Table 5.3-1. Summary of Potential Residual Effect and Significance Rating for Arctic Grayling

	Qualifier	Primary Criteria		Secondary Criteria			Qualifier	Significance Rating
Potential Residual Effect	**Direction (positive, neutral, negative)**	**Magnitude (low, moderate, high)**	**Reversibility (reversible, reversible with effort, irreversible)**	**Duration (short, medium, long)**	**Frequency (once, sporadic, continuous)**	**Geographic Extent (footprint, local, regional, beyond regional)**	**Probability (unlikely, moderate, likely)**	**(Not Significant (N), Significant (S))**
Sedimentation/Erosion potential effects. Mitigation measure will be in place (e.g. winter construction, local sediment controls); however, the placement of silt curtains would prevent Arctic Grayling from accessing the new RSW habitat. Consider the potential residual effect of sedimentation/erosion in order to allow access of Arctic Grayling to new RSW habitat. Decreased Arctic Grayling production caused by mobilization of fine particulate matter.	Negative	Low-moderate	Reversible	Medium	Sporadic	Local	Likely	N

In the absence of using silt curtains (in order to allow for Arctic Grayling passage through RSW), a residual effect arising from the suspension of fine particulate matter could result in decreased Arctic Grayling production through avoidance of turbid sections of stream, or by smothering eggs laid within spawning gravels in the channel. The geographical extent of the residual effect would be limited to the re-aligned RSW and confined to within the Rascal Lake to Goose Lake study area; therefore it would be considered *local*. The residual effect would be sporadic, with the majority of the sediment pulse occurring in year one following the re-alignment. However, subsequent, smaller pulses could occur during the placement of spawning gravels in year 2 and during culvert removal (possibly in years three to five). The potential increase in erosion and sedimentation would be of *medium* duration (primarily limited to the first year following construction) and thus, the potential adverse effect on Arctic Grayling would also be of *medium* duration. The potential residual effect would be *fully reversible* — spawning, rearing and migration should re-establish naturally with no intervention once freshet removes the suspended matter.

Arctic Grayling have a highly adaptable life history that allows for flexibility in its spawning, rearing and foraging locations which can occur in lakes, streams and rivers (Evans, Reist, and Minns 2002). In addition, Arctic Grayling are long lived, iteroparous spawners. This strategy is adaptive to overcome for the loss, or partial loss of yearly cohorts in unpredictable environments like the Arctic. Thus, the magnitude of the potential residual effect due to erosion/sedimentation on Arctic Grayling spawning and migration is anticipated to be *low to moderate*, with a temporary loss of production, largely taking place in year 1 of the re-alignment.

The probability of the potential residual effect occurring is dependent upon whether silt curtains are used to mitigate for sediment/erosion potential, or whether it is deemed preferable to allow access to the newly created RSW habitat. However, even if silt curtains are not used, it is predicted that the potential residual effect of sedimentation/erosion would be ***Not Significant*** due to the flexibility of Arctic Grayling life history and the predicted increase in spawning and rearing habitat provided by the design of the re-aligned RSW and mitigation measures. This significance rating is made with *moderate* certainty. However, there will be a robust monitoring program in place that will allow for adaptation should further sedimentation/erosion mitigation measures become necessary (e.g. placement of silt curtains).

6. Proposed Monitoring Program

6. Proposed Monitoring Program

6.1 OVERVIEW

A monitoring program will be implemented to determine if the proposed enhancement of RSW through re-alignment of RSE is functioning effectively, and to determine progressive enhancement strategies of RSW through the placement of gravel, cobble, and boulders after Year 1 of post-enhancement monitoring.

This Proposed Monitoring Program will commence during Year 1 synchronous with the expansion of the airstrip and construction of the temporary all-weather road. Results from Year 1 monitoring will be used to determine the placement of gravel, cobble and boulders during Year 2.

In order to determine whether the enhanced RSW has successfully replaced lost Arctic Grayling production in RSE, monitoring will occur annually during Years 1, 2, and 3, and again in Years 5 and 6 after the new habitat has had time to settle in and mature and after the removal of the temporary all-weather road culverts. If the all-weather road culverts are removed at a later date, then the Monitoring Program will be modified to include monitoring during and after the culvert removal.

The main objective of the Monitoring Program is to evaluate the effectiveness of compensatory habitat designed to offset losses in Arctic Grayling production in RSE.

6.2 MONITORING PROGRAM SCHEDULE AND DESIGN

Table 6.2-1 presents the proposed schedule for the Monitoring Program. The Monitoring Program will assess Arctic Grayling, fish habitat, and other environmental components of fish habitat for the first 3 years of the stream re-alignment and then again in years 5 and 6. Not all components are scheduled to be sampled in each monitoring year, but rather at intervals allowing for the stream community to establish over time, promoting a quantitative assessment of the offsetting program's effectiveness.

Little baseline information was collected prior to the scheduled construction timing of the re-alignment, partly due to low, intermittent flows and limited fish habitat present along the length of RSW. To address these limitations, it is proposed that the monitoring program include reference sampling sites (RS1 to RS3) located upstream of the junction where RSE will be re-aligned towards RSW (Figure 6.2-1). Monitoring sites (MS1 to MS6) located downstream of this junction will form part of the 'impacted' sites to which upstream, 'un-impacted' reference sites can be compared to.

Because few enhancement works are anticipated to be made during the re-alignment phase (other than gravel and boulder additions in ponds and immediate inflow and outflow sections), data collection conducted prior to the completion of all enhancement works (Year 1) will form part of the baseline collection year(s). Additional habitat enhancement designs (e.g., boulder structures, additional channelization, etc.) will be developed only after the first year of post- re-alignment data are collected such that the most suitable works may be selected and implemented the following winter. Only once these works are completed will the 'Post-habitat enhancement of RSW' begin (Year 2 in Table 6.2-1).

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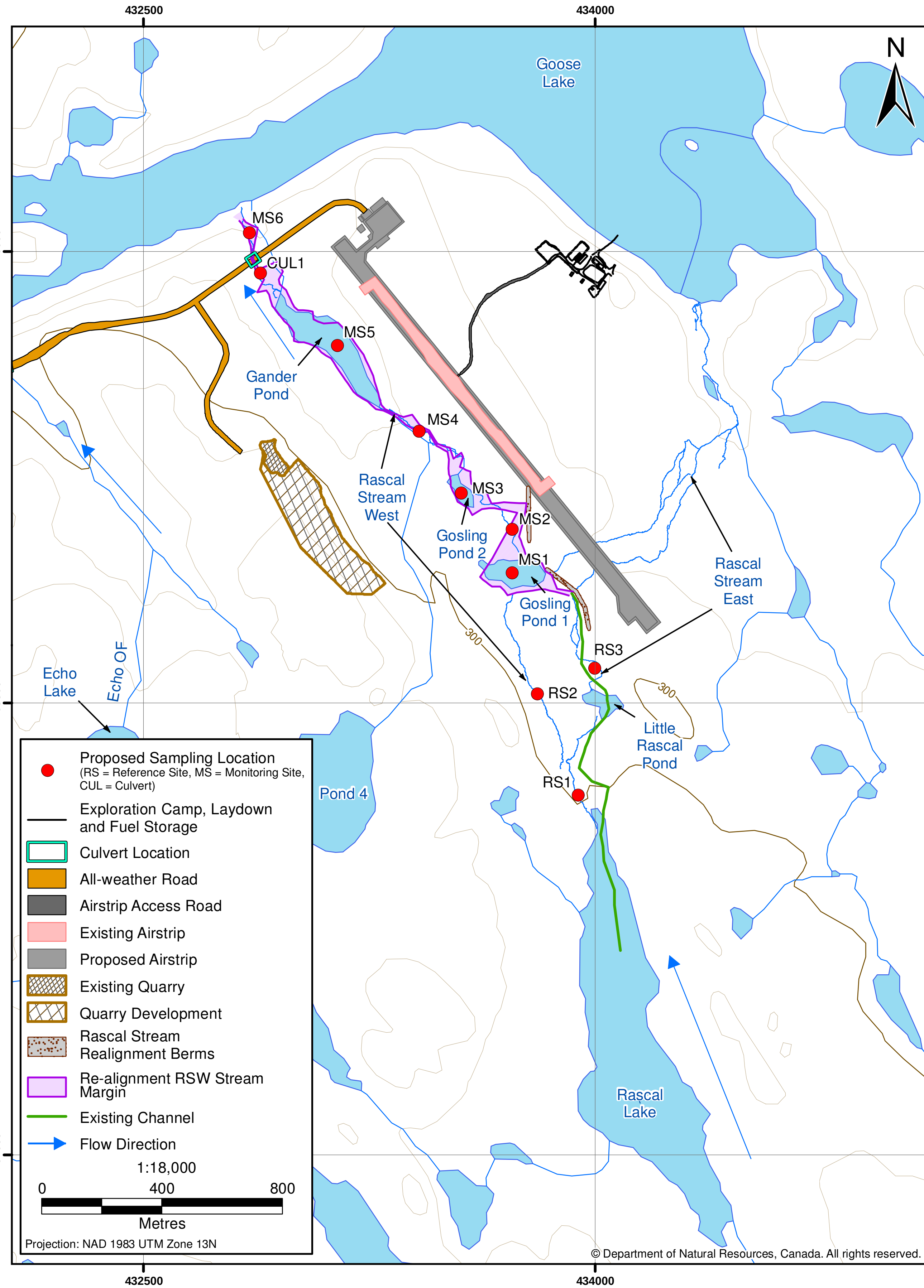

