REPORT

Downstream Assessment of the Goose Lake Water Withdrawal Increase on Arctic Grayling Spawning and Rearing Habitat

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Distribution List

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1.0 INTRODUCTION

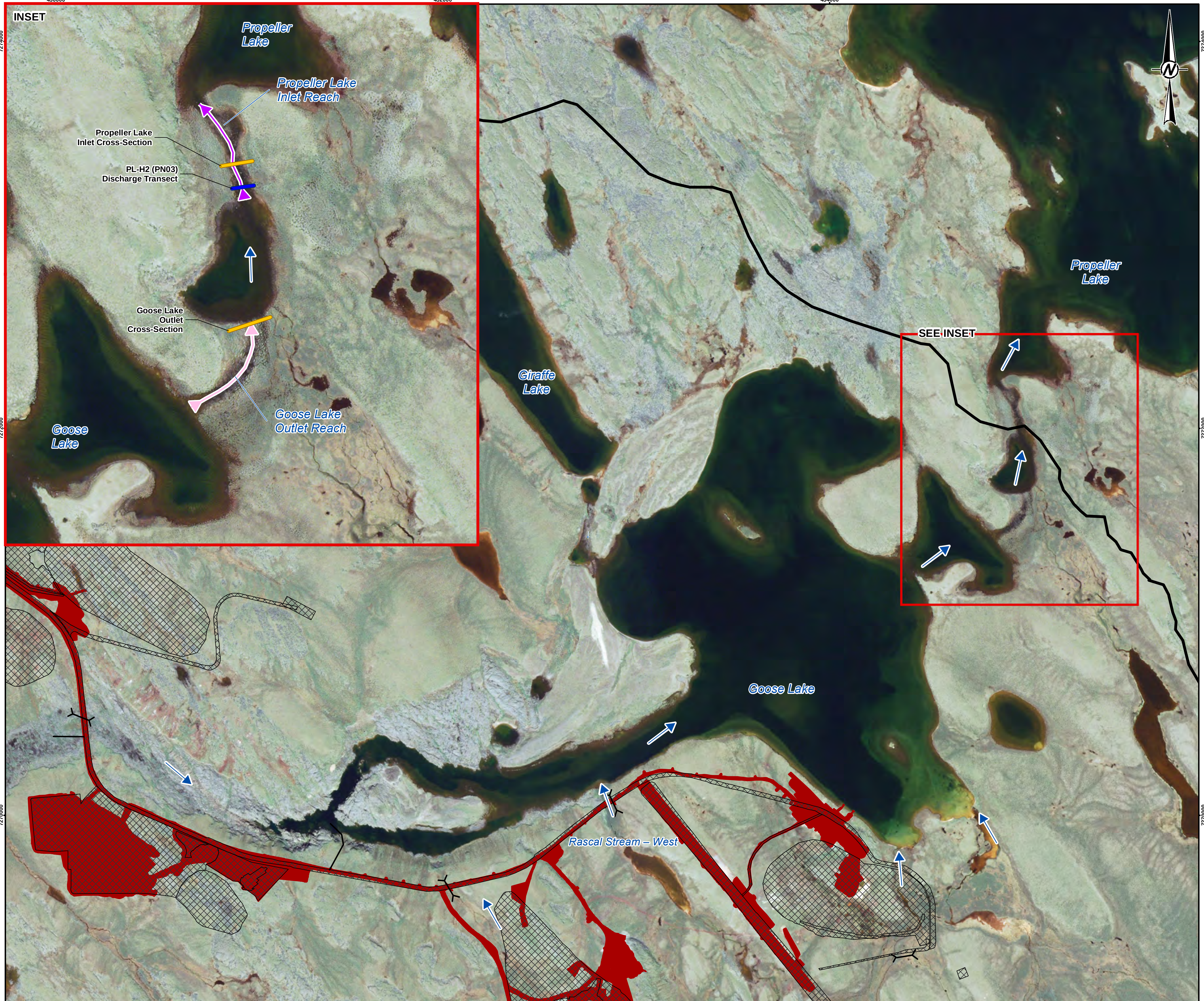
B2Gold Corporation (B2Gold, formerly Sabina) operates the Back River Project (the Project) located in western Nunavut in the continuous permafrost zone of the continental Canadian Arctic. The Project consists of works in the Marine Laydown Area and Goose Lake Property Area. At the Goose Lake Property Area, B2Gold is currently permitted under their approved Water Management Plan (Type A Water Licence, 2AM-BRP1831) and *Fisheries Act* Authorization (12-HCAA-CA7-00007) to withdraw 390,000 m^3 annually from Goose Lake. Through advancement of Detailed Engineering, it was identified that additional water withdrawal from Goose Lake will be required to support milling activities during the operations phase of their Water Management Plan (Sabina 2017). As such, B2Gold is now proposing to increase their annual water withdraw rate by 218,700 m^3 annually from Goose Lake to a total of 608,700 m^3.

In June 2020, B2Gold issued the FEIS (Final Environmental Impact Statement) Modification Package for the Back River Project that included an effects assessment on the proposed increase in Goose Lake water withdrawal on surface water hydrology and fish and fish habitat (Sabina 2020; Golder 2020). It was concluded that the additional increase in water withdrawal to the previously approved rate is expected to result in no significant residual effects to surface water hydrology and fish and fish habitat. Although Fisheries and Oceans Canada (DFO) was confident that mitigation and measures can be used to minimize impacts to Arctic Grayling (*Thymallus arcticus*) and its habitat at the Back River Project, DFO identified a potential downstream risk of causing a HADD (harmful alteration, disruption, or destruction) to Arctic Grayling habitat at the Goose Lake Outlet channels (i.e., Goose Lake Outlet and Propeller Lake Inlet reaches [Figure 1.1]) resulting from changes in channel flow conditions (DFO 2020). As such, B2Gold contracted WSP Canada [WSP] (formally WSP Golder) to evaluate the potential for residual effects to Arctic Grayling habitat within the Goose Lake Outlet channels from planned water withdrawal rate from Goose Lake.

The evaluation considered three main steps (i.e., work objectives). First, using methods consistent with the FEIS (Sabina 2015), hydrological conditions were modelled for two scenarios for the Goose Lake Outlet channels, including baseline and Project-related flow scenarios, where:

- Baseline conditions were defined as the natural flow regime of the environment with no alterations associated with Project activities.
- Project conditions were defined as the altered flowing regime of the environment after considering any Project-related activities, such as, water withdrawal or reductions in drainage areas upstream.

The second step applied a one-dimensional model tool, Hydraulic Toolbox (FHWA 2020) to model flow parameters for two cross-sections of the Goose Lake Outlet channels where detailed data on channel geometry and flows were collected in 2021. Hydraulic model outputs for select parameters from each flow scenario were then summarized and compared to inform the third step of the evaluation of changes to the quantity and quality (i.e., suitability) of habitat in the Goose Lake Outlet channels. The third step of the evaluation included the linkage of hydraulic parameter results to habitat suitability preferences for sensitive life cycle stages of Arctic Grayling (i.e., spawning and rearing). Specifically, previously published Habitat Suitability Index (HSI) models (Larocque et al. 2014; Hubert et al. 1985) were used to evaluate the suitability of spawning and rearing habitat for Arctic Grayling downstream of Goose Lake under the baseline and Project scenarios.



LEGEND

- BATHYMETRY TRANSECT
- DISCHARGE TRANSECT
- GOOSE LAKE OUTLET REACH
- PROPELLER LAKE INLET REACH
- 2022 AS-BUILT FOOTPRINT
- GOOSE PROPERTY PDA
- PROPOSED GOOSE INFRASTRUCTURE FOOTPRINT

KEY MAP

0 0.5 1
1:20,000 KILOMETRES

REFERENCE(S)
FOOTPRINT AND IMAGERY OBTAINED FROM CLIENT. HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 13N DATUM: NAD 83

YYYY-MM-DD	2024-02-07
DESIGNED	CS
PREPARED	SK
REVIEWED	CS
APPROVED	CS

CLIENT
B2GOLD

CONSULTANT
wsp

PROJECT
SABINA BACK RIVER PROJECT

TITLE
OVERVIEW OF THE GOOSE LAKE OUTLET AND THE PROPELLER LAKE INLET ARCTIC GRAYLING HABITAT SUITABILITY ASSESSMENT LOCATIONS

PROJECT NO.	FIGURE	REV.
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2.0 BACKGROUND

2.1 Hydrology and Hydraulics

Water withdrawal from Goose Lake may have implications on the natural flow regime of Goose Lake outflow channels. Characteristics of the natural flow regime, including surface water hydrology (water levels and flows) and the associated flow conditions (e.g., water velocity and depth) can be key drivers of habitat suitability for local fish populations (Larocque at al. 2014). It is also well known that flow regimes in the Canadian Arctic can change annually due to climatic drivers (e.g., precipitation and temperature), and that monthly flow conditions will change naturally through the open-water seasons (i.e., June to September). Therefore, the modelling of flow regimes requires consideration of natural variability into the baseline and Project scenarios and hydraulic modelling (modelling of the flows within the existing channel to predict flow parameters of area, top width, velocity, and depth) to account for potential low-flow years that could negatively impact fish habitat suitability, and to account for seasonal influences that could impact fish habitat suitability during different life cycle stages (i.e., spawning and rearing).

As part of the FEIS Project Modification (Sabina 2020), WSP completed a hydrological assessment of predicted flow conditions associated with the proposed water withdrawal rate from Goose Lake using methods consistent with the FEIS (Sabina 2015) and compared them to the guidelines for baseline and 20-year dry conditions. The interpretation of changes in modelled flows was based, in part, on guidelines on minimum ecological flow requirements for riverine systems (DFO 2013), where ecological flows are defined as the flows and water levels required to sustain the ecological function of the flora and fauna and habitat processes present within the water body and its margins. According to the guidelines, any cumulative water use resulting in an instantaneous increase or decrease within 10% of baseline streamflow conditions is assumed to be within the natural variability of the riverine system. Any cumulative water use resulting in an instantaneous increase or decrease greater than 10% of baseline streamflow or that results in flows that are less than 30% of the mean annual discharge (MAD), suggests a higher potential risk of the flow and water levels affecting the aquatic organisms (e.g., fish) living within the system and a more rigorous assessment may be required.

The results of the FEIS Project Modification (Appendix C, Sabina 2020) assessment predicted a reduction in mean annual flow of 15.6% during average conditions and 21.7% during dry conditions for Goose Lake outflows, due to the 11% reduction in catchment area and updated water withdrawals from Goose Lake. During average conditions, the onset of flow above 30% of the baseline MAD (consistent with approach used in the FEIS [Sabina 2015]) is predicted to be delayed by six days and cease three days earlier, therefore, the extent of the open-water season is expected to be decreased by maximum of nine days from baseline conditions. During one-in-20-year dry conditions, the onset of flow above 30% MAD is predicted be delayed by nine days and the flow is estimated to cease six days earlier, therefore, the extent of the open-water season is expected to be decreased by a maximum of 15 days from baseline conditions.

The predicted changes under the proposed water withdrawal rate were classified as a moderate reduction in streamflow at Goose Lake Outflow, exceeding guidelines of a 10% reduction in streamflow (DFO 2013) but were consistent with the magnitude of changes predicted in the FEIS. The Project Modifications (Sabina 2020) assessment concluded that the increased water withdrawal from Goose Lake would not change the resulting surface water hydrology Valued Ecosystem Component (VEC) magnitude category for effects to hydrological indicators (streamflows and lake volumes) at assessed waterbodies from the FEIS (Sabina 2015). Furthermore, all hydrological indicators had a low (minor) magnitude category for effects and predicted changes remained within acceptable environmental guidelines at the Local Study Area (LSA) boundaries.

In 2021, hydrometric and survey information were collected downstream from Goose Lake at the Goose Lake Outlet and Propeller Lake Inlet reaches during the open-water period (Appendix A). The data collected included channel cross-section profiles (i.e., channel geometries) and stream discharge measurements. The information was collected from the study reaches to support predictive hydraulic modelling under the different flow scenarios that are expected with the proposed water withdrawal rate from Goose Lake. Hydraulic modelling includes the simulation of flows within the existing channel to predict flow parameters of area, top width, velocity and depth. The modelling will also help inform changes to the quality and quantity of habitat supporting sensitive life stages of Arctic Grayling.

2.2 Arctic Grayling

Fish distribution in the Goose Property Area is typical of inland, headwater regions of the Canadian Arctic. Arctic Grayling is one of the dominant species within the fish community of the Goose Lake watershed (Sabina 2015), and a large-bodied fish species that would use the Goose Lake Outlet and Propeller Lake Inlet reaches during sensitive life cycle stages (i.e., spawning, and young-of-the-year [YOY] rearing). Increased water withdrawal from Goose Lake may reduce the suitability of spawning and YOY rearing habitat for Arctic Grayling in the study reaches.

Arctic Grayling are spring spawners and typically use small streams with gravel substrate for spawning habitat. Adults will migrate to spawning habitat around the period of ice break-up and once the water temperature reaches a minimum of 4ºC. The timing for adults to spawn is relatively short, lasting between two to three weeks (Ford et al. 1995). The spawning period commences when adults migrate to spawning habitat, around the period of ice break-up, and concludes once YOY (i.e., fry) emerge (Scott and Crossman 1973). Ice break-up on Goose Lake occurs from mid to late June and YOY emergence is expected to occur two to three weeks later. Therefore, the spawning period for Arctic Grayling in the Goose Lake Outlet and Propeller Lake Inlet reaches is expected to occur, conservatively, from mid-June to mid-July. After YOY emergence, fish may remain in slower flowing sections of the stream environment for rearing before migrating to deeper overwatering habitat in September or October prior to freeze-up. Adults typically migrate back to larger lake environments (e.g., Goose Lake) after they spawn, and therefore, may not require use of the channel habitat for the remainder of the year.

In 2021, data on Arctic Grayling spawning and rearing habitat were collected from the Goose Lake Outlet and Propeller Lake Inlet reaches to support regulatory concerns raised by DFO related to increased water withdrawal rates in Goose Lake (DFO 2020). Results of the field survey are provided in Appendix A. The survey consisted of collecting detailed fish habitat information, spatial data for habitat maps, and reproductive data during a spring spawning assessment. The survey spanned the entire Goose Lake Outlet Reach, measuring 315 m in fluvial length, and the entire Propeller Lake Inlet Reach, measuring 338 m in fluvial length (Appendix A). The survey confirmed that, due to the presence of fish eggs, the Goose Lake Outlet and Propeller Lake Inlet provides spawning habitat for Arctic Grayling (Figure 1.1) and may also provide rearing habitat for YOY based on habitat characterized during the survey (Larocque et al., 2014). However, as flow conditions in these reaches naturally decline and deteriorate over the course of the summer, YOY likely move to the deeper and the slower flowing pool habitat or habitat provided by nearby Goose Lake or Propellor Lake (see habitat map provided in Appendix A).

3.0 METHODS

3.1 Hydrology and Hydraulics

3.1.1 Hydrologic Characterization

Monthly average flows over the open-water period (June to September) were calculated. The calculations used methods and models consistent with the FEIS Project Modifications (Appendix C, Sabina 2020), to calculate mean daily flows for all hydrologic scenarios considered throughout the open-water period. The scenarios considered for hydrological characterization included average and 10-year dry conditions for both the baseline and Project conditions (conditions based on increased Goose Lake withdrawal rates [Appendix C, Sabina 2020]). The 10-year dry condition represents an annual average discharge with 10% likelihood of occurring each year assuming the same monthly distribution as the annual hydrograph. Although previous assessments applied a 20-year dry condition instead of a 10-year dry; this assessment considered a more realistic scenario of low-flows to provide a tighter range of baseline conditions as a conservative approach to the assessment when determining whether predicted effects fall within the natural variability of the system. In other words, the typical natural variability in flows was defined as the range of values provided for the average and 10-year dry scenarios. Mean daily flows for all scenarios were also compared to 30% baseline MAD threshold, previously calculated as 0.13 m^3/s (Sabina 2015).

Available derived daily flows from 2011, 2012, 2013, 2014 (Rescan 2014a), 2021 (Appendix A), and 2022 (WSP 2023) for Propeller Lake Inlet (hydrometric station PN03) were visually compared to baseline and Project daily flows calculated in the Modifications Package (Appendix C, Sabina 2020) by plotting data. It is noted that adjusted regional flows used to characterize the FEIS baseline flows at Goose Lake outlet (1971 to 2011) and observed flows (2011 to 2014, 2021 and 2022) are for the most part, non-overlapping data sets with different climatology. Therefore, caution should be applied in comparing datasets due to natural variability in the climate and therefore hydrograph from year to year.

Hydrometric station PN03 (PL-H2), located within the study reach as shown on Figure 1.1, and associated hydrometric data are considered representative of the reach between Goose Lake and Propeller Lake. From 2011 to 2014, measurements began before and continued until after flows fell below the predicted 30% baseline MAD threshold. In 2021, measurements began during the freshet tail and stopped on 3 August 2021 due to equipment malfunction. In 2022, measurements began early during freshet tail and stopped on 21 September 2022 when equipment was retrieved after flows dropped below the FEIS predicted 30% baseline MAD. The calculated average daily flows from measured data were calculated based on available data for each respective calendar day, therefore, in some cases, where daily flows are available from only one study year, average flow is equal to the single observed flow for the respective day. The observed flow duration for each year is summarized in Table 3.1.

Table 3.1: Summary of Measured Daily Flows for Propeller Lake Inlet (PN03)

Year	Duration
2011	3 June to 2 October
2012	29 May to 23 September
2013	22 May to 19 October
2014	22 May to 24 September
2021	6 July to 3 August
2022	7 June to 21 September

3.1.2 Selected Channel Cross-Sections

Goose Lake Outlet and Propeller Lake Inlet channel cross-section data for the study was surveyed on 4 July 2021 and presented in the 2021 Supplemental Field Program Data Report (Appendix A). The two transects (Goose Lake Outlet Cross-Section and Propeller Lake Inlet Cross-Section) used for this study were surveyed at locations identified as suitable Arctic Grayling spawning habitat and shown in Figure 1.1. Project LiDAR (2012) was used to extend the transects further into the flood plain and estimate the longitudinal slope for each transect. Longitudinal slopes (slopes along channel in the direction of flow) for each transect are presented in Table 3.2.

Table 3.2: Selected Channel Cross-Sections Longitudinal Slopes

Cross-Section Name	Slope (%)
Goose Lake Outlet Cross-Section	1.6
Propeller Lake Inlet Cross-Section	0.02

3.1.3 Hydraulic Modelling

A one-dimensional model tool, Hydraulic Toolbox (FHWA 2020), was used to model flow conditions for the two cross-sections selected for hydraulic and habitat modelling. This model simulates flow parameters such as depth, top width, flow area, and velocity using an open-channel Manning's roughness equation based on the existing channel cross-section geometry, Manning's roughness value, and channel slope for the various flow scenarios. A description of the modelled parameters for is provided below:

- Depth: average flow depth across the modelled cross-section.
- Top width: total wetted width of the modelled cross-section.
- Flow area: cross-sectional area perpendicular to the flow of the modelled cross-section.
- Velocity: average velocity of the flow for the modelled cross-section.

Initial Manning's roughness coefficient (n-value) for shallow flows from Hydraulic Engineering Circular No. 15 (HEC 15) (FWHA 1988) were assumed for the model where Manning's n-value represents the resistance to flow in channels and floodplains. Manning's n-value of 0.078 was used for average water depth greater than 0.15 m and n-value of 0.104 for average water depth less than 0.15 m. These recommended roughness values from literature were validated by comparing modelled results to the 2021 manual discharge and water level measurements at an additional cross-section where manual discharge measurements were completed for three different flows. The data collected during the manual discharge measurements provide the model validation parameters, which include average velocity and average depth. Modelled average flow velocities and average depths were within 0.03 m/s to 0.01 m/s and 0.06 m to 0.02 m from the field measurements for flow rates of 1.4 m^3/s and 0.4 m^3/s, respectively. Therefore, the Manning's n-values were deemed appropriate for modelling the flow conditions discussed in Section 3.1.1 for this study.

The model scenarios simulated represent a total of 16 different condition and month combinations for two cross-section locations resulting 32 total model runs. The flow scenarios modelled for the two cross-sections are summarized below in Table 3.3.

Table 3.3: Hydrology Modelling Scenario Summary for each of Two Cross-Sections

Modelled Scenario	Modelled Months
Baseline Average	June
	July
	August
	September
Baseline (10-year dry)	June
	July
	August
	September
Project Average	June
	July
	August
	September
Project (10-year dry)	June
	July
	August
	September

3.2 Spawning and Rearing Arctic Grayling

The suitability of the Goose Lake Outlet and Propeller Lake Inlet reaches were assessed for Arctic Grayling spawning and YOY rearing habitat. Spawning habitat suitability was assessed during the months of June and July from the two transect locations where eggs were discovered during the 2021 spawning assessment (Table 3.4). YOY rearing habitat suitability was assessed during the months of July to September throughout the entire Goose Lake Outlet Reach and Propeller Lake Inlet Reach (Table 3.5). Hydrometric and fish habitat information collected during the spring of 2021 (Appendix A) and the subsequent hydraulic modelling provided in Section 4.1 were used to assess changes in habitat suitability for Arctic Grayling associated with new water withdrawal rate from Goose Lake.

Table 3.4: Transect Location Where Arctic Grayling Spawning Habitat Suitability was Assessed

Location[(a)]	UTM (NAD 83; Zone 13)	
	Easting	Northing
Goose Lake Outlet Cross-Section	435035	7271667
Propeller Lake Inlet Cross-Section	434977	7272076

(a) The UTM location provided is where Arctic Grayling eggs were discovered during a previous survey.

UTM = Universal Transverse Mercator; NAD = North American Datum.

Table 3.5: Reach Location Where Arctic Grayling YOY Rearing Habitat Suitability was Assessed

Location	UTM (NAD 83; Zone 13)			
	Upstream End		Downstream End	
	Easting	Northing	Easting	Northing
Goose Lake Outlet Reach	434891	7272232	435012	7271679
Propeller Lake Inlet Reach	434996	7271972	434895	7272200

3.2.1 Habitat Suitability Models

The Arctic Grayling habitat suitability assessment was based on the HSI models provided by Larocque et al. (2014) and Hubert et al. (1985). The HSI models were used to assess the suitability of relevant habitat variables associated with Arctic Grayling spawning and YOY rearing. The spawning and rearing model each generated an index based on suitability scores from 0 to 1 for each variable or component within the model (e.g., water velocity, water depth, substrate type, geomorphic habitat type, and fish cover). If the variable scored a 1, this suggested an optimal habitat condition, if the variable scored a 0, this indicated non-suitable habitat, and if a variable scored between 0 and 1, this indicated low to high suitability depending on the score, where low suitability was defined by a score less than 0.5, and high suitability for a score equal to, or greater than 0.5). The individual component model scores were then combined into one composite HSI value for each flow scenario and life cycle stage (i.e., spawning and YOY rearing). The composite HSI value is what was used to assess differences in habitat suitability between flow scenarios (e.g., Project conditions compared to baseline).

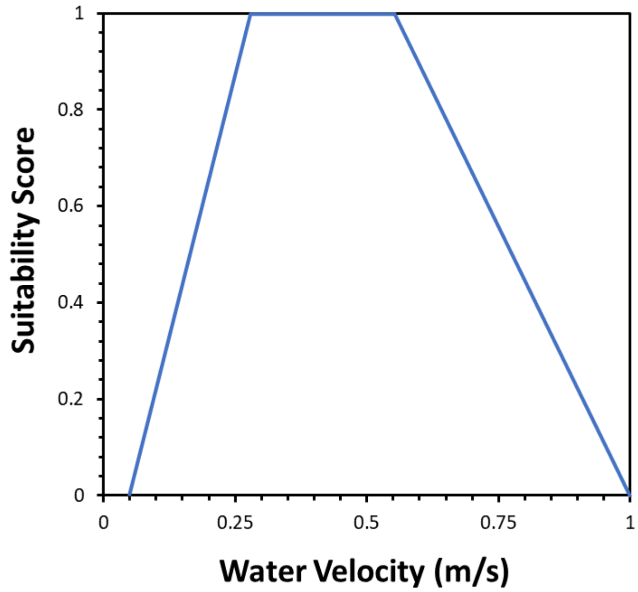
3.2.1.1 Spawning HSI Model

To assess the suitability of Arctic Grayling spawning habitat for the Goose Lake Outlet Cross-Section and the Propeller Lake Inlet Cross-Section, individual component scores were calculated for each of the following variables:

- water velocity (m/s)
- water depth (m)
- substrate type (relative proportion [%])
- geomorphic habitat type (e.g., run, riffle, pool)

Water Velocity

The spawning suitability scores for water velocity were based on the curve provided in Figure 3.1. Based on this curve, water velocities within the range of 0.25 to 0.5 m/s were considered optimal (i.e., score of 1). Water velocities that ranged from 0.05 to 0.25 m/s and from 0.5 to 1.0 m/s was considered either low suitability (i.e., score of 0.5 or less) or high suitability (i.e., a score greater than 0.5), and water velocities less than 0.05 m/s or greater than 1.0 m/s were considered not suitable (i.e., value of 0).

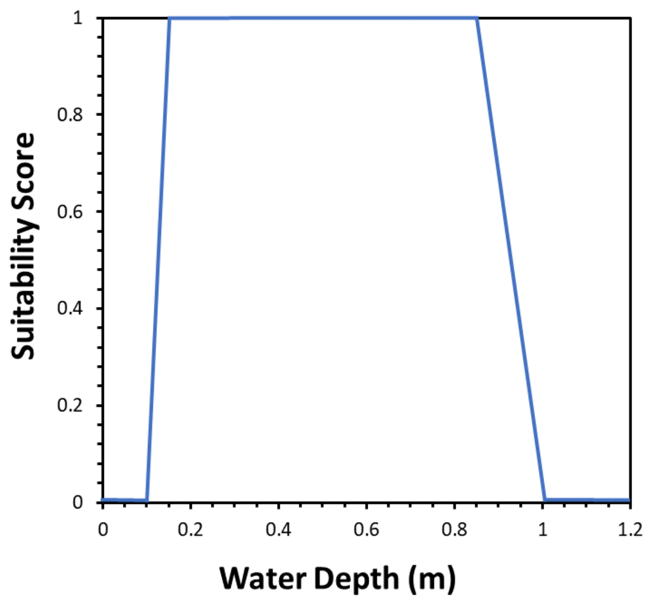


Source: Hubert et al. (1985).

