TABLE OF CONTENTS
SECTION 6

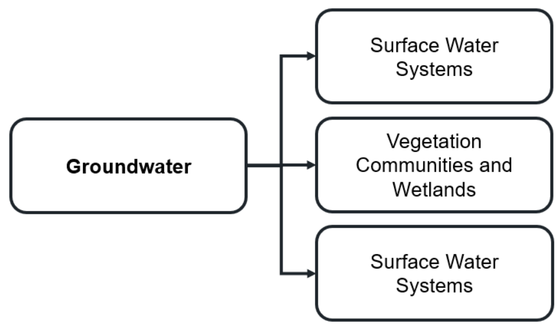
LIST OF TABLES

LIST OF FIGURES

6.5 Groundwater

Groundwater has been included as a valued component (VC) because it is directly linked to other components of the aquatic ecosystem including surface hydrology, surface water quality. The Project is remote and there are no groundwater wells within the Project Development Area (PDA) and Local Study Area (LSA) that are used as a source of drinking water that could be affected by the Project. Further, there are no known groundwater sources of potable water in the in the Project footprint. The closest well to the PDA is 3.6 kilometres (km) from the transmission line, located at the Slate Falls airport. Potential effects to groundwater, including potential changes in groundwater quantity and quality, are evaluated herein as a pathway to effects of the Project on other VCs.

In the absence of mitigation, the assessment of potential changes in groundwater are directly linked to other VCs, and informs the analysis of the following sections:



- **Surface Water (Sections 6.6, 6.7, 6.8 and 6.9):** the assessment of the potential effects in surface water systems includes changes in surface water quality and quantity during all phases of the Project which may be affected by changes in groundwater quality and quantity.
- **Vegetation Communities and Wetlands (Section 6.11):** the assessment of potential effects in vegetation communities and wetlands during the construction and operation phases of the Project may be affected by changes in groundwater levels for vegetation communities and wetlands proximate to the Project.
- **Traditional Land and Resource Use (Section 6.21):** the assessment of potential effects traditional land and resource use during the construction and operation phases of the Project, specifically local water springs may be affected by changes in groundwater.

The assessment of the potential changes in groundwater from the Project are compared to relevant provincial and federal criteria (Section 6.5.1.4). The hydrogeology technical support documentation is included in Appendix L, which includes baseline hydrogeology data (Appendix L-1) and the hydrogeology modelling results (Appendix L-2).

6.5.1 Assessment Approach

The approach to the assessment of potential effects on groundwater includes a description of the relevant regulatory and policy setting, a description of the input obtained through consultation specific to this VC, the identification of criteria and indicators along with the associated rationale, a description of the spatial and temporal boundaries used for this VC along with a description of the attributes used to determine the significance of any residual, adverse effects. The assessment of potential effects is supported by a description of the existing conditions for the VC (Section 6.5.2), the identification and description of applicable pathways of potential effects on the VC (Section 6.5.3) and a description of applicable mitigation measures for the VC (Section 6.5.4). An outline of the analytical methodology conducted for the assessment and the key assumptions and/or conservative approach is found in Section 6.5.5.3. With the application of mitigation measures to the potential effects on the VC, the residual effects are then characterized in Section 6.5.6 and the significance of the residual effects is determined in Section 6.5.7.

6.5.1.1 Regulatory and Policy Setting

The effects assessment for groundwater has been prepared in accordance with the requirements of the federal Environmental Impact Statement (EIS) Guidelines (Appendix B-1) and the provincial approved Amended Terms of Reference (ToR; Appendix B-3). Concordance tables, indicating where EIS Guidelines and ToR requirements have been addressed, are provided in Appendix B-2 and B-5, respectively.

As the Project is located in the Province of Ontario, it will need to meet applicable federal and provincial legislation and regulatory requirements; further information regarding anticipated approval requirements is provided in Section 11. Government policies, objectives, standards or guidelines most relevant to the groundwater VC are summarized below.