Figure 6.2-1

Proposed Monitoring Program Sampling Locations

Sabina Gold & Silver Corp.

Rescan an ERM company

Table 6.2-1. Monitoring Program Schedule and Design Summary

	Year 1 (likely 2015)	Year 2	Year 3	Year 5	Year 6
Monitoring Program Design Year:	**Baseline Post Re-Alignment Year**	**Post-Habitat Enhancement of RSW Monitoring**			
Monitoring Component:					
Stream flow	X	X	X	X	X
Water quality[1]	X	X	X	X	X
Sediment quality	X	-	-	-	X
Periphyton	X	X	-	X	X
Benthic invertebrates	X	X	-	X	X
Fish habitat[1]	X	X	X		X
Number of Arctic Grayling spawners[1]	X	X	X	X	X
Visual counts of Arctic Grayling fry[1]	X	X	X	X	X
Number of outmigrant Arctic Grayling/other fish	X	X	X	X	X
Fish culvert passage assessment	-	X	-	-	-

Note: Monitoring of project construction is not included, but required during berm construction and culvert installation.
[1] Baseline pre- re-alignment data collected in 2013 for RSE and RSW.

6.3 DETAILED MONITORING METHODS

6.3.1 Stream Flow

Detailed hydrological assessments including stream velocity and channel profiles will be required to confirm predicted flows following re-alignment. Hydrological assessments will be taken at each month at 5 transects along each re-aligned RSW section (i.e., between ponds; Figure 5.1-1c) to ensure the flow conditions are within the range of values to support the Arctic Grayling life cycle. In addition, velocity measurements will be taken at the upstream and downstream ends of each culvert (and within each culvert) to ensure Arctic Grayling migration is not restricted by culvert velocities.

Following detailed monthly hydrological and fish habitat assessments conducted in Year 1 (2015), the location and extent of spawning gravel placement will be designed and adapted to conditions observed and will be implemented the following winter.

6.3.2 Water and Sediment Quality

To ensure water and sediments remain within Canadian Council of Ministers of the Environment (CCME) guidelines for aquatic life or at natural background concentrations, water and sediment quality will be monitored at three reference sites upstream of the re-aligned RSW and at six locations within the re-aligned RSW (Figure 6.2-1; Table 6.3-1). Water temperatures will be monitored with stationary data loggers installed at each water and sediment quality sampling station. Manual measurements will also be taken each time data are collected.

Table 6.3-1. Proposed Sampling Stations between Rascal and Goose Lakes

Location	Site	Approximate UTM Coordinates (Zone 13N)		Adult Fish Migration	Culvert Passage	Fry Outmigration	Fish Community	Water Quality	Sediment Quality	Periphyton	Benthic Invertebrates
		Easting	Northing								
Downstream of Rascal Lake	RS1	433964	7268146	X	-	X	X	X	X	X	X
RSW (upstream of Gosling Pond 1)	RS2	433785	7268534	-	-	-	X	X	X	X	X
RSE (upstream of Gosling Pond 1)	RS3	433999	7268616	-	-	-	X	X	X	X	X
Gosling Pond 1	MS1	433724	7268933	-	-	-	X	X	X	X	X
RSW (between Gosling ponds 1 and 2)	MS2	433741	7269108	-	-	-	X	X	X	X	X
Gosling Pond 2	MS3	433554	7269199	-	-	-	X	X	X	X	X
RSW (upstream of Gander Pond)	MS4	433390	7269367	-	-	X	X	X	X	X	X
Gander Pond	MS5	433143	7269688	-	-	-	X	X	X	X	X
Upstream of Culvert	CUL1	432886	7269929	-	X	-	-	-	-	-	-
RSW (upstream of Goose Lake)	MS6	432844	7270030	X	X	X	X	X	X	X	X

Note: RSW = Rascal Stream West, RSE = Rascal Stream East, RS= Reference Site, MS = Monitoring Site. Each site will encompass a 100m section of creek. The upstream and downstream limits of each site will be determined during Year 1 of the monitoring program.

6.3.3 Periphyton

Periphyton samples will be collected using a plate technique to determine the level of initial colonization of primary producers (using Chlorophyll *a*) and to evaluate whole community composition. Periphyton plates will be used at the same sites as water quality sampling sites (Figure 6.2-1; Table 6.3-1). Five samplers will be submerged at each location at the end of July and will be recovered in late August or early September for a total submerged time of approximately 30 days.

Appropriate metrics and indices will be used to evaluate periphyton data including: biomass, density, relative density (i.e., the proportion of each taxonomic group in the community) and several diversity metrics (e.g., Shannon-Weiner Diversity Index, Simpson's Diversity Index, genus richness, G, and maximum dominance).

6.3.4 Benthic Invertebrates

Benthic invertebrate community structure will be sampled at the same sites selected for periphyton sampling (Figure 6.2-1; Table 6.3-1). Benthic invertebrates will be collected using Hester-Dendy samplers to document invertebrate community structure. Samplers will be submerged at the end of July and recovered in late August or early September of each sampling year. Five replicate samples will be collected within 15 m of each designated location.

Metrics and indices used to evaluate benthic invertebrate data will include density, relative density (i.e., the proportion of each taxonomic group in the community), biomass, relative biomass, and several diversity metrics. Particular emphasis will be placed on comparing functional feeding groups between reference and monitored sites.

6.3.5 Fish Habitat

The fish habitat surveys will be conducted along the length of the re-aligned RSW using SHIM twice per year, once during high and once during low flows, following berm construction and culvert installation to compare as built habitat gains to modeled habitat gains (Appendix 5.3) following the re-alignment activities.

6.3.6 Arctic Grayling Spawner and Adult Spring Migrant Monitoring

Along with visual spawner counts conducted at the onset of spring melt, Arctic Grayling spawners and migrants will be enumerated as they move between Rascal and Goose lakes via the re-aligned RSW using fish boxes according to the schedule set out in Table 6.2-1. Two fish boxes will be installed in the spring to track migrations as soon as water begins to flow and boxes will be removed when spawner numbers decline to zero, typically occurring at the end of June. One fish box net will be located at the outlet of Rascal Lake (Site RS1), and another box will be located at the inflow to Goose Lake (MS6; Table 6.3-1). The ratio of visual-survey-fish-counts to box-trap-counts will also be calculated to examine for potential visual underestimation during the spring spawner surveys and it will be compared to baseline data from 2013.

The fish boxes will be serviced once each day during peak spawning migration and once every two days after peak migration. During each visit, all fish will be counted, identified to species, sub-sampled for length and weight, and released in the direction they were swimming. All Arctic Grayling ≥ 170 mm long will be tagged with a unique T-bar Floy Tag attached below the dorsal fin. Tagging of Arctic grayling will allow for evaluation of fish movement patterns and time spent in the re-aligned stream, in addition to fish passage through the stream and installed culverts, and it will also indicate the proportion of the population that overwinters in Rascal Lake and Goose Lake.