Figure 3.1: Habitat Suitability Curve of Spawning Arctic Grayling at Different Water Velocities

Water Depth

The spawning suitability scores for water depth were based on the curve provided in Figure 3.2. Based on this curve, water depths within the range of 0.15 to 0.91 m were considered optimal (i.e., score of 1). Water depths equal to or less than 0.10 m, or equal to or greater than 1 m are considered not suitable (i.e., score of 0).



Source: Larocque et al. (2014).

Figure 3.2: Habitat Suitability Curve of Spawning Arctic Grayling at Different Water Depths

Substrate Type

The spawning suitability scores for dominant substrate type were based on the information provided in Table 3.6. Gravel substrate has been identified as being particularly important for spawning Arctic Grayling (i.e., score of 1) whereas smaller (e.g., sand/silt/clay) and larger (e.g., cobble and boulder) substrate classes provide low-suitability habitat for spawning (Larocque et al., 2014). Hubert et al. (1985), suggests that if a substrate composition is at least 20% gravel, then the spawning suitability score is optimal (i.e., score of 1), regardless of what the rest of the substrate composition is. If gravel is absent, or less than 20%, then the dominant size class of substrate provided in Table 3.6 was used to calculate the suitability score.

Table 3.6: Spawning Habitat Suitability for Arctic Grayling with Different Dominant Substrate Types

Dominant Substrate Type	Spawning Index Value
Bedrock	0
Boulder (≥ 25 cm)	0.33
Cobble (17 to < 25 cm)	0.17
Rubble (6.4 to <17 cm)	0.25
Gravel (0.2 to <6.4 cm)	1.0
Sand (<0.2 cm)	0.17
Silt/Clay (finer than sand)	0.08

Source: Larocque et al. (2014).

Geomorphic Habitat Type

The spawning suitability scores for habitat type were based on the information provided in Table 3.7. In general, spawning typically occurs at locations where water velocity is relatively fast. Both riffles (i.e., score of 1) and runs (i.e., score of 0.8) have optimal or high-suitability conditions for spawning. Slower flowing habitat, such as pools, have low suitability conditions for spawning (i.e., score of 0.4).

Table 3.7: Dominant Geomorphic Habitat Type Suitability for Spawning Arctic Grayling

Dominant Geomorphic Habitat Types	Habitat Description	Spawning Score
Riffles	High velocity/gradient relative to run habitat; surface broken due to submerged or exposed bed material; shallow relative to other channel units; coarse substrate; usually limited instream or overhead cover for juvenile or adult fish (generally > 0.5m deep)	1
Runs	Moderate to high velocity; surface largely unbroken; usually deeper than RF; substrate size dependent on hydraulics	0.8
Pools	Discrete portion of channel featuring increased depth and reduced velocity relative to riffle/run habitats; formed by channel scour	0.4

Source: Larocque et al. (2014).

Note: Habitat types were determined based on the descriptions provided by R.L.& L. (1994) and Hawkins et al (1993). Habitat types that were not present during the habitat survey (e.g., rapids, chute, cascade, etc.) were excluded from the table.

Assumptions applied to the spawning HSI models include:

- The spawning period for the local population of Arctic Grayling in Goose Lake and Propeller Lake is from approximately June to July.
- Physicochemical parameter (i.e., turbidity, temperature, and dissolved oxygen) suitability models were not included since variability in these parameters is driven by source water quality (Goose Lake) which is not expected to change enough under the different flow scenarios to have a meaningful impact on the HSI assessment results. Based on baseline conditions (Sabina 2015), physicochemical water conditions are assumed to be optimal for all life stages of Arctic Grayling.
- Only mean average water velocity could be estimated from the hydraulic predictive modelling. Since the Larocque et al*.* (2014) spawning water velocity model was based on median values, it was substituted for the Hubert et al*.* (1985) spawning and embryo water velocity model which are based on mean average water velocities.
- The dominant substrate type, fish cover, and habitat type are assumed to be representative of the overall habitat condition which will yield an accurate HSI score for their respective parameters.
- The dominant substrate type and geomorphic habitat units (e.g., runs an riffles) will remain constant among the different flow scenarios.

3.2.1.2 YOY Rearing

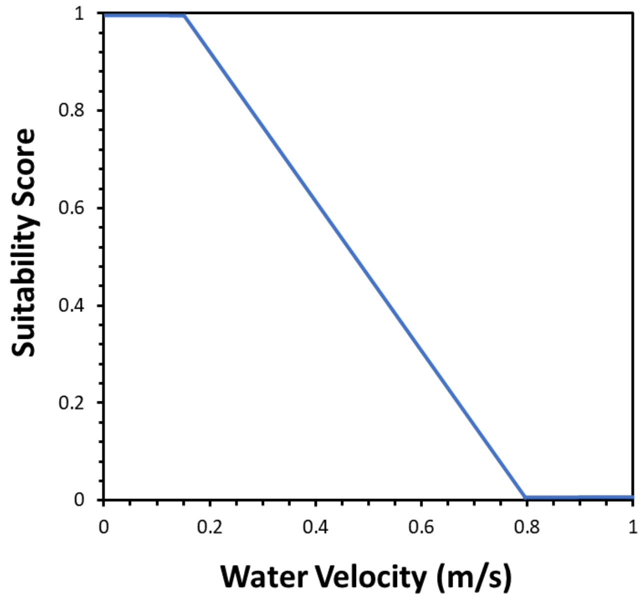
To assess the suitability of Arctic Grayling YOY rearing habitat for the Goose Lake Outlet Reach and the Propeller Lake Inlet Reach, individual component scores were estimated for each of the following variables:

- water velocity (m/s)
- water depth (m)
- substrate type (relative proportion [%])
- fish cover (relative proportion [%])
- geomorphic habitat type (e.g., run, riffle, pool)

The dominant substrate type, habitat type, and fish cover were used as input data for their respective HSI models.

Water Velocity

The YOY rearing suitability scores for average water velocity were based on the curve provided in Figure 3.3. Based on this curve, water velocities within the range of 0 to 0.5 m/s were considered highly suitable to optimal velocities (i.e., score of 0.5 to 1). Water velocities within the range of 0.51 to 0.79 m/s were considered low suitability velocities (i.e., a score less than 0.5) and water velocities of 0.8 m/s and greater were not considered suitable (i.e., score of 0).

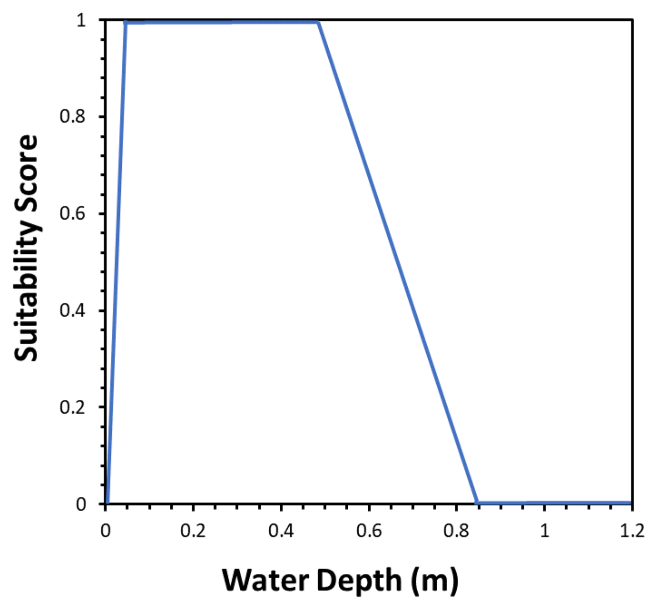


Source: Larocque et al. (2014).

Figure 3.3: Habitat Suitability Curve for Arctic Grayling YOY Rearing at Different Water Velocities

Water Depth

The YOY rearing suitability scores for average water depth were based on the curve provided in Figure 3.4. Based on this curve, water depths within the range of 0.05 to 0.45 m were considered high suitability to optimal depths (i.e., score of 0.5 to 1). Low suitability water depths ranged from 0 to 0.049 m and from 0.65 to 0.84 m (i.e., a score less than 0.5). Water depths of 0.85 m or greater were considered not suitable (i.e., score of 0).



Source: Larocque et al. (2014).

Figure 3.4: Habitat Suitability Curve for arctic Grayling YOY Rearing at Different Water Depths

Substrate Type

The YOY rearing suitability scores for dominant substrate type were based on the information provided in Table 3.8. In general, the optimal substrate type for YOY is typically smaller substrates such as gravel and silt (i.e., score of 1), yet they also associate strongly with cobble. High-quality substrate types include boulder, rubble, and sand. Low-quality substrate types (absent during the survey and not included in the table) consist of bedrock and mud (Larocque et al., 2014).

Table 3.8: Rearing Habitat Suitability for YOY Arctic Grayling with Different Dominant Substrate Types

Dominant Substrate Type	YOY Rearing Score
Boulder (≥ 25 cm)	0.6
Cobble (17 to < 25 cm)	1.0
Rubble (6.4 to <17 cm)	0.6
Gravel (0.2 to <6.4 cm)	1.0
Sand (<0.2 cm)	0.8
Silt (finer than sand)	1.0

Source: Larocque et al. (2014).

Note: Substrate types that were not present during the survey (i.e., bedrock and mud) were excluded from the table.

Fish Cover Type

The YOY rearing suitability scores for fish cover type were based on the information provided in Table 3.9. YOY typically prefer substrate as cover (i.e., score of 1) as they can easily fit within the interstitial space between a large range of substrate sizes (e.g., boulder). Overhead cover is also known to be used by YOY on occasion (i.e., score of 0.25).

Table 3.9: Rearing Habitat Suitability for YOY Arctic Grayling with Different Fish Cover Types

Fish Cover Type	Spawning Scores
Substrate (e.g., gravel to boulder)	1
Overhead (e.g., riparian vegetation, undercut bank)	0.25
Deep Pool	0
Emergent Vegetation	0
Submergent Vegetation	0
Wood Debris	0

Source: Larocque et al. (2014).

Geomorphic Habitat Type

The YOY rearing suitability scores for different habitat types were based on the information provided in Table 3.10. YOY are mostly associated with slow water velocity habitats such as off-channels (i.e., score of 1) and pools (i.e., score of 0.29). Riffles are the only habitat type with relatively quicker flow that YOY have been associated with (i.e., score of 0.14).

Table 3.10: Rearing Habitat Suitability for YOY Arctic Grayling Per Dominant Geomorphic Habitat Type

Dominant Geomorphic Habitat Types	Habitat Description	Spawning Scores
Riffles	High velocity/gradient relative to run habitat; surface broken due to submerged or exposed bed material; shallow relative to other channel units; coarse substrate; usually limited instream or overhead cover for juvenile or adult fish (generally > 0.5m deep)	0.14
Runs	Moderate to high velocity; surface largely unbroken; usually deeper than RF; substrate size dependent on hydraulics	0
Pools	Discrete portion of channel featuring increased depth and reduced velocity relative to riffle/run habitats; formed by channel scour	0.29
Off-channels	Discrete tributary drainages off the main channel; typically consists of shallow, slow flowing water with depositional substrate	1.0

Source: Larocque et al. (2014).

Note: Habitat types were determined based on the descriptions provided by R.L.& L. (1994) and Hawkins et al (1993). Habitat types that were not present during the habitat survey (e.g., river [large watercourse] margins, rapids, chute, cascade) were excluded from the table.

Assumptions applied to the YOY rearing HSI models include:

- The YOY rearing period for the local population of Arctic Grayling in Goose Lake and Propeller Lake is from July to September.
- Physicochemical parameter (i.e., turbidity, temperature, and dissolved oxygen) suitability models were not included since variability in these parameters is driven by source water quality (Goose Lake) which is not expected to change enough under the different flow scenarios to have a meaningful impact on the HSI assessment results. Based on baseline conditions (Sabina 2015), physicochemical water conditions are assumed to be optimal for all life stages of Arctic Grayling.
- The Larocque et al. (2014) water velocity HSI model is based on median average values; however, since only mean average water velocity values could be estimated through predictive modelling for this assessment, they were applied to the model. The Larocque et al. (2014) YOY rearing water velocity model was used since Hubert et al. (1985) does not model water velocity suitability for YOY rearing.
- The dominant substrate type, fish cover, and habitat type are assumed to be representative of the overall habitat condition which will yield an accurate HSI score for their respective parameters.
- Dominant substrate type, fish cover, and habitat type will remain constant for each reach among the different flow scenarios.

3.2.1.3 Composite HSI

A composite HSI score was calculated monthly for each life cycle stage (i.e., spawning and YOY rearing) and flow scenario. The composite HSI scores were calculated using the geometric mean, as recommended in Larocque et al. (2014). The geometric mean was calculated from individual HSI variables (e.g., water velocity, water depth, substrate type, geomorphic habitat type, and fish cover) using the following equations:

$$\text{Composite HSI (Spawning)} = (HSI^{water\ velocity} \times HSI^{water\ depth} \times HSI^{substrate} \times HSI^{geomorphic\ habitat})^{1/4}$$

$$\text{Composite HSI (YOY Rearing)} = (HSI^{water\ velocity} \times HSI^{water\ depth} \times HSI^{substrate} \times HSI^{fish\ cover} \times HSI^{geomorphic\ habitat})^{1/5}$$

Note: The minimum monthly HSI composite score for spawning and rearing was used to assess differences in habitat suitability among flow scenarios.

The resulting composite HSI scores for each flow scenario were then compared. The composite HSI score from the baseline flow scenario was compared to the Project flow scenario to see if, in any given year, the proposed water withdrawal rate will have a negative impact on habitat suitability for spawning and YOY rearing Arctic Grayling. The composite HSI score from the baseline 10-year dry flow scenario was compared to the Project 10-year dry flow scenario to see if, in a 1 in 10-year low flow condition year, the proposed water withdrawal rate will have a negative impact on habitat suitability for spawning and YOY rearing Arctic Grayling.

Assumptions applied to the composite HSI models include:

- For the spawning composite HSI, the minimum composite score calculated between June and July were used for comparison among flow scenarios.
- For the rearing composite HSI, the minimum composite score calculated among July, August, and September were used for comparison among flow scenarios.

The classification of effects to habitat suitability (i.e., HSI values) focused on the results for the average flow condition and considered whether the suitability classification of Project HSI values had changed (e.g., from high to low-quality). Project effects on habitat suitability were, in general, interpreted as low or minor (non-measurable) when effect sizes for the average flow condition were both less than 10% and within the range of natural variability (i.e., conditions ranging between the average and 10-year scenarios). Project effects on habitat quality were, in general, interpreted as moderate (and potentially measurable) if effect sizes for the average flow condition were both in the range of 10% to 30% and within the range of natural variability. If effect sizes for the average flow condition were greater than 30% or greater than 10% and outside that natural variability, it was concluded that the proposed withdrawal rate has the potential to result in moderate to high (measurable) effects to the suitability of fish habitat. A similar approach was taken for the classification of effects to habitat quantity; however, the classification of effects to habitat quantity considered the suitability of habitat (i.e., HSI values). In other words, effects were only classified for a reach if that reach was deemed suitable under baseline conditions, as defined by HSI values greater than 0.5.

4.0 RESULTS AND DISCUSSION

4.1 Hydrology and Hydraulics

Goose Lake Outflow

The predicted Project effects on open-water hydrologic indices for average and 10-year dry conditions are compared to FEIS baseline average and 10-year dry conditions (Table 4.1). In addition, observed hydrologic indices from 2011-2014, 2021, and 2022 are presented in Table 4.1. Note that the observed flow and Project flow data sets cannot be directly compared since they were collected during different years.

Table 4.1: Predicted Baseline and Project Conditions and Average Observed (2011-2014, 2021, and 2022) Hydrologic Indices at Goose Lake Outflow (PN03)

Parameter		Calculated Average Condition	Calculated 10-year Dry Condition	Observed Conditions (2011-2014, 2021, 2022)[a]
Mean annual lake outflow	Baseline (m^3/s)	0.45	0.28	0.32
	Project (m^3/s)	0.38	0.24	n.a.
	Flow Reduction (m^3/s)	0.07	0.04	n.a.
	Flow Reduction (% of Baseline Flow)	15.6%	14.3%	n.a.
Peak daily lake outflow	Baseline (m^3/s)	3.78	2.34	3.92
	Project (m^3/s)	3.35	2.07	n.a.
	Flow Reduction (m^3/s)	0.43	0.27	n.a.
	Flow Reduction (% of Baseline Flow)	11.4%	11.5%	n.a.
Date at onset of lake outflow above FEIS 30% MAD	Baseline	24-May	25-May	24-May to 10-June[b]
	Project	30-May	30-May	n.a.
	Delayed Onset (days)	6	5	n.a.
Date at flow ceasing below FEIS 30% MAD	Baseline[a]	27-October	22-October	28-July to 16-October[c]
	Project	24-October	19-October	n.a.
	Accelerated Ceasing (days)	3	3	n.a.
Total number of flow days above FEIS 30% MAD	Baseline	156	150	54 to 122[b]
	Project	147	142	n.a.
	Reduction of Flow Days (days)	9	8	n.a.

(a) Average of open water season for all years with data - average flows from measured data were calculated based on available data for each respective calendar day.

(b) 2021 and 2022 data not included.

(c) 2021 data not included.

n.a. = not applicable

Baseline and Project average, baseline and Project 10-year dry, and 30% MAD conditions (adapted from Sabina [2020]), are presented in Figure 4.1. The observed daily flows follow a similar hydrograph to the FEIS calculated baseline conditions hydrograph with the FEIS baseline peak flow and freshet tail occurring within the range of the observed flows, and the onset of observed flows above 30% of the baseline MAD occurring between 24 May (2014) and 10 June (2011). For observation years in which the onset of flows was captured (2011-2014), peak freshet flows occurred more rapidly (sharp increase in flows) than FEIS baseline flows. For all observation years, flows fell below FEIS 30% MAD during the summer and increased above 30% MAD late summer or early fall (except 2022). For all years of observed data, flows fell below FEIS 30% MAD between 28 July (2022) and 16 October (2013). The FEIS baseline average and 10-year dry conditions and observed daily flows from 2011, 2012, 2013, 2014 (Rescan 2014a), 2021 (Appendix A), and 2022 (WSP 2023) are presented in Figure 4.2.

The observed flows in August and early September for five years (2011-2014, 2022) are lower than the FEIS calculated baseline flows and fall below the baseline 30% MAD. The observed flows demonstrate the natural variability from year-to-year within the watershed and the resulting flows may not be representative of the long-term average climate. To further compare observed data to the long-term historical FEIS calculated baseline flows, further analysis is required for both flows and driving climatology for the period of record.

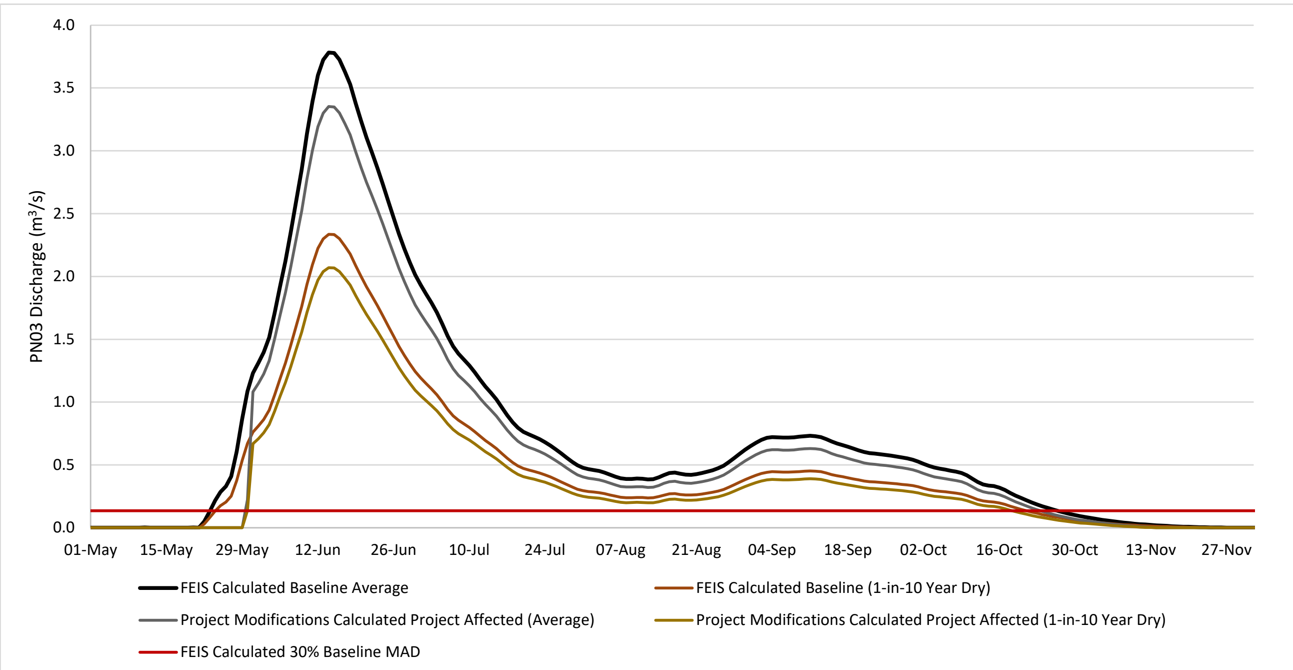


Figure 4.1: FEIS Baseline and Project Scenarios Under Average and 10-Year Dry Flows, with 30% FEIS Baseline MAD

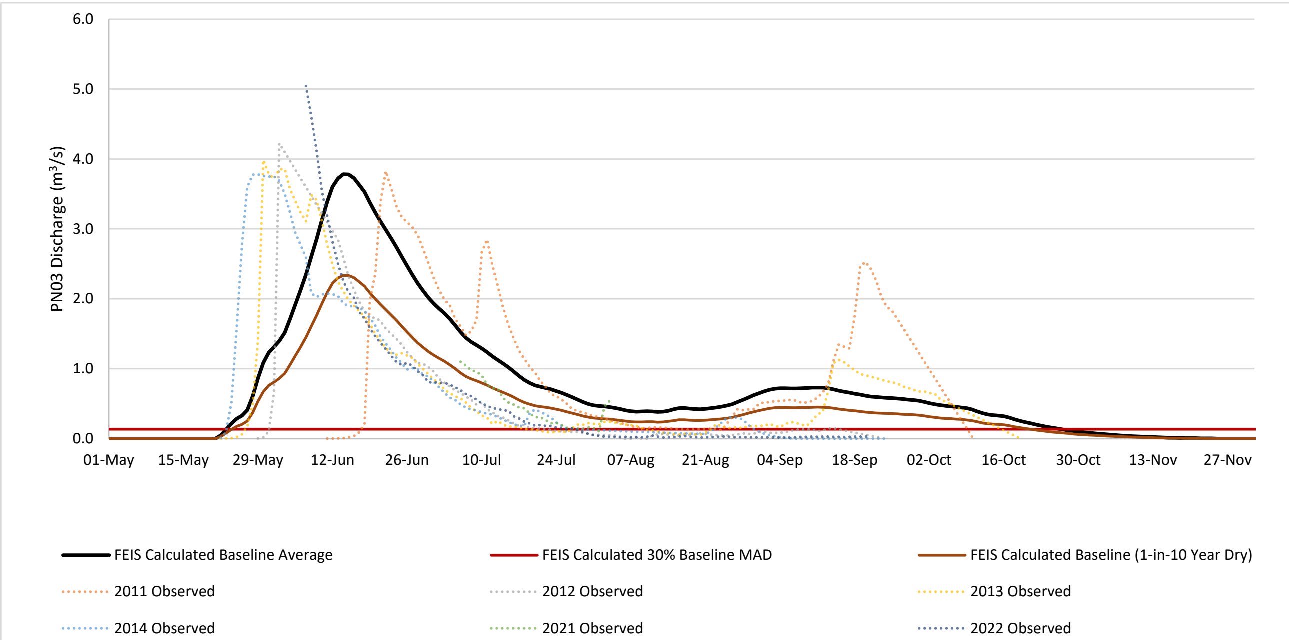


Figure 4.2: FEIS Baseline Average, 1-in-10-year dry conditions, and Observed Flows (2011-2014, 2021, and 2022) at Propeller Lake Inlet

Hydraulic Modelling

Hydraulic modelling results for the Goose Lake Outlet Cross-Section are provided in Table 4.2. Under each flow scenario, the channel flow rate, flow area, depth, and top width were highest in June and lowest in August. This result is consistent with what is expected under natural monthly flow regimes for the area for monthly averages. Overall, the results suggest that the proposed water withdrawal from Goose Lake had minor changes on channel hydraulics for the Goose Lake Outlet Cross-Section location. Monthly flow rates for the Project scenarios were slightly less than the baseline (e.g., 12% less in June). Similarly, depth variables and top width also decreased during the Project scenarios compared to the baseline.

Hydraulic modelling results for the Propeller Lake Inlet Cross-Section are provided in Table 4.3. Hydraulic trends among months and flow scenarios were similar to that of the Goose Lake Outlet. Overall, the results suggest that the proposed water withdrawal from Goose Lake had minor changes on channel hydraulics at the Propeller Lake Inlet Cross-Section location.

