D4 HYDROGEOLOGY UPDATED EFFECTS ASSESSMENT

Marathon Palladium Project Environmental Impact Statement Addendum Appendix D4: Hydrogeology Updated Effects Assessment Report

FINAL

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Prepared for:

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Abbreviations

amsl	above mean sea level
APV	Aquatic Protection Values
BGS	below ground surface
CEAA	*Canadian Environmental Assessment Act*
Cu	copper
DFO	Fisheries and Oceans Canada
EA Act	Ontario's *Environmental Assessment Act*
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
EIS Addendum	Addendum to the Marathon PGM-Cu Environmental Impact Statement
EIS Guidelines	*Guidelines for the Preparation of an Environmental Impact Statement – Marathon Platinum Group Metals and Copper Mine Project*
EPA	*Environmental Protection Act*
Fe	iron
GCDWQ	Guidelines for Canadian Drinking Water Quality
GenPGM	Generation PGM
LSA	local study area
MDMER	Metal and Diamond Mining Effluent Regulations
MECP	Ontario Ministry of the Environment, Conservation, and Parks
MRSA	mine rock storage area
O. Reg.	Ontario regulation
ODWQS	Ontario Drinking Water Quality Standards
OWRA	*Ontario Water Resources Act*
the Panel	Joint Review Panel
PSMF	process solids management facility
PTTW	permit to take water
RSA	regional study area

SID	supporting information document
Stantec	Stantec Consulting Ltd.
SSA	site study area
TSS	total suspended solids
WWR	water well record

1.0 INTRODUCTION

Generation PGM Inc. (GenPGM) proposes to develop the Marathon Palladium Project (the "Project"), which is a platinum group metals (PGM), copper (Cu) and possibly iron (Fe) open pit mine and processing operation near the Town of Marathon, Ontario. The Project is being assessed in accordance with the *Canadian Environmental Assessment Act* (CEAA 2012) and Ontario's *Environmental Assessment Act* (EA Act) through a Joint Review Panel (the Panel) pursuant to the *Canada-Ontario Agreement on Environmental Assessment Cooperation* (2004).

The Project is located approximately 10 km north of the Town of Marathon, Ontario (Figure 1, Appendix A). Marathon is a community of approximately 3,300 people (Statistics Canada 2017) located adjacent to the Trans-Canada Highway (Highway 17) on the northeast shore of Lake Superior, approximately 300 km east of Thunder Bay and 400 km northwest of Sault Ste. Marie. The centre of the Project footprint sits at approximately 48° 47' N latitude, 86° 19' W longitude (UTM NAD83 N16 Easting 550197 and Northing 5403595). The footprint of the proposed Project location is roughly bounded by Highway 17 and the Marathon Airport to the south, the Pic River and Camp 19 Road to the east, Hare Lake to the west, and Bamoos Lake to the north. Access is currently gained through Camp 19 Road (Figure 1, Appendix A). For a more detailed description of the Project refer to Chapter 2 (Volume 1) of the Environmental Impact Statement (EIS) Addendum (CIAR #727).

Stantec Consulting Ltd. (Stantec) has been retained by GenPGM to conduct an updated assessment of potential effects on hydrogeology as a result of the Project. This report provides an update to the effects assessment described in the information currently on the record, including:

- Supporting Information Document (SID) #14: Baseline Report – Hydrogeology, Marathon PGM-Cu Project prepared by True Grit Consulting Ltd. (July 5, 2012) (CIAR #227)
- SID #15: Impact Assessment – Hydrogeology – Marathon PGM-Cu Project prepared by True Grit Consulting Ltd. (July 5, 2012) (CIAR #227)
- Responses to IR24.1, IR24.2, IR24.3, IR24.4, IR24.5, IR24.6.1, IR24.6.2, IR24.7, IR24.8, IR24.15, IR24.16, and IR24.17 (CIAR #380)
- Responses to AIR6 and AIR8 (CIAR #651 and 653)
- Response to SIR6 (CIAR #574)

This hydrogeology effects assessment has been completed to inform the Addendum to the Marathon PGM-Cu Environmental Impact Statement (EIS Addendum) as input to the Panel process. The hydrogeology effects assessment has been prepared pursuant to CEAA, 2012 and in consideration of the *Guidelines for the Preparation of an Environmental Impact Statement – Marathon Platinum Group Metals and Copper Mine Project* (EIS Guidelines) (Canadian Environmental Assessment Agency (CEAA) and Ontario Ministry of the Environment (MOE, now the Ontario Ministry of the Environment, Conservation, and Parks (MECP)), 2011).

1.1 ASSESSMENT PURPOSE AND OBJECTIVES

The purpose of this updated effects assessment is to address 'changes' that may have occurred since the original assessment, including:

- Changes to the characterization of existing baseline conditions since previous baseline studies, as documented in the Marathon Palladium Project Environmental Hydrogeology Updated Baseline Report
- Changes to applicable criteria, standards, and/or thresholds for determining the significance of potential residual environmental effects
- Changes to the Project, including refinements to project components and activities implemented by GenPGM

The information presented in this report is intended to summarize and document existing conditions and to identify changes in groundwater quantity and quality at key receptors in order to determine potential and residual cumulative changes to groundwater quantity and quality. The impact assessment includes the following sections:

- Project overview and purpose of this assessment, as well as the identification of spatial and temporal Project boundaries and groundwater receptors (Section 1.0)
- Summary of previous impact assessment findings (Section 2.0)
- Identification of regulatory framework used for the assessment (Section 3.0)
- Review of baseline conditions within the assessment boundaries specific to the relevant effects being assessed (Section 4.0)
- Methodology and approach used to conduct the impact assessment (Section 5.0)
- Results and mitigation measures to be implemented (Section 6.0)

1.2 ASSESSMENT BOUNDARIES

For the purpose of this assessment, the spatial boundaries considered include the direct and indirect effects related to site preparation, construction/commissioning, operation, and decommissioning/post-closure of the Project. These areas are generally consistent with the spatial boundaries used in the original EIS (2012) and associated supporting information documents, with appropriate revisions/refinements and rationale provided below.

1.2.1 Site Study Area (SSA)

The Site Study Area (SSA) is the direct footprint of the Project. Based on refinements to the Project footprint, and in recognition of project components originally located outside of the SSA, a revised SSA has been developed that encompasses the immediate area in which Project activities and components may occur. As such, the SSA represents the area within which direct physical disturbance may occur as a result of the Project, whether temporary or permanent. The proposed site plan and corresponding SSA are depicted on Figure 1 (Appendix A).

1.2.2 Local Study Area (LSA)

The Local Study Area (LSA) is the maximum area within which environmental effects from Project activities and components can be predicted or measured with a reasonable degree of accuracy and confidence. The LSA is depicted on Figure 1 (Appendix A).

The LSA was selected based on the likely extent of drawdown from open pit dewatering and changes to flow or groundwater quality due to recharge from the process solids management facility (PSMF) and mine rock storage area (MRSA). The LSA is consistent with the boundaries of the baseline three-dimensional numerical groundwater flow model used in the Supporting Information Document #14 – Baseline Report – Hydrogeology, Marathon PGM-Cu (CIAR #227) prepared by True Grit Consulting Ltd. (2012a).

The western boundary of the LSA follows the shoreline of Lake Superior. The northern edge of the LSA follows the shoreline of Bamoos Lake and Hare Lake as well as the creeks between Bamoos Lake and Hare Lake and Hare Lake and Lake Superior. The eastern edge of the LSA follows the Pic River. The southern extent of the LSA coincides with a drainage divide represented by a topographic ridge.

1.2.3 Regional Study Area (RSA)

The Regional Study Area (RSA) is the area within which residual environmental effects from Project activities and components may interact cumulatively with the residual environmental effects of other past, present and future (i.e., certain or reasonably foreseeable) physical activities. The RSA is based on the potential for interactions between the Project and other existing or future potential projects. The RSA is depicted on Figure 1 (Appendix A). With respect to hydrogeology, the RSA is coincident with the LSA (Figure 1, Appendix A) due to the localized nature of potential Project effects.

1.3 TEMPORAL BOUNDARIES PHASES

The temporal boundaries for the Project are defined by the duration and timing of the individual Project phase (Phase 1 – Site Preparation, Phase II –Operations, Phase III – Decommissioning and Post Closure). Through refinements to the Project, the timing and duration of these phases has been revised as follows:

- **Phase I – Site Preparation and Construction**: This phase consists of pre-operation activities to prepare the site for extraction activities, which includes site preparation and construction activities to be completed concurrently over a period of 18 to 24 months (previously 18 months).
    - **Phase IA Site Preparation**: This phase consists of site clearing, grading and excavation to permit the subsequent construction.
    - **Phase IB Construction**: This phase consists of the building of the physical infrastructure and structures necessary to bring the Project into production.
- **Phase II – Operations**: This phase consists of the extraction and processing of selected minerals and will last for approximately 12.7 years (previously 11.5 years)
- **Phase III – Decommissioning and Closure**: While the site will be reclaimed on an on-going basis to the extent practical during all previous phases, this phase consists of the relatively intense period of reclamation and decommissioning upon cessation of mine operations and the duration of time required for the mine site to be stabilized following implementation of the closure plan.
    - **Phase IIIA – Decommissioning / Closure**: This phase will occur throughout the life of the project but the most intensive part (i.e., decommissioning activities), which will occur post-operation, will last for approximately 2 years (no change, previously 2 years).
    - **Phase IIIB – Post-Closure**: This phase will occur following substantial completion of all on-site decommissioning activities and will consist primarily of follow-up and monitoring programs and the subsequent stabilization of existing environmental conditions specific to each VEC (i.e., regeneration of vegetative cover, stabilization of water levels in the pits). For the purposes of the effects assessment, this phase is anticipated to last for up to approximately 45 years (to be confirmed based on the results of the effects assessment) (no change, previously 45 years).

2.0 PREVIOUS ASSESSMENT OF POTENTIAL EFFECTS

In 2012, True Grit Consulting Ltd. (TGCL) was retained by Stillwater Canada Inc. (SCI) to complete a groundwater impact assessment of their proposed mine site located north of the Town of Marathon, Ontario. The purpose of the work was to assess the effects of the proposed mine and associated infrastructure on groundwater levels, flows and discharge at and around the mine site in support of the overall Environmental Assessment (EA) process under CEAA.

Transient numerical groundwater modelling of the potential effects of mine infrastructure on groundwater levels, flow and discharge were carried out for the proposed Stillwater Marathon PGM-Cu project. The transient model consisted of two sequential model runs representing the operational and closure periods of the mine and built upon steady state modelling of baseline conditions previously reported.

The portion of the model that represented the eleven year operational life of the mine was primarily utilized to analyze the effects of the open pits, MRSA, and PSMF on groundwater levels with some analysis of the effects of those altered groundwater levels on groundwater flow. The progression of the open pits over the life of the mine will result in a drawdown of groundwater levels in the areas surrounding the pits; however, due to the low hydraulic conductivity of the bedrock and steep topography of the area, the drawdown was not predicted to extend beyond the local watershed and the flow in the Pic River was not measurably affected in the modelled scenarios.

The portion of the model that represented the closure period was primarily utilized to analyze groundwater flow pathways and discharge rates from beneath the MRSA and PSMF. The conceptual model for the mine site, which was based on field observations and other groundwater studies in the area and supported by the modelling completed for this project, predicted that water recharging the groundwater flow systems beneath the MRSA and PSMF would discharge to nearby surface water bodies. As a result, the primary water chemistry concern was surface water chemistry and the primary groundwater chemistry concern was the chemistry of the groundwater discharging to surface water. A particle tracking application was applied to the groundwater flow model results to predict the flow paths of groundwater originating beneath the MRSA and PSMF. Based on the particle tracking results, a water balance application was applied to calculate the discharge of groundwater from beneath both the MRSA and PSMF to individual watersheds.

Groundwater discharging from beneath the MRSA was predicted to either flow towards the main pit or the Pic River and its tributaries, with the majority of the tracked particles ending up in surface water bodies. A sensitivity analysis was conducted where recharge was varied and the discharge rates were sensitive to recharge. However, the presence of the MRSA was not expected to increase recharge, so the range of recharge values evaluated was expected to be representative.

Groundwater discharging from beneath the PSMF was predicted to flow either north to the streams in watershed (WS) 105 (includes Hare Lake and eventually discharges to Lake Superior), west to the streams in WS106 (flows to Lake Superior), or east to the streams in WS101 (flows to the Pic River). Sensitivity analyses that consisted of simulating grouting beneath the PSMF dams and assuming a uniform hydraulic conductivity in the top model layer across the LSA/RSA both showed substantial decreases in discharge to the streams in WS101 and WS106 while the discharge to the streams in WS105 decreased for the grouting scenario and stayed the same for the uniform hydraulic conductivity scenario.

A spreadsheet-based model was utilized in conjunction with data on volumetric pit refilling rates (precipitation, surface water, and groundwater) and proposed pit topography to estimate the amount of time it will take to refill the open pits. The pits were predicted to fill 40 years after the completion of active pit dewatering.

Additional information on the assessment of effects on groundwater quantity and quality was provided in responses to the following IRs:

- Responses to IR24.1, IR24.2, IR24.3, IR24.4, IR24.5, IR24.6.1, IR24.6.2, IR24.7, IR24.8, IR24.15, IR24.16, and IR24.17 (CIAR #380)
- Responses to AIR6 and AIR8 (CIAR #651 and 653)
- Response to SIR6 (CIAR #574)

3.0 REGULATORY BACKGROUND AND ASSESSMENT CRITERIA

Federal and provincial water quality guidelines are used to protect drinking water and freshwater aquatic biota. This assessment uses the guidelines to screen potential adverse effects to groundwater quantity and quality during construction, operation, and closure of the Project. These guidelines are described below, along with other laws, policies, and guidelines that govern the management and protection of groundwater in Canada and Ontario.

3.1 FEDERAL

The following provides a summary of federal regulations, policies, and/or guidelines that apply directly or indirectly to groundwater.

3.1.1 Fisheries Act

The *Fisheries Act*, administered primarily by Fisheries and Oceans Canada (DFO) with some provisions administered by Environment and Climate Change Canada (ECCC), restricts or controls the deposit of deleterious substances into waters or locations frequented by fish unless authorized by regulation. A number of regulations have been made to carry out the purposes and provisions of the *Fisheries Act*. The Metal and Diamond Mining Effluent Regulations (MDMER) define un-ionized ammonia, arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids (TSS), and radium 226 as deleterious substances and Schedule 4 of the MDMER imposes limits on their concentrations in effluent at the final discharge point to the receiving body of water. With respect to groundwater, the MDMER defines effluent as seepage containing any deleterious substance that flows over, through, or out of the site of a mine. The MDMER Schedule 4 criteria are used to screen the quality of seepage from mine rock and tailings associated with the Project.

The MDMER came into effect on June 1, 2018 and replaces the Metal Mining Effluent Regulations (MMER). The MDMER includes the phasing in of more stringent effluent discharge limits than the previous MMER for deleterious substances for new and existing mines, a new effluent discharge limit for un-ionized ammonia, and the requirement that effluent be non-acutely lethal to Daphnia magna, all of which come into force on June 1, 2021. The more stringent future effluent limits (Schedule 4, Table 2, Column 2 maximum authorized monthly mean concentrations) have been considered in this assessment based on the assumption that the Project will not be in commercial operation before June 1, 2021.

3.1.2 Guidelines for Canadian Drinking Water Quality

The Guidelines for Canadian Drinking Water Quality (GCDWQ) are established by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water and other federal government departments and are published by Health Canada (2019). These guidelines are based on current published scientific research related to health effects, aesthetic effects, and operational conditions of various parameters in drinking water.

In 2019, a health-based maximum acceptable concentration of 0.12 mg/L for manganese was introduced that was not considered as part of the original EIS. For the parameters analyzed as part of the Project, the GCDWQ generally have the same values as the Ontario Drinking Water Quality Standards (ODWQS). Where the criteria for the GCDWQ and ODWQS differed, the criteria based on the most recent update was used for comparison to the data.

The GCDWQ are used conservatively as screening criteria for areas where groundwater is anticipated to flow beyond the spatial boundary of the SSA prior to discharging to a surface water feature.

3.2 PROVINCIAL

3.2.1 Mining Act

The *Mining Act* and *Ontario Regulation 240/00* (O. Reg. 240/00), *Mine Development and Closure under Part VII of the Act* sets out standards and criteria for mine closure. Specifically, with respect to groundwater, these statutes and regulations identify groundwater quality parameters to be monitored from mines, as well as monitoring and certification requirements for assessing the success of closure activities in protecting groundwater from potential mining effects. Additionally, these statutes and regulations provide guidance and direction regarding progressive rehabilitation to accelerate mine site rehabilitation in advance of close out activities. The monitoring requirements for the Project related to groundwater will be developed to meet the requirements under O. Reg. 240/00.

3.2.2 Environmental Protection Act

The *Environmental Protection Act* (EPA) is the principal pollution control statute in Ontario and is used in conjunction with the *Ontario Water Resources Act* (OWRA) to address sources of water pollution. The EPA contains general provisions that can be used to protect surface water and groundwater quality.

Under the EPA, O. Reg. 560/94 (Effluent Monitoring and Effluent Limits – Metal Mining Sector) prescribes criteria for the quality of effluent discharged from a mine. It applies to facilities that discharge a total volume of process water, cooling water, and overflow effluent of more than 50 m^3/d, for those mines that began to discharge on or after August 25, 1994. Process effluent limits and monitoring frequency are specified to comply with Schedule 1 of O. Reg. 560/94. The discharge limits in O. Reg. 560/94 are the same as the historical MMER and less stringent than the updated MDMER. Therefore, the more stringent MDMER are used to screen the quality of seepage from mine rock and tailings associated with the Project.

The EPA sets out requirements regarding discharges to the environment and environmental remediation. Part XV.1 of the EPA and O. Reg. 153/04 pertain to the remediation of contaminated properties. O. Reg. 153/04 applies to properties that are being redeveloped from a less sensitive land use (e.g., industrial) to a more sensitive land use (e.g., residential). In addition, O. Reg. 153/04 can also be applied when there is a request for a Record of Site Condition to be filed on the MECP Brownfield Environmental Site Registry to support other types of approvals (e.g., municipal zone changes, site plan approvals, etc.).

However, in practice, the regulation is applied to the assessment and management of soil, groundwater, and sediment contamination.

Surface water resources may be affected by brownfield properties as a result of the discharge of impacted groundwater to surface water receivers. Under O. Reg. 153/04, the MECP has developed Aquatic Protection Values (APVs) to protect aquatic biota from migration of impacted groundwater to surface water (MOE 2011). The APVs are designed to provide a scientifically defensible and reasonably conservative level of protection for aquatic organisms from the migration of contaminated groundwater to surface water resources. The APVs are the established water quality criteria in surface water and are used to determine the acceptable concentrations in groundwater (GW-3 values) by back-calculating through a defined modelling process that considers a ten times dilution in the receiving environment. For this Project, the APVs are used as a direct comparison where groundwater is anticipated to discharge to surface water features. The use of the APVs in this Updated Hydrogeology Impact Assessment provides a conservative approach for assessing potential groundwater quality effects to surface water as it assumes no attenuation during discharge, nor mixing and assimilation within the receiving water body.

3.2.3 Safe Drinking Water Act

The *Safe Drinking Water Act*, 2002, is an Act to protect existing and future sources of drinking water in Ontario. A number of drinking water regulations have been made under the *Safe Drinking Water Act*, including *O. Reg.*169/03 (ODWQS), which set out prescribed drinking water quality standards in Schedule 1 (microbiological), Schedule 2 (chemical), and Schedule 3 (radiological).

Since the original EIS, there have been amendments to the ODWQS that came into effect between January 1, 2017 and January 1, 2020. The changes included more stringent standards for substances including arsenic, less stringent standards for substances including selenium, the revoking of standards for nitrate + nitrite, and the adoption of standards for substances that were not previously listed under O. Reg. 169/03.

For the parameters analyzed as part of the Project, the GCDWQ and ODWQS generally have the same values as the ODWQS except for pH, colour, barium, copper, cadmium, lead, and manganese with the ODWQS the more stringent criteria except for lead and manganese. In addition, the GCDWQ has criteria for strontium, where the ODWQS does not and the ODWQS has criteria for alkalinity and DOC where the GCDWQ does not.

The ODWQS are used where potential effects of groundwater on drinking water quality are anticipated. There are no groundwater supply users or active groundwater Permit To Take Water (PTTW) holders identified within the Project SSA. Therefore, the ODWQS are used as screening criteria for areas where groundwater is anticipated to flow beyond the boundary of the project development area (PDA) prior to discharging to a surface water feature.

3.2.4 Ontario Water Resources Act

The OWRA is the principal statute governing water quality and quantity in Ontario. It is a general management statute that applies to groundwater and surface water. Administered by the MECP, the OWRA contains several important regulations that protect water resources, including:

- The *Water Taking and Transfer Regulation* (O. Reg. 387/04), which requires a permit for water takings of more than a total of 50,000 L/d (with some exceptions). Section 34 of the OWRA requires the proponent to obtain a PTTW and Section 9 of O. Reg. 387/04 requires all permit holders to collect, record and report data on daily volumes of water withdrawals.
- Guideline B-7: Reasonable Use (MOEE 1994): The Reasonable Use guideline establishes procedures for determining what constitutes the "reasonable use" of groundwater on properties adjacent to sources of contaminants and for establishing levels of parameter discharges considered acceptable by the MECP.

4.0 EXISTING CONDITIONS

Existing hydrogeological conditions for the Project are presented in detail in SID #14 – Baseline Report – Hydrogeology, Marathon PGM-Cu Project (CIAR #227) (True Grit 2012a) and Environmental Hydrogeology Updated Baseline Report (Stantec 2020) (CIAR #722). The existing conditions and the methods used to characterize baseline conditions are summarized below.

4.1 METHODS

Environmental studies have been conducted to determine baseline hydrogeological conditions. These baseline conditions form the basis for determining incremental changes and likely environmental effects of the Project on groundwater quantity and/or flow and groundwater quality. This section summarizes the methods associated with the field programs and hydrogeologic model in order to describe the existing conditions.