If barriers or seasonal restrictions to fish movement are identified in RSW during adult migrant monitoring (e.g. the cascade located in Reach 1 of RSW), those locations may need to be adaptively managed to improve egress.

6.3.7 Summer Fish Community Surveys

Summer fish community surveys will be conducted according to the schedule set out in Table 6.2-1. Newly-emerged Arctic Grayling fry will be enumerated in early to mid-July to help determine if the re-aligned RSW diversion is being used successfully for spawning. Fry will be counted using timed walking surveys of the entire length of stream habitat located between Rascal and Goose lakes, including the re-aligned RSW and the reference sections located upstream of where RSE is diverted to RSW. Subsequent dipnet/pole seine surveys conducted at specific sites will be used to determine fish community and fish-size-at-sampling-date (Table 6.3-1). These data will allow for the direct comparisons of fry health and growth between the re-aligned RSW and baseline measurements taken at RSE, in addition to reference sites located upstream of where RSE is diverted to RSW.

Electrofishing surveys will also be conducted to determine which fish species utilize the newly created habitat in the re-aligned RSW. These electrofishing surveys will take place in mid-August at the same locations as used for the dipnet/pole seine surveys, though additional fry length/weight measurements will be made during the electrofishing surveys.

6.3.8 Fry Outmigration

Juvenile fish movement through the re-aligned RSW prior to winter freeze-up will be monitored using bi-directional fyke nets. Three nets will be installed from early to mid July until freeze-up (~early October) at the same locations as the fish boxes: one at the outlet of Rascal Lake and one at the inflow to Goose Lake (Figure 6.2-1; Table 6.3-1). Each fyke net will be serviced once a day during peak outmigration, and once every two days after peak migration. During each visit, all fish will be counted, identified to species, sub-sampled for length and weight, and released in the direction they were swimming. Fyke nets will allow for the determination of stream residence time of fry and juvenile fish, as well as the total growth of fry during their stream residence. It will also provide information as to lake preferences for overwintering habitat.

6.3.9 Culvert Passage Assessment

An assessment of upstream passage through the culvert will be completed to ensure that the culvert does not restrict egress for fish. A box trap will be installed immediately upstream of the culvert in Year 2 to assess fish movement. Catch at this trap will be compared to the catch at the fish box net located at the outlet of Rascal Lake (Site RS1; Section 6.3.6), downstream of the culvert.

6.3.10 Evaluating Success of the Stream Re-alignment

To evaluate the offsetting plan's success for no net loss of fisheries productivity, primary production (as Chl *a*), periphyton community composition, invertebrate community composition and fish use parameters will be compared to baseline conditions using a Before-After/Control-Impact (BACI) design when data is available, otherwise data collected within the RSW will be compared to those collected in reference areas (i.e., upstream of where RSE is diverted to RSW). For this analysis, control sites will be chosen within the unmodified upstream eastern and western sections of the re-aligned RSW (Figure 6.2-1), impact sites located within the re-aligned RSW (Figure 6.2-1). Temporal trends in measured parameters will also be examined in the final two years of the sampling program.

The re-alignment of the streams and offsetting of RSE habitat will be considered successful if parameters measured in the re-aligned RSW are found to be: 1) greater than that found during baseline conditions in the re-aligned sections of RSW for which data is available (before-after), 2) indistinguishable to that found during baseline conditions in the unmodified upstream eastern and western sections of the re-aligned RSW (control-impact), and 3) improve over successive sampling intervals post-construction (trends through time).

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Appendix 2.1

Rascal Realignment Hydraulic Model

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Memo

To:	Max Brownhill	**Client:**	Sabina Gold & Silver Corp
From:	Samantha Barnes John Duncan	**Project No:**	1CS020.006
Cc:	Kerry Marchinko, ERM Rescan	**Date:**	October 7, 2014
Subject:	Rascal Realignment Hydraulic Model		

1 Introduction

Sabina Gold & Silver Corp. (Sabina) intends to extend the existing airstrip servicing the Goose Lake camp. In order to construct this extension, a stream realignment is required. The work will require that Sabina place a berm on the Rascal Stream East (RSE), realigning it to augment flows along the Rascal Stream West (RSW) watercourse. With the construction of a series of berms, RSE will be realigned towards an existing smaller catchment flowing into Gander Pond. The realigned RSW will generate increased flows into Gander Pond and create new fish habitat to mitigate the loss of habitat from RSE.

A hydraulic model was prepared to analyze velocities and flow depths in the realigned RSW. A temporary access road will be constructed across the realigned stream, which will require culverts to convey the flow and allow for fish passage. One location was identified as a feasible culvert crossing location, where the sizing was governed by conveyance and fish passage design criterion. The diversion berms were incorporated into the model in order to characterize the realigned stream and confirm that water will not pond along the airstrip.

There are stream velocity constraints that exist for the culverts and along the entire stream length to allow fish passage. The goal of the realignment is to create a fish habitat that matches or exceeds the quality of habitat that will be lost from these proposed works.

2 Supporting Information

2.1 Hydrology

RSE currently flows northeast and bypasses the existing airstrip, eventually discharging to Goose Lake. With the airstrip expansion, RSE will lose its upstream flow contributions. The realignment will route 100% of the RSE flow northwest towards Gander Pond, discharging into a nearby location in Goose Lake.

The connection of the Gander Pond and Rascal Lake catchment will significantly increase the flows in Gander Pond since the Rascal catchment is significantly larger than the Gander Pond catchment. Figure 1 shows the catchment areas contributing to each system. The resulting catchment through Gander Pond is equal to 34.3 km^2, whereas the current catchment is 1.8 km^2.

Flows were estimated based on a regional hydrometric analysis. This analysis generated unit peak flows for various regional stations, and compared the flows based on average elevation, and lake cover percentage. A unit peak flow was developed for the Back River Project, and will be described in the SRK Hydrology Report.

Two flow conditions were modelled to assess fish habitat potential. These flows included the monthly average flow in June, which represents the spring snowmelt, and the monthly average flows between July and October denoted as the average fall flow.

The 2-year and 20-year flow events were also modelled to verify the extent of flooding and capacity of the culvert, and the 100-year flow event was modelled to evaluate the freeboard along the berms.

2.2 Topography

Topographical data was provided by Sabina in the form of 1 m LiDAR contours across the complete Goose Property, as well as 25 cm LiDAR in the vicinity of the airstrip.