Table 4.2: Goose Lake Outlet Cross-Section Hydraulic Modelling Results

Scenario	Month	Mean Monthly Flow (m^3/s)	Manning's Roughness (n)	Maximum Depth (m)	Flow Area (m^2)	Average Velocity (m/s)	Top Width (m)	Average Depth (m)
Baseline (Average)	June	2.74	0.104	0.43	8.96	0.31	71.02	0.13
	July	1.05	0.104	0.34	4.06	0.26	41.44	0.10
	August	0.45	0.104	0.26	1.79	0.25	19.05	0.09
	September	0.66	0.104	0.30	2.62	0.25	27.71	0.09
Project (Average)	June	2.42	0.104	0.42	8.19	0.30	68.40	0.12
	July	0.92	0.104	0.33	3.57	0.26	36.65	0.10
	August	0.38	0.104	0.25	1.53	0.25	16.58	0.09
	September	0.56	0.104	0.29	2.28	0.25	24.95	0.09
Baseline (10-year dry)	June	1.69	0.104	0.39	6.27	0.27	60.08	0.10
	July	0.65	0.104	0.30	2.59	0.25	27.44	0.09
	August	0.28	0.104	0.23	1.17	0.24	13.38	0.09
	September	0.40	0.104	0.25	1.60	0.25	17.14	0.09
Project (10-year dry)	June	1.49	0.104	0.37	5.55	0.27	53.37	0.10
	July	0.57	0.104	0.29	2.31	0.25	25.22	0.09
	August	0.24	0.104	0.21	1.02	0.23	12.06	0.08
	September	0.35	0.104	0.24	1.43	0.25	15.68	0.09

Table 4.3: Propeller Lake Inlet Cross-Section – Downstream Hydraulic Modelling Results

Scenario	Month	Mean Monthly Flow (m^3/s)	Manning's Roughness (n)	Maximum Depth (m)	Flow Area (m^2)	Average Velocity (m/s)	Top Width (m)	Average Depth (m)
Baseline (Average)	June	2.74	0.078	0.38	12.89	0.213	65.40	0.20
	July	1.05	0.104	0.31	8.10	0.130	56.06	0.14
	August	0.45	0.104	0.24	4.55	0.099	47.33	0.10
	September	0.66	0.104	0.26	5.92	0.111	51.38	0.12
Project (Average)	June	2.42	0.078	0.37	11.81	0.205	63.37	0.19
	July	0.92	0.104	0.29	7.37	0.125	53.95	0.14
	August	0.38	0.104	0.23	4.03	0.094	45.03	0.09
	September	0.56	0.104	0.25	5.32	0.105	50.26	0.11
Baseline (10-year dry)	June	1.69	0.078	0.32	9.21	0.183	58.33	0.16
	July	0.65	0.104	0.26	5.86	0.111	51.27	0.11
	August	0.28	0.104	0.21	3.24	0.086	41.27	0.08
	September	0.40	0.104	0.23	4.17	0.096	45.25	0.09
Project (10-year dry)	June	1.49	0.078	0.31	8.50	0.175	57.64	0.15
	July	0.57	0.104	0.25	5.38	0.106	50.37	0.11
	August	0.24	0.104	0.20	2.92	0.082	40.18	0.07
	September	0.35	0.104	0.22	3.83	0.092	44.65	0.09

4.2 Arctic Grayling Habitat

4.2.1 Spawning Habitat Suitability

Arctic Grayling spawning HSI component input data are provided in Table 4.4. Dominant substrate type and geomorphic habitat was assumed to remain constant across flow scenarios. Overall, average flow velocity and maximum water depth under each flow scenario was greater at the Goose Lake Outlet Cross-Section compared to the Propeller Lake Inlet Cross-Section. A consistent seasonal trend was observed at both locations where average flow velocity and maximum water depth decreased from June to July under each flow scenario. Under baseline conditions, average water velocity and maximum water depth were highest at the Goose Lake Outlet Cross-Section during the month of June under the baseline average flow scenario with 0.31 m/s and 0.43 m, respectively. Under baseline 10-year dry condition, average water velocity and maximum water depth were lowest at the Propeller Lake Inlet Cross-Section during the month of July with 0.11 m/s and 0.26 m, respectively.

A summary of the Arctic Grayling spawning HSI variable scores are provided in Table 4.5. Baseline component scores for velocity ranged from 0.31 to 1, whereas scores for depth held constant at 1 based model inputs for the two reaches and two baseline flow scenarios combined. Spawning substrates were optimal at both cross-sections. The habitat type (i.e., run habitat) at the Goose Lake Outlet Cross-Section was suboptimal but highly suitable for spawning with a component score of 0.8. The habitat type (i.e., riffle) at the Propellor Lake Inlet Cross-Section was optimal for spawning.

For the Goose Lake Outlet Cross-Section, flow velocity and water depth were optimal for spawning under each flow scenario and month (i.e., score of 1). For the Propeller Lake Inlet Cross-Section, water depth was optimal for spawning, whereas the suitability in flow velocity varied among the different flow scenarios, ranging from a component score of 0.19 (July, Project 10-year dry) to 0.80 (June, baseline average).

The composite HSI results for Arctic Grayling spawning are provided in Table 4.6. The suitability (or quality) of Arctic Grayling spawning habitat at the Goose Lake Outlet Cross-Section was relatively high (i.e., 0.95) and constant across all flow scenarios suggesting that the capacity of habitat to support spawning Arctic Grayling will not change with the proposed water withdrawal rate from Goose Lake.

The suitability of spawning habitat at the Propeller Lake Inlet Cross-Section varied slightly among comparable flow scenarios. The composite HSI for the Project average flow scenario was 3% less compared to the baseline average but remained within the range of natural variability expected between the baseline average and the baseline 10-year dry scenarios. The Project 10-year dry flow scenario was 13% less compared to the baseline 10-year dry. Overall, the results suggest that spawning habitat suitability at the Propeller Lake Inlet location may decrease with the proposed water withdrawal rate from Goose Lake; however, even under a 1 in 10-year dry scenario, the inlet will still provide high-quality (suitable) spawning habitat (i.e., composite HSI of 0.66) for Arctic Grayling.

Table 4.4: Arctic Grayling Spawning HSI Variable Inputs for the Goose Lake Outlet and Propeller Lake Inlet Cross-Sections

Location	Scenario	Month	HSI Variable			
			Predicted Average Flow Velocity (m/s)	Predicted Max Water Depth (m)	Dominant Substrate Type	Habitat Type
Goose Lake Outlet Cross-Section	Baseline (Average)	June	0.31	0.43	GRAVEL	RUN
		July	0.26	0.34	GRAVEL	RUN
	Project (Average)	June	0.3	0.42	GRAVEL	RUN
		July	0.26	0.33	GRAVEL	RUN
	Baseline (10-year dry)	June	0.27	0.39	GRAVEL	RUN
		July	0.25	0.3	GRAVEL	RUN
	Project (10-year dry)	June	0.27	0.37	GRAVEL	RUN
		July	0.25	0.29	GRAVEL	RUN
Propeller Lake Inlet Cross-Section	Baseline (Average)	June	0.21	0.38	GRAVEL	RIFFLE
		July	0.13	0.31	GRAVEL	RIFFLE
	Project (Average)	June	0.21	0.37	GRAVEL	RIFFLE
		July	0.13	0.29	GRAVEL	RIFFLE
	Baseline (10-year dry)	June	0.18	0.32	GRAVEL	RIFFLE
		July	0.11	0.26	GRAVEL	RIFFLE
	Project (10-year dry)	June	0.18	0.31	GRAVEL	RIFFLE
		July	0.11	0.25	GRAVEL	RIFFLE

Note: the relative proportion of gravel substrate at both locations was greater than 20%.

m/s = metres per second; m = metre; max = maximum.

Table 4.5: Arctic Grayling Spawning HSI Component Scores for the Goose Lake Outlet and Propeller Lake Inlet Cross-Sections

Location	Scenario	Month	HSI Component Scores			
			Flow Velocity	Water Depth	Substrate	Habitat Type
Goose Lake Outlet Cross-section	Baseline (Average)	June	1	1	1	0.80
		July	1	1	1	0.80
	Project (Average)	June	1	1	1	0.80
		July	1	1	1	0.80
	Baseline (10-year dry)	June	1	1	1	0.80
		July	1	1	1	0.80
	Project (10-year dry)	June	1	1	1	0.80
		July	1	1	1	0.80
Propeller Lake Inlet Cross-Section	Baseline (Average)	June	0.80	1	1	1
		July	0.42	1	1	1
	Project (Average)	June	0.78	1	1	1
		July	0.39	1	1	1
	Baseline (10-year dry)	June	0.63	1	1	1
		July	0.31	1	1	1
	Project (10-year dry)	June	0.55	1	1	1
		July	0.19	1	1	1

Table 4.6: Arctic Grayling Spawning Composite HSI Results for the Goose Lake Outlet and Propeller Lake Inlet Cross-Sections

Location	Scenario	Composite HSI
Goose Lake Outlet Cross-Section	Baseline (Average)	0.95
	Project (Average)	0.95
	Baseline (10-year dry)	0.95
	Project (10-year dry)	0.95
Propeller Lake Inlet Cross-Section	Baseline (Average)	0.81
	Project (Average)	0.79
	Baseline (10-year dry)	0.75
	Project (10-year dry)	0.66

Note: the composite HSI reported represents the minimum monthly score.

4.2.2 YOY Rearing Habitat Suitability

Arctic Grayling YOY rearing HSI component input data are provided in Table 4.7. Dominant substrate type and geomorphic habitat was assumed to remain constant across flow scenarios. Flow velocity and maximum water depth under each flow scenario was greater at the Goose Lake Outlet Reach compared to the Propeller Lake Inlet Reach. A consistent seasonal trend was observed for both locations where average flow velocity and maximum water depth decreased monthly from July to September under each flow scenario. Under baseline conditions, average water velocity and maximum water depth were highest at the Goose Lake Outlet Cross-Section during the month of July under the baseline average flow scenario with 0.26 m/s and 0.34 m, respectively. Under baseline 10-year dry condition, average water velocity and maximum water depth were lowest at the Propeller Lake Inlet Cross-Section during the month of August with 0.09 m/s and 0.21 m, respectively.

A summary of the Arctic Grayling YOY rearing HSI component scores are provided in Table 4.8. Baseline component scores for velocity ranged from 0.83 to 1, whereas all scores for maximum depth were constant at 1, based on model inputs for the two reaches and two baseline flow scenarios combined. Rearing substrates were optimal in both reaches. However, the dominant habitat type for the Goose Lake Outlet Cross-Section (i.e., run habitat) was considered not suitable for YOY rearing (i.e., component score of 0.01). The dominant habitat type for the Propeller Lake Inlet Cross-Section (i.e., riffle habitat) had low suitability for YOY rearing with a component score of 0.14.

Maximum water depth was optimal for YOY rearing under each flow scenario and month for both the Goose Lake Outlet Reach and the Propeller Lake Inlet Reach (Table 4.8). For the Propeller Lake Inlet Reach, average flow velocity conditions were optimal for YOY rearing under each flow scenario and month. Average flow velocity conditions for the Goose Lake Outlet Reach were highly suitable for YOY rearing under each flow scenario and month, with a component score ranging from 0.83 to 0.87.

The composite HSI results for Arctic Grayling YOY rearing suitability are provided in Table 4.9. In general, the suitability of YOY rearing habitat was higher at the Propeller Lake Inlet Reach compared to the Goose Lake Outlet Reach. The suitability of YOY rearing habitat at the Goose Lake Outlet Reach was relatively low (i.e., composite HSI value of 0.38) and constant across all flow scenarios suggesting that the suitability of spawning habitat will not change with the proposed water withdrawal rate from Goose Lake. However, the relatively low HSI suggests that YOY likely move out of the reach to more suitable habitat downstream (e.g., pool habitat that is located between the Goose Lake Outlet Reach and the Propeller Lake Inlet Reach, or to the mouth of the watercourse in Propeller Lake). The suitability of YOY rearing habitat at the Propeller Lake Inlet Reach was the same between the baseline and Project average flow scenarios (i.e., composite HSI of 0.67) suggesting that, during a typical flow condition year, the proposed water withdrawal rate from Goose Lake will not reduce the quality of YOY rearing habitat.

Table 4.7: Arctic Grayling YOY Rearing HSI Inputs for the Goose Lake Outlet Reach and Propeller Lake Inlet Reach

Location	Scenario	Month	HSI Variable				
			Average Flow Velocity (m/s)	Max Water Depth (m)	Dominant Substrate Type	Dominant Geomorphic Habitat Type	Dominant Fish Cover
Goose Lake Outlet Reach	Baseline (Average)	July	0.26	0.34	GRAVEL	RUN	SUBSTRATE
		August	0.25	0.26	GRAVEL	RUN	SUBSTRATE
		September	0.25	0.3	GRAVEL	RUN	SUBSTRATE
	Project (Average)	July	0.26	0.33	GRAVEL	RUN	SUBSTRATE
		August	0.25	0.25	GRAVEL	RUN	SUBSTRATE
		September	0.25	0.29	GRAVEL	RUN	SUBSTRATE
	Baseline (10-year dry)	July	0.25	0.30	GRAVEL	RUN	SUBSTRATE
		August	0.24	0.23	GRAVEL	RUN	SUBSTRATE
		September	0.25	0.25	GRAVEL	RUN	SUBSTRATE
	Project (10-year dry)	July	0.25	0.29	GRAVEL	RUN	SUBSTRATE
		August	0.23	0.21	GRAVEL	RUN	SUBSTRATE
		September	0.25	0.24	GRAVEL	RUN	SUBSTRATE
Propeller Lake Inlet Reach	Baseline (Average)	July	0.13	0.31	GRAVEL	RIFFLE	SUBSTRATE
		August	0.10	0.24	GRAVEL	RIFFLE	SUBSTRATE
		September	0.11	0.26	GRAVEL	RIFFLE	SUBSTRATE
	Project (Average)	July	0.13	0.29	GRAVEL	RIFFLE	SUBSTRATE
		August	0.09	0.23	GRAVEL	RIFFLE	SUBSTRATE
		September	0.11	0.25	GRAVEL	RIFFLE	SUBSTRATE
	Baseline (10-year dry)	July	0.11	0.26	GRAVEL	RIFFLE	SUBSTRATE
		August	0.09	0.21	GRAVEL	RIFFLE	SUBSTRATE
		September	0.10	0.23	GRAVEL	RIFFLE	SUBSTRATE
	Project (10-year dry)	July	0.11	0.25	GRAVEL	RIFFLE	SUBSTRATE
		August	0.08	0.20	GRAVEL	RIFFLE	SUBSTRATE
		September	0.09	0.22	GRAVEL	RIFFLE	SUBSTRATE

Table 4.8: Arctic Grayling YOY Rearing HSI Component Scores for the Goose Lake Outlet Reach and Propeller Lake Inlet Reach

Location	Scenario	Month	HSI Component				
			Average Flow Velocity	Max Water Depth	Dominant Substrate Type	Dominant Geomorphic Habitat Type	Dominant Fish Cover
Goose Lake Outlet Reach	Baseline (Average)	July	0.83	1	1	0.01	1
		August	0.84	1	1	0.01	1
		September	0.84	1	1	0.01	1
	Project (Average)	July	0.83	1	1	0.01	1
		August	0.84	1	1	0.01	1
		September	0.84	1	1	0.01	1
	Baseline (10-year dry)	July	0.84	1	1	0.01	1
		August	0.85	1	1	0.01	1
		September	0.84	1	1	0.01	1
	Project (10-year dry)	July	0.84	1	1	0.01	1
		August	0.87	1	1	0.01	1
		September	0.84	1	1	0.01	1
Propeller Lake Inlet Reach	Baseline (Average)	July	1	1	1	0.14	1
		August	1	1	1	0.14	1
		September	1	1	1	0.14	1
	Project (Average)	July	1	1	1	0.14	1
		August	1	1	1	0.14	1
		September	1	1	1	0.14	1
	Baseline (10-year dry)	July	1	1	1	0.14	1
		August	1	1	1	0.14	1
		September	1	1	1	0.14	1
	Project (10-year dry)	July	1	1	1	0.14	1
		August	1	1	1	0.14	1
		September	1	1	1	0.14	1

Table 4.9: Arctic Grayling YOY Rearing Composite HSI Results for the Goose Lake Outlet Reach and Propeller Lake Inlet Reach

Location	Scenario	Composite HSI
Goose Lake Outlet Cross-Section	Baseline (Average)	0.38
	Project (Average)	0.38
	Baseline (10-year dry)	0.38
	Project (10-year dry)	0.38
Propeller Lake Inlet Cross-Section	Baseline (Average)	0.67
	Project (Average)	0.67
	Baseline (10-year dry)	0.67
	Project (10-year dry)	0.67

Note: the composite HSI reported is the minimum monthly score.

4.2.3 Habitat Quantity

Changes to habitat quantity were assessed using the hydraulic modelling results, specifically wetted width as a correlate of changes to area (Table 4.2; Table 4.3). Baseline seasonal variability in the wetted widths for the cross-sections was described using the average versus 10-year dry statistics. Baseline seasonal variability in the wetted width for Goose Outlet Cross-Section was defined by a decrease of 10.9 m in June (-15.4%), 14 m in July (-33.8%), 5.7 m in August (-29.8%), and 10.6 m in September (-38.1%) under the 10-year dry baseline scenario. Baseline seasonal variability in the wetted widths for the Propellor Lake Inlet Cross-Section was defined by a decrease of 7.1 m in June (-10.8%), 4.8 m in July (-8.5%), 6.1 m in August (-12.8%), and 6.1 m in September (-11.9%) under the 10-year dry baseline scenario.

For Arctic Grayling in the Goose Lake Outlet Reach, the Project average scenario will have the largest relative effect in August, overlapping with the rearing stage. In comparison to the baseline average scenario, the Project average scenario reduced the wetted width of the channel (i.e., top width) by 2.6 m (-3.7%) in June, 4.8 m (-11.6%) in July, 2.5 m (-13%) in August, and 2.8 m (-10%) in September. In comparison to the baseline 10-year dry scenario, the Project 10-year dry scenario reduced the wetted width of the channel (i.e., top width) by 6.7 m (-11.1%) in June, 2.2 m (-8.1%) in July, 1.3 m (-9.9%) in August, and 1.5 m (-8.5%) in September. Under both the average and dry condition, the predicted effects fall within their respective natural baseline variability of wetted widths.

Similar seasonal trends in the effects of proposed water withdrawals were observed for the Propellor Lake Inlet Reach; however, the magnitude of effects for the Propeller Lake Inlet Reach was smaller relative to Goose Lake Outlet Reach. The Project average scenario reduced the wetted width of the channel by 2.0 m (-3.1%) in June, 2.1 m (-3.8%) in July, 2.3 m (-4.9%) in August, and 1.1 m (-2.2%) in September. The Project 10-year dry scenario reduced the wetted width of the channel by 0.7 m (-1.2%) in June, 0.91 m (-1.8%) in July, 1.1 m (-2.6%) in August, and 0.6 m (-1.3%) in September. Under both average and dry conditions, the predicted effects for both study reaches fall within their respective natural baseline variability of wetted widths.

5.0 SUMMARY AND CONCLUSIONS

B2Gold proposed to increase their annual water withdrawal rate from Goose Lake from 390,000 to 608,700 m^3 in the FEIS Modification Package (Sabina 2020). Although previous field studies suggested that Arctic Grayling may use habitat downstream of Goose Lake for spawning and rearing, Sabina (2020) predicted that the risk of residual effects to Arctic Grayling reproduction would be low (minor), in part, because the lake outflow provides only fair-quality spawning habitat for Arctic Grayling (Rescan 2014b). Subsequent review by DFO identified that the proposed water withdrawal rate may have implication on the suitability of Arctic Grayling habitat downstream from the lake (i.e., Goose Lake Outlet and Propeller Lake Inlet reaches). As follow up to Sabina (2020), WSP conducted additional field studies and assessed the suitability of Arctic Grayling spawning and YOY rearing habitat in the Goose Lake Outlet Reach and the Propeller Lake Inlet Reach under different flow scenarios associated with the proposed water withdrawal rate from Goose Lake.

Under the new water withdrawal rate, Goose Lake outflows are expected to be, on average, 15.6% less compared to baseline conditions (i.e., natural flow regime) (Sabina 2020). Typical ecological flow conditions (above 30% MAD) for the Goose Lake Outlet and Propeller Lake Inlet are expected to be reduced by nine days during the open-water period. The onset of spring ecological flow is expected to be delayed by six days and late-summer ecological flows are expected to cease three days earlier. The six-day delay in suitable flow conditions has the potential influence adult spawning behaviour for individuals that utilize the Goose Lake outflows for spawning habitat, shifting the spawning window for adult Arctic Grayling, which can span two to three weeks (Stewart et al. 2007).

In terms of habitat specific changes during the spawning and rearing period, the following summarizes key results of the water withdrawal assessment provided in this technical memorandum:

- The spawning habitat assessment indicated that both the Goose Lake Outlet and Propeller Lake Inlet reaches will provide high quality spawning habitat for Arctic Grayling under each baseline and Project average scenarios. The overall quality of spawning habitat is not expected to change for the Goose Lake Outlet Reach and is only expected to undergo minor changes to the Propeller Lake Inlet Reach (3% decrease under average conditions) suggesting that the proposed water withdrawal rate from Goose Lake will have either non-measurable or minor changes on the suitability of spawning habitat for the local population of Arctic Grayling.
- The spawning assessment indicated that when comparing baseline and Project scenarios, the magnitude of effect on the suitability of habitat was stronger for the 1 in 10-year dry condition versus average condition in the Propellor Lake Inlet Reach but were similar for the Goose Lake Outlet Reach.
- The spawning habitat assessment indicated that under average conditions, the water withdrawal will decrease the wetted width by 3% to 12% during average flow conditions (Project versus baseline), along the channel margins for both the Goose Lake Outlet and Propeller Lake Inlet during the spawning period. Predicted decreases in wetted width during the month of June (peak spawning period) were only 4% in the Goose Lake Outlet Reach, and 3% in the Propellor Lake Inlet Reach, and both results are within the range of expected natural variability suggesting either that there will no measurable reduction in the capacity of habitat to support rearing YOY.

- The YOY rearing habitat assessment suggested that the Propeller Lake Inlet generally has higher quality habitat for YOY rearing than the Goose Lake Outlet, although the quality of habitat is not expected to change under the new withdrawal rate for either reach. The results suggest that the proposed water withdrawal from Goose Lake will have no implications on the suitability of YOY rearing habitat in either reach for Arctic Grayling.
- The YOY rearing assessment indicated that when comparing baseline and Project scenarios, the magnitude of effect on the suitability of habitat was similar for the 1 in 10-year dry condition and average condition for both the Propellor Lake Inlet Reach and Goose Lake Outlet Reach
- The YOY rearing assessment indicated that the quantity of YOY rearing habitat will decrease by 10% to 13% during average flow conditions (Project versus baseline) within Goose Lake Outlet. However, since the suitability of this habitat is relatively low (i.e., composite HSI score of 0.38), the likelihood of YOY moving to optimal rearing habitat downstream (i.e., the slow flowing pool between the Goose Lake Outlet and Propeller Lake Inlet reaches, or adjacent lake habitat) is high regardless of the flow scenario. Furthermore, effects are within the range of expected natural variability suggesting either that there will be no measurable reduction in the capacity of habitat to support rearing YOY. The magnitude of habitat loss along the channel margins in the Propeller Lake Inlet resulting from a decrease in wetted width is relatively minor (i.e., 2% to 5%), which is within the range of expected natural variability suggesting either that there will be no measurable reduction in the capacity of habitat to support rearing YOY.

Based on the above summary of results, it was concluded that there is the potential for residual effects to fish habitat, but that effects to the local Arctic Grayling population would be low (non-measurable) in magnitude. Residual effects, if any, would be reversible during the closure phase of the Back River Mine once water withdrawals for milling are no longer required. These conclusions are consistent with those drawn in the assessment provided in the FEIS Project Modification (Sabina 2020).

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Signature
Date 2024-02-08
PERMIT NUMBER: P407
NT/NU Association of Professional Engineers and Geoscientists

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APPENDIX A

Supplemental Hydrology and Fish Habitat Data Report - 2021 Open-Water Period

REPORT

Sabina Back River Project - Goose Property Area: Supplemental Hydrology and Fish Habitat Data Report

2021 Open-Water Period

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20412211-100-R-Rev0-2700

31 March 2022

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder), on behalf of Nuqsana Golder Engineering and Environmental Inc. (Nuqsana Golder), was retained by Sabina Gold & Silver Corp. (Sabina) to collect hydrology and fisheries information from the Goose Property Area (Site) during the 2021 open-water period. This information was collected as part of environmental data collection objectives directed by regulatory requirements (i.e., the water licence requirements) for the development and operation of the Back River Project (Project) and to support 2021 Goose Lake hydrodynamic model calibration and validation. Data collection at the Goose Lake outlet and Propeller Lake inlet reach is intended to support regulatory expectations and concerns raised by Fisheries and Oceans Canada (DFO) related to increased water withdrawal rates in Goose Lake (DFO 2020).

Three field visits were conducted during open-water conditions in 2021, the first occurring after freshet (July 1 to 7), the second during summer conditions (July 22 to 26) and the third during the fall (September 2 to 4). The 2021 field activities (summarized in Table 1) included the following objectives:

- To characterize the hydrology for Goose Lake throughout the open-water season, with measurements including:
  - Manual and continuous water levels in Goose Lake and manual and continuous water levels and discharges in the Propeller Lake inlet reach.
  - Manual discharge measurements for the inflow tributaries and the outflow of Goose Lake.
- To collect data and compare 2021 collected data to select 2014 stage-discharge rating curves at Propeller Lake inflow and to create a stage-discharge rating curve for the true outlet of Goose Lake, useful for hydrodynamic modelling.
- To characterize water quality for inflow tributaries and the outflow of Goose Lake, with measurements including:
  - In-situ field measurements of water quality.
  - Total Dissolved Sediment (TDS) sampling (reported as part of the Aquatic Effects Monitoring Program [AEMP]).
- To characterize spring spawning activity and fish habitat conditions from the Goose Lake outlet reach through to the Propeller Lake inlet reach.
- To observe and document the state of rock-weir mitigations in Rascal Stream West.

