The distribution of Arctic Grayling throughout Rascal Stream West from Gander Pond to Goose Lake as documented by visual observations is summarized in Table 3-4. No fish were observed prior to 17 May, likely due to the presence of an ice shelf in Goose Lake preventing upstream migration of fish that overwinter in Goose Lake. The presence of the ice shelf was identified by B2Gold using a drone to collect aerial imagery and was later confirmed by a WSP field technician on 11 May.

In total, 108 Arctic Grayling observations were made during visual surveys, of which 78 were adults and 30 were juveniles. Two Lake Trout (*Salvelinus Namaycush*) were observed in Goose Lake near the secondary channel outflow, 15 Ninespine Stickleback (*Pungitius pungitius*), one Slimy Sculpin (*Cottus cognatus*), and five unidentified fish were observed in the primary channel and secondary channel near Goose Lake. All visual survey data is provided in Appendix E.

Multiple visual surveys were conducted during the day; therefore, total counts may not be representative of number of fish in the stream as fish were likely counted more than once. Much of the secondary channel downstream of the culvert was obscured by overhanging vegetation, and submerged branches of overhanging vegetation created turbulence, decreasing visibility into the stream.

On 19 May, strong winds and increased turbidity levels both upstream and downstream of the construction area caused low visibility in the stream. On the morning of 20 May, there was a thin layer of ice on the shoreline of Goose Lake, on the pools in the stream, and on Gander Pond.

Table 3-4: Arctic Grayling Observations Made During Visual Surveys

Date	Number of Arctic Grayling Observed			
	Goose Lake	Secondary Channel (below culvert)	Diversion Channel	Primary Channel (above diversion)
17-May	0	0	0	9 (adult)
18-May	0	0	0	0
19-May	0	3 (juvenile)	0	0
20-May	0	1 (juvenile)	0	6 (adult)
21-May	1 (adult)	2 (adult) 3 (juvenile)	0	4 (adult)
22-May	0	1 (adult) 4 (juvenile)	0	1 (adult)
23-May	1 (adult)	5 (adult) 6 (juvenile)	3 (adult)	18 (adult) 2 (juvenile)
24-May	3 (adult)	8 (adult) 8 (juvenile)	1 (adult) 1 (juvenile)	14 (adult) 2 (juvenile)
25-May	0	0	0	1 (adult)

3.2.2 Kick Net Surveys

Kick net surveys were conducted at all potential Arctic Grayling spawning habitat identified between Goose Lake and Gander Pond (Table 3-5). Arctic Grayling eggs were captured in the secondary and diversion channel (Table3-5; Appendix A, Photo 37). No Arctic Grayling eggs were observed in the primary channel.

Table 3-5: Kick Net Survey Data, 24 May 2023

Location	Coordinates (Zone 13W, UTM NAD83)		Max. Depth (m)	Total Area Kicked (m^2)	Habitat Type[a]	Substrate[b]	Species	No. Eggs	Average Egg Diameter (mm)
	Easting	Northing							
Secondary Channel	432862	7270105	0.2	2	R3	Co/Gr/Bo/Sa	ARGR	5	4
Diversion Channel	432875	7270057	0.3	2	R3	Gr/Co/Bo	-	0	-
Diversion Channel	432873	7270055	0.4	4	R3	Gr/Sa/Co/Bo	-	0	-
Diversion Channel	432872	7270047	0.3	5	R3	Co/Bo/Gr	ARGR	2	4
Diversion Channel	432866	7270042	0.2	1	R3	Gr/Co	ARGR	7	4
Primary Channel	432860	7269989	0.3	4	Rf	Gr/Co	-	0	-
Primary Channel	432864	7269973	0.3	5	Rf	Bo/Co/Gr	-	0	-
Primary Channel	432884	7269935	0.4	3	R3	Bo/Co/Sa/Or	-	0	-
Primary Channel	432867	7269955	0.3	2	R3	Co/Bo/Gr/Sa	-	0	-

(a) As defined by O'Neil and Hildebrand (1986). Run 3 is a shallow (<0.75 m deep) moderate velocity area with low instream cover; Riffle is a shallow (<0.5 m deep), high velocity and gradient area dominated by coarse substrate.

(b) Or = Organics; Sa = Sand (0.06-2 mm); Gr = Gravel (2-64 mm); Co = Cobble (64-256 mm); Bo = Boulder (>256 mm).

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; ARGR = Arctic Grayling; - = not applicable.

4.0 SUMMARY

WSP provided environmental monitoring services for the Project from 10 to 25 May 2023. Monitoring services included turbidity sampling, fish rescues and fish passage assessments.

Turbidity conditions in Rascal Stream West were monitored at upstream and downstream sampling locations relative to the crossing construction area. Overall, there were instances when turbidity conditions at some of the downstream stations were elevated above guidelines, relative to background; however, these elevations were typically short in duration (i.e., less than 24-hours) and mitigated with the implementation of erosion and sediment controls. A longer duration (i.e., more than 24-hours) turbidity elevation was observed at a subset of downstream sampling locations starting on 15 May. These readings were largely attributed to water seepage through work area, and under or through the temporary road. To mitigate potential effects, B2Gold and their Contractor attempted to speed up the pace of construction, re-positioned pump outlets to allow sediment to settle prior to entering Goose Lake, installed additional silt fences, and re-positioned the heavy mobile equipment to reduce sedimentation into the watercourse.

Construction on the secondary channel culvert was completed on 15 May. Flow from the primary channel (i.e., upstream from the construction area) was directed into the secondary channel culvert by a diversion berm. High flows on 16 May resulted in surface water flowing over the diversion berm and into the isolated construction work area of the primary channel. Construction was subsequently paused on 17 May due to a combination of excessive seepage into the work area and the presence of spawning Arctic Grayling moving through the Project area. WSP remained on-site until 25 May to monitor turbidity and to collect additional fish and fish habitat information. During which time adult Arctic Grayling were observed moving from Goose Lake to upstream spawning habitat in Rascal Stream West. The observations suggest that adults were successful in navigating through the newly constructed secondary channel culvert and diversion channel to upstream spawning habitat.

Construction on the primary channel culvert resumed by the end of August during late summer baseflow conditions. A successful fish rescue was conducted on 31 August, prior to any instream work, in pool habitat in the primary channel located just upstream from the diversion berm. Young of year Arctic Grayling and Ninespine Stickleback were removed from the pool and relocated downstream from the construction area (near the confluence with Goose Lake). The primary channel culverts were then installed in the dry, within the isolated section of watercourse, in early September. Subsequent field studies are scheduled during the spring and summer of 2024 to assess the suitability of Arctic Grayling spawning and rearing habitat in RSW. Results from this study will, in part, help determine if Arctic Grayling are able to access RSW habitat upstream from the culvert construction areas.

Signature Page

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https://golderassociates.sharepoint.com/sites/168863/project files/5 technical work/08000 fisheries and hydrology/7. rsw construction monitoring/culvert construction/report/22567626-152-r-rev0-10000-rsw construction monitoring report/22567626-152-r-rev0-10000-rsw construction monitoring report 2023 12dec_23.docx

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APPENDIX A

Rascal Stream West Culvert Construction Photographs

Photo 1: Dewatering pumps in upper pond and lower pond upstream of twin multiplate culvert excavation, 10 May 2023.

Photo 2: Lower pond seeping into twin multiplate excavation through temporary road, 10 May 2023.

Photo 3: Dewatering pump discharge downstream of secondary culvert excavation, facing Goose Lake, 10 May 2023.

Photo 4: Temporary culverts discharging twin multiplate culvert excavation, facing Goose Lake, 10 May 2023.

Photo 5: Secondary culvert excavation with bedding placed, looking downstream, 11 May 2023.

Photo 6: Twin multiplate culvert excavation, 11 May 2023.

Photo 7: Checking for ice shelf in Goose Lake, 11 May 2023.

Photo 8: View of the D/S pump outlet, facing Goose Lake, 12 May 2023.

Photo 9: View of seepage under the road, facing Goose Lake, 12 May 2023.

Photo 10: View of the twin multiplate excavation, facing Goose Lake, 12 May 2023.

Photo 11: View of the RSW inflow upper pond and pump set up, 12 May 2023.

Photo 12: View of the downstream pump outlet, facing Goose Lake, 14 May 2023.

Photo 13: View of secondary culvert outlet, facing Goose Lake, 15 May 2023.

Photo 14: View of the downstream temporary culvert outlet, facing Goose Lake, 15 May 2023.

Photo 15: View of the downstream side of the diversion berm, facing upstream, 15 May 2023.

Photo 16: View of the diversion dam and diversion channel, facing downstream, 15 May 2023.