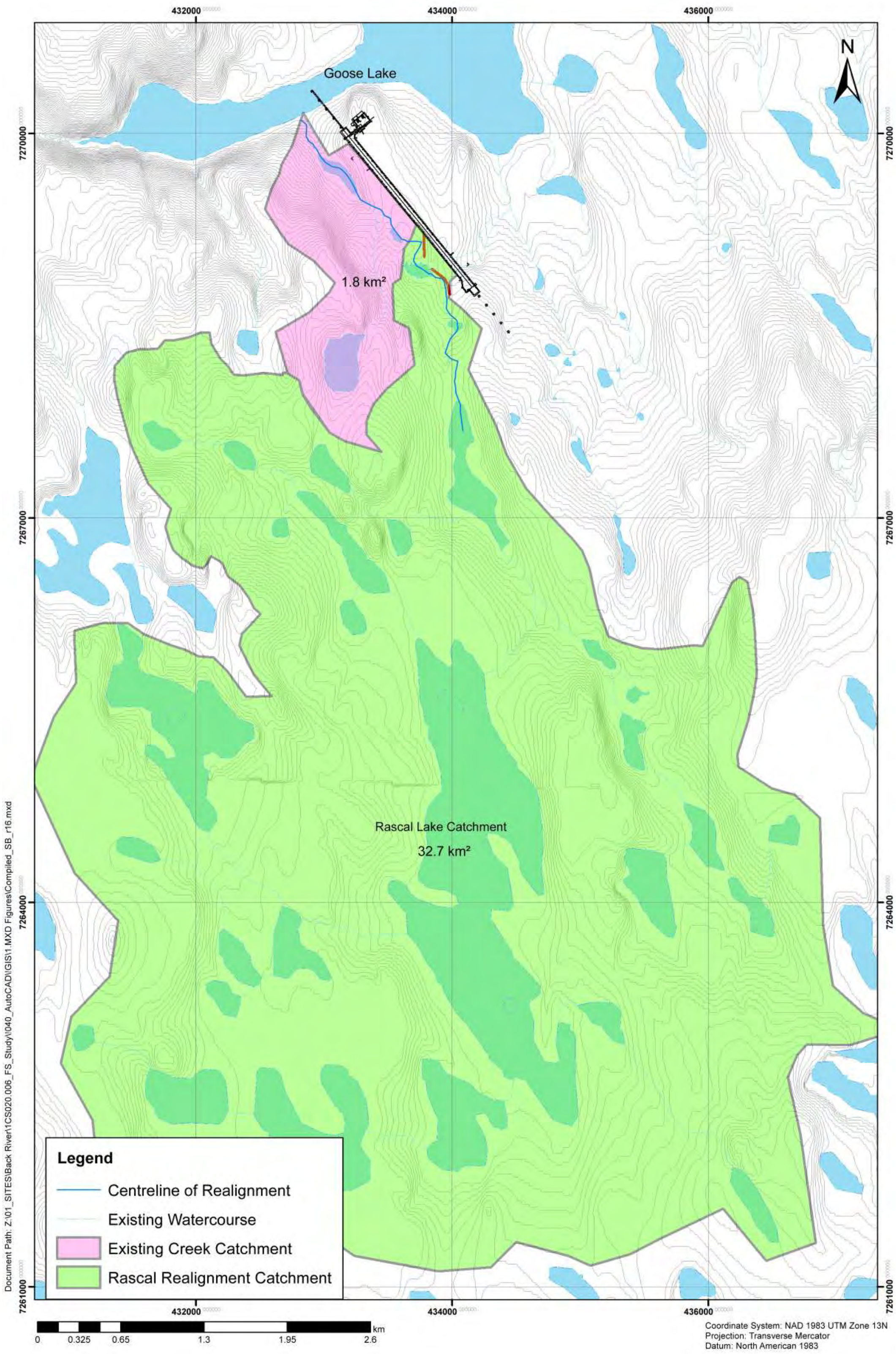


Figure 1: Catchments for Rascal Lake and Gander Pond

3 Design Criteria

The hydrotechnical design criteria that were used for the Rascal realignment design are defined from a compilation of civil engineering best management practices, SRK professional judgment working in the north and ERM Rescan prescribing the fish passage criterion (Table 1).

Table 1: Hydrotechnical Design Criteria

Item	Value	Unit	Source/Comments
Channel Design			
Average fall flow	0.27	m^3/s	*Specified by SRK*
Average June flow	1.22	m^3/s	*Specified by SRK*
2-year peak flow	2.4	m^3/s	*Specified by SRK*
Manning's roughness for channel	0.029	n/a	*Based on substrate material and riprap. Assumed D_{50}= 10 cm.*
Preferred velocity range	0.05 – 0.80	m/s	*Based on fish habitat requirements*
Berm Design			
100-year peak flow	5.1	m^3/s	*Specified by SRK*
Side slopes	1.5:1 (H:V)	m	*Specified by SRK*
Minimum freeboard	0.3	m	*(U.S. Bureau of Reclamation [USBOR], 1978)*
Minimum height	2.3	m	*Specified by SRK*
Minimum top width	6	m	*Specified by SRK*
Culvert Design			
20 year-peak flow	4.2	m^3/s	*Specified by SRK*
Manning's roughness for bottom of culvert	0.040	n/a	*For gravel, cobbles and few small boulders (Chow V. T., 1994)*
Maximum velocity over short length	1	m/s	*Based on fish passage requirements supplied by ERM Rescan*

Due to the presence of permafrost across the realignment area, excavation into the existing ground is to be minimized. Long-term ponding in the area adjacent to the works should also be minimized to prevent differential thawing in the permafrost beneath the airstrip.

4 Hydraulic Model

4.1 Hydraulic Model

The hydraulic model used for this project was HEC-RAS. HEC-RAS is a one-dimensional computer program developed by the US Army Corps of Engineers and is typically used to estimate hydraulic parameters for flow through natural rivers and other channels.

The realigned RSW hydraulic model was prepared as a steady state model, with fixed flows established for each specified event, including the average fall flow, the average June flow, and the peak 2-year, 20-year, and 100-year return period events.

A TIN model was prepared using the 25 cm LiDAR topography which was extended using the 1 m LiDAR data. The TIN was defined to include the floodplain and channel extents along the 3 km reach of the realignment. The hydraulic model included the proposed berm structures adjacent to the airstrip, as well as the culvert crossing beneath a proposed access road. A total of 48 cross-sections were generated in ARCGIS with the application ARC-GeoRAS and transformed into geometric data for HEC-RAS. Cross-sections were then interpolated at a minimum of 20 m spacing within HEC-RAS. Figure 6 illustrates a plan view of the HEC-RAS model showing the realignment, cross-sections and 100-year flood extents.

The stream reach analyzed had a longitudinal slope that varies between zero and 0.03 m/m and consists of several ponds and meandering sections. The model provides a representation of the water levels and hydraulic parameters expected during the different flow events.

4.2 Alternative Analysis

4.2.1 Berm Alignment

The historical alignment of RSE routes water immediately south of the existing airstrip to Goose Lake. The lower reach of the channel north of the airstrip is in conflict with other mining infrastructure and it was therefore decided to realign RSE towards the RSW watercourse, through Gander Pond to Goose Lake. The realignment is accomplished with minimal excavation by constructing the south berm illustrated on Figure 2. There is a low point situated adjacent to the proposed extension downstream of the south berm along the new alignment, and the proposed north berm will restrict water from ponding along the airstrip. For each flow event, HEC-RAS produced an aerial view of the ponding extents within each cross-section. Based on available topography and HEC-RAS model results, the berms were generated in an iterative process to minimize the length of berm, while ensuring that no water shall impinge on the airstrip during the design events.