Table 1: Summary of Hydrology and Fisheries Field Activities at Site during the 2021 Open-water Period

Location	Program/Activities		
	Spring (1 to 7 July 2021)	Summer (22 to 26 July 2021)	Fall (2 to 4 September 2021)
Goose Lake Outlet (GLO-01) and Propeller Lake Inlet (PL-H2 [PN03])	- spawning assessment - fish habitat assessment - discharge measurements - installation of staff gauge and deployment of Solinst Levelogger and Barologger data transducers for continuous water levels - cross-section survey for hydraulic and habitat modelling	- discharge measurements - manual water level survey - discharge measurements	- discharge measurements - manual water level survey and retrieval of staff gauge and Solinst Levelogger and Barologger data transducers for continuous water level measurements

Table 1: Summary of Hydrology and Fisheries Field Activities at Site during the 2021 Open-water Period

Location	Program/Activities		
	Spring (1 to 7 July 2021)	Summer (22 to 26 July 2021)	Fall (2 to 4 September 2021)
Goose Lake inflow tributaries (PN04, PN05, PN07, PN07, PN08, and PN09)	- field water quality sampling - discharge measurements	- field water quality sampling - discharge measurements	- field water quality sampling - discharge measurements
Rascal Stream West (near PN05)	- qualitative characterization of rock-weir substrate mitigation, and fish movement potential - flow velocity conditions - flow discharge measurement	-none	
Goose Lake (CG-L1)	- manual water level survey, installation of staff gauge, and deployment of Solinst Levelogger and Barologger data transducers	- manual water level survey	- manual water level survey and retrieval of staff gauge and Solinst Levelogger and Barologger data transducers for continuous water level measurements

1.1 Study Area

Hydrology and fisheries data were collected from locations within the Goose Property as shown on Figure 1. Measurement or sampling locations included the Goose Lake inflow tributaries, Goose Lake and the outlet, the Goose Lake outlet reach and Propeller Lake inlet reach, and Rascal Stream West.

REFERENCE(S)

FOOTPRINT AND IMAGERY OBTAINED FROM CLIENT. HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 13N DATUM: NAD 83

YYYY-MM-DD	2022-04-01
DESIGNED	CS
PREPARED	SP
REVIEWED	CS
APPROVED	CS

CLIENT: Sabina

CONSULTANT: GOLDER MEMBER OF WSP

PROJECT
SABINA BACK RIVER PROJECT

TITLE
OVERVIEW OF 2021 OPEN-WATER SEASON FISH AND HYDROLOGY SITES

PROJECT NO.	FIGURE	REV.
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

2.0 HYDROLOGY

The 2021 hydrology field program comprised three site visits between July and September during open-water conditions at eight stations and included manual discharge measurements and water level surveys, continuous water level collection from pressure transducer data loggers, cross-section surveys downstream of the Goose Lake outlet. Not all measurements were completed at all stations as described below.

2.1 Methods

2.1.1 Hydrometric Data Collection Methods

2.1.1.1 Manual Discharge Measurements

Six Goose Lake inlet stream stations (PN04, PN05, PN07, PN07, PN08, and PN09) were monitored in 2021, as shown in Figure 1. These stations were visited three times and during each program, the following activities were completed and data collection included:

- stream discharge measurement, using a top-setting wading rod and a Hach FH950 velocity current meter; and,
- observations and photography of flow conditions.

2.1.1.2 Manual and Continuous Water Levels

Two stations, GC-L1 and PL-H2 (PN03), were selected as continuous hydrometric stations to characterize the open-water season Goose Lake water levels, the outflows from Goose Lake, and the inflows to Propeller Lake. Stations are shown in Figure 1. These stations were visited three times and during each program, the following activities were completed and data collection included:

- Discrete water level surveys, referenced to the existing station benchmarks (Rescan 2011, 2012, 2013 and 2014);
- Staff gauge readings were recorded (the field program included installation and retrieval of staff gauges at the same locations as 2011 to 2014 staff gauge locations) and the water levels at the staff gauge were surveyed to provide a datum for the staff gauge.
- Installation, download, and retrieval of Solinst Levelogger® 5 M5 (Levelogger) self-contained datalogger instruments, set to measure and record water levels on 5-minute intervals. The Levelogger measured absolute pressure (water and atmospheric pressure) expressed in metres.
- A Solinst Barologger® 5 M1.5 (Barologger) with the same sampling interval was installed at GC-L1 to compensate for atmospheric pressure fluctuations so that water levels could be calculated from the Leveloggers at each station.

2.1.1.3 Goose Lake Outlet Reach and Propeller Lake Inlet Reach Cross-Sections

Cross-section surveys of the Goose Lake Outlet Reach (1 cross-section) and Propeller Lake Inlet Reach (2 cross-sections) were conducted to support fisheries assessments and flow depth and velocity characterization of the reaches. These locations were identified as potential spawning habitat for regional fish species. Field data collected included surveys of the channel bathymetry, topography above the water level, and water level. The water level was collected with an associated discharge measurement (Section 2.1.1.1). Surveys were completed using an optical level and stadia rod and were referenced to existing station benchmarks (Rescan 2011, 2012, 2013 and 2014).

2.1.2 Stage-Discharge Curve Development

A stage-discharge rating curve is required to derive discharge from water level measurements (discrete or continuous) for a stream or lake outlet. Stage-discharge rating curves were created or updated for two stations:

- At PL-H2 (PN03), the manual discharge measurements and surveyed stream water levels completed in 2021 were added to the historical dataset. All available manual discharge measurements and concurrent water level surveys from Rescan (2011-2014) and 2021 Golder field programs were used to develop a rating curve for PL-H2 (PN03).
- A lake stage-discharge rating curve for the true outlet of Goose Lake was developed in 2021. Prior to 2021, no manual discharge measurements were recorded at the true outlet of Goose Lake, as discharge measurements were completed at Propeller Lake inlet station PL-H2 (PN03), a more suitable location for discharge measurements. Goose Lake Outlet station (GLO-01) was visited three times in 2021 and discharge measurements were completed each site visit to support the development of a lake stage-discharge rating curve for Goose Lake outlet.

2.1.3 Quality Assurance and Quality Control

Quality assurance (QA) and quality control (QC) practices determine data integrity and are relevant to all aspects of a study, from data collection to data analysis and reporting. QA encompasses management and technical practices designed to ensure that the data generated are of consistent high quality. QC is an aspect of QA and includes the procedures used to measure and evaluate data quality, and the corrective actions to be taken when data quality objectives are not met.

The field program used the following QA procedures:

- using appropriately trained staff to collect data, and following appropriate technical procedures for field measurements;
- re-surveying the main points using a second optical level setup;
- using and maintaining the field equipment according to the manufacturer specifications; and,
- completing all paperwork including documentation of field activities in a field notebook.
- The field equipment was maintained by regular servicing and calibration. The main technical specifications for instruments used in the field were:
  - Handheld GPS Garmin Map 62s unit accuracy of 3 to 5 m.
  - Hach FH950 units with internal data quality control systems that warn the user if the main measured values exceed expected criteria for a velocity measurement. The user needs to review the warnings, if any, and choose the adjustments needed. At the end of each discharge measurement, the unit’s software provides a QC summary and potential warnings to be considered in the discharge analysis.
  - Optical level measures elevation differences with a minimum accuracy of 0.01 m.

The Project QC method included a review of field data collected by field crews; assessment of field data sheets for completeness; review of calculation tables for surveys and discharges; comparison of all Barologger records and selection of appropriate records for barometric compensation; comparison of all compensated Levelogger recorded water levels; and review of discharge measurement summary sheets as produced by the Hach FH950.

2.2 Results

2.2.1 Discharge Measurements at Goose Lake Inflow Streams

Station locations and discharge data for the Goose Lake inflow stream stations visited in 2021 are summarized in Table 2. Detailed discharge measurement data for each station are presented in Appendix A. Associated water quality data collected or sampled during the same visits are presented and discussed in Section 3.1.1.5.

Table 2: 2021 Discharge Summary for Goose Lake Inflow Streams

Station	UTM (NAD83; Zone 13)		Date and Time	Discharge (m^3/s)
	Easting	Northing		
PN04	430774	7270010	2021-07-05 9:10	0.188
			2021-07-24 9:40	0.021 (1)
			2021-09-04 7:35	0.008 (2)
PN05	432891	7269919	2021-07-05 11:00	0.115 (3)
			2021-07-05 11:15	0.151 (4)
			2021-07-24 11:30	0.014
			2021-09-04 8:40	0.012 (5)
PN06	432744	7271610	2021-07-05 8:20	0.437
			2021-07-25 16:15	0.079
			2021-09-04 10:20	0.025
PN07	432091	7269573	2021-07-05 9:50	0.002
			2021-07-24 0:47	negligible (6)
			2021-09-04 8:15	0.0001 (7)
PN08	434269	7269719	2021-07-05 14:45	0.272
			2021-07-23 14:55	0.066
			2021-09-04 12:40	0.020
PN09	434688	7269634	2021-07-05 14:00	0.009
			2021-09-04 13:05	0.001

1) Discharge measurement 120 m downstream of Rescan coordinates (2014) due to channel constraints
2) Discharge measurement 20 m downstream of Rescan coordinates (2014) due to channel constraints
3) Discharge measurement 160 m downstream of Rescan coordinates (2014) at Rascal stream bridge footings – highly turbulent flow
4) Discharge measurement 20 m downstream of Rascal stream bridge footings – smooth laminar flow
5) Discharge measurement 40 m downstream of Rescan coordinates (2014) due to channel constraints
6) No observable flow, no discharge measurement taken
7) Very low flow but discharge is visible at time of measurement

2.2.2 Goose Lake (GC-L1 and GLO-01)

Goose Lake shoreline station (GC-L1) the true outlet of Goose Lake station (GLO-01) were visited three times in 2021. Details for the site visits at GC-L1 are presented in Table 3.

Table 3: 2021 GLO-01 Field Data Summary

Date and Time	UTM		Discharge (m^3/s)	Scaling Ratio of Discharges Between GLO-01 and PL-H2 (PN03)[a]	Activities
	Easting	Northing			
2021-07-05 9:10	434878	7271462	1.344	0.94	Discharge measurement
2021-07-24 10:10			0.375	0.87	Discharge measurement
2021-09-04 7:35			0.110	0.98	Discharge measurement

a) The scaling ratio is based on discharge values presented in Table 3 and Table 5, for the discharges measured within a day of each other.

A comparison of the measured discharges from GLO-01 and PL-H2 (PN03), presented as a ratio, were completed and shown in Table 3. PL-H2 (PN03), the Propeller Lake Inlet station, is the historical station and provides a more suitable location for discharge measurements when compared to the outlet of Goose Lake. The scaling calculation in 2021 was completed to assess the suitability of using a direct scaling factor to estimate the Goose Lake outlet flows from the downstream PL-H2 (PN03) station flows. Based on drainage areas of the two stations (PL-H2 [PN03] drainage area of 101.6 km^2 (Rescan 2014) and GLO-01 drainage area of 95 km^2 [calculated as part of this study]) a scaling factor of 0.94 is estimated. The field-based calculated scaling factors range from 0.87 to 0.98 and average 0.93, therefore validating the desktop scaling factor of 0.94 over the range of measured flows. It is recommended that the scaling factor is used to estimate GLO-01 discharges when GC-L1 water levels are not available and only PL-H2 (PN03) discharges are available.

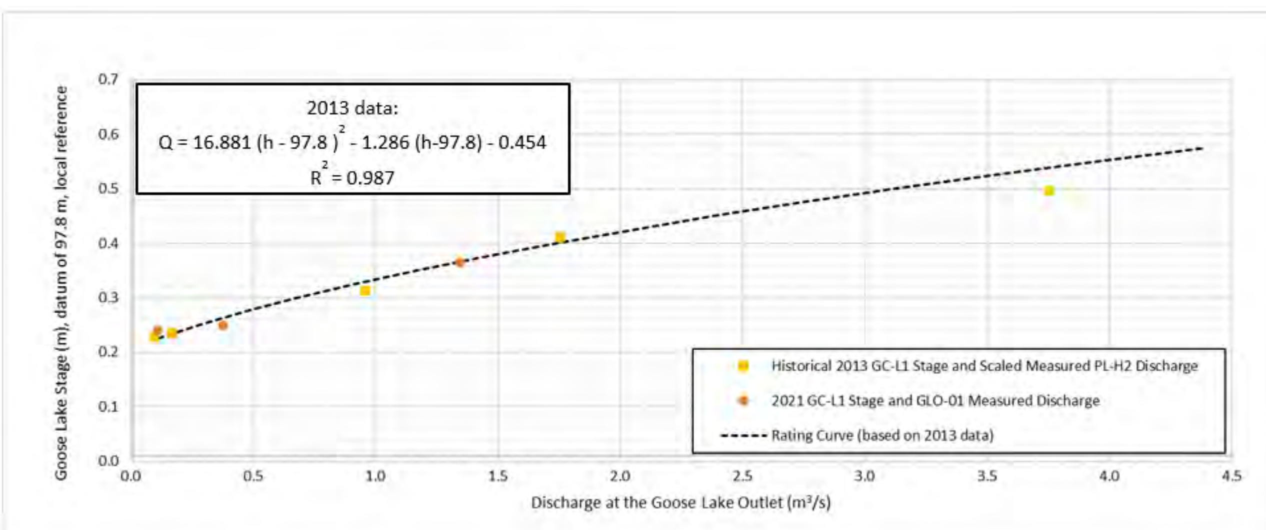
Details for the site visits at GC-L1 are presented in Table 4.

Table 4: 2021 GC-L1 Field Data Summary

Date and Time	UTM		Lake Water Level (m)	Activities
	Easting	Northing		
2021-07-06 13:00	435007	7272014	98.165	Manual water level survey and deployed Levelogger
2021-07-25 12:15			98.050	Manual water level survey, discharge measurement, and Levelogger download
2021-09-04 15:00			98.041	Manual water level survey, discharge measurement, remove Levelogger and staff gauge

Note: Water level relative to local reference BM054; elevation = 100.000 m (Rescan 2014)

A Goose Lake stage-discharge curve for the outlet of Goose Lake was constructed with 2013 (Rescan 2013) paired lake water levels and discharges (scaled PL-H2 [PN03] discharges as discussed above). Data collected in 2021 were added to the stage-discharge rating curve, as shown in Figure 2, however, as the 2021 data plot well on the 2013 rating curve, no update the to the rating curve for Goose Lake outlet is recommended in 2021.

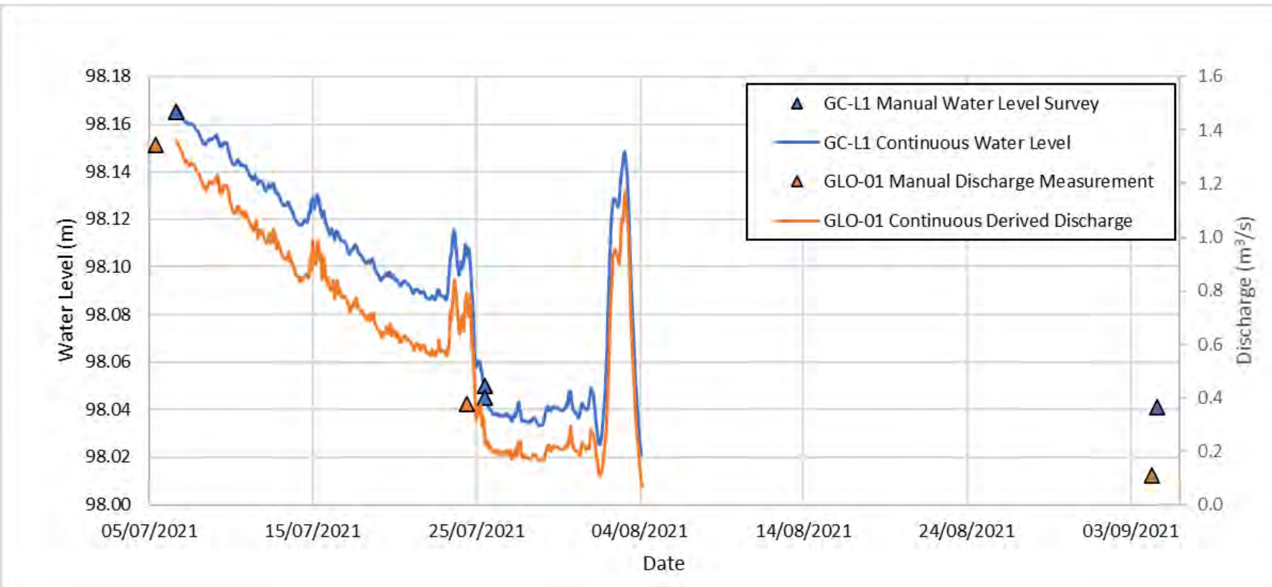


Note: GC-L1 stage datum of 97.8 m is relative to local reference BM054; elevation = 100.000 m (Rescan (2014)

Figure 2: Goose Lake Outlet Lake Stage-Discharge Rating Curve

Based on the continuous water levels from the data loggers at GC-L1, a continuous water level hydrograph was derived for a period of 6 July to 3 August 2021. Data between 4 August to 4 September 2021 were corrupted and unusable due to instrumentation malfunction (more specifically the instrument firmware was corrupt and was confirmed through investigation by the instrument supplier). The Goose Lake Outlet Lake Stage-Discharge Rating Curve was used to derive discharges at the outlet of Goose Lake (GLO-01).

The water level hydrograph for GC-L1 and the discharge hydrograph for GLO-01, as well as discrete manual measurements for the open-water season of 2021 are presented in Figure 3. Derived discharge at GLO-01 are based on the Goose Lake Outlet Lake Stage-Discharge Rating Curve. Tables of mean daily lake water level and temperatures (at GC-L1) and derived discharge at the outlet (GLO-01) are presented in Table B-1 in Appendix B.



Note: Water level relative to local reference BM054; elevation = 100.000 m (Rescan 2014)

Figure 3: 2021 GC-L1 Water Level and GLO-01 Hydrograph

2.2.3 Propeller Lake Inlet (PL-H2 [PN03])

Propeller Lake inlet hydrometric station PL-H2 (PN03) was visited four times in 2021. Details for each site visit are presented in Table 5.

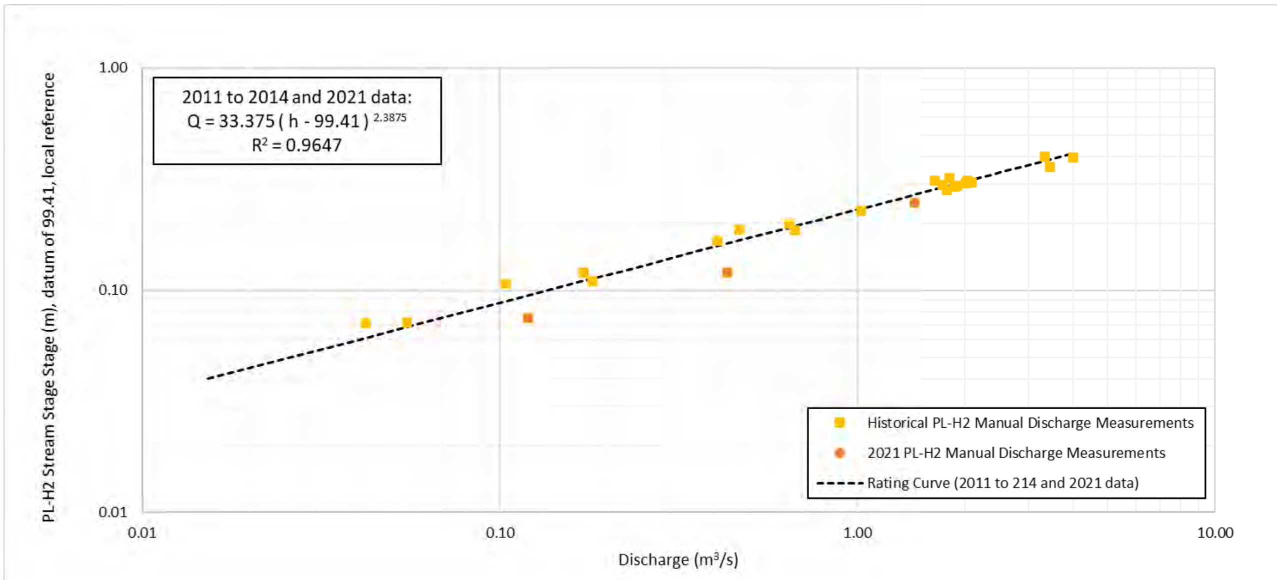
Table 5: 2021 PL-H2 (PN03) Field Data Summary

Date and Time	UTM		Stream Water Level (m)	Discharge (m^3/s)	Activities
	Easting	Northing			
2021-07-04 9:35	435007	7272014	99.650	1.434	Manual water level survey and discharge measurement
2021-07-06 12:00			99.656	-	Manual water level survey, deployed data logger and installed staff gauge
2021-07-24 14:00			99.530	0.432	Manual water level survey, discharge measurement, and data logger download
2021-09-03 14:00			99.485	0.112	Manual water level survey, discharge measurement, remove data logger and staff gauge

Note: Water level relative to local reference BM004; elevation = 100.000 m (Rescan 2014)

The manual discharge measurements and water levels from historical programs (Rescan 2011 to 2014) and the 2021 program are shown in Figure 4. As the 2021 program provided insufficient data points to create an independent 2021 stream stage-discharge rating curve, all open-water data points are used to estimate the rating curve equation.

There is a potential datum shift for the 2021 measurements as the measurements generally fall below the historical data, however there are insufficient data points to confirm a datum shift or to derive a separate 2021 rating curve). If a datum shift is confirmed in subsequent monitoring, it may be explained by uplift of the local benchmarks through freeze-thaw heaving of boulders near the wetted channel. Therefore, it is recommended for the 2021 stage-discharge rating curve, that the complete dataset (2011-2014 and 2021) be used for the stage-discharge rating curve at station PL-H2 (PN03).

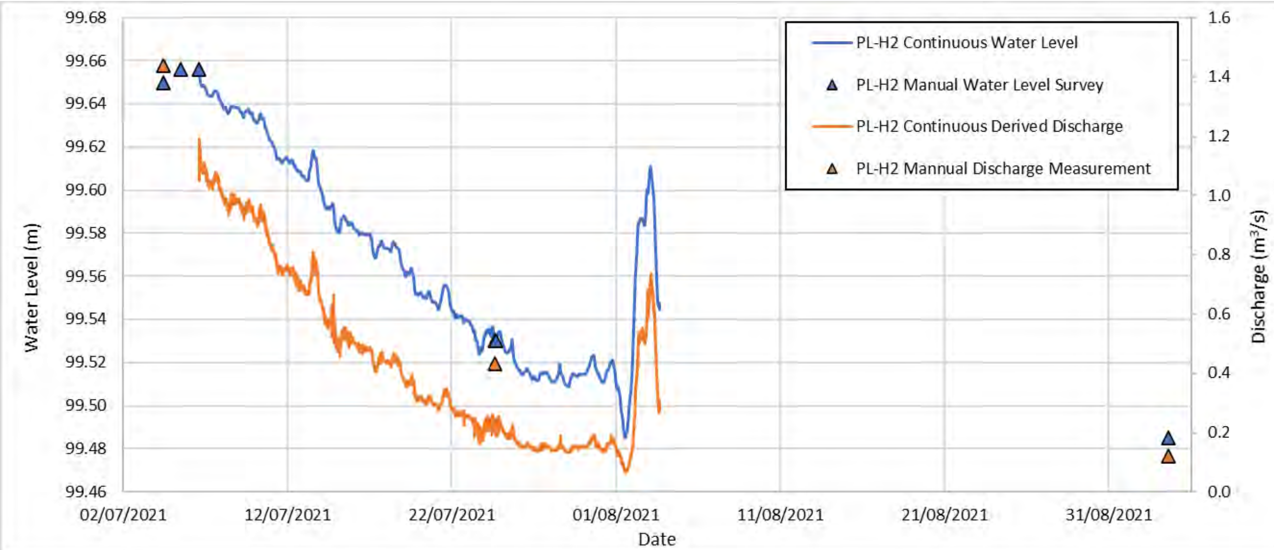


Note: PL-H2 stage datum of 99.41 m is relative to local reference BM004; elevation = 100.000 m (Rescan 2014)

Figure 4: PL-H2 (PN03) 2021 Stage-Discharge Rating Curve

Based on the continuous water levels from the data loggers, a continuous hydrograph was derived for a period of 6 July to 3 August 2021. Data between 4 August to 4 September 2021 were corrupted and unusable due to instrumentation malfunction (more specifically the instrument firmware was corrupt and was confirmed through investigation by the instrument supplier).

The water level and discharge hydrographs for PL-H2 (PN03), as well as discrete manual measurements for the open-water season of 2021, are presented in Figure 5. Tables of mean daily water level, derived discharge, and temperature are presented in Table B-2 in Appendix B.



Note: Water level relative to local reference BM004; elevation = 100.000 m (Rescan 2014)

Figure 5: 2021 PL-H2 (PN03) Water Level and Discharge Hydrograph

2.2.4 Channel Cross-Section and Water Level Surveys

Cross-section surveys of the Goose Lake Outlet Reach (1 cross-section) and Propeller Lake Inlet Reach (2 cross-sections), collected 4 July 2021 at approximately 15:30, are shown in Figure 6, Figure 7 and Figure **8**. The cross-section locations are shown on Figure 1. Station 0 is located on the left downstream bank of each channel.

