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REPORT

Dam Breach Assessment and Inundation Study

Valentine Gold Tailings Management Facility

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Distribution List

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Marathon Gold Corp. (Marathon) to complete a dam breach and inundation assessment for the proposed Tailings Management Facility (TMF) for the Valentine Gold Project. The TMF perimeter dam, if breached, has the potential to affect the downstream environment. In 2020, a dam breach assessment (DBA) was performed on the prefeasibility-level TMF design (Golder 2020). Since then, the TMF design has been updated, resulting in the need for an updated assessment. The updated analysis and results are documented in this report.

2.0 SITE DESCRIPTION

The proposed Valentine Gold Project is located approximately 84 km southwest of Millertown, 340 km northwest of St. John's and within the Central Uplands of Newfoundland as shown in Figure 1. The mine is accessed by a 76 km long, well-maintained gravel road from Millertown to the northeast of the site. The site is situated amidst gentle to moderately steep, hilly terrain and the ground surface elevation ranges from approximately 320 m to 480 m above sea level (masl). A distinct northeast trending ridge occurs along the length of the property. The ground cover consists of a mixture of boggy ground, spruce and fir forests, and grassy clearings with many small ponds and streams. Victoria Lake is located south of the site and is contained by Victoria Dam which is a hydroelectric reservoir. Valentine Lake lies north of the site. Below are background data governing site operations:

- Life of mine: 14 years
- Mill throughput: Ramps up from 0.465 Mtpa in Year 1 (2023) to 4.0 Mtpa in Year 6 (2028)
- Total tonnage of tailings produced: 47.06 million tonnes
- Mining method: Open Pit
- Disposal method: Thickened tailings, sub-aerial
- Tailings disposal location: Year 1 to Year 10 to the TMF, Year 10 to Year 14 to Leprechaun Pit
- Total tonnage of tailings to TMF: 30.1 million tones
- Tailings specific gravity: 2.68
- Tailings discharge solids content: 65% (by mass)

The proposed Valentine Gold Project containment facilities consist of a TMF for tailings storage and a Polishing Pond for water management and effluent polishing. Figure 2 shows the general arrangements of the overall site plan and TMF's for the Ultimate Stage while Figure 3 shows a typical cross-section of the TMF dam. Table 1 shows the catchments areas of the proposed Valentine Gold Project site facilities for the Ultimate Stage (Golder 2021a).

Table 1: Valentine Gold Site Drainage Areas (Golder 2021a)

Site Facility	Collecting Area (ha)	Surface Type	Collecting Area (ha)
Tailings Storage Facility	241.0	Natural Ground	71.1
		Prepared Ground	20.4
		Pond and wet tailings	84.5
		Dry tailings beach	65.0
Polishing Pond	8.4	Natural Ground	2.2
		Pond	6.2
Total	**249.4**		

2.1 Tailings Management Facility (TMF)

The proposed TMF dam is a downstream raised rockfill embankment with upstream filter zones and an inclined geomembrane liner as a seepage barrier. The TMF is bound by embankments on west, south and east faces. Throughout the operating period, tailings deposition will occur on the north and west side of the TMF with the tailings pond maintained on the eastern side of the facility. The foundation beneath the containment facility is granular till and/or bedrock. The TMF's crest elevation varies between 408.3 masl at the western portion of the dam and 393.5 masl at the northeast portion. Downstream and upstream slopes are 2 horizontal (H): 1 vertical (V) and 3H:1V, respectively.

The emergency spillway, located on the northeastern abutment of the dam, is an open cut channel with an invert elevation of 390.5 masl and a width of 45 m at the spillway channel inlet. The TMF collects runoff and process water. Water is reclaimed from the tailings pond for processing. Excess water is treated in a water treatment plant and Polishing Pond prior to being discharged to the environment.

Under the ultimate stage, the maximum operating water level (MOWL) in the TMF is 388.4 m, which is 2.1 m below the spillway invert, providing sufficient storage for the Environmental Design Flood (EDF). Under the inflow design flood (IDF) scenario- which has been selected as the flood generated under the probable maximum precipitation (PMP)- and with the mill and tailings slurry and reclaim water pumping systems operational, the maximum water surface elevation in the TMF is 391.0 masl for the Ultimate Stage. It is assumed that the pond would be at the MOWL prior to the PMP event (CDA 2020).

The main characteristics of the three studied TMF dam breach locations (Locations A, B, and C – as defined in Section 3.0) are summarized in Table 2. The locations shown in the inset of Figure 4 provide an overview of these locations.

Table 2: Tailings Management Facility Perimeter Dam Characteristics – Ultimate Stage

Dam Characteristic	Location A[1]	Location B	Location C
Dam Design Section	Downstream raised rockfill embankment with upstream filter zones		
Crest Elevation at Breach Location (masl)[2]	393.5	393.5	405.5
Dam Crest Length (m)[3]	3,345		
Dam Crest Width (m)	10		
Elevation of Dam Foundation (m)	358.5	353	386.5
Maximum Dam Height Above Foundation (m)	35.0	40.5	19.0
Overall Downstream Dam Slope (H:V)	2H:1V		
Overall Upstream Dam Slope (H:V)	3.5H:1V[4]		
Maximum Tailings Elevation (masl)	432.0	435.0	408.0
Spillway Invert (masl)	390.5		
Maximum Operating Water Level (masl)	388.4		
Probable Maximum Flood Level (masl)	391.0		

Locations shown in Figure 4

Notes:

1) Tailings pond accumulates on eastern side of the facility (Location A).
2) Crest elevation ranges from 393.5 masl to 408.3 masl. The values presented in the table are the approximate crest elevation at the selected breach location.
3) Corresponds to the length of the entire perimeter.
4) Intermediate slope (between benches) is 3H:1V.

The TMF will be constructed in stages, with the ultimate dam lift occurring in Year 8 and operated until Year 14. The analysis was carried out for the maximum tailings dam section prior to closure to assess the maximum potential impacts of downstream inundation. Following the lowering of the tailings pond at closure, the potential impacts of a dam breach will be less. Consequently, the Ultimate Stage was the selected setup upon which the breach analysis was conducted.

3.0 OBJECTIVES OF DAM BREACH ANALYSIS

The overall objective of this analysis is to assess the flooding and tailings runout impacts downstream of the TMF in the unlikely event of a breach of a perimeter embankment and release of water and/or tailings water. Dam breach and related inundation studies are based on hypothetical scenarios. A dam breach and inundation study does not constitute an implied weakness in the design and construction of the dam or any likelihood of failure. Rather, it assumes that a breach is initiated irrespective of likelihood and assumes hypothetical but credible failure modes based on assumed site conditions and historic dam failures at other locations. This is a sensitivity study, which will be used to also confirm hazard classification for the TMF dams, and to provide information crucial for effective emergency preparedness planning.

Specific objectives include the following:

- Review various dam failure mechanisms and determine the plausible failure scenarios
- Estimate the volume of tailings and water released from a hypothetical dam breach
- Determine the areal extent of the flooding impact in the event of a dam failure
- Determine peak flood wave water levels and travel time resulting from the hypothetical dam failure

- Estimate runout extent of a tailings-only breach release in the event of a dam failure

The TMF will be developed over six stages, including start-up. A tailings pond will form at the toe of the deposited tailings towards the east end of the TMF. With continued tailings deposition, the size of the TMF Pond increases from 0.34 Mm^3 in Year 1 to 0.76 Mm^3 in Year 10. At the Ultimate Stage configuration, the potential magnitude of water and liquefied tailings discharged from site in the event of a breach is considered to be the greatest. This configuration was therefore used in this dam breach assessment and inundation study. Tailings storage in the Leprechaun Pit is not considered in this analysis.

Embankments and dams can potentially fail at any location. For the purpose of this study, dam breach locations have been selected based on dam configurations and the topography to represent the worst-case scenarios.

The three locations assessed for this study were Locations A, B and C (Figure 3):

- Location A: At this location, the pond depth is at its maximum, resulting in the highest head to drive release flows in the event of a breach. Under fair-weather conditions, the water level in the pond is lower than the tailings beach against the dam. Under PMP conditions, the water level could rise and come in contact with the dam; allowing for both water and tailings release in the event of a breach under flood conditions.
- Location B: This location has the largest tailings depth. It is also the location where, if a breach were to occur, the resulting flow path is closest to the Victoria Dam. The tailings deposition has been modified to maintain the pond away from the dam. Under fair-weather or PMF conditions, the release of water under a breach is not anticipated. There is, however, the potential for a tailings release in the event of a breach at this location.
- Location C: The tailings dam is higher than Location A and does not contain the pond. Although there is no potential for water to be released at the western part of the TMF dam, a tailings breach at this location is a potential risk to the plant site and personnel.

Figure 4 shows the flow paths associated with the three potential breach failures.

A breach of the TMF dam could result in water and/or tailings discharging into Victoria River, potentially ponding near the toe of the Victoria Dam, and more likely, flowing downstream, ultimately discharging to Red Indian Lake, approximately 60 km northeast of the site. Red Indian Lake discharges to Bay of Exploits via the Exploits River. Depending on the location, a breach in the dam could also potentially impact the plant site and / or the Polishing Pond, before the discharge is conveyed towards the Victoria River.

The simulations of the flood wave resulting from a release of water and tailings from a hypothetical failure of the TMF dam at Location A were conducted along the flow path as shown in Figure 4 as follows:

- A failure of the dam at Location A would release the impounded water and tailings, with the surge wave travelling along headwater of the Victoria River reaching the confluence with Red Cross Lake approximately 5.1 km downstream of the TMF; then through the confluence with Valentine Lake and Long Lake a further 1.7 km downstream.
- The surge wave will then propagate through the downstream subwatershed along several confluences of Victoria River including Quinn Lake, Kelly's Pond and Bobby's Pond approximately 14.3 km, 40.3 km and 45.5 km downstream the TMF, respectively, before reaching the inlet to Red Indian Lake approximately 60.0 km downstream the TMF.

The inhabited areas and relevant infrastructure along the flood wave paths resulting from a breach at Location A are the following:

- The first point of interest along the flow path is the Victoria Dam. Although it is upstream of the breach locations, the mild slope of the river in that location will generate backwater flows that will result in water flowing towards the toe of the Victoria Dam.
- A point of interest along the flood wave path is an abandoned railroad (referred to as Crossing 1 herein), located approximately 6.3 km downstream of the TMF. Crossing 1 is not considered critical infrastructure.
- The main points of interest along the flood wave path include dwellings and a hunting lodge located approximately 40 km downstream of the TMF and a gravel forestry access road used for forestry operations and recreational use (referred to as Crossing 2 herein), located 60 km downstream of the TMF (less than 200 m upstream the inlet to Red Indian Lake).

There is no water ponded on the southern and western portions of the TMF (even during extreme events); therefore, a breach of the dam at those locations (Locations B and C, respectively) would release tailings only. While a breach failure at Location B could infrastructure downstream along the Victoria River, a breach failure at Location C could also potentially impact site facilities (i.e., the Process Plant, Truck Shop, Polishing Pond, ROM Pad, and the exploration camp on the shores of Lake Victoria as shown in Figure 2) before tailings flow into the Victoria River.

The failure consequences will be evaluated for both the fair weather (FW – with tailings pond at the MOWL) and flood (PMF – with tailings pond at the maximum PMF level) conditions. CDA (2007) recommends that dam consequence classification should be based on incremental damages to the downstream environment had the dam not failed. The consequence classification for the dam is discussed in Section 9.0 below.

The following hypothetical breach scenarios are defined as part of this DBA and inundation study:

1) Scenario A-FW: the initial water and tailings release at Location A under fair-weather conditions to the maximum depth of the pond (CASE 1A in CDA 2020) (Sections 4.0 and 5.0)

   Scenario A-RO: Following the initial release of water and tailings under fair weather conditions, there is a subsequent runout release of liquefied tailings at Location A to the full height of the dam at this location (CASE 2A in CDA 2020) (Sections 4.0 and 5.0)

2) Scenario A-PMF: the initial water and tailings release at Location A under flood-induced conditions to the maximum depth of the pond (CASE 1A in CDA 2020) (Sections 4.0 and 5.0)

   Scenario A-RO: Following the initial release of water, there is a subsequent runout release of liquefied tailings at Location A to the full height of the dam at this location (CASE 2A in CDA 2020). (Sections 4.0 and 5.0)

3) Scenario B-RO: Runout release of liquefied tailings at Location B to the full height of the dam at this location (CASE 2A in CDA 2020) (Sections 6.0 and 7.0)

4) Scenario C-RO: Runout release of liquefied tailings at Location C to the full height of the dam at this location (CASE 2A in CDA 2020) (Sections 6.0 and 7.0)

4.0 WATER AND TAILINGS RELEASE (TMF DAM LOCATION A)

This DBA follows the guidance document proposed by the Canadian Dam Association (CDA 2020) to assess the impact of a water and tailings release. The approach used provides relatively conservative estimates of the breach outflows. The numerical modelling for this approach followed a three-stage process:

1) **Breach Parameters** - Estimation of the breach formation parameters (geometry, development time) to be used in the hydrologic model as described on Section 4.1.2. The Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) model (HEC-HMS, 2021) software Version 4.6.1, developed by the U.S. Army Corps of Engineers (USACE), was used to develop the hydrologic model.

2) **Hydrologic Modelling** – This step estimates the pond's release volumes and the consequential breach outflow hydrographs. The volume of fluid released is discussed in Subsection 4.2.1 while the development of the hydrograph is described below in Subsection 4.2.2. The consequences of dam failure depend on the potential for release of the impounded water and tailings. The volume of water retained by the dam will govern the impact on the downstream area. HEC-HMS was used to generate the breach outflow hydrographs. The outflow hydrographs were then used as inputs to model the flood wave routing downstream.

   The dam breach analysis was carried out based on the following assumptions and criteria:

   - The TMF will be managed in a manner such that it adequately maintains storage for flood conditions. The initial water level in the TMF is therefore assumed to be at a MOWL of 388.4 masl for fair-weather ("sunny day") and flood-induced ("rainy day") conditions.
   - During the Probable Maximum Flood (PMF) event, the water level in the TMF will rise from the initial water level. The maximum water elevation reached in the TMF under a PMF event will be 391.0 masl (0.5 m above the spillway invert).
   - For the purpose of flood routing, the emergency spillway was considered unobstructed at the time of dam failure.

3) **Flood Routing** -The movement of the peak flood wave along the downstream path was simulated using the Hydrologic Engineer Center – River Analysis System (HEC-RAS) software Version 5.0.7 (HEC-RAS, 2016). This model performs the channel flood routing and calculates the potential inundation area and travel time. This version of the software can perform two-dimensional (2D) unsteady hydrodynamic routing. The outflow hydrographs generated by HEC-HMS were used as volumetric source terms at the breach locations to perform the flood routing. The flood routing is described further in Section 4.3.

4.1 Dam Breach Parameters

4.1.1 Failure Modes

The intent of the dam breach study is to identify credible, but conservative scenarios for dam failure for the purpose of emergency planning and confirmation of dam classifications. Several failure mechanisms have historically resulted in dam breaks (i.e., earthquakes, landslides, overtopping, internal erosion or piping, foundation failure and slope failures). Overtopping and piping failures are the most common causes of recorded dam failures (ICOLD 1995).

Geotechnical slope instability leading to a dam breach is unlikely as the TMF dams are expected to be founded on competent foundations, and the downstream slopes have been designed to meet the minimum target factors of safety (CDA 2013, 2019). The compacted rockfill and foundation soils are also not considered susceptible to liquefaction during an extreme seismic event.

Piping is the internal erosion of the embankment material due to the flow of water. While it is primarily a design and construction issue, piping can also develop over time due to burrowing animals, decaying root systems below the pond reservoir level, deterioration of the liner material or cracking caused by deformation. Piping manifests in the form of concentrated seepage and erosion of the dam fill, which can progress and cause a collapse of the dam crest.

Dam overtopping occurs when the inflow to the pond exceeds its storage and discharge capacities resulting in a rise of water level higher than the dam crest. Rapid down cutting would ensue as the dam fill is eroded by the flowing water. Both overtopping and piping, if not identified and corrected, could lead to a rapid breach of the dam section through progressive erosion of the fill materials and an uncontrolled release of the impounded water.

The failure modes used for the proposed Valentine Gold Project dam breach analysis at Location A were selected based on the following considerations:

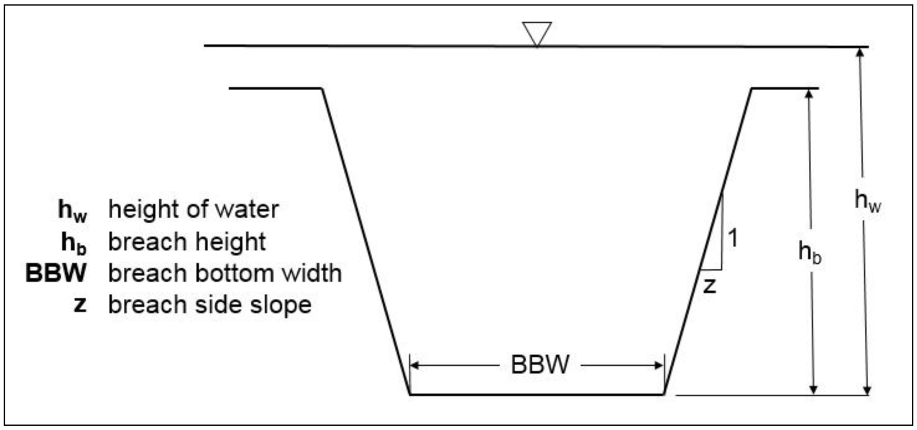
- Under fair-weather conditions, a piping failure at Location A is unlikely as the tailings pond level will be below the deposited tailings and approximately 120 m away from the TMF’s upstream dam face. However, piping was considered as the most plausible failure mechanism at Location A.
- Under the PMF, a piping failure at Location A is plausible as with the increased water volume the pond will approach the upstream face of the dam in the eastern region. An overtopping failure at Location A is not considered feasible as the spillway will maintain the pond water surface level well below the TMF’s dam crest.

The piping failure mode was therefore considered as the most plausible mechanism of failure for Location A under both fair-weather and PMF conditions.

Following the initial released of water and scoured tailings, additional tailings runout may occur at location A as tailings continue to erode from the scour of the initial water and tailings release.

4.1.2 Estimation of Breach Parameters

Every dam breach scenario requires unique dam breach parameters, as these are based on the physical characteristics specific to each breach (i.e., dam geometry, dam construction, and volume of impounded water and tailings) and the failure mechanism. The parameters necessary to characterize a dam breach are the breach geometry (breach bottom width, breach height, and breach side slope) as demonstrated in Schematic 1, as well as the breach development time (i.e., time of failure).



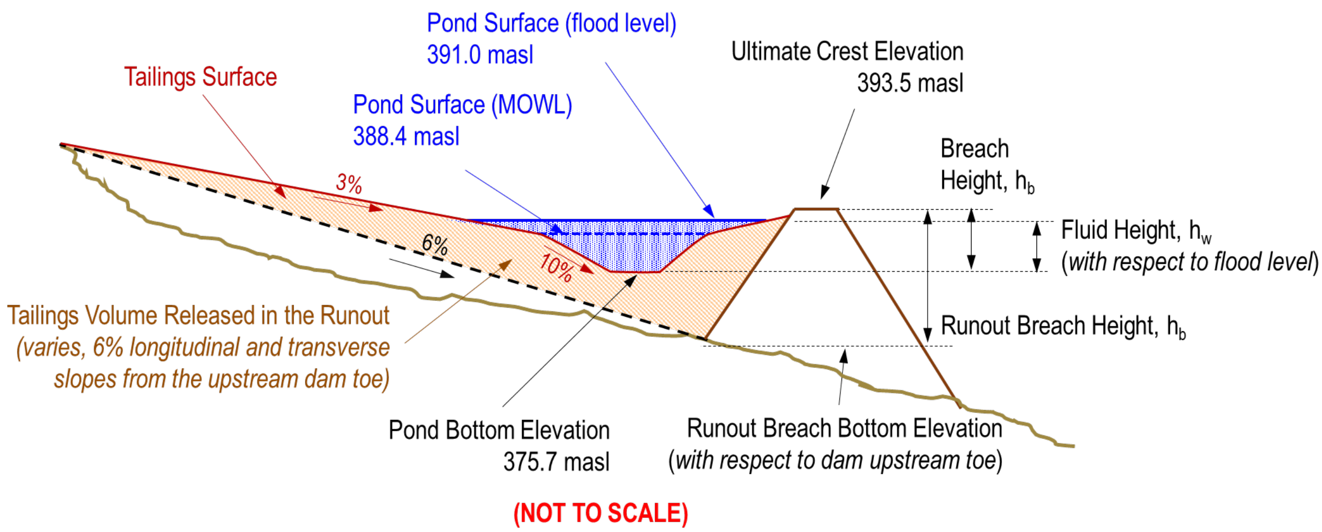
Schematic 1: Parameters of an Idealized Dam Breach

In the current study, the breach height h_b is considered to be the height from the dam crest to the breach channel's invert as a consequence to the erosive force of the released water.

Dam breach parameters for this study have been estimated using empirical relationships and methods developed from historic water dam failures as presented on Table 3. The various empirical equations typically result in a large variation in estimated values of the breach parameters. Because the equations vary widely, several available relationships have been used to develop an appropriate range of dam breach geometry values and development times. In the case of the elevation where piping is assumed to initiate, a range indicating the maximum and minimum value is based on the water surface level at the onset of the breach and the crest elevation of the previous dam raise, respectively.

The range of values are used to perform the sensitivity analysis of the breach outflow hydrographs. During a dam failure event in which water is released some of the impounded tailings will become entrenched and flow with the water. For the current study, the effective water storage was increased by 20% to account for tailings flow as slurry. Treating slurry flow as water will yield conservative estimates for flood inundation levels and time of travel.