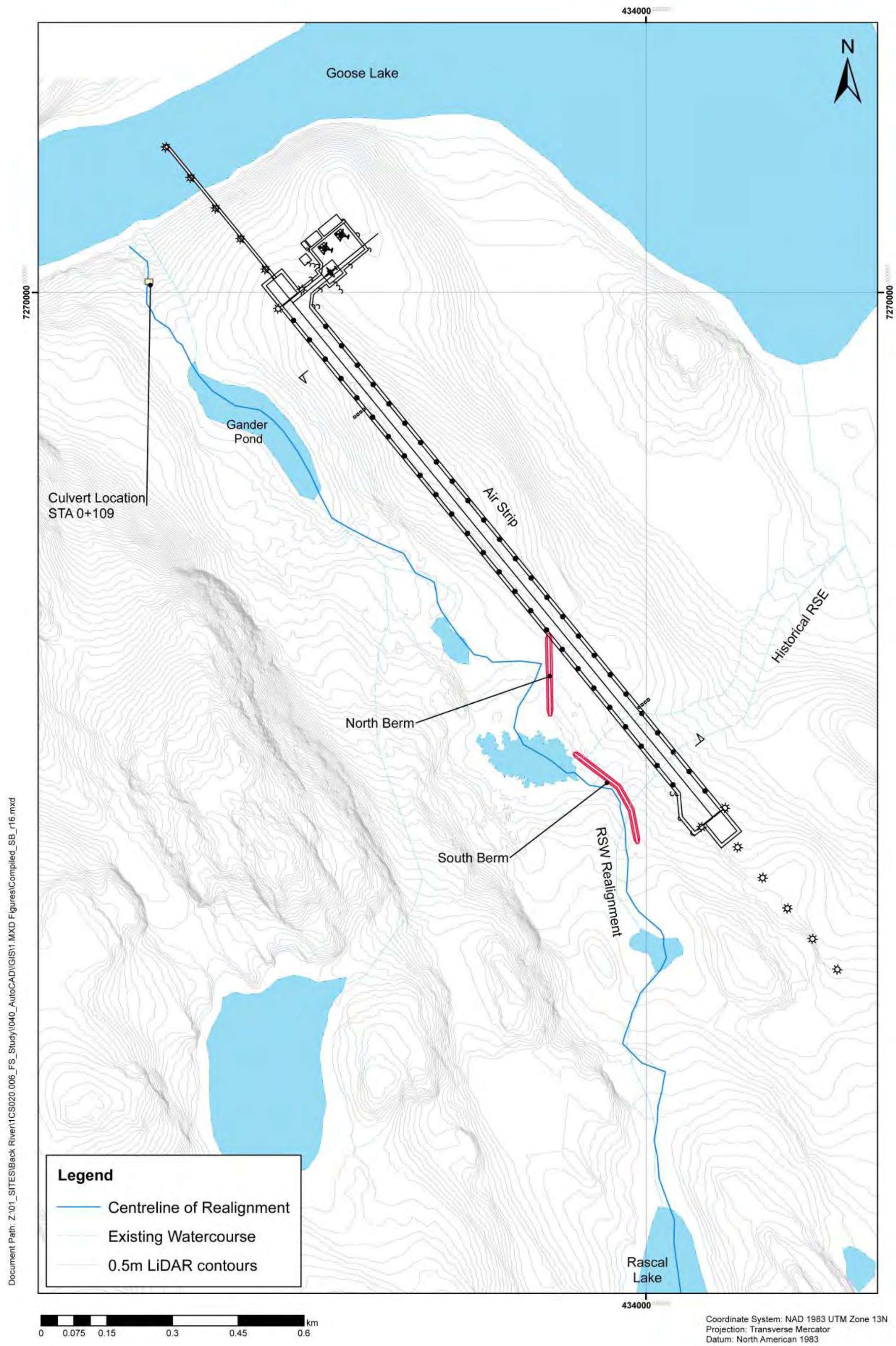


Figure 2: Rascal Realignment

4.2.2 Culvert Location and Sizing

The culvert location was selected based on stream slope and cross-sectional topography to minimize the fill required for the road crossing. The crossing location is identified in Figure 2, at Station 0+109. The longitudinal slope in this section is 3.6% along the base of the culvert.

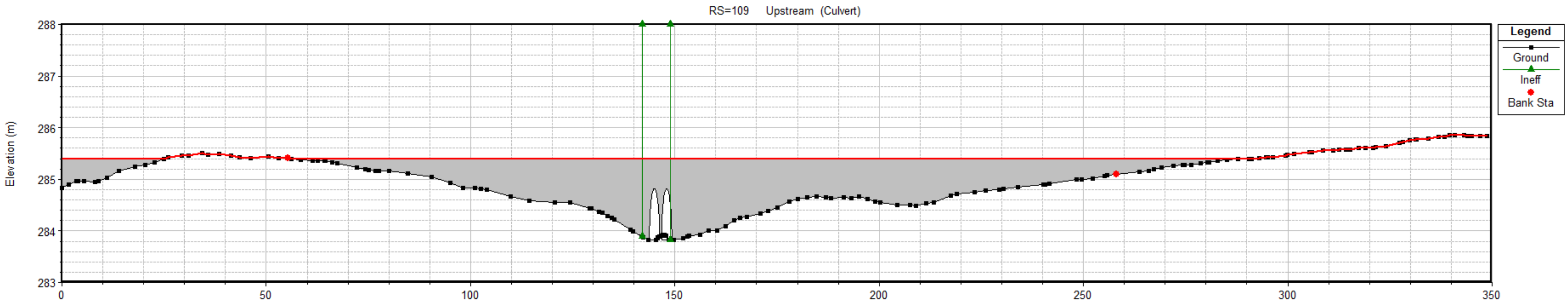
Two culvert alternatives were assessed;

- 2 x 2.5 m box culverts
- 2 x 2.5 m Corrugated Steel Pipe (CSP) culverts

The culverts will be filled with subgrade and large boulders or baffles to facilitate fish passage and increase the roughness in the pipe. The cross-section at the culvert location is provided in Figure 3, for the box and CSP culverts.

The box culverts will be embedded below existing ground by approximately 15 cm in order to place the substrate layer. Several boulders with a minimum diameter of 0.4 m will also be placed within the culverts to reduce velocities during high flow events.

The CSP culverts will need to be filled with substrate to a depth equal to 40% of the culvert diameter. This will require an excavation below existing ground of 1 m.



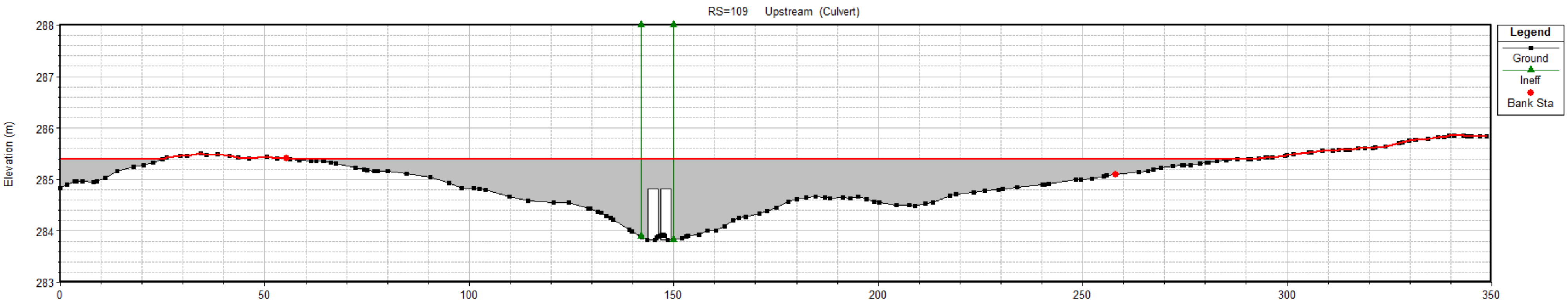


Figure 3: Cross-section along Proposed Culvert, for Box and CSP culverts

5 Results

The results of the HEC-RAS model are presented in terms of the channel, berms, and culverts.

5.1 Channel Results

Velocity and water depth profile results are presented for the channel along the realigned centreline. The velocities in each cross-section allow for the selection of an appropriate substrate material based on the fish habitat classification. Velocity profiles for each alternative are presented in Figure 4, for average fall flow and average June flow. The water depth profile ensures that there is sufficient depth for fish passage, and is presented in Figure 5 during the average fall flow and average June flow.