Mining Act

The *Mining Act*, as amended by the *Building More Mines Act*, and Ontario Regulation 35/24 (O. Reg. 35/24), 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. 35/24.

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 Ministry of the Environment, Conservation and Parks (MECP), the OWRA contains several important regulations that protect water resources, including the Water Taking and Transfer Regulation (O. Reg. 387/04), which specifies requirements and triggers for approval of surface or groundwater takings for various purposes.

Water Quality Guidelines

Water Quality Guidelines (WQG) are numeric or narrative criteria that are developed by governments or international organizations to identify the concentrations of parameters (milligrams per litre; mg/L) in water that are protective of the various water users or receptors, including aquatic life, wildlife, livestock/agriculture and drinking water. WQG are utilized for benchmarking and assessing potential changes to water quality.

Groundwater quality is benchmarked against surface water quality guidelines for the protection of aquatic life. Further, aquatic life criteria are generally the most stringent (relative to agriculture or drinking water receptors); note, aquatic life criteria are not directly applicable to groundwater quality and are used for benchmarking purposes only.

6.5.1.2 Influence of Consultation with Indigenous communities, Government and the Public

Consultation has been ongoing for several years prior to and throughout the environmental assessment process, and will continue with government agencies, Indigenous communities, and the public through the life of the Project. Section 2 provides more detail on the extensive consultation process. The Record of Consultation (Appendix D) includes detailed comments received during the development of the final EIS/EA.

Feedback received through consultation has been addressed through direct responses (in writing and follow up meetings) and incorporated into the final EIS/EA, as appropriate. The key comments that influenced the effects assessment for groundwater between the draft and final EIS/EA is provided below:

Baseline Groundwater Data

In response to comments received from the MECP, Impact Assessment Agency of Canada (IAAC), Northwestern Ontario Métis Community (NWOMC), Cat Lake First Nation (CLFN), Lac Seul First Nation (LSFN), Slate Falls Nation (SFN) and Mishkeegogamang Ojibway Nation (MON), groundwater baseline data was supplemented, resulting in a higher degree of confidence for the environmental assessment predictions. Supplemental data collected included:

- Water level monitoring and hydraulic test data from 15 additional screened monitoring well installations;
- Vibrating wire installations at ten new locations, and water level monitoring from 26 monitoring ports equipped with dataloggers;
- Automated pressure transducers monitoring groundwater level fluctuations in 25 monitoring wells;
- Packer testing at new drillhole locations, including 71 new unique measurements;
- Hydraulic testing in 29 pre-existing monitoring well installations;
- Additional stratigraphic boreholes and test pits from 2021 and 2022 investigations;
- Bedrock outcropping mapping information from historical surveys; and,
- Additional quarterly groundwater quality data from 2021, 2022 and 2023.

The results of these studies are discussed below under Existing Conditions (Section 6.5.2) with additional details included in the Baseline Hydrogeology Report (Appendix L-1).

CLFN and LSFN requested further information on the long-term monitoring and additional monitoring wells for the deep groundwater system. An investigation program was undertaken at site to provide additional hydrogeological characterization of the deep bedrock flow system. This investigation program included drilling and packer testing of additional deep bedrock boreholes; and multi-level vibrating wire piezometer (VWP) installations (equipped with data loggers to allow for ongoing water level monitoring) in five deeper bedrock boreholes. The deep groundwater system is not a large contributor of either flow into the open pit or a pathway for seepage, as the fracture networks at depths have very limited connectivity and neither transport nor store significant quantities of groundwater. This is further discussed in the Baseline Hydrogeology Report (Appendix L-1, Section 5.2.2) of the EIS/EA.

CLFN, LSFN and MECP requested further information on the additional monitoring wells, including borehole logs and monitoring well details that have been installed since 2021. The Baseline Hydrogeology Report (Appendix L-1, Appendix A) includes an updated compilation of borehole logs that contain geological descriptions, and borehole logs for installations since 2019. Numerous borings, hydraulic test locations, and groundwater monitoring installations have been located within or directly adjacent to the proposed CDF footprint, including shallow bedrock conductivity testing inside and around of the proposed footprint of the CDF.