During a breach, the erosive force of the water and slurried tailings will first erode the dam to the TMF pond bottom elevation. After this occurs, the erosive forces of the mobilised tailings may continue to erode the dam until it reaches the upstream toe of the dam. This secondary event is assumed to occur at a slower rate than the initial failure, and thus occurs after the tailings pond has emptied. Accordingly, the peak discharge hydrograph will be governed by the release of the pond storage.



Schematic 2: Conceptual Breach Channel Profile

Table 3: Regression Equations for Predicting Breach Parameters in Embankments Dams

Breach Width and Formation Time Equations		Notes
Average Breach Width (B) Equations		
Froehlich (1995a)	$B = 0.1803K_0V_wH_b$	Dependent on volume and height (overtopping). Where K_0 = 1.4 for overtopping and K_0 = 1.0 for other failure modes.
Froehlich (2008)	$B = 0.27K_0V_w^{0.32}H_b^{0.04}$	Equation developed in 2008 based on 74 embankment dam failures, it is an updated version of the 1995 equation. Where dimensionless coefficient K_0 = 1.3 for overtopping failure and K_0 = 1.0 for other failure modes.
Fread (2001)	$B = 9.5K_0(V_rH)^{0.25}$	Dependent on volume and height.
MacDonald & Langridge-Monopolis (1984) – earthfill dam	$V_{er} = 0.0261(V_wh_w)^{0.769}$	Useful as a check of the geometries of other predictions. Based on breach formation factor defined as the product of the volume of breach outflow and the depth of water above the breach invert at the time of failure.
MacDonald/Langridge-Monopolis (1984) – Non-earthfill dam	$V_{er} = 0.0261(V_wh_w)^{0.852}$	Non-earthfill (e.g., rockfill).
Breach Formation Time (t_f) Equations		
Von Thun and Gillette (1990) - erosion resistant soils	$t_f = 0.020h_w + 0.25$	Dependent on height only. More relevant for rockfill, erosion resistant cores, etc.
Froehlich (1995b)	$t_f = 0.00254(V_w)^{0.53}h_b^{-0.9}$	Dependent on volume and height.
Froehlich (2008)	$t_f = 63.2(V_w \div gH_b^2)^{0.5}$	Dependent on volume and height.
Fread (2001)	$t_f = 0.3\ V_r^{0.53}/H^{0.9}$	Dependent on volume and height.
MacDonald & Langridge-Monopolis (1984) – earthfill dam	$t_f = 0.0179V_{er}^{0.364}$	Based on V_{er} calculated for earthfill dams.

Sensitivity Analysis

Sensitivity analyses were performed for the outflow hydrographs using a range of dam breach parameters evaluated for each dam breach scenario under CASE 1A in CDA 2020 (i.e., Scenarios A-FW and A-PMF) using the equations presented in Table 3. These analyses were performed using HEC-HMS software.

The Monte Carlo method was used to estimate the uncertainty in the outflow hydrographs given the uncertainty in each of three dam breach parameters; final breach bottom width, breach formation time and piping elevation. The Monte Carlo method works by creating several alternative models of the dam breach using an automated sampling procedure. Each breach model is created by sampling the model parameters according to their individual Probability Density Function (PDF). Each model is simulated to obtain an outflow hydrograph response corresponding to the sampled parameter values. The outflow hydrograph results were analyzed statistically to evaluate the uncertainty in the simulated breach response. Golder selected representative dam breach parameters leading to realistic but conservative outflow hydrographs for each scenario based on the sensitivity analysis results. The breach parameters that led to a peak flow corresponding to the mean plus one standard deviation results of the sensitivity analysis were selected.

The key failure characteristics including the estimated dam breach parameters for Scenarios A-FW and A-PMF are summarized in Table 4.

Table 4: Dam Breach Parameters, Location A – Fair-Weather and PMF Conditions

Dam / Breach Parameter	Scenario A-FW	Scenario A-PMF
Breach Location[1]	Location A	
Climate Condition	Fair-Weather	Flood Induced
Breach Failure Mechanism	Piping	
Pond Water Elevation (masl)	388.4	391.0
Volume of Water Released from Pond (x 1,000 m³)	799	1,458
Tailings Elevation Against the Dam (masl)	389.9	
Estimate of Volume of Tailings Released[2] (x 1,000 m³)	160	292
Final Bottom Breach Width (m)[3]	13.2	18.4
Final Top Width of Breach (m)[3]	39.5	43.3
Pond Bottom Elevation (masl)	375.7	
Final Bottom Elevation of Breach (masl)[3]	375.7	
Foundation Elevation (masl)	358.5	
Final Breach Height (m)[3]	17.8	17.8
Piping Elevation (masl)	387.75	390.75
Breach Side Slope (H:1V)	0.7	
Maximum Depth of Water behind Breach (m)[3]	12.7	15.3
Breach Formation Time (hr)	0.297	0.404
Peak Outflow (m³/s)	1,067	1,735

Notes:

1) Breach location chosen to maximize the volume of fluid released.

2) Tailings volume represents the amount of tailings released due to dynamic liquefaction and erosion of tailings as described in Subsection 4.2.1. This volume is added to the free pond volume as effective storage in assessing breaching parameters.

3) Final breach geometry and dimensions reported here in this table correspond to the release of the water in the pond. The final breach geometry and dimensions corresponding to a tailings runout are defined in Section 4.4.

Following the initial water and tailings release, further downcutting could occur due to the highly erosive forces of the liquified tailings such that the breach channel invert would propagate towards the upstream toe of the dam following the initial release of the pond volume (Scenario A-RO – Case 2A). The breach parameters estimated for such an event are presented in Section 4.4.

4.2 Hydrologic Modelling and Dam Breach Simulations

4.2.1 Volume of Water Released and Tailings Mobilized

The proposed TMF dam impounds both water and tailings. In this study, the total volume of 'water only' considers the "free" water, defined as the water above the tailings surface. The pore water within the tailings is accounted for in the mobilized tailings volume.

The volume of "free" water released from the TMF Pond was calculated based on the pond volume above the tailings surface up to the MOWL for the fair-weather scenario and maximum water level in the pond under the PMF scenario. As stated previously, after reviewing the tailings and pond volumes over the life of mine, the ultimate stage was selected for the dam breach assessment as it will result in the most critical release of tailings and water in the even of a breach. The pond volumes were calculated from stage-storage curves developed from the CAD model pertaining to the updated project design (Golder 2021a). The estimates of water volume to be released are presented in Table 4 for Scenarios A-FW and A-PMF.

The volume of tailings mobilized due to erosion for hypothetical breaches of Location A of the TMF dam containing a supernatant pond (i.e., CASE 1A in CDA, 2020) was assumed to be 20% of the volume of the "free" water. As previously mentioned, it is credible that a tailings runout follows the initial release of water from the TMF pond, consequently breaching the TMF dam to its base (CASE 2A in CDA 2020). The tailings estimates for this mode of failure is discussed in Section 4.4.

4.2.2 Breach Outflow Modelling

A HEC-HMS hydrologic model was developed to simulate the hydrological response in a watershed and to simulate a reservoir dam failure either by overtopping or piping failure modes.

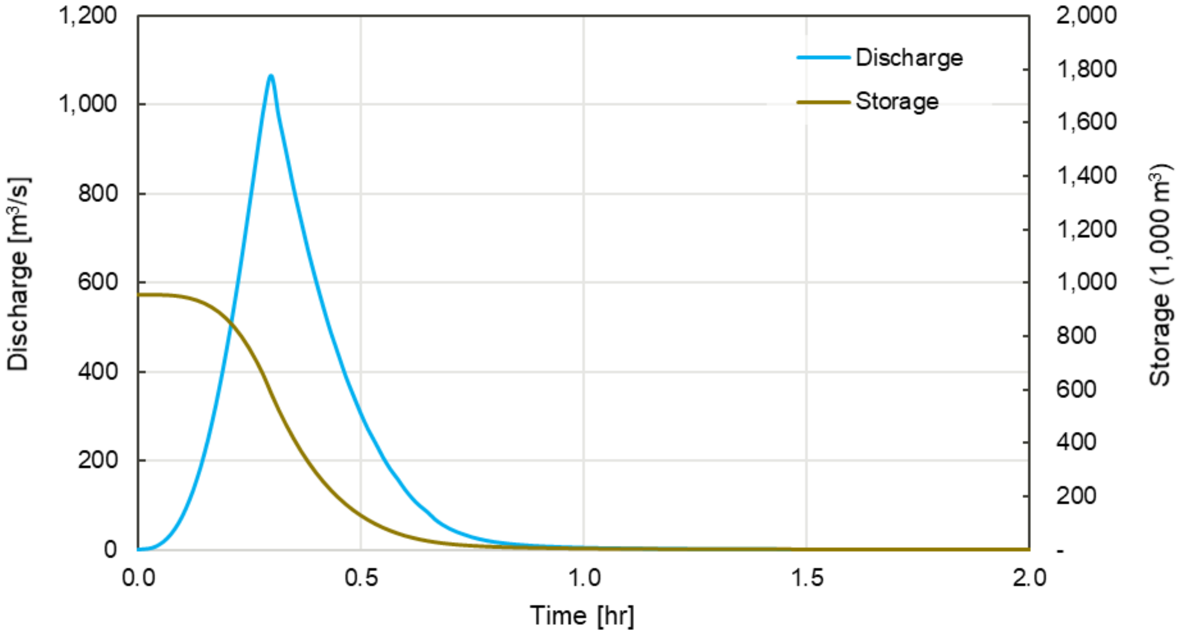
The hydrologic model inputs are as follows:

- Piping failure mode for both fair-weather and flood-induced (PMF) scenarios
- Initial water level in the TMF Pond assumed at MOWL 388.4 masl under fair-weather conditions
- Initial water level in the TMF Pond at the start of the PMP storm is assumed at MOWL 388.4 masl. The maximum water level in the TMF Pond 18 hours into the PMP storm was estimated at 391.0 masl. In the hydrologic model, the dam breach was triggered at 391.0 masl, corresponding to the maximum water surface level in the pond
- 24-hr Probable Maximum Precipitation (PMP) depth used for the Buchans Environment and Climate Change Canada (ECCC) meteorological station (ID: 8400698) is 450.3 mm (Meteorological Service of Canada, 2016).
- Breach parameters as listed in Table 4
- Stage-Storage curve developed for the TMF Pond and tailings
- Emergency Spillway stage-discharge rating curve in the PMF scenario (spillway invert level is at 390.5 masl)

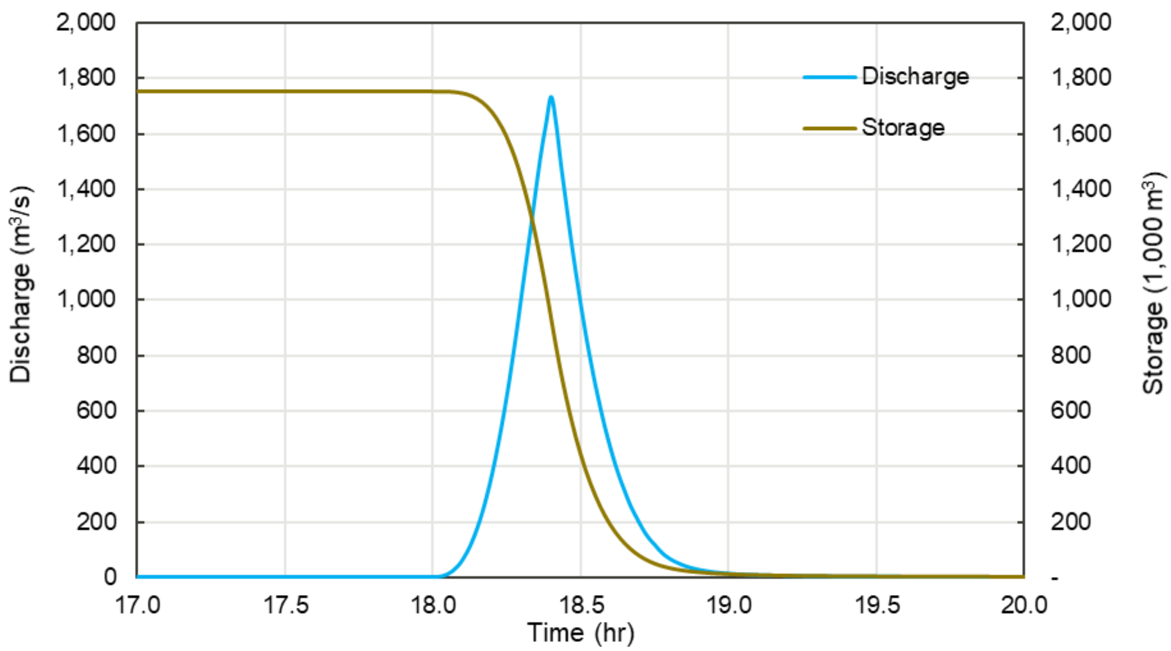
The breach geometry was estimated assuming the failure would occur where the tailings surface against the dam is at its lowest as a conservative approach. This assumption provides the maximum plausible breach size and consequently the largest outflow. The breach geometry presented in Table 4 was estimated for the maximum dam height for the flood wave path direction, as it generates the largest peak outflow and largest inundation consequences.

The peak outflows resulting from the hypothetical failure simulation corresponding to the fair-weather and flood-induced scenarios are presented in Table 4. The peak discharge from the breach is governed mostly by the volume of water in the TMF Pond.

Under fair-weather conditions (Scenario A-FW), the breach peak outflow from a piping failure at Location A reporting to Victoria River is 1,067 m^3/s. Under the flood-induced failure at Location A (Scenario A-PMF), the peak breach outflow is 1,735 m^3/s for the piping failure mode. The generated outflow hydrographs are presented on Graph 1 and Graph 2.



Graph 1: HEC-HMS TMF Location A Breach Outflow Under Fair-Weather Conditions – Piping Failure (Scenario A-FW)



Graph 2: HEC-HMS TMF Location A Dam Breach Outflow Under PMF Conditions – Piping Failure (Scenario A-PMF)

4.2.3 Baseline Flows in Downstream Watersheds

The baseline hydrological conditions of the downstream watersheds refer to the downstream water levels and flows along the flood path prior to dam failure. The hydrological conditions are dependent on the proposed initial conditions (i.e., fair-weather or flood events including PMF weather conditions). Canadian Dam Association (CDA) recommends evaluating incremental dam breach failure consequences taking into consideration initial conditions that are most likely to occur coincident with the breach event (CDA 2019).

A HEC-HMS model was developed for the Victoria River watershed, downstream the TMF dam. Subwatershed delineation was conducted using 2 m topographic contour data assisted by available online cartographic resources (NHN 2020). For modeling purposes, the watershed was divided into the following two subwatershed areas:

- From the headwaters at Victoria Lake Dam up to the confluence of Quinn Lake with an area of 580 km², including approximately 84 km² of lake surface.
- From the confluence of Quinn Lake up to the inlet of Red Indian Lake with an area of 314 km², including approximately 15 km² of lake surface.

Figure 5 shows a map of the two delineated sub-watersheds as well as the encompassing watershed of Red Indian Lake.

Fair-weather stream flows in the downstream flow paths were prorated based on the unit flow rate for the Great Rattling Brook above Tote River Confluence Water Survey of Canada (WSC) hydrometric station (ID: 02Y008) for the month of August (0.012 $m^3/s/km^2$), as presented in the 2020 hydrology baseline report (Stantec 2020). The 24-hour PMP was used to generate the baseline hydrological conditions in the downstream catchments for the flood-induced scenario.

Table 5 shows the 24-hour precipitation for return periods from 2-year to 100-year, extracted from Intensity-Duration-Frequency (IDF) information for the Stephenville ECCC meteorological station developed by Conestoga-Rovers & Associates (CRA 2015) and which were presented in the 2020 hydrology baseline study (Stantec, 2020). Golder selected to use IDF curves adjusted for climate change corresponding to the 2011-2040 time horizon, during which the volume of water in the TMF is at its maximum. The 1,000-year rainfall was extrapolated from the 2- to 100-year rainfalls. The PMP rainfall of 450.3 mm was extracted from the Buchans Environment and Climate Change Canada (ECCC) meteorological station (ID: 8400698) rain depth, duration and frequency analysis data (Meteorological Service of Canada, 2016).

Table 5: 24-hr Rainfall Events for Stephenville ECCC Meteorological Station (ID: 8403800)

Duration (hr)	Return Period (Years)							
	2	5	10	25	50	100	1,000[1]	PMP[2]
	Rainfall (mm)							
24-hr	65.1	86.4	100.7	118.6	131.8	144.8	192.5	450.3

Notes:

1) 1,000-year rainfall depth extrapolated from lower return periods (i.e., 2- to 100-year)
2) PMP rainfall depth extracted from Buchans ECCC Meteorological Station (ID: 8400698)

The initial conditions downstream of the dams under the PMF event were generated and assessed using a hydrological model. The following is a simplified description of the approach adopted:

1) Watershed characteristics such as drainage area, average length of stream channels and channel slopes from the delineated sub-watersheds were extracted from mapping software and input into the hydrological model.

2) A high-level calibration of a hydrologic input parameter representing precipitation losses was performed for the 24-hr 100-year storm event hydrographs. This input parameter was adjusted by matching the computed 100-year peak flow to an estimate derived from the regional regression equation defined in the 2020 baseline hydrology report (Stantec, 2020) for the North East hydrologic region of Newfoundland.

3) The PMF hydrographs were generated using the calibrated precipitation loss derived for the 24-hr 100-year storm and by applying the 24-hr PMP value of 450.3 mm.

4) The flood hydrographs under the PMP event and for the Victoria River watershed were estimated at three locations along the Victoria River as part of the downstream routing:

   i) Confluence of Red Cross Lake: Runoff at this location represents 10% of the runoff generated in the headwater subwatershed.

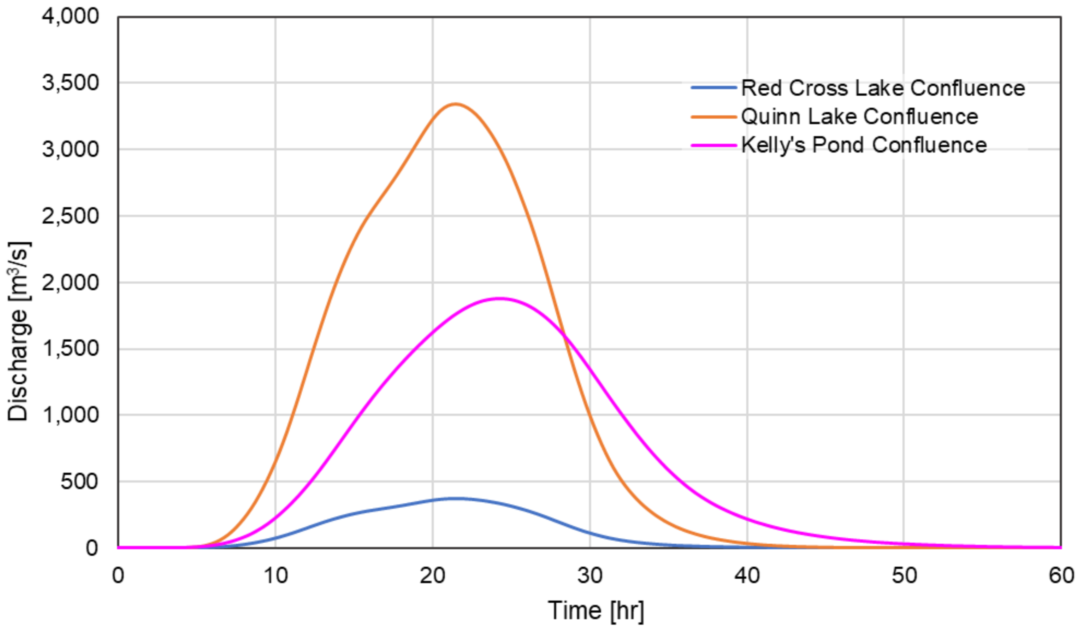
   ii) Confluence of Quinn Lake: Runoff at this location represents the remainder (i.e., 90%) of the runoff generated in the headwater subwatershed.

   iii) Confluence of Kelly's Pond: Runoff at this location represents the entire runoff generated in the downstream subwatershed.

The generated PMF hydrographs, as shown in Graph 3, were used as lateral inflows (i.e., natural watershed inflows to the waterways) in conjunction with the simulated dam breach flood wave to assess incremental consequences of a dam breach.

The setup of the hydrological model during the PMP event assumes that the flow through the dams along the Victoria River are unregulated. It is also assumed that no outflow from Victoria Lake into Victoria River will occur during the PMP event.

Under fair-weather conditions, the prorated baseline flows estimated for the two subwatersheds were apportioned according to the same ratios defined for the PMP baseline conditions (10% and 90% of runoff from the headwater subwatershed at the confluence of Red Cross Lake and Quinn Lake, respectively, and 100% of the runoff from the downstream subwatershed at the confluence of Kelly's Pond).



Graph 3: PMF Lateral Inflow Hydrographs Routed at Downstream Locations Along Victoria River

4.3 Flood Wave Routing

The HEC-RAS program used for the present analysis was Version 5.0.7. HEC-RAS is a computer program that models the hydraulics of water flowing through natural rivers and other channels. This version of the program (Version 5.0.7) can perform two-dimensional (2D) unsteady flow analysis, making it more suitable to support flood map development. The flood model has found wide acceptance by many since its public release in 2016. HEC-RAS was used to simulate the movement of the flood wave downstream of the breached dam to define the duration and spatial extent of the inundation area.

The hydraulic modelling using HEC-RAS involves the following steps:

- Preparation of the geometric model from the DEM generated based on available topographic data as described in the section below.
- Definition of model inputs.
- Definition of boundary conditions.
- Simulation of unsteady flow analysis.