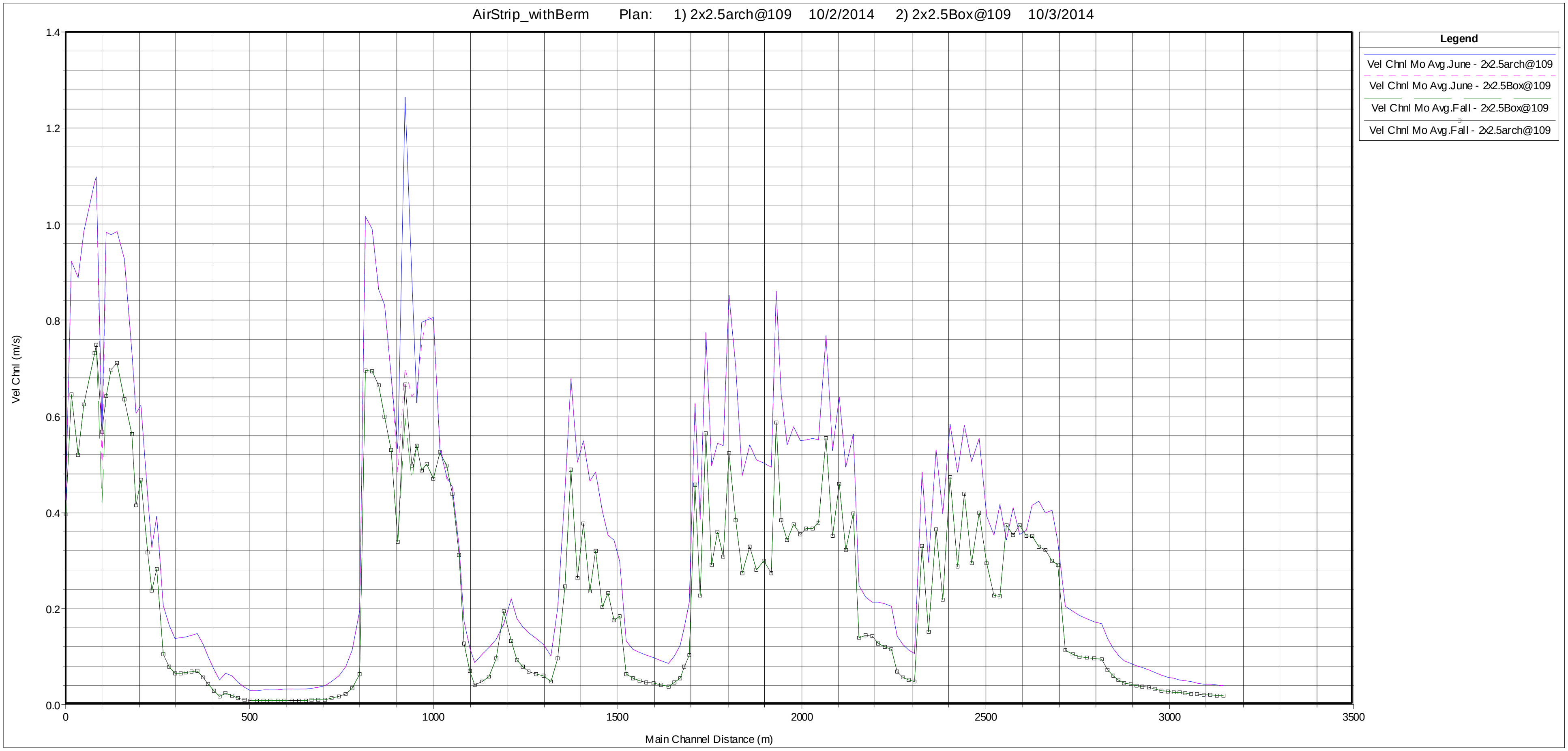


Figure 4: Velocity Profile for Average Fall Flow and Average June Flow

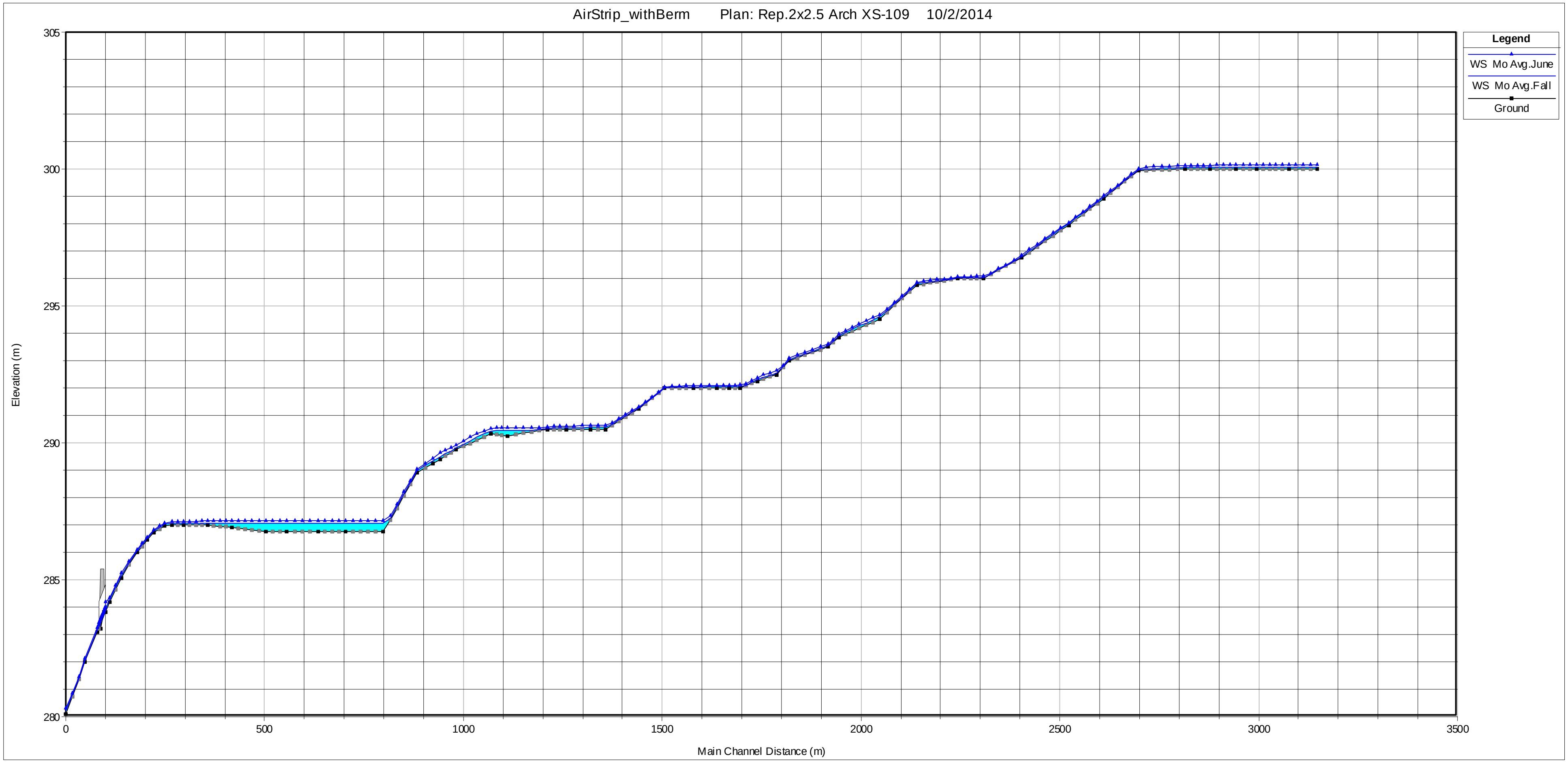


Figure 5: Water depth profile with culvert at location, for Average Fall Flow and Average June Flow

5.2 Berm Selection

The flooding extents show the limit of potential ponding during each flow event. The berm alignments were selected based on the results of the 100-year and 20-year return period flood events. The 100-year return flood event with the culverts in place is illustrated in Figure 6. Two berms were necessary to ensure that no water would pool adjacent to the airstrip for both the 20 and 100-year events. Based on the flood extents, the downstream and upstream berm were designed with a length of 180 m and 270 m respectively. Berm alignments are shown in Figure 2. The berm heights were governed by the minimum height criterion used to bring the permafrost line to the bottom of the berm section. The haul road and culverts are expected to be in place for only a few years during the project early works. Upon removal of the haul road and culverts, adequate freeboard exists on the berms during the 100-year design event.