Photo 17: View of the excavation pond, facing Goose Lake, 16 May 2023.

Photo 18: View of the RSW secondary channel showing flooding on tundra, facing upstream, 16 May 2023.

Photo 19: View of the pump discharge downstream of temporary culvert, facing Goose Lake, 16 May 2023.

Photo 20: Excavator working in excavation pond, 16 May 2023.

Photo 21: Very turbid water at monitoring station DS2.2, 16 May 2023.

Photo 22: Block net installed in the primary channel just downstream of Gander Pond, facing upstream, 17 May 2023.

Photo 23: Three adult Arctic Grayling observed in the primary channel, 17 May 2023.

Photo 24: Block net installed downstream of the primary channel, facing upstream, 17 May 2023.

Photo 25: Block net filling with debris, facing upstream, 17 May 2023.

Photo 26: Arctic Grayling captured electrofishing, 17 May 2023.

Photo 27: Turbidity monitoring station DS1, looking upstream, 17 May 2023.

Photo 28: Turbidity monitoring station DS2, looking upstream, 17 May 2023.

Photo 29: Turbidity monitoring station DS3, looking upstream, 17 May 2023.

Photo 30: Turbidity monitoring station DS1.3, looking upstream, 17 May 2023.

Photo 31: Turbidity monitoring station DS2.3, looking upstream, 17 May 2023.

Photo 32: Turbidity monitoring station DS3.3, looking downstream, 17 May 2023.

Photo 33: Turbidity monitoring station DS1.2, looking upstream, 17 May 2023.

Photo 34: Turbidity monitoring station DS 2.2, looking upstream, 17 May 2023.

Photo 35: Turbidity monitoring station DS3.2, looking downstream, 17 May 2023.

Photo 36: Turbidity monitoring station US1, looking downstream, 17 May 2023.

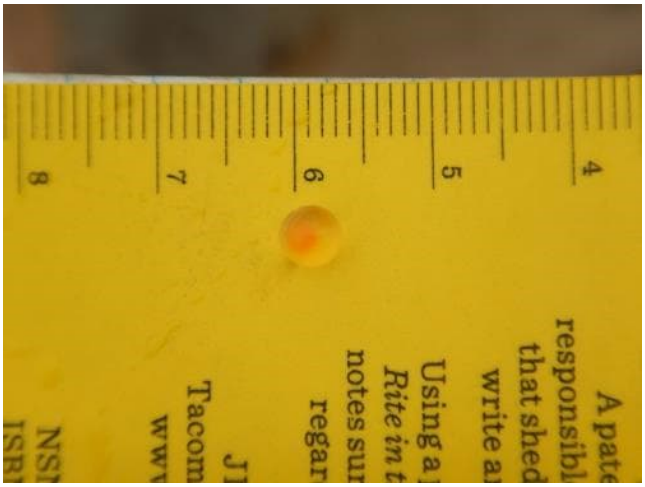

Photo 37: Arctic Grayling egg captured from Rascal Stream West during kick net surveys, 24 May 2023.

Photo 38: Completed twin steel culverts in the primary channel of RSW, facing upstream, 17 September 2023.

APPENDIX B

Construction Log

Table B-1: Construction Log, 10 May to 25 May 2023

Date	Time	Construction Activity
10-May-23	12:00	Water from rapid snow melt and overland flow into construction zone. Water located in downstream half of secondary culvert excavation and dewatering pump not operational.
10-May-23	15:00	Secondary culvert excavation at excavation extents
11-May-23	8:00	Only one pump operational, resulting in reduced flows. No flow exiting temporary culverts.
11-May-23	12:30	Four pumps operating with increased flow. Flow discharging through temporary culverts.
11-May-23	16:00	Flow from temporary culverts decreased and discharge passing into riprap, interstitial flows. Discharge from pumps is visibly turbid.
11-May-23	16:45	WSP recommended relocation of pump inlets upstream of temporary earth dam to decrease turbidity.
11-May-23	16:45	Placed transition layer, bedding layer, and secondary corrugated steel culvert.
12-May-23	7:20	50 mm clear crush stockpiled for backfill for secondary culvert. Three pumps running, keeping flow out of lower excavation pond. Minimal water in twin excavation. Some water in downstream end of secondary culvert excavation.
12-May-23	8:45	WSP recommended adjustments to pump discharge hoses to remove kinks. Three pumps maintaining flow. No flow into lower pond; all flow upstream of temporary earth dam.
12-May-23	9:45	WSP recommended placing riprap at pump outlets. Erosion occurring in natural surface material. Construction crew placed riprap at pump outlets.
12-May-23	11:45	Four pumps maintaining flow through culverts.
12-May-23	12:25	Excavator in place to begin backfill.
12-May-23	13:45	One pump removed from upper pond and relocated to dewater secondary culvert excavation. Flow overtopping earth dam weir and flowing into lower pond.
12-May-23	14:15	Dewatering of secondary excavation begun. Plate tamper delivered to site for compacting backfill. Plate tamper was damaged.
12-May-23	15:00	Twin excavation slowly filling with water.
12-May-23	15:15	Two pumps dewatering RSW as hoses are being realigned for excavator access. All pumps dewatering and water level below weir top.
12-May-23	16:40	Backfill material placed on left downstream side to 0.3 m above secondary culvert invert.
13-May-23	7:30	Four pumps operational. Flow overtopping earth dam weir. Sheen visible around downstream pump. Notified Ledcor. Cause is likely from refuelling pump. Sheen is flowing into lower pond. WSP recommended placing spill pads. Crew continued backfilling overnight (0.3 m fill on LDB, 0.9 m fill on RDB).
13-May-23	8:45	Spill pads and socks placed at location of sheen. Sheen not proceeding downstream.
13-May-23	11:00	Corrected misaligned upper section of culvert. Backfill compaction for secondary corrugated steel pipe culvert completed by jack tamper. Backfill is clear crush, very poorly graded, no fines.
13-May-23	15:00	Water levels increased in lower pond. Sheen visible in twin excavation. WSP recommended placing an absorbent sock boom in twin excavation to corral the sheen. Sheen continues to flow into lower pond despite absorbent beds and socks.
13-May-23	16:15	Sock boom installed. Some sheen seepage at knots in boom. WSP recommended relocating leaking pump hose away from spill location and adding more spill pads. Leaking hose relocated, created diversion for water around sheen location. Added more spill pads.
13-May-23	17:00	1.2 m backfill clear crush placed on LDB. 1.5 m on RDB. Sheen ceased entering lower pond.
14-May-23	8:45	Four pumps operational. Flow overtopping earth dam weir. Backfill complete to 0.3 m above top of culvert. Max particle size 75-100 mm. Large particles on top, smaller below (25 mm). Compaction with jack tamper. Some sheen visible at downstream end of twin excavation downstream of sock boom. Sheen does not appear to be re-entering stream in lower pond. Improved around pumps.
14-May-23	12:30	Culvert at 3.7% with raised inlet.
14-May-23	14:30	Flow slowly increased in RSW. Four pumps at maximum capacity unable to maintain flow below temporary earth dam weir. Flow discharging through temporary culvert from twin excavation.