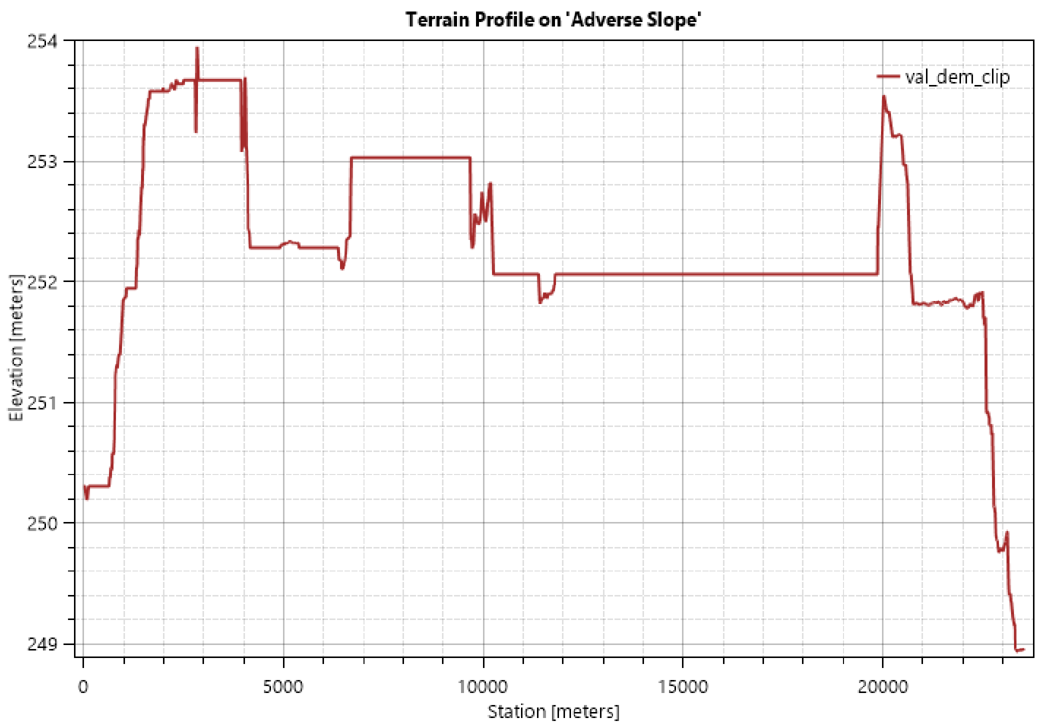
4.3.1 Geometric Model

An accurate terrain model is required for the development of a two-dimensional (2D) hydraulic model. The data source for the Project area are 10 m interval contours developed by the Government of Newfoundland. A 2 m DEM was then created by interpolating this contour dataset.

The grading plan of the access road, provided by Stantec (March 2021) was incorporated into the DEM.

Challenges Encountered

The resolution of the downstream topographic information provides low accuracy as there were both sudden and gradual increases of up to 3 m in bottom elevation along a 20 km reach of the Victoria River approximately 4 km downstream of Crossing 1 (Graph 4). Although it is not unusual to encounter adverse slopes (uphill) in digital terrain data (especially where crossings are present), this particular case does not coincide with crossings. This resulted in severe ponding within the river, event during low flow scenarios.



Graph 4: Adverse Slopes in the Terrain Data

Several attempts were made to correct the issue regarding the sudden increases and adverse slopes. The terrain was updated by lowering the ground elevation along this reach by means of a 5 m wide channel at the river's thalweg with 1:1 average side-slopes to facilitate the propagation of the flood wave in the hydraulic model.

4.3.2 Flow Domain / Model Boundaries

Red Indian Lake is a large freshwater body located approximately 60 km downstream of the TMF, with the largest drainage area in Central Newfoundland – 5,580 km^2 – approximately seven times the drainage area at its inlet with Victoria River. Red Indian Lake receives runoff from 10 riverine systems including Victoria River and has a surface area of 187 km^2, nearly 500 times the size of the TMF Pond by area. It is therefore anticipated that the water and tailings released from the TMF in the event of a dam breach will have negligible impacts on Red Indian Lake.

The flow domain for the TMF Location A dam failure simulations (Scenarios A-FW and A-PMF) extended from the downstream toe of Victoria Dam up to a station 1 km upstream of the inlet to Red Indian Lake. The reason for truncating the downstream model boundary is to avoid imposing a water surface level that is dependent on inflow from other sub-watersheds within the Red Indian Lake watershed.

4.3.3 Model Inputs

The following key inputs were required to simulate the movement of the dam breach flood hydrograph:

- Inflow hydrographs (dam breach flood hydrograph) immediately downstream of the dams for Location A which were generated by a hydrologic model using HEC-HMS. A total of two hydrographs, one under fair-weather and one under the PMF scenarios were input. The generation of these hydrographs is described in Subsection 4.2.2.
- Lateral inflow hydrographs under the PMF event for the TMF Location A failure by piping (Scenario A-PMF) were assigned at locations of confluences of the flood paths with the main streams. A total of three lateral inflows for the flood wave path were considered. The generation of these hydrographs is described in Subsection 4.2.3.
- Lateral inflow under fair-weather conditions was input based on the average streamflow rate estimated for the month of August from the Great Rattling Brook above Tote River Confluence WSC hydrometric station (ID: 02Y0008) as described in Subsection 4.2.3.
- Two roughness (Manning's) coefficients of 0.035 and 0.06 was used for the river channel and floodplain, respectively.

4.4 Tailings Runout Modeling

The tailings liquefaction runout at Location A was not simulated using a hydrological model due to the slurry-like flow behaviour of liquefied tailings. Instead, the failure was simulated as a tailings runout using Muk3D, which estimates the post-failure tailings footprint based on a defined beach slope downstream. The post-failure beach slope of the tailings deposited downstream the TMF was taken at the minimum grade suggested in CDA 2020 (2%) to yield conservative estimates. As presented in Section 3.0, runout of liquefied tailings will occur at Location A after the initial release of the pond upstream of the dam.

4.4.1 Estimation of Volume of Tailings Mobilized

There are several physical mechanisms that contribute to the mobilization of tailings including static and dynamic liquefaction (flow of tailings from sudden loss of strength), erosion of the tailings due to the turbulent flow exiting the breach, and erosion of the tailings surface due to the shear force on the tailings surface from the flow velocity as the water level in the tailings area drops. The estimation of the volume of mobilized tailings due to these mechanisms is very complex considering the spatial variability of tailings surface slopes and elevations, as do the tailings properties and the flow velocities. Instead, Golder used a simplified but conservative estimate where the approach based on the post failure tailings surface following the dam breach.

The volume of tailings mobilized due to liquefaction and erosion for a hypothetical breach at Locations A of the TMF dam was estimated based on an approximate geometrical configuration of the post-failure profile of the tailings surface in the failure scar area after its release downstream. Golder selected conservative post failure geometrical parameters in order to construct the projected tailings surface following the dam breach. A post failure slope equal to 6% within the TMF, corresponding to the average post liquified residual angle (CDA 2020), was adopted. The final width of the breach control section (breach entrance) was extrapolated by extending the width estimated following the initial release of water to the dam foundation. The extrapolation of the final breach channel width for the runout analysis was based on the width estimated for Scenario A-PMF since it is larger.

The key failure characteristics including the estimated dam breach parameters are summarized in Table 6.

Table 6: Tailings Runout Dam Breach Parameters – Location A

Dam / Breach Parameter	Scenario A-RO	
Climate Condition	Fair-Weather	Flood Induced
Tailings Elevation Against the Dam (masl)	389.9	
Estimate of Volume of Tailings Released[1,2] (Mm^3)	N/A	3.23
Final Bottom Breach Width (m)	26	36
Final Top Width of Breach (m)	96	106
Bottom Elevation of Breach (masl)	358.5	
Foundation Elevation (masl)	358.5	
Ultimate Breach Height (m)	35	
Final Breach Side Slope[3] (H:1V)	1	

Notes:

1) Not estimated for fair-weather condition. The runout analysis was based on the estimate of the volume of tailings released for the flood-induced conditions since the breach width is larger than the fair-weather conditions

2) Hydrograph characteristics not estimated as flow properties of liquefiable tailings are characterised as mudflow.

3) Assumed.

5.0 WATER AND TAILINGS RELEASE SIMULATIONS RESULTS (TMF DAM LOCATION A)

Maximum flood wave depth, peak flow, maximum flow velocity, maximum of the product of flood wave depth and flow velocity and peak flood wave travel time since initiation of the breach for the fair-weather and flood-induced conditions, respectively, were estimated using the HEC-RAS software for the following three simulations (Figure 6 through Figure 24:

- Dam breach at the TMF Location A under fair-weather (Scenario A-FW)
- Dam breach at the TMF Location A under flood-induced conditions (Scenario A-PMF)
- Victoria River flows under a PMF event (no dam breach).

Tables summarizing the results at specific stations of interest are shown on the Flood Inundation Map figures for the TMF East Dam breach failures under the fair-weather and flood-induced conditions on Figure 6 and Figure 13, respectively. Values at select points of interest such as trail/road crossings, dwellings/lodges and confluences along the flow path are shown on these figures. The critical points of interest within the model boundary are the Victoria Dam, the dwellings and hunting lodge upstream of Station 6 and the forestry access road immediately upstream the inlet to Red Indian Lake (i.e., Crossing 2). These points have been identified as critical infrastructure as they hold a strong potential for loss of life if they are inundated with a high enough velocity.

The Flood Inundation Maps also include the maximum water depth multiplied by flow velocity, which is an indicator of potential loss of life. The critical threshold is 0.37 m^2/s (0.6 m depth multiplied by 0.6 m/s stream velocity), OMNR (2002).

5.1 Red Indian Lake Impacts: Qualitative Analysis

The breach of the TMF Dam from Location A has the potential to release water and tailings through the flood wave path shown on Figure 4. Based on the release volume of water and tailings estimated, it is predicted that the increase in water surface elevation of Red Indian Lake as a result of a breach in the TMF dam will be in the order of millimetres, which justifies the downstream extent in the model. The assimilative capacity study issued under separate cover as part of this Project (Golder 2021b) describes the water quality downstream.

5.2 Fair-Weather Breach – Location A

A hypothetical failure of the TMF during fair-weather conditions at Location A (Scenario A-FW) would release the impounded water and suspended tailings. The consequential surge wave from the breaches will propagate downstream the Victoria River towards Red Indian Lake.

Results of inundation, flow depth, velocity and depth multiplied by velocity for a fair-weather failure (Scenario A-FW) are presented in Figure 6 through Figure 12. Based on the model results, none of the critical infrastructure would be inundated under this scenario. Details of the inundation near the Victoria Dam, dwellings and lodge and Crossing 2 are shown in Figure 10 Figure 11 and Figure 12, respectively. The following results can also be interpreted from this scenario:

- The peak outflow from the fair-weather breach scenario will attenuate by 71% after having traveled a distance of 1.6 km.
- The peak flow at Station 1 is 309 m^3/s above base conditions.
- The peak of the flood wave at the inlet of Red Indian lake is 14 m^3/s (3.6 m^3/s above baseline conditions).
- Victoria Dam will not be impacted under the fair-weather breach as the released water stops 0.7 km away from the toe of the dam.
- Crossing 1 will be inundated under the fair-weather breach. At this location, the peak depth multiplied by velocity exceeds the threshold value of 0.37 m^2/s (OMNR, 2002).
- Crossing 2 will not be inundated under the fair-weather breach and the flows at this location do not exceed the critical depth times velocity threshold value of 0.37 m^2/s.
- The dwellings and land hunting lodges upstream of Kelly's Pond Confluence are not impacted under a fair-weather breach.

5.3 PMF Breach– Location A

Results of inundation, maximum flow depth, maximum flow velocity and maximum depth multiplied by velocity along the flood wave flow path for the flood-induced failure by piping at Location A (Scenario A-PMF) are presented in Figure 13 through Figure 24. The Victoria Dam is shown in more detail in Figure 20. Details of the inundation around the dwellings and hunting lodge, upstream of Station 6, are shown Figure 21 and Figure 22. Details of the inundation Around Crossing 2 is shown in Figure 23 and Figure 24.

The following results can also be interpreted for this scenario:

- The initial release volume for the PMP-induced dam breach is 1.75 Mm^3, which represents approximately 0.5% of the PMF baseline no-dam failure runoff volume (328.8 Mm^3) at the Red Indian lake inlet.

- The peak water flow at the inlet of Red Indian Lake under a PMP-induced dam breach is about 4,228 m^3/s compared to a no-dam failure flow of 4,207 m^3/s (an incremental increase of 21 m^3/s).
- Victoria Dam will not be impacted under the PMP-induced breach as the released water stops 0.5 km away from the toe of the dam.
- The peak outflow from the PMP breach scenario will attenuate by 58% after having traveled a distance of 1.6 km.
- Crossings 1 and 2, as well as the dwellings and hunting lodge will be inundated under the PMF event with or without a dam breach.
- The arrival time of the flood wave at the dwellings and hunting lodge is 11 hours from the time of the breach. The arrival time of the flood wave at the Red Indian Lake is approximately 12 hours from the time of the breach.
- Under the PMF scenario with a dam breach, the incremental maximum depth multiplied by velocity did not exceed the threshold value of 0.37 m^2/s at locations outside riverbanks; the breach has no incremental impact on critical points of interest.

5.4 Tailings Runout– Location A

Following the initial water and tailings release, up to 3.23 Mm^3 tailings will runout eastward towards the Victoria River where it will be deposited. The maximum runout distance is approximately 1.8 km, with a maximum depth of tailings of 12 m. The runout distance will reach 1.2 km upstream and 1.2 km downstream in Victoria River, measured from where the main flow path connects with Victoria River. The upstream extent of the tailings runout will stop approximately 2.0 km from the Victoria Dam. The extent of the runout tailings and tailings depths are shown in Figure 25.

6.0 TAILINGS RUNOUT ANALYSES (TMF DAM LOCATIONS B AND C)

Outside of the zone of influence of the TMF Pond, breaches may still occur, releasing liquefiable tailings (defined as CASE 2A or CASE 2B in CDA 2020). The potential downstream impacts were assessed for potential breached at Locations B and C.

6.1 Dam Breach Parameters

6.1.1 Failure Modes

Geotechnical slope instability leading to a dam breach is unlikely as the dams are expected to be founded on competent foundations, and the downstream slopes have been designed to meet the minimum target factors of safety (CDA 2013 and 2019).

For TMF Locations B and C, given that piping and overtopping are not credible modes of failure (since there is no water against the dam-even under an extreme storm scenario), it is assumed that the most plausible cause for a geotechnical failure would be seismic loading coupled by poor construction or defective materials resulting in slope instability. It should be noted that the dam foundation is not susceptible to liquefaction. This sequence of events was assumed to occur at the southern and western portions of the TMF leading to liquefaction of the tailings and their runout downstream (Scenarios B-RO and C-RO).

6.2 Tailings Runout Modeling

As with Location A, the tailings liquefaction failures at Locations B and C simulated as a tailings runout using Muk3D due to the slurry-like flow behaviour of liquefied tailings. The post-failure beach slope of the tailings deposited downstream the TMF was taken at the minimum grade suggested in CDA 2020 (2%) to yield conservative estimates. The terrain layer used for the runout analysis incorporated the grading plan of the plant site and access road (Stantec, 2021), as well, the most recent polishing pond dam location (Golder 2021) into the topographic data from Aethon (2019) and the Government of Newfoundland.

6.2.1 Estimation of Volume of Tailings Mobilized

There are several physical mechanisms that contribute to the mobilizing of tailings including static and dynamic liquefaction (flow of tailings from sudden loss of strength), erosion of the tailings due to the turbulent flow exiting the breach, and erosion of the tailings surface due to the shear force on the tailings surface from the flow velocity as the water level in the tailings area drops. The estimation of the volume of mobilized tailings due to these mechanisms is very complex considering the spatial variability of tailings surface slopes and elevations, as do the tailings properties and the flow velocities. Instead, Golder used a simplified but conservative estimate where the approach based on the post failure tailings surface following the dam breach.

The volume of tailings mobilized due to liquefaction and erosion for a hypothetical breach at Locations A, B and C of the TMF dam was estimated based on an approximate geometrical configuration of the post-failure profile of the tailings surface in the failure scar area after its release downstream. Golder selected conservative post failure geometrical parameters in order to construct the projected tailings surface following the dam breach. A post failure slope equal to 6% within the TMF, corresponding to the average post liquified residual angle (CDA 2020), was adopted. The width of the breach control section (breach entrance) was taken as three times the dam height at that location.

The key failure characteristics including the estimated dam breach parameters are summarized in Table 7.

Table 7: Tailings Runout Dam Breach Parameters – Locations B C

Dam / Breach Parameter	Scenario B-RO	Scenario C-RO[2]
Location	**Location B**	**Location C**
Breach Failure Mechanism	Slope Instability	Slope Instability
Tailings Elevation Against the Dam (masl)	390.5	404.5
Estimate of Volume of Tailings Released[2] (Mm^3)	6.20	1.05
Final Bottom Breach Width (m)	122[1]	57[1]
Final Top Width of Breach (m)	203	95
Bottom Elevation of Breach (masl)	353.0	386.6
Foundation Elevation (masl)	353.0	386.6
Ultimate Breach Height (m)	40.5	18.9
Final Breach Side Slope[3] (H:1V)	1	1

Notes:

1) Assumed as three times breach height.

2) Hydrograph characteristics not estimated as flow properties of liquefiable tailings are characterised as mudflow.

3) Assumed.

7.0 TAILINGS RUNOUT RESULTS (TMF DAM LOCATIONS B AND C)

The results of the tailings runout model discussed herein are based on the current natural topography and grading plan. The extent of the runout tailings and tailings depths are shown in Figure 25.

7.1 Scenario B-RO

The 6.2 Mm^3 tailings will runout southward towards the Victoria River. It is predicted that the tailings will be deposited in the Victoria River immediately south of the TMF but will stop approximately 150 m short of reaching Victoria Dam. The maximum runout distance is approximately 2.2 km, with a maximum depth of tailings of 22 m. The runout distance will reach 1.2 km upstream and 1.5 km downstream in Victoria River, measured from where the main flow path connects with Victoria River.

7.2 Scenario C-RO

The 1.05 Mm^3 tailings will runout in a southeast direction towards the Victoria River. It is predicted that the Truck Shop Wash pad could be partially inundated as a result of the tailings runout. The maximum predicted inundation depths immediately downstream the dam and within the Truck Shop Wash are approximately 3.5 m and 2.0 m, respectively. It is also predicted that the Polishing Pond dam shell will be partially in the runout flow path, with a maximum predicted inundation depth of approximately 0.5 m. The tailings runout will partially follow the TMF southwestern dam shell, until the released tailings flow downstream and are finally deposited south of the TMF in the Victoria River. As with Scenario B-RO, the tailings will stop approximately 150 m short of reaching Victoria Dam. The runout distance will reach about 840 m upstream and 740 m downstream in Victoria River, measured from where the main flow path connects with Victoria River. The maximum depth of tailings in the Victoria River is 7.5 m. Since the terrain model was developed using a truncated topographic dataset, it is expected that the downstream extent of the runout footprint would extend further downstream, but not extend beyond the downstream extent of the footprint corresponding to the runout emanating from Location B.

The runout model considers the future grading plan of the plant site infrastructure as well as the Polishing Pond. It is expected that the grading and configuration of the plant site will impact the ultimate inundation extent and depth within the plant site area.

While the location of the runout analysis was selected based on the largest potential tailings release, a failure north of the selected location will likely impact both the Truck Shop Wash and ROM Pad. The topographic characteristics of the site also indicate the runout path follows the downstream toe of the southernmost portion of the TMF Dam for about 500 m. The depth of tailings at the toe is approximately 4 m. Given the slope and gross width of the rockfill dam, the net effect of any scour in the vicinity as tailings are deposited is expected to be minor. Consequently, the rockfill dam shell is unlikely to be affected.

8.0 DAM BREACH SUMMARY

This dam breach assessment provides useful information to identify hazards and consequences from a hypothetical failure of water and tailings containment dams in the proposed Valentine Gold Project TMF. The present study will support the emergency response planning and verify the Hazard Potential Classification of the dams following CDA guidelines, as presented in Section 9.0, below.

Subsection 5.0 provides a summary of the inundation characteristics for all scenarios analysed in this study. The conclusions are as follows:

TMF Dam Location A – Fair-Weather Scenario

- Under fair-weather conditions the most plausible mode of failure is piping.
- The breach outflow hydrograph undergoes a significant attenuation within the first 2 km (> 70%).
- Crossing 1 may be inundated under the fair-weather breach. At this location, the peak depth multiplied by velocity exceeds the threshold value of 0.37 m^2/s.
- No potential loss of life or critical infrastructure is anticipated due to the breach at Location A by piping.
- Following the initial release of water and tailings, there will be a subsequent runout of liquefied tailings below the base of the pond and down to the dam foundation level. The liquefied tailings are predicted to runout eastwards towards the Victoria River, but will have no impact on any points of interest.

TMF Dam Location A – PMF Scenario

- Under PMF conditions the most plausible mode of failure is piping.
- The breach outflow hydrograph undergoes a significant attenuation within the first 2 km (> 50%).
- Crossings 1 and 2, as well as the dwellings and hunting lodge will be inundated under the PMF event with or without a dam breach.
- The incremental maximum depth multiplied by velocity did not exceed the threshold value of 0.37 m^2/s at locations outside riverbanks; the breach has no incremental impact on critical points of interest.
- Downstream of the TMF, no potential loss of life or critical infrastructure is anticipated due to the breach failure of Location A incrementally under the PMF scenario.
- Following the initial release of water and tailings, there will be a subsequent runout of liquefied tailings below the base of the pond and down to the dam foundation level. The liquefied tailings are predicted to runout eastwards towards the Victoria River, but will have no impact on any points of interest.

TMF Dam Location B – Tailings Runout Scenario

- The tailings runout analysis conducted for the Location B failure is assumed to occur following a geotechnical failure, such as seismic loading coupled by poor construction or defective materials resulting in slope instability.
- The runout analysis is based on the existing topographic features of the site. The tailings are predicted to runout southwards towards Victoria River, but will have no impact on any points of interest.
- Long-term tailings deposition planning is critical to prevent the tailings pond from developing at Location B and instead pushing the pond eastward towards Location A.