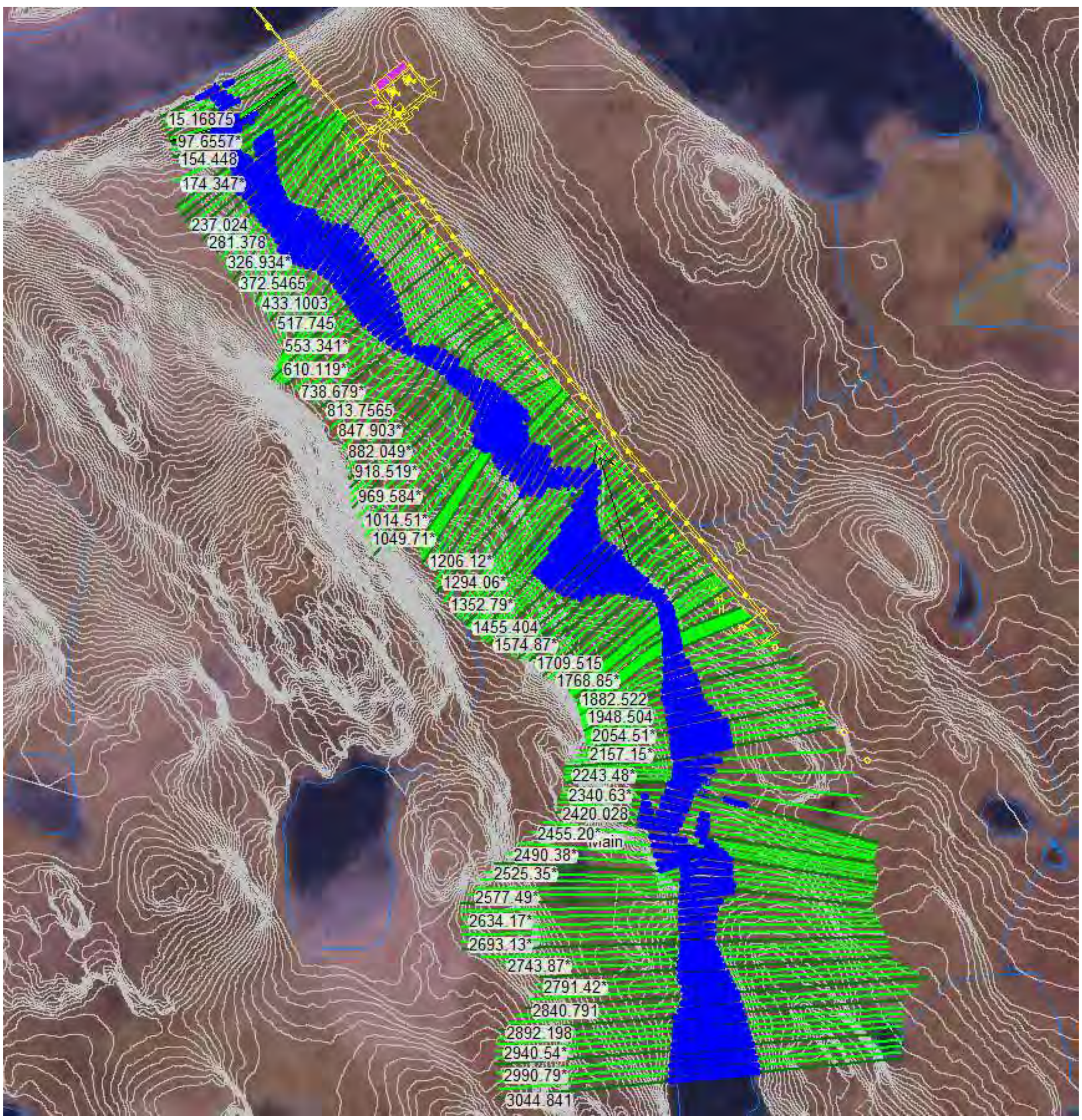


Figure 6: HEC-RAS Model Plan View with 100 year flooding extents

5.3 Culvert Results

The maximum recommended current velocity for sustained swimming in Arctic Grayling is 1.5 m/s. This velocity became the limiting factor in the culvert sizing, and was set as the maximum velocity for the culvert during June average flows, which coincides with the timing of fish swimming upstream. Velocities higher than 1.5 m/s during the month of June will require boulder placement or baffles throughout the culvert in order to provide areas of reduced velocities.

Based on this velocity constraint, two culvert options were proposed. These alternatives include two adjacent 2.5 m diameter box culverts, versus two adjacent 2.5 m diameter CSP culverts. The upstream and downstream velocities for the 2 culvert alternatives are presented in Table 2. The minimum water depths are also presented for the average fall flows to illustrate the minimum depth expected in the culvert during open water season other than the snowmelt period. Both culvert options were also found to have enough capacity to convey the 20-year flood event.

Table 2: Culvert Design Summary

Culvert Station	Culvert Description	Upstream Culvert Velocity in June (m/s)	Downstream Culvert Velocity in June (m/s)	Minimum Water Depth in Culvert in fall (m)
0+109	2 x 2.5m submerged CSP	1.35	1.39	0.07
0+109	2 x 2.5m box	1.35	1.38	0.07

6 Recommendation

Based on the results presented in Table 2, both culvert alternatives will provide similar hydraulic results. The velocities presented could be mitigated by placing boulders in the culverts to create low velocity resting areas for fish. It is recommended that either two 2.5 m box culverts or two 2.5 m CSP culverts be installed. The bottom of the culverts will contain substrate material as well as large boulders to facilitate the fish passage.

The CSP culverts will require an excavation depth of approximately 1 m through permafrost in order to properly place the substrate material and achieve the hydraulic results presented in the HEC-RAS model. It is best practice to avoid excavating through permafrost and as such, the preference would be to install box culverts over CSP culverts.

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Memo

To:	Max Brownhill	**Client:**	Sabina Gold & Silver Corp.
From:	Iozsef Miskolczi	**Project No:**	1CS020.006
Cc:	John Duncan, SRK	**Date:**	October 8, 2014
Subject:	Rascal Stream East Realignment		

1 Introduction

Sabina Gold & Silver Corp. plans to extend the existing airstrip servicing the Goose Lake camp. This work will require placing a berm on the Rascal Stream East that will realign it to augment flows along Rascal Stream West watercourse. A second berm is required along the watercourse to avoid water from ponding along the airstrip. Figure 1 shows the location of the stream realignment and berms in relation to the airstrip.

The hydraulic design of the realignment was completed by SRK as documented in the October 3, 2014, memo. This memo documents design criteria and parameters for the berms.

2 Description of Berms

Ponding water around the Goose Lake camp airstrip could cause permafrost degradation in the area and failure of the airstrip embankment. The berms will direct flows to the Rascal Stream West watercourse to keep ponding water away from the airstrip.

The South Berm will redirect water from Rascal Stream East towards a natural pond further west of the airstrip. Water in the pond will overflow through an existing ephemeral channel and flow towards Gander Pond to the north. The North Berm was designed to prevent water from overtopping the ephemeral channel and ponding in a low spot against the airstrip.

3 Design Criteria and Parameters

The berms were designed to divert water during normal and high flows (freshet) and to provide protection from a 1 in 100 year flood event. The berms must be resistant to erosion and not susceptible to freeze-thaw damage.

The berms' geometries are shown in Figure 1. The cross section shows the berms are 2.3 m high with a crest widths of 6 m and side-slope grades of 1.5H:1V. The 6 m crest width was specified for constructability. The berms will be terminated at the same 1.5H:1V grades.

The material quantities required for construction are provided in Table 1. The liner quantities do not include overlap and wastage.

