Golder Associates

TECHNICAL MEMORANDUM

DATE	August 5, 2016	**PROJECT No.**	1408383.3500.3502
		DOC NO.	014 (Rev 0)
TO	Sandra Pouliot Canadian Malartic Corporation		
CC	Ken De Vos		
FROM	Adwoa Cobbina, Adam Auckland and Gerard Van Arkel	**EMAIL**	acobbina@golder.com

ASSESSMENT OF POTENTIAL IMPACTS TO DOWNSTREAM WATER QUALITY IN THE EVENT OF FAILURE OF THE TMF RECLAIM POND DAM – HAMMOND REEF GOLD PROJECT

1.0 INTRODUCTION

In January of 2016, Canadian Malartic Corporation (CMC) received Information Request #3 from the Canadian Environmental Assessment Agency (CEAA) in response to the Hammond Reef Gold Project (HRGP) Environmental Impact Statement/Environmental Assessment (EIS/EA) and previously issued information requests and corresponding responses from CMC. Information Request #3 included a new comment regarding the potential impacts to the downstream environment in the unlikely event of a failure of the Tailings Management Facility (TMF) Reclaim Pond containment dam and subsequent release of stored water. Specifically, Information Request (IR) T(3)-09 states:

> *"Section 10.7 of the EIS Guidelines requires the EIS to describe the magnitude of an accident or malfunction, including the quantity, mechanism, rate, form and characteristics of the contaminants likely to be released into the environment. The discussion of a tailings dam failure scenario in section 6.6.5 of the EIS is limited to thickened tailings escaping (or slumping over) the tailings containment structure. Figure 5-9 depicts the various stages of tailings deposition, water pooling within the tailings management facility (TMF), and dam(s) construction over time. The figure suggests that the failure of any of the labeled dams may result in TMF water (contact water) entering the ecosystem and nearby waterbodies.*
>
> *The potential environmental effects on receiving water bodies from a catastrophic dam failure, which results in TMF water partially to fully discharging into the receiving environment during the various stages of tailings deposition, are unclear.*
>
> *The information is needed for the Agency to analyze potential effects from accidents and malfunctions."*

IR T(3)-09 has requested the following:

1. *Provide an analysis of the potential effects of the quality and volume(s) of tailings management facility (TMF) water that would escape the TMF under a worst-case dam failure scenario during the various stages of tailings deposition and dam construction outlined in Figure 5-9 (particularly Stage 1A and Stage 4). Justify that the location of the dam break selected for each example would result in a worst-case scenario release of TMF water, and include details on the*

significance of the effects based on the Agency's methodology for assessing significance (including the criteria of magnitude, geographic extent, duration, frequency, reversibility, ecological/social/cultural context); and likelihood of occurrence of the worst-case scenario.

2. *Describe the drainage pathways for the tailings dam failure scenarios and include the topographic information to support the analysis of item 1. Characterize the effects of TMF water quality on nearby water bodies for each dam failure scenario.*

3. *Describe the contingency and response plans to address the effects of the TMF water that would escape the TMF during the scenarios outlined in item 1.*

CMC requested that Golder Associates (Golder) assess the potential impact of a TMF reclaim pond dam failure on the downstream environment in response to this IR. This memorandum describes the method and results of this assessment.

2.0 DESIGN GUIDELINES AND PROBABILITY OF DAM FAILURE (LIKELIHOOD OF OCCURRENCE)

By its nature, a dam breach assessment presumes that a failure will occur and then assesses the consequences of the presumed failure. It is not a risk assessment because it does not consider the improbability of the failure actually occurring. The TMF Reclaim Pond dams have been designed according to Canadian Dam Association (CDA) Guidelines and Ministry of Natural Resources and Forestry (MNRF) Guidelines. The MNRF has authority to approve dams in Ontario and CDA guidelines are referenced in the Ontario Mine Closure regulations. In particular, the stability of the dams has been designed to resist an earthquake with a recurrence interval of 2,500 years. Furthermore, an emergency spillway will be provided to protect the dams against overtopping and that spillway will be designed to safely route a storm with a recurrence interval of 10,000 years. The detailed design of the TMF dams will be peer reviewed by an independent expert in tailings dam construction and operation. In addition, the Mining Association of Canada (MAC) in their Towards Sustainable Mining (TSM) initiative provides guidelines for best practices for management of tailings dams. CMC intends to develop a customized tailings management system that addresses the specific needs of the HRGP, meets applicable regulations at local, provincial and federal levels and meets Industry Best Management Practices where possible.

The principal design objective is to provide dams that will not fail. The design will specifically take into consideration all modern regulations, lessons learned from past experience and will be designed to withstand the extreme events discussed above without failure. Therefore, the likelihood of occurrence of a dam failure is extremely low.

Furthermore, the failure scenarios assessed in this memorandum have the potential to occur only during a relatively short period of time (i.e., 11 years of operations and approximately 2 years during closure), thus further limiting the probability of occurrence. Under post-closure conditions, the emergency spillway will be lowered and water quality will have improved to a level that it is suitable for discharge to the environment.

3.0 DEFINITION OF WORST CASE ASSESSMENT SCENARIOS

For the purposes of estimating potential consequences, however unlikely, a failure of the TMF Reclaim Pond dam has been assumed to occur. The TMF reclaim pond will have the capacity to impound up to 6.2 M-m^3 of water during all stages of operations which provides sufficient capacity to run the mill under average climatic conditions, as well as provides sufficient capacity to contain the design storm event.

The tailings will be thickened to a solids content of 50% to 70% (by weight) prior to discharge to the TMF. A conical discharge method is proposed for deposition of the thickened tailings with a central discharge point that will be gradually raised to achieve the required storage capacity. Precipitation and water released from the tailings due to consolidation will flow radially outwards and will collect in the TMF Reclaim Pond. If a breach of the TMF Reclaim Pond dam were to occur, the thickened tailings behind and beneath the water in the Reclaim Pond would slump and maintain a steeper slope within the relative confines of the TMF rather than being discharged to the environment with the water. Although some slumping and erosion of the tailings surface would occur during a breach, it is expected that the tailings will remain in place and that only water, with potentially elevated concentrations of suspended solids due to tailings erosion, will be released to the receiving waterbodies in the event of a dam failure.

The primary receivers that could potentially be impacted by a breach of the TMF Reclaim Pond dam are the Upper Marmion Reservoir, particularly Sawbill Bay, and Lizard Lake (Figure 1). A dam failure could result in the release of water to Upper Marmion Reservoir during Stages 1A, 3 and 4 of the mine life (Figure 2 or Figure 5-9 of the EIS/EA) or to Lizard Lake during any stage of the operating life of the mine.

In terms of impacts to receiving waterbodies, the worst case scenario would be the release of largest possible volume of water volume to a particular receiver during a low flow period when less water would be available in the receiver for mixing and dilution of the release water. The worst case scenario for each of the primary receiving water bodies are defined in this section.

3.1 Upper Marmion Reservoir (Sawbill Bay)

The largest potential volume of water impoundment upstream of Sawbill Bay occurs during Stage 1A of the dam construction staging plan. During this stage, based on topography, up to 4.1 M-m^3 of water could be impounded within the Sawbill Bay watershed. During subsequent stages of the TMF development, this area is infilled with tailings and the Reclaim Pond gradually relocates to within the Lizard Lake watershed.

Based on the historical record of flows and levels in the Upper Marmion Reservoir, the lowest levels in the reservoir occurred in March, 2003. Therefore, a Stage 1A breach, resulting in the discharge of 4.1 M-m^3 of water to Sawbill Bay during March of 2003 has been selected as the worst case scenario for assessment of impacts to Sawbill Bay and Upper Marmion Reservoir.

3.2 Lizard Lake

The largest potential water impoundment upstream of Lizard Lake occurs during Stages 2, 3 and 4 of the dam construction staging plan. During these stages, up to 6.2 M-m^3 of water could be impounded within the Lizard Lake watershed. This is the maximum volume of water that could be potentially stored in the TMF Reclaim Pond. During Stage 4, the reclaim Pond will have its largest potential water depth and therefore a higher potential head during a breach compared to other stages, resulting in higher initial discharge rates to the receiver.

Based on the record of simulated inflows to Lizard Lake, the lowest flows in Lizard Lake occurred in September, 1994. Therefore, a Stage 4 breach, resulting in the discharge of 6.2 M-m^3 of water to Lizard Lake during September of 1994 has been selected as the worst case scenario for assessment of impacts to Lizard Lake.