TMF Dam Location C – Tailings Runout Scenario

- Similar to Location B, the tailings runout analysis conducted for the Location C failure is assumed to occur following a geotechnical failure, such as seismic loading coupled by poor construction or defective materials resulting in slope instability.
- The runout analysis is based on the existing topographic mapping and design features associated with the plant site. The tailings are predicted to runout in a southeast direction towards the Victoria River, and will impact the Process Plant and any personnel within the runout path. In addition, the Polishing Pond dam shell will be partially inundated. The tailings will be deposited in Victoria River, but it is predicted that the tailings will not reach Victoria Dam. The tailings are predicted to runout southwards towards Victoria River but will have no impact on any points of interest.

9.0 VERIFICATION OF THE HAZARD POTENTIAL CLASSIFICATION

The results from the hypothetical dam breach were used to review the existing Hazard Potential Classifications (HPC) for the proposed Valentine Gold Project TMF dam. The dams were classified based on anticipated impacts of hypothetical dam failure in terms of loss of life, financial loss, and environmental and cultural damage in accordance with CDA Dam Safety Guidelines (CDA 2013). Table 8 serves as the basis for establishing the classification of dams according to the CDA Dam Safety Guidelines.

The dam safety program established in Newfoundland and Labrador requires that dams be designed, operated and maintained to meet the requirements of CDA Dam Safety Guidelines

Table 8: Dam Classification (CDA 2013)

Dam Class	Population at Risk	Incremental Losses		
		Loss of Life	Environmental and Cultural Values	Infrastructure and Economics
Low	None	Nil	Minimal short-term No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary Only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat Restoration or compensation in kind is highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities, for dangerous substances)
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat Restoration or in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

The analyses herein indicate that a failure at Location C poses a potential life safety risk for the population downstream in the Truck Shop Wash at the Ultimate Stage. The analyses herein indicate that the breach failure of the proposed TMF at Locations A and B pose no incremental life safety risks for populations downstream of the TMF.

Economic losses are potentially LOW, as there is no damage expected to the critical infrastructure identified as a result of a dam breach failure.

Environmental consequences from the breach failures of the TMF dam are assessed as part of the assimilative capacity study for this Project (Golder 2021b). The assimilative capacity assessment determined environmental effects related to water chemistry are moderate and alone would only correspond to a SIGNIFICANT classification. However, while not assessed directly in either assessments, environmental effects related to habitat destruction as a result of erosion and tailings deposition are assumed to correspond to a HIGH dam classification. A VERY HIGH dam classification is not selected as the affected habitat is not considered “critical” habitat.

On the basis of the assumed 100 or fewer lives at risk during the operating period, a VERY HIGH dam classification is appropriate (Table 8).

The current design criteria adopted for the proposed TMF dams are appropriate for the VERY HIGH dam classification.

10.0 RECOMMENDATIONS FOR FUTURE WORK

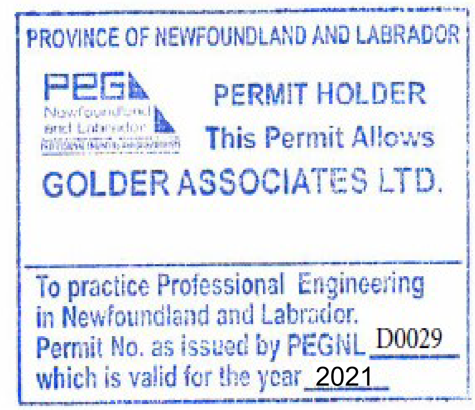
- As stated in Section 4.3.1, issues with the topographic data added a level of uncertainty to the analysis. The model was adjusted and successfully used for the assessment. However, for future studies, ground surveys are recommended to confirm the actual ground conditions. In addition to the river reach described in Section 4.3.1, it is also recommended to verify the bathymetric and drainage characteristics of the Victoria River, particularly near crossings, confluences, dwellings, and in narrow reaches where rapids and overfalls are often encountered.
- The hydrologic inputs are based on regional data (Section 4.2.3). For more accurate estimations of flow in the Victoria River, a flow monitoring program could be considered for the purpose of fulfilling hydraulic model calibration requirements. Continuous flow monitoring during periods of rainfall will improve estimates of loss parameters that govern hydrologic processes in downstream receivers and consequently estimates of baseline flows.
- While a relocation of the Plant Site 300 m west or southwest could potentially avert a potential inundation due to a tailings runout from the TMF Location C, the lives of the personnel conducting operations nearby the Plant Site remain at risk. The same is true for the polishing pond, where relocating it 50 to 100 m south could avoid a potential inundation, but the lives of the personnel conducting operations at the polishing pond remain at risk. Given the low risk of dam failure at this location the current layout of the process plant and associated infrastructure is acceptable.
- A potential dam failure and subsequent runoff of tailings at Location B was determined to have no impact on the Victoria Lake Dam on the basis that the tailings pond is pushed to the east side of the TMF and not released under the breach scenario. Future tailings deposition planning should focus on pushing the operating pond to the east side of the TMF in the location of the reclaim barge and emergency spillway.
- While a dam breach poses no threat to the dwellings along the Victoria River and to the communities along Red Indian Lake, it is still recommended to put in place a comprehensive emergency preparedness plan to ensure that there is a failure detection system and that all downstream stakeholders are notified expeditiously during a dam incident and that the appropriate evacuation requirements are met.

11.0 CLOSING

We trust the above meets your present requirements. If you have any questions, please contact the undersigned.

SIGNATURE PAGE

Golder Associates Ltd.



Adwoa Cobbina, P.Eng. (ON)
Water Resource Specialist

Peter Merry, P.Eng. (NL)
Principal, Project Director

Mahmoud Al-Riffai, Ph.D., P.Eng. (ON)
Water Resource Specialist

'To Be Signed at a Later Date'

Shiu Kam, P.Eng. (NL)
Principal, Senior Consultant

AC/PM/ms

Attachment: Figures 1-25

https://golderassociates.sharepoint.com/sites/126654/project files/5 technical work/05 reports/dam breach assessment (2021 update)/rev 0/doc files/20141194 (600) marathon gold_dam breach assessment_rev0_23dec21.docx

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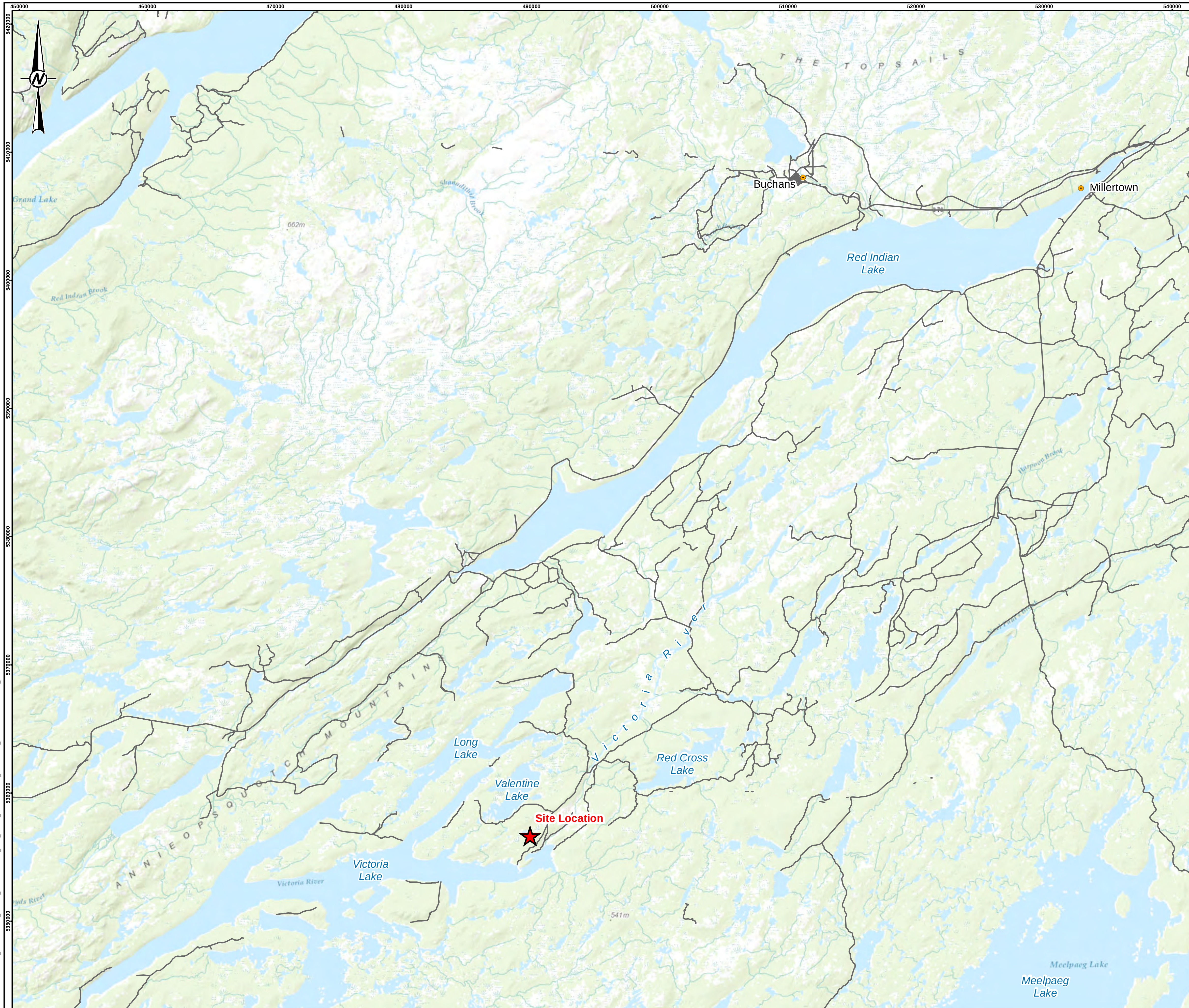
FIGURES



LEGEND

- Site Location
- Roads
- Waterbody

KEY MAP

0 7,500 15,000

1:300,000 METRES

NOTE(S)

REFERENCE(S)

SERVICE LAYER CREDITS: © OPENSTREETMAP (AND) CONTRIBUTORS, CC-BY-SA
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT
MARATHON GOLD

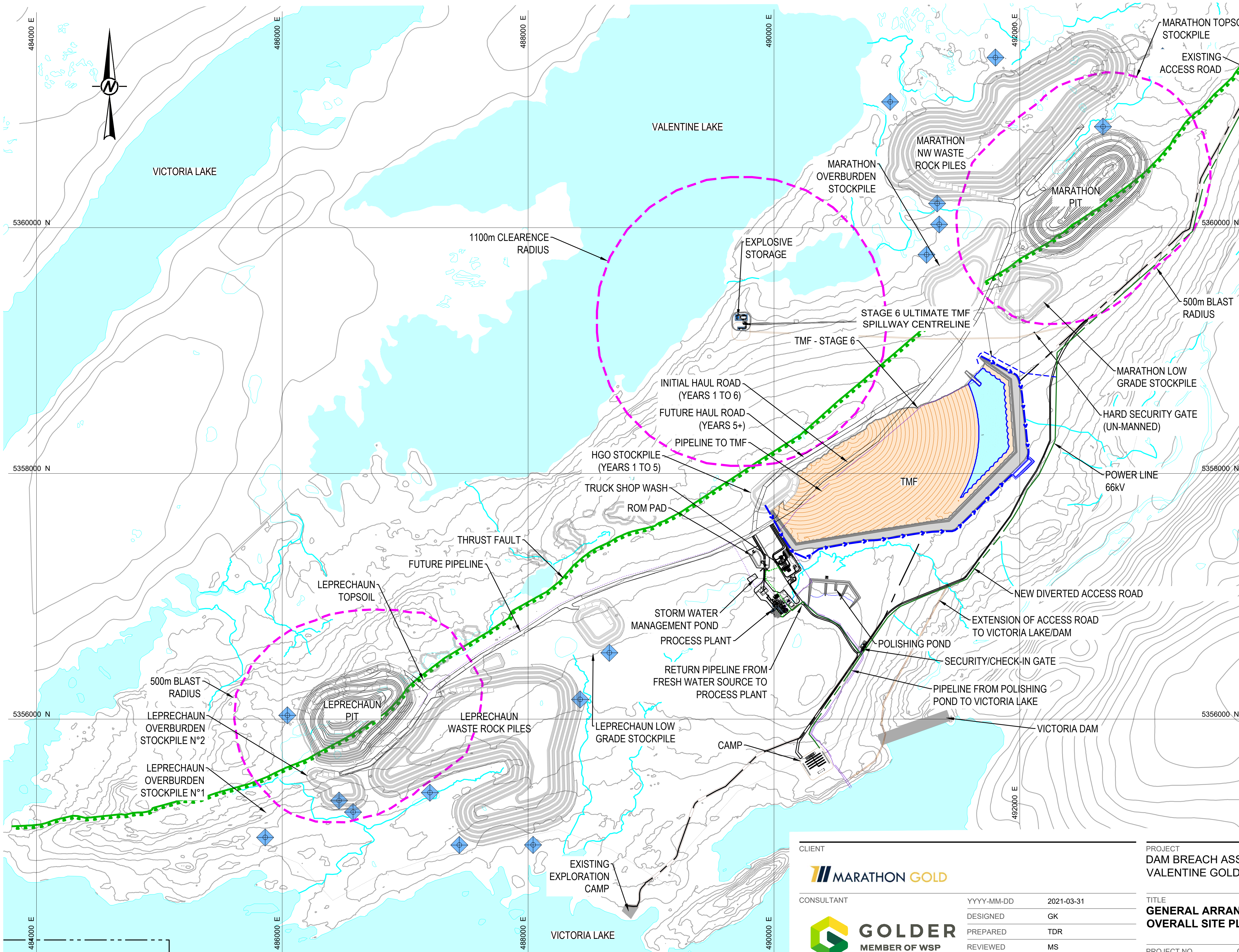
PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
SITE LOCATION PLAN

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	JUNE 2020
DESIGNED	MS
PREPARED	RRD
REVIEWED	PA
APPROVED	WPM

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	1



LEGEND

PROPERTY BOUNDARY

THRUST FAULT

NOTE(S):

1. PROJECTION: NAD83 UTM ZONE 21.

REFERENCES:

1. GROUND CONTOURS WERE PROVIDED BY CLIENT. FILENAME MRG_01_Valentine_Mine_Survey_Data_Delievery.ZIP, DATED 11/6/2019.
2. BASEPLAN PROVIDED BY AUSENCO. FILENAME 104878-0000-G-001__RevD_metres.DWG. DATED JAN18. 2021
3. STOCKPILES AND HAULAGE ROADS WERE UPDATED WITH FILES Valentine FS - Haul Roads - dxf - DRAFT - 201203.ZIP, Valentine FS - Leprechaun Stockpiles - dxf - DRAFT - 201203.ZIP AND Valentine FS - Marathon Stockpiles - dxf - DRAFT - 201203.ZIP AND Valentine FS - Marathon Stockpiles Update - dxf-DRAFT-201211.zip.
4. WATERCOURSES PROVIDED BY STANTEC. FILENAME WATER_BODIES_SHP AND WATERCOURSES_FINAL _2020.SHP DATED NOVEMBER 2, 2020.

CLIENT

MARATHON GOLD

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-03-31
DESIGNED	GK
PREPARED	TDR
REVIEWED	MS
APPROVED	WPM

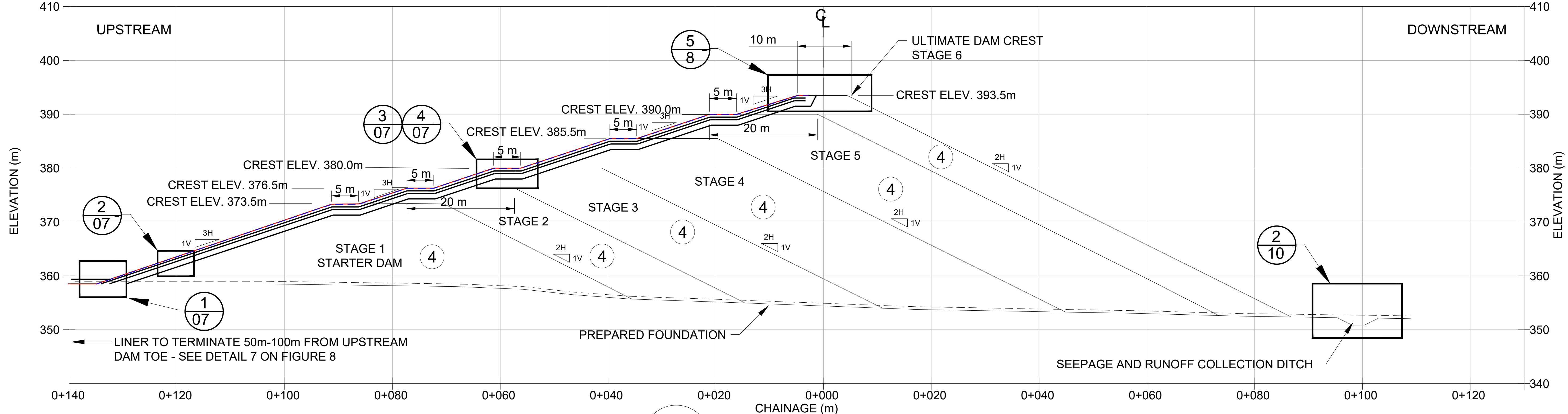
PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

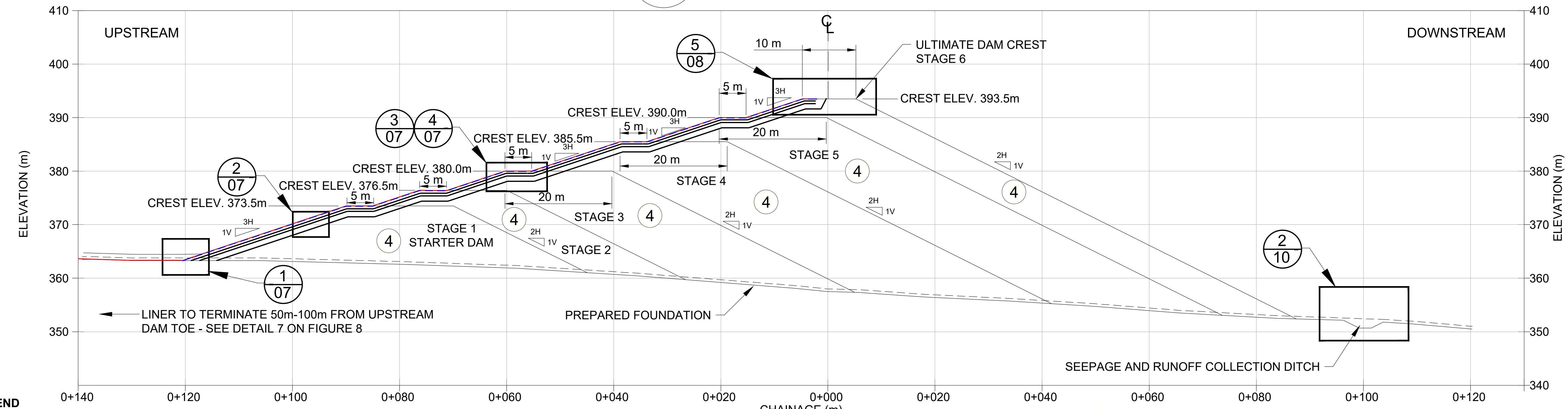
TITLE

GENERAL ARRANGEMENT
OVERALL SITE PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0001	0	2



SCALE 1:750 m — A / 03 — TYPICAL SECTION A - A'



SCALE 1:750 m — B / 03 — TYPICAL SECTION B - B'

LEGEND

- - - - ORIGINAL GROUND

CONSTRUCTION MATERIALS

1. FILTER / BEDDING SAND - 25mm MINUS
2. TRANSITION SAND AND GRAVEL - 75mm MINUS
3. SELECT ROCK FILL - 450mm MINUS
4. ROCK FILL - 900mm MINUS
5. ROAD SURFACING

LLDPE GEOMEMBRANE - 80mil DOUBLE SIDED TEXTURED

NON-WOVEN GEOTEXTILE (TERRAFIX 600R OR EQUIV.)