4.1.1 Baseline Hydrogeological Study

The baseline hydrogeological study included detailed field programs conducted between 2008 and 2011 and is documented in SID #14: Baseline Report – Hydrogeology, Marathon PGM-Cu Project (CIAR #227) (True Grit 2012a). Additional groundwater level and quality sampling was completed at existing monitoring wells in 2012, 2013, and 2020 and was subsequently documented in the Environmental Hydrogeology Updated Baseline Report (Stantec 2020) (CIAR #722). The following activities were completed between 2008 and 2011 as part of the baseline field program:

- Borehole drilling to assess the spatial extent of hydrostratigraphic units (Golder 2007; Golder 2008; Knight Piésold 2011a/b; True Grit 2012a)
- Installation of 36 groundwater monitoring wells to allow groundwater level and groundwater quality monitoring (Golder 2008; Knight Piésold 2011a/b; True Grit 2012a)
- Hydraulic response testing at up to 56 monitoring wells and/or boreholes to assess the hydraulic conductivity of the screened material (Golder 2008; Knight Piésold 2011a/b; True Grit 2012a)
- Completion of 40 packer tests at six boreholes at depths up to 235 m below ground surface (BGS) to assess the hydraulic conductivity of bedrock with depth (Golder 2007)
- Manual groundwater level monitoring at 36 monitoring wells to assess groundwater flow patterns and seasonal variations in water levels (True Grit 2012a)
- Monthly to seasonal groundwater sampling at up to 36 monitoring wells to assess groundwater quality (True Grit 2012a)

In 2012, 2013 and 2020, monitoring of groundwater levels and water quality continued and results of field work completed in 2012, 2013, and 2020 further support the environmental effects assessment for hydrogeology. The following activities were completed between 2012 and 2020 as part of the baseline hydrogeology update (Stantec 2020) (CIAR #722):

- Manual groundwater level monitoring at 36 monitoring wells in 2012 and 2013 to validate baseline groundwater flow patterns and seasonal variations in water levels
- Spring, summer, and fall groundwater sampling at up to 36 monitoring wells in 2012 and 2013 to assess groundwater quality
- Manual groundwater level measurements at nine monitoring wells and pressure transducers installed in eight monitoring wells for continuous water level monitoring in June and July 2020 to validate baseline groundwater level variations
- Groundwater quality sampling of nine monitoring wells in June and July 2020 to validate baseline groundwater quality characterization

The monitoring locations are shown on Figure 2. The data collected from the field program was used in conjunction with available geological mapping from the Geological Survey of Canada (GSC) and well record information from the MECP Water Well Record (WWR) and PTTW databases to develop a detailed understanding of the baseline hydrogeological conditions:

The lithological data collected from borehole drilling and water level monitoring data was used to define hydrostratigraphic units for overburden and bedrock. A hydrostratigraphic unit is defined as a geologic formation, or part/groups of formation(s), with similar hydrogeological characteristics relating to groundwater flow. The development of the hydrostratigraphic units for the Project are presented in detail in SID #14: Baseline Report – Hydrogeology, Marathon PGM-Cu Project (CIAR #227) (True Grit 2012a).

Groundwater flow velocity was estimated using Darcy’s Law (horizontal hydraulic gradient and horizontal hydraulic conductivity) and theoretical porosity (Fetter 2000) of a given hydrostratigraphic unit. The horizontal hydraulic gradient was calculated from the groundwater flow contours produced using groundwater level measurements. The horizontal hydraulic conductivity of a hydrostratigraphic unit was estimated based on single well response testing and/or packer testing. These results are compared with estimates of travel times to key receptors derived from the groundwater flow model.

Baseline groundwater quality was characterized using field data collected for the Project. Groundwater is anticipated to ultimately discharge to surface water features and, therefore, groundwater quality is compared directly to the CWQG-FAL, PWQOs, and APVs. As groundwater has the potential to be used as a water supply source, the baseline water quality is also compared to the GCDWQ and ODWQS. Groundwater quality is further evaluated based on hydrostratigraphic unit and spatial distribution to develop summary water quality statistics. In preparing the summary statistics, the mean concentration for each parameter was determined for each monitoring well. These data were combined to develop mean concentrations for each parameter to determine the summary statistics for each hydrostratigraphic unit.

Concentrations reported below the method detection limits are included in the statistics by assuming a concentration of half of the detection limit.

4.1.2 Hydrogeological Model

A numerical, three-dimensional finite difference groundwater flow model was developed to represent baseline conditions and to assess the potential effects of the operation and closure phases of the Project on groundwater resources and the consequent indirect effects on surface water resources (True Grit 2012a). The groundwater flow model is specifically used to provide estimates of:

- Changes in groundwater levels (drawdown), including changes to water table position and groundwater flow, due to dewatering of the open pit during operation.
- The time to fill the open pit from groundwater inflow and the change in groundwater levels and flow once the open pit has filled at closure.
- Changes to groundwater flow and discharge to wetlands, creeks, and lakes under baseline, operation, and closure.
- Groundwater recharge and flow pathways from the MRSA, ore stockpile, PSMF, and water management pond developed for the Project under operation and closure.

The MODFLOW-NWT numerical groundwater flow code is used to simulate steady state groundwater flow under baseline, operation, and closure scenarios. The groundwater flow model consists of five layers based on hydraulic conductivity. The model grid is 11,500 m long and 10,500 m wide and the southwest corner of the grid has UTM (NAD 27) coordinates of 542,000 E and 5,397,500 N (Zone 16). The base grid has cells measuring 100 m by 100 m. The grid is refined to 50 m by 50 m in the area around the open pit and mine facilities and further refined to 25 m by 25 m in the area of the open pit. Constant head boundaries are assigned for major lakes and drain boundaries are assigned for rivers and creeks within the model domain. The western edge of the model domain is Lake Superior, the northern edge of the model domain is Bamoos Lake, Hare Lake, and the creeks between Bamoos Lake and Hare Lake and Hare Lake and Lake Superior. The eastern edge of the model domain is the Pic River. The southern extent of the model was defined as a no-flow boundary. The boundary does not necessarily follow a drainage or groundwater flow divide and, as a result, the model may not be as representative near this boundary. However, this boundary is over 5 km from site infrastructure and, therefore, does not have an appreciable impact on the accuracy of the model in the area of the SSA. The upper boundary of the model is defined by the ground surface from the digital elevation model (DEM) and the bottom boundary is set at -100 m above mean sea level (amsl), about 100 m below the base of the North Pit which is the deepest of the three pits at 300 m deep.

Calibration of the model was achieved by adjusting hydraulic conductivity, recharge, and the conductance of drain cells. The calibration process involved varying model parameters using WinPEST until an acceptable match to water levels was obtained. The model is calibrated to be within acceptable industry standards and the model parameters fall within the observed ranges of hydraulic conductivity and estimated recharge rates. Details of the model development and calibration are presented in SID #14: Baseline Report – Hydrogeology, Marathon PGM-Cu Project (CIAR #227) (True Grit 2012a).

4.2 OVERVIEW

4.2.1 Local Geology and Hydrostratigraphy

The surficial geology within the LSA/RSA can be subdivided into two areas based on elevation. Below an elevation of approximately 320 m, thick deposits of massive to varved glaciolacustrine silts and clays are present within the numerous valleys, such as the Pic River. These deposits formed by deep water deposition when the ancestral Lake Superior was much higher than it is today. As the lake level receded, shallow water deposits of silty sand and fine sand formed, such as the glaciofluvial sand and gravel deposits located northeast and east of Marathon.

Above an elevation of approximately 320 m amsl, the geology is dominated by rugged bedrock topography. A thin veneer of ground moraine is generally present, as are localized areas of organics where drainage is poor, and/or thick accumulations of fine sediments in deeper ravines and valleys. The ground moraine generally consists of silty sand till with abundant gravel, cobbles, and boulders.

Bedrock was encountered at 17 nested borehole locations completed as part of environmental baseline studies and 859 boreholes completed as part of exploration and condemnation drilling. From the drilling, bedrock depth ranged from exposed at ground surface to greater than 61 m with an average depth of 3.34 m BGS.

Based on the detailed field investigations, the following hydrostratigraphic units are interpreted across the LSA/RSA and are presented below. These hydrostratigraphic units are illustrated on the cross-sections presented on Figure 3 through Figure 5 with the cross-section locations presented on Figure 2. Figure 6 presents the surficial geology for the SSA and surrounding area.

- **Organics:** Organic material in the form of peat and muck is present in localized areas where drainage is poor and/or where thick accumulations of fine sediments in the deeper ravines and valleys are observed.

- **Glaciolacustrine Sediments:** A glaciolacustrine plain associated with the Pic River and its tributaries is observed in the northern portion of the SSA, in the vicinity of and east of the open pit. The glaciolacustrine sediments are generally composed of variable mixture silt and clay with pockets of sand. Moderate local relief of the glaciolacustrine plain has resulted in the glaciolacustrine sediment to be dissected, gullied as a result of drainage patterns. The unit is deeper than the boreholes drilled, with the deepest borehole being terminated at 20 m BGS within glaciolacustrine sediments. This hydrostratigraphic unit is limited in horizontal extent by the edges of the Pic River Valley and associated tributaries.

- **Ice Contact Delta Sediments** – Ice contact delta consisting of sand and gravel is located to the south of the SSA, along Highway 17 and a portion of the existing access road for the SSA.

- **Ground Moraine:** Discontinuous ground moraine is observed as silty sand till with abundant gravel, cobbles and boulders. Found as a drift veneer over bedrock, where present.

- **Bedrock:** Bedrock geology is presented on Figure 7. Bedrock within the SSA consists predominantly of Eastern Gabbro Series of the Proterozoic Coldwell Complex (eastern portion of Unit 35 on Figure 7) and syenite (western portion of Unit 35 of Figure 7). The Eastern Gabbro Series strikes near north and dips to the west. The Eastern Gabbro Series intrudes and bisects much older Archean intermediate pyroclastic rocks that have undergone partial melting as a result of the heat of intrusion of the Coldwell Complex. The Archaean intermediate pyroclastic rocks (Unit 6 on Figure 7) form the footwall located in the eastern portion of the SSA. Bedrock is generally located at surface or below a drift veneer of ground moraine, except in areas associated with bedrock valleys where bedrock is found at depth underlying glaciolacustrine deposits. Bedrock topography is described as knobby and hummocky.

Lineaments in bedrock, commonly highlighted by surface water drainage patterns, are presented on Figure 7. Two main fault structures, trending east-west (4900N on Figure 7) and southeast-northwest (TDL Gap on Figure 7), exist in the area of the open pits and it is likely that other smaller faults also exist in the area (Figure 7). The main east-west trending fault through the North Pit (4900N on Figure 7) was intersected in angled drill hole GD6-03 at a downhole depth of approximately 202 to 207 m. It was found to consist of less than 1.5 m of highly fractured and altered (chloritized) rock with a very low rock mass quality designation. The north-south trending fault located east of the open pits (TDL Gap on Figure 7) was intersected in drill hole M-05-107 (134.0 to 138.5 m downhole depth) and was found to consist of approximately 4.5 m of predominantly graphite.

The remaining lineaments are generally located outside the proposed open pit areas and do not appear to have been intersected by explorations drill holes. Additional details with respect to the faults and potential control on hydraulic conductivity of bedrock and groundwater flow are presented in Section 4.2.3 and Section 4.2.4, respectively.

4.2.2 Groundwater Use

Figure 8 presents the locations of identified PTTWs and water supply wells in the LSA/RSA. A review of the MECP WWR database (October 7, 2020) indicates 43 wells are located within the LSA/RSA summarized in Table 4.1. Of the 43 wells, 11 are designated as abandoned and 14 are designated as a test or observation hole (some of which were completed to support the baseline monitoring for the Project). The remaining 18 wells are designated as water supply wells (7 public, 5 domestic, 5 commercial, and 1 municipal). All but one of these water supply wells were installed prior to 1990.

Nine (9) water supply wells are located along Highway 17 (Figure 8), within 470 m to 1,900 m of the southern boundary of the SSA. The water supply wells are designated as commercial, public, and/or domestic with seven of the wells completed in bedrock and two of the wells completed in overburden. The depth of the wells ranged from 31 m to 177 m in bedrock and 25 m to 31 m in overburden.

The remainder of the water supply wells (9) are located within the Town of Marathon along Peninsula Road, and are located greater than 2,800 m from the southern SSA boundary. The water supply wells are designated as commercial, public, and/or domestic with all but one well completed in bedrock at depths ranging from 41 m to 148 m BGS. The one overburden well (6100895) is completed at a depth of 41 m in gravel and sand.

The water supply for the Town of Marathon is from five groundwater supply wells located throughout the community of Marathon. Three WWRs designated as municipal were obtained for the Town of Marathon, one of which is located within the LSA/RSA (6103471) (Table 4.1). The groundwater supply wells are completed in the overburden and have maximum supply capacities ranging from 19.25 L/s to 32 L/s (Marathon 2020). The groundwater protection zones for the water supply wells are presented on Figure 8 and were obtained from the Town of Marathon’s Official Plan Land Use Schedule E. The extent of the groundwater protection zone is located south and southwest of the SSA and greater than 4 km from the proposed open pit, extending from the water supply wells located in the Town of Marathon toward the intersection of Highway 17 and Peninsula Road.

A review of the MECP PTTW database indicates one PTTW within the LSA (Figure 8) (232-BA6HHF). The PTTW is for surface water and is held by the Corporation of the Town of Marathon for the irrigation supply of the Peninsula Golf Course. PTTW No. 232-BA6HHF allows taking surface water (620 m^3/d) for irrigation of the golf course. The MECP PTTW database does not indicate whether the permit is active or whether the source of water is an irrigation pond or stream.

The Town of Marathon municipal supply is permitted under PTTW No. 7154-8N8GY8 and allows a maximum rate of taking from groundwater of 1,961.28 m^3/d, 1,663.2 m^3/d, 2,289.6 m^3/d, 2,289.6 m^3/d, and 2,764.8 m^3/d from Well Nos. 2, 3, 4, 5, and 6, respectively.

There are no groundwater supply users or active groundwater PTTW holders identified within the SSA. Prior to commencement of the Project, GenPGM will carry out a water well survey within and adjacent to the SSA to confirm the results of the MECP WWR and PTTW database review.

Table 4.1: Summary of Water Wells Located Within LSA and RSA

Well ID	Easting (m)	Northing (m)	Ground Elevation (m amsl)	Well Depth (m)	Well Status	Well Use	Date Completed	Screened Unit	Top of Screen (m BGS)	Bottom of Screen (m BGS)	Groundwater Elevation (m amsl)	Distance to SSA (m)
Water Supply												
6100196*	545573	5394987	189.50	29.57	Water Supply	Municipal	05-Jul-63	Medium Sand	22.25	28.35	176.09	6,866
6100197	548573	5399602	305.74	24.99	Water Supply	Public	21-Dec-54	Fine Sand	-	-	284.40	1,876
6100493	547038	5401197	299.56	58.83	Water Supply	Public	17-Jun-63	Granite	-	-	289.51	591
6100494	547183	5401127	298.77	32.31	Water Supply	Commercial	26-Aug-66	Rock	-	-	292.67	655
6100674	547123	5398190	256.52	148.44	Water Supply	Commercial	06-Nov-69	Granite	-	-	229.09	3,592
6100675	546798	5401302	300.70	36.58	Water Supply	Commercial	08-Oct-69	Granite	-	-	291.25	466
6100733	547258	5398267	261.62	50.29	Water Supply	Domestic	22-Jun-70	Rock	-	-	228.10	3,516
6100818	547048	5398386	258.76	67.06	Water Supply	Commercial	10-Jun-71	Rock	-	-	246.57	3,390
6100893	547098	5401162	298.89	34.75	Water Supply	Public	15-May-58	Granite	-	-	289.75	620
6100895	547378	5398977	279.81	41.45	Water Supply	Public	09-Mar-72	Gravel / Sand	39.93	41.45	258.47	2,814
6101264	548098	5400227	306.96	67.06	Water Supply	Domestic	05-Sep-74	Basalt	-	-	296.29	1,818
6103119	547123	5398176	256.25	85.95	Water Supply	Public	29-Sep-83	Granite	-	-	225.16	3,606
6103120	547194	5398159	257.86	120.70	Water Supply	Public	29-Sep-83	Granite	-	-	226.77	3,623
6103173	546868	5398115	247.82	88.39	Water Supply	Domestic	13-Apr-84	Granite	-	-	235.63	3,647
6103218*	545626	5395355	194.04	25.30	Water Supply	Municipal	05-Jun-84	Sand	17.68	23.77	185.51	6,494
6103219*	545649	5395085	191.82	25.91	Water Supply	Municipal	07-Aug-84	Sand	17.98	24.08	182.98	6,757
6103263	547908	5400737	314.44	31.09	Water Supply	Public	24-Jun-84	Sand	26.52	29.57	293.11	1,287
6103471	547447	5398100	263.66	46.33	Water Supply	Municipal	20-Oct-85	Granite	-	-	242.02	3,693
6103485	548490	5399704	306.99	91.74	Water Supply	Commercial	04-Sep-86	Conglomerate	-	-	-	1,889
6104557	547106	5398298	258.28	92.05	Water Supply	Domestic / Commercial	15-Dec-89	Granite	-	-	247.61	3,484
6107526	548321	5399863	307.97	176.78	Water Supply	Domestic	16-May-05	Granite	-	-	-	1,962
Test / Observation Wells												
7166083	548264	5402363	various	various	Observation Wells	Monitoring	07-Apr-11	various	-	-	-	0
7231354	551457	5407108	various	various	Observation Wells	Monitoring	08-Oct-11	various	-	-	-	0
7277926	546875	5401262	300.03	11.28	Monitoring and Test Hole	Monitoring	02-Dec-16	Sand / Silt	8.23	11.28	-	523
7277927	546897	5401251	299.88	11.28	Monitoring and Test Hole	Monitoring	02-Dec-16	Sand / Silt	8.23	11.28	-	538
7277928	546913	5401259	300.51	10.67	Monitoring and Test Hole	Monitoring	02-Dec-16	Sand / Silt	7.62	10.67	-	533
7277929	546860	5401283	300.80	10.67	Monitoring and Test Hole	Monitoring	02-Dec-16	Sand / Silt	7.62	10.67	-	499
7277930	546910	5401302	302.67	3.35	Monitoring and Test Hole	Monitoring	02-Dec-16	Sand	0.91	3.35	-	490
7237923	549908	5400415	349.29	21.64	Observation Wells	Monitoring	-	Sand	18.59	21.64	-	335

Table 4.1: Summary of Water Wells Located Within LSA and RSA

Well ID	Easting (m)	Northing (m)	Ground Elevation (m amsl)	Well Depth (m)	Well Status	Well Use	Date Completed	Screened Unit	Top of Screen (m BGS)	Bottom of Screen (m BGS)	Groundwater Elevation (m amsl)	Distance to SSA (m)
7250733	549813	5400548	359.43	75.59	Observation Wells	Monitoring	29-Sep-15	Gravel	-	-	-	320
7250734	549803	5400565	360.75	40.23	Observation Wells	Monitoring	21-Sep-15	Gravel / Sand	34.14	40.23	326.65	322
7250735	550062	5400548	360.03	52.12	Observation Wells	Monitoring	20-Sep-15	Gravel	-	-	310.96	138
7289045	546004	5397812	211.92	8.10	Observation Wells	Monitoring	10-May-17	Sand / Gravel / Clay	3.10	8.10	-	4,008
7289046	545915	5397664	206.80	6.30		Monitoring	10-May-17	Sand / Gravel	2.40	6.30	-	4,170
7289047	545915	5397664	206.80	6.60	Observation Wells	Monitoring	10-May-17	Sand / Silt / Clay	3.10	6.60	-	4,170
7289048	545912	5397596	206.05	6.60	Observation Wells	Monitoring	10-May-17	Sand / Gravel	4.40	6.60	-	4,238
Abandoned												
7106885	549919	5400415	349.42	5.20	Abandoned-Other		14-May-08	Clay / Silt	-	-	-	328
7250731	549925	5400553	362.11	35.05	Abandoned-Other	Not Used	20-Sep-15	Gravel	-	-	-	223
7250732	549931	5400555	362.24	36.58	Abandoned-Other	Not Used	20-Apr-15	Gravel	-	-	-	217
6100896	547358	5398977	279.52	24.38	Abandoned-Quality		15-Jan-72	Sand / Boulders	-	-	-	2,812
6100199	547123	5398197	256.66	47.55	Abandoned-Supply		12-Aug-62	Granite	-	-	-	3,585
6100594	547338	5398877	276.97	73.15	Abandoned-Supply		22-Jul-68	Rock	-	-	-	2,911
6100595	547448	5398767	276.51	71.63	Abandoned-Supply		10-Jul-68	Rock	-	-	-	3,029
6103472	547543	5398021	264.90	76.81	Abandoned-Supply	Municipal	18-Oct-85	Granite	-	-	-	3,697
6104080	545649	5397609	197.54	9.75	Abandoned-Supply	Not Used	12-Sep-88	Rock	-	-	-	4,282
6104081	545632	5397672	197.46	11.28	Abandoned-Supply	Not Used	10-Sep-88	Gravel	-	-	-	4,225
6106438**	547307	5398859	276.02	91.44			05-Aug-99	Granite	-	-	-	2,927

Notes:
m metres
amsl above mean sea level
SSA Site Study Area
* Town of Marathon water supply well that is located outside the LSA/RSA, information is provided for reference
** Based on WWR, this borehole was backfilled with grout and abandoned

4.2.3 Estimation of Hydraulic Conductivity

Results from the hydraulic conductivity testing were highly variable and dependent on the lithology tested. Test results are summarized below and discussed in terms of each hydrostratigraphic unit.

Glaciolacustrine Sediments

Rising head tests were completed at nine monitoring wells screened in clay associated with glaciolacustrine sediments along the Pic River valley and associated tributaries (Golder 2008; True Grit 2012a). The horizontal hydraulic conductivity ranges from $2x10^{-9}$ to $5x10^{-9}$ m/s with a geometric mean horizontal hydraulic conductivity for the glaciolacustrine sediments of $3x10^{-9}$ m/s. Three monitoring wells are screened across pockets of sand within the glaciolacustrine material, which corresponded with horizontal hydraulic conductivities ranging from $1x10^{-6}$ m/s to $6x10^{-8}$ m/s with a geometric mean of $3x10^{-7}$ m/s.

Ground Moraine and/or Coarse-Grained Glaciolacustrine Sediments

Rising head tests were completed at 13 monitoring wells screened in silt to sand with cobbles and boulders classified as ground moraine and/or coarse-grained glaciolacustrine sediments (Golder 2008; Knight Piésold 2011a/b; True Grit 2012a). The horizontal hydraulic conductivity ranges over two orders of magnitude, reflective of the variation in the composition of the unit across the SSA. The hydraulic conductivity of the ground moraine and coarse-grained glaciolacustrine sediments across the SSA ranges from $4x10^{-5}$ m/s to $3x10^{-7}$ m/s with a geometric mean horizontal hydraulic conductivity of $1x10^{-6}$ m/s.