4.0 DERIVATION OF BREACH OUTFLOWS

Breach outflow hydrographs were developed using dam breach parameters (i.e., breach formation time, and final breach dimensions) as defined by Froehlich (2008) to assess the potential water quality impacts to Upper Marmion Reservoir and Lizard Lake with the lake wide mixing models developed for the EIS/EA (see Lake Water Quality TSD; Golder 2013a). Using the Froehlich approach, breach parameters are calculated using empirical formulas and are a function of reservoir volume and elevation at the time of the breach, the bottom elevation of the breach (assumed in this case to be the elevation at the base of the dam) and the type of breach (piping or dam overtopping). A piping breach was assumed as worst case scenario because overtopping failure is mitigated by maintaining capacity for the design storm and the provision of the emergency spillway. It has also been assumed that the entire impounded water volume will be released during a breach. This is a conservative assumption because, in reality, some water way remain within low lying areas where the ground elevation is less than the lowest dam elevation. The estimated maximum breach dimensions are presented in Table 1. The estimated breach outflow hydrographs are presented in Table 2. Under both breach scenarios, approximately 9 hours would be required to drain the TMF Reclaim Pond.

Table 1: Estimated Maximum Breach Parameters

Parameter	Upper Marmion Reservoir (Sawbill Bay)	Lizard Lake
Construction Stage	1A	4
Maximum Potential Water Volume	4.1 M-m^3	6.2 M-m^3
Breach Base Width	27.8 m	32.0 m
Breach Bottom Elevation	418.0 m	427.0 m
Breach Top Width	50.9 m	58.6 m
Breach Top Elevation (Dam Crest)	434.5 m	446.0

Table 2: Estimated Breach Outflow Hydrographs

Time (h)	Discharge to Sawbill Bay (m^3/s)	Discharge to Lizard Lake (m^3/s)
0	-	-
1	927	1,414
2	113	172
3	39	59
4	22	32
5	12	19
6	7	11
7	4	6
8	2	4
9	1	2

5.0 HYDRODYNAMIC MIXING MODEL

The potential impacts of a dam failure on water quality in the receiving environment were assessed using the lake-wide hydrodynamic mixing models (i.e., box-models) developed for the EIS/EA lake water quality assessments completed for Upper Marmion Reservoir and Lizard Lake (see Lake Water Quality TSD; Golder, 2013a). The hydrodynamic models were set up to provide an estimate of the mixing that can be expected at various locations within Upper Marmion Reservoir and Lizard Lake. The models were developed based on the general flow distribution and volumes of the waterbodies. Within the models, the waterbodies were divided into compartments. The divisions between the compartments were based on lake bathymetry and were positioned at locations where shallow depths would tend to hydraulically separate the compartments. Each compartment in the model was assumed to be well-mixed with no vertical stratification. The models for Upper Marmion Reservoir and Lizard Lake are described in detail in Golder (2013a) and summarized briefly in the following sections.

5.1 Upper Marmion Reservoir

5.1.1 Original Hydrodynamic Model

The compartments of the Upper Marmion Reservoir hydrodynamic model are shown in Figure 3. The model predicts impacts up to the Raft Lake Dam. Figure 4 shows a schematic of the model, including the connecting flows that were used in the mass balance. Key components of the original model include:

- Water levels in the reservoir were fixed to match the record of water levels and Raft Lake Dam outflows.
- Inflows to the reservoir as described in the Hydrology TSD (Golder 2013b);
- Connecting flows were allowed to move in either direction depending on the inflows and changes in water elevation (e.g., backflow into Sawbill Bay during filling of Upper Marmion Reservoir in the spring). These reverse flows were also incorporated into the mass balance modelling.
- Mine effluent discharge released to model compartment 6 as described in the Site Water Quality TSD (Golder 2013c).

The original model results indicate that most of the model compartments have a residence time of less than 10 days. The exceptions are the northern and central basins of Sawbill Bay (compartments 7b and 7c, respectively) and compartment 10 which have residence times of over a year. Therefore, the main flow-through portion of the reservoir can expect to see responses to effluent loads on a short time frame (e.g., one month) while Sawbill Bay is expected to respond to effluent discharges on a longer time frame (e.g., years).

5.1.2 Updated Hydrodynamic Model with Breach Inflow

The potential impacts to water quality in Upper Marmion Reservoir in the event of a dam failure were assessed by modifying the original model in the following manner:

- Breach inflows (Table 2) were assumed to be released to Basin 7c in March of 2003 (see Section 3.1).
- Water levels within the Reservoir were allowed to fluctuate instead of being fixed to historical levels in order to accommodate the additional breach inflow (i.e., inflows to Upper Marmion Reservoir and outflows from the Raft Lake Dam were unchanged from the original model).

5.2 Lizard Lake

5.2.1 Original Hydrodynamic Model

The compartments of the Lizard lake hydrodynamic model are shown in Figure 5. Figure 6 shows a schematic of the model. The model predicts impacts in Lizard Lake up to its outlet. Model input data included:

- Daily inflows to Lizard Lake estimated using a HEC-HMS Model (Golder 2013b); and
- Seepage flows from the TMF Reclaim Pond to Lizard Lake in accordance with the EIS/EA (Golder 2013c).

The model results indicate that the Lizard Lake compartments 1, 2 and 3 have residence times of 44, 46 and 108 days, respectively.

5.2.2 Updated Hydrodynamic Model with Breach Inflow

The potential impacts to water quality in Lizard Lake in the event of a dam failure were assessed by modifying the original model in the following manner:

- Dam breach inflows (Table 2) were assumed to be released to Basin 2 in September of 1994 (see Section 3.1). Basin 2 was selected for the following reasons:
    1) The dam is highest upstream of Basin 2 and therefore, a breach at this location would cause the fastest discharge of water; and
    2) Inflow to Basin 2 would result in the most impact to the neighboring compartments, based on model sensitivity analysis.

6.0 POTENTIAL IMPACTS TO WATER QUALITY

All potentially mine impacted flows, including mine effluent, TMF seepage and potential breach flows, were assumed to have a generic concentration of 100 particles per unit volume to allow tracking of mine release water in the models. Therefore, when examining the results presented in this memorandum, a predicted particle concentration can be interpreted as being equivalent to the percentage of the mine water concentration within each model compartment (e.g., a predicted concentration of 1% means that the water volume within the model compartment is comprised of one part mine release water and ninety-nine parts fresh water).

The following two modelling scenarios were run for each model:

1) Without dam breach to determine baseline mine water concentrations in each compartment, including only mine effluent discharge into Basin 6 of the Upper Marmion Reservoir Model and only TMF seepage inflows to Lizard Lake.
2) With dam breach to determine peak concentrations as well as the time required for concentrations to return to the baseline (i.e, pre-breach) conditions.

6.1.1 Model Results – Upper Marmion Reservoir

Table 3 provides the results of the modelling analysis for Upper Marmion Reservoir. In Table 3, the mean baseline concentrations are the average mine water concentrations in the compartments over the simulation period in the no breach model. The peak concentration is the highest daily average concentration in each compartment. The duration of elevated concentration is the period of time required for the peak concentration to return to the simulated baseline concentration. The key results can be summarized as follows:

- Water quality in Sawbill Bay (compartments 7a -7c) would be most impacted by a dam breach. Compartment 7c would have the highest peak concentration because this is where the breach discharge would occur. Due the normal circulation patterns in Sawbill Bay and regular back flooding resulting from water level management at Raft Lake Dam, it is predicted to take up to 6 years to return to pre-breach concentrations;
- Compartments 3, 6, 8, 9 and 11 are predicted to take under a year to return to baseline concentrations;
- A dam breach would have limited to no impact to compartments 1, 2, 3, 4 or 10.

Figure 7 shows the concentration profiles in Sawbill Bay (compartment 7c) and at the Raft Lake Dam (compartment 11) under the baseline and dam breach modelling scenarios.

Table 3: Dam Breach Results – Upper Marmion Reservoir

Basin	Mean Baseline Concentration (%)[1]	Dam Breach Scenario	
		Peak Daily Average Concentration (%)	Duration Of Elevated Concentration (Years)[2]
1	0	0	-
2	0	0	-
3	0	0.1	-
4	0	0.1	-
5	0.4	1.1	0.4
6	0.5	1.3	0.6
7a	0.2	2.4	4.0
7b	0.1	3.1	5.6
7c	0.1	8.2	6.2
8	0.4	1.0	0.4
9	0.4	0.9	0.3
10	0.3	0.4	-
11	0.4	0.9	0.3

Notes:
1. Baseline concentrations consider only the release of mine effluent to compartment 6.
2. Duration of elevated concentration defined as period of time required for peak mine water concentration to return to baseline concentration.

6.1.2 Model Results – Lizard Lake

Table 4 provides the results of the analysis for Lizard Lake. A dam breach to Lizard Lake would release 6.2 Mm^3 of mine water to compartment 2 of Lizard Lake, which has an estimated storage volume of 1.6 Mm^3. This would result in and estimated lake water level rise of nearly 3 m, accounting for increased outflows from the lake during a dam breach event. A peak mine water concentration of 89 % is predicted immediately following the breach. The water quality would improve with time, requiring just under 2 years to return to pre-breach concentrations. Figure 8 shows the concentration profiles in the lake basins under the dam breach scenario.