Table B-1: Construction Log, 10 May to 25 May 2023

Date	Time	Construction Activity
14-May-23	15:15	Observed sheen on ground around pumps. WSP recommended wiping fuel hose with absorbent pad after refueling pumps.
14-May-23	16:00	Sheen was observed flowing into lower excavation pond below temporary earth dam.
14-May-23	16:30	Backfill completed to 0.6 m above the culvert crest with raw esker material. Track packed by dozer. Clear crush backfilled to 1.5 m on both sides of culvert. Raw esker material placed above to 0.6 m above crest. Last lift track packed. RoQ (Run of Quarry) material placed above track-packed raw esker material.
15-May-23	7:45	Backill material, raw esker placed upstream of secondary culvert. Backfill and plug was set below and in front of culvert inlet prior to placing raw esker.
15-May-23	9:45	Secondary culvert ready for receiving diverted flow. Road breached/excavated downstream of secondary culvert. Large release of sediment and increase in turbidity. Dewatering pumps discharging into inlet of secondary culvert. Excavator widening and increasing depth of secondary culvert downstream channel. Large apron in place to reduce erosion of ground surface.
15-May-23	12:30	Construction of upstream diversion berm on RDB begins. Introducing sediment and turbidity into upper pond, lower pond, and pump discharge through secondary culvert.
15-May-23	14:00	Increase in turbidity due to diversion dam construction.
15-May-23	14:50	Temporary earth dam weir plugged. RSW pooling behind temporary earth dam.
15-May-23	15:30	Diversion dam complete. High turbidity flowing through secondary culvert. Temporary apron undersized for flow and eroding. WSP recommended placing large riprap to reduce energy and erosion on LDB. Pumps shut down.
15-May-23	16:00	Turbidity levels reducing as flow continues and approaches steady state.
16-May-23	9:30	Night shift removed temporary road through twin excavation. Prepping to remove sediment and saturated soil. Lower pond is fully isolated upstream and downstream.
16-May-23	9:45	Water pumped out of lower pond to downstream of primary culvert area. WSP recommended to pump upstream and let it settle to decrease turbidity downstream.
16-May-23	10:50	Potential fish sighting in lower pond. WSP recommended Ledcor stop pumping and install end-of-pipe screens on pump. Pumping stopped.
16-May-23	11:45	Ledcor used mosquito netting to make a temporary screen for pump and started pumping again.
16-May-23	13:00	WSP completed four seine net passes in lower pond. No fish caught or observed. Installed a block net in front of pump.
16-May-23	13:45	Excavator working in lower pond. High turbidity downstream of pump out. WSP recommended Ledcor stop pumping or move the pump outlet further upstream to allow the sediment to settle.
16-May-23	14:00	Pump-out stopped.
16-May-23	14:30	Pump outflow moved further upstream.
16-May-23	14:45	No flow downstream of primary culvert location as pumpout has stopped.
16-May-23	15:00	Excavator moved out of lower pond. Pump moved to deeper location in lower pond.
16-May-23	16:45	WSP completed two more seine net passes in lower pond. No fish caught or observed.
17-May-23	7:05	Water in lower pond. Flow is breaching dam at the same rate as it is pumped out. Two pumps in pond.
17-May-23	8:00	WSP recommended a screen on the second pump.
17-May-23	8:30	Ledcor plans to divert water at the outlet of Gander Pond directly into secondary channel and add another berm across the primary channel at the Gander Pond outlet.
17-May-23	9:45	WSP installed one block net at Gander Pond outflow.
17-May-23	10:45	WSP observed three adult Arctic Grayling in primary channel of RSW. WSP recommended diversion held off until the stream can be isolated and fished out.
17-May-23	13:00	All block nets installed by WSP.
17-May-23	14:00	WSP conducted one backpack electrofishing pass. Three adult Arctic Grayling captured and relocated upstream of block nets in Gander Pond. Five more adult Arctic Grayling observed.

Table B-1: Construction Log, 10 May to 25 May 2023

Date	Time	Construction Activity
17-May-23	15:30	B2Gold consulting with WSP and decided to pause construction due to high flows making it difficult to manage water in the excavation area.
17-May-23	16:00	All block nets removed.
18-May-23	7:00	Pumps gone. Lower pond backfilled in the middle, creating two ponds. Seepage coming through backfill increasing turbidity downstream.
18-May-23	10:00	WSP recommended a silt fence to decrease turbidity downstream of excavation ponds.
18-May-23	13:00	Haul truck and bulldozer on site backfilling the excavation pond that is further upstream.
18-May-23	15:00	Crane on site removing culvert pieces. Dozer levelling and flattening new road.
18-May-23	15:30	Silt fence installed.
19-May-23	9:00	Roller compacting road.

APPENDIX C

Turbidity Monitoring Data: Quality Assurance and Quality Control

INTRODUCTION

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting. QA encompasses management and technical practices designed to ensure that the data generated are of consistent and acceptable quality. QC is an aspect of QA and consists of the procedures used to measure and evaluate data quality, and the corrective actions to be taken when data quality objectives are not met. This appendix describes QA/QC practices applied during this study, evaluates QC data, and describes the implications of QC results to the interpretation of study results and incorporates best practices described by PMEC 2006.

QUALITY ASSURANCE

QA applicable to this study cover three areas of internal management, as described below.

Field Staff Training and Operations

WSP field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to approved specific work instructions (SWIs) to the field crew and established WSP technical procedures. SWIs describe exact sampling locations and provide specific sampling instructions, equipment needs and calibration requirements. They also provide specific guidelines for field record keeping.

Field work was completed by following the SWI and a Project Risk Assessment and Safety Plan (PRASP). This field program was preceded by a pre-field meeting attended by the field crew and the project manager, during which the purpose of the field program was discussed, roles of crew members were specified, questions regarding the SWI were addressed, and equipment needs, field logistics, and contingency plans were discussed. During field work, field data were recorded on standardized field data sheets or in a bound field book, according to established field record-keeping procedures. In addition, field crews checked-in with the project manager regularly to provide an update on work completed.

Sample Handling and Meter Calibration

Turbidity samples were collected in 1.2 L plastic bottles at 60% stream depth; bottles were triple rinsed with stream water at their respective site before the sample was collected to the potential of cross-contamination. A 20 mL subsample was decanted from each well-mixed sample bottle and transferred into a test vial; each test vial was triple rinsed with sample water before the actual sample was transferred. Turbidity from each subsample was measured using a LaMotte 2020TI portable turbidity meter. The precision for the LaMotte 2020TI is two decimal points for levels between 0.00 to 10.99 NTU, one decimal points for levels between 11.0 to 109.9 NTU and no decimal points for levels between 110 to 1100 NTU. The meter was calibrated daily with a 0 and 10 or 100 NTU standards to ensure accuracy and the calibrations were logged. If any turbidity measurements were more than 5% above or below the known turbidity level for each standard solution, the meter was calibrated using the blank (0 NTU) and the standard solution closest to the turbidity levels measured in the field. Before the subsample was measured, the outside of the test vial was dried with paper towel before being wiped clean with ultra-low lint tissues to eliminate false readings caused by diffraction of light away from the turbidity meter sensor. The test vial was then inverted three times to ensure even mixing before triplicate readings were taken.

Office Operations

Office-related QA consisted of using appropriately trained personnel for each task and senior review of work products at appropriate milestones, use of standardized data manipulation/summary tools, filing of data and project information according to standardized protocols, and establishment of a data management system for an organized and consistent system of data storage, QC, and retrieval.

QUALITY CONTROL

QC applicable to this study cover three areas of internal management, as described below.

Field QC Procedures

For sample collection procedures, QC sampling consisted of the collection of replicate and split samples. Split and replicate QC samples collected during the field program accounted for approximately 8% of the total number of samples collected. Each QC sample type is described below:

- Split samples consist of a single sample divided into three portions. The samples were then processed and analyzed in succession. The split samples were used to assess meter precision among subsamples.
- Replicate sampling consisted of the collection of three discrete turbidity grab-samples in quick succession. The samples were then processed in succession. The replicate samples were used to assess sampling precision.

Furthermore, a triplicate reading was recorded for each sample (i.e., QC and non-QC samples). Triplicate measurements consisted of taking three consecutive readings with the same subsample. Triplicate measurements were used to assess meter precision for each subsample.

Office QC Procedures

Relevant fundamentals of office-based QC included the following:

- comparing sample data entered into the project database against field reports to verify accuracy of data transcription
- creating backup files before each major operation as data were being manipulated
- verifying the accuracy of calculations performed to generate summary statistics
- checking split and replicate samples for evidence of unacceptable variation (see next section)
- checking field-collected data for completeness, and unexpected values and trends

Data Quality Evaluation

Split and replicate QC samples were evaluated for meter and sampling precision. Differences between concentrations measured in QC samples were calculated as the relative standard deviation (RSD) and the relative percent difference (RPD).

The RSD was calculated using the following formula:

$$RSD = (\text{standard deviation among QC split or replicate samples}/\text{mean}) \times 100$$

The RSD data were reviewed to check that calculated levels were less than 18% (PMEC 2006).

The RPD was calculated using the following formula:

$$RPD = (|\text{difference in concentration between split samples}| / \text{mean concentration}) \times 100$$

The RSD data were reviewed to check that calculated levels were less than 25% (PMEC 2006).

Quality Control Results

In total, 348 grab-samples were collected for turbidity analysis, with 29 (8%) of these samples being split or replicate samples. In general, 97.1% of the triplicate samples (i.e., 338 of 348 samples) had RSDs within QA/QC guidelines (PMEC 2006). Split sample RSD and RPD resulted in 67% and 100%, respectively, of acceptable quality relative to the QC guidelines. Replicate sample RSD and RPD resulted in 100% and 78%, respectively, of acceptable quality relative to the QC guidelines. Approximately 94% of the split samples (i.e., 16 of 17 samples) and 83% of replicate samples (i.e., 10 of 12 samples) had RPDs and RSDs within QA/QC guidelines. This result suggests there was moderate precision within and among split and replicate sample readings, respectively. Overall, this result is likely a reflection of the low number of QC samples collected rather than sampling or metre precision related issues, and therefore, the turbidity data was deemed to be of acceptable quality.