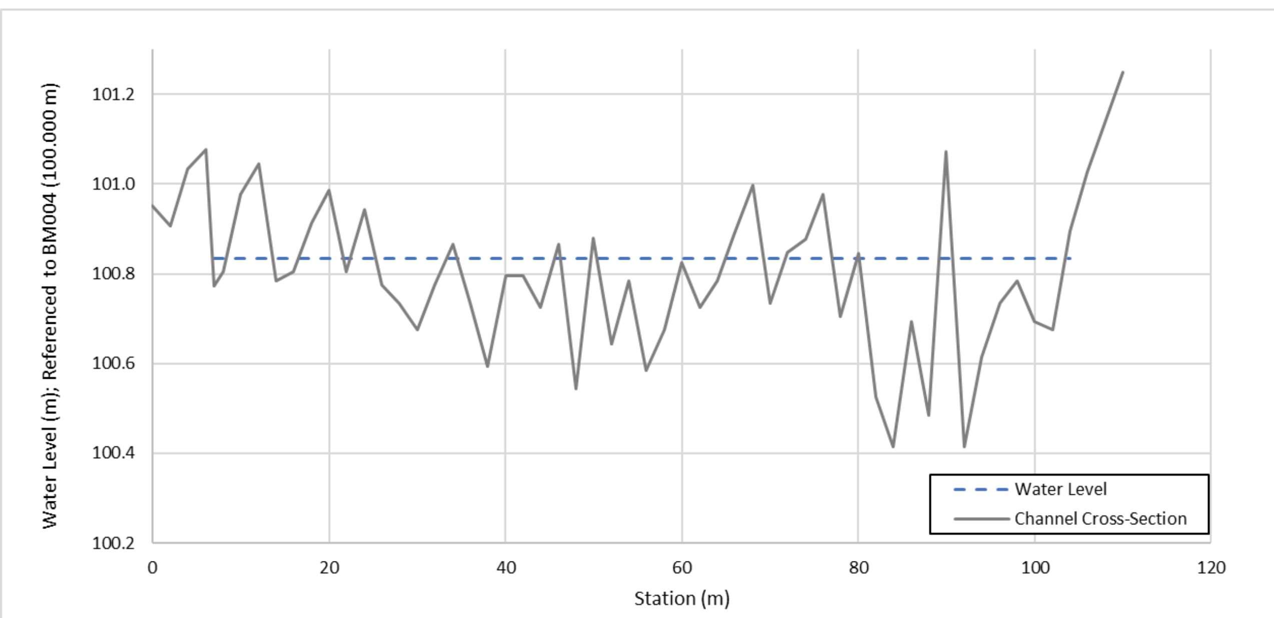


Figure 6: Goose Lake Outlet Cross-Section

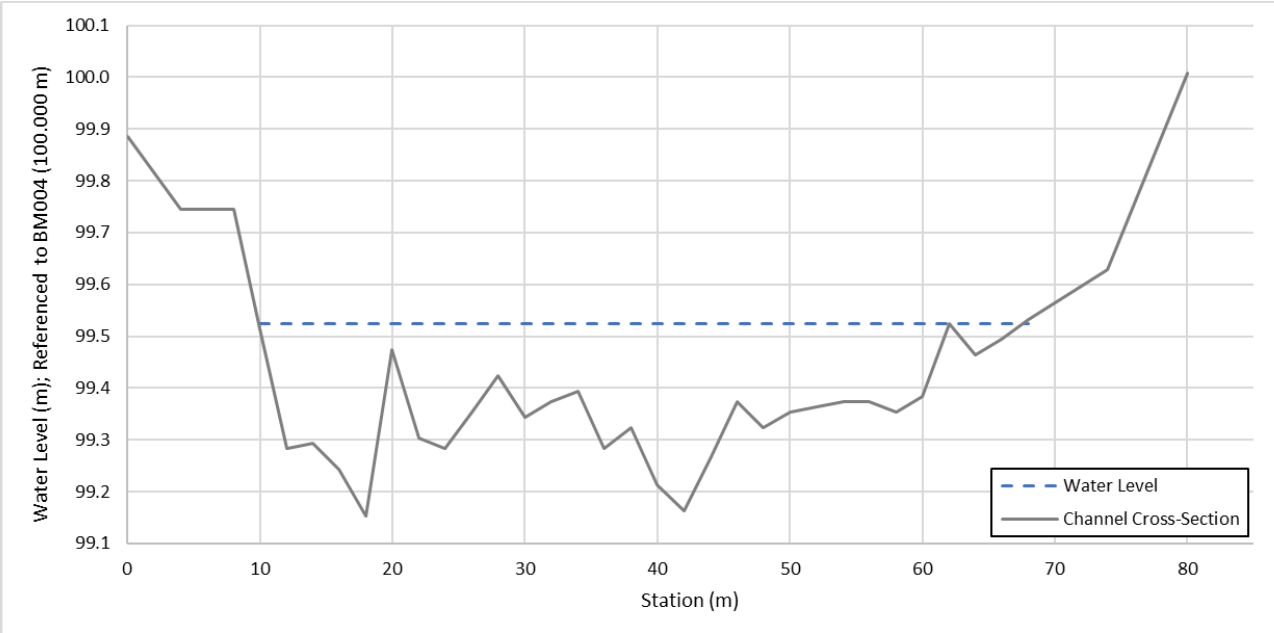


Figure 7: Propeller Lake Inlet Cross-Section – Upstream

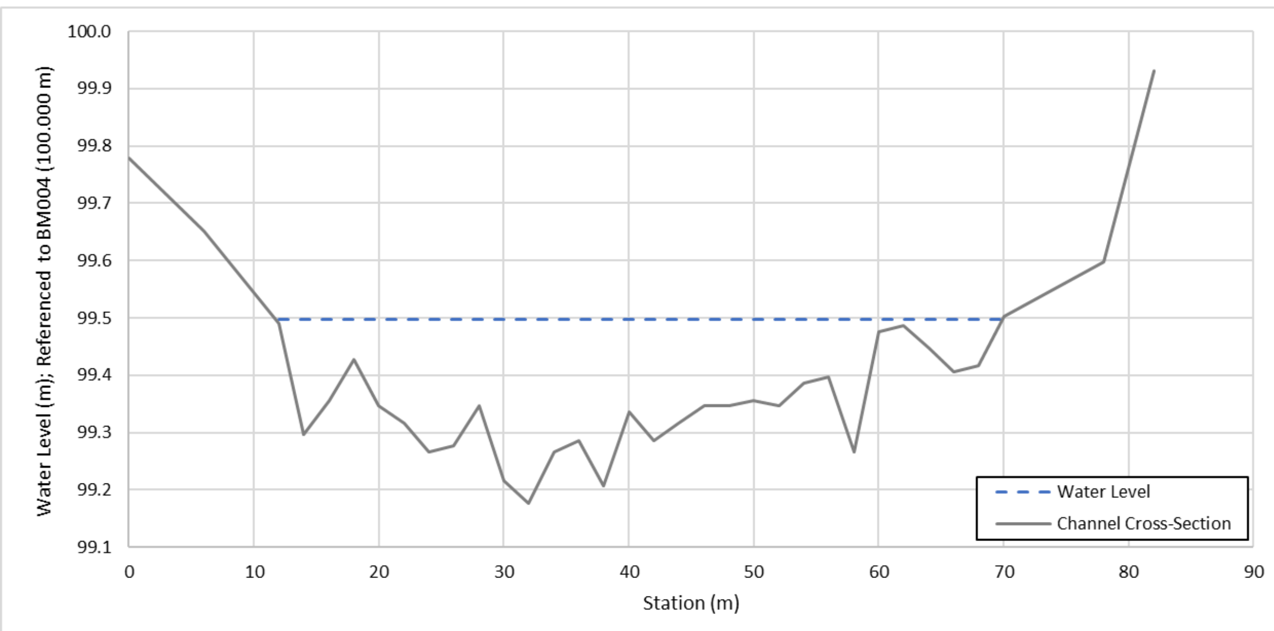


Figure 8: Propeller Lake Inlet Cross-Section – Downstream

3.0 FISH AND FISH HABITAT

Information on fish and fish habitat were collected during spring freshet conditions when spawning activity was underway or nearing completion for regional spring spawning fish species (i.e., Arctic Grayling). Spawning and rearing habitat surveys were conducted at the Goose Lake outlet, Propeller Lake inlet and their associated connector pond (Figure 1; Table 6). Information on spawning suitability for regional fish species from these locations will subsequently inform minimum flow requirements for these habitats to support sensitive life stages (e.g., egg incubation, spawning) for fish. In addition, field (*in-situ*) water quality measurements were recorded from Goose Lake inflow tributary stations during the spring, summer and fall surveys to better understand seasonal variability in physicochemical habitat conditions among peripheral watercourses (Table 2).

A survey of the lower reach of Rascal Stream West (higher grade section; Table 6) was completed to assess fish movement potential and to evaluate flow mitigation structures (series of rock weirs) that were installed in the summer of 2020. The flow mitigation structures were installed to increase fish movement potential from Goose Lake into the upstream habitats of Rascal Stream West during high-flow periods (e.g., spring freshet).

Table 6: Locations of the Spring Fish Habitat Surveys near Site, July 2021

Station	Date	Surveyed Length (m)	UTM (NAD 83; Zone 13)			
			Upstream End		Downstream End	
			Easting	Northing	Easting	Northing
Goose Lake Outlet Reach	2 July 2021	315	434891	7272232	435012	7271679
Connector Pond	4 July 2021	320	435012	7271679	434996	7271972
Propeller Lake Inlet Reach	4 July 2021	338	434996	7271972	434895	7272200
Rascal Stream West	5 July 2021	132	432864	7269960	432830	7270085

NAD = North American Datum; m = metre

3.1.1 Methods

3.1.1.1 Detailed Fish Habitat

Detailed fish habitat parameters were recorded from survey stations presented in Table 6. Surveyed areas were divided into channel units based on changing classes (shallow, moderately deep or deep) and/or types of hydraulic habitat (e.g., run, riffle and pool) present within the survey area (Hawkins *et al.,* 1993; R.L.&L Environmental Services Ltd. 1994). Classes were assigned a numeric grade (except for riffle habitat) of 1 through 3 based on depth, substrate type and water surface tension. For example, a shallow run (R3) has a mean and maximum depth of less than 0.5 and 0.75 m, respectively, with coarse substrate and little to no broken surface tension. A deep run (R1) has a mean and maximum depth of >1.0 and >1.5 m, respectively, with coarse substrate and irregular surface tension. The hydraulic habitat type (e.g., run, riffle, flat, pool) is also based on substrate and flow; for example, run habitat will have coarse substrate and moderate to high flow rates and flat habitat will have fine substrate and a low flow rate.

The following types of information were collected from each channel unit:

- habitat type and class (e.g., shallow run [R3])
- maximum water depth
- channel dimensions, including channel unit length, mean channel width and mean wetted width
- water depth and velocity profiles

- water temperature
- percent instream cover for fish (visually estimated)
- percent overhead cover for fish (visually estimated)
- percent substrate type based on particle size (visually estimated), including clay/silt (less than 0.06 millimetres [mm]), sand (0.06 to 2.0 mm), gravel (2 to 64 mm), cobble (64 to 256 mm) and boulder (greater than 762 mm)
- features that might impede or obstruct fish movements (e.g., waterfall)
- percent unstable banks (visually estimated)

Areas containing suitable spawning habitat for Arctic Grayling were marked as a waypoint and subsequently sampled for of fish eggs. Suitable Arctic Grayling spawning habitat includes the following characteristics: locations within small streams where a riffle transitions into a run; 2 to 10ºC water temperature; gravel substrate material; and current velocities that range from 0.34 m/s to 1.46 m/s (Hubert *et al*., 1985).

3.1.1.2 Fish Habitat Mapping

Fish habitat maps were drawn in the field for the Goose Lake outlet, connector pond and Propeller Lake inlet stations presented in Table 6. Habitat features were visually estimated and drawn on grided paper. Habitat features included the valley gradient off the left and right downstream bank (rated as low to high grade), the riparian vegetation type, wetted and bankfull widths, undercut banks, flow direction, channel units with their associated hydraulic habitat type and class, substrate type and any other notable features that may affect fish communities (e.g., fish barriers) (Hawkins *et al.,* 1993*;* R.L.&L Environmental Services Ltd. 1994). The maps also include the locations where Arctic Grayling egg sampling occurred and where eggs were captured. Fish and fish habitat features identified and mapped in the field were later transferred and used as digitized georeferenced features over satellite imagery in a geographic information system (GIS). Satellite imagery was dated 2016, from ArcGIS' Mosaic Dataset. Conditions observed in the field were similar to those illustrate on the satellite imagery with additional flooding off the right-downstream-bank of the Goose Lake outlet.

3.1.1.3 Spawning Activity Assessment

Locations earmarked during the detailed fish habitat survey as having suitable spawning habitat for coarse substrate spawners (e.g., gravel substrate with shallow depth and moderate flow velocity) were sampled for fish eggs. Eggs were sampled using a 400 µm mesh D-frame kick net. A plume was created by disturbing (kicking) a 1 m by 1 m area of benthic substrate, the contents of which were received in the net and evaluated for the presence of fish eggs. If eggs were present, sampling was stopped in that section of the watercourse, if no eggs were present, another 1 m x 1 m plot nearby was disturbed; this process was repeated for up to 5 separate plots assuming no eggs found.

If eggs were found, the number of eggs captured, and the size (diameter length) of the eggs was recorded. Photographs were also taken of the eggs with a ruler (for scale) before being released back to the location of capture. Depth, flow velocity (mid-water column) and substrate conditions were noted from each egg (kick) sampling location.

3.1.1.4 Rascal Stream West Mitigation Structures

A 132 m section of Rascal Stream West that underwent channel modification, in the form of flow mitigation structures (rock weirs), was surveyed on 5 July 2021 (Table 6). Fish movement potential across habitat features was assessed from low to high potential based on flow velocity and potential fish barriers (e.g., vertical drops). General observations on hydraulic habitat types and associated substrate particle size (e.g., boulder, cobble, gravel) were noted and photographed. Flow velocity was measured along a transect just downstream from the Site bridge. Flow velocity, depth and discharge was measured using a Hach FH950 Portable Flow Metre along a tagline extended across the watercourse, perpendicular to flow.

3.1.1.5 Goose Lake Inflow Tributaries – Field Water Quality

Field (*in situ*) water quality measurements were recorded from Goose Lake inflow tributary stations and at PL-H2 (PN03). The locations of these stations are provided in Table 2. Water quality measurements were recorded during the spring, summer and fall programs from point locations at 0.3 m depth (approximately). Water quality during the spring was measured using a multi-parameter Hanna Pen, the following parameters were recorded: temperature, pH, and conductivity. Water quality during the summer and fall was measured using a multi-parameter YSI probe, the following parameters were recorded: temperature, pH, conductivity, specific conductivity, and dissolved oxygen. A malfunction of the specific conductivity and dissolved oxygen probe during the summer program prevented capture of these measurements at PN06, PN08 and PN09 stations.

In addition to the in-situ sampling, TDS samples were collected, however, methods and results for the TDS sampling is included in AEMP reporting.

3.1.2 Results

3.1.2.1 Detailed Fish Habitat

Detailed fish habitat data are presented in Appendix C, Table C-1. A summary of the fish habitat data, by station, is presented in Table 7. A total of 973 m of habitat was surveyed among stations, including the 315 m Goose Lake outlet reach, the 320 m connector pond, and the 338 m Propeller Lake inlet reach. The hydraulic habitat in the Goose Lake and Propeller Lake watercourse sections consisted of shallow runs (R3) and riffles (RF). Habitat in the connector pond consisted of shallow (P3) to deep (P1) pool habitat.

The Goose Lake outlet reach was flooded off the right downstream bank with a mean wetted width of 72.9 m (ranging from 62 to 94 m) and mean bankfull width of 58.2 m (ranging from 48 to 73 m). The maximum depth observed throughout the reach was 0.38 m. The dominant and subdominant hydraulic habitat types were riffle (66%) and run (34%), respectively. Instream cover was prevalent for small fish (0 to 60 mm length size class) and limited for larger fish (greater than a 150 mm length size class). Instream cover was primarily provided by substrate (69%) with a smaller amount provided by turbulent water (15%); overhanging cover for fish was limited throughout. The dominate and subdominant substrate types were boulder (59%) and cobble (30%), respectively. Pockets of gravel substrate were observed at the confluence with Goose Lake and at the downstream end of the outlet. These areas were noted as having suitable coarse substrate spawning habitat and were subsequently sampled for fish eggs (Appendix D, Figure D-1).

The connector pond had a wetted and bankfull width of 300 and 330 m, respectively. Depth increased gradually from the shoreline to the centre of the pond, with shallow pond habitat (P3) along the shoreline through to deep pool habitat in the middle of the pond (P1). Depths typically exceeded 1.2 m within 30 m off the shoreline. Instream cover was prevalent for all size classes of the regional fish species. Instream cover was provided by depth (50%)

and substrate (40%); overhanging cover for fish was limited throughout. The dominant and subdominant substrate types were boulder (40%) and cobble (30%).

The Propeller Lake inlet reach had a mean wetted width of 56.1 m (ranging from 38 to 78 m) and mean bankfull width of 67.9 m (ranging from 46 to 90 m). The maximum depth observed throughout the reach was 0.6 m. The dominant and subdominant hydraulic habitat types were run (76%) and riffle (24%), respectively. Instream cover was prevalent for small fish (0 to 60 mm length size class) and limited for larger fish (greater than a 150 mm length size class). Instream cover was primarily provided by substrate (47%) with a smaller amount provided by emergent (2%) and submergent aquatic vegetation (5%); overhanging cover for fish was limited throughout. The dominant and subdominant substrate types were boulder/cobble (41%) and gravel (12%), respectively. Gravel substrate was limited, and the presence of gravel beds was not observed. Small amounts of gravel substrate were intermixed with cobble and boulder substrate throughout. These areas were noted as having suitable spawning habitat for Arctic Grayling and subsequently sampled for eggs (Appendix D, Figure D-3).

Table 7: Summary of Fish Habitat Information Collected from the Goose Lake Outlet Reach, Propeller Lake Inlet Reach and the Connector Pond Stations, July 2021

Parameter	Station		
	Goose Lake Outlet Reach	Connector Pond	Propeller Lake Inlet Reach
Physical Channel Parameters			
Length Surveyed (m)	315	320	338
Wetted Area (m^2)	22,950	96,000	18,966
Bank-full Area (m^2)	18,326	105,600	22,935
Mean Wetted Width (m) (Min - Max)	72.9 (62 - 94)	300 -	56.1 (38 - 78)
Mean Bankfull Width (m) (Min - Max)	58.2 (48 - 73)	330 -	67.9 (46 - 90)
Max Depth (m)	0.38	>1.2	0.6
Mean Transect Flow Velocity (m/s)	0.22	-	0.27
Mean Transect Temperature (°C)	7.0	-	9.4
Habitat Type (% area)			
Shallow Run (R3)	34	0	76
Riffle (RF)	66	0	24
Pool (shallow P1 to deep P3)	0	100	0
Instream Cover per Fish Size Class (% area)			
0-60 mm length	69	76	58
61-150 mm length	23	71	31
>150 mm length	14	46	11
Instream Cover (% area)			
Substrate (SUB)	69	40	47
Woody debris (WD)	0	0	0
Emergent Aquatic Vegetation (EAV)	0	0	2
Depth/turbulence (D/T)	15	50	0
Submerged Aquatic Vegetation (SAV)	1	0	5
Overhanging Cover (% area)			
Undercut Bank (UCB)	7	0	6
Overhanging Grass (OHG)	5	0	5
Overhanging Woody Vegetation (OHWV)	0	0	0
Substrate (% area)			
Organic matter (Or)	0	0	0
Clay/Silt (C/S)	1	5	1
Sand (Sa)	2	5	6
Gravel (Gr)	10	20	12
Cobble (Co)	30	30	41
Boulder (Bo)	59	40	41
Bedrock (Br)	0	0	0

m^2 = square-metre; m = metre; m/s = metres per second; min = minimum; max = maximum; % = percent; Temp = temperature; °C = degree Celsius; Jul = July; R3 = shallow run habitat; RF = riffle habitat; P1 to 3 = shallow to deep pool habitat; > = greater than; - = data not collected; mm = millimetre

3.1.2.2 Fish Habitat Mapping

Fish habitat maps are presented in Appendix D; Figures D-1 to D-3.

3.1.2.3 Spawning Activity Assessment

Suitable coarse substrate (e.g., gravel, small cobble) spawning habitat was observed in both the Goose Lake outlet reach and the Propeller Lake inlet reach. A summary of sampling results is presented in Table 8. Fish eggs were captured from both watercourse sections, one Arctic Grayling egg (3 mm diameter) from the Goose Lake outlet reach and two eggs (3 mm diameters) were captured from the Propeller Lake inlet reach (Photo 1 through 4). Locations of where the eggs were captured are included on their respective habitat maps (Appendix D, Figure D-1 and D-3).

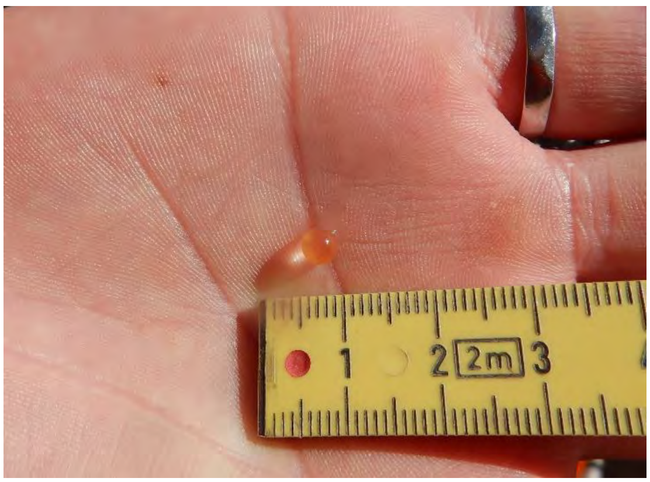


Photo 1: Single Arctic Grayling egg captured from the Goose Lake outlet reach (2 July 2021).

Photo 2: View of substrate in the Goose Lake outlet reach where the Arctic Grayling egg was captured (2 July 2021).

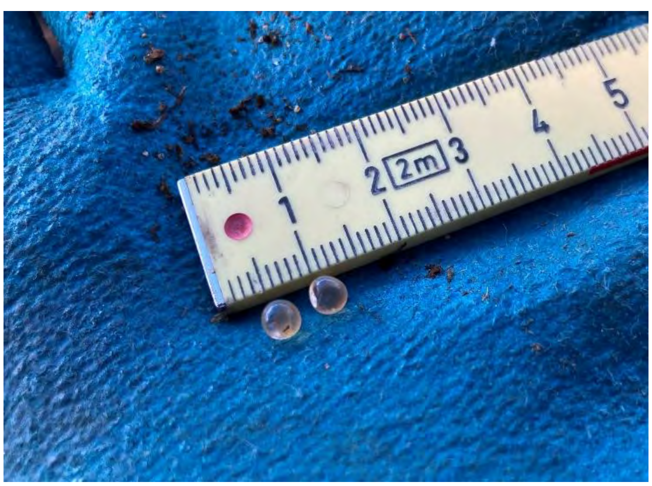


Photo 3: Pair of Arctic Grayling eggs captured from the Propeller Lake inlet reach (4 July 2021).

Photo 4: View of substrate in the Propeller Lake inlet reach where the Arctic Grayling eggs were captured (4 July 2021).

Table 8: Summary of Fish Egg Sampling Results from the Goose Lake Outlet and Propeller Lake Inlet Reach, July 2021

Station	Eggs Found? (Yes; # or No)	Average Egg Diameter (mm)	Species	Water Depth (m)	Velocity (m/s)	Substrate%	UTM (NAD 83; Zone 13)	
							Easting	Northing
Goose Lake Inlet Reach	No	-	-	0.20	0.21	5% Co, 30% Sa, 65% Gr	434865	7271463
	No	-	-	0.20	0.14	15% Co, 30% Sa, 55% Gr	434880	7271464
	No	-	-	0.22	0.18	10% Co, 40% Sa, 50% Gr	434881	7271456
	No	-	-	0.12	0.16	20% Co, 20% Bo, 20% Sa, 40% Gr	434990	7271589
	No	-	-	0.25	0.16	25% Co, 20% Bo, 55% Gr	435022	7271675
	No	-	-	0.19	0.06	25% Co, 20% Bo, 55% Gr	435022	7271675
	No	-	-	0.15	0.07	25% Co, 20% Bo, 55% Gr	434991	7271668
	Yes; 1	3	Arctic Grayling	0.16	0.24	20% Co, 15% Bo, 25% Sa, 40% Gr	435035	7271667
Propeller Lake Inlet Reach	Yes; 2	3	Arctic Grayling	0.20	0.21	10% Co, 10% Bo, 30% Sa, 50% Gr	434977	7272076
	No	-	-	0.18	0.20	10% Co, 10% Bo, 30% Sa, 50% Gr	434974	7272075
	No	-	-	0.10	0.20	10% Co, 10% Bo, 30% Sa, 50% Gr	434965	7272099
	No	-		0.21	0.25	10% Co, 10% Bo, 30% Sa, 50% Gr	434963	7272094
	No	-	-	0.20	0.23	10% Co, 10% Bo, 30% Sa, 50% Gr	434950	7272136
	No	-	-	0.28	0.18	10% Co, 10% Bo, 30% Sa, 50% Gr	434954	7272148
	No	-	-	0.22	0.24	5% Co, 10% Bo, 35% Sa, 50% Gr	434904	7272205
	No	-	-	0.2	0.19	5% Co, 10% Bo, 35% Sa, 50% Gr	434901	7272213

NAD = North American Datum; m = metre; m/s = metres per second; % = percent; # = number; - = data not collected; mm = millimetre; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; Br = bedrock.

3.1.2.4 Rascal Stream West Mitigation Structures

A summary of observations are provided in Table 9. Photographs of habitat and associated substrate are provided in Appendix E. The mean flow velocity downstream from the Site bridge was 0.31 m/s, ranging from 0 to 0.94 m/s along the transect. Discharge was 0.115 m^3/s and mean depth was 0.16 m at the time of the measurements. Detailed flow velocity measurements for Rascal Stream West (hydrometric station: PN05) are provided in Appendix A; Table A-7.