Table 4: Dam Breach Results – Lizard Lake

Basin	Mean Baseline Concentration (%)[1]	Dam Breach Scenario	
		Peak Daily Average Concentration (%)	Duration Of Elevated Concentration (Years)[2]
1	0.28	40.6	0.7
2	0.39	88.5	1.1
3	0.41	50.2	1.9

Notes:
1. Baseline concentrations consider only the release seepage from the TMF in accordance with EIS/EA.
2. Duration of elevated concentration defined as period of time required for peak mine water concentration to return to baseline concentration.

7.0 DISCUSSION

This assessment has been conducted assuming worst-case scenarios, as requested by T(3)-09. The maximum potential breach volumes (4.1 Mm^3 and 6.2 Mm^3 for Upper Marmion Reservoir and Lizard Lake, respectively) assume that the design storage capacity provided within the TMF Reclaim Pond for the design storm has been fully consumed. This would only occur during an extreme precipitation rainfall event with a very low probability of occurrence. The assessment also assumes a breach during a low flow condition. Therefore, the results presented herein are considered to be an upper-bound estimate of potential impacts with no possibility of actually occurring because a low flow condition would not persist if a design storm event were to occur. Furthermore, if such an extreme precipitation event were to occur, it would generate wider reaching and potentially more severe impacts on the overall watersheds of Upper Marmion Reservoir and Lizard Lake, beyond what would be generated from a failure of a single mine reclaim pond dam.

The probability of failure of the TMF Reclaim Pond dam is considered to be extremely low. Nevertheless, if a failure of the TMF Reclaim Pond dam and subsequent release of impounded water to Upper Marmion Reservoir (via Sawbill Bay) or to Lizard Lake were to occur, there would be a temporary increase in the concentration of mine release water in the receiving water bodies. Worst case peak concentrations of mine release water, immediately following a dam breach, are predicted to increase by 8% and 88% above baseline concentrations, respectively, for Upper Sawbill Bay (model compartment 7c) and Lizard Lake (model compartment 2). Concentrations would quickly diminish as shown in Figures 7 and 8 and continue to improve with time as the mine release water is further mixed and the waterbodies are flushed with natural inflows. As such, the potential impact of a dam breach on water quality would be short-term and reversible. Sawbill Bay is predicted to be completely recovered to pre-breach conditions in approximately 6 years and the majority of other impacted areas of Upper Marmion Reservoir are predicted to recover in under a year. Lizard Lake is predicted to recover within 2 years.

The rapid release of water during a failure would have the potential to result in erosion of the tailings deposited beneath the Reclaim Pond and erosion of the existing terrain between the dam breach location and the receiving water body. Such erosion would result in the potential for elevated concentrations of suspended sediments in the breach flow. Under both failure scenarios, the relative short distance between the Reclaim Pond and the receiver would limit the potential for surface erosion. Suspended sediments would settle in the receiving waterbodies and could be dredged if necessary. The tailings are non-acid generating and have low metal leaching potential (see Geochemistry, Geology and Soil TSD), therefore, once deposited there would be immediate sedimentation impacts on the bottom sediments, but no residual impact on water quality would be expected.

The water in the TMF Reclaim Pond is predicted to have a higher concentration of total dissolved solids (TDS) than the water in Upper Marmion Reservoir. Therefore, a dam breach may have to potential to result in temporary vertical stratification within Sawbill Bay or other deeper compartments of Upper Marmion Reservoir due to its higher relative density. If a breach were to occur, monitoring would be conducted to assess if stratification is occurring and, if required, remediation measures such as mechanical mixing will be implemented. Stratification is not likely to occur within Lizard Lake because, due to its relative shallow depth, it is expected to by vertically well mixed.

The TMF Reclaim Pond water quality (see Table 4-13 of the Site Water Quality TSD), is predicted to have concentrations of cyanide, cadmium, cobalt, copper, molybdenum and uranium exceeding Ontario Provincial Water Quality Objectives (PWQO) for the protection of aquatic life. In the event of a dam breach, this water would be mixed with the water in Upper Marmion Reservoir or Lizard Lake. Although concentrations will be reduced due to mixing and dilution, temporary exceedances of PWQO guidelines for the above noted parameters would be expected to occur within some components of Upper Marmion Reservoir or Lizard Lake. The modelling presented in this memorandum show that this condition would be temporary and reversible.

There are no predicted social or cultural consequences of a dam failure because there are no communities or significant archaeological site or artifacts located in the potentially impacted areas downstream of the TMF Reclaim dams.

By its nature, a dam breach assessment presumes that a dam will fail. In fact, the potential or probability of failure of the TMF Reclaim Pond dams is extremely small and the risk will be managed through proper design, operation, inspection and maintenance. This is an important consideration when reviewing the results of this assessment. Despite the extremely low probability of failure, impacts resulting from a dam failure can be evaluated and are presented herein, the results of the assessment presented herein show that even in the extremely unlikely event of a dam breach impacts to water quality would be temporary and reversible.

8.0 CLOSURE

Should you have any questions regarding the content of this memorandum, please contact the undersigned.

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<Original signed by>

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AC/GVA/AA/KDV/sk

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References

Boileau, 2004. 2004 to 2014 Seine River Water Management Plan. March 31, 2004.

Froehlich, 2008. "Embankment Dam Breach Parameters and Their Uncertainties." Journal of Hydraulic Engineering. December 2008. P 1708.

Golder, 2013a. Hammond Reef Gold Project: Lake Water Quality Technical Support Document. Version 1. Project Number 10-1118-0020. Doc No. 2012-076. Issued February 2013.

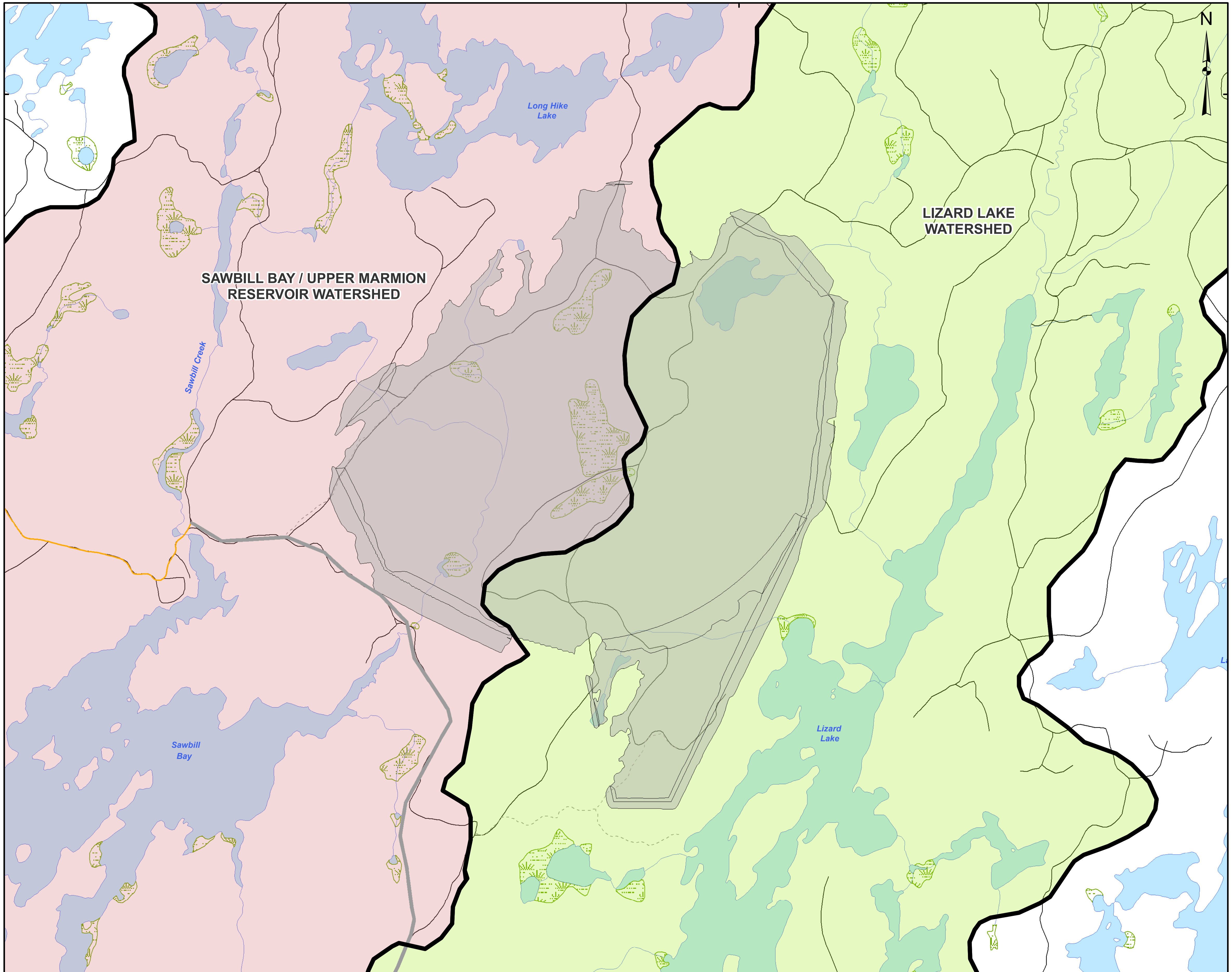
Golder, 2013b. Hammond Reef Gold Project: Hydrology Technical Support Document. Version 1. Project Number 10-1118-0020. Doc No. 2012-078. Issued February 2013.