APPENDIX D

Turbidity Monitoring Data

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
10-May	13:00	US1	1	1.5	1.6	1.6	1.6	-
10-May	13:15	DS3	2	5.2	5.3	5.5	5.3	-
10-May	13:15	DS2	3	7.3	7.3	6.9	7.2	-
10-May	13:15	DS1	4	9.6	10.7	9.7	10.0	-
10-May	14:00	DS3.1	5	6.9	6.8	6.7	6.8	-
10-May	14:00	DS2.1	6	3.8	3.5	3.5	3.6	-
10-May	14:00	DS1.1	7	3.3	2.9	2.8	3.0	-
11-May	7:30	DS3	8	3.1	3.1	3.2	3.1	-
11-May	7:35	DS2	9	3.3	3.0	3.3	3.2	-
11-May	7:40	DS1	10	3.4	3.5	3.6	3.5	-
11-May	8:00	US1	11	1.7	1.9	1.9	1.8	-
11-May	15:40	DS3.1	12	4.2	4.4	4.4	4.3	-
11-May	15:45	DS2.1	13	6.0	5.8	5.5	5.7	-
11-May	15:45	DS1.1	14	15.5	15.4	15.5	15.5	-
11-May	16:00	US1	15	3.0	3.0	2.9	3.0	-
11-May	16:05	DS3	16	39.7	39.9	39.3	39.6	-
11-May	16:05	DS2	17	57.8	59.8	60.8	59.5	-
11-May	16:05	DS1	18	79.9	80.6	73.7	78.1	-
12-May	7:45	US1	19	1.2	1.1	1.1	1.1	-
12-May	7:50	DS3	20	4.4	3.9	3.6	4.0	-
12-May	7:55	DS2	21	6.7	5.9	6.1	6.2	-
12-May	8:00	DS1	22	2.7	3.0	2.6	2.8	-
12-May	10:05	US1	23	2.4	2.5	2.4	2.4	-
12-May	10:10	DS3	24	2.6	2.5	2.6	2.5	-
12-May	10:15	DS2	25	3.3	3.2	3.1	3.2	-
12-May	10:20	DS1	26	4.3	3.7	4.2	4.1	-
12-May	14:35	US1	27	1.9	1.4	1.7	1.6	-
12-May	14:40	DS3	28	2.1	2.1	2.0	2.1	-
12-May	14:45	DS2	29	2.5	2.3	2.2	2.3	-
12-May	14:50	DS1	30	2.1	1.9	2.2	2.0	-
12-May	15:25	DS3.2	31	53.7	54.1	52.5	53.4	-
12-May	15:30	DS2.2	32	56.8	56.2	56.8	56.6	-
12-May	15:35	DS1.2	33	66.3	67.4	67.6	67.1	-
12-May	16:15	US1	34	3.1	3.0	3.0	3.0	-
12-May	16:20	DS3	35	4.9	4.8	4.7	4.8	-
12-May	16:25	DS2	36	3.3	3.7	3.3	3.4	-
12-May	16:30	DS1	37	1.8	1.9	2.0	1.9	-
12-May	16:35	DS3.2	38	25.2	23.9	25.1	24.7	-
12-May	16:40	DS2.2	39	23.4	23.6	24.6	23.9	-
12-May	16:45	DS1.2	40	24.3	25.0	23.8	24.4	-
13-May	8:15	US1	41	0.9	1.0	1.0	1.0	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
13-May	8:17	DS3	42	1.6	1.4	1.4	1.5	-
13-May	8:19	DS2	43	1.2	1.3	1.2	1.2	-
13-May	8:21	DS1	44	1.0	1.0	1.0	1.0	-
13-May	8:23	DS3.2	45	5.5	5.8	5.8	5.7	-
13-May	8:25	DS2.2	46	6.4	5.8	6.6	6.3	-
13-May	8:27	DS1.2	47	6.5	5.9	5.8	6.1	-
13-May	12:15	US1	48	0.9	1.0	1.0	1.0	-
13-May	12:17	DS3	49	4.4	4.2	4.2	4.3	Split 1
13-May	12:19	DS3	50	3.5	3.3	3.2	3.4	Split 2
13-May	12:21	DS3	51	2.5	2.1	2.1	2.3	Split 3
13-May	12:23	DS2	52	9.0	9.0	8.9	9.0	-
13-May	12:25	DS1	53	2.7	2.1	2.1	2.3	-
13-May	12:27	DS3.2	54	8.2	8.7	8.3	8.4	-
13-May	12:29	DS2.2	55	2.0	1.9	1.7	1.8	-
13-May	12:31	DS1.2	56	6.9	7.5	7.4	7.3	-
13-May	15:15	US1	57	1.6	1.5	1.4	1.5	Replicate 1
13-May	15:17	US1	58	1.6	1.5	1.3	1.5	Replicate 2
13-May	15:19	US1	59	1.3	1.4	1.4	1.4	Replicate 3
13-May	15:21	DS3	60	1.5	1.5	1.5	1.5	-
13-May	15:23	DS2	61	1.8	1.6	1.2	1.6	-
13-May	15:25	DS1	62	1.3	1.9	1.3	1.5	-
13-May	15:27	DS3.2	63	8.2	8.6	9.0	8.6	-
13-May	15:29	DS2.2	64	8.8	9.3	9.4	9.2	-
13-May	15:31	DS1.2	65	8.7	8.6	8.7	8.7	-
14-May	9:00	US1	66	0.7	0.7	0.7	0.7	-
14-May	9:10	DS3	67	1.4	1.1	1.3	1.2	-
14-May	9:12	DS2	68	1.1	0.8	0.8	0.9	-
14-May	9:14	DS1	69	1.1	1.1	1.1	1.1	Split 1
14-May	9:14	DS1	70	1.3	1.0	0.9	1.1	Split 2
14-May	9:14	DS1	71	1.1	1.0	1.0	1.1	Split 3
14-May	9:16	DS3.2	72	3.5	3.5	3.4	3.5	-
14-May	9:18	DS2.2	73	3.6	3.5	3.4	3.5	-
14-May	9:20	DS1.2	74	3.4	3.4	3.4	3.4	-
14-May	15:00	US1	75	1.1	1.0	1.2	1.1	Replicate 1
14-May	15:00	US1	76	1.1	1.1	1.0	1.0	Replicate 2
14-May	15:00	US1	77	1.2	1.2	1.2	1.2	Replicate 3
14-May	15:05	DS3	78	0.9	0.9	0.9	0.9	-
14-May	15:07	DS2	79	0.8	0.9	0.8	0.8	-
14-May	15:09	DS1	80	1.3	1.3	1.4	1.3	-
14-May	15:11	DS3.2	81	4.8	4.7	4.7	4.7	-
14-May	15:13	DS2.2	82	5.5	5.6	5.5	5.5	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
14-May	15:15	DS1.2	83	6.3	6.2	6.3	6.3	-
14-May	15:17	DS3.1	84	2.9	2.9	3.1	3.0	-
14-May	15:19	DS2.1	85	2.4	2.5	2.6	2.5	-
14-May	15:21	DS1.1	86	1.9	1.9	1.9	1.9	-
15-May	8:30	US1	87	1.8	1.8	1.9	1.8	-
15-May	8:40	DS3	88	1.3	1.2	1.2	1.2	Replicate 1
15-May	8:40	DS3	89	1.5	1.5	1.5	1.5	Replicate 2
15-May	8:40	DS3	90	1.2	1.2	1.1	1.1	Replicate 3
15-May	8:42	DS2	91	1.0	0.9	0.9	0.9	-
15-May	8:44	DS1	92	1.2	1.3	1.1	1.2	-
15-May	8:46	DS3.2	93	3.1	3.2	3.1	3.1	-
15-May	8:48	DS2.2	94	3.2	3.2	3.0	3.2	-
15-May	8:50	DS1.2	95	3.4	3.5	3.3	3.4	-
15-May	8:52	DS3.1	96	2.3	2.3	2.2	2.3	-
15-May	8:54	DS2.1	97	1.9	1.9	2.1	2.0	-
15-May	8:56	DS1.1	98	2.0	2.1	2.1	2.1	-
15-May	8:58	DS3.2	99	91	94	89	91	-
15-May	9:00	DS2.2	100	122	121	109	117	-
15-May	9:02	DS1.2	101	25.0	28.1	28.1	27.1	-
15-May	14:00	US1	102	1.31	1.37	1.31	1.33	-
15-May	14:10	DS3	103	10.3	10.3	10.1	10.3	-
15-May	14:12	DS2	104	8.3	8.3	8.3	8.3	-
15-May	14:14	DS1	105	2.5	2.5	2.4	2.5	-
15-May	14:16	DS3.2	106	79.5	72.9	71.5	74.6	-
15-May	14:18	DS2.2	107	73.2	75.5	75.5	74.7	-
15-May	14:20	DS1.2	108	72.3	70.5	69.7	70.8	-
15-May	14:22	DS3.1	109	55.0	49.0	48.0	50.7	Split 1
15-May	14:22	DS3.1	110	44.0	43.0	42.0	43.0	Split 2
15-May	14:22	DS3.1	111	46.0	43.0	47.0	45.3	Split 3
15-May	14:24	DS2.1	112	42.0	40.0	45.0	42.3	-
15-May	14:26	DS1.1	113	45.7	48.2	48.2	47.4	-
16-May	10:05	DS3	114	8.2	8.2	7.8	8.1	-
16-May	10:10	DS2	115	6.3	6.8	6.7	6.6	-
16-May	10:15	DS1	116	10.1	10.1	10.1	10.1	-
16-May	10:25	DS3.2	117	35.0	33.9	32.7	33.9	-
16-May	10:30	DS2.2	118	54.3	64.7	62.3	60.4	-
16-May	10:32	DS1.2	119	51.7	56.9	53.4	54.0	-
16-May	10:33	DS3.1	120	70.2	79.0	77.1	75.4	-
16-May	10:35	DS2.1	121	105	103	101	103	-
16-May	10:37	DS1.1	122	51.0	86.4	92.0	76.5	-
16-May	11:35	US1	123	0.6	0.7	0.7	0.7	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [a]	QA/QC
16-May	12:00	DS3	124	5.7	7.6	6.7	6.6	-
16-May	12:02	DS2	125	11.3	11.1	12.3	11.6	-
16-May	12:04	DS1	126	16.7	14.8	13.4	15.0	-
16-May	12:15	DS3.2	127	1357	1367	1355	1360	-
16-May	12:18	DS2.2	128	3183	3179	3111	3158	Split 1
16-May	12:22	DS2.2	129	2952	2939	2944	2945	Split 2
16-May	12:28	DS1.2	130	2216	2211	2209	2212	-
16-May	12:31	DS3.1	131	70.9	78.6	77.5	75.7	-
16-May	12:35	DS2.1	132	1166	1181	1180	1176	-
16-May	12:40	DS1.1	133	3891	3921	3928	3913	-
16-May	12:18	US1	134	1.1	1.2	1.1	1.2	-
16-May	14:15	DS3	135	10.6	11.0	10.2	10.6	-
16-May	14:18	DS2	136	11.3	11.7	11.4	11.5	-
16-May	14:20	DS1	137	13.1	12.7	11.0	12.3	-
16-May	14:35	DS3.2	138	1104	1117	1115	1112	-
16-May	14:37	DS2.2	139	2377	2375	2376	2376	-
16-May	14:39	DS1.2	140	2408	2458	2464	2443	-
16-May	14:50	DS3.1	141	119	102	104	108	-
16-May	15:00	US1	142	0.9	0.9	0.9	0.9	-
16-May	15:50	DS3	143	61	57	55	58	-
16-May	15:52	DS2	144	63	59	53	58	-
16-May	15:53	DS1	145	59	64	67	63	-
16-May	16:00	DS3.3	146	60	65	63	63	-
16-May	16:02	DS2.3	147	66	63	62	64	-
16-May	16:06	DS1.3	148	80	78	82	80	-
16-May	16:20	DS1.2	149	181	186	186	184	-
16-May	16:25	DS2.2	150	626	626	624	625	Split 1
16-May	16:25	DS2.2	151	628	632	631	630	Split 2
16-May	16:30	DS3.2	152	47.3	45.6	45.2	46.0	-
16-May	16:40	US1	153	0.8	0.8	0.7	0.8	Split 1
16-May	16:40	US1	154	0.8	0.8	0.8	0.8	Split 2
17-May	7:33	DS3	155	3.2	3.5	3.9	3.5	-
17-May	7:35	DS2	156	3.4	3.9	4.2	3.8	-
17-May	7:37	DS1	157	3.2	3.3	3.2	3.3	-
17-May	7:42	DS3.3	158	5.4	4.7	4.6	4.9	-
17-May	7:43	DS2.3	159	4.4	4.7	4.3	4.5	-
17-May	7:45	DS1.3	160	2.7	2.8	2.9	2.8	-
17-May	7:55	DS3.2	161	2.9	2.9	3.1	3.0	-
17-May	7:56	DS2.2	162	10.9	11.1	11.0	11.0	-
17-May	7:59	DS1.2	163	17.0	16.3	16.9	16.7	-
17-May	8:15	US1	164	0.8	0.8	0.7	0.8	Replicate 1