IAAC requested confirmation that the porphyry bedrock does not extend beyond the Portage Zone for the groundwater modelling, and the extent of high hydraulic conductivity in a simulated sensitivity variant. Since release of the draft EIS/EA, additional information has been collected and the bedrock hydrostratigraphy model for the site has been updated in the Baseline Hydrogeology Report (Appendix L-1). The data, along field investigation completed in 2022 including packer testing in boreholes, has been used to inform the hydrogeological modelling (Appendix L-2, Section 3.2.1 and Figure 3.2-2). The hydraulic conductivity reported hydraulic conductivity results that were typical of competent bedrock.

CLFN and LSFN requested clarification on the method used to determine hydraulic conductivity for overburden and bedrock. Hydraulic conductivity estimates obtained through falling head testing of the 12 piezometer installations provided in Appendix A (Table 2.3) to the baseline hydrogeology report of the draft EIS/EA, are reliable and are carried forward in the main baseline hydrogeology report (Appendix L-1 of the draft EIS/EA). The data is further discussed in detail in the Baseline Hydrogeology Report (Appendix L-1, Section 5.2) and the Hydrogeological Modeling Report (Appendix L-2, Section 3.2).

Further, CLFN and LSFN requested hydraulic conductivity analysis graphs to present the results of curve matching. Hydraulic conductivity estimates were obtained from falling head tests conducted in monitoring wells which were installed within boreholes. Hydraulic conductivity estimates were made using Bouwer Rice method however curve matching plots of the falling head test data are not available. However, the results from the hydraulic tests in site monitoring wells (and packer tests) are presented in the Baseline Hydrogeology Report (Appendix L-1, Section 5.2).

IAAC requested the rationale for the values and conclusions presented for hydraulic conductivity of bedrock. Hydraulic testing has continued since the preparation of the draft EIS/EA. The Baseline Hydrogeology Report (Appendix L-1, Section 5.2) in the EIS/EA has been revised to incorporate the most updated data / information and includes the rationale to explain the selection of hydraulic conductivity.

IAAC and MECP requested confirmation whether the structural features extend into metavolcanic and metasedimentary rocks, and whether they impart a higher hydraulic conductivity to these rocks. Further, IAAC requested confirmation of whether any of the other modelled or known faults intersect project infrastructure or the isthmus between Springpole and Birch lakes. Additional information has continued to be collected since the draft EIS/EA, and the bedrock hydrostratigraphy model for the site has been included in the Baseline Hydrogeology Report (Appendix L-1, Section 5.1.1). The data shows that a zone of unconsolidated granular material (i.e., the zone of highly altered/disintegrated rock; 'UGM') associated with the ore zone is surrounded by / adjacent to a zone of low RQD rock (together previously identified as the Portage Zone). These zones are surrounded by a more competent country/host rock. The UGM zone and low RQD zone would have a more substantial effect on groundwater flows around the pit than local structures, given their comparative volume, although the east-west trending structures may have some influence on interaction of the CDF with the open pit. These structures are planned to be tested in future programs as part of ongoing project engineering. As overburden is removed from the pit slopes during pit development and these structures are potentially exposed, a grouting program may be employed to seal these surficial expressions. Sensitivity analysis has been conducted to assess the potential effect of these faults and included in the Hydrogeologic Modelling Report (Appendix L-2, Section 7).

CLFN, LSFN and IAAC requested further information on the cross-sections for the geologic and structural and the associated groundwater levels. The cross-sections are shown in Figure 6.5-6 have been produced and included in the Baseline Hydrogeology Report (Appendix L-1, Section 5.1.1). Further, the 3-D hydrostratigraphic model has been updated with additional data collected since the draft EIS/EA and included in the Baseline Hydrogeology and Hydrogeological Modelling Report (Appendix L-2, Section 5.1.2). In addition, updated water level monitoring information, including time series datalogger data, has been provided.