Golder, 2013c. Hammond Reef Gold Project: Site Water Quality Technical Support Document. Version 1. Project Number 10-1118-0020. Doc No. 2012-076. Issued February 2013.

Attachments:

Figure 1: Watersheds Potentially Affected By TMF Reclaim Pond Dam Failure
Figure 2: Tailings Deposition and Dam Construction Staging Plan
Figure 3: Model Compartments Upper Marmion Reservoir
Figure 4: Box Model for Upper Marmion Reservoir
Figure 5: Model Compartments Lizard Lake
Figure 6: Box Model for Lizard Lake
Figure 7: Upper Marmion Reservoir Concentrations Under Tailings Dam Failure Scenario
Figure 8: Lizard Lake Concentrations Under Tailings Dam Failure Scenario

FIGURES



LEGEND

- Trail
- Road
- River/Stream
- Lake
- Wetland
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Project Facilities (Ultimate Configuration)
- Sawbill Bay / Upper Marmion Reservoir Watershed
- Lizard Lake Watershed
- Watershed Divide

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500
SCALE 1:25,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT

TITLE
WATERSHEDS POTENTIALLY AFFECTED BY TMF RECLAIM POND DAM FAILURE

Golder Associates
Mississauga, Ontario

PROJECT NO. 1408383			SCALE AS SHOWN	REV. ION 1
DESIGN	CGE	14 Nov. 2008	FIGURE: 1	
GIS	SO	25 Jul. 2016		
CHECK	AC	25 Jul. 2016		
REVIEW	THW	25 Jul. 2016		

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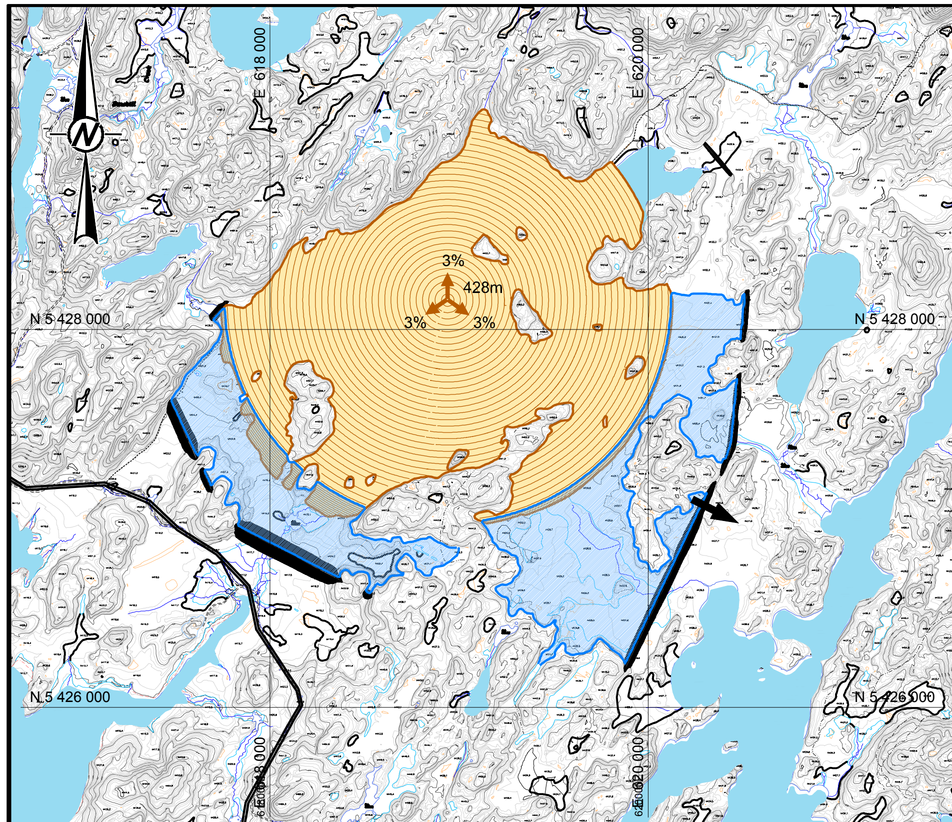
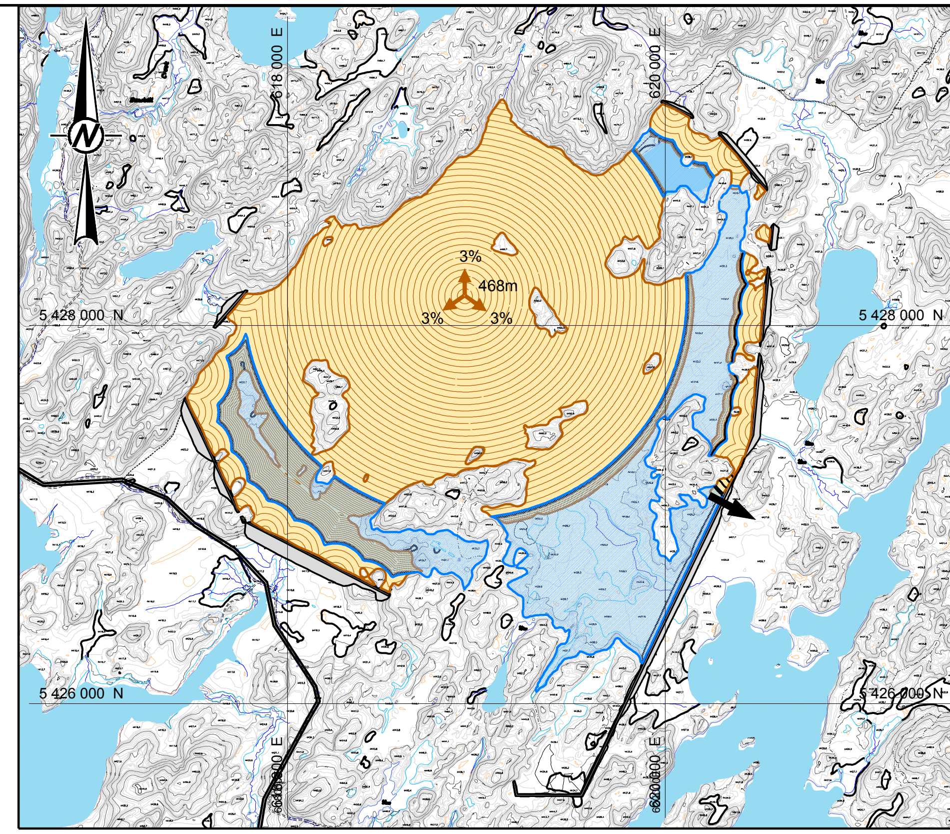
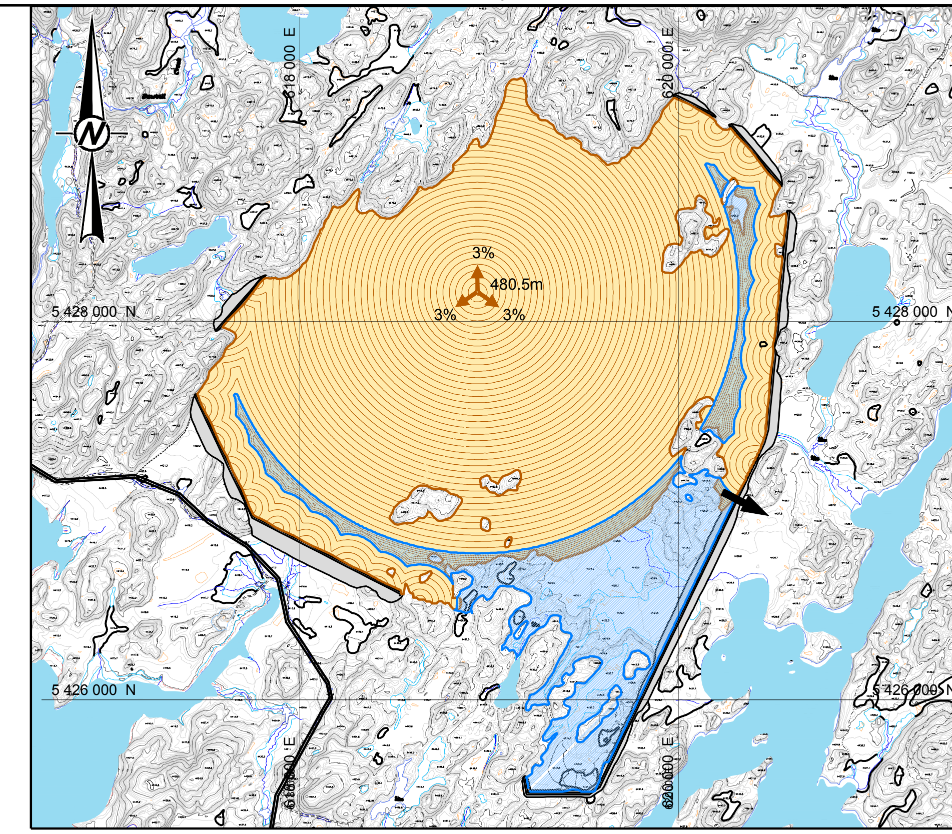