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
17-May	8:15	US1	165	0.4	0.4	0.4	0.4	Replicate 2
18-May	7:15	DS1	166	3.3	3.1	3.1	3.1	-
18-May	7:19	DS2	167	2.6	2.8	2.8	2.7	-
18-May	7:20	DS3	168	3.2	2.9	2.7	2.9	-
18-May	7:11	DS1.2	169	41.1	38.6	39.6	39.8	-
18-May	7:08	DS2.2	170	42.8	39.0	39.3	40.4	-
18-May	7:06	DS3.2	171	23.1	24.5	24.4	24.0	Replicate 1
18-May	7:06	DS3.2	172	24.7	26.4	27.4	26.2	Replicate 2
18-May	7:48	DS1.3	173	2.1	2.2	2.1	2.1	-
18-May	7:46	DS2.3	174	2.5	2.4	2.4	2.4	-
18-May	7:44	DS3.3	175	2.9	2.8	2.9	2.9	Split 1
18-May	7:44	DS3.3	176	2.7	2.7	2.6	2.7	Split 2
18-May	7:55	US1	177	1.9	2.1	2.1	2.0	-
18-May	7:50	DS0	178	1.4	1.5	1.6	1.5	-
18-May	10:15	DS1	179	1.0	1.0	1.0	1.0	-
18-May	10:17	DS2	180	1.9	1.5	1.4	1.6	-
18-May	10:19	DS3	181	1.3	1.2	1.2	1.3	-
18-May	10:22	DS1.2	182	16.4	16.3	16.6	16.4	-
18-May	10:24	DS2.2	183	15.7	16.1	16.3	16.0	-
18-May	10:26	DS3.2	184	11.3	11.3	11.2	11.3	-
18-May	10:22	DS1.3	185	1.2	2.2	2.3	1.9	-
18-May	10:24	DS2.3	186	1.1	1.3	1.5	1.3	Replicate 1
18-May	10:26	DS2.3	187	1.1	1.1	1.1	1.1	Replicate 2
18-May	10:24	DS3.3	188	1.2	1.2	1.3	1.3	-
18-May	10:45	DS0	189	1.1	1.1	1.0	1.1	Split 1
18-May	10:45	DS0	190	1.1	1.2	1.2	1.1	Split 2
18-May	13:00	DS3.2	191	8.2	8.4	8.1	8.2	-
18-May	13:02	DS2.2	192	12.2	12.0	12.1	12.1	-
18-May	13:03	DS1.2	193	13.7	13.6	14.1	13.8	-
18-May	13:00	DS1	194	1.6	1.6	1.6	1.6	-
18-May	13:02	DS2	195	2.2	2.5	2.4	2.4	Split 1
18-May	13:04	DS2	196	2.5	2.4	2.6	2.5	Split 2
18-May	13:10	DS3	197	2.0	2.2	2.0	2.1	-
18-May	13:11	DS3.3	198	1.7	1.5	1.8	1.6	-
18-May	13:12	DS2.3	199	2.4	2.7	2.6	2.6	-
18-May	13:40	DS1.3	200	1.3	1.2	1.2	1.3	-
18-May	13:42	US1	201	1.2	1.2	1.2	1.2	-
18-May	13:02	DS0	202	7.5	7.8	7.9	7.8	-
18-May	15:28	DS0	203	1.2	1.5	1.3	1.3	Replicate 1
18-May	15:28	DS0	204	1.1	1.0	0.9	1.0	Replicate 2
18-May	15:30	US1	205	0.5	0.6	0.9	0.7	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
18-May	15:30	DS1	206	1.1	0.9	0.9	1.0	-
18-May	15:32	DS2	207	1.6	1.6	1.5	1.6	-
18-May	15:34	DS3	208	1.6	1.6	1.7	1.6	-
18-May	15:42	DS3.2	209	34.4	37.1	37.4	36.3	-
18-May	15:43	DS2.2	210	52.1	56.5	58.3	55.6	-
18-May	15:44	DS1.2	211	53.8	55.2	55.9	55.0	Split 1
18-May	15:44	DS1.2	212	58.9	56.2	57.4	57.5	Split 2
18-May	15:36	DS3.3	213	1.2	1.2	1.3	1.2	-
18-May	15:38	DS2.3	214	2.1	2.0	2.1	2.1	-
18-May	15:39	DS1.3	215	1.7	1.8	2.0	1.8	-
19-May	7:00	DS1	216	1.6	1.4	1.4	1.4	-
19-May	7:02	DS2	217	2.7	2.8	2.6	2.7	-
19-May	7:04	DS3	218	2.6	2.6	2.4	2.5	-
19-May	7:06	DS1.2	219	11.9	11.1	10.5	11.2	-
19-May	7:08	DS2.2	220	11.1	11.1	10.6	10.9	-
19-May	7:10	DS3.2	221	6.9	6.8	6.7	6.8	-
19-May	7:12	DS1.3	222	8.4	8.0	8.0	8.1	-
19-May	7:14	DS2.3	223	1.5	1.6	1.5	1.6	-
19-May	7:16	DS3.3	224	1.4	1.6	1.7	1.6	Replicate 1
19-May	7:18	DS3.3	225	1.3	1.1	1.2	1.2	Replicate 2
19-May	7:20	US1	226	1.8	2.1	2.1	2.0	-
19-May	7:22	DS0	227	2.0	2.0	2.0	2.0	-
19-May	9:10	DS1	228	2.7	2.7	2.7	2.7	-
19-May	9:12	DS2	229	3.6	3.8	3.7	3.7	-
19-May	9:14	DS3	230	2.7	2.4	2.6	2.5	Split 1
19-May	9:14	DS3	231	2.4	2.5	2.4	2.5	Split 2
19-May	9:16	DS1.2	232	7.8	8.1	8.0	8.0	-
19-May	9:18	DS2.2	233	8.5	8.4	8.4	8.4	-
19-May	9:20	DS3.2	234	5.9	5.6	5.7	5.7	Replicate 1
19-May	9:28	DS3.2	235	6.3	6.3	6.4	6.3	Replicate 2
19-May	9:22	DS1.3	236	2.7	3.0	2.8	2.9	-
19-May	9:24	DS2.3	237	2.8	2.6	2.5	2.6	-
19-May	9:26	DS3.3	238	1.8	1.7	1.8	1.8	-
19-May	9:30	US1	239	1.1	1.2	1.2	1.2	-
19-May	9:32	DS0	240	1.2	1.3	1.3	1.3	-
19-May	13:15	DS1	241	8.2	7.2	6.7	7.4	-
19-May	13:17	DS2	242	7.2	6.9	6.9	7.0	-
19-May	13:19	DS3	243	4.4	4.8	4.7	4.6	-
19-May	13:21	DS1.2	244	10.4	9.7	9.9	10.0	-