Table 9: Summary of Rascal Stream West Mitigation Structure Assessment and Habitat Observations, 5 July 2021

Distance Upstream from the Goose Lake Confluence (m)	Habitat and Substrate Description	Fish Movement Potential	UTM (NAD 83; Zone 13)	
			Easting	Northing
240	Riffle; large boulder and cobble substrate	High	432864	7269960
233	Cascade; cobble substrate	Moderate	432863	7269969
217	Riffle; boulder and cobble substrate	Moderate to High	432857	7269983
194	Chute, with vertical drop; cobble and boulder substrate	Low	432859	7270006
189	Riffle with dispersed flow; cobble and boulder substrate	Moderate	432858	7270011
155	Cascade; cobble and boulder substrate	High	432850	7270040
108	Run; cobble substrate	High	432830	7270085

NAD = North American Datum

3.1.2.5 Goose Lake Inflow Tributaries – Field Water Quality

Field water quality measurements from the Goose Lake inflow tributary stations are presented in Appendix F, Table F-1.

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Date 2022-04-07

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APPENDIX A

Manual Discharge Measurement Data

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	04-Jul
Waterbody:	PN03	**Start Time**	8:53
Crossing ID:	PN03 (PL-H2)	**End Time**	9:34

BM UTM Location		**Survey**			**Datalogger SN:**	
East	435007	BM004	1.088 (10:15)	1.088 (15:10)	**Transducer SN:**	190090338808
North	7272014	WL_read	1.438 (10:15)	1.438 (15:10)	**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev	99.650	99.650	**Crew:**	DM/CC

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.170**
2	2.00	0.17		0.01		**0.003**	**0.260**
3	4.00	0.09		0.01		**0.002**	**0.180**
4	6.00	0.09		0.07		**0.013**	**0.240**
5	8.00	0.15		0.06		**0.018**	**0.370**
6	10.00	0.22		0.09		**0.040**	**0.500**
7	12.00	0.28		0.16		**0.090**	**0.460**
8	14.00	0.18		0.10		**0.036**	**0.400**
9	16.00	0.22		0.06		**0.026**	**0.430**
10	18.00	0.21		0.19		**0.080**	**0.500**
11	20.00	0.29		0.15		**0.087**	**0.550**
12	22.00	0.26		0.27		**0.140**	**0.490**
13	24.00	0.23		0.23		**0.106**	**0.550**
14	26.00	0.32		0.06		**0.038**	**0.660**
15	28.00	0.34		0.11		**0.075**	**0.700**
16	30.00	0.36		0.14		**0.101**	**0.560**
17	32.00	0.20		0.18		**0.072**	**0.610**
18	34.00	0.41		0.17		**0.139**	**0.770**
19	36.00	0.36		0.15		**0.108**	**0.770**
20	38.00	0.41		0.09		**0.074**	**0.750**
21	40.00	0.34		0.09		**0.061**	**0.510**
22	42.00	0.17		0.10		**0.034**	**0.330**
23	44.00	0.16		0.14		**0.045**	**0.200**
24	46.00	0.04		0.08		**0.006**	**0.220**
25	48.00	0.18		0.04		**0.014**	**0.390**
26	50.00	0.21		0.06		**0.025**	**0.210**
27	52.00	0.00		-0.17		**0.000**	**0.000**
28						**0.000**	**0.000**

NOTES:		**RESULTS:**		
			Q (m3/s)	**1.434**
			A(m2)	**11.78**
			B(m)	**52.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	24-Jul	
Waterbody:		PN03			**Start Time**	14:00	
Crossing ID:		PN03			**End Time**	15:30	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	435007	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7272014	WL_read	0.180		**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:** CM/EE		

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (°)	Qi (m3/s)	Ai (m2)
1	43.00	0.00		0.00			**0.003**
2	42.50	0.01		0.00		**0.000**	**0.013**
3	42.00	0.04		0.08		**0.002**	**0.040**
4	41.50	0.12		0.06		**0.004**	**0.085**
5	41.00	0.22		0.05		**0.006**	**0.075**
6	40.50	0.08		0.01		**0.000**	**0.058**
7	40.00	0.15		0.05		**0.004**	**0.058**
8	39.50	0.08		0.08		**0.003**	**0.035**
9	39.00	0.06		0.01		**0.000**	**0.033**
10	38.50	0.07		0.07		**0.002**	**0.048**
11	38.00	0.12		0.03		**0.002**	**0.045**
12	37.50	0.06		0.03		**0.001**	**0.033**
13	37.00	0.07		0.13		**0.005**	**0.058**
14	36.50	0.16		0.04		**0.003**	**0.060**
15	36.00	0.08		0.02		**0.001**	**0.045**
16	36.50	0.10		-0.03		**-0.003**	**0.143**
17	35.00	0.09		0.01		**0.001**	**0.035**
18	34.50	0.05		-0.04		**-0.001**	**0.058**
19	34.00	0.18		0.03		**0.003**	**0.105**
20	33.50	0.24		0.03		**0.004**	**0.083**
21	33.00	0.09		0.03		**0.001**	**0.043**
22	32.50	0.08		0.02		**0.001**	**0.040**
23	32.00	0.08		0.00		**0.000**	**0.035**
24	31.50	0.06		0.09		**0.003**	**0.038**
25	31.00	0.09		0.04		**0.002**	**0.035**
26	30.50	0.05		0.12		**0.003**	**0.055**
27	30.00	0.17		0.03		**0.003**	**0.075**
28	29.50	0.13		0.08		**0.005**	**0.090**
29	29.00	0.23		0.03		**0.003**	**0.098**
30	28.50	0.16		0.04		**0.003**	**0.068**
31	28.00	0.11		0.10		**0.006**	**0.048**
32	27.50	0.08		0.08		**0.003**	**0.058**
33	27.00	0.15		0.12		**0.009**	**0.085**
34	26.50	0.19		0.12		**0.011**	**0.093**
35	26.00	0.18		0.12		**0.011**	**0.093**
36	25.50	0.19		0.13		**0.012**	**0.083**
37	25.00	0.14		0.15		**0.011**	**0.078**
38	24.50	0.17		0.12		**0.010**	**0.090**
39	24.00	0.19		0.08		**0.008**	**0.095**
40	23.50	0.19		0.10		**0.010**	**0.098**
41	23.00	0.20		0.04		**0.004**	**0.090**
42	22.50	0.16		0.09		**0.007**	**0.063**
43	22.00	0.09		0.06		**0.003**	**0.058**
44	21.50	0.14		0.04		**0.003**	**0.060**
45	21.00	0.10		0.03		**0.002**	**0.065**
46	20.50	0.16		0.08		**0.006**	**0.080**
47	20.00	0.16		0.04		**0.003**	**0.083**
48	19.50	0.17		0.07		**0.006**	**0.090**
49	19.00	0.19		0.07		**0.007**	**0.108**
50	18.50	0.24		0.09		**0.011**	**0.105**
51	18.00	0.18		0.09		**0.008**	**0.105**
52	17.50	0.24		0.08		**0.010**	**0.113**
53	17.00	0.21		0.08		**0.008**	**0.135**
54	16.50	0.33		0.07		**0.012**	**0.155**
55	16.00	0.29		0.09		**0.013**	**0.118**
56	15.50	0.18		0.04		**0.004**	**0.100**
57	15.00	0.22		0.10		**0.011**	**0.093**
58	14.50	0.15		0.10		**0.008**	**0.103**
59	14.00	0.26		0.11		**0.014**	**0.143**
60	13.50	0.31		0.08		**0.012**	**0.133**
61	13.00	0.22		0.12		**0.013**	**0.115**
62	12.50	0.24		0.13		**0.016**	**0.100**
63	12.00	0.16		0.13		**0.010**	**0.098**
64	11.50	0.23		0.06		**0.007**	**0.133**
65	11.00	0.30		0.08		**0.012**	**0.148**
66	10.50	0.29		0.11		**0.016**	**0.130**
67	10.00	0.23		0.02		**0.002**	**0.125**
68	9.50	0.27		0.09		**0.012**	**0.115**
69	9.00	0.19		0.09		**0.009**	**0.085**
70	8.50	0.15		0.04		**0.003**	**0.085**
71	8.00	0.19		0.07		**0.007**	**0.070**
72	7.50	0.09		0.06		**0.003**	**0.045**
73	7.00	0.09		0.03		**0.001**	**0.053**
74	6.50	0.12		0.07		**0.004**	**0.055**
75	6.00	0.10		0.05		**0.003**	**0.080**
76	5.50	0.22		0.03		**0.003**	**0.088**
77	5.00	0.13		0.03		**0.002**	**0.050**
78	4.50	0.07		0.00		**0.000**	**0.038**
79	4.00	0.08		0.04		**0.002**	**0.040**
80	3.50	0.08		0.05		**0.002**	**0.063**
81	3.00	0.17		0.06		**0.005**	**0.058**
82	2.50	0.06		0.02		**0.001**	**0.015**
83	2.00	0.00		0.00		**0.000**	**0.000**
84						**0.000**	**0.000**
NOTES:	Staff gauge = 0.180 m				**RESULTS:**	**Q (m3/s)**	**0.432**
						A(m2)	**6.28**
						B(m)	**41.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	03-Sep	
Waterbody:		PN03			**Start Time**	13:24	
Crossing ID:		PN03 (PL-H2)			**End Time**	13:56	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	435007	BM004	0.988		**Transducer SN:**	190090338808	
North	7272014	WL_read	1.503		**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev	99.485		**Crew:**	DM/JV	

STATION Start RDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.090**
2	1.50	0.12		0.00		**0.000**	**0.165**
3	3.00	0.10		0.02		**0.003**	**0.203**
4	4.50	0.17		0.00		**0.000**	**0.210**
5	6.00	0.11		0.02		**0.003**	**0.165**
6	7.50	0.11		0.01		**0.002**	**0.135**
7	9.00	0.07		0.03		**0.003**	**0.158**
8	10.50	0.14		0.03		**0.006**	**0.180**
9	12.00	0.10		0.03		**0.005**	**0.173**
10	13.50	0.13		0.02		**0.004**	**0.203**
11	15.00	0.14		0.01		**0.002**	**0.233**
12	16.50	0.17		0.03		**0.008**	**0.240**
13	18.00	0.15		0.04		**0.009**	**0.188**
14	19.50	0.10		0.07		**0.011**	**0.143**
15	21.00	0.09		0.07		**0.009**	**0.225**
16	22.50	0.21		0.04		**0.013**	**0.308**
17	24.00	0.20		0.01		**0.003**	**0.270**
18	25.50	0.16		0.01		**0.002**	**0.248**
19	27.00	0.17		0.01		**0.003**	**0.233**
20	28.50	0.14		0.04		**0.008**	**0.210**
21	30.00	0.14		0.01		**0.002**	**0.218**
22	31.50	0.15		0.02		**0.005**	**0.180**
23	33.00	0.09		0.03		**0.004**	**0.173**
24	34.50	0.14		0.02		**0.004**	**0.105**
25	36.00	0.00		0.00		**0.000**	**0.075**
26	37.50	0.10		0.00		**0.000**	**0.180**
27	39.00	0.14		0.00		**0.000**	**0.330**
28	40.50	0.30		0.01		**0.005**	**0.255**
29	42.00	0.04		0.01		**0.001**	**0.180**
30	43.50	0.20		0.00		**0.000**	**0.240**
31	45.00	0.12		-0.01		**-0.002**	**0.144**
32	46.20	0.12		0.00		**0.000**	**0.018**
33	46.50	0.00		0.00		**0.000**	**0.000**
34						**0.000**	**0.000**
NOTES:					**RESULTS:**	**Q (m3/s)**	**0.112**
						A(m2)	**6.07**
						B(m)	**46.5**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina		**Date**		05-Jul	
Waterbody:		PN04		**Start Time**		8:39	
Crossing ID:		PN04		**End Time**		9:09	
BM UTM Location		**Survey**		**Datalogger SN:**			
East	430774	BM1_BM2_read		**Transducer SN:**		190090338808	
North	7270010	WL_read		**Meter Type/SN:**		FH950 190041004229	
Elevation, Zone	13W	WL_Elev		**Crew:**		DM/CC	

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.002**
2	0.15	0.02		0.10		**0.000**	**0.011**
3	0.30	0.12		0.12		**0.002**	**0.020**
4	0.45	0.15		0.11		**0.002**	**0.028**
5	0.60	0.22		0.04		**0.001**	**0.036**
6	0.75	0.26		0.05		**0.002**	**0.041**
7	0.90	0.28		0.09		**0.004**	**0.051**
8	1.05	0.40		0.07		**0.004**	**0.063**
9	1.20	0.44		0.06		**0.004**	**0.068**
10	1.35	0.46		0.07		**0.005**	**0.091**
11	1.50	0.76		0.00		**0.000**	**0.104**
12	1.65	0.62		0.14		**0.013**	**0.083**
13	1.80	0.48		0.24		**0.017**	**0.062**
14	1.95	0.35		0.43		**0.023**	**0.049**
15	2.10	0.30		0.45		**0.020**	**0.041**
16	2.25	0.25		0.45		**0.017**	**0.034**
17	2.40	0.20		0.43		**0.013**	**0.033**
18	2.55	0.24		0.34		**0.012**	**0.033**
19	2.70	0.20		0.39		**0.012**	**0.038**
20	2.85	0.30		0.30		**0.014**	**0.035**
21	3.00	0.17		0.34		**0.009**	**0.023**
22	3.15	0.13		0.34		**0.007**	**0.017**
23	3.30	0.10		0.31		**0.005**	**0.011**
24	3.45	0.05		0.28		**0.002**	**0.005**
25	3.60	0.02		0.12		**0.000**	**0.002**
26	3.75	0.00		0.00		**0.000**	**0.000**
27						**0.000**	**0.000**
NOTES:					**RESULTS:**	**Q (m3/s)**	**0.188**
						A(m2)	**0.98**
						B(m)	**3.8**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	24-Jul	
Waterbody:		PN04			**Start Time**	9:39	
Crossing ID:		PN04			**End Time**	10:12	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	430822	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7269958	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	CM/EE	
STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	1.00	0.00		0.00			**0.000**
2	1.00	0.08		0.00		**0.000**	**0.004**
3	1.05	0.08		0.24		**0.001**	**0.005**
4	1.10	0.11		0.13		**0.001**	**0.006**
5	1.15	0.14		0.07		**0.000**	**0.007**
6	1.20	0.14		0.08		**0.001**	**0.007**
7	1.25	0.14		0.12		**0.001**	**0.007**
8	1.30	0.13		0.12		**0.001**	**0.006**
9	1.35	0.12		0.12		**0.001**	**0.006**
10	1.40	0.11		0.16		**0.001**	**0.005**
11	1.45	0.10		0.11		**0.001**	**0.005**
12	1.50	0.10		0.15		**0.001**	**0.007**
13	1.55	0.16		0.17		**0.001**	**0.008**
14	1.60	0.14		0.13		**0.001**	**0.007**
15	1.65	0.14		0.15		**0.001**	**0.007**
16	1.70	0.14		0.15		**0.001**	**0.008**
17	1.75	0.16		0.14		**0.001**	**0.007**
18	1.80	0.13		0.12		**0.001**	**0.007**
19	1.85	0.13		0.13		**0.001**	**0.007**
20	1.90	0.14		0.11		**0.001**	**0.006**
21	1.95	0.10		0.11		**0.001**	**0.004**
22	2.00	0.07		0.06		**0.000**	**0.000**
23	2.00	0.00		0.00		**0.000**	**0.000**
24						**0.000**	**0.000**
25	3.25	0.00		0.00		**0.000**	**0.001**
26	3.30	0.05		0.08		**0.000**	**0.003**
27	3.35	0.06		0.08		**0.000**	**0.003**
28	3.40	0.08		0.12		**0.000**	**0.005**
29	3.45	0.10		0.11		**0.001**	**0.006**
30	3.50	0.13		0.08		**0.001**	**0.007**
31	3.55	0.16		0.15		**0.001**	**0.009**
32	3.60	0.18		0.16		**0.001**	**0.006**
33	3.65	0.06		0.08		**0.000**	**0.002**
34	3.70	0.00		0.00		**0.000**	**0.000**
35						**0.000**	**0.000**
NOTES:	Recorded in two sections to capture the two distinct channels.				**RESULTS:**	**Q (m3/s)**	**0.021**
						A(m2)	**0.17**
						B(m)	**2.7**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	04-Sep	
Waterbody:		PN04			**Start Time**	7:20	
Crossing ID:		PN04			**End Time**	7:35	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	430774.41	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7270010.49	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV	

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.003**
2	0.10	0.06		0.08		**0.000**	**0.010**
3	0.20	0.14		0.04		**0.001**	**0.015**
4	0.30	0.15		0.01		**0.000**	**0.014**
5	0.40	0.12		0.00		**0.000**	**0.012**
6	0.50	0.11		-0.01		**0.000**	**0.011**
7	0.60	0.11		-0.02		**0.000**	**0.013**
8	0.70	0.14		-0.02		**0.000**	**0.013**
9	0.80	0.12		0.03		**0.000**	**0.012**
10	0.90	0.12		0.11		**0.001**	**0.017**
11	1.00	0.21		0.10		**0.002**	**0.020**
12	1.10	0.19		0.11		**0.002**	**0.018**
13	1.20	0.16		0.07		**0.001**	**0.012**
14	1.30	0.08		0.02		**0.000**	**0.006**
15	1.40	0.05		0.00		**0.000**	**0.007**
16	1.50	0.08		-0.01		**0.000**	**0.006**
17	1.60	0.04		0.00		**0.000**	**0.003**
18	1.70	0.02		-0.02		**0.000**	**0.001**
19	1.80	0.00		0.00		**0.000**	**0.000**
20						**0.000**	**0.000**

NOTES:	Discharge measrement 20 m downstream of PN04 station	**RESULTS:**	**Q (m3/s)**	**0.008**
			A(m2)	**0.19**
			B(m)	**1.8**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET						
Project Name, Number:	20412211 Sabina			**Date**	05-Jul	
Waterbody:	PN05			**Start Time**	10:30	
Crossing ID:	PN05			**End Time**	10:55	
BM UTM Location		**Survey**		**Datalogger SN:**		
East	432847	BM1_BM2_read		**Transducer SN:**	190090338808	
North	7270067	WL_read		**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev		**Crew:**	DM/CC	

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.009**
2	0.10	0.17		0.12		**0.002**	**0.018**
3	0.20	0.18		0.24		**0.004**	**0.019**
4	0.30	0.20		0.14		**0.003**	**0.019**
5	0.40	0.18		0.69		**0.012**	**0.020**
6	0.50	0.21		0.71		**0.015**	**0.022**
7	0.60	0.22		0.94		**0.021**	**0.025**
8	0.70	0.27		0.29		**0.008**	**0.027**
9	0.80	0.27		0.00		**0.000**	**0.027**
10	0.90	0.26		0.22		**0.006**	**0.024**
11	1.00	0.22		0.33		**0.007**	**0.021**
12	1.10	0.20		0.48		**0.010**	**0.021**
13	1.20	0.22		0.39		**0.009**	**0.018**
14	1.30	0.14		0.23		**0.003**	**0.014**
15	1.40	0.14		0.44		**0.006**	**0.015**
16	1.50	0.15		0.42		**0.006**	**0.009**
17	1.60	0.02		0.12		**0.000**	**0.004**
18	1.70	0.06		0.22		**0.001**	**0.008**
19	1.80	0.09		0.14		**0.001**	**0.009**
20	1.90	0.09		0.00		**0.000**	**0.086**
21						**0.000**	**0.000**

NOTES:	Directly downstream of bridge footings - very turbulent flow	**RESULTS:**	**Q (m3/s)**	**0.115**
			A(m2)	**0.41**
			B(m)	**1.9**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	05-Jul	
Waterbody:		PN05			**Start Time**	11:00	
Crossing ID:		PN05-DS			**End Time**	11:11	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	432830	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7270085	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/CC	
STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.10	0.00		0.00			**0.011**
2	0.20	0.21		-0.01		**0.000**	**0.034**
3	0.35	0.24		0.08		**0.003**	**0.037**
4	0.50	0.25		0.17		**0.006**	**0.042**
5	0.65	0.31		0.24		**0.011**	**0.050**
6	0.80	0.35		0.30		**0.016**	**0.052**
7	0.95	0.34		0.47		**0.024**	**0.052**
8	1.10	0.35		0.49		**0.026**	**0.057**
9	1.25	0.41		0.52		**0.032**	**0.058**
10	1.40	0.36		0.41		**0.022**	**0.050**
11	1.55	0.31		0.22		**0.010**	**0.040**
12	1.70	0.22		0.06		**0.001**	**0.002**
13	1.72	0.00		0.00		**0.000**	**0.000**
14						**0.000**	**0.000**
NOTES:	20 m downstream of bridge footings in smooth laminar flow.				**RESULTS:**	**Q (m3/s)**	**0.151**
						A(m2)	**0.48**
						B(m)	**1.6**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	24-Jul	
Waterbody:		PN05			**Start Time**	11:18	
Crossing ID:		PN05			**End Time**	11:35	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	432891	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7269919	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	CM/EE	

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	1.00	0.00		0.00			**0.002**
2	1.05	0.06		0.03		**0.000**	**0.004**
3	1.10	0.08		0.06		**0.000**	**0.004**
4	1.15	0.10		0.11		**0.001**	**0.005**
5	1.20	0.10		0.13		**0.001**	**0.006**
6	1.25	0.12		0.15		**0.001**	**0.007**
7	1.30	0.14		0.16		**0.001**	**0.008**
8	1.35	0.16		0.16		**0.001**	**0.008**
9	1.40	0.16		0.15		**0.001**	**0.008**
10	1.45	0.16		0.15		**0.001**	**0.008**
11	1.50	0.15		0.14		**0.001**	**0.007**
12	1.55	0.14		0.14		**0.001**	**0.007**
13	1.60	0.13		0.14		**0.001**	**0.007**
14	1.65	0.14		0.13		**0.001**	**0.007**
15	1.70	0.12		0.13		**0.001**	**0.006**
16	1.75	0.10		0.13		**0.001**	**0.005**
17	1.80	0.08		0.12		**0.000**	**0.004**
18	1.85	0.08		0.12		**0.000**	**0.004**
19	1.90	0.08		0.12		**0.000**	**0.004**
20	1.95	0.08		0.09		**0.000**	**0.002**
21	2.00	0.00		0.00		**0.000**	**0.000**
22						**0.000**	**0.000**
NOTES:	Recorded in two sections to capture the two distinct channels.				**RESULTS:**	**Q (m3/s)**	**0.014**
						A(m2)	**0.11**
						B(m)	**1.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	04-Sep
Waterbody:	PN05	**Start Time**	8:35
Crossing ID:	PN05	**End Time**	8:42

BM UTM Location		**Survey**			**Datalogger SN:**	
East	432889	BM1_BM2_read			**Transducer SN:**	190090338808
North	7269934	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.004**
2	0.10	0.08		0.02		**0.000**	**0.009**
3	0.20	0.09		0.16		**0.001**	**0.009**
4	0.30	0.08		0.18		**0.001**	**0.008**
5	0.40	0.08		0.17		**0.001**	**0.008**
6	0.50	0.08		0.18		**0.001**	**0.009**
7	0.60	0.09		0.18		**0.002**	**0.010**
8	0.70	0.10		0.21		**0.002**	**0.010**
9	0.80	0.09		0.18		**0.002**	**0.008**
10	0.90	0.06		0.14		**0.001**	**0.003**
11	1.00	0.00		0.00		**0.000**	**0.000**
12						**0.000**	**0.000**

NOTES:	20 m downstream of bridge footings - smooth laminar flow	**RESULTS:**	**Q (m3/s)**	**0.012**
			A(m2)	**0.08**
			B(m)	**1.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET						
Project Name, Number:	20412211 Sabina			**Date**	05-Jul	
Waterbody:	PN06			**Start Time**	7:40	
Crossing ID:	PN06			**End Time**	8:15	

BM UTM Location		**Survey**			**Datalogger SN:**	
East	432744	BM1_BM2_read			**Transducer SN:**	190090338808
North	7271610	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/CC

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	6.00	0.00		0.00			**0.158**
2	7.75	0.18		0.01		**0.003**	**0.245**
3	9.50	0.10		0.01		**0.002**	**0.143**
4	11.00	0.09		0.04		**0.006**	**0.263**
5	12.75	0.21		0.03		**0.011**	**0.368**
6	14.50	0.21		0.01		**0.004**	**0.341**
7	16.25	0.18		0.05		**0.016**	**0.333**
8	18.00	0.20		0.07		**0.025**	**0.298**
9	19.75	0.14		0.01		**0.002**	**0.298**
10	21.50	0.20		0.03		**0.011**	**0.289**
11	23.25	0.13		0.02		**0.005**	**0.201**
12	25.00	0.10		0.04		**0.007**	**0.324**
13	26.75	0.27		0.03		**0.014**	**0.359**
14	28.50	0.14		0.07		**0.014**	**0.077**
15	29.60	0.00		0.00		**0.000**	**0.000**
16	35.20	0.00		0.00		**0.000**	**0.055**
17	35.75	0.20		0.24		**0.026**	**0.176**
18	36.30	0.44		0.34		**0.082**	**0.215**
19	36.85	0.34		0.28		**0.052**	**0.192**
20	37.40	0.36		0.28		**0.055**	**0.215**
21	37.95	0.42		0.10		**0.023**	**0.170**
22	38.50	0.20		0.10		**0.011**	**0.121**
23	39.05	0.24		0.14		**0.018**	**0.099**
24	39.60	0.12		0.15		**0.010**	**0.063**
25	40.15	0.11		0.12		**0.007**	**0.030**
26	40.70	0.00		0.00		**0.000**	**0.000**
27	41.25	0.00		0.00		**0.000**	**0.033**
28	41.80	0.12		0.04		**0.003**	**0.039**
29	42.35	0.02		0.07		**0.001**	**0.105**
30	43.30	0.20		0.23		**0.029**	**0.030**
31	43.60	0.00		0.00		**0.000**	**0.000**
32						**0.000**	**0.000**

NOTES:	Recorded in two sections to capture the two distinct channels.	**RESULTS:**	**Q (m3/s)**	**0.437**
			A(m2)	**5.24**
			B(m)	**37.6**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	25-Jul
Waterbody:	PN06	**Start Time**	16:13
Crossing ID:	PN06	**End Time**	16:50

BM UTM Location		**Survey**			**Datalogger SN:**	
East	432744	BM1_BM2_read			**Transducer SN:**	190090338808
North	7271610	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	CM/EE