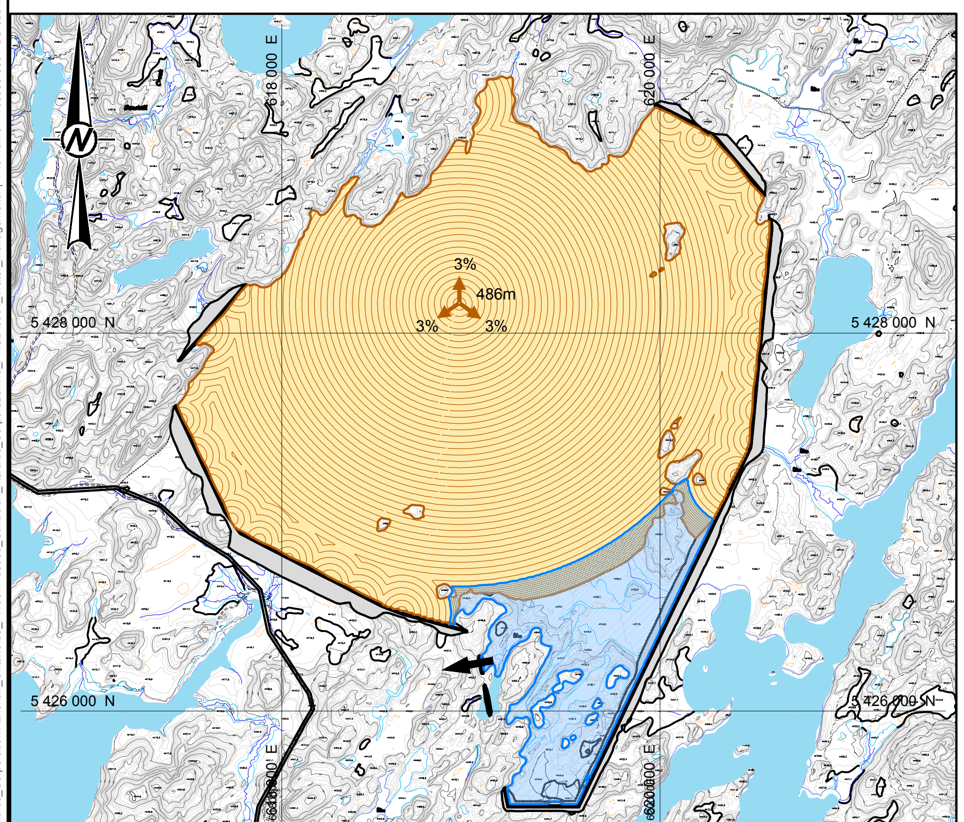
STAGE 1A (LINER) - YEAR 0 T0 2.3



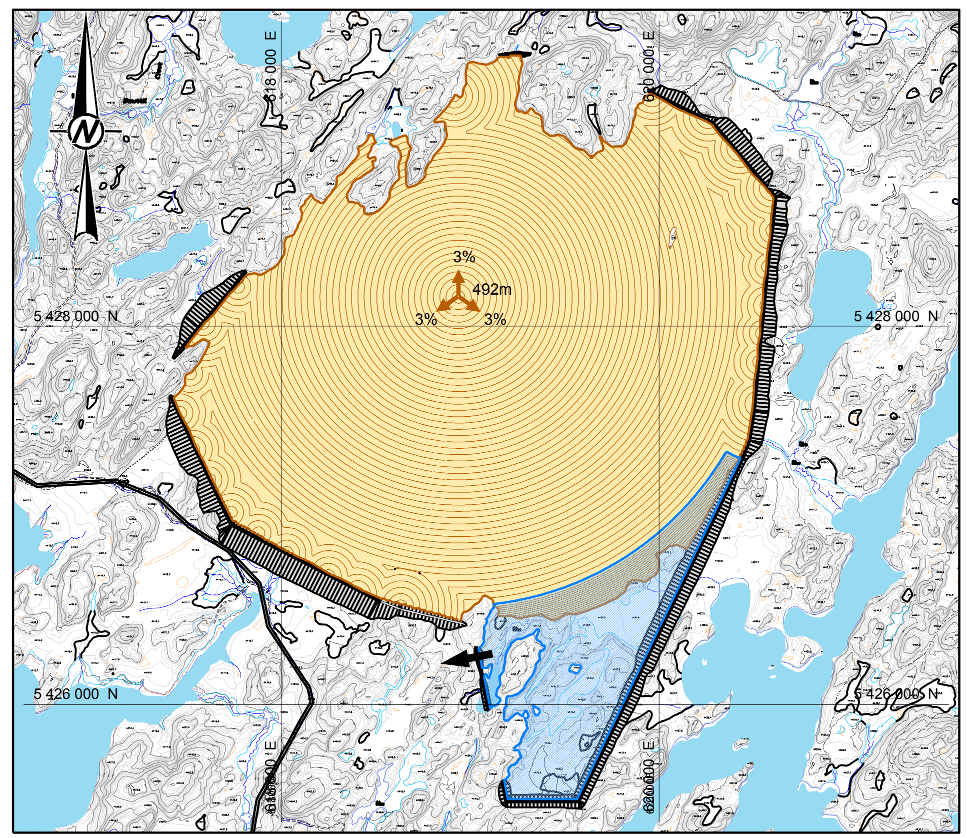
STAGE 1B (ROCKFILL) - YEAR 2.3 TO 3



STAGE 2 - YEAR 3 TO 6



STAGE 3 - YEAR 6 T0 8



STAGE 4 (ULTIMATE) - YEAR 8 TO 10.5

LEGEND

- TAILINGS / RECLAIM DAM
- DEPOSITED TAILINGS
- TAILINGS DISCHARGE LOCATION
- RECLAIM POND
- EMERGENCY SPILLWAY
- INTERNAL RECLAIM POND CONNECTION DITCH
- EXISTING GROUND SURFACE CONTOURS (1m INTERVAL)
- EXISTING WATERBODIES

NOTE(S)

1. GRID IS NAD83 ZONE 18. ELEVATIONS ARE GEODETIC (masl).
2. TOTAL TAILINGS STORAGE AT END OF STAGE 4 IS 165 M-m³.
3. RECLAIM POND CAPACITY IS 6.2 M-m³ DURING ALL STAGES.
4. EMERGENCY SPILLWAY LOCATION MOVES FROM EAST SIDE TO WEST SIDE OF RECLAIM POND PRIOR TO STAGE 3 (YEAR 6)

REFERENCE(S)

LIDAR CONTOURS - PROVIDED BY AEROGEOMATICS LTD AND BRETT RESOURCES (1m RESOLUTION, JULY 2010)