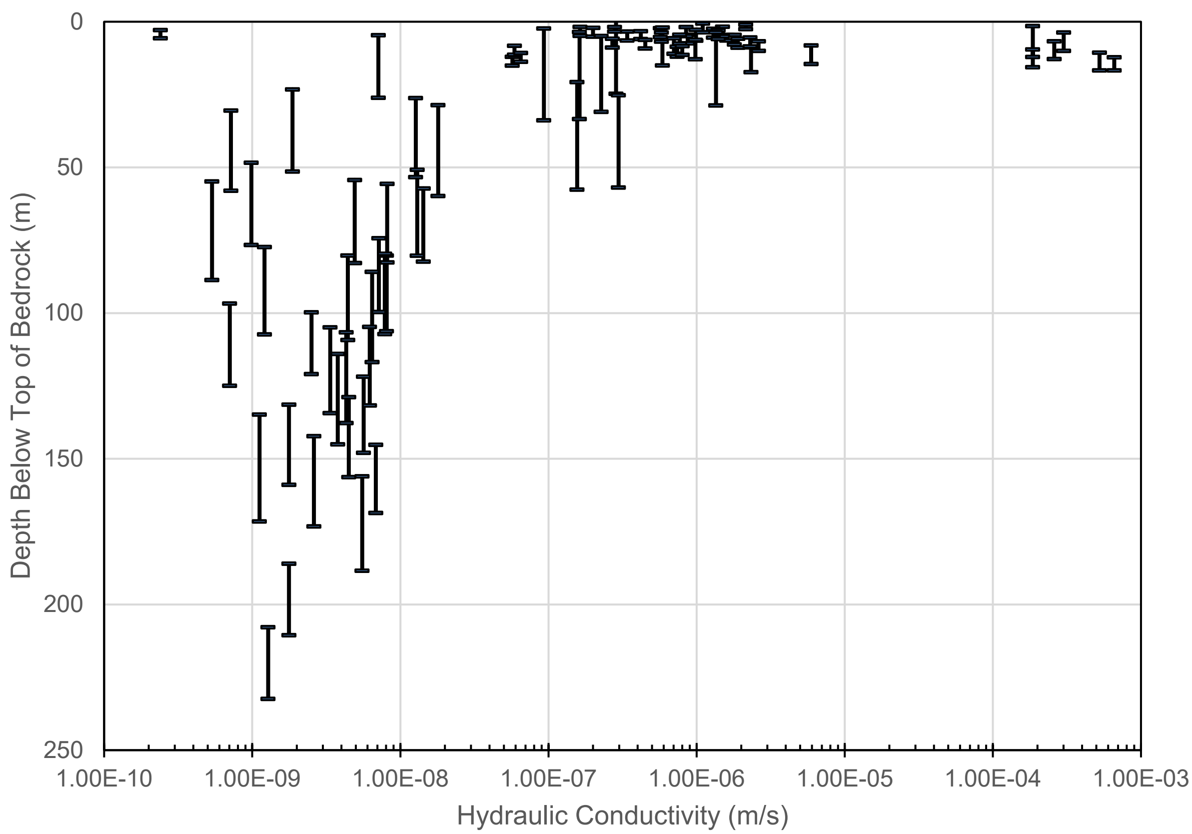
Bedrock

Rising head tests and/or packer tests were completed at 34 monitoring wells in bedrock (Golder 2007; Golder 2008; Knight Piésold 2011a/b; True Grit 2012a). Packer testing was completed in intermediate and deep bedrock at six boreholes in the area of the open pit. Intermediate and deep bedrock packer testing was completed on 26 bedrock intervals with test intervals ranging from 20 m to 35 m thick to depths up to 235 m below the top of bedrock. Graph 4.1 presents the hydraulic conductivity with depth below top of bedrock.

The hydraulic conductivity of the bedrock decreases with depth, with the upper portions being the most transmissive due to increased weathering and/or fracturing. The hydraulic conductivity of bedrock was dependent on the presence and characteristics of fractures and not the stratigraphy of the rocks. The hydraulic conductivity of the upper bedrock, defined as the upper 60 m, varies over more than six orders of magnitude from $2x10^{-10}$ m/s to $7x10^{-4}$ m/s with a geometric mean of $6x10^{-7}$ m/s. Hydraulic testing was completed at an additional 16 bedrock intervals at depths less than 60 m where no measurable flow was recorded during the in situ hydraulic testing (i.e. hydraulic conductivity was too low to measure with the tested method). From 60 m to 150 m below the top of bedrock, the geometric mean hydraulic conductivity was $4x10^{-9}$ m/s. For depths greater than 150 m below the top of bedrock, the geometric mean hydraulic conductivity was $3x10^{-9}$ m/s.

Structural Features

Deep geotechnical borehole drilling and packer testing in the vicinity of the main open pit did not encounter significant water transmitting fractures, despite boreholes being located to intersect structural lineaments (Golder 2007). When intersected, the structural lineaments were characterized as 1 to 2 m thick consisting of healed chlorite-talc-hematite fractures. Measured hydraulic conductivity of borehole intervals associated with structural lineaments was on the order of $5x10^{-9}$ m/s and similar to the overall estimates of bedrock hydraulic conductivity. The results did not demonstrate a significant differentiation in the hydraulic conductivity of the faults compared to the surrounding bedrock in the boreholes.



Graph 4.1: Hydraulic Conductivity of Bedrock with Depth Below Top of Bedrock

4.2.4 Groundwater Flow and Velocity

Figure 9 presents the predicted groundwater elevation in overburden and shallow bedrock within the LSA/RSA with measured manual measurements at monitoring wells collected in June 2020. For the LSA/RSA, groundwater is strongly influenced by topography, which results in localized groundwater flow from topographic highs with groundwater discharge to wetland areas or surface water features. A groundwater flow divide, associated with a topographic high, is evident in the area of the open pits, with flow divided to the east toward the Pic River and to the west toward a tributary of Bamoos Lake. Within the area of the PSMF, groundwater flow is to the south, toward a tributary of the Pic River with a small component of flow north toward the Hare Lake watershed (WS105).

Seasonal groundwater level fluctuations were similar in wells completed in overburden and shallow bedrock and, as a result, these units were interpreted to be hydraulically connected.

The low hydraulic conductivity of bedrock at depth precludes an intermediate and regional flow system from acting as a significant contaminant transport pathway or sources of groundwater inflow to the open pits. Consistent with Sykes et al. (2009), the intermediate and regional groundwater flow in the Canadian Shield may not be prevalent and water entering the subsurface at areas of recharge will exit the subsurface in the adjacent discharge area.

4.2.5 Groundwater Discharge

The calibrated groundwater flow model was used to estimate groundwater flow and discharge to several watercourses located within the LSA/RSA under existing conditions. The predicted average annual discharge rates, for watercourses with greater than 8 m^3/d (0.1 L/s) average annual discharge, are summarized in Table 4.2 with the watershed boundaries presented on Figure 10.

Table 4.2: Groundwater discharge To Watercourses and Lakes Under Baseline Conditions (m^3/d)

Watershed	Baseline Discharge Rate
WS101	1,252.4
WS102	1,001.9
WS103	287.2
WS104	477.8
WS105	1,958.5
WS106	2,243.8
WS107	113.7
WS108	100.2
WS109	1,673.6
WS110	4.8

Table 4.2: Groundwater discharge To Watercourses and Lakes Under Baseline Conditions (m^3/d)

Watershed	Baseline Discharge Rate
WS111	8.7
WS112	25.4
WS113	48.8
WS114	143.4
WS115	14.4
WS116	126.3
WS117	34.5
Pic River	1,301.0

A visual assessment of the watershed delineation for the SSA was completed as a quality assurance / quality control measure particularly of the lake network southeast of Rag Lakes in WS109. As shown on Figure 10, the lake network southeast of Rag Lakes in WS109 appears to be disconnected from a stream system. Visual field inspection of this lake network showed water flowing south towards a wetland with no discharge pathway, indicating a possible connection into the groundwater system at the south end of the lake network. As such, the lake network south of Rag Lakes was kept within WS109 as the flow pattern was not directed towards WS101 or WS116.

Springs were not encountered within the SSA or LSA/RSA but some intermittent seasonal groundwater seeps were noted in the spring along the steeper slopes west of the Pic River.

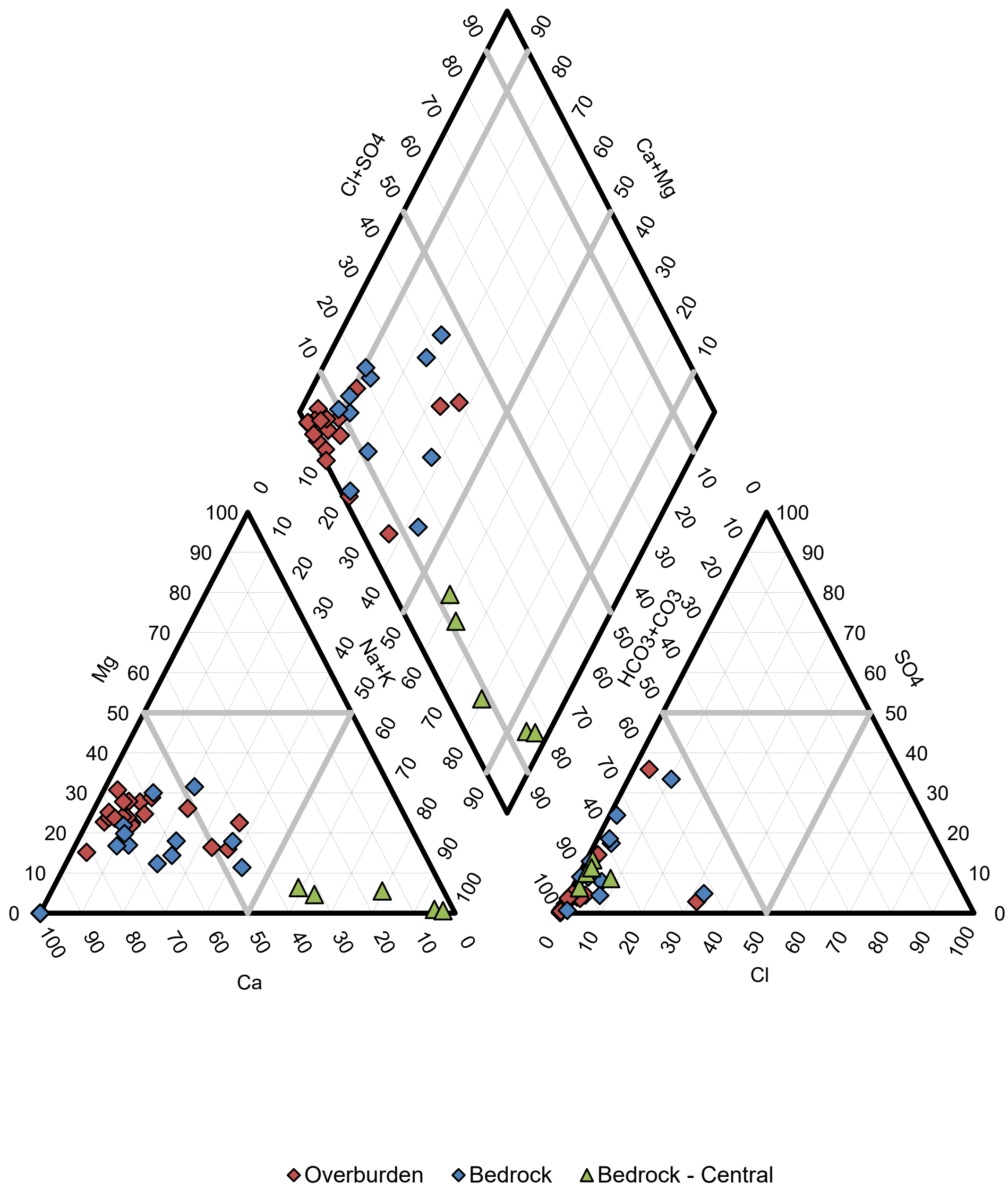
4.2.6 Groundwater Quality

The SSA is predominantly forested with no known anthropogenic sources related to past or current land uses. Therefore, the groundwater samples from monitoring wells completed within the LSA are representative of background groundwater quality.

Graph 4.2 presents a piper plot of mean concentrations of anions and cations for monitoring wells completed in overburden and bedrock. Overburden and bedrock groundwater is classified as calcium bicarbonate except for six bedrock monitoring wells located within the central portion of the SSA (BH08-3A, BH08-7A, BH09-9A, BH11-107A, BH112A, and KP11-03B). The mean concentration of these six bedrock monitoring wells is classified as sodium bicarbonate and had a slightly lower hardness (mean of 25 mg/L) compared to the other bedrock monitoring wells (mean of 89 mg/L). The overburden groundwater quality was harder (mean of 280 mg/L) compared to bedrock (mean of 67 mg/L). Similarly, concentrations of iron and manganese were slightly greater in overburden (mean of 4.3 mg/L and 0.62 mg/L, respectively) compared to bedrock (mean of 1.4 mg/L and 0.20 mg/L, respectively).

Water quality statistics, including minimum, maximum, mean, median, 75th percentile, and standard deviation were calculated from the monitoring data from each of these areas and compared to the GCDWQ, ODWQS, and APV in Table 4.3. In the following discussion, the mean groundwater concentrations were used to identify exceedances of the GCDWQ, ODWQS, and APV.

Mean groundwater concentrations in the overburden and bedrock exceed the GCDWQ and ODWQS aesthetic objectives for dissolved organic carbon (DOC), hardness, iron, and manganese. The groundwater in overburden was hard compared to the groundwater in bedrock. The mean hardness of groundwater in overburden versus bedrock was 280 mg/L and 67 mg/L, which were outside of the opposite end points of the GCDWQ and ODWQS range of 80 mg/L to 100 mg/L, respectively. The mean colour of groundwater in overburden and bedrock exceeds the ODWQS and/or GCDWQ aesthetic objective of 5 TCU. In 2019, a GCDWQ health-based MAC for manganese was introduced. The mean groundwater concentration of manganese in overburden of 0.62 mg/L exceeds the GCDWQ MAC of 0.12 mg/L. The mean groundwater concentration of aluminum in bedrock exceeds the GCDWQ and ODWQS operational guidelines for aluminum. Elevated concentrations of these parameters are typical of groundwater in Ontario and are reflective of the natural mineralization and geochemical processes in the area. No parameters had mean concentrations above the APV.



Graph 4.2: Mean Groundwater Chemistry – Piper Diagram

Table 4.3: Baseline Groundwater Quality Statistics – Background

Parameters	Units	GCDWQ / ODWQS	APV	Wells Completed in Overburden							Number of wells with mean exceeding:		Wells Completed in Bedrock							Number of wells with mean exceeding:	
				Minimum	Median	Mean	75th Percentile	Maximum	Standard Deviation	Number of Wells	GCDWQ / ODWQS	APV	Minimum	Median	Mean	75th Percentile	Maximum	Standard Deviation	Number of Wells	GCDWQ / ODWQS	APV
General Chemistry																					
Dissolved Organic Carbon	mg/L	5 **	n/v	2.1	**5.5**	**11**	**11**	**83**	18	19	10	-	1.5	4.9	**5.8**	**7.7**	**16.8**	3.9	17	8	-
Total Dissolved Solids	mg/L	500	n/v	89	343	381	449	**1,270**	249	19	2	-	56	154	181	226	418	98	17	0	-
Ammonia (as N)	mg/L	n/v	n/v	0.047	0.62	2.8	2.9	14	4.2	19	-	-	0.012	0.10	0.18	0.14	0.94	0.26	17	-	-
Chloride	mg/L	250	180	0.43	0.86	4.9	1.6	45	12	19	0	0	0.38	1.6	4.7	3.1	41	9.7	17	0	0
Color, True	TCU	5 **	n/v	1.7	**9.0**	**12**	**14**	**43**	10.5	19	15	-	1.5	**9.3**	**43**	**25**	**220**	72	17	12	-
Fluoride	mg/L	1.5	n/v	0.047	0.10	0.17	0.25	0.37	0.13	6	0	-	0.23	0.42	1.2	**1.6**	**2.8**	1.5	3	1	-
Hardness (as CaCO3)	mg/L	80-100 **	n/v	**32**	**280**	**280**	**391**	**626**	153	19	19	-	**6.7**	**51**	**67**	99	**207**	57	17	16	-
Nitrate (as N)	mg/L	10	n/v	0.013	0.023	0.059	0.029	0.59	0.13	19	0	-	0.015	0.058	0.37	0.47	2.6	0.65	17	0	-
Nitrite (as N)	mg/L	1	n/v	0.0090	0.010	0.013	0.012	0.030	0.0064	19	0	-	0.0091	0.014	0.016	0.019	0.030	0.0062	17	0	-
pH	S.U.	6.5**-10.5*	n/v	6.9	7.7	7.6	7.8	7.9	0.31	19	0	-	7.0	7.8	7.8	8.2	8.7	0.57	17	0	-
Sulfate	mg/L	500	n/v	0.49	5.9	24	8.0	342	77	19	0	-	0.45	11	14	16	61	13	17	0	-
Dissolved Metals																					
Aluminum	mg/L	0.1 **	n/v	0.012	0.015	0.025	0.034	**0.11**	0.023	19	1	-	0.0080	0.033	**0.12**	**0.11**	**0.59**	0.18	17	5	-
Antimony	mg/L	0.006	2	0.00030	0.0010	0.00094	0.0012	0.0016	0.00043	19	0	0	0.00027	0.00054	0.00079	0.0013	0.0016	0.00051	17	0	0
Arsenic	mg/L	0.010	0.15	0.00047	0.0017	0.0030	0.0051	0.0096	0.0029	19	0	0	0.00044	0.00050	0.00054	0.00050	0.00085	0.00013	17	0	0
Barium	mg/L	1 **	2	0.0050	0.039	0.077	0.13	0.23	0.072	19	0	0	0.0045	0.0059	0.019	0.018	0.10	0.025	17	0	0
Beryllium	mg/L	n/v	0.0053	0.00036	0.00046	0.00049	0.00048	0.0010	0.00015	19	-	0	0.00038	0.00047	0.00048	0.00048	0.0008	0.00010	17	-	0
Boron	mg/L	5	3.55	0.020	0.030	0.042	0.056	0.13	0.029	19	0	0	0.022	0.024	0.031	0.030	0.065	0.013	17	0	0
Cadmium	mg/L	0.005 **	0.00021	0.000018	0.000039	0.000040	0.000050	0.000072	0.000014	19	0	0	0.000019	0.000037	0.000040	0.000041	0.00011	0.000021	17	0	0
Chromium	mg/L	0.05	0.064	0.00041	0.00061	0.00072	0.00077	0.0018	0.00034	19	0	0	0.00046	0.00053	0.00062	0.00056	0.0015	0.00029	17	0	0
Cobalt	mg/L	n/v	0.0052	0.00020	0.00034	0.0013	0.0020	0.0066	0.0018	19	-	1	0.00020	0.00025	0.00042	0.00037	0.0020	0.00045	17	-	0
Copper	mg/L	1 **	0.0069	0.00044	0.0009	0.0021	0.0013	0.021	0.0046	19	0	1	0.00048	0.0013	0.0032	0.0014	0.027	0.0065	17	0	2
Iron	mg/L	0.3	n/v	0.012	**0.78**	**4.3**	**7.3**	**17**	5.7	19	11	-	0.017	0.083	**1.4**	**0.88**	**13**	3.4	17	5	-
Lead	mg/L	0.005 *	0.0020	0.00037	0.00046	0.00045	0.00047	0.00050	0.000037	19	0	0	0.00037	0.00046	0.00046	0.00048	0.00050	0.000030	17	0	0
Manganese	mg/L	0.05 **	n/v	0.013	**0.21**	**0.62**	**1.1**	**2.7**	0.78	19	16	-	0.0025	**0.12**	**0.20**	**0.35**	**0.63**	0.21	17	13	-
Mercury	mg/L	0.001	0.00077	ND	ND	ND	ND	ND	ND	19	-	-	ND	ND	ND	ND	ND	ND	17	-	-
Molybdenum	mg/L	n/v	0.73	0.00040	0.0011	0.0021	0.0019	0.018	0.0039	19	-	0	0.00044	0.0013	0.0019	0.0016	0.0074	0.0019	17	-	0
Nickel	mg/L	n/v	0.039	0.00082	0.0016	0.0022	0.0038	0.0047	0.0015	19	-	0	0.00082	0.0010	0.0016	0.0011	0.0089	0.0020	17	-	0
Selenium	mg/L	0.05	0.005	0.00036	0.00045	0.00086	0.00058	0.0031	0.00091	19	0	0	0.00036	0.00050	0.00053	0.00050	0.0016	0.00029	17	0	0
Silver	mg/L	n/v	0.00012	0.000044	0.000050	0.000067	0.000050	0.00027	0.000053	19	-	1	0.000044	0.000050	0.000074	0.000052	0.00039	0.000083	17	-	1

Table 4.3: Baseline Groundwater Quality Statistics – Background

Parameters	Units	GCDWQ / ODWQS	APV	Wells Completed in Overburden									Wells Completed in Bedrock								
				Minimum	Median	Mean	75th Percentile	Maximum	Standard Deviation	Number of Wells	Number of wells with mean exceeding: GCDWQ / ODWQS	Number of wells with mean exceeding: APV	Minimum	Median	Mean	75th Percentile	Maximum	Standard Deviation	Number of Wells	Number of wells with mean exceeding: GCDWQ / ODWQS	Number of wells with mean exceeding: APV
Sodium	mg/L	200	180	1.6	11	21	19	168	37	19	0	0	1.4	16	25	41	97	27	17	0	0
Thallium	mg/L	n/v	0.04	0.00012	0.00015	0.00014	0.00015	0.00015	0.000013	19	-	0	0.00012	0.00014	0.00014	0.00015	0.00015	0.000009	17	-	0
Tungsten	mg/L	n/v	n/v	0.0037	0.0050	0.0053	0.0050	0.011	0.0017	19	-	-	0.0044	0.0062	0.015	0.010	0.10	0.024	17	-	-
Uranium	mg/L	0.02	0.033	0.0018	0.0023	0.0037	0.0024	**0.024**	0.0051	19	1	0	0.0019	0.0023	0.0024	0.0024	0.0040	0.00045	17	0	0
Vanadium	mg/L	n/v	0.02	0.00046	0.00068	0.00079	0.0010	0.0017	0.00033	19	-	0	0.00042	0.00047	0.00066	0.00050	0.0022	0.00046	17	-	0
Zinc	mg/L	5	0.089	0.0027	0.0042	0.0059	0.0066	0.018	0.0038	19	0	0	0.0020	0.0045	0.0082	0.0083	0.030	0.0079	17	0	0
Zirconium	mg/L	n/v	n/v	0.00050	0.0011	0.0011	0.0014	0.0020	0.00040	19	-	-	0.00046	0.00083	0.00094	0.0013	0.0018	0.0005	17	-	-

Notes:
Grey highlight: Parameter exceeds APV
Bold: Parameter exceeds GCDWQ / ODWQS
GCDWQ: Guidelines for Canadian Drinking Water Quality (Federal)
ODWQS: Ontario Drinking Water Quality Standards (Provincial)
APV: Aquatic Protection Values (Provincial) from Ground Water and Sediment Standards for Use under Part XV.1 of the Ontario Environmental Protection Act
n/v: no guideline
ND: not detectable
OB overburden
BR bedrock
*: the provincial and federal criteria differed so the federal criteria is presented as it is more stringent and/or developed based on more recent science, or there is no provincial objective
**: the provincial and federal criteria differed so the provincial criteria is presented as it is more stringent and/or developed based on more recent science, or there is no federal guideline

5.0 EFFECTS ASSESSMENT METHODOLOGY

The environmental effects analysis for groundwater quantity and flow, and groundwater quality, is carried out using a number of analytical methods and tools, and includes laboratory analytical data, three-dimensional numerical groundwater flow modelling, water quality modelling, and mass balance loading calculations. The techniques are described in detail in the SID #14 – Baseline Report – Hydrogeology (CIAR #227) (True Grit 2012a) and associated Hydrogeology Updated Baseline Report (Stantec 2020) (CIAR #722) as well as within this section.