Assessment Methods

IAAC requested the rationale for not requiring a regional study area. The maximum extent of potential effects is restricted to local waterbodies adjacent to the mine site infrastructure that act as hydrogeological boundaries (also corresponding to the modelled the groundwater modelling domain) which is defined as the local study area. As a result, a regional study area is not required to be defined for groundwater. The spatial boundaries discussed below in section 6.5.1.3 includes this clarification.

IAAC requested further information on the pit drawdown to support the assessment of potential effects on fish and fish habitat. Additional groundwater modelling (Appendix L-2) has been completed to support the EIS/EA and shows the area of drawdown into the nearshore areas of Birch Lake to assess habitats potentially affected, in Figure 6.1-2.

Water Quality Criteria

CLFN and LSFN requested clarification on the applicable water quality guideline applicable to groundwater, and MECP requested that groundwater quality be compared to conservative surface water quality standards such as PWQOs, supported where appropriate by Canadian Water Quality Guidelines. The aquatic protection values (APV) were selected as a basis of comparison for groundwater quality predictions in the draft EIS/EA as they are designed specifically for groundwater to provide a scientifically defensible and reasonably conservative level of protection for most aquatic organisms from the migration and discharge of groundwater to surface water. The APVs were applied to the assessment of potential effects on groundwater that ultimately discharges to surface water. However, considering the MECP feedback and traditional land use information provided, the APVs have been replaced in the EIS/EA with surface water quality guidelines for the protection of aquatic life that are used as a conservative benchmark for the assessment of groundwater quality, as described in Section 6.5.1.1 of the EIS/EA.

Pathways of Potential Effects

CLFN and LSFN requested additional clarification on whether aggregate sources will be tested prior to use in Project infrastructure. The proposed aggregate sources will be tested prior to use for the construction of the mine access road. The sources identified in draft EIS/EA are sand and gravel type material similar to that used in forestry road operations in the area and not anticipated to have material ARD potential. The development of the proposed sand and gravel aggregate sources is not planned to be excavated below the water table, and as a result there is no effect pathway on groundwater from this activity. The construction of the mine access road, airstrip and the transmission line are planned to occur during frozen conditions, be above the water table, and will occur within a small area for a very short period of time and will be effectively managed with standard best practices, such as limiting the active construction area to the extent possible, and having erosion and sediment control and spill contingency plans. As a result, there are no effect pathways on groundwater.

IAAC requested a comparison of the predicted groundwater and surface water quality that is impacted by seepage from the CDF with guidelines protective of human health and therefore, the predicted surface water quality has been compared to guidelines protective of human health in the final EIS/EA, as described in the Human and Ecological Risk Modelling Report (Appendix R). Based on traditional knowledge and land use information, the groundwater pathway was excluded for human health, as groundwater use has not been identified in proximity to the CDF.

MECP commented that surface water quality can be affected by mine rock and tailings due to seepage. Section 6.5.4 of the EIS/EA and Section 4.6 of Appendix V-1 include the CDF design measures addressing seepage mitigation. Section 6.5.6 of the EIS/EA includes an assessment of seepage from the co-disposal facility (CDF) and ore stockpiles, and the results are carried forward into the assessment of surface water quality in Birch Lake (Section 6.6), and the north basin of Springpole Lake (Section 6.7). With the implementation of proposed mitigation measures, including tailings and mine rock management, highly favourable CDF foundation conditions, seepage capture with perimeter ditching around the CDF and the ore stockpiles, there are no exceedances of applicable water quality guidelines in the receiver.