CLIENT: MARATHON GOLD

CONSULTANT: GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-01-27
DESIGNED	GK
PREPARED	TDR
REVIEWED	MS
APPROVED	WPM

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
TMF DAM TYPICAL SECTIONS

PROJECT NO.	CONTROL	REV.	FIGURE
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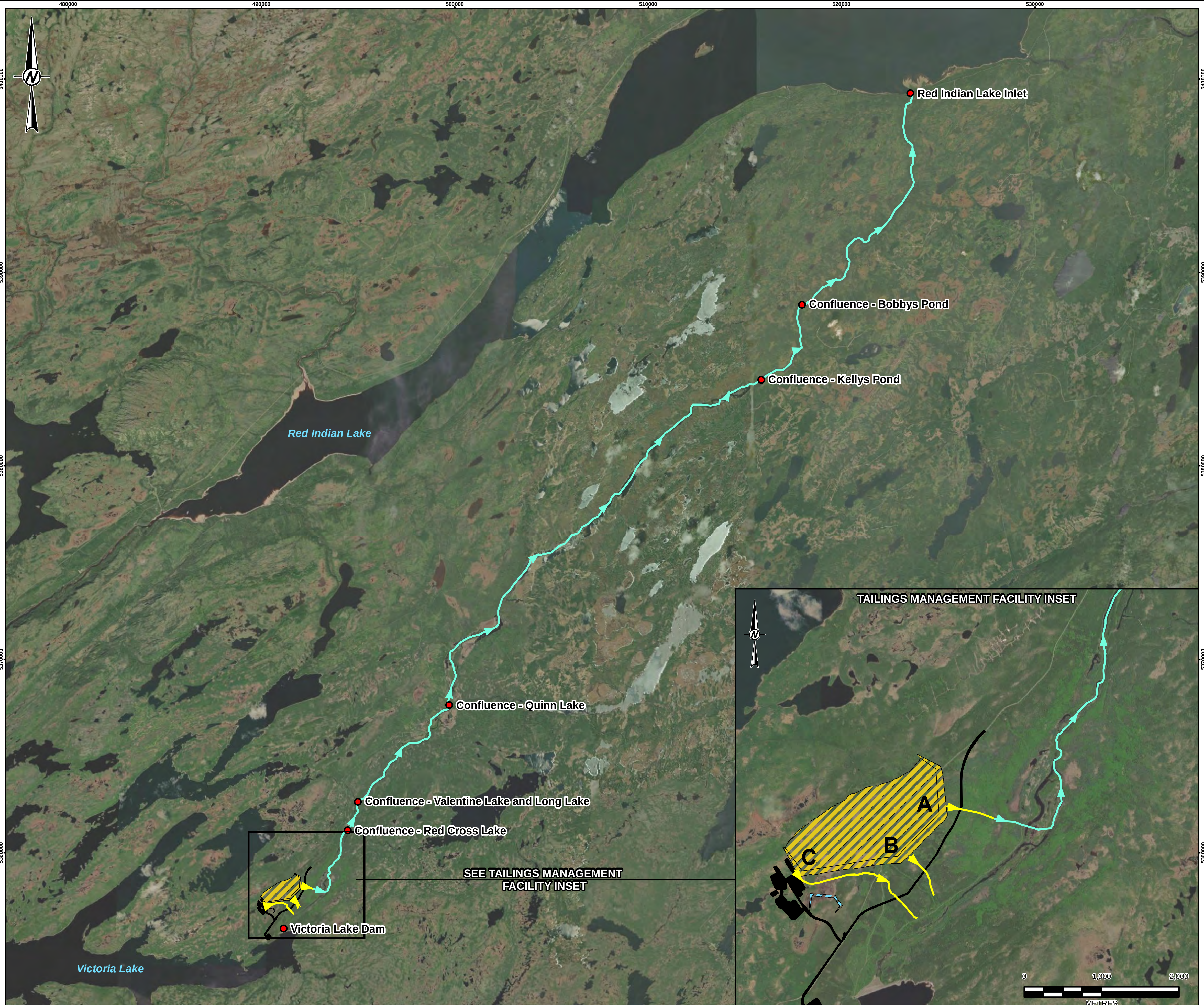

LEGEND

- Runout Path
- Floodwave Path
- Polishing Pond
- TAILINGS MANAGEMENT FACILITY
- PLANT SITE INFRASTRUCTURE

0 5,000 10,000

1:200,000 METRES

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

FLOODWAVE AND TAILINGS RUNOUT PATHS

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	4

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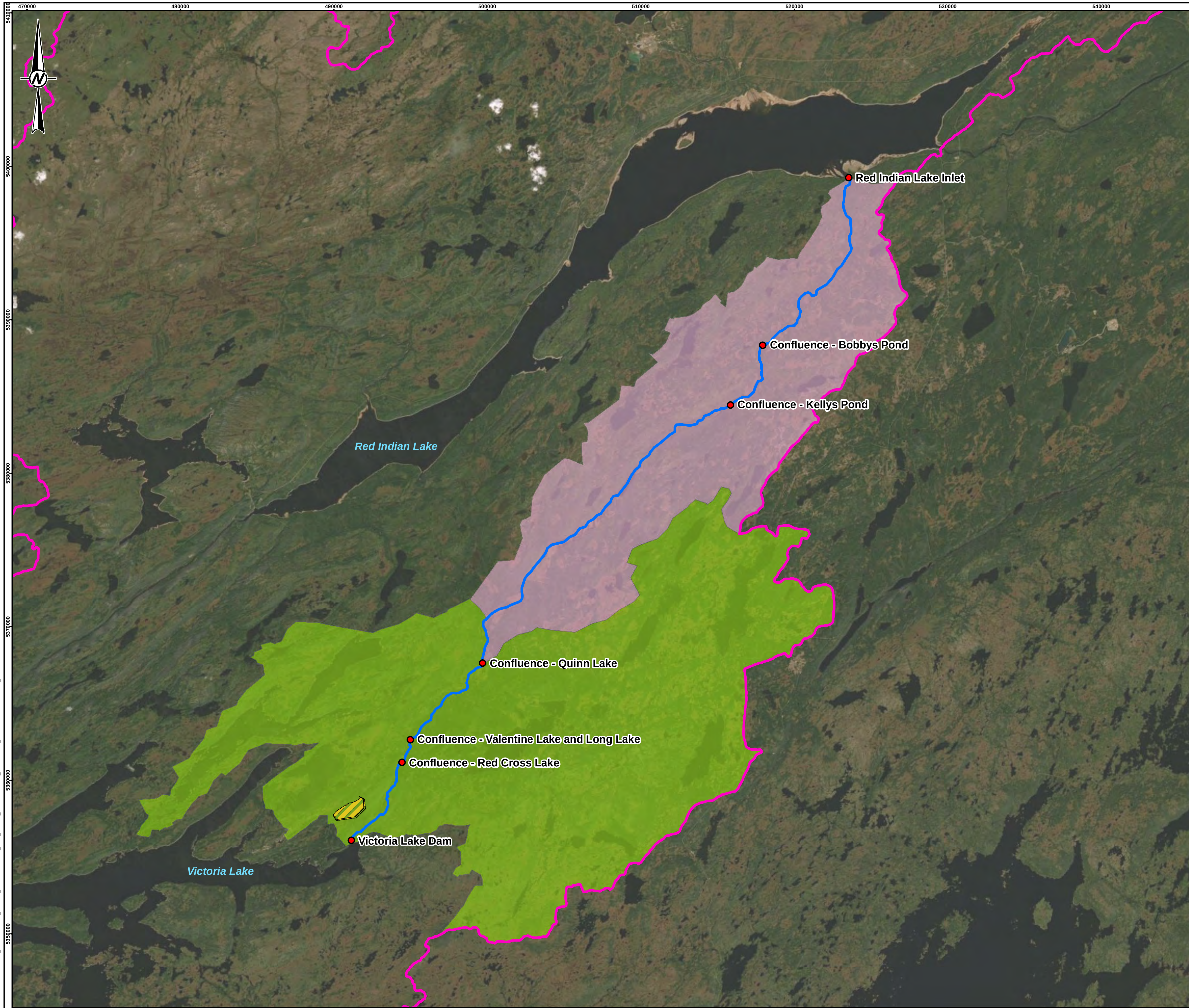
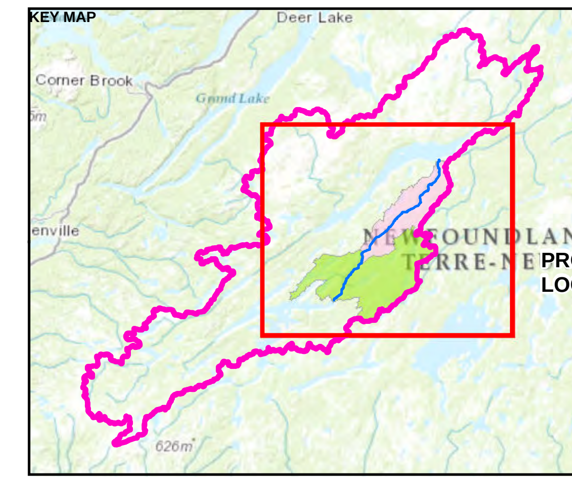


LEGEND

- VICTORIA RIVER
- TAILINGS MANAGEMENT FACILITY
- VICTORIA RIVER - DOWNSTREAM QUINN LAKE, LONG LAKE AND VALENTINE LAKE CONFLUENCE
- VICTIRIA RIVER - QUINN LAKE, LONG LAKE AND VALENTINE LAKE CONFLUENCE
- RED INDIAN LAKE WATERSHED



0 5,000 10,000
1:250,000 METRES

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
MODELLED VICTORIA RIVER SUBWATERSHED AREAS

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm

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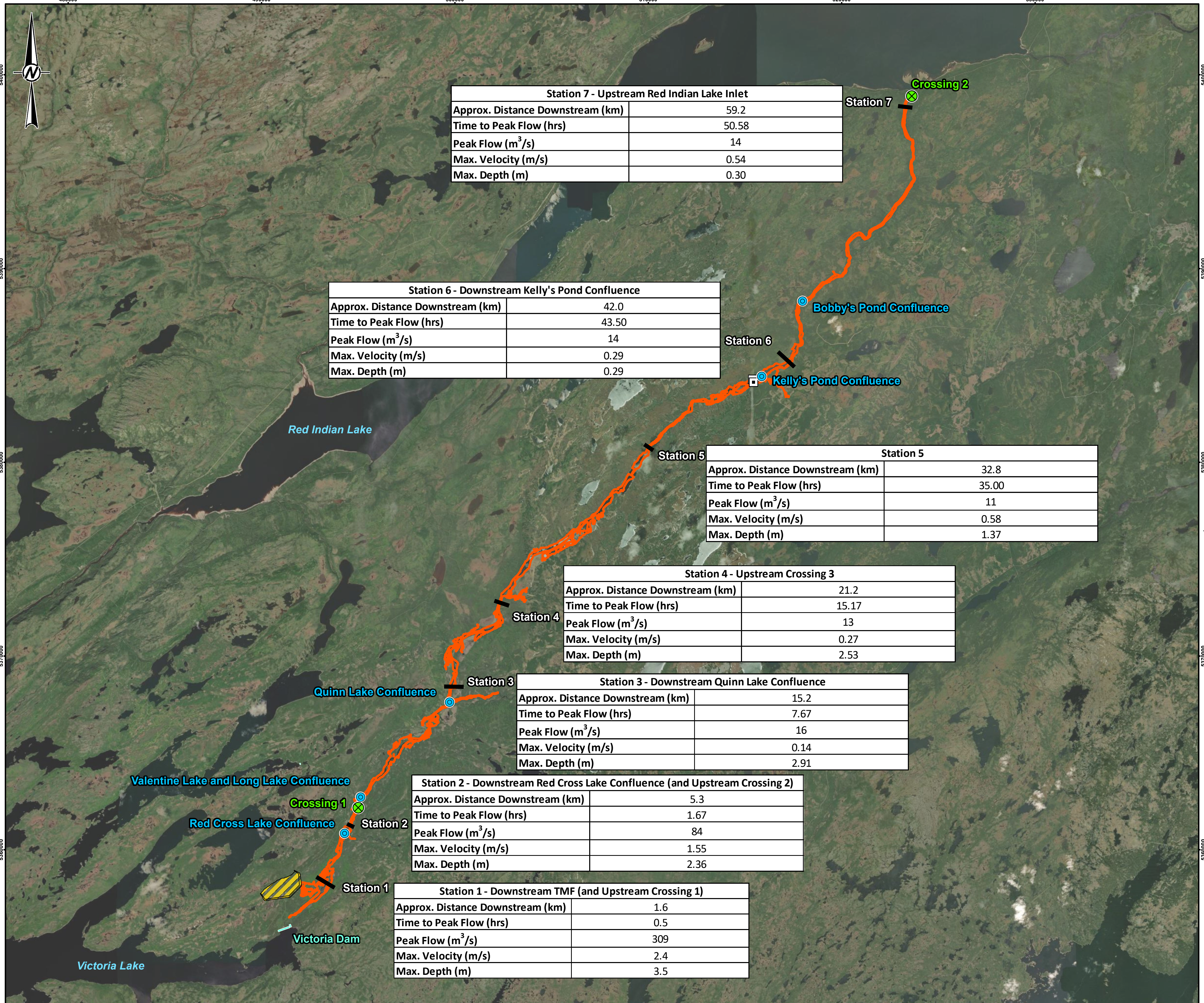


Station 7 - Upstream Red Indian Lake Inlet	
Approx. Distance Downstream (km)	59.2
Time to Peak Flow (hrs)	50.58
Peak Flow (m^3/s)	14
Max. Velocity (m/s)	0.54
Max. Depth (m)	0.30

Station 6 - Downstream Kelly's Pond Confluence	
Approx. Distance Downstream (km)	42.0
Time to Peak Flow (hrs)	43.50
Peak Flow (m^3/s)	14
Max. Velocity (m/s)	0.29
Max. Depth (m)	0.29

Station 5	
Approx. Distance Downstream (km)	32.8
Time to Peak Flow (hrs)	35.00
Peak Flow (m^3/s)	11
Max. Velocity (m/s)	0.58
Max. Depth (m)	1.37

Station 4 - Upstream Crossing 3	
Approx. Distance Downstream (km)	21.2
Time to Peak Flow (hrs)	15.17
Peak Flow (m^3/s)	13
Max. Velocity (m/s)	0.27
Max. Depth (m)	2.53

Station 3 - Downstream Quinn Lake Confluence	
Approx. Distance Downstream (km)	15.2
Time to Peak Flow (hrs)	7.67
Peak Flow (m^3/s)	16
Max. Velocity (m/s)	0.14
Max. Depth (m)	2.91

Station 2 - Downstream Red Cross Lake Confluence (and Upstream Crossing 2)	
Approx. Distance Downstream (km)	5.3
Time to Peak Flow (hrs)	1.67
Peak Flow (m^3/s)	84
Max. Velocity (m/s)	1.55
Max. Depth (m)	2.36

Station 1 - Downstream TMF (and Upstream Crossing 1)	
Approx. Distance Downstream (km)	1.6
Time to Peak Flow (hrs)	0.5
Peak Flow (m^3/s)	309
Max. Velocity (m/s)	2.4
Max. Depth (m)	3.5

LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY
- INUNDATION BOUNDARY (FW BREACH)

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
3. THE DAM BREACH ANALYSIS AND INUNDATION MAPS ARE BASED ON THE DIGITAL ELEVATION MODEL (DEM) GENERATES USING THE 10 M CONTOURS DEVELOPED BY THE GOVERNMENT OF NEWFOUNDLAND AND 1 M CONTOURS DEVELOPED BY AETHON AERIAL SOLUTIONS (2019). THE INUNDATION MAPS ARE INTENDED TO GUIDE THE DEVELOPMENT OF OVERALL EMERGENCY RESPONSE PLANS AND THE ASSESSMENT OF THE CONSEQUENCE OF DAM FAILURE; THE ACCURACY OF THE PREDICTED INUNDATION ZONES REFLECTS THIS PURPOSE.
4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

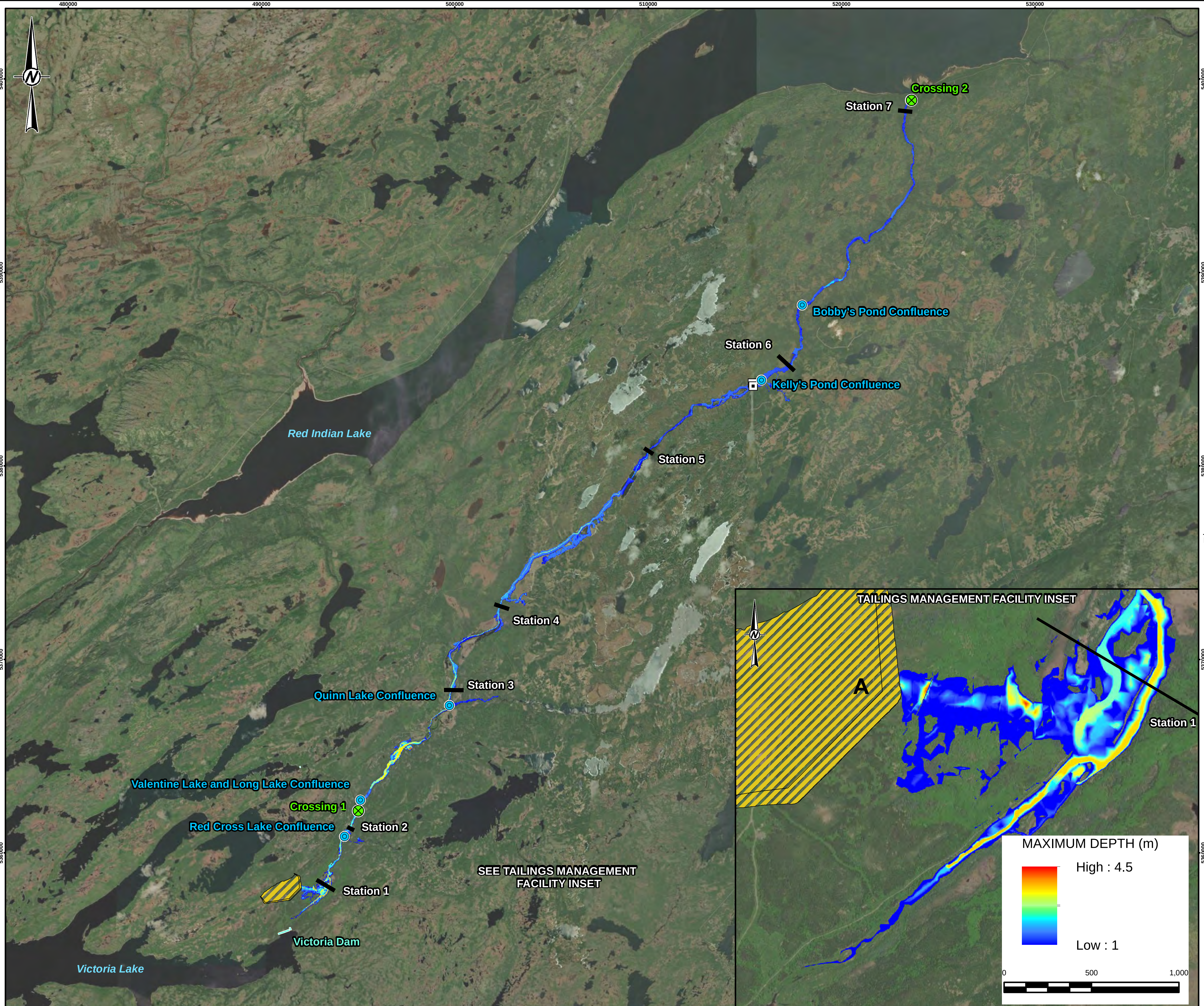
PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
INUNDATION AREA OF SIMULATED FAIR-WEATHER BREACH (SCENARIO A-FW)

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	6



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM DEPTH (m)
HIGH : 4.5
LOW : 0

0 5,000 10,000
1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
3. THE DAM BREACH ANALYSIS AND INUNDATION MAPS ARE BASED ON THE DIGITAL ELEVATION MODEL (DEM) GENERATES USING THE 10 M CONTOURS DEVELOPED BY THE GOVERNMENT OF NEWFOUNDLAND AND 1 M CONTOURS DEVELOPED BY AETHON AERIAL SOLUTIONS (2019). THE INUNDATION MAPS ARE INTENDED TO GUIDE THE DEVELOPMENT OF OVERALL EMERGENCY RESPONSE PLANS AND THE ASSESSMENT OF THE CONSEQUENCE OF DAM FAILURE; THE ACCURACY OF THE PREDICTED INUNDATION ZONES REFLECTS THIS PURPOSE.
4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

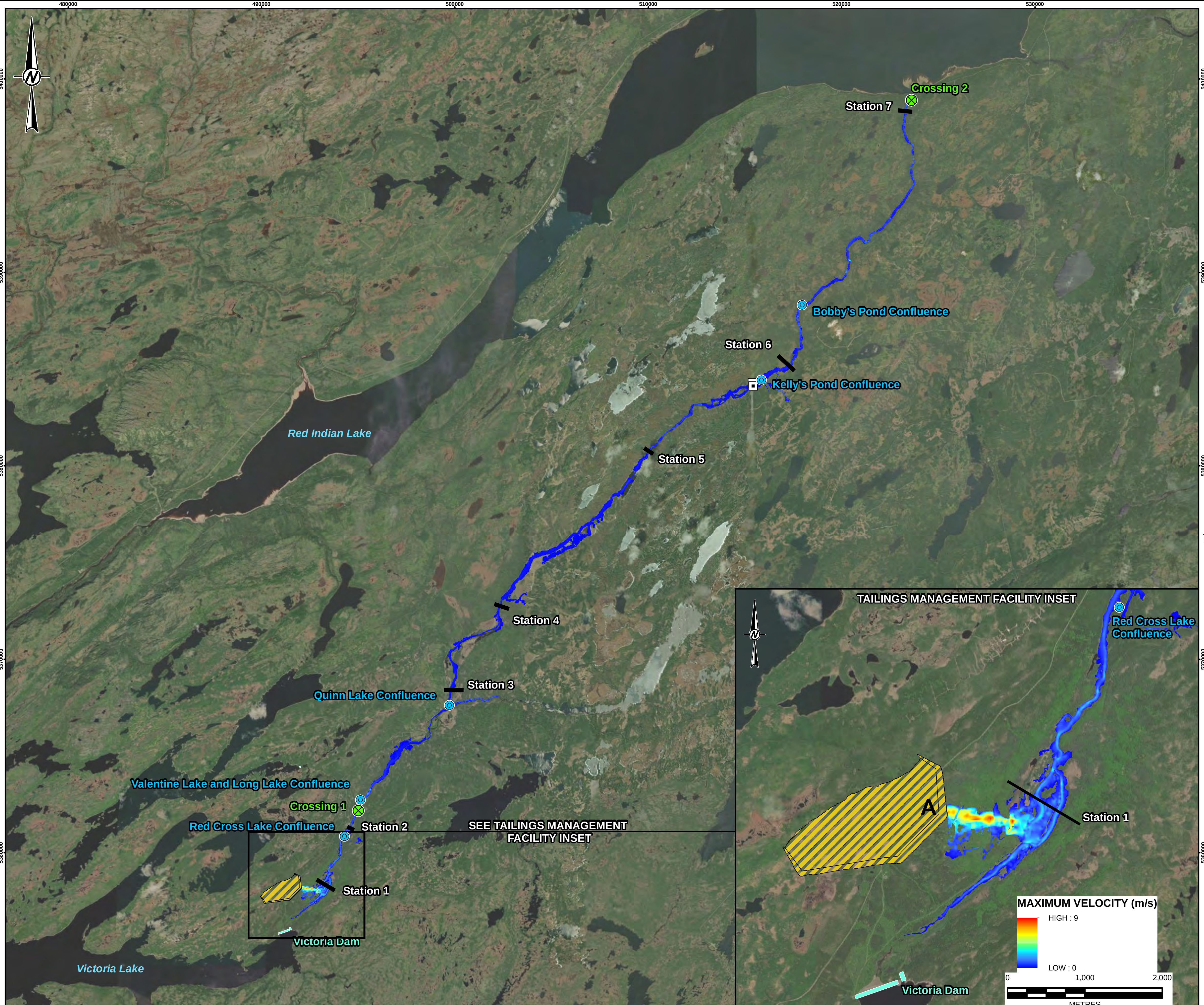
TITLE
MAXIMUM DEPTH FOR FAIR-WEATHER BREACH (SCENARIO A-FW)