The numerical, three-dimensional finite element groundwater flow model developed for the LSA to simulate baseline conditions, described in Section 4.1.2, was modified to assist in the evaluation of the potential effects of the Project on groundwater. The model provides quantitative predictions about changes in groundwater levels and flow under each Project phase for the following:

- Dewatering rates from staged development of the open pits and associated changes to groundwater levels (drawdown) and baseflow to surrounding waterbodies
- Groundwater inflow rates to the open pits at progressive stages during filling with water to form a pit lake
- Interactions of the pit lakes with groundwater levels and baseflow to surrounding waterbodies
- Groundwater recharge originating from the operation and closure of the MRSA and ore stockpile. For the assessment, all groundwater recharge originating from the MRSA and ore stockpile was assumed to discharge to the natural environment to provide a conservative assessment of groundwater loading to the receiving environment
- Groundwater recharge originating from the operation and closure of the PSMF
- Groundwater recharge originating from the operation and closure of the water management pond
- Groundwater recharge originating from the MRSA, ore stockpile, PSMF, and water management pond and discharging to surface water receivers did not consider physical flow processes, such as dispersion and diffusion, and chemical processes, such as adsorption and precipitation or dissolution

A water quality model was built and updated as part of the EIS Amendment that couples water quantity and mass transfer of selected parameters from different Project components (Ecometrix 2012b; Appendix D11 of the EIS Addendum [Vol 2]). The results of the model were used to predict the water quality and recharge associated with the MRSA, ore stockpile, PSMF, and water management pond during operation and decommissioning/post-closure. The predicted water quality for each mine source was then used, together with the groundwater discharge rates predicted with the groundwater flow model, to estimate potential effects of Project activities on groundwater quality and loading to surface water receivers. The predicted effect of the Project on the quantity and quality of groundwater users was evaluated.

5.1 MODEL APPLICATION AND PROJECT DEVELOPMENT

Starting with the calibrated groundwater flow model previously developed (True Grit 2012a), the following modifications were completed to simulate operation and decommissioning/post-closure phases of mine development. The construction phase of mine life was not simulated for groundwater as project activities are limited compared to operation. Where dewatering is required, it is short term and within the shallow groundwater table (e.g. 1 to 2 m) (e.g. temporary dewatering for construction of foundations for site infrastructure). The model was applied with the same methodology as the groundwater flow modelling completed for the original EIS (True Grit 2012b). Where deviations from the original groundwater flow model methodology occurred, the deviations were noted. Figure 1 presents the mine plan, for reference.

5.1.1 Open Pit Progression

Three open pits will be developed: the North Pit, Central Pit, and South Pit. The footprint of each open pit is presented on Figure 1 and have corresponding depths of 300 m, 120 m, and 200 m for the North, Central, and South pits, respectively. Open pit extents are considered approximate at the cessation of mining operations and subject to refinement during detailed design and approval processes. The North Pit will be mined over the life of mine, which is estimated to be 12.7 years. The Central Pit and South Pit development are anticipated to be completed in years 10 and 6 of mine life, respectively, after which they are expected to receive Type 1 mine rock (South Pit), Type 2 mine rock (Central Pit) and/or process solids (Central Pit) and allowed to flood to submerge the Type 2 material.

To evaluate the effects of groundwater inflows to the open pits, the calibrated groundwater flow model was modified to include the extent and depth of the open pits for three specified stages of development and one stage of closure as discussed below:

- Year 3: representing an early stage of development when the North Pit and South Pit have been developed to depths of 183 m and 166 m, respectively, and prior to development of the Central Pit below the groundwater table
- Year 6: representing an intermediate development stage of the open pit when the North Pit is developed to a depth of 226 m, the extent of the South Pit is developed to the full depth of 200 m, and prior to the development of the Central Pit below the groundwater table
- Year 12: representing the end of mining and the extent of the open pits where the North Pit is developed to the full depth of 300 m and the Central Pit is fully developed to a depth of 120 m. The South Pit remains the same as modelled for year 6 where the pit was developed to a depth of 200 m. For a conservative evaluation of the effect of open pit dewatering on groundwater levels and discharge, the three open pits were modelled in the dewatered state whereas the mine plan indicates

the water level in the Central and South pits will begin to rise prior to year 12 to submerged Type 2 material that is backfilled in these pits

- Post-Closure: representing the formation of the pit lake within the North and Central pits and the backfilling of the South Pit and a portion of the Central Pit

Modelling of the open pit was completed consistent with the methodology presented in the original EIS (True Grit 2012b) but with the updated pit shells and backfilling sequence. Model cells that were intersected by the walls or floor of the open pit were identified and assigned as a seepage face boundary condition in the model. The seepage face was assigned using the MODFLOW DRAIN package at these locations. Model cells that were located above the DRAIN cells within the footprint of the open pit were set as inactive cells. The conductance of the DRAIN cells was specified based on the hydraulic conductivity of the bedrock in the cells multiplied by the width, length, and thickness of the cell.

Each of the three open pit development stages (i.e., years 3, 6, and 12 of mine life) were simulated in the model as separate steady-state model runs. The simulations of years 3, 6 and 12 of mine life were conducted by modifying the calibrated baseline model and completing three separate model runs with the results compared to the baseline conditions. The results from each steady-state simulation were not used as input to the next simulation. This approach of completing three separate steady-state model runs provides much higher inflow rates in the earlier stages of open pit development than would have been predicted by completing one single steady-state model run for the end of life of mine (Year 12). While increased inflows due to storage in the aquifer material and the slightly higher hydraulic gradients during the initial dewatering period may be expected, the use of the multiple steady-state model runs is expected to reduce this potential effect and the model will provide a long-term representation of groundwater inflows over the life of mine.

The groundwater inflow to the open pit after dewatering is terminated was simulated to provide estimated volumes for use in the updated water balance model (Appendix D5 of the EIS Addendum [Vol. 2]). Groundwater inflow for each of the three open pits was simulated by adjusting the stage of the DRAIN cells representing the seepage faces. The stage of the water level forming a pit lake was specified at generally 25 m intervals over the entire depth of the North Pit. It was assumed that the North Pit lake would discharge naturally at an elevation of approximately 262 m amsl through a spillway with overland drainage to the Pic River (via WS103). The Central Pit would be backfilled to an elevation of 254 m amsl with a combination of process solids and mine rock with Type 2 material which would be flooded to form a pit lake with the surface water level of the pit lake controlled by a spillway with an elevation of 271 m amsl. Above an elevation of 271 m amsl, water would discharge from the Central Pit to the North Pit. The South Pit will be backfilled with mine rock material to above the water table, forming the southern portion of the MRSA in closure. A spillway with an elevation of 271 m amsl will be constructed at the northern edge of the South Pit to allow groundwater discharge from the South Pit to the Central Pit. Steady-state model runs were conducted at each of the pit lake stages to predict the groundwater inflow rate into the open pit.

5.1.2 Mine Rock Storage Area and Ore Stockpile

The MRSA is located along the eastern limits of the open pit and will receive the collection of surplus mine rock. Recharge through the MRSA has the potential to affect groundwater quality and, as a result, the model was used to determine the discharge location and flux of water recharging the groundwater flow system from beneath the MRSA.

As part of the updated groundwater flow modelling, the structure of the MRSA and ore stockpile was added to the groundwater flow model as a layer of high permeability material on top of the existing ground surface. A hydraulic conductivity of 0.0012 m/s was assigned to the MRSA layer which is consistent with literature values of mine rock material (Amos et al. 2015). The groundwater flow model assumes the MRSA and ore stockpile will be sufficiently permeable due to the large grain size typical of mine rock and ore that groundwater recharge will not be affected during the operational phase of the mine. A recharge rate of 79 mm was applied to the MRSA for operations phase and is consistent with the modelled scenarios presented in the original EIS (True Grit 2012b).

In the closure phase of the Project, the MRSA, as represented during operation with the MRSA constructed to the full extent at the stages of mine development, was maintained through closure. The MRSA benches and plateaus will be rehabilitated with a vegetated cover to promote runoff and reduce infiltration. The ore stockpile will be removed and the underlying pad will be rehabilitated, and the recharge rate was assumed to remain consistent with the baseline rate determined during the calibration of the model. The reductions in infiltration due to partial revegetation of the MRSA was assumed to result in reduced seepage at the base of the MRSA. To be conservative and consistent with previous modelling efforts, the recharge through the MRSA in closure was maintained at 79 mm.

As part of this EIS Amendment, a DRAIN cell was assigned at ground surface along the perimeter of the MRSA to allow a prediction of toe seepage from the MRSA. The conductance of the DRAIN cells was specified based on the hydraulic conductivity in the cells multiplied by the width, length, and thickness of the cell.

The calibrated groundwater flow model was also used to better understand the fate of groundwater that originates from the MRSA and ore stockpile and to estimate discharge rates to the receiving environment. A forward particle tracking approach was used, where a particle was released from each model cell within the modelled feature. The travel paths of the particles were simulated through the model domain forward in time for 100 years.

5.1.3 Process Solids Management Facility

The PSMF is located in the western portion of the SSA as shown on Figure 1. Recharge through the PSMF has the potential to affect groundwater quality and, as a result, the model was used to determine the discharge location and flux of water recharging the groundwater flow system from beneath the PSMF.

As part of this updated groundwater flow modelling, the structure of the PSMF was added to the groundwater flow model whereas previously the recharge at surface within the model was altered to simulate the PSMF. The materials for the PSMF were simulated using material placed in a single layer in the groundwater flow model, placed on top of the existing ground surface. The dams of the PSMF were constructed of coarse rock of high permeability, with a layer of HDPE placed on the upstream side of the dam, between the tailings and the rock fill of the dam. The tailings were assumed to have a hydraulic conductivity of $1x10^{-6}$ m/s. The HDPE liner on the upstream side of the rock fill was simulated as a no flow boundary which would conservatively assume no toe seepage and, therefore, seepage from the PSMF would be directed out the base of the facility.

Consistent with the previous modelling completed as part of the original EIS (True Grit 2012b), the presence of the PSMF was simulated by assigning a river boundary condition to the upper layer of the model (layer 1) over the area covered by the PSMF. Head elevations of 340 m amsl and 378 m amsl were assigned to Cell 1 and Cell 2 of the PSMF, respectively; the elevations were obtained from the water balance model for the PSMF (Appendix D5 of the EIS Addendum [Vol. 2]). Since the hydraulic conductivity of the process solids has been estimated to be similar to or greater than the native bedrock and overburden, the conductance of the river boundary was calculated based on the vertical conductivity of the cell in the top layer of the model. The depth of the river was set to the depth of the process solids. The PSMF, as represented during operation with the PSMF constructed to the full extent at the stages of mine development, was maintained through closure.

In order to determine groundwater seepage migration pathways from the PSMF, a forward particle tracking approach was used as described in Section 5.1.2.

5.1.4 Water Management

Water will be collected around the mine site using a series of pumps, pipelines, and/or surface ditches to convey water to management ponds and/or catch basins. As the surface ditches will be constructed above the groundwater table, the ditches will not interact with groundwater and have not been considered in the assessment of effects of the Project on groundwater.

Water from the PSMF and open pits (which includes natural groundwater and surface water inflows, as well as drainage off the ore stockpile) will be managed in the water management pond. Water pumped from the open pit will be transferred to collection pond 1 and then conveyed to the water management pond. Collection pond 1 is located adjacent to the ore stockpile and will be constructed above the water table and lined; therefore, no interactions with groundwater are predicted. A series of seepage collection basins have been included around the PSMF to collect seepage and direct it back into the PSMF for reuse in the process. Water from the water management pond will be reclaimed to the process plant.

Run-off from the MRSA area reports naturally to the Pic River through WS102 and WS103 (Figure 10) on the east side of the mine site. Water draining the MRSA will be collected via surface ditches and/or natural topography that conveys contact water to two catch basins located below the eastern limit of the MRSA. The retention ponds have been located to take advantage of the topography of the area and utilize existing natural drainage channels to route contact water to the ponds. The catch basins will be sized to manage the environmental design storm, which is based on a 1 in 25-year rainfall event. Water collected in the catch basins will be pumped to the water management pond. In the event that the environmental design storm is exceeded, water will be routed from the MRSA catch basins via the catch basin overflow spillways to the Pic River. The overflow spillways have been sized to convey a 1 in 100 year rainfall event. In closure, water collected in the catch basins may be pumped to the open pit to accelerate pit filling.

Runoff from the Process Plant area, Truck Shop / Warehouse area, and aggregate plant area will be collected in the storm water management (SWM) Pond. The SWM Pond will be located in the upper portion of WS101, east of the PSMF. The amount of water in the SWM Pond at any given time will be temporary and based on precipitation events as water collected in the SWM pond will be transferred to the water management pond or directly to the water treatment plant for discharge to Hare Lake. Therefore, interactions of the SWM Pond with groundwater are anticipated to be limited and temporary.

Consistent with the original EIS, Collection Pond 1 and the SWM Pond were not included in the assessment of effects on groundwater as the ponds are not anticipated to substantially interact with groundwater. As part of this updated groundwater flow modelling for the EIS Amendment, the water management pond was added to the groundwater flow model. The presence of the water management pond was modelled by assigning a river boundary condition to the upper layer of the model (layer 1) over the area covered by the water management pond. A head elevation of 340 m amsl was assigned to the water management pond. The head elevation was obtained from the water balance model for the water management pond (Appendix D5 of the EIS Addendum [Vol. 2]). The conductance of the river boundary was calculated based on the vertical conductivity of the cell in the top layer of the model. The depth of the river was set to the depth of the water management pond. The water management pond was represented in the operational and closure model scenarios as it was assumed the water management pond will operate until water quality is sufficient for direct discharge to the environment.

The calibrated groundwater flow model was also used to better understand the groundwater seepage rates from the water management pond and to understand the fate of seepage from the pond to the receiving environment. In order to determine groundwater seepage migration pathways from the water management pond, a forward particle tracking approach was used as described in Section 5.1.2.

6.0 RESULTS AND DISCUSSION

The groundwater flow model was used to simulate the effects of the Project during operation and closure on groundwater levels and flow and the fate of groundwater originating from the MRSA, PSMF, and water management pond. As part of these simulations, the model was used to predict groundwater inflows to the open pits under dewatering conditions and groundwater inflows to the open pit as it was filling. The results of the updated prediction of effects of the Project are evaluated in terms of the potential impact to groundwater resources.

6.1 OPEN PIT DEWATERING AND FILLING RATES

The groundwater inflow rates to the North, Central, and South Pits for years 3, 6, and 12 of mine life are presented in Table 6.1. These rates only consider inflows to the open pits due to groundwater and do not consider surface water runoff or precipitation inflows. The steady-state pumping rates to maintain a dewatered seepage face for each of the model runs (years 3, 6, and 12 of mine life) were used to interpret groundwater pumping rates over the life of mine by assuming a linear increase between each year in the Project water balance model (Appendix D5 of the EIS Addendum [Vol. 2]).

Table 6.1: Groundwater Inflow Rates (m^3/d)

Year of Mine Life	North Pit Inflow	Central Pit Inflow	South Pit Inflow
3	294.26	n/a	326.27
6	369.54	n/a	457.44
12	481.30	135.60	376.80

NOTES:
n/a: not applicable
The Central Pit is not developed until after year 6.

In year 3 of mine life, the development of the North and South Pits has commenced and groundwater inflow rates of 294 m^3/d and 326 m^3/d, respectively, are predicted. In year 6 of mine life, there is ongoing development of the North Pit and the South Pit is developed to a depth of 200 m and the groundwater inflow rate correspondingly increases to 370 m^3/d and 457 m^3/d, respectively. The development of the Central Pit commences after year 6 of mine life. Year 12 of mine life represents the final year of open pit development for the North, Central, and South pits. For the impact assessment, year 12 of mine life model scenario assumed a dewatered state for the three pits to conservatively predict the potential changes in water levels and groundwater discharge as a result of open pit dewatering. However, the mine plan indicates the South Pit will be backfilled with mine rock to above ground surface, becoming integrated with the MRSA. The Central Pit will be backfilled with Type 2 mine rock and/or process solids to an elevation of 254 m amsl. Subsequently, the water levels in the South and Central pits will be allowed to rise as early as year 6 and 10 of mine life, respectively, to keep the mine rock and/or process solids submerged. The groundwater inflow rate for the fully dewatered North, Central, and South pits were predicted as 481 m^3/d, 136 m^3/d, and 377 m^3/d, respectively, for a combined groundwater inflow rate of 994 m^3/d. The groundwater inflow rate from the South Pit decreases in year 12 of mine life compared to year 6, despite a larger extent, because of the capture of some groundwater by the development and dewatering of the Central Pit.

The rate of groundwater inflow and time for the open pits to fill after the end of mining activities is presented in Table 6.2. The groundwater inflow rate for the North Pit decreases from 509 m^3/d at a pit lake elevation of -5 m amsl to 377 m^3/d at a final pit lake elevation of 262 m amsl. The groundwater inflow rate for the Central Pit decreases from 164 m^3/day at a groundwater elevation of 140 m amsl to 51 m^3/day at the final pit lake elevation of 271 m amsl. The South Pit groundwater inflow rate decreases from 360 m^3/d at a groundwater elevation of 131 m amsl to 333 m^3/d at a groundwater elevation of 262 m amsl. The groundwater inflow rates to the open pits presented in Table 6.2 were incorporated into the Project water balance model (Appendix D5 of the EIS Addendum [Vol. 2]) to evaluate the overall time to fill the open pits during closure, considering both groundwater and surface water sources.

Table 6.2: Predicted Open Pits Filling Rates and Times After the End of Mining Activities – Closure

Water Elevation in Pit (m amsl)	North Pit Groundwater Inflow (m^3/d)	Central Pit Groundwater Inflow (m^3/d)	South Pit Groundwater Inflow (m^3/d)
-5	509.35	-	-
25	509.08	-	-
50	507.13	-	-
75	504.08	-	-
100	500.30	-	-
131.1	492.75	-	360.28
140.4	489.76	163.52	360.49
175	477.50	163.40	361.43
200	466.52	161.81	361.18
225	452.77	154.76	357.86
250	430.76	131.18	344.80
262	377.30	114.13	333.27
271	-	51.00	-

Notes:
amsl above mean sea level
\- not applicable

6.2 GROUNDWATER HEADS AND FLOW

The simulated steady-state water table at the end of mine life (year 12) is presented on Figure 11. Changes in the water table elevation due to dewatering of the open pits are evident primarily in the area of the open pit and PSMF.

The drawdown, or change in water level elevation due to dewatering of the open pits at the end of life of mine (Year 12), in comparison to baseline conditions is shown on Figure 12 for the overburden and shallow bedrock. The 1.0 m drawdown contour, resulting from dewatering of the open pits, extends over an area of approximately 500 m to the west of the open pits, 900 m to the east, and 900 m to the south and north. The drawdown increases to more than 10 m within 400 m of the open pits. Local mounding of the water table of up to 10 m within the MRSA, located adjacent to the eastern boundary of the open pits, limits the extent of drawdown due to dewatering of the open pits. The mounding of the MRSA is a reflection of the size of the pile and the four order of magnitude difference between the hydraulic conductivity of the MRSA versus the underlying hydrostratigraphic unit.

Figure 12 also presents the predicted zone of influence of the PSMF on groundwater levels compared to baseline conditions. As identified by the -0.5 m drawdown contour, mounding of the water table within the area of the PSMF is predicted to extend up to 1,200 m and generally less than 800 m, from the limits of the PSMF.

The water table elevations in Post Closure, when the pit lakes have formed, are presented on Figure 13 and the change in water table position compared to baseline conditions (drawdown) are presented on Figure 14. As shown, at the end of closure, the residual drawdown of the water table is predicted to extend about 500 m west, 800 east, and 900 m north and south of the open pits. Mounding of the water table is predicted to extend up to 1,300 m and 800 m from the limits of the PSMF and MRSA, respectively.

When comparing the location of groundwater users (Figure 8) to the drawdown at the end of operations (Figure 12) and post-closure (Figure 14), there are no groundwater users located within the predicted area of drawdown or mounding. Therefore, an effect of the Project on groundwater users is not predicted.

6.3 GROUNDWATER SEEPAGE AND DISCHARGE

The effects of open pit dewatering and mounding of the water table from the development of the MRSA and PSMF on groundwater flow and levels also result in changes to groundwater discharge conditions in watercourses and lakes near these mine features. Table 6.3 provides a comparison between groundwater discharge to the various surface water features under dewatering of the open pits at end of life of mine (year 12) and in post-closure, when the pit lakes have formed, in comparison with pre-development (baseline) conditions.

Table 6.3: Groundwater Discharge to Watercourses and Lakes Under Dewatered (Year 12), Pit Lake (Post Closure), and Baseline Conditions (m³/d)

Water Budgets	Baseline Discharge Rate	End of Mining (Year 12)	Post-Closure
WS101	1,252.4	1,505.7	1,517.2
WS102	1,001.9	46.5	46.5
WS103	287.2	27.5	30.1
WS104	477.8	733.7	768.9
WS105	1,958.5	2,466.6	2,417.7
WS106	2,243.8	1,893.9	1,894.0
WS107	113.7	105.4	107.3
WS108	100.2	72.0	31.7
WS109	1,673.6	2,091.8	2,092.2
WS110	4.8	13.6	15.7
WS111	8.7	18.1	21.5
WS112	25.4	122.9	133.3
WS113	48.8	64.5	67.7
WS114	143.4	212.2	217.7
WS115	14.4	20.2	20.6
WS116	126.3	154.4	154.5
WS117	34.5	46.0	50.1
Pic River	1,301.0	1,723.7	1,726.7
MRSA Perimeter Toe Seepage[4]	-	137.9	507.0

Notes:
1. WS: watershed
2. Positive value represents flow from groundwater to surface water
3. Negative value represents flow from surface water to groundwater
4. Assumes the MRSA is fully saturated

The overall groundwater discharge during operations compared to baseline conditions for watersheds WS102, WS103, WS107, WS108 decreases as a result of open pit development. The groundwater discharge rate for these watersheds remains less than baseline in closure due to the permanent lowering of the groundwater table in the vicinity of the open pits.

Mounding of the water table in the vicinity of the MRSA results in an increase in groundwater discharge to adjacent watersheds WS110, WS111, WS112, WS113, WS114, WS117, and the Pic River. The effect of mounding of the water table in the vicinity of the MRSA remains in closure and the termination of open pit dewatering and the formation of pit lakes results in a further increase in groundwater discharge for these watersheds in closure compared to operations.

Toe seepage from the MRSA was simulated with the groundwater flow model. About 138 m^3/d is predicted as toe seepage from the MRSA at the end of operation. In closure, the mounding of the water table within the MRSA increases as result of the termination of open pit dewatering and the amount of toe seepage from the MRSA is predicted to increase to 507 m^3/d.