19-May	13:23	DS2.2	245	11.2	10.6	10.7	10.8	-
19-May	13:25	DS3.2	246	7.0	7.3	7.3	7.2	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
19-May	13:27	DS1.3	247	4.7	4.9	4.9	4.8	Split 1
19-May	13:27	DS1.3	248	3.9	5.0	4.3	4.4	Split 2
19-May	13:29	DS2.3	249	4.4	4.3	4.7	4.4	-
19-May	13:31	DS3.3	250	3.4	3.7	3.7	3.6	-
19-May	13:33	US1	251	5.4	4.9	4.8	5.0	-
19-May	13:35	DS0	252	4.5	4.3	4.6	4.5	-
19-May	15:15	DS1	253	4.4	5.3	5.3	5.0	-
19-May	15:17	DS2	254	3.9	3.9	4.1	4.0	-
19-May	15:19	DS3	255	3.9	3.9	3.8	3.9	-
19-May	15:21	DS1.2	256	6.5	6.5	6.7	6.6	-
19-May	15:23	DS2.2	257	7.9	7.6	7.3	7.6	-
19-May	15:25	DS3.2	258	5.0	5.0	5.1	5.1	-
19-May	15:27	DS1.3	259	5.4	5.4	5.5	5.4	Split 1
19-May	15:29	DS1.3	260	4.2	4.9	4.6	4.6	Split 2
19-May	15:31	DS2.3	261	4.9	4.9	5.3	5.0	-
19-May	15:33	DS3.3	262	4.7	4.5	4.4	4.5	-
19-May	15:35	US1	263	3.6	4.5	4.5	4.2	-
19-May	15:37	DS0	264	3.7	3.9	4.5	4.0	-
20-May	7:00	DS1	265	2.6	2.5	2.5	2.5	-
20-May	7:02	DS2	266	3.4	3.5	3.5	3.5	-
20-May	7:04	DS3	267	2.7	2.7	2.7	2.7	-
20-May	7:06	DS1.2	268	4.1	3.9	4.1	4.0	-
20-May	7:08	DS2.2	269	3.8	3.9	3.9	3.9	-
20-May	7:10	DS3.2	270	3.8	3.9	3.9	3.9	-
20-May	7:12	DS1.3	271	2.9	3.2	3.1	3.1	-
20-May	7:14	DS2.3	272	2.4	2.4	2.4	2.4	-
20-May	7:16	DS3.3	273	3.1	3.2	3.2	3.1	Split 1
20-May	7:18	DS3.3	274	4.4	3.8	3.9	4.0	Split 2
20-May	7:20	US1	275	1.7	1.7	1.8	1.7	-
20-May	7:22	DS0	276	2.7	2.8	2.7	2.7	-
20-May	13:30	DS1	277	1.8	1.8	1.8	1.8	-
20-May	13:32	DS2	278	3.3	3.6	3.5	3.5	-
20-May	13:34	DS3	279	2.5	2.7	2.6	2.6	-
20-May	13:36	DS1.2	280	4.2	4.4	4.3	4.3	-
20-May	13:38	DS2.2	281	4.3	4.1	4.1	4.2	Split 1
20-May	13:40	DS2.2	282	4.1	4.2	4.2	4.1	Split 2
20-May	13:42	DS3.2	283	3.9	3.4	3.4	3.5	-
20-May	13:44	DS1.3	284	2.5	2.3	2.1	2.3	-
20-May	13:46	DS2.3	285	2.0	2.0	2.1	2.0	-
20-May	13:48	DS3.3	286	2.1	2.1	2.2	2.1	-
20-May	13:50	US1	287	1.5	1.7	1.4	1.5	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [a]	QA/QC
20-May	13:52	DS0	288	1.5	1.6	1.7	1.6	-
21-May	8:15	DS1	289	1.1	1.1	1.1	1.1	-
21-May	8:17	DS2	290	2.2	2.2	2.2	2.2	-
21-May	8:19	DS3	291	1.7	1.6	1.6	1.6	-
21-May	8:21	DS1.2	292	4.8	4.8	4.8	4.8	-
21-May	8:23	DS2.2	293	4.5	4.9	4.9	4.8	-
21-May	8:25	DS3.2	294	3.8	4.0	3.8	3.9	-
21-May	8:27	DS1.3	295	1.4	1.5	1.6	1.5	Replicate 1
21-May	8:27	DS1.3	296	2.0	1.8	1.8	1.9	Replicate 2
21-May	8:29	DS2.3	297	1.4	1.6	1.4	1.5	-
21-May	8:31	DS3.3	298	1.6	1.6	1.5	1.6	-
21-May	8:33	US1	299	1.4	1.4	1.4	1.4	-
21-May	8:35	DS0	300	1.5	1.5	1.4	1.4	-
22-May	8:15	DS1	301	1.2	1.1	1.1	1.1	-
22-May	8:17	DS2	302	1.9	1.8	1.8	1.9	-
22-May	8:19	DS3	303	1.6	1.7	1.5	1.6	-
22-May	8:21	DS1.2	304	4.1	4.1	3.9	4.0	-
22-May	8:23	DS2.2	305	4.4	4.6	4.5	4.5	-
22-May	8:25	DS3.2	306	4.9	4.8	4.6	4.7	-
22-May	8:27	DS1.3	307	1.4	1.3	1.4	1.4	-
22-May	8:29	DS2.3	308	3.6	3.3	3.2	3.4	Replicate 1
22-May	8:29	DS2.3	309	3.0	3.0	3.1	3.1	Replicate 2
22-May	8:31	DS3.3	310	2.1	1.9	2.0	2.0	-
22-May	8:33	US1	311	1.1	0.9	0.9	1.0	-
22-May	8:35	DS0	312	1.0	1.1	1.0	1.0	-
23-May	8:00	DS1	313	1.2	1.2	1.1	1.2	-
23-May	8:02	DS2	314	1.8	1.7	1.8	1.8	-
23-May	8:04	DS3	315	1.3	1.8	1.6	1.5	-
23-May	8:06	DS1.2	316	3.4	3.4	3.4	3.4	-
23-May	8:08	DS2.2	317	4.0	3.5	3.4	3.6	Split 1
23-May	8:08	DS2.2	318	3.9	3.8	3.7	3.8	Split 2
23-May	8:12	DS3.2	319	3.9	4.3	4.0	4.1	-
23-May	8:14	DS1.3	320	1.8	1.3	1.2	1.4	-
23-May	8:16	DS2.3	321	2.8	2.6	1.9	2.5	-
23-May	8:18	DS3.3	322	3.1	3.0	3.0	3.0	-
23-May	8:20	US1	323	1.0	1.2	0.9	1.0	-
23-May	8:22	DS0	324	1.7	1.5	1.3	1.5	-
24-May	8:00	DS1	325	1.0	1.1	1.0	1.0	-
24-May	8:02	DS2	326	2.4	2.6	2.5	2.5	-
24-May	8:04	DS3	327	1.4	1.6	1.3	1.4	-
24-May	8:06	DS1.2	328	5.3	5.3	5.2	5.3	-