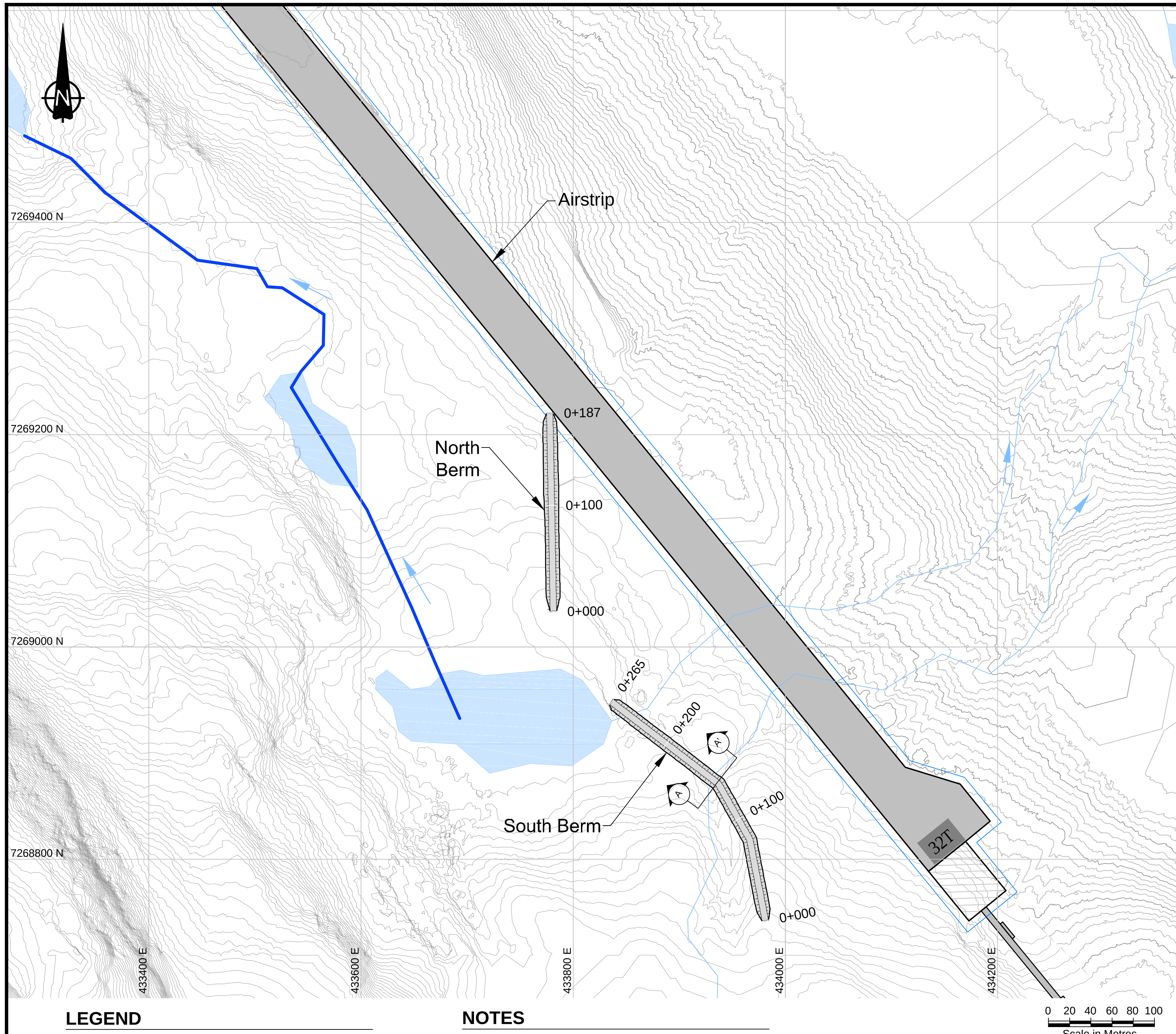
Table 1: Material Quantities Summary

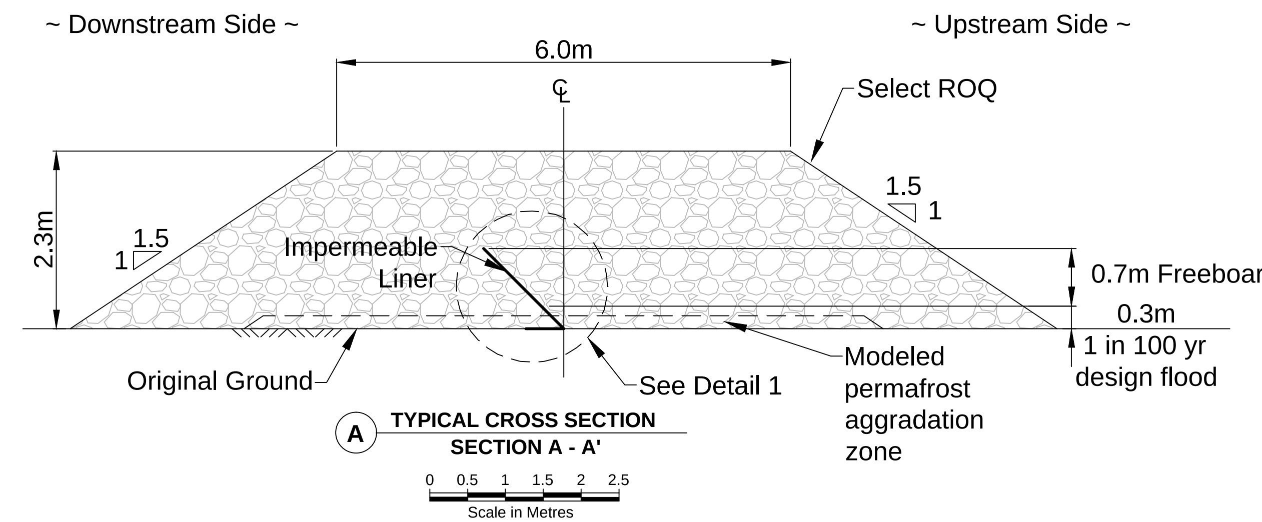
	North Berm	South Berm
Length (m)	187	265
Fill Volume (m^3)	4,100	5,800
Liner Quantity (m^2)	374	530

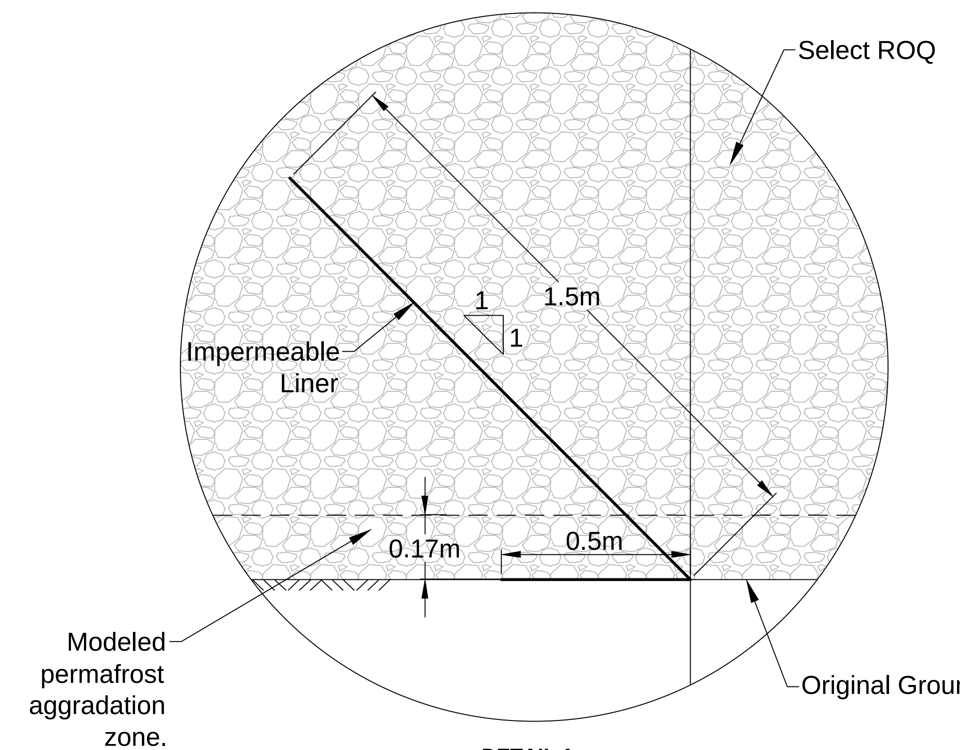
The berms will be constructed of select waste rock or run-of-quarry material. The fill shall be well graded, containing sufficient quantities of gravel, sand, and silt sized particles. The maximum boulder size shall not exceed 1,000 mm in any direction.

To provide the required stream realignment, an impermeable liner shall be installed within the fill, near the centerline of the berm. The design drawing includes installation details. Ground preparation for liner installation should include clearing vegetation in the contact area between the original ground surface and liner. The installation should be performed ideally in the winter, and the disturbance should be kept to minimum to protect the permafrost.

Based on the thermal modelling completed by SRK for the Back River project, the 2.3 m height of the rock fill will result in permafrost aggradation of about 17 cm above the original ground level. This would ensure adequate water-tightness of the structure, with the liner being well keyed-in to the permafrost.







DETAIL 1

1 **TIE-IN OF IMPERMEABLE LINER**

0 0.1 0.2 0.3 0.4 0.5

Scale in Metres

LEGEND

- Existing Flow Path
- Major Contour (5m)
- Minor Contour (1m)
- Rascal West Flow Augmentation
- Centerline of Creek
- Design Crest
- Design Toe
- Riprap
- Pond Area

NOTES

1. Liner welding is not required. Minimum overlap of 0.5m.
2. Select Run of Quarry (ROQ) material shall be well-graded, containing sufficient quantities of gravel, sand and silt sized materials; the maximum boulder size shall not exceed 1000mm in any direction. Basic screening or manual selection may be used to achieve the desired gradation.

srk consulting	Sabina GOLD & SILVER CORP	Rascal West Realignment Berm Plan and Details
SRK JOB NO.: – FILE NAME: Sabina Goose Overview – Sept 17.dwg	Sabina Gold and Silver Corp.	DATE: October 2014 · APPROVED: JD · FIGURE: 1