The PSMF will have a lower hydraulic conductivity than the original ground surface resulting in lower recharge and subsequently groundwater discharge to surface water features within watershed WS106 during operations and through closure. However, mounding of the water table within the vicinity of the PSMF will result in an increase in groundwater discharge to watersheds WS101, WS105, and WS109.

Generally, the groundwater discharge rates for each watershed represents a small component of total flow for the given watershed. The effect of changes in groundwater discharge rates on surface water receivers is evaluated in the Surface Water Hydrology Updated Effects Assessment Report (Appendix D3 of the EIS Addendum [Vol 2]).

The fate of groundwater that recharges beneath the MRSA, ore stockpile, PSMF, and water management pond was determined through particle tracking. The particle traces at the end of mine life (Year 12), conservatively representing the dewatered state of the three open pits, are presented on Figure 15 and represent 100 years of travel. The particle traces were used to quantify the inflow rates to the open pits and discharge to surface water features from the MRSA, ore stockpile, PSMF, and water management pond and are presented in Table 6.4.

As shown in Table 6.4, groundwater recharge from beneath the MRSA discharges primarily to the open pits (78%) with the remainder of discharge to WS101 (17%) (Pic River and its tributaries) and WS102 West (5%). Groundwater recharge from beneath the ore stockpile is captured by the dewatering associated with the Central and South pits where it will be pumped to collection pond no. 1 prior to being transferred to the water management pond for use as process water or treated, if required, and discharged to Hare Lake. Groundwater recharge from beneath the PSMF discharges primarily to WS106 (68%) with the remainder of discharge to WS105 (32%) (Hare Lake and its tributaries). Groundwater recharge from beneath the water management pond discharges to WS101, a tributary of the Pic River.

Table 6.4: Predicted Groundwater Discharge Rates (m^3/d) from MRSA, Ore Stockpile, PSMF, and Water Management Pond to Receiving Environment at End of Operation

Receptor / Watershed	Mine Feature			
	MRSA	Ore Stockpile	PSMF	Water Management Pond
North Pit	54.2	-	-	-
Central Pit	33.7	18.5	-	-

Table 6.4: Predicted Groundwater Discharge Rates (m^3/d) from MRSA, Ore Stockpile, PSMF, and Water Management Pond to Receiving Environment at End of Operation

Receptor / Watershed	Mine Feature			
	MRSA	Ore Stockpile	PSMF	Water Management Pond
South Pit	150.0	18.6	-	-
WS101 (Pic River and Tribs)	52.1	-	-	122.0
WS102 West	16.4	-	-	-
WS105	-	-	155.6	-
WS106	-	-	334.8	-
Total	306.4	37.1	490.4	122.0
Notes: WS: watershed				

The particle traces in post-closure (pit lakes) are presented on Figure 16 and represent 100 years of travel after the start of post-closure (pit lake full). The particle traces were used to quantify the inflow rates and travel times to the open pits and discharge to surface water features from the MRSA, PSMF, and water management pond and are presented in Table 6.5. The ore stockpile would be exhausted and rehabilitated in post-closure and, therefore, seepage from the ore stockpile in post-closure is not considered.

As shown in Table 6.5, the groundwater recharge from beneath the PSMF discharges primarily to WS106 (70%) with the remainder of discharge to WS105 (30%) (Hare Lake and its Tributaries). Groundwater recharge from beneath the MRSA discharges primarily to the WS101 (62%), the Pic River and associated tributaries. The remainder of groundwater recharge from beneath the MRSA discharges to the North and Central Pits (25%) and WS102 West (13%). Groundwater recharge from beneath the water management pond discharges to WS101, a tributary of the Pic River.

Table 6.5: Predicted Groundwater Discharge Rates (m^3/d) from MRSA, PSMF, and Water Management Pond to Receiving Environment at Post Closure (Pit Lake)

Receptor / Watershed	Mine Feature		
	MRSA	PSMF	Water Management Pond
North Pit	35.4	-	-
Central Pit	66.5	-	-
South Pit	-	-	-
WS101 (Pic River and Tributaries)	171.0	-	121.5
WS102 West	18.8	-	-
WS105	-	112.3	-
WS106	-	366.3	-
Total	291.7	478.6	121.5
Notes: WS: watershed			

When comparing the location of groundwater users (Figure 8) to the particle traces from mine facilities at the end of operations (Figure 15) and post-closure (Figure 16), there are no groundwater users located within the predicted flow paths that represent the 100 year time of travel. Therefore, an effect of the Project on groundwater users is not predicted. The effect of changes in the quality of groundwater discharge to surface water receivers is evaluated in the Surface Water Quality Effects Assessment Update Report (Appendix D11 of the EIS Addendum [Vol 2]). The quality of seepage from the mine facilities is provided in the following section for reference.

6.4 GROUNDWATER SEEPAGE QUALITY

During operation, recharge from the MRSA, ore stockpile, PSMF, and water management pond have the potential to affect groundwater quality.

Table 6.6 provides a summary of geomean concentrations during non-frozen months (March to November) for groundwater recharge originating from these sources at the end of operation. The groundwater concentrations for the MRSA and PSMF were estimated in the original EIS (Ecometrix 2012b). The groundwater concentrations for the MRSA, ore stockpile, PSMF, and water management pond were updated as part of this EIS Addendum (Appendix D11 of the EIS Addendum [Vol 2]). Groundwater concentrations of seepage from these facilities were incorporated into the updated surface water quality model for the Project (Appendix D11 of the EIS Addendum [Vol 2]).

Table 6.6: Predicted Geomean Concentrations (mg/L) of Groundwater Recharge from Project Components

Parameter	Units	GCDWQ / ODWQS	APV	MRSA		PSMF	Ore Stockpile	Water Management Pond	
				Operation	Closure	Operation / Closure	Operation	Operation	Closure
General Chemistry									
Ammonia (as N)	mg/L	n/v	n/v	8.6	7.3	-	0.28	10	8
Nitrate (as N)	mg/L	10	n/v	**68**	**58**	0.060	2.2	**77**	**66**
Nitrite (as N)	mg/L	1	n/v	**1.6**	**1.3**	0.030	0.050	**1.8**	**1.5**
Dissolved Metals									
Aluminum	mg/L	0.1 **	n/v	**0.13**	**0.13**	0.087	0.020	**0.13**	**0.13**
Arsenic	mg/L	0.010	0.15	**0.054**	**0.062**	0.00060	0.00055	**0.061**	**0.070**
Cadmium	mg/L	0.005 **	0.00021	0.00014	0.00016	0.000033	0.000025	0.00016	0.00018
Cobalt	mg/L	n/v	0.0052	0.0037	0.0042	0.000060	0.0014	0.0042	0.0048
Copper	mg/L	1 **	0.0069	0.026	0.029	0.00050	0.012	0.029	0.033
Iron	mg/L	0.3	n/v	0.0044	0.0044	0.076	0.0044	0.0044	0.0044
Lead	mg/L	0.005 *	0.0020	0.0014	0.0016	0.000020	0.000078	0.0016	0.0018
Molybdenum	mg/L	n/v	0.73	0.012	0.014	0.028	0.00014	0.014	0.015
Nickel	mg/L	n/v	0.039	0.010	0.012	0.0030	0.0055	0.011	0.013
Selenium	mg/L	0.05	0.005	0.020	0.023	0.00057	0.00056	0.022	0.026
Uranium	mg/L	0.02	0.033	0.0059	0.0067	0.00015	0.00018	0.0066	0.0076
Vanadium	mg/L	n/v	0.02	0.040	0.046	0.0011	0.000089	0.046	0.052
Zinc	mg/L	5	0.089	0.041	0.047	0.0020	0.0017	0.046	0.053

NOTES:
Grey highlight: Parameter exceeds APV
Bold: Parameter exceeds GCDWQ / ODWQS
GCDWQ: Guidelines for Canadian Drinking Water Quality (Federal)
ODWQS: Ontario Drinking Water Quality Standards (Provincial)
APV: Aquatic Protection Values (Provincial) from Ground Water and Sediment Standards for Use under Part XV.1 of the Ontario Environmental Protection Act
n/v: no guideline
ND: not detectable
OB overburden
BR bedrock
*: the provincial and federal criteria differed so the federal criteria is presented as it is more stringent and/or developed based on more recent science, or there is no provincial objective
**: the provincial and federal criteria differed so the provincial criteria is presented as it is more stringent and/or developed based on more recent science, or there is no federal guideline

Groundwater recharge from the MRSA during operation is predicted to be below the MDMER. Geomean concentrations in groundwater recharge from the MRSA are predicted to exceed the GCDWQ, ODWQS, and/or APVs for the following parameters:

- **GCDWQ and/or ODWQS**: nitrate, nitrite, aluminum, arsenic
- **APV**: copper, selenium, vanadium

During closure, the same parameters are predicted to exceed the GCDWQ, ODWQS, and/or APV in seepage from the MRSA. The APV and ODWQS are used to identify constituents of potential concern for the MRSA, although groundwater originating from this area is predicted to discharge to either the open pit or surface water. The constituents of potential concern for the MRSA are: nitrate, nitrite, arsenic, copper, selenium, and vanadium. The concentration of aluminum in background groundwater quality exceeds the ODWQS and GCDWQ operational guidelines and therefore aluminum was not identified as a constituent of potential concern for the MRSA.

Groundwater recharge from the ore stockpile during operation is predicted to be below the MDMER. Geomean concentrations in groundwater recharge from the ore stockpile are predicted to exceed the GCDWQ, ODWQS, and/or APVs for the following parameters:

- **GCDWQ and/or ODWQS:** no parameters
- **APV:** copper

The APV and ODWQS are used to identify constituents of potential concern for the ore stockpile, although groundwater originating from this area is predicted to discharge to the Central and South pits. The constituent of potential concern for the ore stockpile during operation is copper. In closure, the ore stockpile will be decommissioned.

Groundwater recharge from the PSMF during operation and closure is predicted to be below the MDMER. Geomean concentrations in groundwater recharge from the PSMF are predicted to be less than the GCDWQ, ODWQS, and/or APVs. There are no constituents of concern identified for the PSMF during operation or closure.

Groundwater recharge from the water management pond during operation is predicted to be below the MDMER. Geomean concentrations in groundwater recharge from the water management pond are predicted to exceed the GCDWQ, ODWQS, and/or APVs for the following parameters:

- **GCDWQ** and/or **ODWQS**: nitrate, nitrite, aluminum, arsenic
- **APV**: copper, selenium, vanadium

During closure, the same parameters are predicted to exceed the GCDWQ, ODWQS, and/or APV in seepage from the water management pond. The APV and ODWQS are used to identify constituents of potential concern for the water management pond, although groundwater originating from this area is predicted to discharge to surface water. The constituents of potential concern for the water management pond are: nitrate, nitrite, arsenic, copper, selenium, and vanadium. The concentration of aluminum in background groundwater quality exceeds the ODWQS and GCDWQ operational guidelines and therefore aluminum was not identified as a constituent of potential concern for the MRSA. In closure, the water management pond will be decommissioned once water quality meets criteria for discharge to the environment.

6.5 PREDICTION CONFIDENCE

The approach used in model simulations completed for this Project was to incorporate conservative assumptions for predicting effects that may result from the Project. This report presents the assumptions made in developing these conservative predictions and discusses the high level of confidence in these predictions which are summarized as follows.

The modelling was conducted using an equivalent porous media approach. As discussed in the original Baseline Hydrogeology Report (True Grit 2012a) (CIAR #227), this is appropriate based on the regional scale of the modelling and considering that flow was predicted to occur primarily through the shallow weathered bedrock, which is highly fractured and, therefore, behaves like a porous medium.

Groundwater inflow rates and effects on groundwater levels and discharge are over predicted for the end of operations. The results from modelling conducted for the end of operation assumes a dewatered state for each of the three open pits whereas the mine plan indicates the South and Central Pits will be backfilled with Type 2 mine rock and/or process solids and the water level in the pits will be allowed to rise to submerge the mine rock and/or process solids.

Groundwater recharge rates at the MRSA, PSMF, and water management pond to the receiving environment are conservatively “over predicted” in two ways. First, the results from modelling conducted for the end of operation assumes a dewatered state for each of the three open pits whereas the mine plan indicates the water level in the South and Central pits will be allowed to rise sooner than end of operations, as mentioned above. Second, all of the recharge applied within the MRSA, PSMF, and water management pond are assumed to be carried through to the final receptors.

The groundwater flow modelling was conducted using a model calibrated to water levels and baseflow targets to establish baseline conditions as described in the original Baseline Hydrogeology Report (True Grit 2012a) (CIAR #227). Predictions made using the model are based on several conservative assumptions to reduce the influence of uncertainty in the predictions. Therefore, the confidence in the predictions made using the model is considered high.

6.6 FOLLOW-UP AND MONITORING

Management and Monitoring Program Basis and Objectives

The primary effect on groundwater quantity and flow is a lowering of the water table as a result of dewatering the open pit during construction and operation and, to a lesser extent, during closure when the open pit refills. The effect on groundwater quality is an increase in concentrations of parameters in seepage (as noted in Section 6.4) from the MRSA, ore stockpile, PSMF, and water management pond to groundwater, although the effect is likely limited given the decades to centuries of advective groundwater travel time and potential for natural attenuation of the parameters along the groundwater flow paths.

Although there are no groundwater well users within the areas where effects of the Project on groundwater are anticipated, Generation PGM will develop a follow-up and monitoring program to monitor groundwater levels and groundwater quality at key Project locations. Monitoring data from these locations will be used to verify and confirm the anticipated effects identified in the groundwater flow model and to meet regulatory requirements related to specific permits or conditions of approval.

Monitoring Methods

During construction, a detailed groundwater monitoring program will be developed and implemented, building on the baseline monitoring program, to confirm potential changes in groundwater associated with future mine operation. The EIS follow-up and monitoring program for groundwater will be developed based on regulatory requirements for both quantity and quality. During closure, the groundwater monitoring program will be continued to document the recovery in groundwater levels as the open pit fills.

The type of monitoring equipment, selection of monitoring stations, frequency of sample collection, and duration of the program will be based on federal and provincial guidelines and consultation with government agencies. However, it is anticipated that the monitoring program will generally comprise the following key elements:

- Monitoring wells at select locations around the open pits to monitor groundwater levels during construction, operation, and closure as the open pits are dewatered during construction and operation and subsequently recovers with recovery of the pits staggered and occurring through operation and into closure.
- Monitoring wells/drive point piezometers in the vicinity of key surface water features to collect groundwater levels during construction, operation, and closure to monitor the effects on groundwater levels due to open pit dewatering and recovery.
- Monitoring wells upgradient, cross-gradient, and downgradient of the PSMF, MRSA, and ore stockpile will be established to collect groundwater levels and assess water quality during construction, operation, and closure to document changes to groundwater levels and flow and groundwater quality.

- Groundwater quality samples from monitoring wells will be monitored annually with a subset of monitoring wells monitored in spring, summer, and fall during construction, operation, and decommissioning/closure with the frequency progressively reduced based on monitoring results and Project phase. Winter groundwater sampling is not feasible as, based on the baseline data, the monitoring wells are generally frozen and not possible to sample. Groundwater quality samples will be analyzed for general chemistry parameters and select dissolved metals.
- Follow-up monitoring results will be compared with applicable regulatory standards set out in GCDWQ, ODWQS, APVs and Project-specific regulatory approvals.
- A water well survey will be completed within and adjacent to the SSA to confirm the results of the MECP WWR and PTTW database review.

Monitoring Locations and Frequencies

Groundwater monitoring locations will be reviewed at regular intervals. Monitoring locations/stations may be added or removed from the monitoring program in accordance with their utility in monitoring the effects of the Project on the environment.

Monitoring locations will be maintained until the location is no longer required. If a monitoring location/station is no longer required but is identified as part of a regulatory approval, it will only be removed from the monitoring program once the required amendments are approved.

7.0 SUMMARY AND CONCLUSIONS

Hydrogeology modelling was conducted to identify changes to groundwater levels and flow pathways to inform the assessment of potential effects of the Project on groundwater and surface water resources. The modelling was conducted using Modflow NWT and was calibrated to baseline conditions.

The operation of the open pits will require the open pits to be dewatered. The dewatering of the open pits will result in the drawdown of the water table, with the 1.0 m drawdown interval extending approximately 500 m to 900 m from the edge of the open pits. There are no groundwater users located within the drawdown zone of the open pits or mounding of the water table in the vicinity of the MRSA, and/or PSMF and, therefore, an effect on the quantity for groundwater users is not predicted. As dewatering progresses, the average annual groundwater inflow rates increase from a combined dewatering rate of the North and South Pits of 621 m^3/d in Year 3 to a combined dewatering rate of the North, Central, and South Pits of 994 m^3/d at the end of operation. The updated estimate of groundwater inflows is slightly lower than the original EIS estimate of 1,322 m^3/d due to a smaller pit shell.

The dewatering of the open pit and mounding of the water table in the vicinity of the MRSA and PSMF will also result in changes to groundwater discharge conditions in watercourses and lakes located near the open pit, MRSA, and PSMF. Groundwater discharge to most surface water features increases as a result of mounding of the water table in association with the MRSA and PSMF. For watersheds that are directly overprinted by the open pit and PSMF, the groundwater recharge is reduced and a reduction in the corresponding groundwater discharge is predicted for these watersheds that are directly overprinted. The potential effect of changes in groundwater discharge on surface water features is assessed in the Surface Water Hydrology Updated Effects Assessment Report (Appendix D3 of the EIS Addendum [Vol 2]). The predicted change in groundwater discharge to surface water features in operation and closure compared to baseline conditions was similar to that predicted in the original EIS with the same surface water features affected but generally less change in groundwater discharge rate from baseline conditions than that predicted in the original EIS. A smaller effect on the groundwater discharge rate to surface water features is predicted due to the redesigned open pits and smaller dewatering requirement compared to the original EIS.

Groundwater discharge to surface water features associated with Project facilities represents a minor component of the overall surface water flow systems. The receptors of seepage from Project facilities were consistent with the original EIS and the rate of discharge from the Project facility to the receiver was slightly less due to a reduced dewatering requirement of the open pits compared to the original EIS. The potential effect of changes in the quantity of groundwater discharge on surface water features is assessed in the Surface Water Hydrology Updated Effects Assessment Report (Appendix D3 of the EIS Addendum [Vol 2]). There are no groundwater users located within the flow path of groundwater recharge associated with Project facilities and, therefore, an effect on the quality for groundwater users is not predicted. The potential effect of changes in the quality of groundwater discharge on surface water features is assessed in the Surface Water Quality Effects Assessment Update (Appendix D11 of the EIS

Addendum [Vol 2]). The results of this updated effects assessment of effects of the Project on groundwater were consistent with the findings of the original EIS (True Grit 2012b).

8.0 REFERENCES

Amos, Richard T., David W. Blowes, Brenda L. Bailey, David C. Sego, Leslie Smith, and A. Ian M. Ritchie. 2015. "Waste-Rock Hydrogeology and Geochemistry." *Applied Geochemistry*, Environmental Geochemistry of Modern Mining, 57 (June): 140–56. https://doi.org/10.1016/j.apgeochem.2014.06.020.

Canadian Council of Ministers of the Environment (CCME). 2018. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Canadian Council of Ministers of the Environment, 1999, updated 2007 and on-line version.

Ecometrix. 2012a. Geochemical Assessment of Mine Components at the Marathon PGM-CU Project Site. Prepared for Stillwater Canada Inc. July 2012.

Ecometrix. 2012b. Supporting Information Document No. 6 – Water Quality and COPC Fate Modelling for the Marathon PGM-Cu Project. Prepared for Stillwater Canada Inc. July 2012.

Fetter Jr., C.W. 2000. Applied Hydrogeology. 4th Edition, Prentice-Hall, Upper Saddle River, 598 p.

Golder Associates Ltd. (Golder). 2007. Report on Recommendations for Open Pit Rock Slope Design Marathon PGM-Cu Project. March, 2007.

Golder Associates Ltd. (Golder). 2008. Preliminary Geotechnical Investigation (Phases 1 and 2) Preliminary Foundation Recommendations, Marathon PGM Project. May 30, 2008.

Health Canada. 2019. Guidelines for Canadian Drinking Water Quality – Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

Knight Piésold Ltd. 2011a. 2011 Winter Site Investigation Summary Stillwater Canada Inc. Marathon PGM-Cu Project. June 20, 2011.

Knight Piésold Ltd. 2011b. 2011 Summer and Fall Site Investigation Summary Stillwater Canada Inc. Marathon PGM-Cu Project. November 18, 2011.

Town of Marathon (Marathon). 2020. Water and Wastewater Systems website: https://www.marathon.ca/en/living-here/water-and-wastewater-systems.aspx#Wells-5. Accessed November 13, 2020.

Ministry of the Environment (MOE). 2011. Rationale for the Development of Soil and Ground Water Standards for use at Contaminated Sites in Ontario. April 15, 2011.

Ministry of Environment and Energy (MOEE). 1994. Guideline B-7 (formerly 15-08) Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities. Ontario Ministry of Environment and Energy, April 1994.

Stantec Consulting Ltd. (Stantec). 2020. Marathon Palladium Project, Environmental Hydrogeology Updated Baseline Report. Prepared for Generation PGM Inc. November 26, 2020.