0 1,000 2,000
1:40,000 METRES

CLIENT
CANADIAN MALARTIC CORPORATION

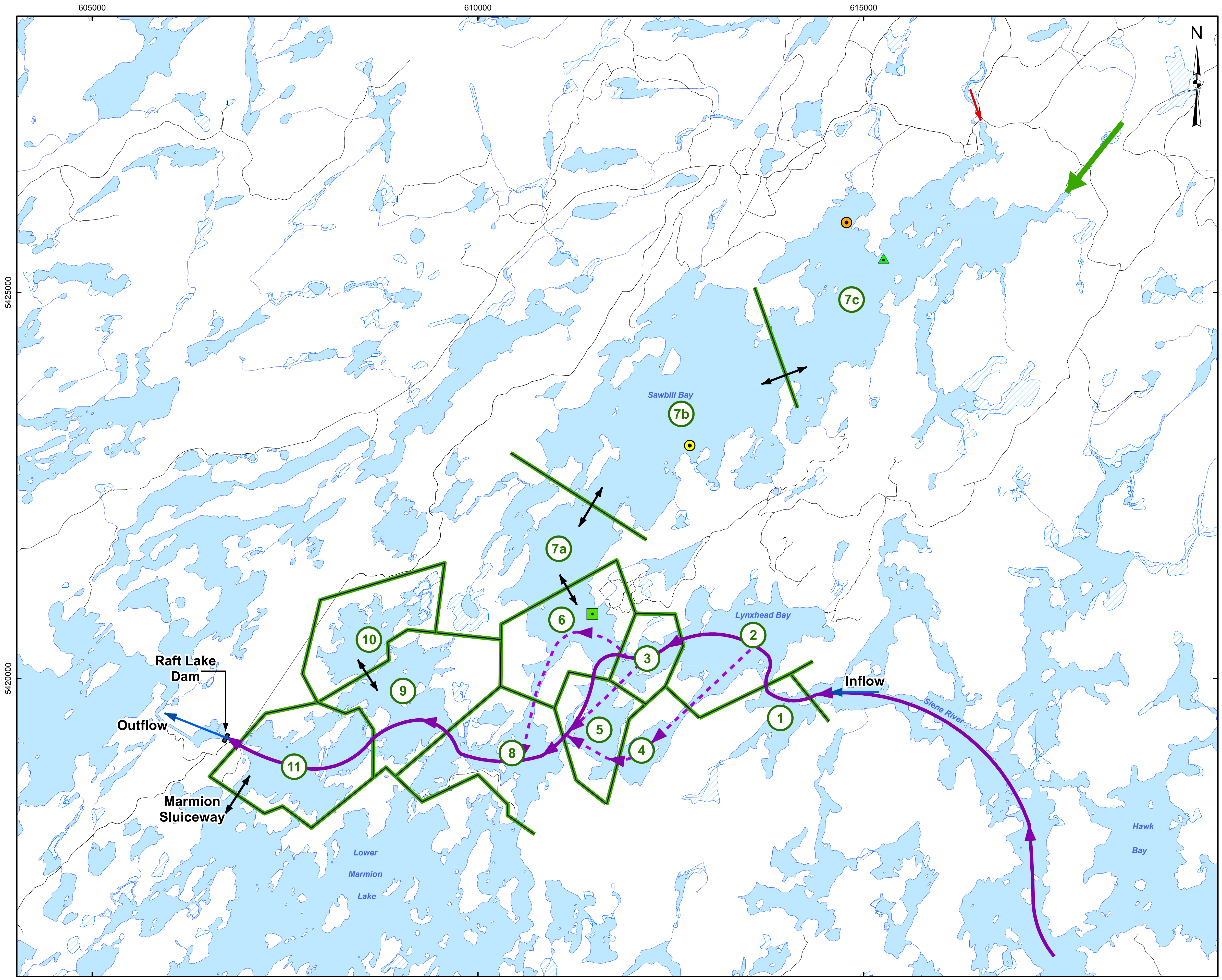
PROJECT
HAMMOND REEF GOLD PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2013-12-02
DESIGNED	RM
PREPARED	TDR
REVIEWED	DCJ
APPROVED	JKB

TITLE
TAILINGS DEPOSITION AND DAM CONSTRUCTION STAGING PLAN

PROJECT NO.	PHASE	REV.	FIGURE
1408383	3502	A	2



LEGEND

- Effluent Discharge Point
- Discharge Location
- Freshwater Intake - Camp Site Potable
- Freshwater Intake - Process and Plant Potable
- Main River Flow
- Secondary Flow Path
- Water Level Drive Exchange Flow
- Major Tributaries
- Dam Breach Flow Direction
- Road
- River/Stream
- Lake
- Wetland
- Model Compartment

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000 1,500 2,000
SCALE 1:50,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT

TITLE
MODEL COMPARTMENTS
UPPER MARMION RESERVOIR

Golder Associates
Mississauga, Ontario

PROJECT NO. 1408383			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008	**FIGURE: 3**	
GIS	SO	25 Jul. 2016		
CHECK	AC	25 Jul. 2016		
REVIEW	KDV	25 Jul. 2016		

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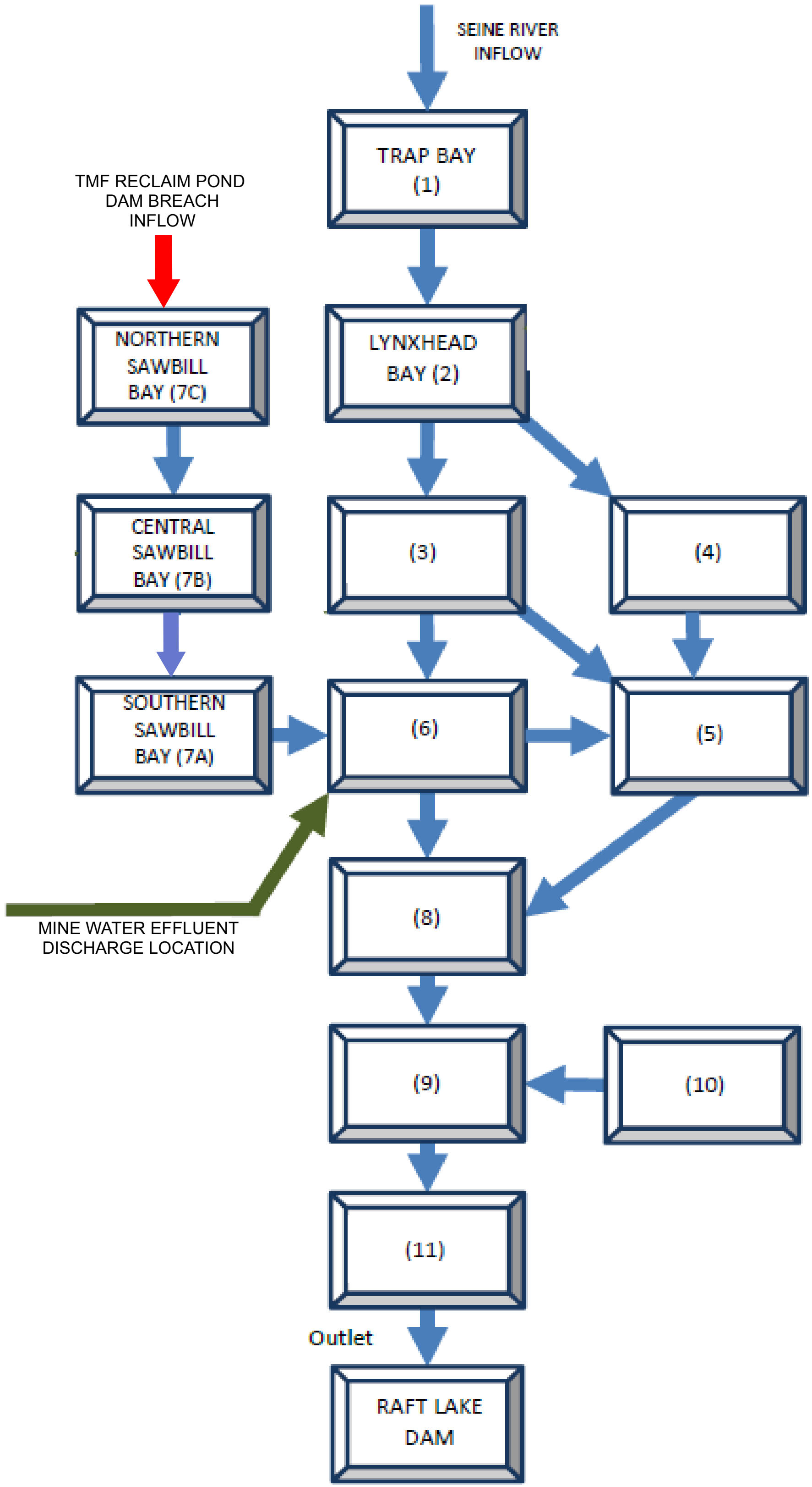