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	13.00	0.00		0.00			**0.000**
2	13.00	0.10		0.00		**0.000**	**0.060**
3	12.70	0.30		0.05		**0.005**	**0.061**
4	12.40	0.11		0.04		**0.001**	**0.054**
5	12.10	0.25		0.04		**0.003**	**0.055**
6	11.80	0.12		0.08		**0.003**	**0.063**
7	11.50	0.30		0.04		**0.004**	**0.054**
8	11.20	0.06		0.00		**0.000**	**0.034**
9	10.90	0.17		0.00		**0.000**	**0.044**
10	10.60	0.12		0.04		**0.001**	**0.028**
11	10.30	0.07		0.02		**0.000**	**0.020**
12	10.00	0.06		0.01		**0.000**	**0.009**
13	9.70	0.00		0.00		**0.000**	**0.027**
14	9.40	0.18		0.05		**0.003**	**0.027**
15	9.10	0.00		0.00		**0.000**	**0.033**
16	8.80	0.22		0.02		**0.001**	**0.045**
17	8.50	0.08		0.00		**0.000**	**0.039**
18	8.20	0.18		0.02		**0.001**	**0.064**
19	7.90	0.25		0.06		**0.005**	**0.086**
20	7.60	0.32		0.07		**0.007**	**0.096**
21	7.30	0.32		0.06		**0.006**	**0.108**
22	7.00	0.40		0.04		**0.005**	**0.110**
23	6.70	0.33		0.06		**0.006**	**0.083**
24	6.40	0.22		0.07		**0.005**	**0.078**
25	6.10	0.30		0.06		**0.005**	**0.071**
26	5.80	0.17		0.05		**0.003**	**0.041**
27	5.50	0.10		0.04		**0.001**	**0.051**
28	5.20	0.24		0.01		**0.001**	**0.051**
29	4.90	0.10		0.04		**0.001**	**0.033**
30	4.60	0.12		0.05		**0.002**	**0.035**
31	4.30	0.11		0.05		**0.002**	**0.047**
32	4.00	0.20		0.04		**0.002**	**0.054**
33	3.70	0.16		0.06		**0.003**	**0.071**
34	3.40	0.31		0.04		**0.004**	**0.047**
35	3.10	0.00		0.00		**0.000**	**0.000**
36	2.80	0.00		0.00		**0.000**	**0.000**
37	2.50	0.00		0.00		**0.000**	**0.000**
38	2.50	0.00		0.00		**0.000**	**0.000**
39	2.20	0.00		0.00		**0.000**	**0.000**
40	1.90	0.00		0.00		**0.000**	**0.015**
41	1.60	0.10		0.03		**0.001**	**0.032**
42	1.30	0.11		-0.01		**0.000**	**0.032**
43	1.00	0.10		0.01		**0.000**	**0.027**
44	0.70	0.08		0.01		**0.000**	**0.033**
45	0.40	0.14		0.00		**0.000**	**0.000**
46	0.40	0.00		0.00		**0.000**	**0.000**
47						**0.000**	**0.000**

NOTES:	Recorded in two sections to capture the two distinct channels.	**RESULTS:**	**Q (m3/s)**	**0.079**
			A(m2)	**1.91**
			B(m)	**12.6**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	04-Sep	
Waterbody:		PN06			**Start Time**	10:02	
Crossing ID:		PN06			**End Time**	10:19	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	432744	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7271610	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV	

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.011**
2	0.15	0.15		0.07		**0.002**	**0.017**
3	0.30	0.08		0.09		**0.001**	**0.011**
4	0.45	0.06		0.07		**0.001**	**0.013**
5	0.60	0.11		0.12		**0.002**	**0.022**
6	0.75	0.18		0.04		**0.001**	**0.026**
7	0.90	0.16		0.08		**0.002**	**0.023**
8	1.05	0.14		0.01		**0.000**	**0.020**
9	1.20	0.13		0.16		**0.003**	**0.024**
10	1.35	0.19		0.14		**0.004**	**0.026**
11	1.50	0.16		0.19		**0.005**	**0.026**
12	1.65	0.19		0.11		**0.003**	**0.029**
13	1.80	0.20		0.04		**0.001**	**0.020**
14	1.95	0.06		0.05		**0.000**	**0.008**
15	2.10	0.05		0.02		**0.000**	**0.011**
16	2.25	0.09		0.01		**0.000**	**0.013**
17	2.40	0.08		0.02		**0.000**	**0.004**
18	2.50	0.00		0.00		**0.000**	**0.000**
19						**0.000**	**0.000**
NOTES:					**RESULTS:**	**Q (m3/s)**	**0.025**
						A(m2)	**0.30**
						B(m)	**2.5**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET					
Project Name, Number:	20412211 Sabina			**Date**	05-Jul
Waterbody:	PN07			**Start Time**	9:40
Crossing ID:	PN07			**End Time**	9:48

BM UTM Location		Survey			Datalogger SN:	
East	432091	BM1_BM2_read			Transducer SN:	190090338808
North	7269573	WL_read			Meter Type/SN:	FH950 190041004229
Elevation, Zone	13W	WL_Elev			Crew:	DM/CC

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.004**
2	0.05	0.16		0.02		**0.000**	**0.008**
3	0.10	0.16		0.04		**0.000**	**0.008**
4	0.15	0.16		0.05		**0.000**	**0.008**
5	0.20	0.14		0.05		**0.000**	**0.007**
6	0.25	0.12		0.03		**0.000**	**0.006**
7	0.30	0.10		0.02		**0.000**	**0.005**
8	0.35	0.08		0.03		**0.000**	**0.004**
9	0.40	0.06		0.02		**0.000**	**0.003**
10	0.45	0.04		0.01		**0.000**	**0.001**
11	0.50	0.01		0.00		**0.000**	**0.000**
12	0.55	0.00		0.00		**0.000**	**0.000**
13						**0.000**	**0.000**

NOTES:	Minimal flow but flow is observed	RESULTS:	Q (m3/s)	0.002
			A(m2)	0.05
			B(m)	0.6

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:	20412211 Sabina			**Date**	04-Sep		
Waterbody:	PN07			**Start Time**	8:11		
Crossing ID:	PN07			**End Time**	8:13		
BM UTM Location		**Survey**		**Datalogger SN:**			
East	432091	BM1_BM2_read		**Transducer SN:**	190090338808		
North	7269573	WL_read		**Meter Type/SN:**	FH950 190041004229		
Elevation, Zone	13W	WL_Elev		**Crew:**	DM/JV		

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.003**
2	0.05	0.11		0.01		**0.000**	**0.005**
3	0.10	0.10		0.01		**0.000**	**0.003**
4	0.15	0.02		0.00		**0.000**	**0.001**
5	0.20	0.00		0.00		**0.000**	**0.000**
6						**0.000**	**0.000**

NOTES:	Minimal flow but flow is observed	**RESULTS:**	**Q (m3/s)**	**0.0001**
			A(m2)	**0.01**
			B(m)	**0.2**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	05-Jul
Waterbody:	PN08	**Start Time**	14:11
Crossing ID:	PN08	**End Time**	14:45

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434269	BM1_BM2_read			**Transducer SN:**	190090338808
North	7269719	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/CC

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.010**
2	0.20	0.10		0.50		**0.010**	**0.027**
3	0.40	0.17		0.32		**0.011**	**0.024**
4	0.60	0.07		0.48		**0.007**	**0.021**
5	0.80	0.14		0.26		**0.007**	**0.028**
6	1.00	0.14		0.31		**0.009**	**0.032**
7	1.20	0.18		0.33		**0.012**	**0.026**
8	1.40	0.08		0.52		**0.008**	**0.020**
9	1.60	0.12		0.32		**0.008**	**0.022**
10	1.80	0.10		0.33		**0.007**	**0.020**
11	2.00	0.10		0.27		**0.005**	**0.017**
12	2.20	0.07		0.04		**0.001**	**0.011**
13	2.40	0.04		0.27		**0.003**	**0.027**
14	2.70	0.14		0.17		**0.004**	**0.001**
15	2.71	0.00		0.00		**0.000**	**0.000**
16	5.00	0.00		0.00		**0.000**	**0.007**
17	5.10	0.14		0.22		**0.005**	**0.022**
18	5.30	0.08		0.38		**0.006**	**0.021**
19	5.50	0.13		0.12		**0.003**	**0.029**
20	5.70	0.16		0.11		**0.004**	**0.031**
21	5.90	0.15		0.46		**0.014**	**0.032**
22	6.10	0.17		0.56		**0.019**	**0.038**
23	6.30	0.21		0.29		**0.012**	**0.033**
24	6.50	0.12		0.60		**0.014**	**0.025**
25	6.70	0.13		0.72		**0.019**	**0.028**
26	6.90	0.15		0.65		**0.020**	**0.034**
27	7.10	0.19		0.74		**0.028**	**0.048**
28	7.30	0.29		0.53		**0.031**	**0.043**
29	7.50	0.14		0.38		**0.008**	**0.007**
30	7.60	0.00		0.00		**0.000**	**0.000**
31						**0.000**	**0.000**

NOTES:	Recorded in two sections to capture the two distinct channels.	**RESULTS:**	**Q (m3/s)**	**0.272**
			A(m2)	**0.68**
			B(m)	**7.6**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	23-Jul
Waterbody:	PN08	**Start Time**	14:55
Crossing ID:	PN08	**End Time**	15:25

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434269	BM1_BM2_read			**Transducer SN:**	190090338808
North	7269719	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	CM/EE

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	1.00	0.00		0.00			**0.000**
2	1.00	0.13		0.00		**0.000**	**0.014**
3	1.10	0.15		0.34		**0.005**	**0.016**
4	1.20	0.17		0.43		**0.007**	**0.016**
5	1.30	0.14		0.39		**0.005**	**0.014**
6	1.40	0.14		0.12		**0.002**	**0.015**
7	1.50	0.15		-0.05		**-0.001**	**0.016**
8	1.60	0.16		-0.03		**0.000**	**0.016**
9	1.70	0.16		0.11		**0.002**	**0.012**
10	1.80	0.08		0.22		**0.002**	**0.012**
11	1.90	0.16		0.26		**0.004**	**0.017**
12	2.00	0.17		0.22		**0.004**	**0.017**
13	2.10	0.17		0.12		**0.002**	**0.017**
14	2.20	0.16		0.08		**0.001**	**0.015**
15	2.30	0.14		0.15		**0.002**	**0.013**
16	2.40	0.12		0.13		**0.002**	**0.013**
17	2.50	0.13		0.31		**0.004**	**0.013**
18	2.60	0.12		0.20		**0.002**	**0.013**
19	2.70	0.13		0.13		**0.002**	**0.012**
20	2.80	0.11		0.28		**0.003**	**0.012**
21	2.90	0.12		0.49		**0.006**	**0.010**
22	3.00	0.07		0.41		**0.003**	**0.010**
23	3.10	0.12		0.49		**0.006**	**0.011**
24	3.20	0.09		0.38		**0.003**	**0.008**
25	3.30	0.07		0.00		**0.000**	**0.000**
26	3.30	0.00		0.00		**0.000**	**0.000**
27						**0.000**	**0.000**

NOTES:		**RESULTS:**	**Q (m3/s)**	**0.066**
			A(m2)	**0.31**
			B(m)	**2.3**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	04-Sep
Waterbody:	PN08	**Start Time**	12:18
Crossing ID:	PN08	**End Time**	12:35

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434269	BM1_BM2_read			**Transducer SN:**	190090338808
North	7269719	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.009**
2	0.20	0.09		0.10		**0.002**	**0.016**
3	0.40	0.07		0.01		**0.000**	**0.013**
4	0.60	0.06		0.09		**0.001**	**0.012**
5	0.80	0.06		0.10		**0.001**	**0.017**
6	1.00	0.11		0.00		**0.000**	**0.014**
7	1.20	0.03		0.08		**0.000**	**0.013**
8	1.40	0.10		0.18		**0.004**	**0.015**
9	1.60	0.05		0.03		**0.000**	**0.010**
10	1.80	0.05		0.01		**0.000**	**0.005**
11	2.00	0.00		0.00		**0.000**	**0.000**
12	2.60	0.00		0.00		**0.000**	**0.001**
13	2.65	0.06		0.19		**0.001**	**0.002**
14	2.70	0.00		0.00		**0.000**	**0.000**
15	3.00	0.00		0.00		**0.000**	**0.001**
16	3.20	0.01		0.06		**0.000**	**0.001**
17	3.40	0.00		0.00		**0.000**	**0.002**
18	3.60	0.02		0.02		**0.000**	**0.008**
19	3.80	0.06		0.00		**0.000**	**0.013**
20	4.00	0.07		0.03		**0.000**	**0.009**
21	4.20	0.02		0.12		**0.000**	**0.012**
22	4.40	0.10		0.17		**0.003**	**0.010**
23	4.60	0.00		0.00		**0.000**	**0.009**
24	4.80	0.09		-0.01		**0.000**	**0.015**
25	5.00	0.06		0.29		**0.003**	**0.012**
26	5.20	0.06		0.23		**0.003**	**0.006**
27	5.40	0.00		0.00		**0.000**	**0.000**
28						**0.000**	**0.000**

NOTES:	Recorded in two sections to capture the two distinct channels.	**RESULTS:**	**Q (m3/s)**	**0.020**
			A(m2)	**0.23**
			B(m)	**5.4**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET						
Project Name, Number:	20412211 Sabina			**Date**	05-Jul	
Waterbody:	PN09			**Start Time**	13:36	
Crossing ID:	PN09			**End Time**	13:55	
BM UTM Location		**Survey**		**Datalogger SN:**		
East	434688	BM1_BM2_read		**Transducer SN:**	190090338808	
North	7269634	WL_read		**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev		**Crew:**	DM/CC	

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.008**
2	0.15	0.10		0.01		**0.000**	**0.021**
3	0.30	0.18		0.01		**0.000**	**0.029**
4	0.45	0.20		0.01		**0.000**	**0.032**
5	0.60	0.23		0.01		**0.000**	**0.037**
6	0.75	0.26		0.01		**0.000**	**0.045**
7	0.90	0.34		0.01		**0.001**	**0.056**
8	1.05	0.40		0.00		**0.000**	**0.062**
9	1.20	0.43		0.01		**0.001**	**0.066**
10	1.35	0.45		0.01		**0.001**	**0.068**
11	1.50	0.46		0.01		**0.001**	**0.068**
12	1.65	0.44		0.01		**0.001**	**0.065**
13	1.80	0.42		0.01		**0.001**	**0.060**
14	1.95	0.38		0.01		**0.001**	**0.054**
15	2.10	0.34		0.02		**0.001**	**0.050**
16	2.25	0.32		0.01		**0.000**	**0.046**
17	2.40	0.29		0.02		**0.001**	**0.040**
18	2.55	0.24		0.01		**0.000**	**0.030**
19	2.70	0.16		0.00		**0.000**	**0.016**
20	2.90	0.00		0.00		**0.000**	**0.000**
21						**0.000**	**0.000**

NOTES:		RESULTS:		
			Q (m3/s)	**0.009**
			A(m2)	**0.85**
			B(m)	**2.9**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	04-Sep
Waterbody:	PN09	**Start Time**	12:50
Crossing ID:	PN09	**End Time**	13:01

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434688	BM1_BM2_read			**Transducer SN:**	190090338808
North	7269634	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV

STATION Start LDB	DISTANCE FROM RDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.015**
2	0.15	0.20		-0.01		**0.000**	**0.035**
3	0.30	0.26		0.00		**0.000**	**0.042**
4	0.45	0.30		-0.01		**0.000**	**0.044**
5	0.60	0.29		0.01		**0.000**	**0.044**
6	0.75	0.30		0.01		**0.000**	**0.047**
7	0.90	0.32		0.01		**0.000**	**0.050**
8	1.05	0.34		0.01		**0.001**	**0.052**
9	1.20	0.35		-0.01		**-0.001**	**0.055**
10	1.35	0.38		0.00		**0.000**	**0.056**
11	1.50	0.37		0.00		**0.000**	**0.056**
12	1.65	0.38		0.00		**0.000**	**0.038**
13	1.75	0.38		0.00		**0.000**	**0.051**
14	1.90	0.30		0.01		**0.000**	**0.038**
15	2.05	0.20		0.02		**0.001**	**0.026**
16	2.20	0.15		-0.02		**0.000**	**0.007**
17	2.30	0.00		0.00		**0.000**	**0.000**
18						**0.000**	**0.000**

NOTES:		**RESULTS:**	**Q (m3/s)**	**0.001**
			A(m2)	**0.66**
			B(m)	**2.3**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	03-Jul
Waterbody:	Goose Lake True Outlet	**Start Time**	9:10
Crossing ID:	GLO-01	**End Time**	9:43

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434878	BM1_BM2_read			**Transducer SN:**	190090338808
North	7271462	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/CC

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	1.00	0.00		0.00			**0.340**
2	3.00	0.34		0.27		**0.184**	**0.650**
3	5.00	0.31		0.16		**0.099**	**0.580**
4	7.00	0.27		0.19		**0.103**	**0.530**
5	9.00	0.26		0.17		**0.088**	**0.500**
6	11.00	0.24		0.19		**0.091**	**0.470**
7	13.00	0.23		0.14		**0.064**	**0.490**
8	15.00	0.26		0.19		**0.099**	**0.560**
9	17.00	0.30		0.14		**0.084**	**0.510**
10	19.00	0.21		0.16		**0.067**	**0.390**
11	21.00	0.18		0.15		**0.054**	**0.400**
12	23.00	0.22		0.20		**0.088**	**0.390**
13	25.00	0.17		0.12		**0.041**	**0.310**
14	27.00	0.14		0.24		**0.067**	**0.370**
15	29.00	0.23		0.13		**0.060**	**0.390**
16	31.00	0.16		0.05		**0.016**	**0.260**
17	33.00	0.10		0.17		**0.034**	**0.220**
18	35.00	0.12		0.12		**0.029**	**0.360**
19	37.00	0.24		0.02		**0.007**	**0.265**
20	38.00	0.29		0.13		**0.038**	**0.145**
21	39.00	0.00		0.00		**0.000**	**0.000**
22	40.00	0.00		0.00		**0.000**	**0.130**
23	41.00	0.26		0.12		**0.031**	**0.130**
24	42.00	0.00		0.00		**0.000**	**0.000**
25						**0.000**	**0.000**

NOTES:		RESULTS:		
			Q (m3/s)	**1.344**
			A(m2)	**8.39**
			B(m)	**41.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET							
Project Name, Number:		20412211 Sabina			**Date**	24-Jul	
Waterbody:		Goose Lake True Outlet			**Start Time**	16:40	
Crossing ID:		GLO-01			**End Time**	17:05	
BM UTM Location		**Survey**			**Datalogger SN:**		
East	434878	BM1_BM2_read			**Transducer SN:**	190090338808	
North	7271462	WL_read			**Meter Type/SN:**	FH950 190041004229	
Elevation, Zone	13W	WL_Elev			**Crew:**	CM/EE	
STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	42.00	0.00		0.00			**0.120**
2	41.00	0.24		0.08		**0.019**	**0.225**
3	40.00	0.21		0.08		**0.025**	**0.410**
4	38.00	0.20		0.09		**0.036**	**0.390**
5	36.00	0.19		0.09		**0.034**	**0.440**
6	34.00	0.25		0.10		**0.050**	**0.440**
7	32.00	0.19		0.02		**0.008**	**0.380**
8	30.00	0.19		0.04		**0.015**	**0.350**
9	28.00	0.16		0.05		**0.016**	**0.280**
10	26.00	0.12		0.20		**0.048**	**0.230**
11	24.00	0.11		0.13		**0.029**	**0.370**
12	22.00	0.26		0.04		**0.021**	**0.420**
13	20.00	0.16		0.04		**0.013**	**0.250**
14	18.00	0.09		0.03		**0.005**	**0.290**
15	16.00	0.20		0.03		**0.012**	**0.410**
16	14.00	0.21		0.05		**0.021**	**0.330**
17	12.00	0.12		0.00		**0.000**	**0.220**
18	10.00	0.10		0.12		**0.024**	**0.200**
19	8.00	0.10		0.00		**0.000**	**0.160**
20	6.00	0.06		-0.01		**-0.001**	**0.060**
21	4.00	0.00		0.00		**0.000**	**0.000**
22						**0.000**	**0.000**
NOTES:	Recorded in two sections to capture the two distinct channels.				**RESULTS:**	**Q (m3/s)**	**0.375**
						A(m2)	**5.98**
						B(m)	**38.0**

OPEN WATER DISCHARGE CALCULATION SPREADSHEET

Project Name, Number:	20412211 Sabina	**Date**	03-Sep
Waterbody:	Goose Lake True Outlet	**Start Time**	12:15
Crossing ID:	GLO-01	**End Time**	12:41

BM UTM Location		**Survey**			**Datalogger SN:**	
East	434878	BM1_BM2_read			**Transducer SN:**	190090338808
North	7271462	WL_read			**Meter Type/SN:**	FH950 190041004229
Elevation, Zone	13W	WL_Elev			**Crew:**	DM/JV

STATION Start LDB	DISTANCE FROM LDB (m)	DEPTH (m)	Velocity 0.2 DEPTH (m/s)	Velocity 0.6/0.8 DEPTH (m/s)	Optional ANGLE OF FLOW (º)	Qi (m3/s)	Ai (m2)
1	0.00	0.00		0.00			**0.158**
2	1.50	0.21		0.05		**0.016**	**0.300**
3	3.00	0.19		0.03		**0.009**	**0.293**
4	4.50	0.20		0.03		**0.009**	**0.255**
5	6.00	0.14		0.05		**0.011**	**0.240**
6	7.50	0.18		0.03		**0.008**	**0.263**
7	9.00	0.17		0.02		**0.005**	**0.248**
8	10.50	0.16		0.01		**0.002**	**0.218**
9	12.00	0.13		0.05		**0.010**	**0.218**
10	13.50	0.16		0.05		**0.012**	**0.150**
11	15.00	0.04		0.00		**0.000**	**0.060**
12	16.50	0.04		0.07		**0.004**	**0.075**
13	18.00	0.06		0.00		**0.000**	**0.075**
14	19.50	0.04		-0.02		**-0.001**	**0.128**
15	21.00	0.13		0.01		**0.002**	**0.180**
16	22.50	0.11		0.02		**0.003**	**0.120**
17	24.00	0.05		0.03		**0.002**	**0.113**
18	25.50	0.10		0.02		**0.003**	**0.180**
19	27.00	0.14		0.02		**0.004**	**0.218**
20	28.50	0.15		0.02		**0.005**	**0.113**
21	30.00	0.00		0.00		**0.000**	**0.060**
22	31.50	0.08		0.04		**0.005**	**0.060**
23	33.00	0.00		0.00		**0.000**	**0.012**
24	33.60	0.04		0.01		**0.000**	**0.018**
25	34.50	0.00		0.00		**0.000**	**0.068**
26	36.00	0.09		0.01		**0.001**	**0.068**
27	37.50	0.00		0.00		**0.000**	**0.068**
25	39.00	0.09		0.00		**0.000**	**0.113**
26	41.50	0.00		0.00		**0.000**	**0.000**
27						**0.000**	**0.000**

NOTES:		**RESULTS:**	**Q (m3/s)**	**0.110**
			A(m2)	**4.07**
			B(m)	**41.5**

APPENDIX B

Continuous Station Mean Daily Data

Table B-1: Mean Daily Lake Water Level and Temperature at GC-L1 and Mean Daily Derived Discharge at GLO-01

Date	GC-L1 Mean Daily Lake Water Level (m) [a]	GLO-01 Mean Daily Discharge (m^3/s)	GC-L1 Mean Daily Lake Temperature (°C)
2021-07-06 [b]	98.17	1.34	5.5
2021-07-07	98.16	1.27	6.4
2021-07-08	98.15	1.20	8.1
2021-07-09	98.15	1.18	10.8
2021-07-10	98.14	1.09	9.6
2021-07-11	98.14	1.03	12.1
2021-07-12	98.13	0.99	12.1
2021-07-13	98.13	0.91	12.3
2021-07-14	98.12	0.86	13.1
2021-07-15	98.12	0.90	10.6
2021-07-16	98.11	0.80	10.5
2021-07-17	98.11	0.74	12.2
2021-07-18	98.10	0.69	12.6
2021-07-19	98.10	0.65	13.3
2021-07-20	98.09	0.62	14.0
2021-07-21	98.09	0.59	13.6
2021-07-22	98.09	0.57	14.4
2021-07-23	98.10	0.68	13.6
2021-07-24	98.10	0.65	11.1
2021-07-25	98.05	0.28	11.0
2021-07-26	98.04	0.19	10.9
2021-07-27	98.04	0.19	10.5
2021-07-28	98.03	0.18	11.6
2021-07-29	98.04	0.20	12.5
2021-07-30	98.04	0.22	13.0
2021-07-31	98.04	0.21	12.7
2021-08-01	98.04	0.20	11.7
2021-08-02	98.12	0.86	11.5
2021-08-03 [b]	98.12	0.66	11.7

(a) Water levels relative to local reference BM054; elevation = 100.000 m (RESCAN 2014)

(b) Partial daily record

Table B-2: Mean Daily Stream Water Level, Derived Discharge, and Temperature at PL-H2

Date	PL-H2 Mean Daily Stream Water Level (m) [a]	PL-H2 Mean Daily Derived Discharge (m^3/s)	PL-H2 Mean Daily Stream Temperature (ºC)
2021-07-06 [b]	99.65	1.10	12.6
2021-07-07	99.64	1.05	11.5
2021-07-08	99.64	0.98	12.3
2021-07-09	99.64	0.96	13.9
2021-07-10	99.63	0.90	14.8
2021-07-11	99.62	0.77	13.9
2021-07-12	99.61	0.72	13.2
2021-07-13	99.61	0.71	13.5
2021-07-14	99.59	0.58	14.6
2021-07-15	99.58	0.52	10.8
2021-07-16	99.58	0.49	10.3
2021-07-17	99.57	0.44	12.0
2021-07-18	99.57	0.44	12.9
2021-07-19	99.56	0.36	14.2
2021-07-20	99.55	0.31	14.5
2021-07-21	99.55	0.31	16.0
2021-07-22	99.54	0.26	17.4
2021-07-23	99.53	0.22	14.4
2021-07-24	99.53	0.23	9.2
2021-07-25	99.53	0.19	9.5
2021-07-26	99.52	0.15	10.1
2021-07-27	99.51	0.15	9.9
2021-07-28	99.51	0.15	11.7
2021-07-29	99.51	0.15	13.0
2021-07-30	99.52	0.16	12.9
2021-07-31	99.52	0.16	14.1
2021-08-01	99.50	0.10	12.2
2021-08-02	99.57	0.46	11.8
2021-08-03 [b]	99.59	0.54	11.6