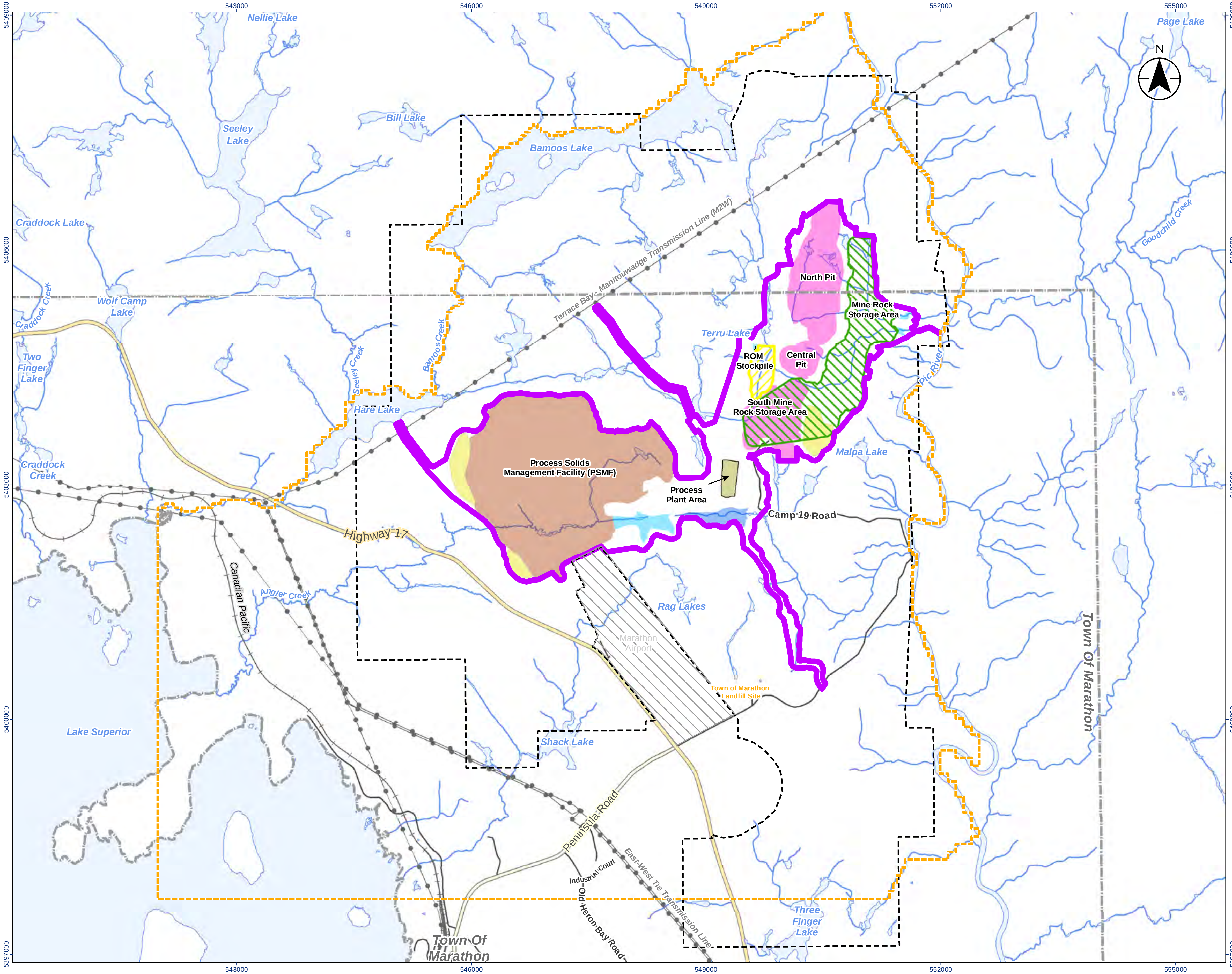
Statistics Canada. 2017. Marathon, Town [Census subdivision], Ontario, Ontario (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed September 8, 2020)

Sykes, J.F., S.D. Normani, M.R. Jensen, and E.A. Sudicky. 2009. Regional-scale groundwater flow in a Canadian Shield setting. Canadian Geotechnical Journal. V. 46, pp. 813-827.

True Grit Consulting Ltd. (True Grit). 2012a. Baseline Report – Hydrogeology, Marathon PGM-Cu Project. Prepared for Stillwater Canada Inc. July 5, 2012.

True Grit Consulting Ltd. (True Grit). 2012b. Impact Assessment – Hydrogeology, Marathon Cu-PGM Project. Prepared for Stillwater Canada Inc. July 5, 2012.

APPENDIX A
Figures



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Manadement Facility (PSMF)
- Water Management Pond

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.

Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-17

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
1

Title
Site, Local and Regional Study Areas

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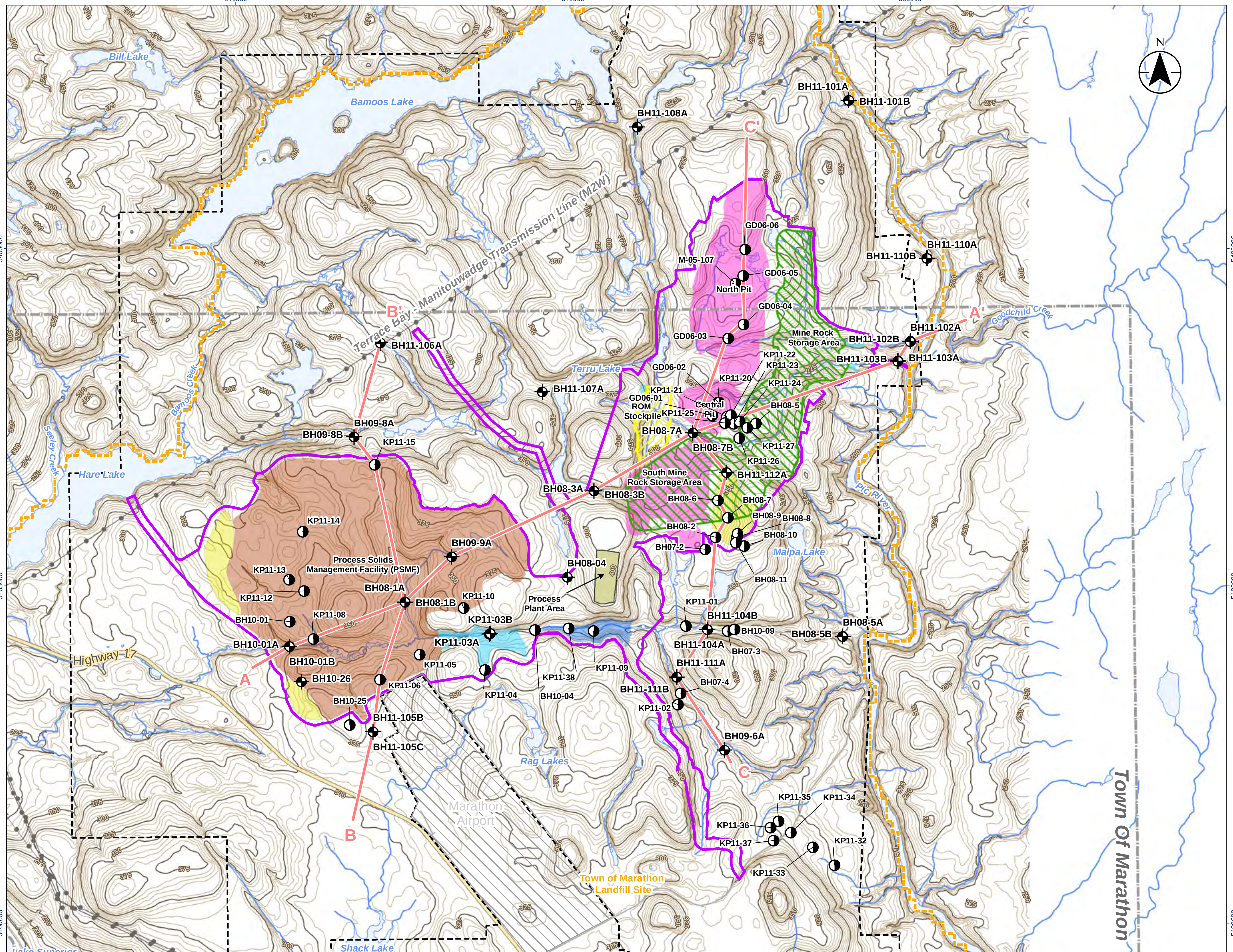

Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Monitoring Well
- Borehole
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Cross Section Location
- Topographic Contour (5 m Intervals)
- Topographic Contour (25 m Intervals)
- Highway
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Solids Management Facility (PSMF)
- Water Management Pond

0 1 2 km

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Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

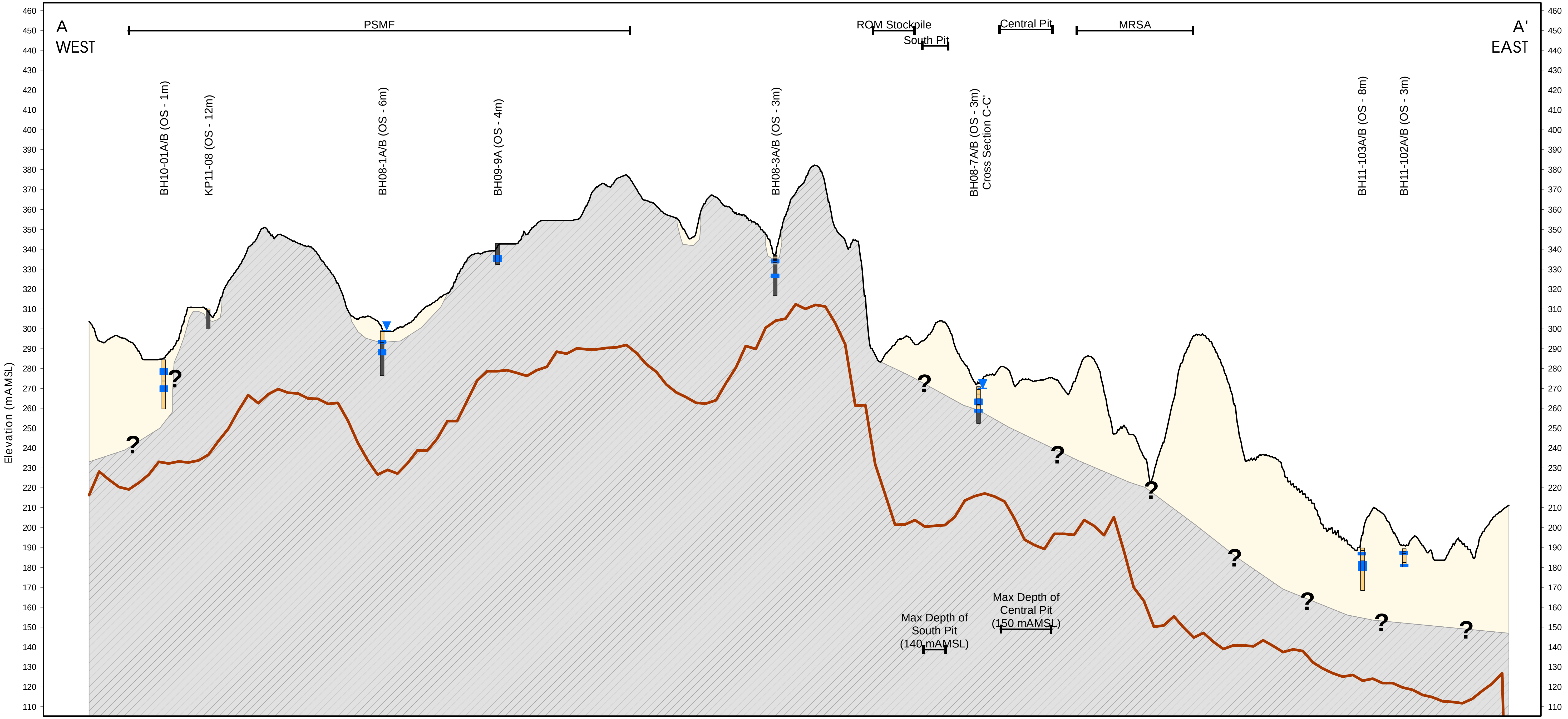
Project Location
Marathon

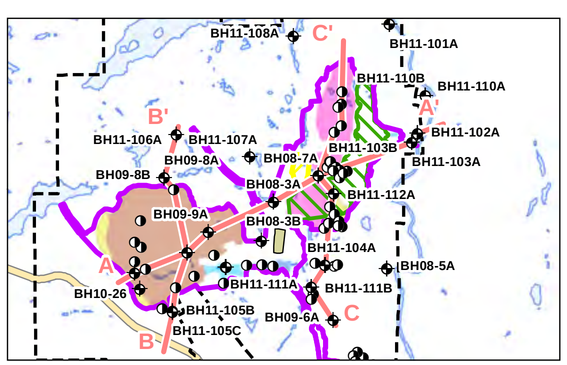
129673006 REVA
Prepared by DH on 2021-01-17

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
2

Title
Groundwater Monitoring Network





Notes
1.

Well ID (Offset)

MW1-15 (OS m)

Sand

Stratigraphy

Water Level

Well Screen

Well Lithology

Overburden

Bedrock

Description

Lower Boundary of Layer 1 in Groundwater Flow Model

10x Vertical Exaggeration

0 390 780 metres

1:20,000 (At original document size of 11x17)

Stantec

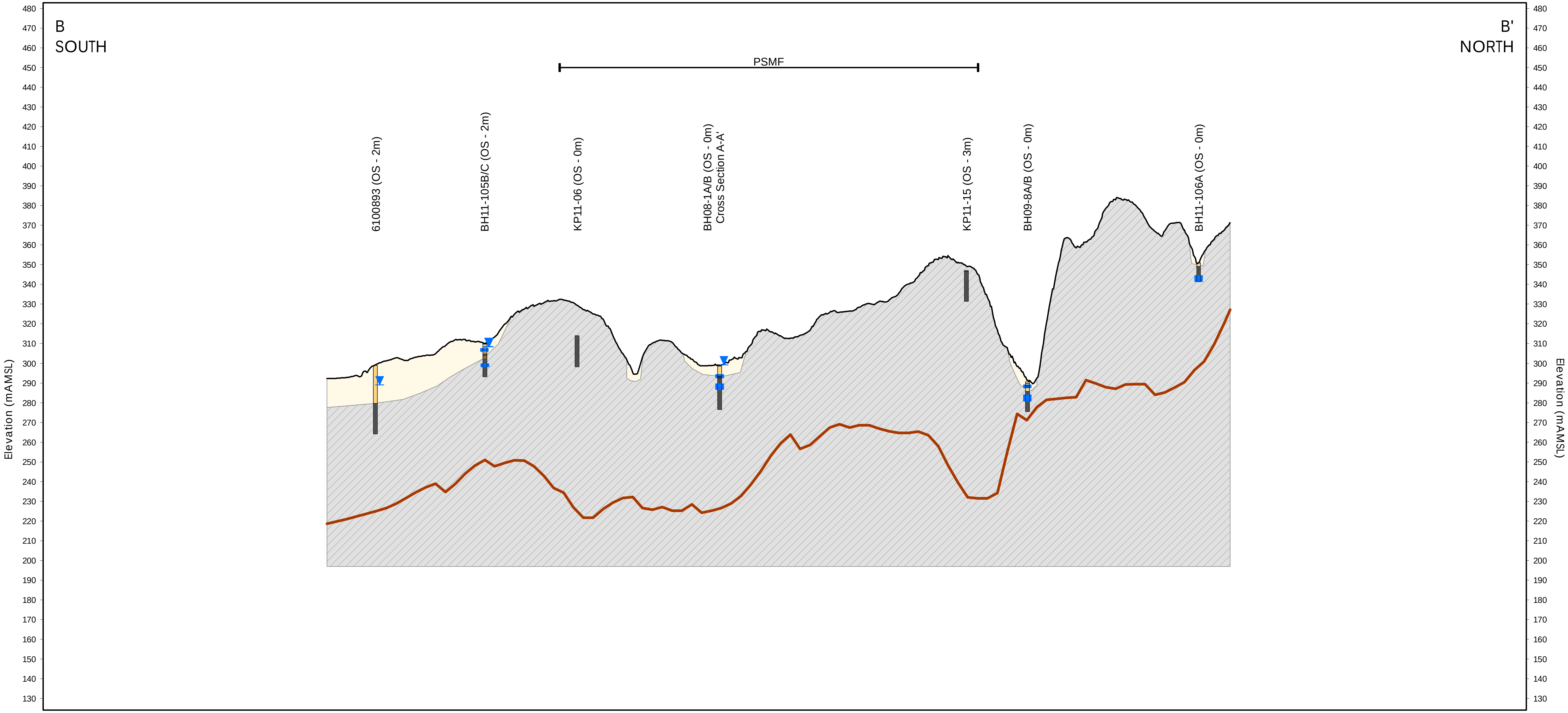
Project Location
Marathon

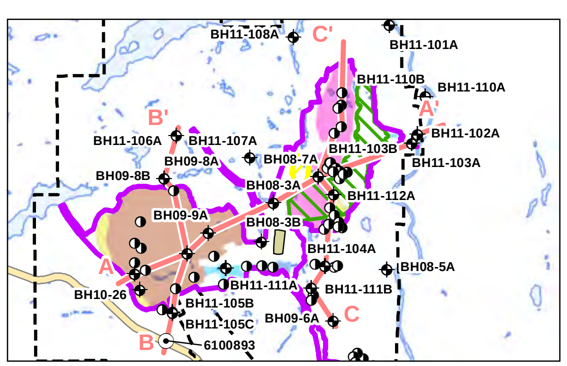
129673006 REVA
Prepared by dharvey on 2021-01-19
Technical Review by KML on 2017-06-21

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
3

Title
Cross-Section A-A'





Notes
1.

MW1-15 (OS m)

Well ID (Offset)

Sand Stratigraphy

Water Level

Well Screen

Well Lithology

Overburden

Bedrock

Lower Boundary of Layer 1 in Groundwater Flow Model

Overburden

Bedrock

10x Vertical Exaggeration

0 390 780 metres

1:20,000 (At original document size of 11x17)

Stantec

Project Location
Marathon

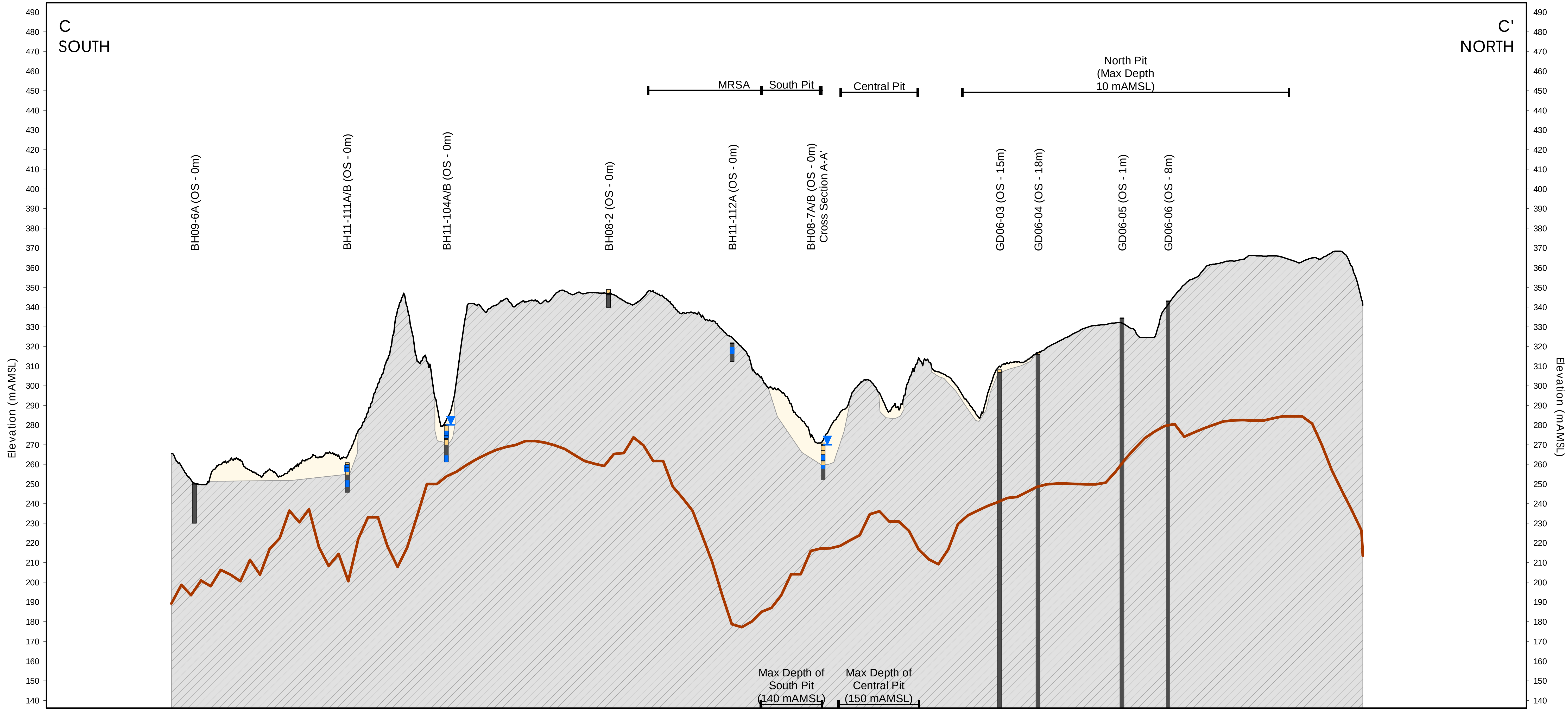
129673006 REVA
Prepared by dharvey on 2021-01-19
Technical Review by KML on 2017-06-21

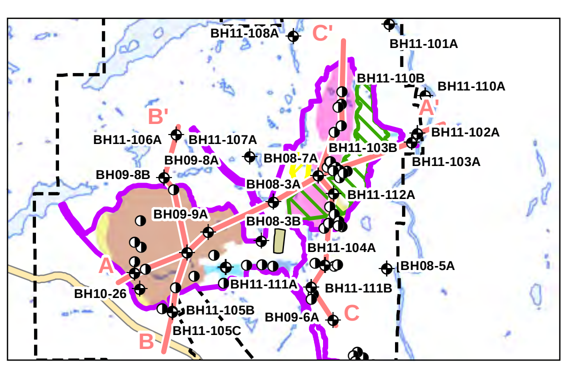
Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
4

Title
Cross-Section B-B'

Revised: 2021-01-19 By: dharvey





Notes
1.

MW1-15 (OS m)

Well ID (Offset)

Sand

Stratigraphy

Water Level

Well Screen

Well Lithology

Overburden

Bedrock

Description

Lower Boundary of Layer 1 in Groundwater Flow Model

Overburden

Bedrock

10x Vertical Exaggeration

0 390 780 metres

1:20,000 (At original document size of 11x17)

Stantec

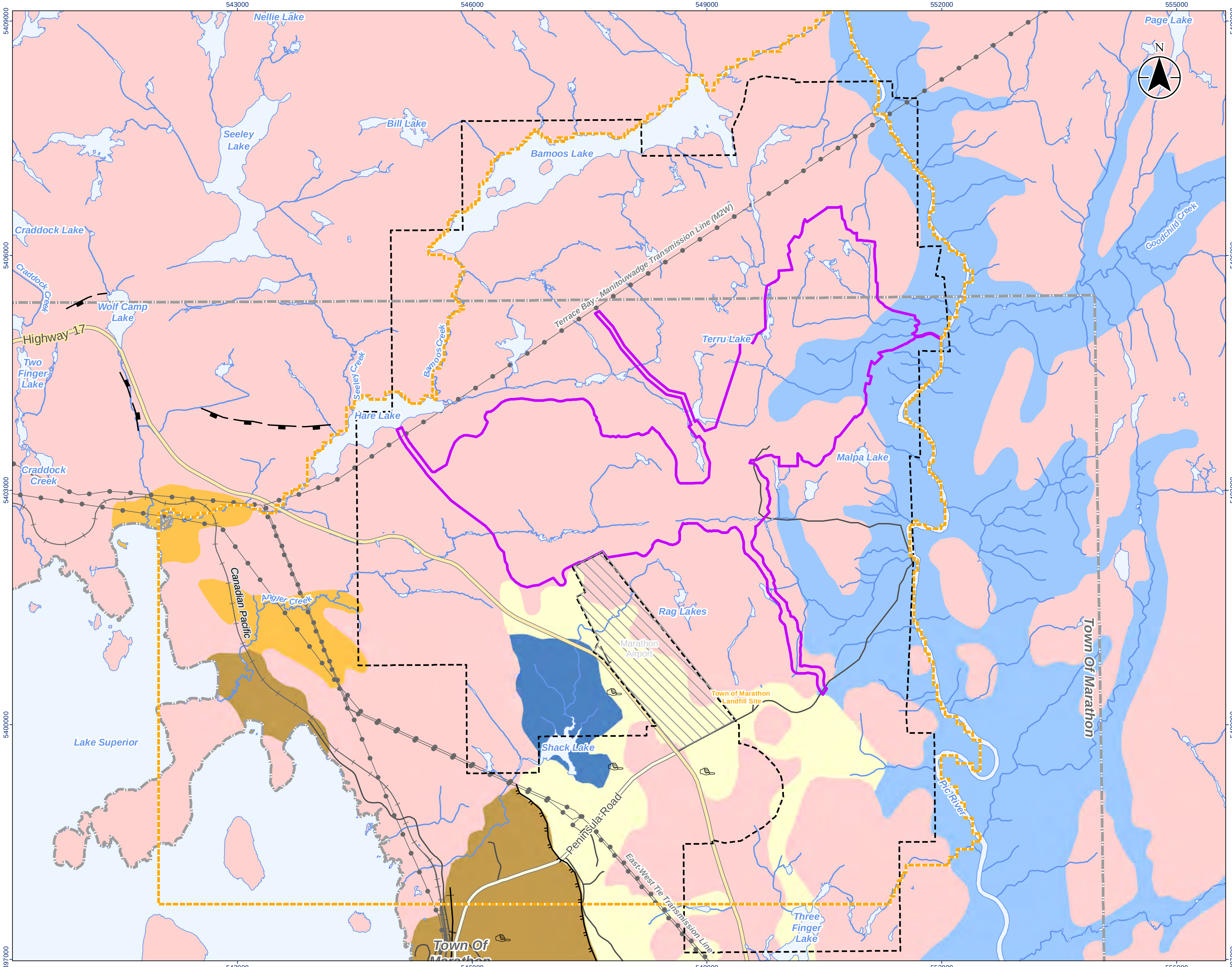
Project Location
Marathon

129673006 REVA
Prepared by dharvey on 2021-01-19
Technical Review by KML on 2017-06-21

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
5

Title
Cross-Section C-C'



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody
- Sand/ Gravel Pit
- Abandoned Shoreline
- Escarpment
- Steep-Walled Valleys
- Ice contact delta
- Outwash plain
- Raised beach
- Glaciolacustrine delta
- Glaciolacustrine plain
- Bedrock knob (with discontinuous drift veneer)

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. Surficial Geology mapping provided by the Ontario Ministry of Energy, Northern Development and Mines as part of the Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS) MRD 160.

Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-13

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
6

Title
Surficial Geology

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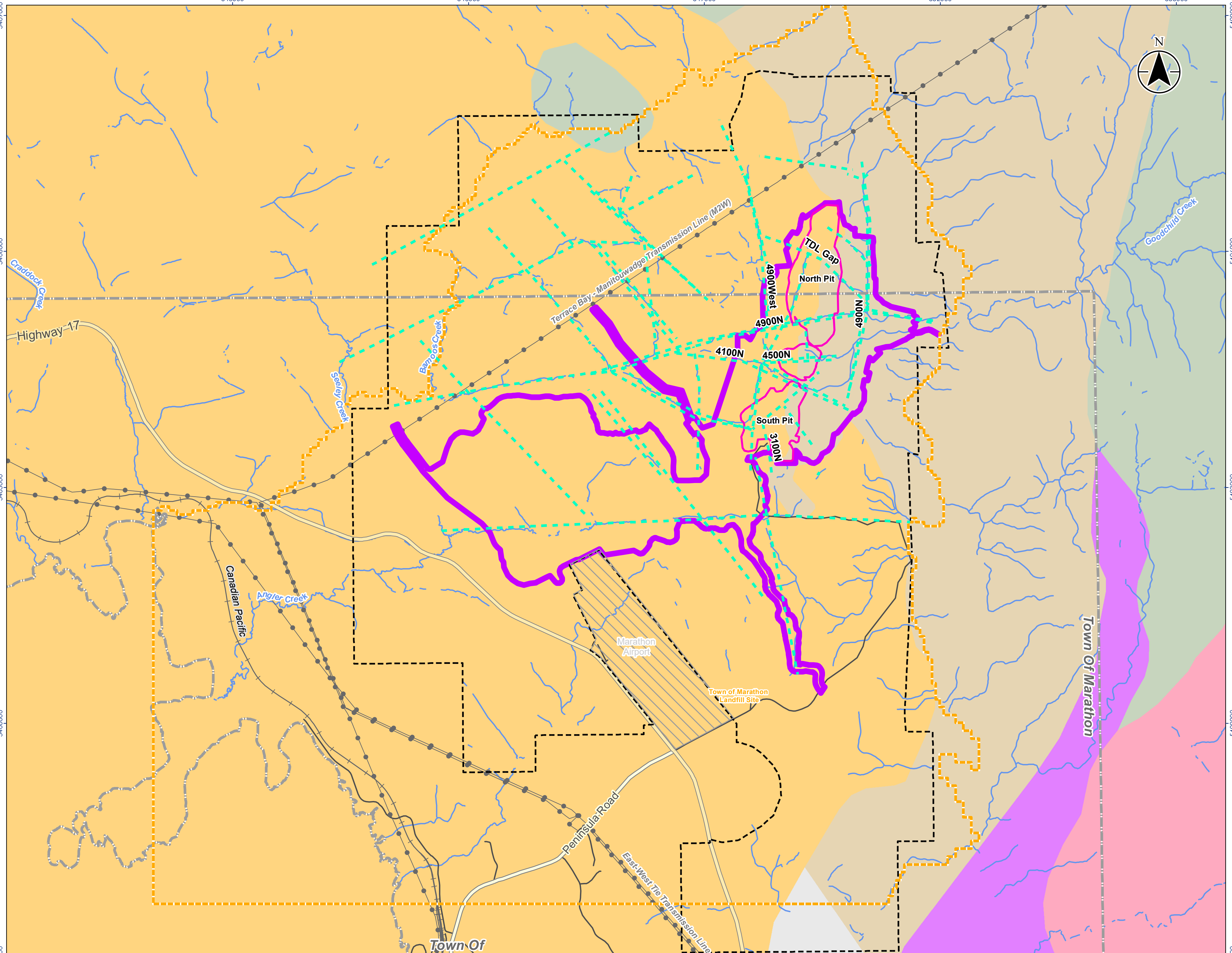
V:\01609\active_Other_PCs_Active\1296_Manitoba\129673006 Marathon PGM\gis_cad\gis\mxds\Groundwater\report_figures\GW_Impact_Assessment\129673006_IA_GW_Fig06_SurficialGeology.mxd Revised: 2021-01-13 By: dharvey



Stantec

Legend

- Regional / Local Study Area (Groundwater)
- Project Boundary (MLAS, MENDM Changed 2017)
- Site Study Area Boundary
- Open Pit
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Lineaments

Bedrock Geology

- 35: Alkalic intrusive suite and carbonatite (circa 1.1 to 1.2 Ga): alkalic syenite, ijolite, nepheline syenite, fenite, associated mafic and ultramafic rocks, and minor carbonatite
- 32: Osler Gp., Mamainse Point Fm., Michipicoten Island Fm.
- 15: Massive granodiorite to granite: massive to foliated granodiorite to granite
- 7a: Wacke, siltstone, arkose
- 6: Felsic to intermediate metavolcanic rocksgt: rhyolitic, rhyodacitic, dacitic and andesitic flows, tuffs and breccias, chert, iron formation, minor metasedimentary and intrusive rocks; related migmatites
- 6a: Dacitic and andesitic flows, tuffs and breccias
- 5: Mafic to intermediate metavolcanic rocksgt: basaltic and andesitic flows, tuffs and breccias, chert, iron formation, minor metasedimentary and intrusive rocks, related migmatites

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. Bedrock Geology provided by the Ontario Ministry of Energy, Northern Development and Mines as part of the Ontario Geological Survey MRD 126.
4. Lineaments based on Information Request 9.1.1

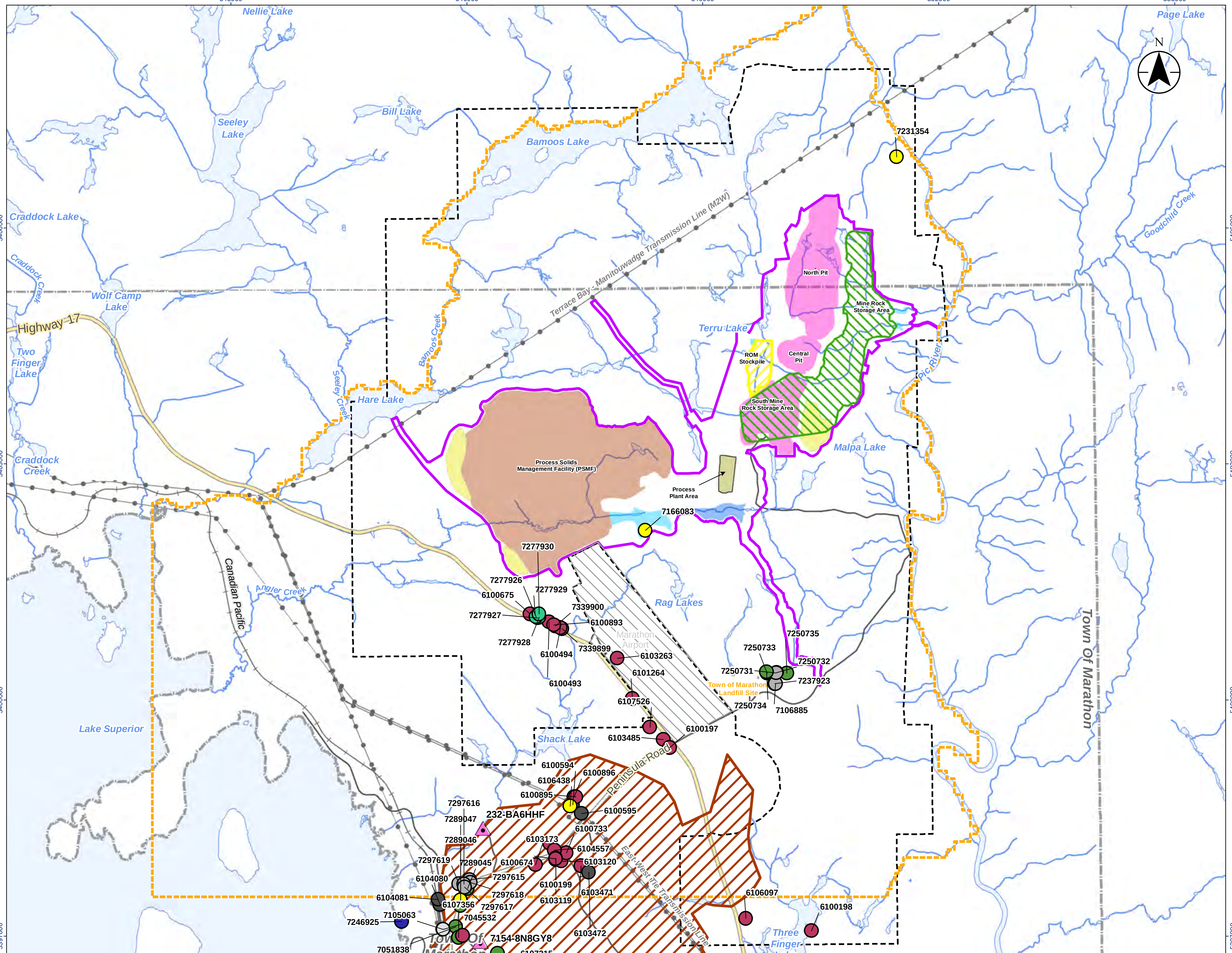
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-03-12

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
7

Title
Bedrock Geology



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Town of Marathon Groundwater Protection Zone
- Waterbody
- Permit to Take Water (MECP)

Water Well Records (Final Status, MECP)

- Abandoned Monitoring and Test Hole
- Abandoned-Other
- Abandoned-Quality
- Abandoned-Supply
- Monitoring and Test Hole
- Observation Wells
- Test Hole
- Water Supply
- Unknown

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1927 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.

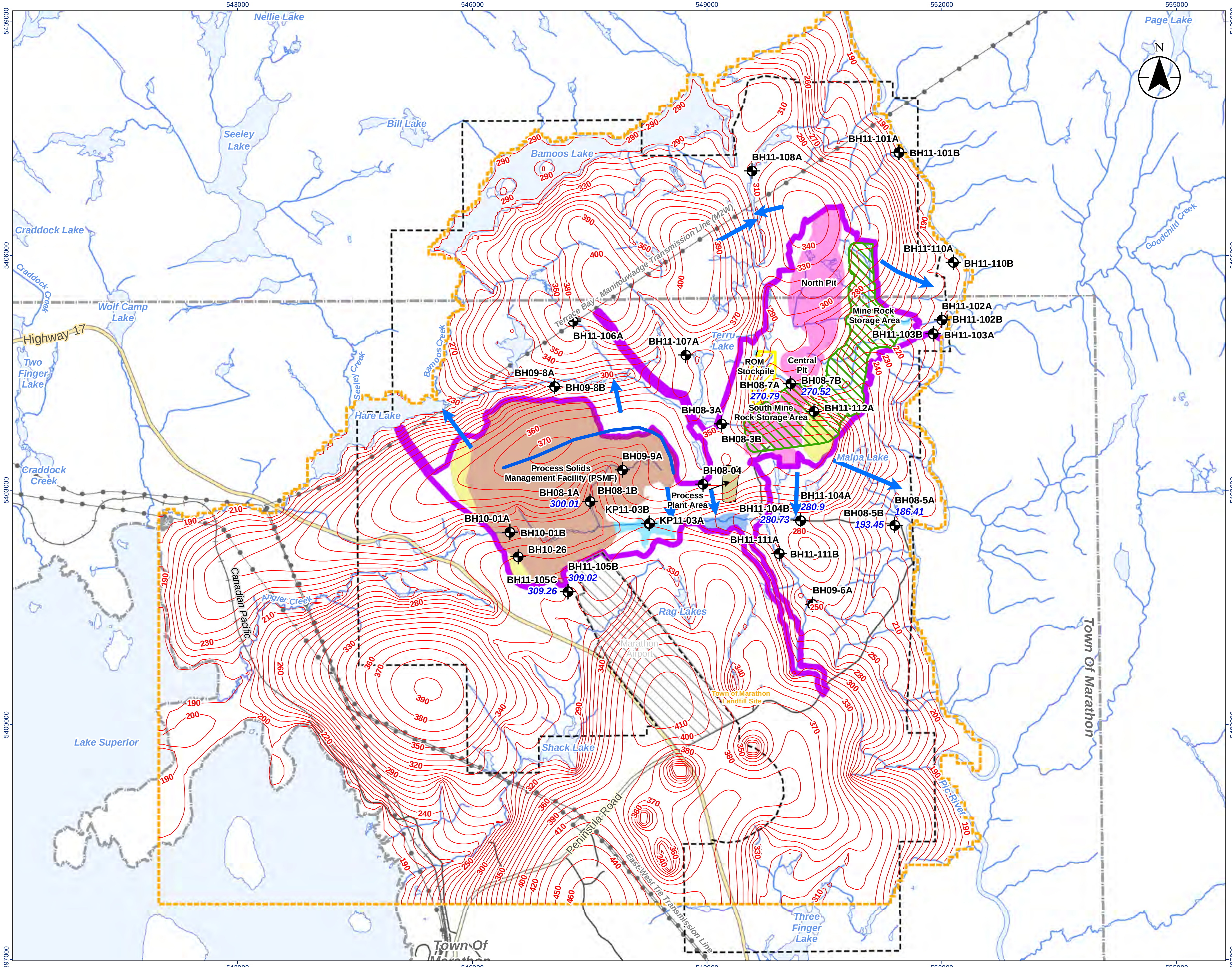
Project Location Marathon

129673006 REVA
Prepared by DH on 2021-01-18

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
8

Title
Groundwater Use (MECP WWR and PTTW)



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Stantec

N

Legend

- Regional / Local Assessment Area (Groundwater)
- Monitoring Well Location
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Modeled Groundwater Contour (m AMSL)
- Groundwater Flow Divide
- Groundwater Flow Direction
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody
- 186.41 Groundwater Elevation (m AMSL, June 2020)

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
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3. Groundwater elevations are in m asl.

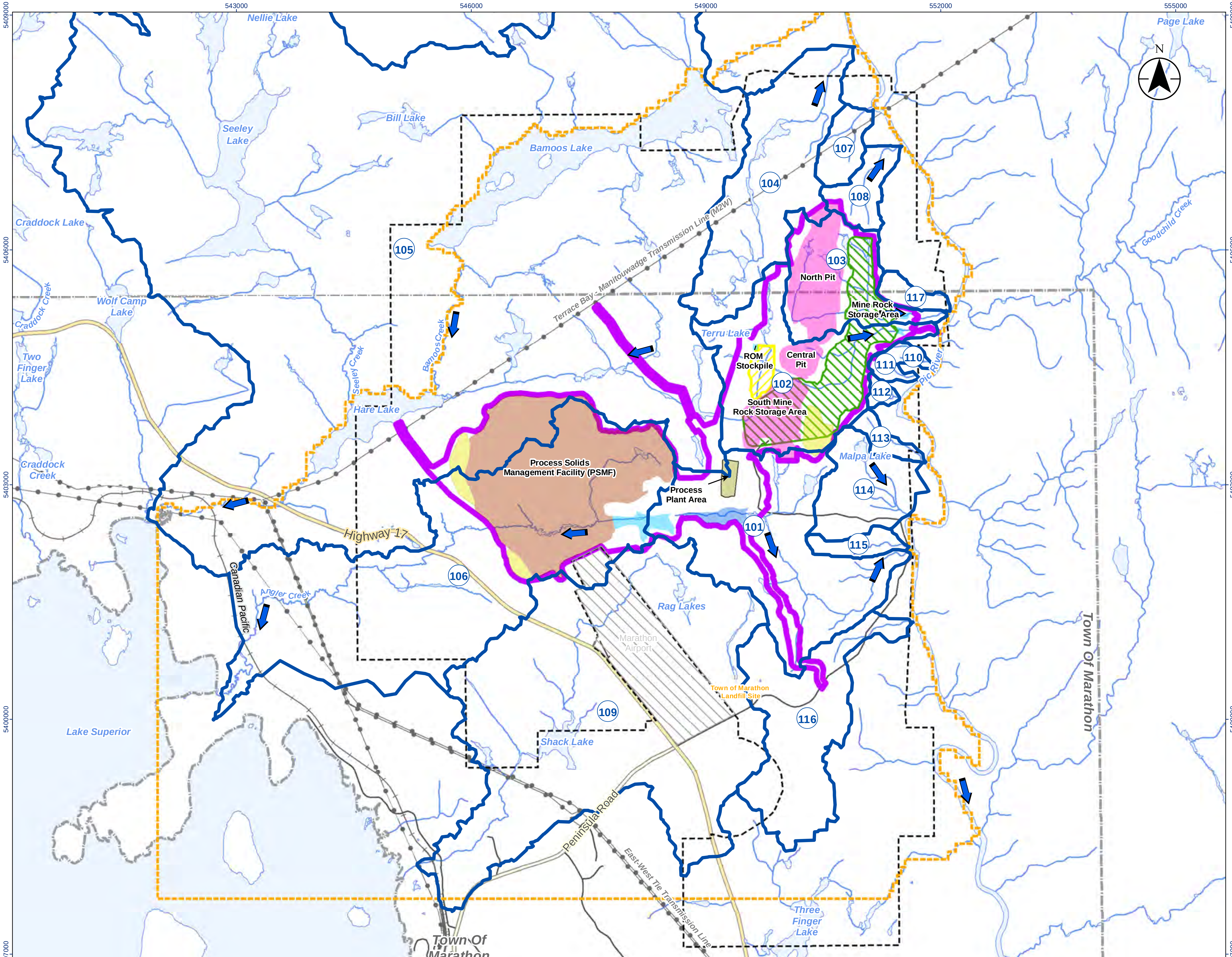
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-17

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
9

Title
Predicted and Measured Groundwater Elevations - Baseline Conditions



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Surface Water Flow Direction
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody
- Watershed Boundary

Mine Plan Polygons

- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond
- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.

Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-14

Client/Project
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MARATHON PALLADIUM PROJECT

Figure No.
10

Title
Watershed Boundaries

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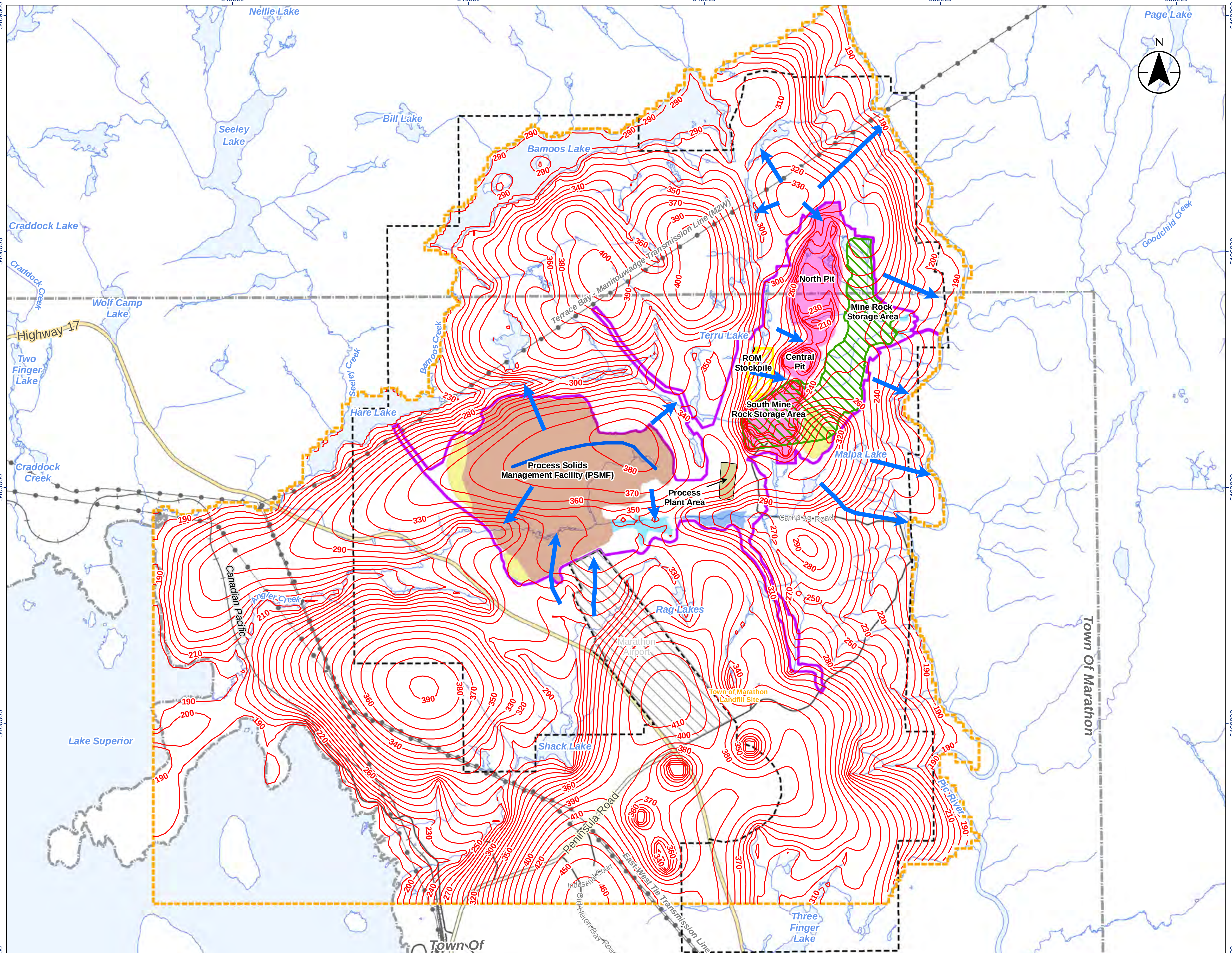
V:\01609\active\...\129673006_IA_GW_Fig10_WatershedBoundaries.mxd Revised: 2021-01-14 By: dharvey



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Modeled Groundwater Contour (m AMSL)
- Groundwater Flow Divide
- Groundwater Flow Direction
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. Groundwater elevations are in m asl.
4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

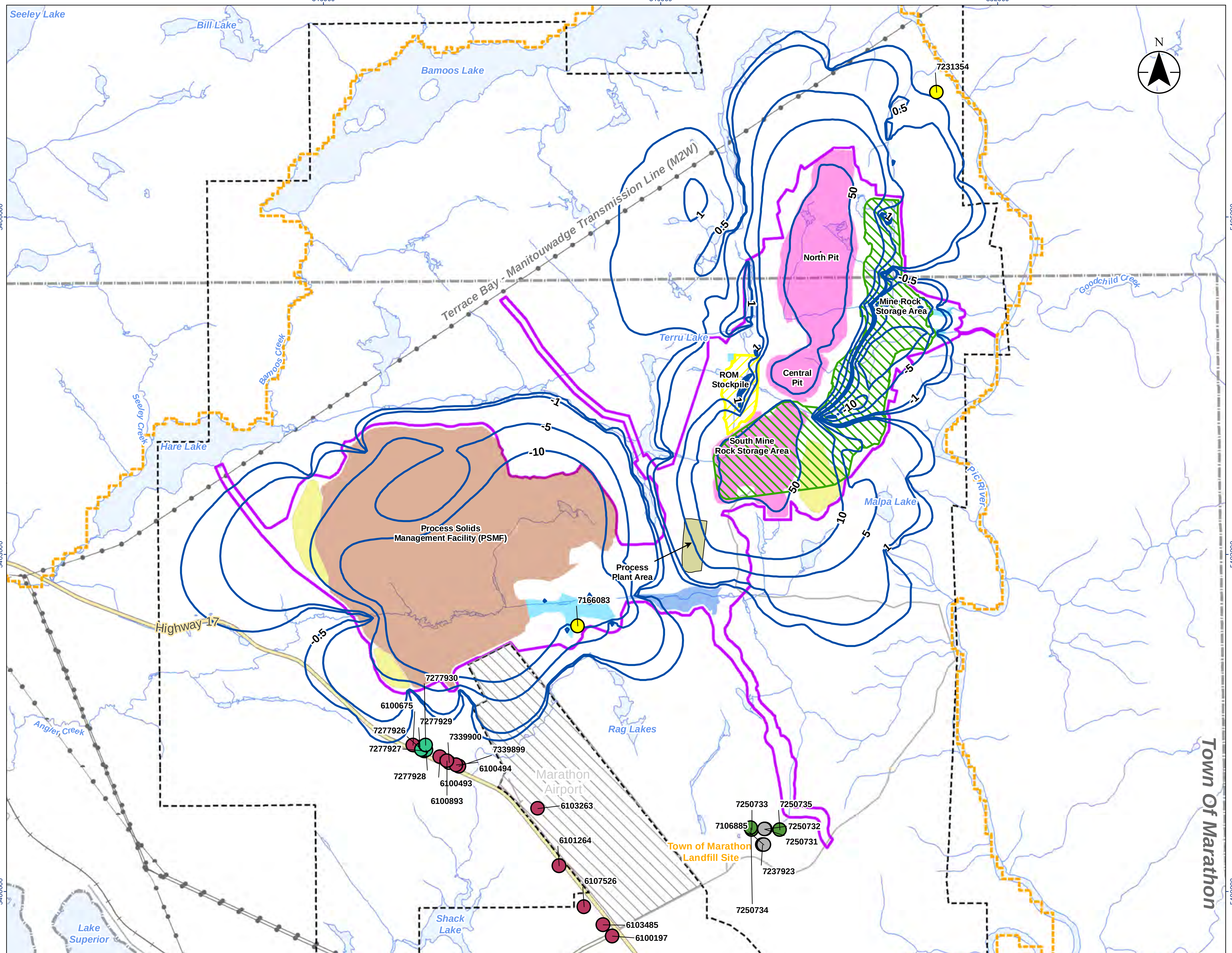
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-14

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
11

Title
Predicted Water Table Elevation Contours at End of Operation



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Groundwater Drawdown Contours [3]
- Highway
- Major Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Water Well Records (Final Status, MECP)

- Abandoned-Other
- Monitoring and Test Hole
- Observation Wells
- Water Supply
- Unknown

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:35,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. Groundwater drawdown is displayed in metres below surface.
4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

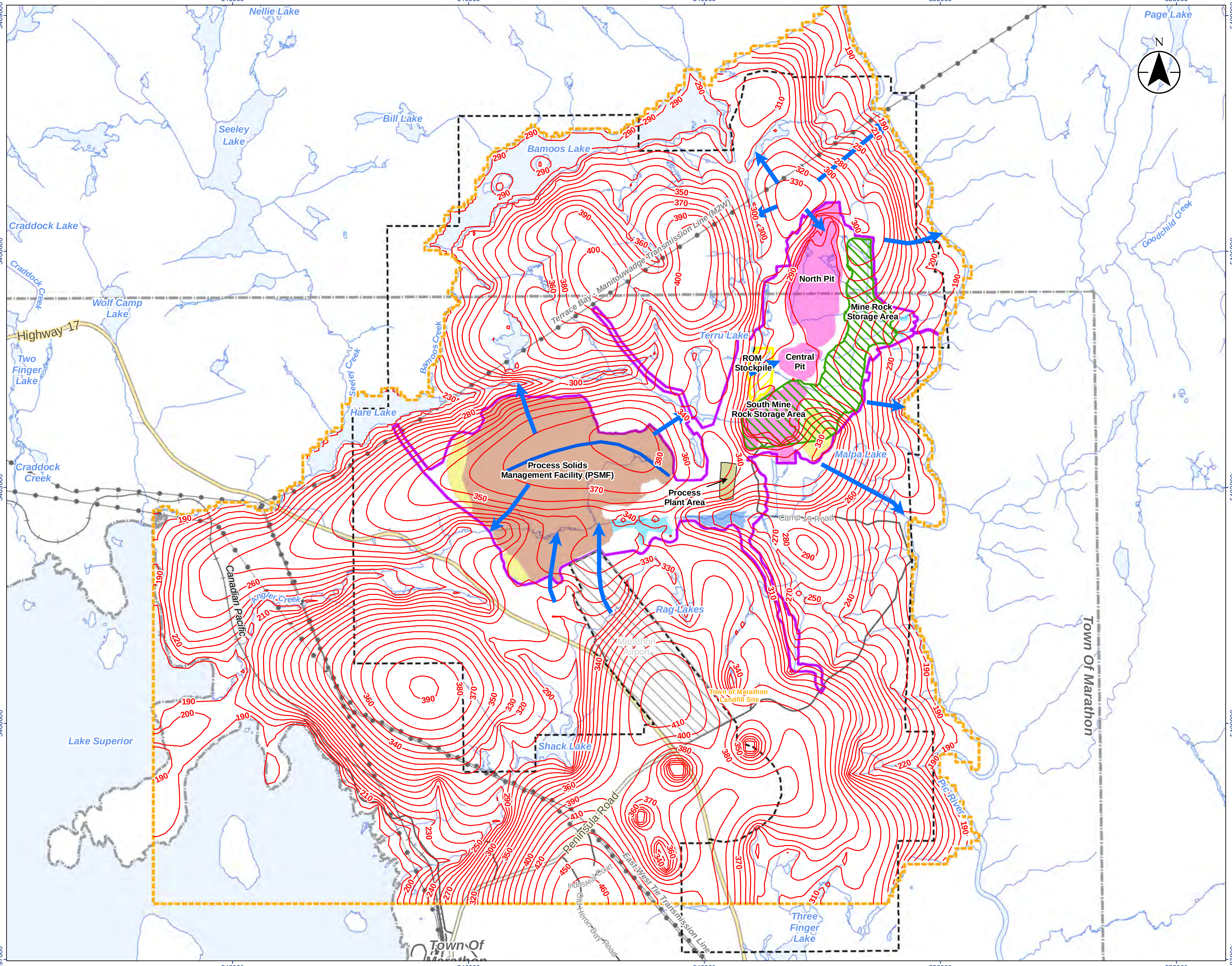
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-18

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
12

Title
Simulated Water Table Drawdown at End of Operation



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Modeled Groundwater Contour (m AMSL)
- Groundwater Flow Divide
- Groundwater Flow Direction
- Highway
- Major Road
- Minor Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:50,000 (At original document size of 11x17)

Notes
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4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

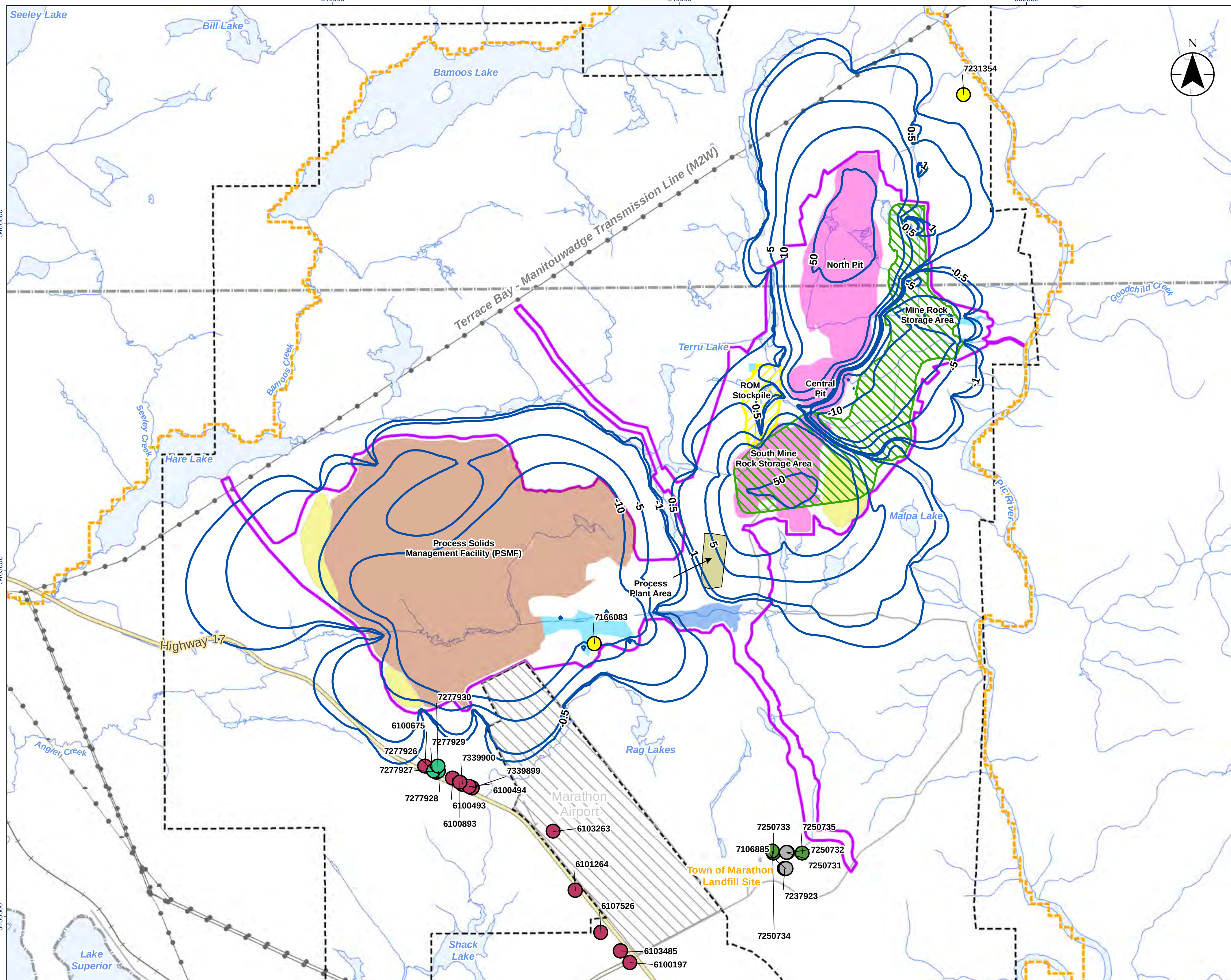
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-14

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
13

Title
Predicted Water Table Elevation Contours at Post Closure (Pit Lakes)



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Groundwater Drawdown Contours [3]
- Highway
- Major Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Water Well Records (Final Status, MECP)

- Abandoned-Other
- Monitoring and Test Hole
- Observation Wells
- Water Supply
- Unknown

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:35,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
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3. Groundwater drawdown is displayed in metres below surface.
4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

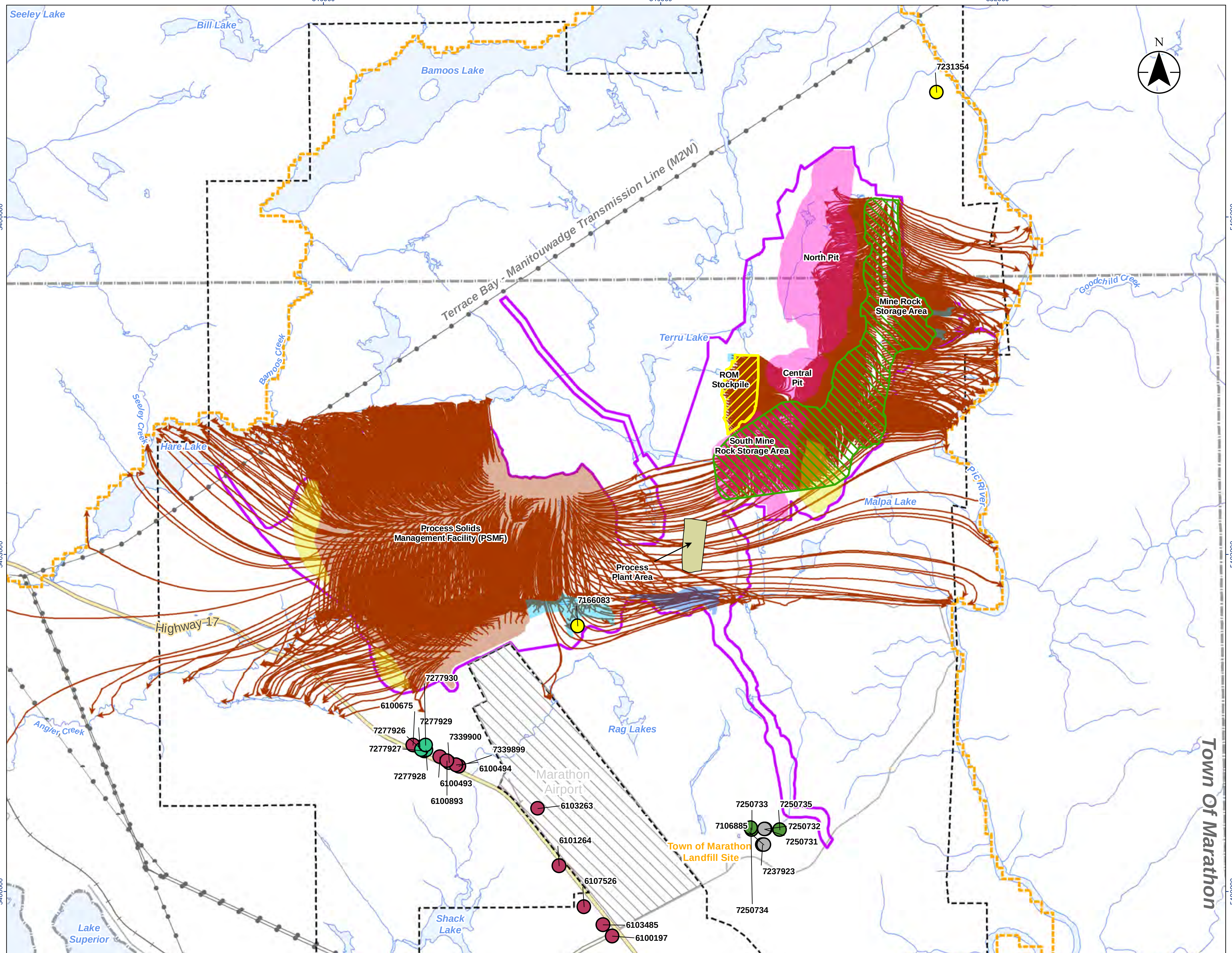
Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-18

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
14

Title
Simulated Water Table Drawdown at Post Closure (Pit Lakes)



Stantec

Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Particle Traces
- Highway
- Major Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Water Well Records (Final Status, MECP)

- Abandoned-Other
- Monitoring and Test Hole
- Observation Wells
- Water Supply
- Unknown

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:35,000 (At original document size of 11x17)

Notes

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2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2018.
3. Groundwater drawdown is displayed in metres below surface.
4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

Project Location
Marathon

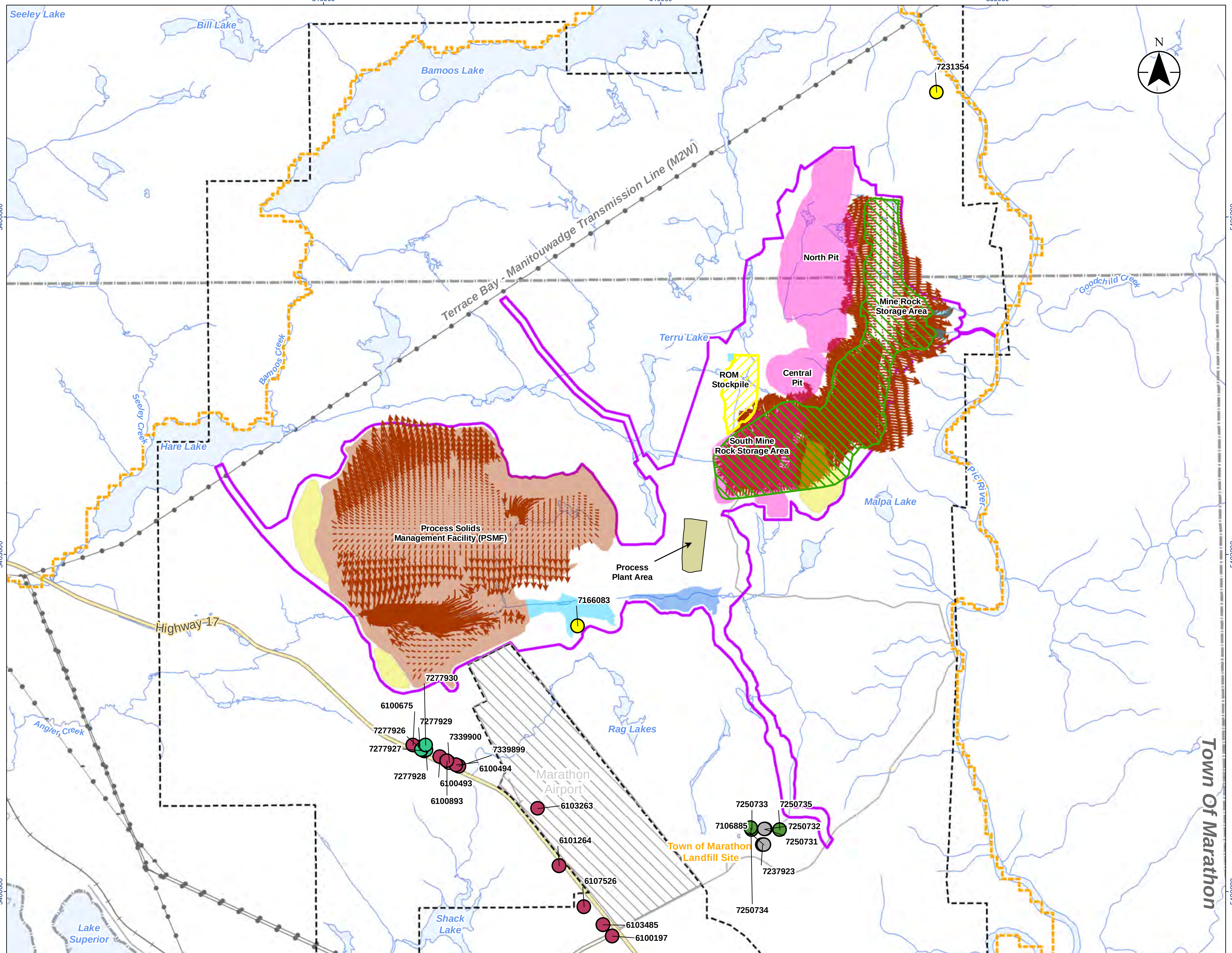
129673006 REVA
Prepared by DH on 2021-01-18

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
15

Title
Particle Traces from Stockpiles, PSMF, and Water Management Pond to Open Pit and Receiving Environment Under Dewatering Conditions (Year 12)

Revised: 2021-01-18 By: dharvey



Legend

- Regional / Local Assessment Area (Groundwater)
- Approximate Limit of Surface Rights (current and/ or planned)
- Site Study Area Boundary
- Particle Traces
- Highway
- Major Road
- Hydro Line
- Railway
- Watercourse
- Airport
- Municipal Boundary, Lower Tier
- Waterbody

Water Well Records (Final Status, MECP)

- Abandoned-Other
- Monitoring and Test Hole
- Observation Wells
- Water Supply
- Unknown

Proposed Mine Features

- Mine Rock Storage Area (MRSA)
- Process Plant Area
- ROM Stockpile
- Stormwater Management Pond
- Open Pit
- Overburden Stockpile
- Process Soilds Management Facility (PSMF)
- Water Management Pond

0 1 2 km

1:35,000 (At original document size of 11x17)

Notes
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3. Groundwater drawdown is displayed in metres below surface.
4. The proposed mine features depicted on this drawing are intended to represent a generalized and conceptual overview of the major mine components at the end of operations stage of mine life.

Project Location
Marathon

129673006 REVA
Prepared by DH on 2021-01-18

Client/Project
GENERATION PGM INC.
MARATHON PALLADIUM PROJECT

Figure No.
16

Title
Particle Traces from Stockpiles, PSMF, and Water Management Pond to Open Pit and Receiving Environment at Post Closure (Pit Lakes)