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM VELOCITY (m/s)

HIGH : 9

LOW : 0

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
MAXIMUM VELOCITY FOR FAIR-WEATHER BREACH (SCENARIO A-FW)

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	8

PATH: S:\Clients\Marathon_Gold\Valentine_Gold\99_PROJ\20141194_Dam_Breach_Assessment\40_PROD\0003_DamBreachAssessment_2020\20141194-0003-CM-0014.mxd PRINTED ON: 2021-05-07 AT: 3:56:56 PM

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM DEPTH * VELOCITY (m^2/s)

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
3. THE DAM BREACH ANALYSIS AND INUNDATION MAPS ARE BASED ON THE DIGITAL ELEVATION MODEL (DEM) GENERATES USING THE 10 M CONTOURS DEVELOPED BY THE GOVERNMENT OF NEWFOUNDLAND AND 1 M CONTOURS DEVELOPED BY AETHON AERIAL SOLUTIONS (2019). THE INUNDATION MAPS ARE INTENDED TO GUIDE THE DEVELOPMENT OF OVERALL EMERGENCY RESPONSE PLANS AND THE ASSESSMENT OF THE CONSEQUENCE OF DAM FAILURE; THE ACCURACY OF THE PREDICTED INUNDATION ZONES REFLECTS THIS PURPOSE.
4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

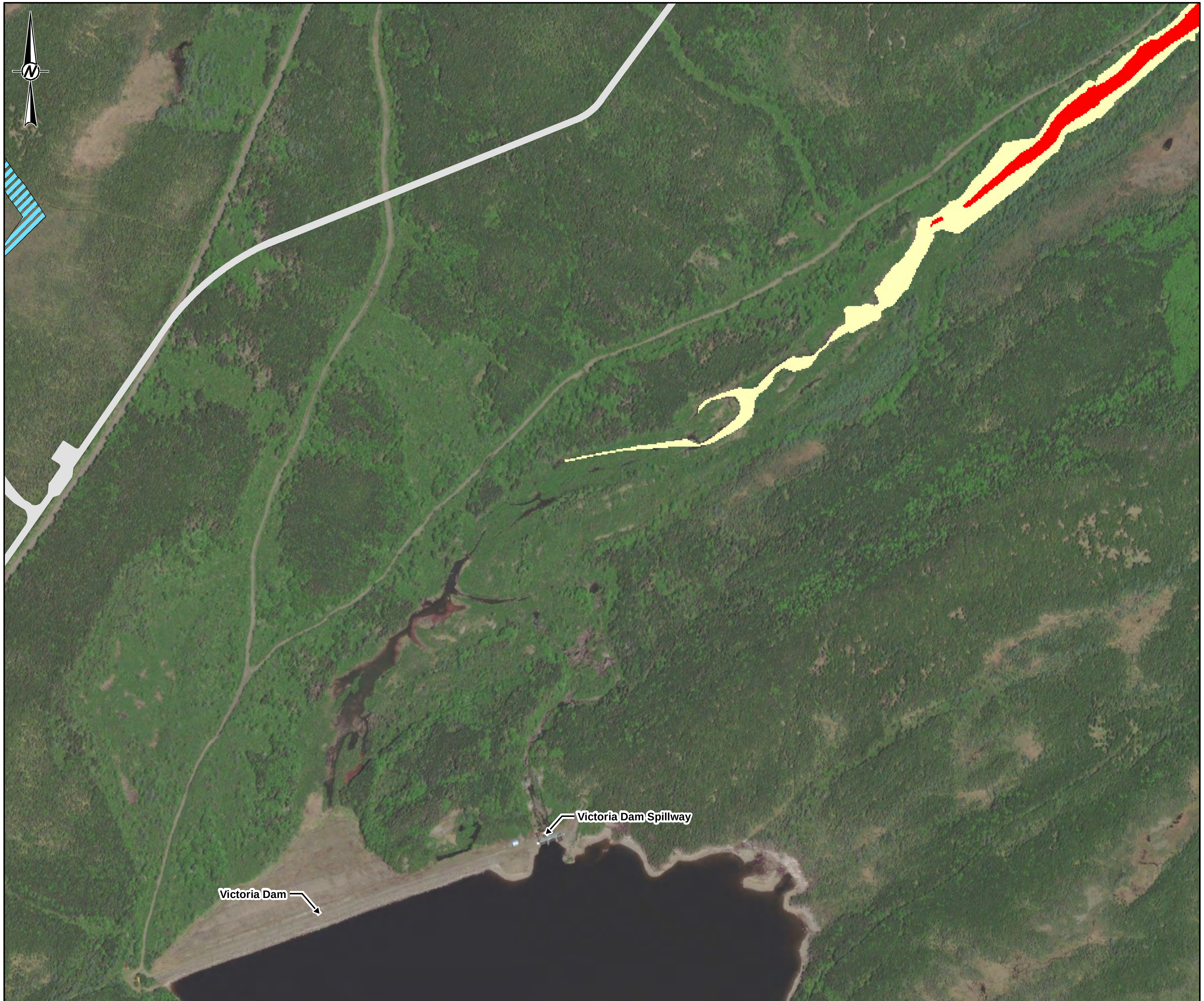
MAXIMUM DEPTH X VELOCITY FOR FAIR-WEATHER BREACH (SCENARIO A-FW)

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	9



LEGEND

POLISHING POND

PLANT SITE INFRASTRUCTURE

MAXIMUM DEPTH * VELOCITY (m^2/s)

0 - 0.37

GREATER THAN OR EQUAL TO 0.37

0 250 500

1:6,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

MAXIMUM DEPTH X VELOCITY FOR FAIR-WEATHER BREACH (SCENARIO A-FW) NEAR VICTORIA DAM

CONSULTANT

GOLDER
MEMBER OF WSP

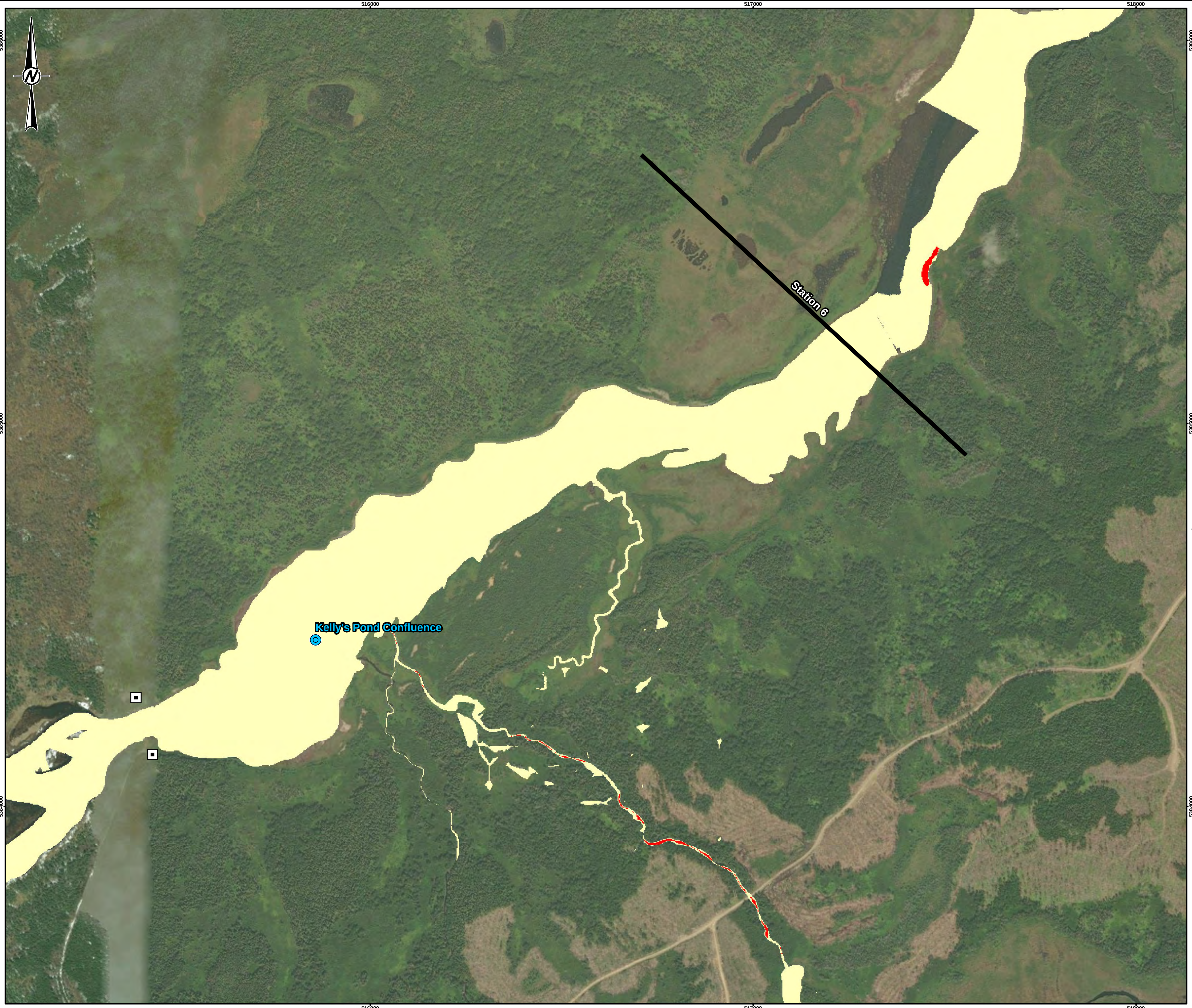
YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	10

PATH: S:\Clients\Marathon_Gold\Valentine_Gold\99_PROJ\20141194_Dam_Breach_Assessment\40_PROD\0003_DamBreachAssessment_2020\20141194-0003-CM-0022.mxd PRINTED ON: 2021-05-07 AT: 4:00:21 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



LEGEND

- DWELLING/LODGE
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION

MAXIMUM DEPTH * VELOCITY m^2/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 250 500

1:10,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

MAXIMUM DEPTH X VELOCITY FOR FAIR-WEATHER BREACH (SCENARIO A-FW) AROUND DWELLINGS / LODGE

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	11

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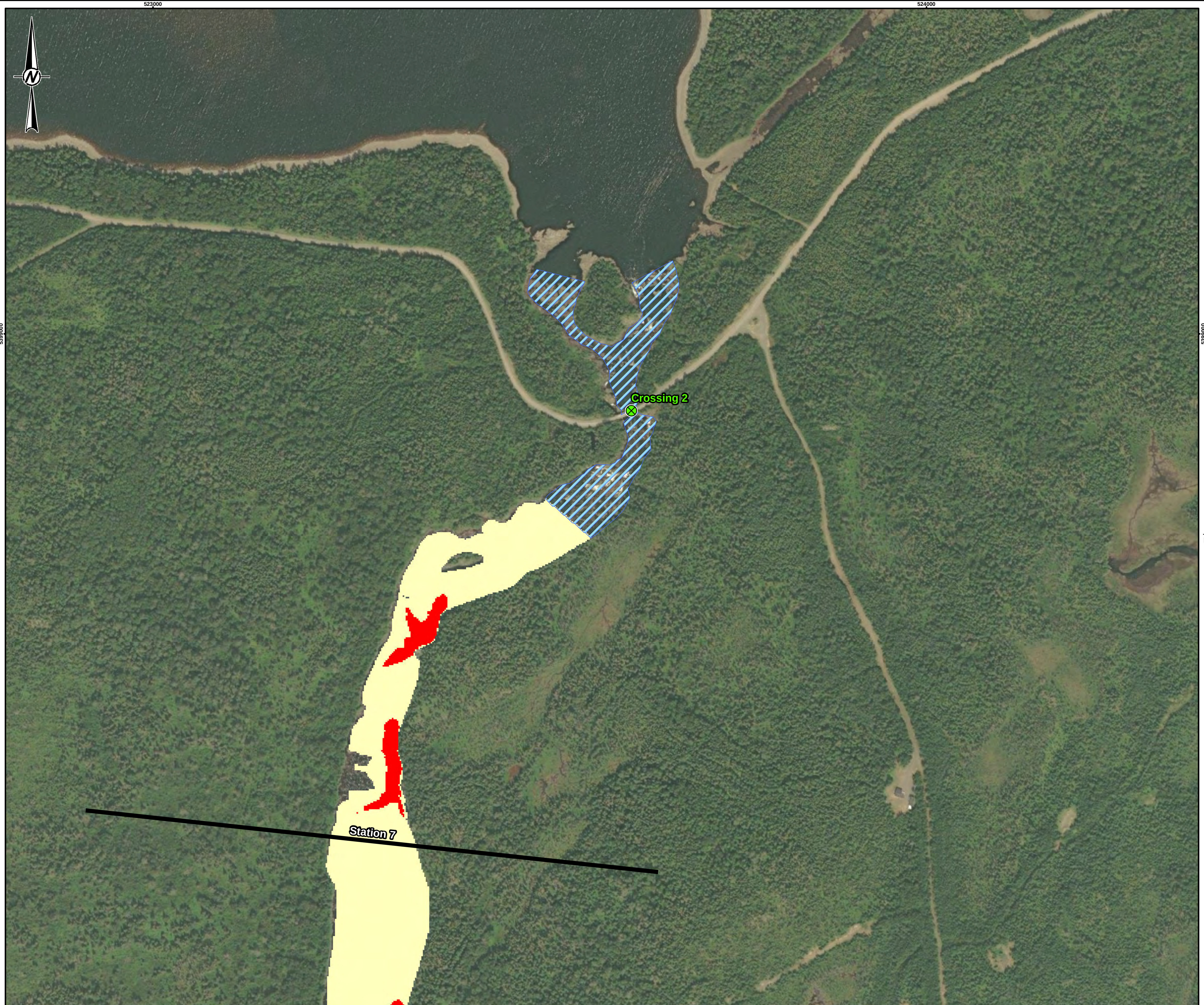

LEGEND

- CROSSING
- STATION PROFILE LOCATION
- EXPECTED INUNDATION DOWNSTREAM

MAXIMUM DEPTH * VELOCITY m²/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 150 300

1:5,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

MAXIMUM DEPTH X VELOCITY FOR FAIR-WEATHER BREACH (SCENARIO A-FW) AROUND CROSSING 2

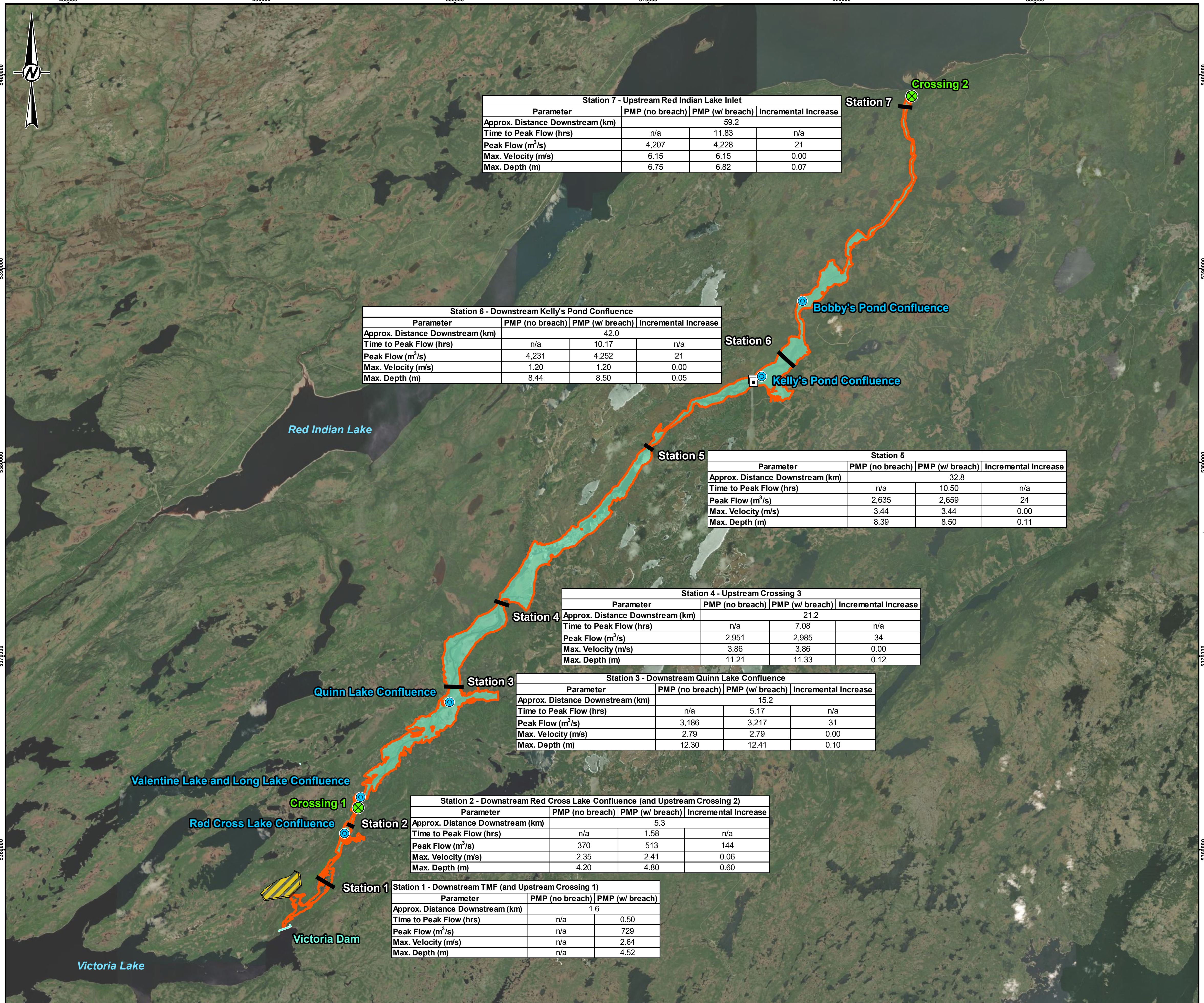
CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



Station 7 - Upstream Red Indian Lake Inlet

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	59.2		
Time to Peak Flow (hrs)	n/a	11.83	n/a
Peak Flow (m^3/s)	4,207	4,228	21
Max. Velocity (m/s)	6.15	6.15	0.00
Max. Depth (m)	6.75	6.82	0.07

Station 6 - Downstream Kelly's Pond Confluence

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	42.0		
Time to Peak Flow (hrs)	n/a	10.17	n/a
Peak Flow (m^3/s)	4,231	4,252	21
Max. Velocity (m/s)	1.20	1.20	0.00
Max. Depth (m)	8.44	8.50	0.05

Station 5

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	32.8		
Time to Peak Flow (hrs)	n/a	10.50	n/a
Peak Flow (m^3/s)	2,635	2,659	24
Max. Velocity (m/s)	3.44	3.44	0.00
Max. Depth (m)	8.39	8.50	0.11

Station 4 - Upstream Crossing 3

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	21.2		
Time to Peak Flow (hrs)	n/a	7.08	n/a
Peak Flow (m^3/s)	2,951	2,985	34
Max. Velocity (m/s)	3.86	3.86	0.00
Max. Depth (m)	11.21	11.33	0.12

Station 3 - Downstream Quinn Lake Confluence

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	15.2		
Time to Peak Flow (hrs)	n/a	5.17	n/a
Peak Flow (m^3/s)	3,186	3,217	31
Max. Velocity (m/s)	2.79	2.79	0.00
Max. Depth (m)	12.30	12.41	0.10

Station 2 - Downstream Red Cross Lake Confluence (and Upstream Crossing 2)

Parameter	PMP (no breach)	PMP (w/ breach)	Incremental Increase
Approx. Distance Downstream (km)	5.3		
Time to Peak Flow (hrs)	n/a	1.58	n/a
Peak Flow (m^3/s)	370	513	144
Max. Velocity (m/s)	2.35	2.41	0.06
Max. Depth (m)	4.20	4.80	0.60

Station 1 - Downstream TMF (and Upstream Crossing 1)

Parameter	PMP (no breach)	PMP (w/ breach)
Approx. Distance Downstream (km)	1.6	
Time to Peak Flow (hrs)	n/a	0.50
Peak Flow (m^3/s)	n/a	729
Max. Velocity (m/s)	n/a	2.64
Max. Depth (m)	n/a	4.52

LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY
- INUNDATION BOUNDARY (PMF BREACH)
- INUNDATION BOUNDARY (PMF NO BREACH)

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

INUNDATION AREA OF PMF NO BREACH AND PMF BREACH (SCENARIO A-PMF)