(a) Water levels relative to local reference BM004; elevation = 100.000 m (RESCAN 2014)

(b) Partial daily record

APPENDIX C

Fish Habitat Parameter Data

Table C-1: Detailed Fish Habitat Parameter Data Collected from the Goose Lake Outlet, Propeller Lake Inlet and the Connector Pond Stations, July 2021

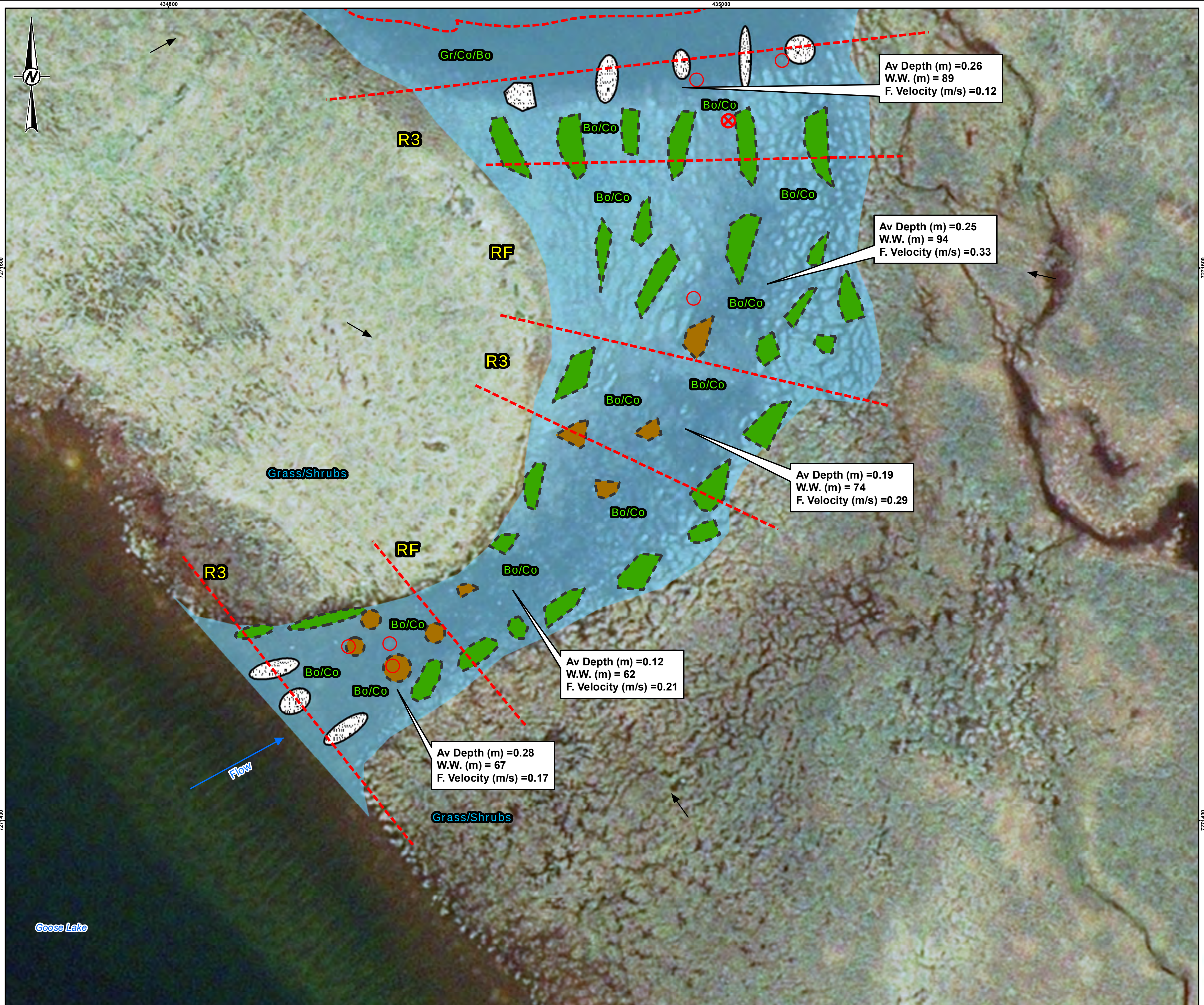
Station	Date	NAD 83; Zone 13				Channel Unit #	Fish Barrier Present?	Physical Channel Parameters							Transect Data						Temp (°C)
		Upstream End		Downstream End																	
		Easting	Northing	Easting	Northing			Hydraulic Habitat	Length (m)	Cumulative Length (m)	Max Depth (m)	Wetted Width (m)	Channel Width (m)	% Unstable Banks	1/4 Depth (m)	1/4 Vel m/s (60% Depth)	1/2 Depth (m)	1/2 Vel m/s (60% Depth)	3/4 Depth (m)	3/4 Vel m/s (60% Depth)	
Goose Lake Outlet Reach	02-Jul-21	434891	7272232	435012	7271679	1	No	R3	66	66	0.38	67	48	5	0.3	0.15	0.2	0.16	0.35	0.21	7.1
						2	No	RF	129	195	0.25	62	52	5	0.10	0.011	0.15	0.38	0.12	0.23	7.0
						3	No	R3	35	230	0.38	74	65	0	0.19	0.21	0.2	0.45	0.19	0.20	7.0
						4	No	RF	75	305	0.34	94	73	5	0.34	0.25	0.23	0.34	0.19	0.39	7.0
						5	No	R3	10	315	0.32	89	70	0	0.22	0.12	0.25	0.15	0.30	0.10	7.0
Connector Pond	04-Jul-21	435012	7271679	434996	7271972	1	No	P1 to 3	320	320	>1.5	300	330	0	-	-	-	-	-	-	-
Propeller Lake Inlet Reach	04-Jul-21	434996	7271972	434895	7272200	1	No	R3	123	123	0.48	52	65	1	0.33	0.11	0.41	0.15	0.21	0.21	9.4
						2	No	RF	35	158	0.23	40	56	5	0.10	0.25	0.2	0.65	0.15	0.38	9.3
						3	No	R3	70	228	0.31	78	90	5	0.21	0.15	0.14	0.26	0.14	0.21	9.4
						4	No	RF	45	273	0.24	72	82	5	0.2	0.37	0.24	0.38	0.13	0.26	9.4
						5	No	R3	65	338	0.6	38	46	0	0.36	0.29	0.46	0.21	0.48	0.15	9.5

Station	Channel Unit #	% Instream Cover per Fish Length			Fish Habitat Cover (%)									Substrate Composition%						
					Instream Cover (%)						Overhanging Cover (%)									
		0-60 mm	61-150 mm	>150 mm	SWD	LWD	SUB	SAV	EAV	D/T	UCB	OHG	OHWV	Or	C/S	Sa	Gr	Co	Bo	Br
Goose Lake Outlet Reach	1	60	35	15	0	0	60	0	0	10	5	2	0	0	1	5	30	22	42	0
	2	80	20	12	0	0	80	2	0	15	5	2	0	0	0	0	0	30	70	0
	3	50	20	15	0	0	45	0	0	10	10	10	0	0	3	2	20	30	45	0
	4	70	20	15	0	0	75	0	0	20	10	10	0	0	0	0	0	35	65	0
	5	50	15	10	0	0	40	0	0	5	0	0	0	0	2	13	40	20	25	0
Connector Pond	1	75	70	45	0	0	40	0	0	50	0	0	0	0	5	5	20	30	40	0
Propeller Lake Inlet Reach	1	70	40	10	0	0	50	0	0	10	0	0	0	0	0	5	10	40	45	0
	2	65	25	5	0	0	80	5	5	10	5	5	0	0	0	0	0	30	70	0
	3	40	15	10	0	0	40	10	5	5	5	10	0	0	0	10	20	35	35	0
	4	60	50	20	0	0	45	5	0	5	0	1	0	0	0	0	10	50	40	0
	5	30	10	5	0	0	35	5	0	10	0	5	0	0	5	10	10	50	25	0

NAD = North American Datum; # = number; m = metre; % = percent; Temp = temperature; °C = degree Celsius; Jul = July; R3 = shallow run habitat; RF = riffle habitat; P1 to 3 = shallow to deep pool habitat; > = greater than; - = data not collected; mm = millimetre; SWD = small woody debris; LWD = large woody debris; SUB = substrate; SAV = submerged aquatic vegetation; EAV = emergent aquatic vegetation; D/T = depth/turbulence; UCB = undercut bank; OHG = overhanging grass; OHWV = overhanging woody vegetation; Or = organic matter; C/S = clay/silt; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; Br = bedrock.

APPENDIX D

Fish Habitat Maps



LEGEND

- ARCTIC GRAYLING EGG CAPTURED
- EGG SAMPLING LOCATION
- CHANNEL UNIT BREAK
- FLOW DIRECTION
- BOULDER OUTCROP
- BOULDER/COBBLE OUTCROP
- GRASS ISLAND
- GRAVEL
- WATERBODY

BANK SLOPE

- HIGH
- MODERATE
- LOW

- LABEL - CHANNEL TYPE
- LABEL - HABITAT FEATURES
- LABEL - SUBSTRATE TYPE

CHANNEL TYPES

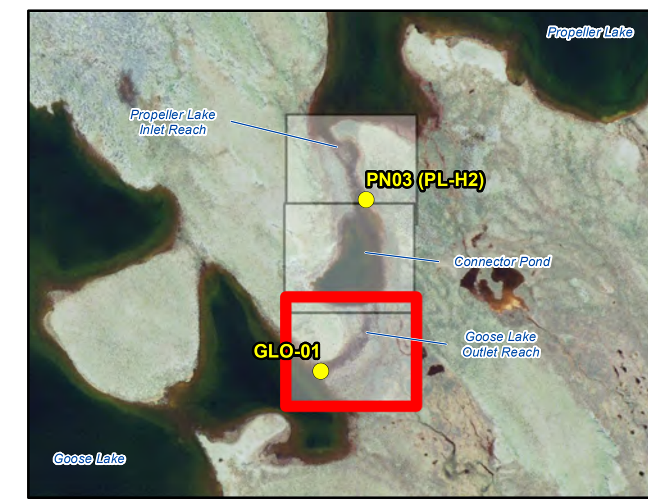
- P1 - POOL CLASS 1
- P2 - POOL CLASS 2
- P3 - POOL CLASS 3
- R3 - RUN CLASS 3 - <0.5 M
- RF - RIFFLE

HABITAT FEATURES

GRASS/SHRUBS

SUBSTRATE TYPES

- Bo/Co - BOULDER/COBBLE
- Co - BOULDER
- Co/Bo - COBBLE/BOULDER
- Gr/Co/Bo - GRAVEL/COBBLE/BOULDER



0 25 50
1:1,400 METRES

NOTE(S)
F.VELOCITY = FLOW VELOCITY
W.W. = WETTED WIDTH
AV DEPTH = AVERAGE DEPTH

REFERENCE(S)
PHOTOSAT IMAGERY OBTAINED FROM THE CLIENT.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
Sabina

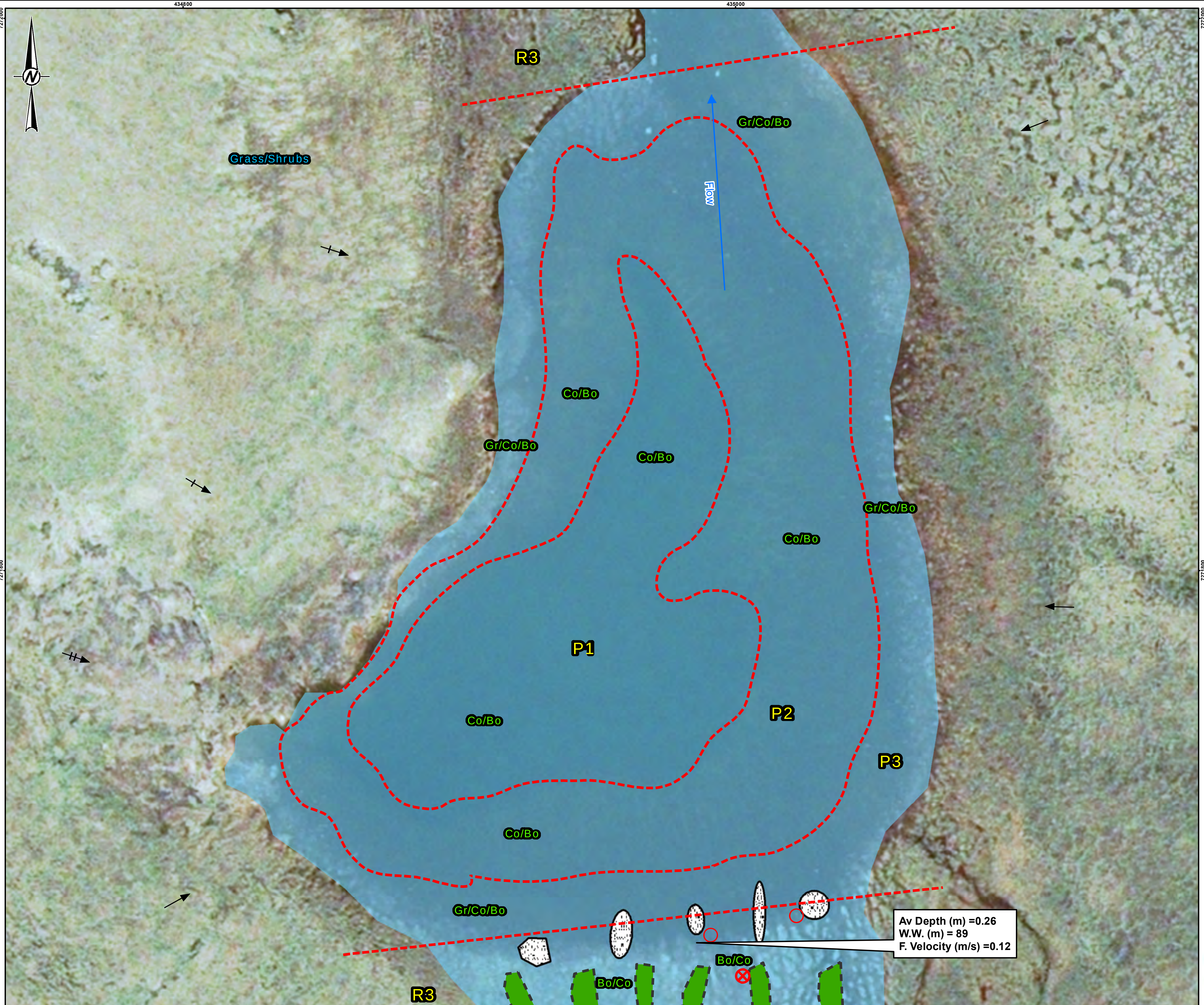
PROJECT
SABINA BACK RIVER PROJECT

TITLE
GOOSE LAKE OUTLET REACH FISH HABITAT MAP, JULY 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-04-01
DESIGNED	CC
PREPARED	LB
REVIEWED	CS
APPROVED	CS

PROJECT NO.	PHASE	REV.	FIGURE
20412211	2600	0	D-1



LEGEND

- ARCTIC GRAYLING EGG CAPTURED
- EGG SAMPLING LOCATION
- CHANNEL UNIT BREAK
- FLOW DIRECTION
- BOULDER OUTCROP
- BOULDER/COBBLE OUTCROP
- GRASS ISLAND
- GRAVEL
- WATERBODY

BANK SLOPE

- HIGH
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- R3 - RUN CLASS 3 - <0.5 M
- RF - RIFFLE

HABITAT FEATURES

GRASS/SHRUBS

SUBSTRATE TYPES

- Bo/Co - BOULDER/COBBLE
- Co - BOULDER
- Co/Bo - COBBLE/BOULDER
- Gr/Co/Bo - GRAVEL/COBBLE/BOULDER

0 25 50
1:1,400 METRES

NOTE(S)
F.VELOCITY = FLOW VELOCITY
W.W. = WETTED WIDTH
AV DEPTH = AVERAGE DEPTH

REFERENCE(S)
PHOTOSAT IMAGERY OBTAINED FROM THE CLIENT.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
Sabina GOLD & SILVER CORP.

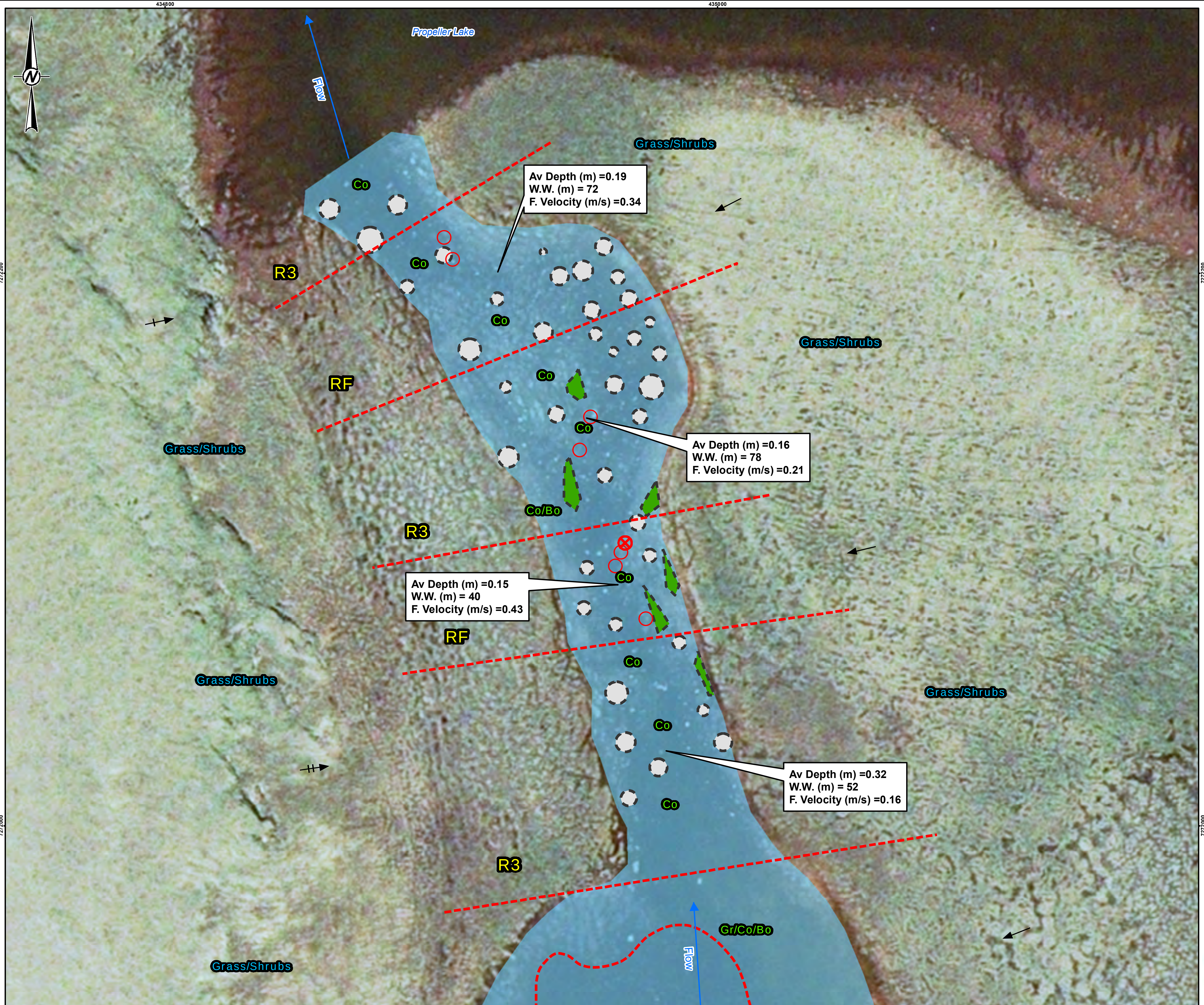
PROJECT
SABINA BACK RIVER PROJECT

TITLE
GOOSE-PROPELLER LAKE CONNECTOR POND HABITAT MAP, JULY 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-04-01
DESIGNED	CC
PREPARED	LB
REVIEWED	CS
APPROVED	CS

PROJECT NO.	PHASE	REV.	FIGURE
20412211	2600	0	D-2



LEGEND

- ARCTIC GRAYLING EGG CAPTURED
- EGG SAMPLING LOCATION
- CHANNEL UNIT BREAK
- FLOW DIRECTION
- BOULDER OUTCROP
- BOULDER/COBBLE OUTCROP
- GRASS ISLAND
- GRAVEL
- WATERBODY

BANK SLOPE

- HIGH
- MODERATE
- LOW

- LABEL - CHANNEL TYPE
- LABEL - HABITAT FEATURES
- LABEL - SUBSTRATE TYPE

CHANNEL TYPES

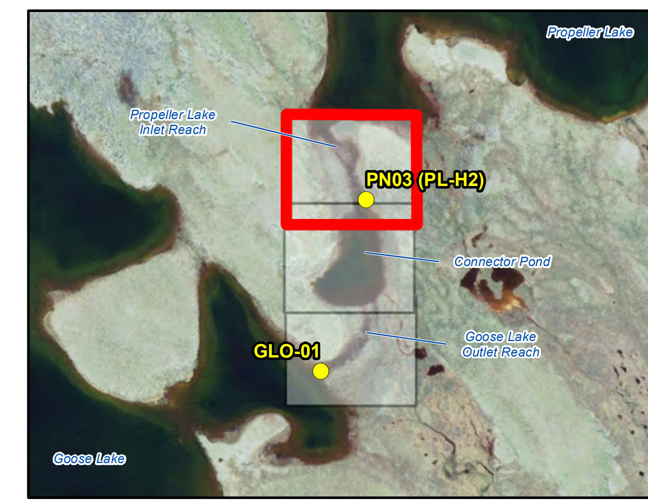
- P1 - POOL CLASS 1
- P2 - POOL CLASS 2
- P3 - POOL CLASS 3
- R3 - RUN CLASS 3 - <0.5 M
- RF - RIFFLE

HABITAT FEATURES

GRASS/SHRUBS

SUBSTRATE TYPES

- Bo/Co - BOULDER/COBBLE
- Co - BOULDER
- Co/Bo - COBBLE/BOULDER
- Gr/Co/Bo - GRAVEL/COBBLE/BOULDER



0 25 50

1:1,400 METRES

NOTE(S)
F.VELOCITY = FLOW VELOCITY
W.W. = WETTED WIDTH
AV DEPTH = AVERAGE DEPTH

REFERENCE(S)
PHOTOSAT IMAGERY OBTAINED FROM THE CLIENT.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
Sabina GOLD & SILVER CORP.

PROJECT
SABINA BACK RIVER PROJECT

TITLE
PROPELLER LAKE INLET REACH FISH HABITAT MAP, JULY 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-04-01
DESIGNED	CC
PREPARED	LB
REVIEWED	CS
APPROVED	CS

PROJECT NO.	PHASE	REV.	FIGURE
20412211	2600	0	D-3

APPENDIX E

Rascal Stream West – Flow Mitigation Structures

Habitat and Substrate Photographs

Photo E-1: Facing downstream at riffle habitat located 240 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-2: View of large boulder and cobble substrate flow mitigation structure located 240 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-3: View of cascade habitat with cobble substrate located 233 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-4: Facing downstream at riffle habitat located 217 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-5: View of a boulder and a cobble flow mitigation structure located 217 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-6: Facing downstream at a hydraulic chute containing a vertical drop located 194 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-7: Facing upstream at a hydraulic chute containing a vertical drop located 194 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-8: Facing downstream at riffle habitat with dispersed flow located 189 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-9: Facing downstream at cascade habitat near the Site bridge, located 155 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-10: View of a cobble and boulder flow mitigation structure in cascade habitat located 145 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

Photo E-11: Facing downstream at run habitat within an unmodified section of the watercourse located 108 m upstream from the Goose Lake confluence on Rascal Creek – West, 5 July 2021.

APPENDIX F

Goose Lake Inflow Tributaries and Outflow

Field Water Quality

Table F-1: Summary of Field Water Quality Measurements Recorded during the 2021 Open-water Period from Goose Lake Inflow Tributary and Outflow Stations

Station	Season	Parameter				
		Temperature (ºC)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
PL-H2 (PN03)	Spring	9.6	7.1	24	-	-
	Summer	10.5	6.7	52	72	9.3
	Fall	14.1	6.3	23	29	13.7
PN04	Spring	8.9	7.4	45	-	-
	Summer	9.1	5.7	39	98	7.2
	Fall	6.9	6.1	58	89	9.0
PN05	Spring	12.0	7.3	32	-	-
	Summer	6.8	6.3	44	67	11.4
	Fall	7.7	6.3	35	52	15.4
PN06	Spring	7.0	8.0	23	-	-
	Summer	11.2	6.6	36	-	-
	Fall	11.0	6.6	23	31	14.2
PN07	Spring	11.4	7.2	46	-	-
	Summer	6.5	5.8	71	103	9.5
	Fall	6.9	6.0	58	89	9.0
PN08	Spring	12.7	7.1	33	-	-
	Summer	12.1	6.2	27	-	-
	Fall	10.3	6.7	20	27	15.1
PN09	Spring	13.7	7.1	24	-	-
	Summer	15.9	6.3	47	-	-
	Fall	11.1	6.6	34	46	14.7

^{0}C = temperature; µS/cm = micro-Siemens per centimetre; mg/L = milligrams per litre; - = data was not collected.

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