Table D-1: Turbidity Readings in Rascal Stream West, 10 to 25 May 2023

Date	Time	Location	Sample ID	Reading 1	Reading 2	Reading 3	Average [(a)]	QA/QC
24-May	8:08	DS2.2	329	1.6	1.5	1.5	1.5	-
24-May	8:10	DS3.2	330	4.5	4.5	4.4	4.4	-
24-May	8:12	DS1.3	331	1.2	1.3	1.3	1.3	Split 1
24-May	8:12	DS1.3	332	1.1	1.1	1.0	1.1	Split 2
24-May	8:16	DS2.3	333	3.2	2.3	2.2	2.6	-
24-May	8:18	DS3.3	334	1.6	1.4	1.5	1.5	-
24-May	8:20	US1	335	1.4	1.1	1.3	1.3	-
24-May	8:22	DS0	336	0.8	0.9	0.8	0.8	-
25-May	7:00	DS1	337	1.6	1.7	1.5	1.6	-
25-May	7:02	DS2	338	1.8	1.9	1.8	1.9	-
25-May	7:04	DS3	339	1.7	1.6	1.5	1.6	-
25-May	7:06	DS1.2	340	4.0	4.0	4.0	4.0	-
25-May	7:08	DS2.2	341	3.6	3.6	3.6	3.6	Replicate 1
25-May	7:08	DS2.2	342	4.1	3.9	3.9	4.0	Replicate 2
25-May	7:10	DS3.2	343	3.9	3.8	3.8	3.8	-
25-May	7:12	DS1.3	344	1.8	1.7	2.3	1.9	-
25-May	7:16	DS2.3	345	1.3	1.8	1.7	1.6	-
25-May	7:18	DS3.3	346	1.7	1.6	1.6	1.7	-
25-May	7:20	US1	347	1.4	1.3	1.3	1.3	-
25-May	7:22	DS0	348	1.3	1.3	1.2	1.3	-

(a) Highlighted cells indicate an exceedance in turbidity level guidelines (CCME 2002).

QA/QC = Quality Assurance and Quality Control.

APPENDIX E

Fish Passage Assessment Data

Table E-1: Habitat Assessment Data in Rascal Stram West, 20 May 2023

Location	Unit ID Starting From Goose Lake	Coordinates (Zone 13W, UTM NAD83)		Direction From Culvert	Habitat Type [a]	Length (m)	Water Depth (m)			Wetted Width (m)			Bankfull Width (m)			Substrate (% Area) [c]							Instream Cover (% Area)						Unstable Banks (%)	
		Easting	Northing				Max	Mean Max	ΔB-W [b]	Min	Max	Mean	Min	Max	Mean	Or	Si	Sa	Gr	Co	Bo	Be	SUB	WD	D/T	AV	OV	UC	LBD	RDB
Secondary Channel	1	432875	7270163	Downstream	Run 3	78	0.6	0.4	0	5.3	20	15	0.5	1.8	1.3	20	10	60	2	5	3	0	10	0	30	5	50	12	0	0
Secondary Channel	2	432853	7270107	Downstream	Riffle	10	0.3	0.2	0	15	15	15	0.4	1.3	1.2	0	0	0	10	40	50	0	20	0	5	0	50	5	50	0
Secondary Channel	3	432863	7270105	Downstream	Run 3	10	1	0.5	0	5.2	12	5.5	5.2	5.8	5.5	0	20	20	30	20	10	0	10	0	0	0	0	0	100	100
Diversion Channel	4	432886	7270075	Upstream	Run 3	40	0.6	0.5	0.2	1.2	2	1.4	1.3	2.5	1.8	0	5	5	20	30	40	0	20	0	0	0	0	0	100	0
Primary Channel	5	432867	7270037	Upstream	Pool	30	1.5	1	0	20	30	22	20	30	22	40	30	0	10	10	10	0	2	0	20	0	0	0	30	0
Primary Channel	6	432864	7270005	Upstream	Riffle	50	0.5	0.3	0.1	1	1.5	1.2	1.2	1.7	1.4	0	0	0	20	30	50	0	20	0	30	0	10	5	0	0
Primary Channel	7	432867	7269955	Upstream	Run 3	50	0.7	0.5	0.1	2	4.5	3	2.4	5	3.5	30	20	20	0	5	25	0	5	0	5	0	5	0	0	0
Primary Channel	8	432892	7269916	Upstream	Run 2	50	2	1	0.1	0.8	5.5	3	2	6	3.4	30	20	20	0	0	30	0	10	0	30	10	5	0	0	0
Primary Channel	9	432923	7269892	Upstream	Run 3	50	0.8	0.3	0.1	0.8	3.5	2.5	1.5	4	3	45	30	20	0	0	5	0	0	0	0	10	0	0	0	0

(a) As defined by O'Neil and Hildebrand (1986). Run 3 is a shallow (<0.75 m deep) moderate velocity area with low instream cover; Riffle is a shallow (<0.5 m deep), high velocity and gradient area dominated by coarse substrate; Pool is a discrete portion of channel with increased depth and reduced velocity compared to run habitat; Run 2 is a 0.75 to 1.0 m deep, moderate to high velocity area with moderate to high instream cover.

(b) Vertical difference between current water surface elevation and bankfull elevation.

(c) Or = Organics; Si = Silt (<0.06 mm); Sa = Sand (0.06-2 mm); Gr = Gravel (2-64 mm); Co = Cobble (64-256 mm); Bo = Boulder (>256 mm).

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; SUB = Substrate; WD = Woody Debris; D/T = Depth/Turbulence; AV = Aquatic Vegetation; OV = Overhanging Vegetation; UC = Undercut Banks; LDB = Left Downstream Bank; RDB = Right Downstream Bank.

Table E-2a: Crossing Assessment Upstream and Downstream of Culvert Location in Rascal Stream West, 20 May 2023

Location	Coordinates (Zone 13W, UTM NAD83)		Watercourse Characteristics						Riparian composition				Bank Description									
									Within 3 m of Bank		Within 3-25 m of Bank		LDB					RDB				
	Easting	Northing	Pattern	Confinement	Channel Form	Stage	Groundwater Seepage	Stream Type	LDB	RDB	LDB	RDB	Slumping	UCB	Vegetated	Stability	Height (m)	Slumping	UCB	Vegetated	Stability	Height (m)
Downstream of Culvert	432870	7270100	Broad	Unconfined	Open	Flooded	No	Small Permanent	90% Bare, 10% Tundra	90% Bare, 10% Tundra	90% Bare, 10% Tundra	90% Bare, 10% Tundra	No	No	No	Low	2	No	No	No	Low	2
Upstream of Culvert	432888	7270070	Winding	Unconfined	Irregular	High	No	Small Permanent	Bare	Bare	50% Bare, 50% Tundra	Bare	No	No	No	Low	1	No	No	No	Moderate	0.2

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; LDB = Left Downstream Bank; RDB = Right Downstream Bank; UCB = Undercut Banks.

Table E-2b: Crossing Assessment Upstream and Downstream of Culvert Location in Rascal Stream West, 20 May 2023

Location	Coordinates (Zone 13W, UTM NAD83)		Substrate (% Area) [a]							Substrate (% Area) [a]							Substrate (% Area) [a]							Sensitivity to Construction
			Bed							LDB							RDB							
	Easting	Northing	Or	Cl	Si	Sa	Gr	Co	Bo	Or	Cl	Si	Sa	Gr	Co	Bo	Or	Cl	Si	Sa	Gr	Co	Bo	
Downstream of Culvert	432870	7270100	0	0	10	70	20	0	0	0	0	0	10	40	20	30	0	0	0	10	50	30	10	High
Upstream of Culvert	432888	7270070	0	0	0	5	25	20	50	0	0	0	20	20	10	50	0	0	0	0	30	50	20	High

(a) Or = Organics; Si = Silt (<0.06 mm); Sa = Sand (0.06-2 mm); Gr = Gravel (2-64 mm); Co = Cobble (64-256 mm); Bo = Boulder (>256 mm).