PROJECT

HAMMOND REEF GOLD PROJECT

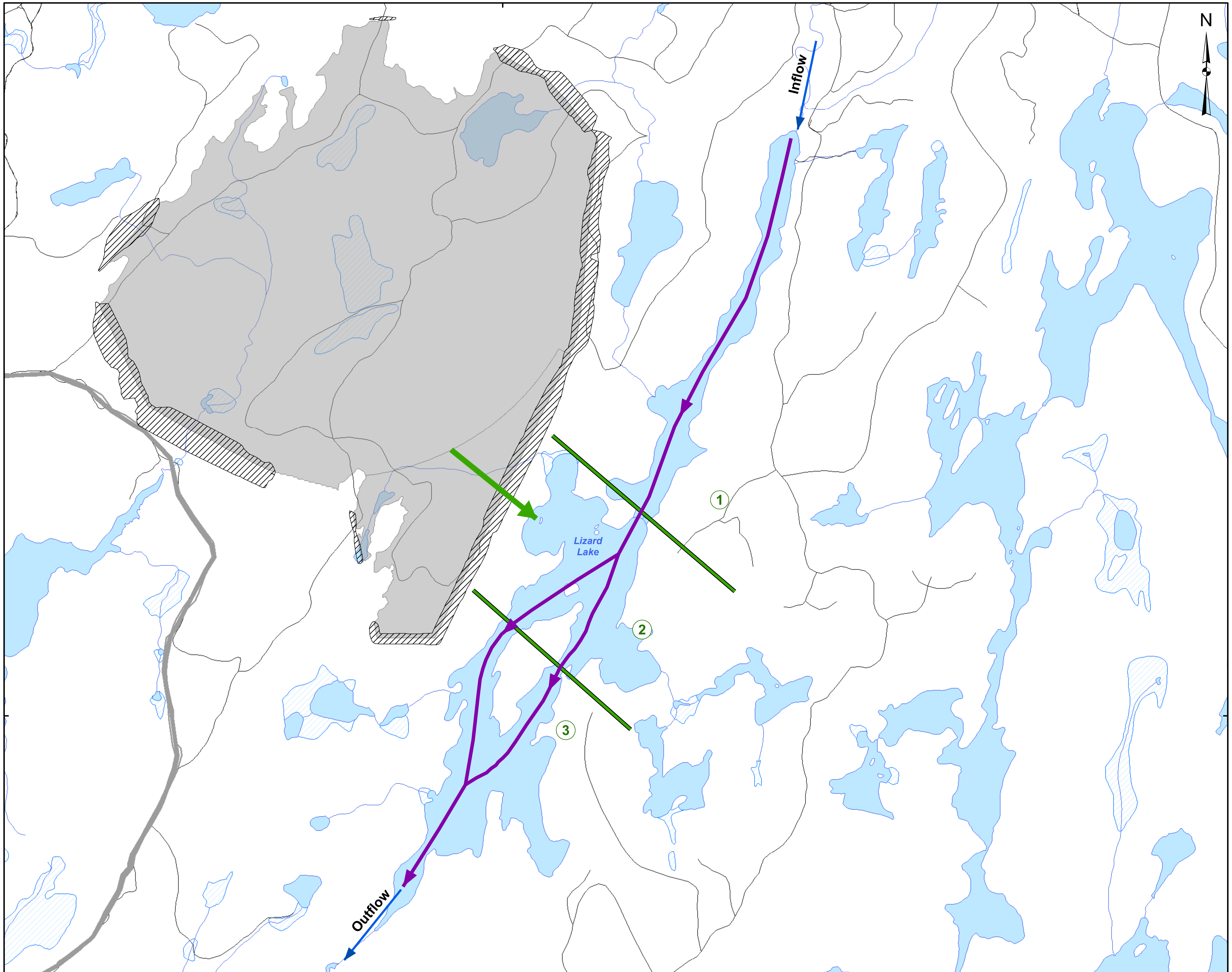
TITLE

BOX MODEL FOR UPPER MARMION RESERVOIR

Golder Associates
Mississauga, Ontario

PROJECT NO. 1408383			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	12 Nov. 2012	**FIGURE: 4**	
GIS	SO	25 Jul. 2016		
CHECK	AC	25 Jul. 2016		
REVIEW	KJD	25 Jul. 2016		

G:\Projects\2013\13-1118-0010_Osisko_Hammond_Reef\GIS\MXDs\Reporting\1408383\BoxModelforUpperMarmionLake.mxd



LEGEND

- Dam Breach Flow Direction
- Main River Flow
- Model Compartment Boundary
- Road
- River/Stream
- Lake
- Wetland
- Tailings Management Facility
- Tailings Management Facility Dam

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000
SCALE 1:25,000 METRES

PROJECT
HAMMOND REEF GOLD PROJECT

TITLE
MODEL COMPARTMENTS LIZARD LAKE

Golder Associates
Mississauga, Ontario

PROJECT NO. 1408383			SCALE AS SHOWN	VERSION 1
DESIGN	CGE	14 Nov. 2008	FIGURE: 5	
GIS	SO	25 Jul. 2016		
CHECK	AC	25 Jul. 2016		
REVIEW	KJD	25 Jul. 2016		

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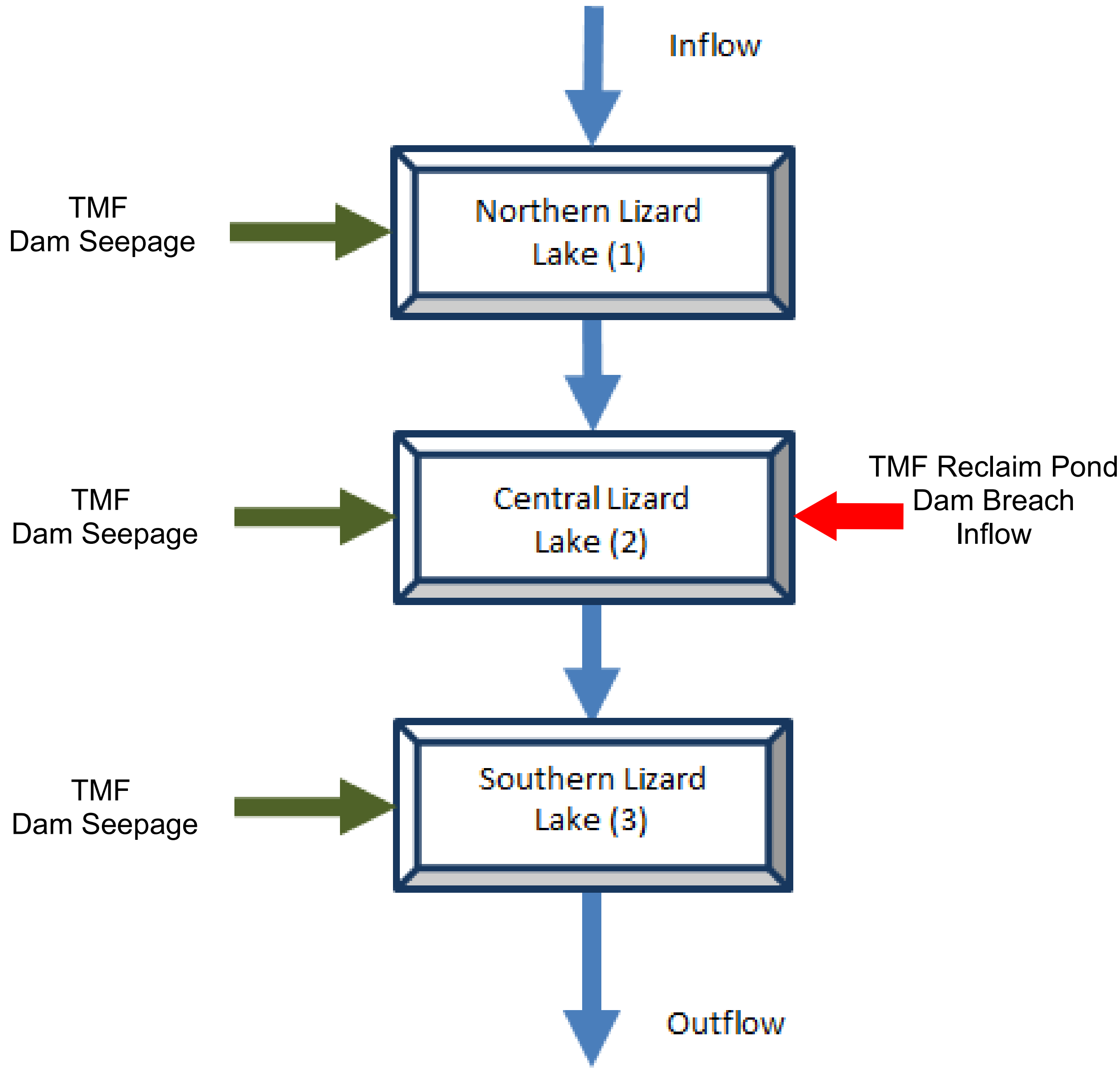

PROJECT

HAMMOND REEF GOLD PROJECT

TITLE

BOX MODEL FOR LIZARD LAKE

Golder Associates
Mississauga, Ontario

PROJECT NO. 1408383			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	12 Nov. 2012	**FIGURE: 6**	
GIS	SO	25 Jul. 2016		
CHECK	AC	25 Jul. 2016		
REVIEW	KJD	25 Jul. 2016		