CONSULTANT

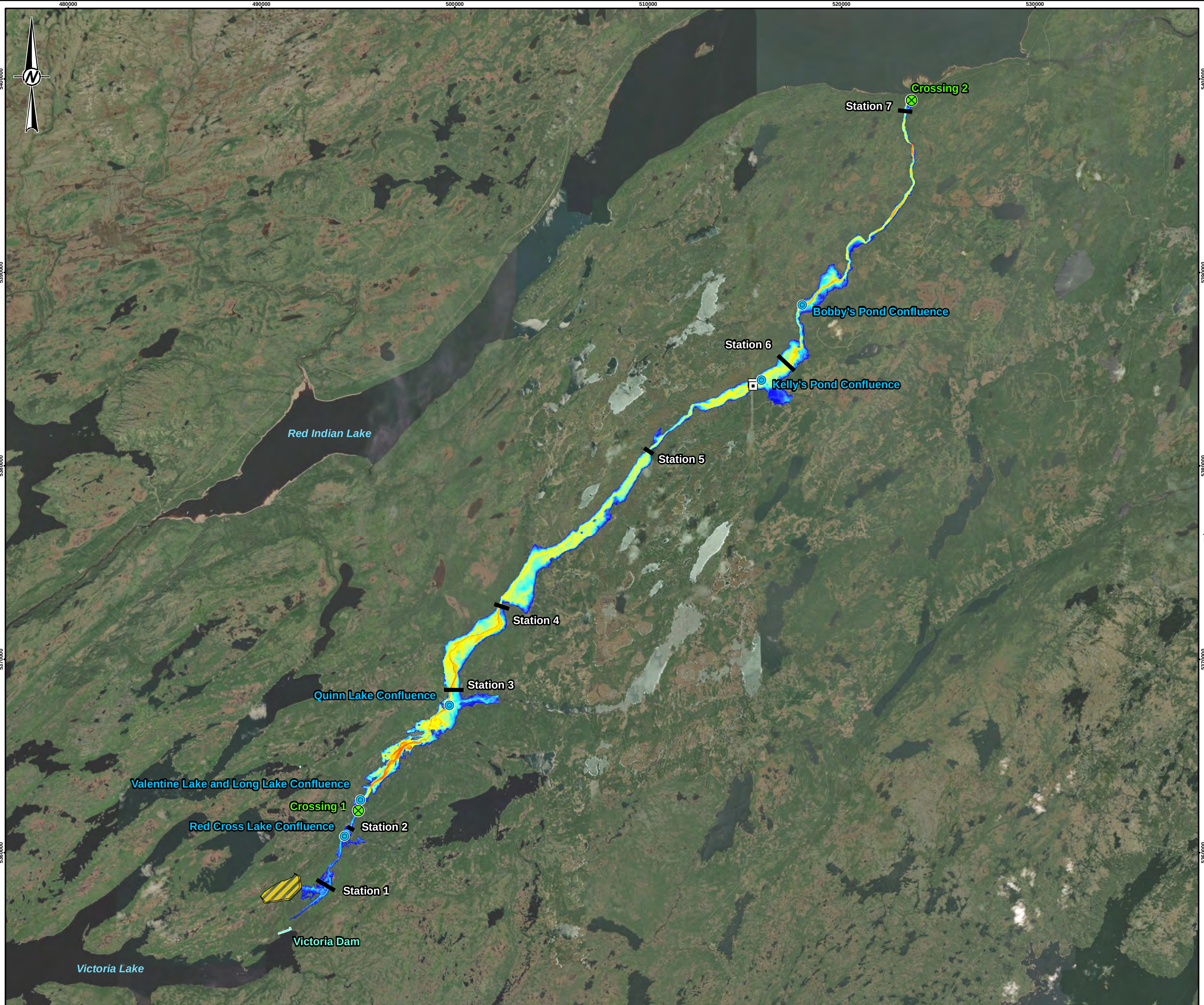
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM DEPTH (m)
HIGH : 14
LOW : 0

0 5,000 10,000
1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
MAXIMUM DEPTH FOR PMF BREACH (SCENARIO A-PMF)

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	14

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25mm

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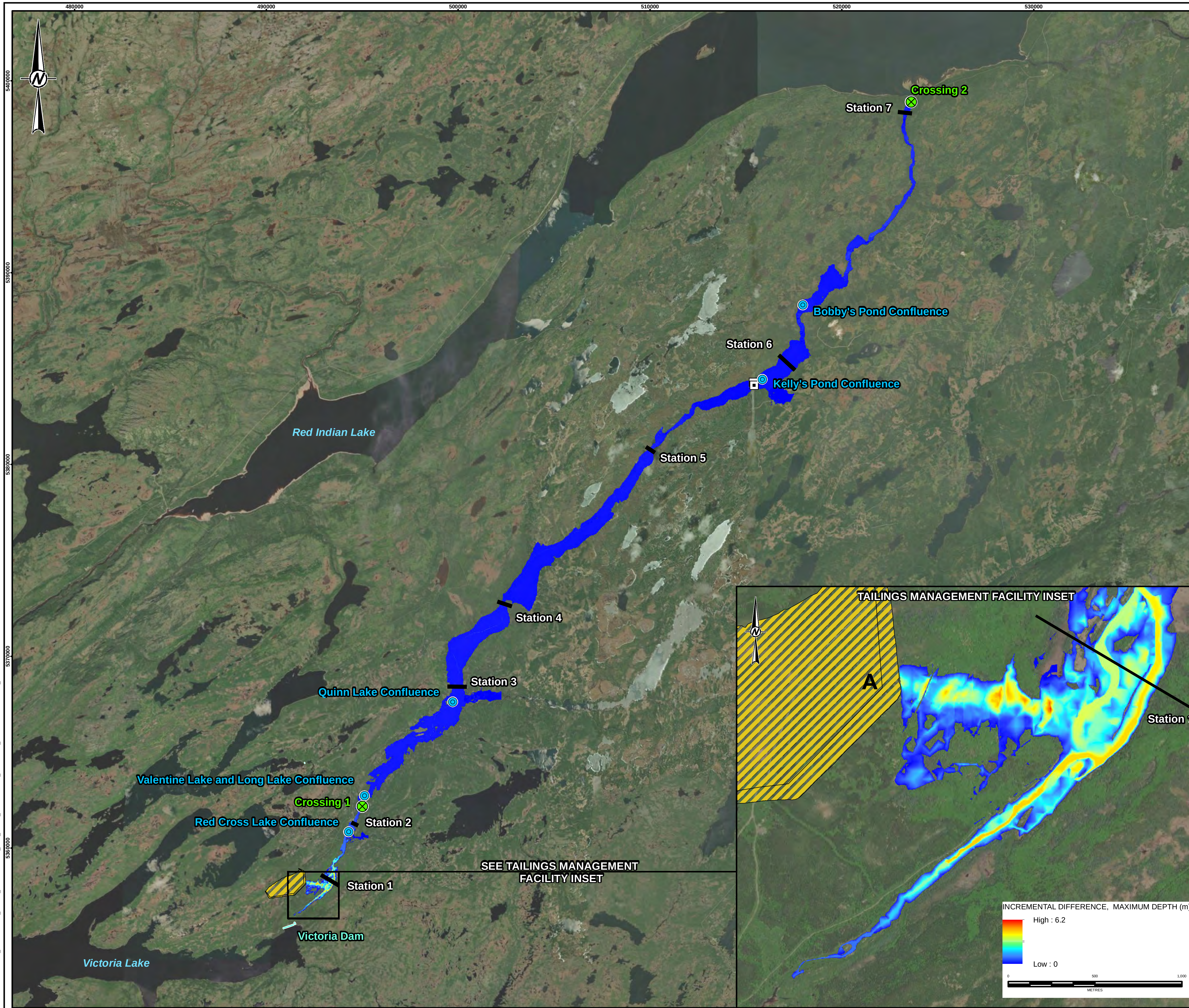

LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

INCREMENTAL DIFFERENCE, MAXIMUM DEPTH (m)

HIGH : 6.2

LOW : 0

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

INCREMENTAL DIFFERENCE IN MAXIMUM INUNDATION DEPTH BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF)

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	15

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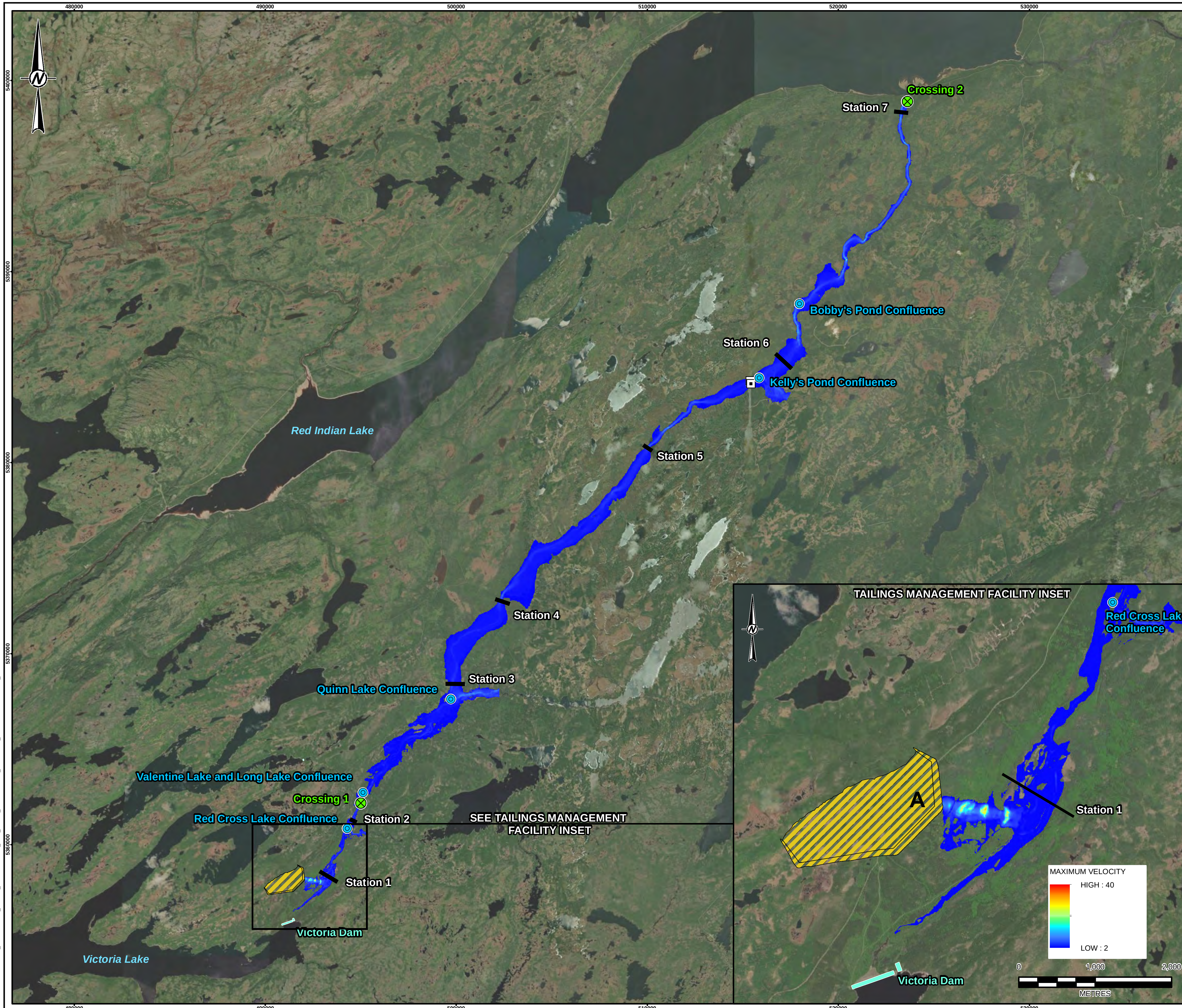
25mm



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM VELOCITY (m/s)
HIGH :40
LOW : 0

0 5,000 10,000
1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
3. THE DAM BREACH ANALYSIS AND INUNDATION MAPS ARE BASED ON THE DIGITAL ELEVATION MODEL (DEM) GENERATES USING THE 10 M CONTOURS DEVELOPED BY THE GOVERNMENT OF NEWFOUNDLAND AND 1 M CONTOURS DEVELOPED BY AETHON AERIAL SOLUTIONS (2019). THE INUNDATION MAPS ARE INTENDED TO GUIDE THE DEVELOPMENT OF OVERALL EMERGENCY RESPONSE PLANS AND THE ASSESSMENT OF THE CONSEQUENCE OF DAM FAILURE; THE ACCURACY OF THE PREDICTED INUNDATION ZONES REFLECTS THIS PURPOSE.
4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

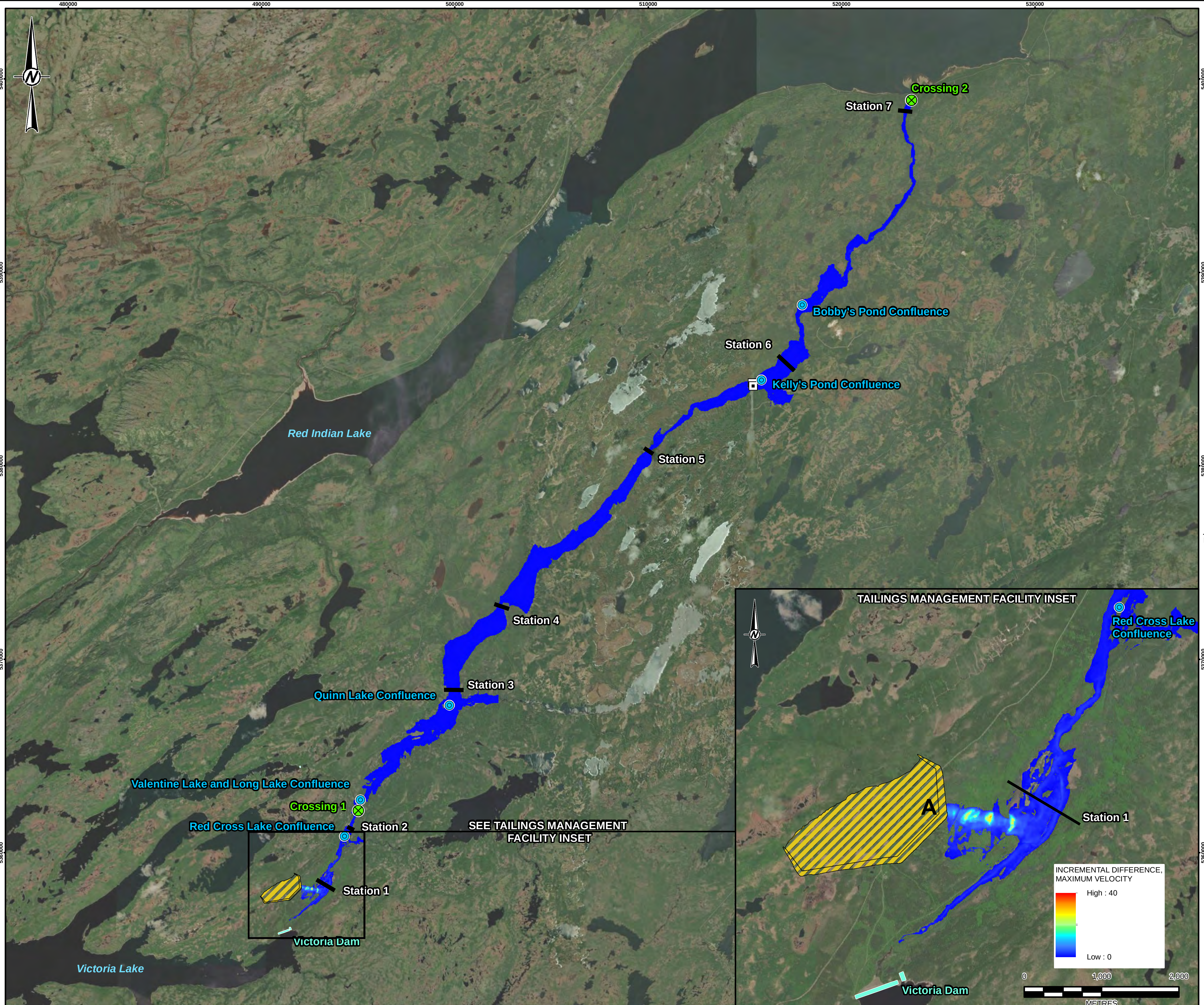
PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
MAXIMUM VELOCITY FOR PMF BREACH (SCENARIO A-PMF)

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	16



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

INCREMENTAL DIFFERENCE, MAXIMUM VELOCITY (m/s)

High : 40

Low : 0

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

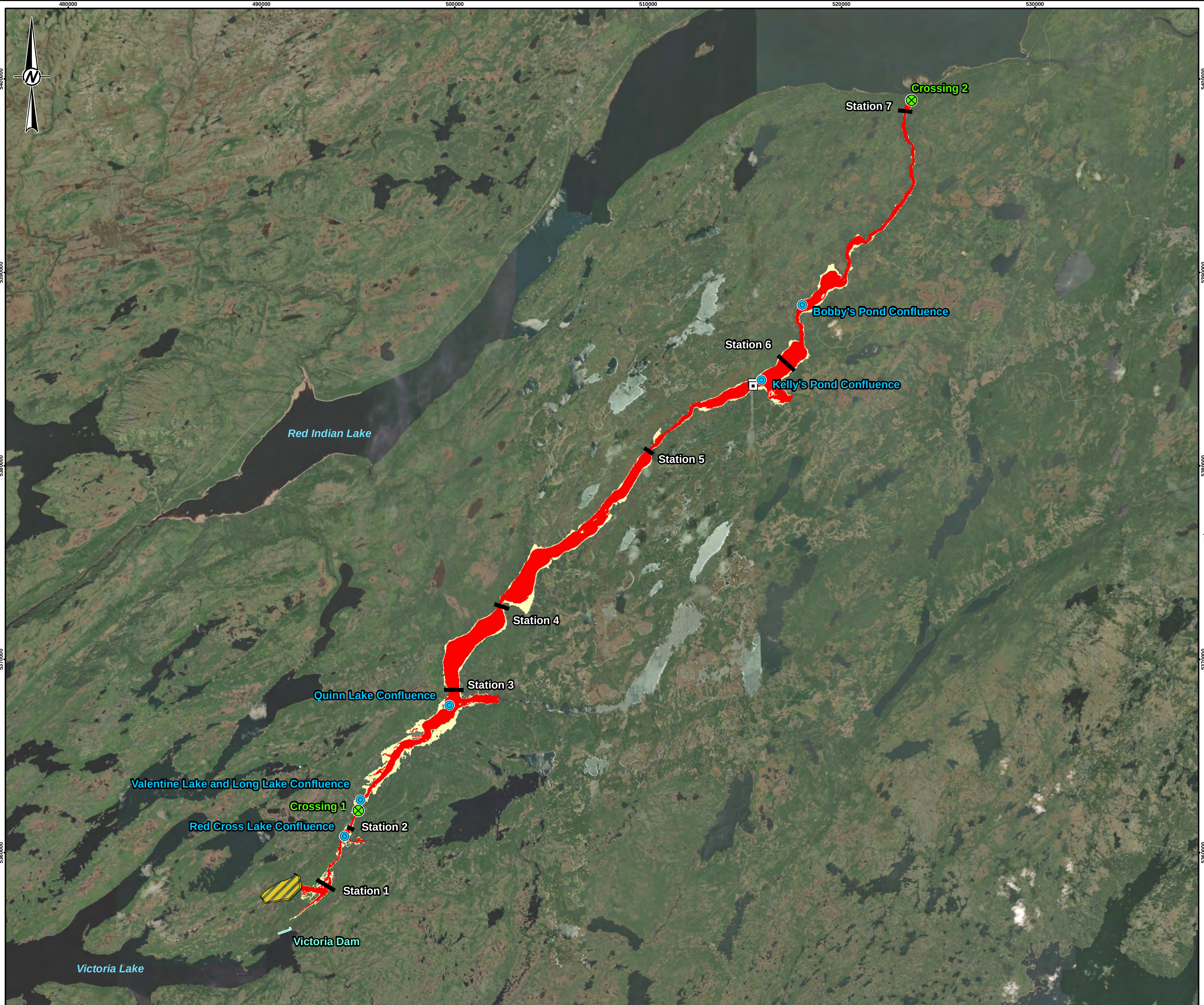
INCREMENTAL DIFFERENCE IN MAXIMUM VELOCITY BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF)

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	17



LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

MAXIMUM DEPTH * VELOCITY m^2/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
MAXIMUM DEPTH X VELOCITY FOR PMF BREACH (SCENARIO A-PMF)