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; LDB = Left Downstream Bank; RDB = Right Downstream Bank; UCB = Undercut Banks.

Table E-3: Visual Survey Data from Rascal Stream West, 17 to 25 May 2023

Date	Time	Survey Type	Observation Location	Coordinates (Zone 13W, UTM NAD83)		Fish Count					
						ARGR		LKTR	NNST	SLSC	UNK SBF
				Easting	Northing	Adult	Juvenile	Adult	UNK	Adult	UNK
17-May	10:45	Walking	Primary channel, 80 m downstream of Gander Pond	432895	7269915	3	0	0	0	0	0
17-May	12:00	Incidental	Primary channel at Gander Pond	432949	7269854	1	0	0	0	0	0
17-May	14:00	Incidental	Primary channel, 25 m downstream of Gander Pond	432937	7269877	5	0	0	0	0	0
19-May	13:00	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
	15:00	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
	17:00	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
20-May	7:00	Walking	No observations	-	-	0	0	0	0	0	0
	9:30	Walking	No observations	-	-	0	0	0	0	0	0
	11:30	Walking	Diversion channel, at pool created by berm	432867	7270037	2	0	0	0	0	0
			Primary channel, 40 m downstream of Gander Pond	432930	7269882	2	0	0	0	0	0
	16:00	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
			Diversion channel, at pool created by berm	432867	7270037	2	0	0	0	0	0
21-May	8:30	Walking	No observations	-	-	0	0	0	0	0	0
	10:30	Walking	Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	0	0	1
			Secondary channel, pool just downstream of rock ledge	432851	7270106	1	1	0	0	0	0
			Secondary channel, just downstream of culvert	432868	7270103	0	1	0	0	0	0
	13:55	Stationary	Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
	15:00	Walking	Goose Lake, near secondary channel outflow	432875	7270166	1	0	0	0	0	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
			Primary channel, just below chute	432859	7270010	2	0	0	0	0	0
			Primary channel, 130 m downstream of Gander Pond	432868	7269957	1	0	0	0	0	0
			Primary channel, 25 m downstream of Gander Pond	432937	7269877	1	0	0	0	0	0
22-May	8:20	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	1	1	0	0	0	0
	10:30	Walking	Secondary channel, pool just downstream of rock ledge	432851	7270106	0	1	0	0	0	0
	11:15	Stationary	Diversion channel	432881	7270064	0	0	0	0	0	0
	13:45	Walking	No observations	-	-	0	0	0	0	0	0
	14:15	Stationary	Diversion channel	432881	7270064	0	0	0	0	0	0
	15:15	Walking	Side channel of secondary channel, near Goose Lake	432835	7270164	0	0	0	0	1	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	2	0	0	0	0
			Primary channel, 120 m downstream of Gander Pond	432870	7269948	1	0	0	0	0	0

Table E-3: Visual Survey Data from Rascal Stream West, 17 to 25 May 2023

Date	Time	Survey Type	Observation Location	Coordinates (Zone 13W, UTM NAD83)		Fish Count					
						ARGR		LKTR	NNST	SLSC	UNK SBF
				Easting	Northing	Adult	Juvenile	Adult	UNK	Adult	UNK
23-May	8:20	Walking	Primary channel, 40 m downstream of Gander Pond	432930	7269882	2	0	0	0	0	0
	9:55	Stationary	Secondary channel, just downstream of culvert	432868	7270103	0	1	0	0	0	0
	11:00	Walking	Diversion channel, at pool created by berm	432867	7270037	1	0	0	0	0	0
			Primary channel, just below chute	432859	7270010	3	0	0	0	0	0
	13:25		Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	4	0	0
	13:25	Walking	Goose Lake, near secondary channel outflow	432875	7270166	1	0	0	0	0	0
			Secondary channel, just downstream of culvert	432868	7270103	3	1	0	0	0	0
			Diversion channel, at pool created by berm	432867	7270037	1	0	0	0	0	0
			Primary channel, just below chute	432859	7270010	1	2	0	0	0	0
			Primary channel, 130 m downstream of Gander Pond	432868	7269957	1	0	0	0	0	0
			Primary channel, 90 m downstream of Gander Pond	432886	7269920	2	0	0	0	0	0
			Primary channel, 40 m downstream of Gander Pond	432930	7269882	1	0	0	0	0	0
			Primary channel, 30 m downstream of Gander Pond	432929	7269873	2	0	0	0	0	0
	14:00	Stationary	Secondary channel, just downstream of culvert	432868	7270103	2	3	0	0	0	0
	15:30	Walking	Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	1	0	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	0	0	0	0	1
			Secondary channel, just downstream of culvert	432868	7270103	0	1	0	0	0	0
			Diversion channel	432873	7270050	1	0	0	0	0	0
			Primary channel, 120 m downstream of Gander Pond	432870	7269948	1	0	0	0	0	0
			Primary channel, 70 m downstream of Gander Pond	432897	7269898	1	0	0	0	0	0
			Primary channel, 40 m downstream of Gander Pond	432930	7269882	4	0	0	0	0	0

Table E-3: Visual Survey Data from Rascal Stream West, 17 to 25 May 2023

Date	Time	Survey Type	Observation Location	Coordinates (Zone 13W, UTM NAD83)		Fish Count					
						ARGR		LKTR	NNST	SLSC	UNK SBF
				Easting	Northing	Adult	Juvenile	Adult	UNK	Adult	UNK
24-May	8:00	Walking	Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	4	0	0
			Secondary channel, 35 m downstream of culvert outflow	432855	7270121	0	1	0	0	0	0
			Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
			Primary channel, just below chute	432859	7270010	0	1	0	0	0	0
			Primary channel, just above chute	432860	7269989	1	0	0	0	0	0
			Primary channel, 130 m downstream of Gander Pond	432868	7269957	0	1	0	0	0	0
			Primary channel, 70 m downstream of Gander Pond	432897	7269898	2	0	0	0	0	0
			Primary channel, 25 m downstream of Gander Pond	432937	7269877	3	0	0	0	0	0
	9:00	Stationary	Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
	10:00	Walking	Goose Lake, near secondary channel outflow	432875	7270166	0	0	1	0	0	0
			Secondary channel, 35 m downstream of culvert outflow	432855	7270121	0	1	0	0	0	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	2	0	0	0	0
			Primary channel, just above chute	432860	7269989	1	0	0	0	0	0
	13:25	Walking	Side channel of secondary channel, near Goose Lake	432859	7270162	0	0	0	0	0	1
			Diversion channel, at pool created by berm	432867	7270037	0	1	0	0	0	0
			Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	4	0	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	2	0	0	0	0
			Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
			Primary channel, 50 m downstream of Gander Pond	432913	7269896	1	0	0	0	0	0
			Primary channel, 40 m downstream of Gander Pond	432930	7269882	1	0	0	0	0	0
	14:05	Stationary	Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
	16:05	Walking	Goose Lake, near secondary channel outflow	432875	7270166	3	0	0	0	0	0
			Side channel of secondary channel, near Goose Lake	432859	7270162	0	0	0	0	0	1
			Side channel of secondary channel, near Goose Lake	432835	7270164	0	0	0	0	0	1
			Goose Lake, near original primary channel outflow	432827	7270164	0	0	1	0	0	0
			Original primary channel, just upstream of Goose Lake	432826	7270153	0	0	0	2	0	0
			Secondary channel, 60 m downstream of culvert outflow	432852	7270149	2	0	0	0	0	0
			Secondary channel, 35 m downstream of culvert outflow	432855	7270121	1	0	0	0	0	0
			Secondary channel, pool just downstream of rock ledge	432851	7270106	0	2	0	0	0	0
			Secondary channel, just downstream of culvert	432868	7270103	1	0	0	0	0	0
			Diversion channel	432876	7270058	1	0	0	0	0	0
			Primary channel, 130 m downstream of Gander Pond	432868	7269957	3	0	0	0	0	0
			Primary channel, 50 m downstream of Gander Pond	432913	7269896	2	0	0	0	0	0
25-May	7:00	Walking	Primary channel, 130 m downstream of Gander Pond	432868	7269957	1	0	0	0	0	0

UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983; ARGR = Arctic Grayling; LKTR = Lake Trout; NNST = Ninespine Stickleback; SLSC = Slimy Sculpin; UNK = Unknown; SBF = Small-bodied Fish; - = not applicable.

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