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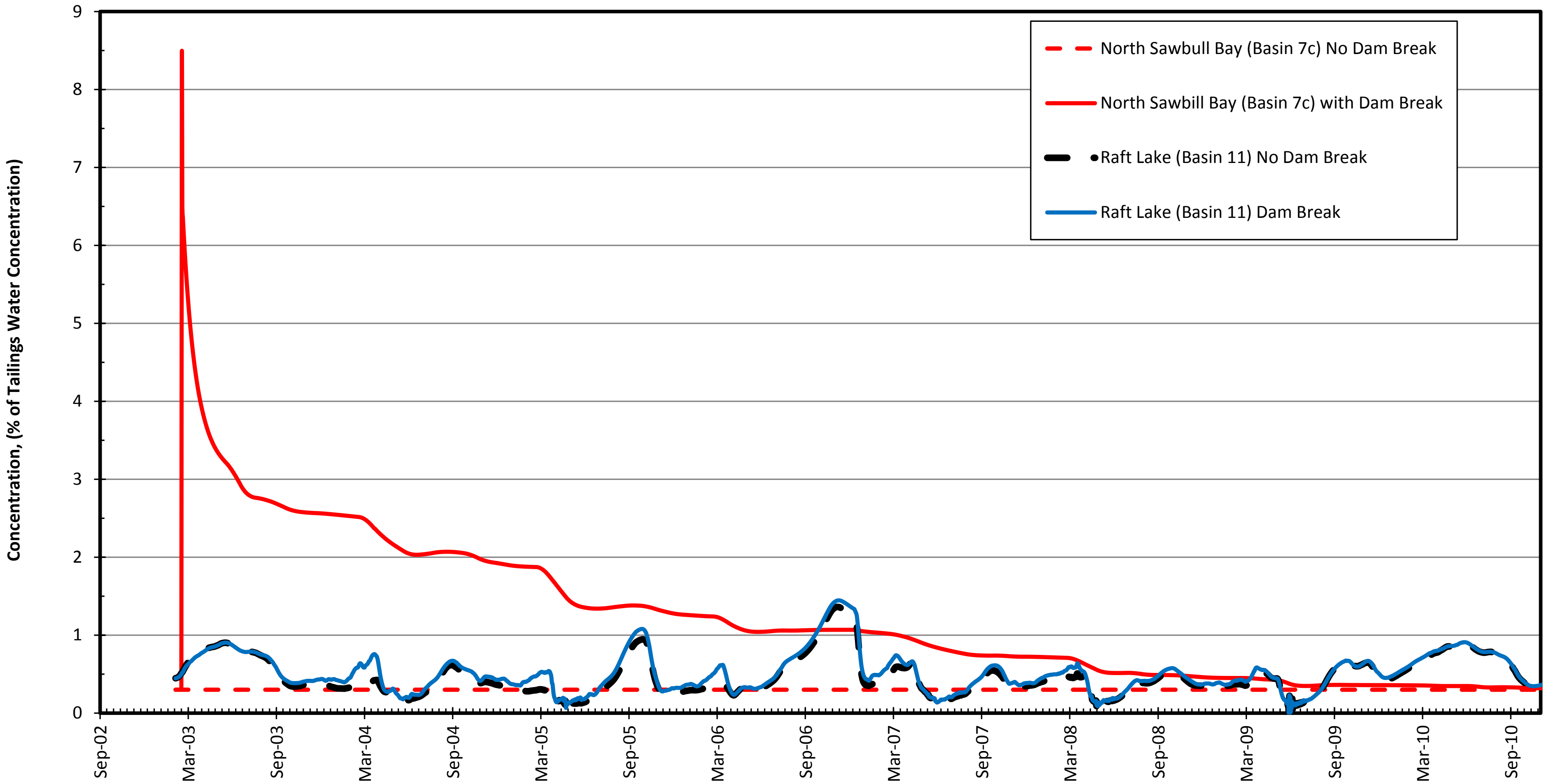
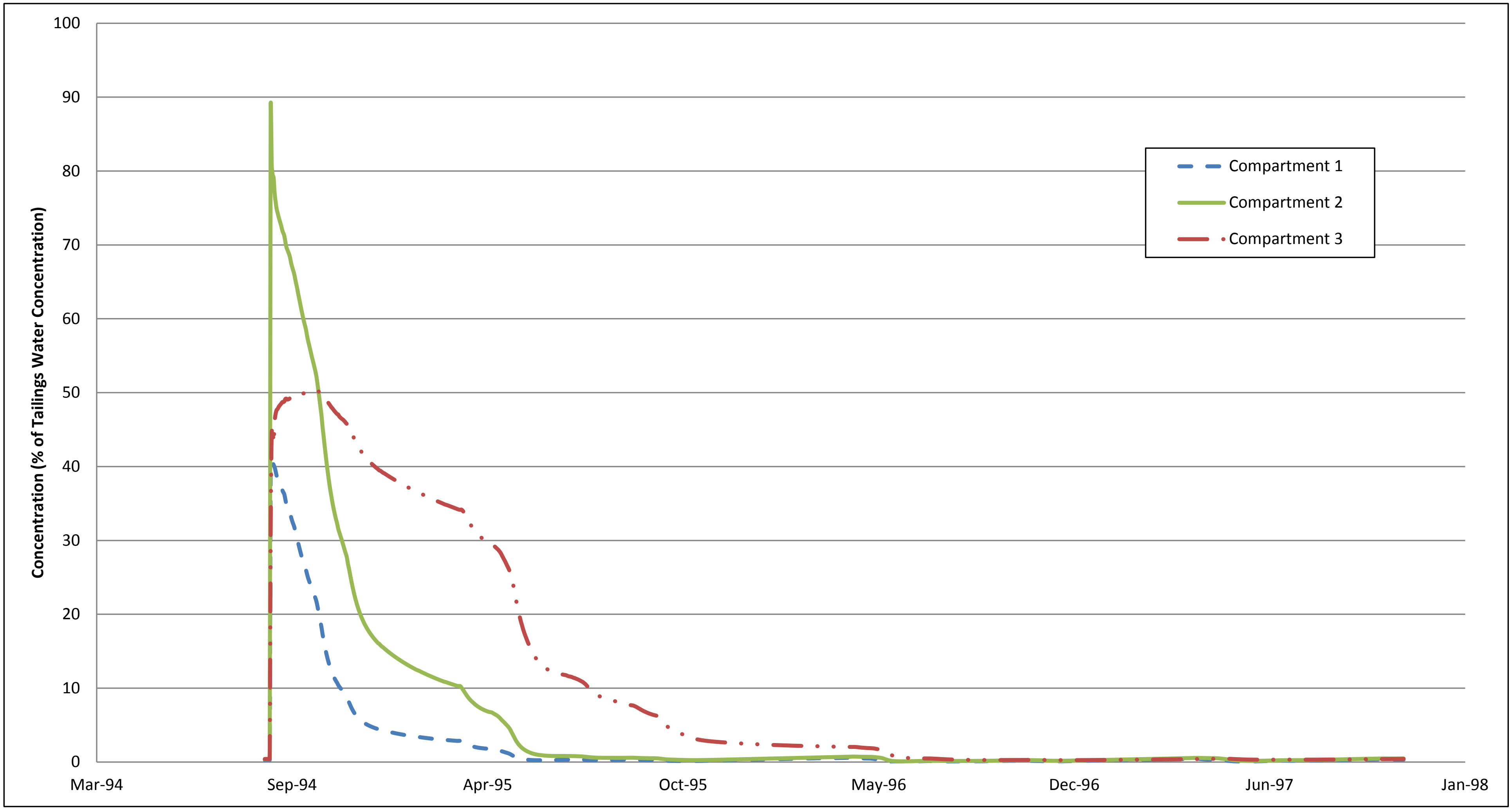


Assumptions:
1) Stage 1a Taillings Dam
2) Release of up to 4.1M-m³ to Sawbill Bay
3) Tailings water concentration of 100 particles per unit volume

PROJECT	HAMMOND REEF GOLD PROJECT			
TITLE	UPPER MARMION RESERVOIR CONCENTRATIONS UNDER TAILINGS DAM FAILURE SCENARIO			
Golder Associates	PROJECT NO. 1408383			REV. 0.0
	DESIGN	SO	05-May-2014	FIGURE: 7
	GIS	SO	29-Mar-2016	
	CHECK	AC	29-Mar-2016	
	REVIEW	DG	29-Mar-2016	



Assumptions:
1) Stage 4 (Ultimate) Taillings Dam
2) Release of up to 6.2M-m^3 to Lizard Lake
3) Tailings water concentration of 100 particles per unit volume

PROJECT **HAMMOND REEF GOLD PROJECT**			
TITLE **LIZARD LAKE CONCENTRATIONS UNDER TAILINGS DAM FAILURE SCENARIO**			
PROJECT NO. 1408383			REV. 0.0
DESIGN	SO	05-May-2014	**FIGURE: 8**
GIS	SO	29-Mar-2016	
CHECK	DH	29-Mar-2016	
REVIEW	DG	29-Mar-2016	

Golder Associates