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	18

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

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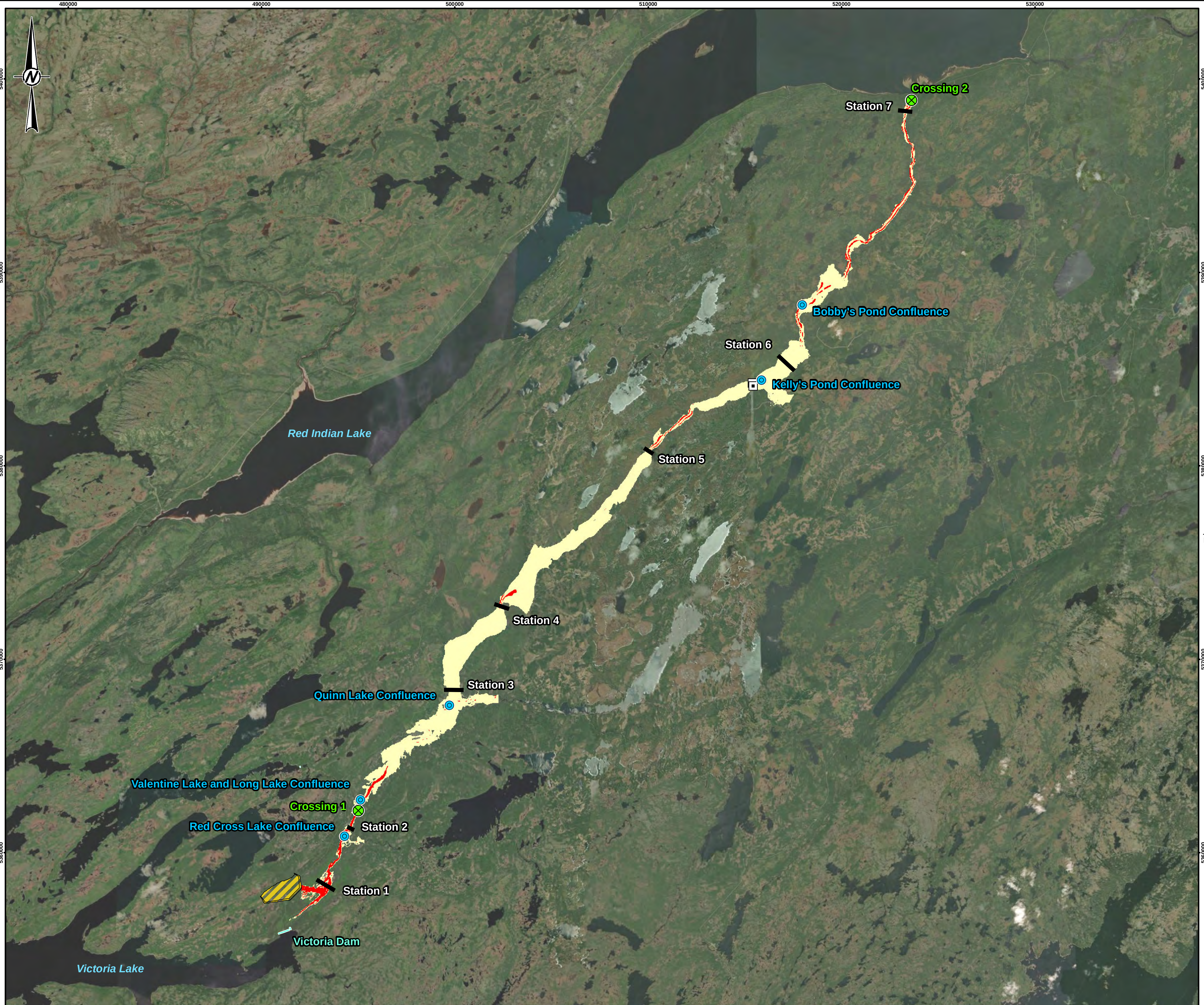

LEGEND

- DWELLING/LODGE
- CROSSING
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION
- TAILINGS MANAGEMENT FACILITY

INCREMENTAL DIFFERENCE, MAXIMUM DEPTH*VELOCITY m^2/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 5,000 10,000

1:200,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

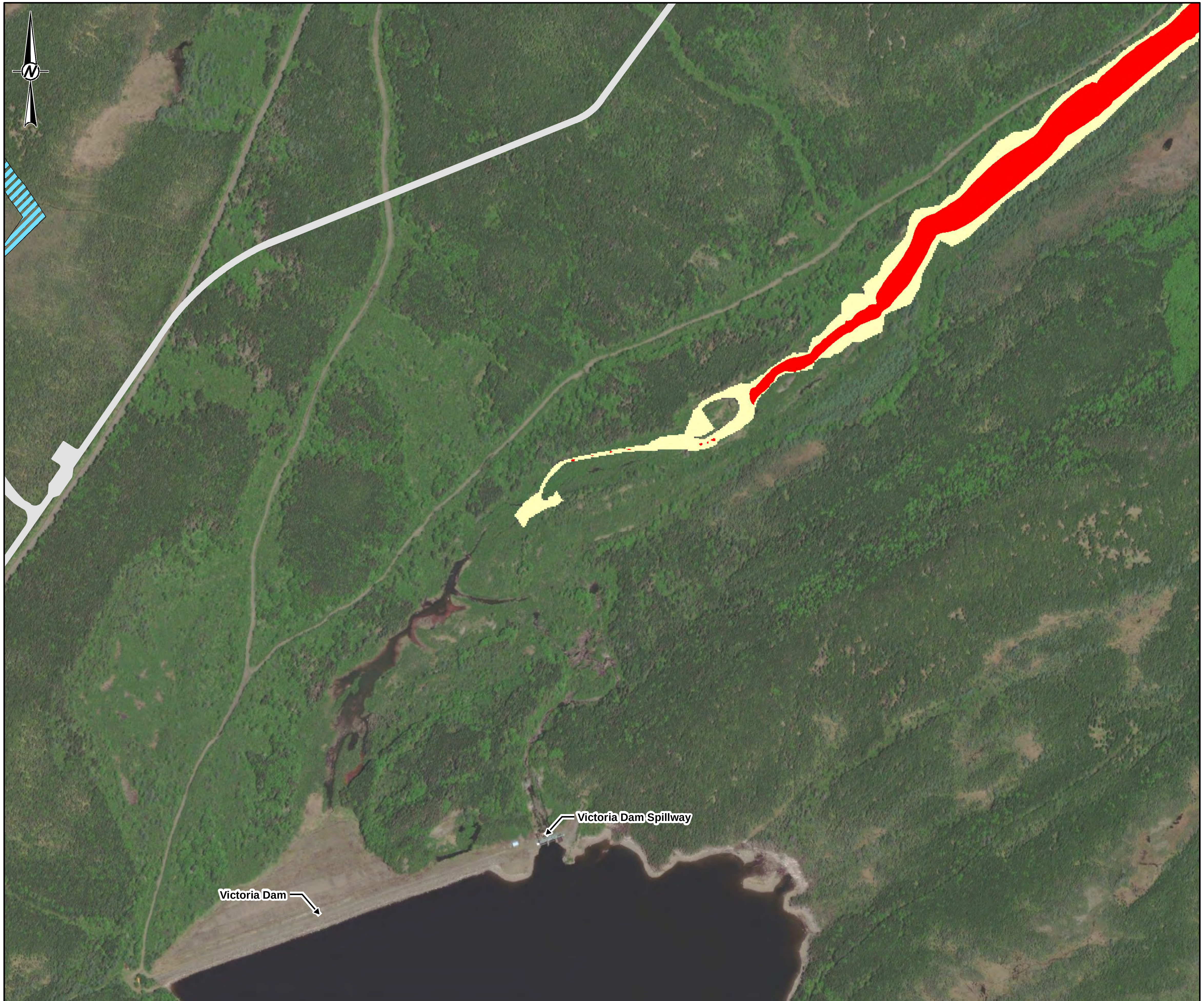
INCREMENTAL DIFFERENCE IN MAXIMUM DEPTH X VELOCITY BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF)

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	19



LEGEND

- POLISHING POND
- PLANT SITE INFRASTRUCTURE

MAXIMUM DEPTH * VELOCITY (m^2/s)

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 250 500

1:6,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

INCREMENTAL DIFFERENCE IN MAXIMUM DEPTH X VELOCITY BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF) NEAR VICTORIA DAM

CONSULTANT

GOLDER MEMBER OF WSP

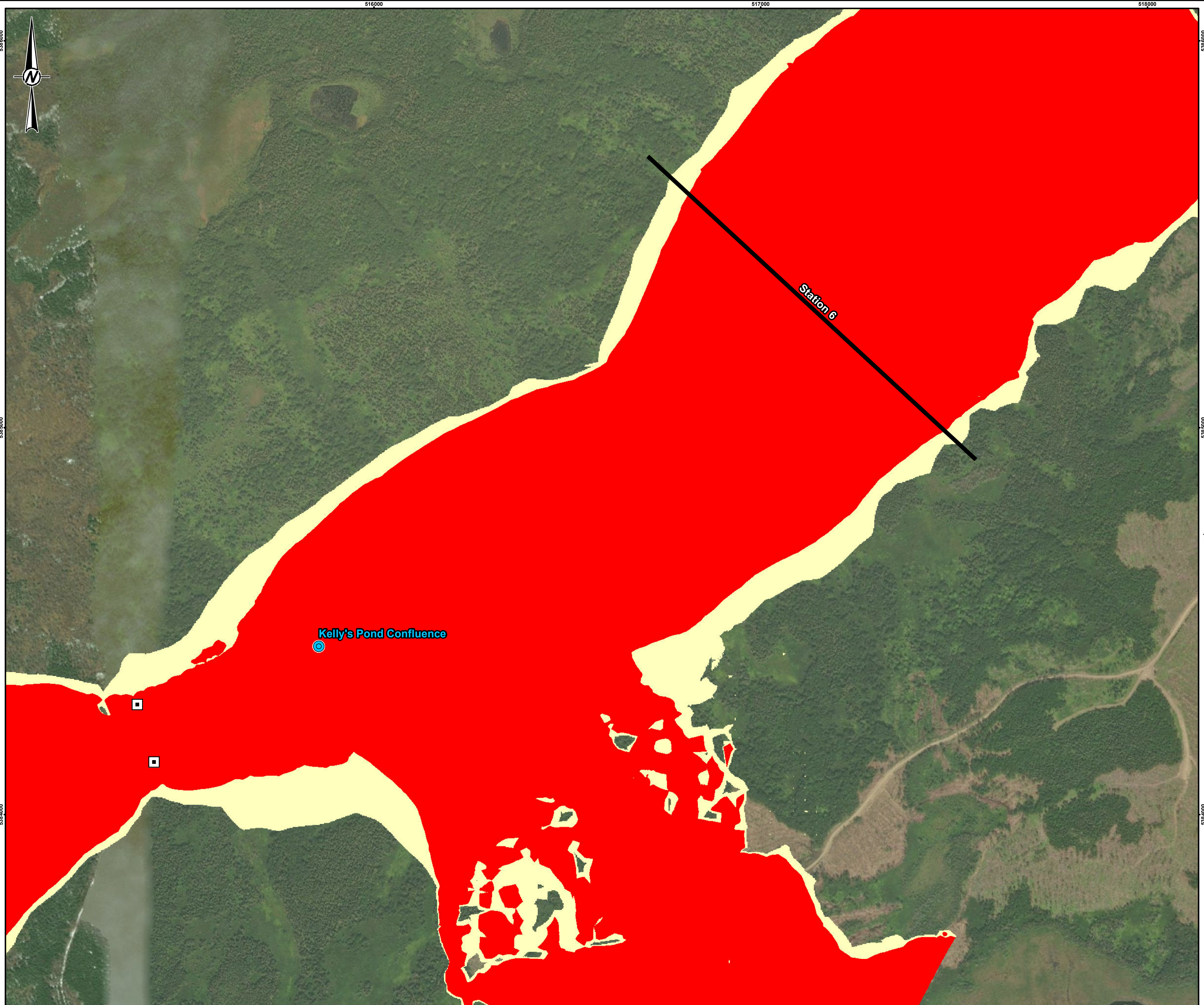
YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	20

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

PATH: S:\Clients\Marathon_Gold\Valentine_Gold\99_PROJ\20141194_Dam_Breach_Assessment\40_PROD\0003_DamBreachAssessment_2020\20141194-0003-CM-0023.mxd PRINTED ON: 2021-12-23 AT: 4:01:22 PM



LEGEND

- DWELLING/LODGE
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION

MAXIMUM DEPTH * VELOCITY (m^2/s)

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 250 500
1:10,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

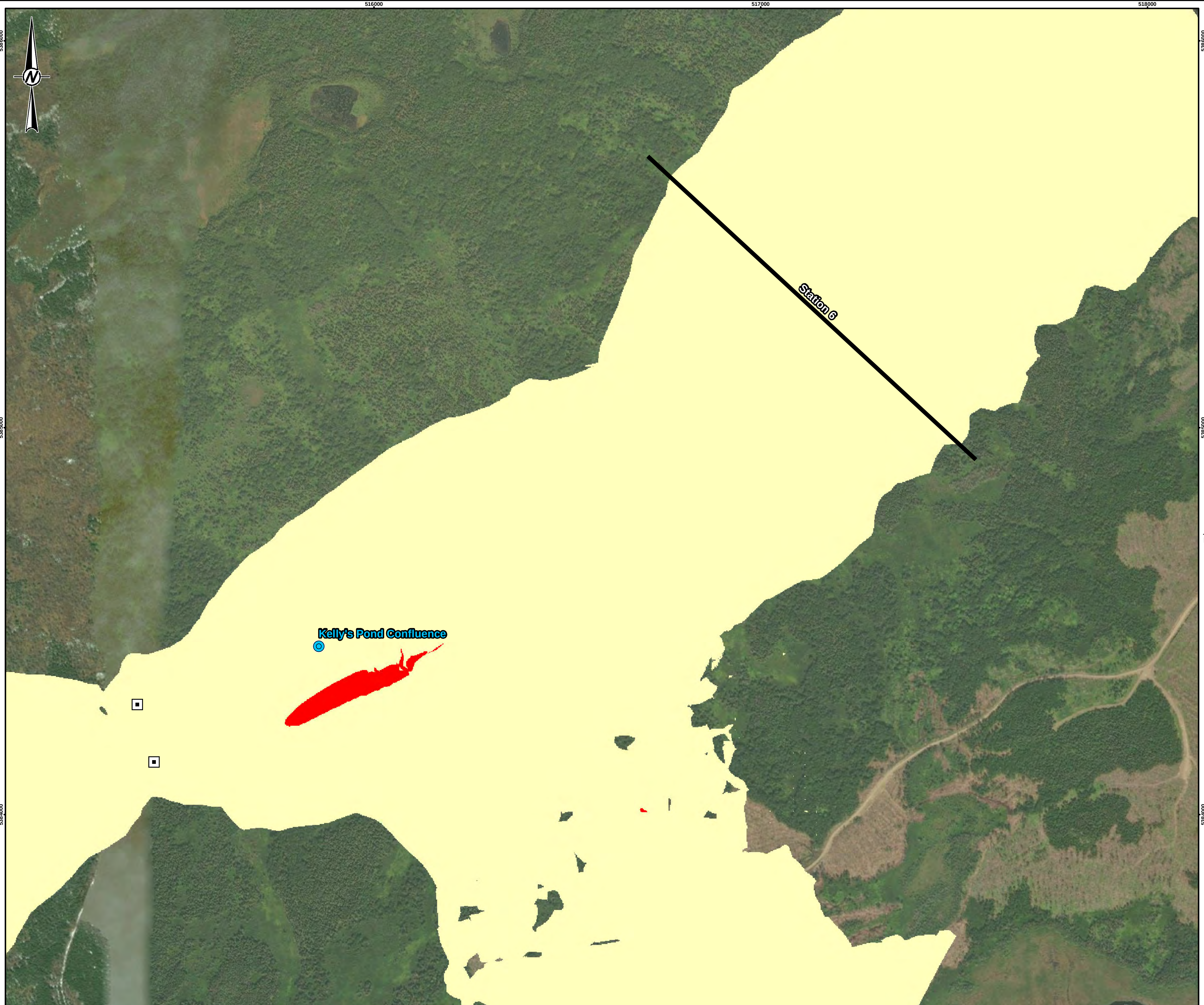
TITLE
MAXIMUM DEPTH X VELOCITY FOR PMF BREACH (SCENARIO A-PMF) AROUND DWELLINGS / LODGE

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	21

25mm



LEGEND

- DWELLING/LODGE
- VICTORIA RIVER CONFLUENCE
- STATION PROFILE LOCATION

INCREMENTAL DIFFERENCE, MAXIMUM DEPTH*VELOCITY (m^2/s)

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 250 500

1:10,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT
MARATHON GOLD CORPORATION

PROJECT
DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE
INCREMENTAL DIFFERENCE IN MAXIMUM DEPTH X VELOCITY BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF) AROUND DWELLINGS / LODGE

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	22

LEGEND

- CROSSING
- STATION PROFILE LOCATION
- EXPECTED INUNDATION DOWNSTREAM

MAXIMUM DEPTH * VELOCITY m^2/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 500 1,000

1:15,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

MAXIMUM DEPTH X VELOCITY FOR PMF BREACH (SCENARIO A-PMF) NEAR CROSSING NO. 2

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-06
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	23

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

LEGEND

- CROSSING
- STATION PROFILE LOCATION
- EXPECTED INUNDATION DOWNSTREAM

INCREMENTAL DIFFERENCE, MAXIMUM DEPTH*VELOCITY m^2/s

- 0 - 0.37
- GREATER THAN OR EQUAL TO 0.37

0 500 1,000

1:15,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

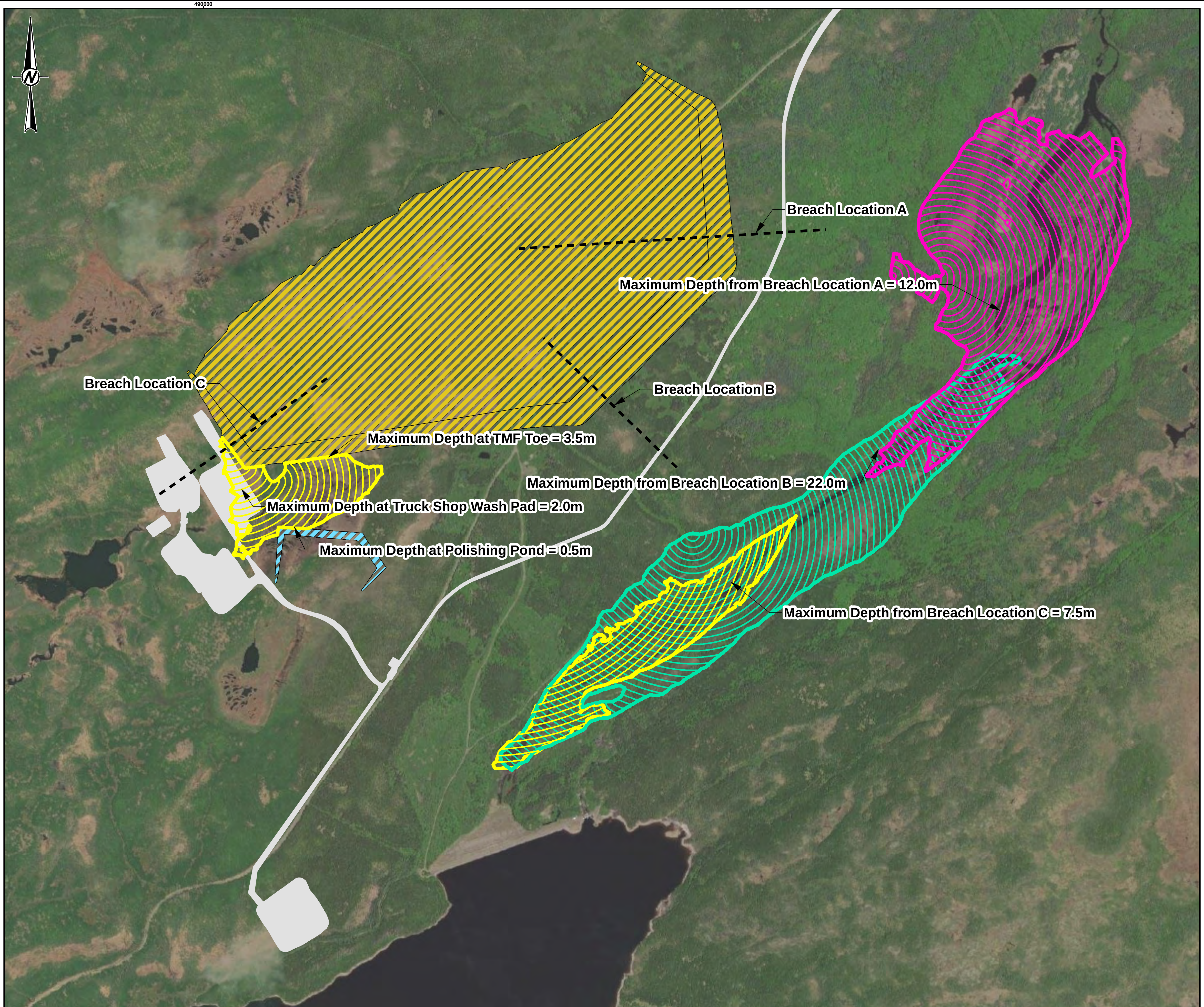
INCREMENTAL DIFFERENCE IN MAXIMUM DEPTH X VELOCITY BETWEEN THE PMF BREACH AND PMF NO BREACH (SCENARIO A-PMF) NEAR CROSSING 2

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	24



LEGEND

- BREACH CHANNEL CENTERLINE
- RUNOUT CONTOURS FOR BREACH LOCATION A
- RUNOUT FOOTPRINT FOR BREACH LOCATION A
- RUNOUT CONTOURS FOR BREACH LOCATION B
- RUNOUT FOOTPRINT FOR BREACH LOCATION B
- RUNOUT CONTOURS FOR BREACH LOCATION C
- RUNOUT FOOTPRINT FOR BREACH LOCATION C
- POLISHING POND
- TAILINGS MANAGEMENT FACILITY
- PLANT SITE INFRASTRUCTURE

0 250 500

1:15,000 METRES

LIMITATIONS

1. THE FOLLOWING LIMITATIONS APPLY TO ALL INUNDATION FIGURES.
2. THE INUNDATION MAPS MUST BE READ AND INTERPRETED IN CONJUNCTION WITH THE DAM BREACH ASSESSMENT TECHNICAL MEMO, ASSUMPTIONS, AND LIMITATIONS.
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4. UNCERTAINTY IN THE MOBILIZED FLUID VOLUMES AND THEIR RHEOLOGICAL PROPERTIES LEADS TO UNCERTAINTY IN THE DELINEATION OF INUNDATED AREAS AND FLOW PROPERTIES AT ANY GIVEN LOCATION; GOLDER HAS FOLLOWED ACCEPTED PRACTICES TO ADDRESS UNCERTAINTY, HOWEVER, RESIDUAL UNCERTAINTY REMAINS.

REFERENCE(S)

1. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 21

CLIENT

MARATHON GOLD CORPORATION

PROJECT

DAM BREACH ASSESSMENT AND INUNDATION STUDY
VALENTINE GOLD TAILINGS MANAGEMENT FACILITY

TITLE

TAILINGS RUNOUT DEPOSITION (SCENARIOS A-RO, B-RO AND C-RO)

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	CGE
PREPARED	RRD
REVIEWED	MAR
APPROVED	SK

PROJECT NO.	CONTROL	REV.	FIGURE
20141194	0003	0	25

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