Northwest Ontario Métis Community (NWOMC) requested further information on the smaller waterbodies and how they may interact with Métis harvesting. The smaller waterbodies which could be temporarily affected by the mine dewatering are all in close proximity to the mine operations. These smaller waterbodies are typically inhabited by small-bodied fish, which were not identified as fish typically harvested in the NWOMC Traditional Knowledge and Land Use study. A Fish Habitat Offsetting and Compensation Plan (Appendix F) has been developed to offset losses of fish habitat within the affected area and will mitigate changes in harvesting. The Plan includes the reclamation of inland lakes at closure where possible, and the development of new littoral habitat directly connected to Springpole Lake which will benefit both small-bodied and large-bodied fish. The inclusion of habitat measures that will benefit small-bodied fish is described in Section 8 of the revised Fish Habitat Offsetting and Compensation Plan. After mining ends and the site is reclaimed, groundwater levels are predicted to return to pre-mining levels and pre-mining groundwater flow patterns will generally re-establish themselves. Smaller waterbodies that may have experienced changes in groundwater inflow will return to normal.

CLFN requested a description of how the groundwater changes to waterbodies L-1, L-2, L-16 and L-19 may impact the animals, plants, and ecosystems of these smaller lakes, and the incidental impacts to Indigenous rights and interests. This section provides an assessment of the potential effects of the Project on groundwater quantity and quality, and Section 6.6 to 6.9 provide an assessment of the effects on surface water quality and quantity. These assessments are supported by the Hydrogeology Modelling Report (Appendix L-2), the Mine Site Water Balance (Appendix M-2), the Receiver Water Balance (Appendix M-3), the Mine Site Water Quality Model (Appendix K-4) and the Surface Water Quality Model (Appendix N-2). The results of the modelling reports and effects assessment supports the assessment of aquatic and terrestrial resources including fish (Section 6.10), vegetation communities and wetlands (Section 6.11) and wildlife species (Section 6.12, 6.13, 6.14, 6.15 and 6.16). For those waterbodies not included for offsetting, the predictive models developed to support the final EIS/EA determined that water quality parameters remain below applicable guidelines for surface water quality (Appendix N-2) in the receiving waterbodies. The results of the assessment on water, plants and wildlife are considered in the assessment of potential effects on human and ecological health in Section 6.24, which have predicted no residual effects on ecological and human health. These sections and modelling reports inform potential effects on traditional land use as described in Section 6.21.

Analytical Methods

IAAC requested the incorporation of a shallow, weathered, more permeable bedrock zone (with higher hydraulic conductivity) into the conceptual and numerical groundwater flow models. Based on field investigations, the shallowest bedrock (upper 10 to 20 metres) generally shows the highest hydraulic conductivity values; however, many low hydraulic conductivity values also occur in this interval. This is a fairly typical occurrence whereby variability is greatest at surface, which decreases with depth along with the overall average value. The shallow bedrock hydraulic conductivity values are based on single hole test (i.e., packer tests and rising / falling head tests). While these tests are valuable for inferring localized conditions, the zone of influence for these types of tests is small compared to, for example, a pumping test. The likelihood that the permeable fractures intersecting the test wells are persistent over large scales (as represented in the hydrogeological model), is low. This is evidenced by the occurrence of shallow water levels observed in topographic highs which have thin to no overburden. If shallow bedrock contained persistent fracture networks, it would tend to drain rather than retain water. Satisfying the measured shallow bedrock hydraulic conductivity values during model calibration is balanced with the measured water levels and applied recharge. In this case, shallow bedrock hydraulic conductivity was generally lowered during calibration in effort to retain water levels at the topographic highs, whilst also maintaining recharge rates within a realistic range. The country rock zone has been further considered as part of the overall bedrock hydrostratigraphic model update (Appendix L-1, Section 5.1.1) of the EIS/EA. Calibration is achieved by shortening the shallow bedrock zone in the model (from a range of 50 to 70 m to 25 m) to correspond with the highest zone of variability in the observed data, with the rest being allocated to the revised intermediate bedrock zone. Description of the updated modelled layers is given in the Hydrogeological Modelling Report (Appendix L-2, Section 3.1).

CLFN, LSFN and IAAC requested an analysis of the pump test responses for monitoring wells, including the determination of transmissivity and the average hydraulic conductivity, and updates to the hydrogeology model. Distance-drawdown plots for data provide insight into which wells are likely best connected to the pumping well (and therefore whose hydraulic conductivity estimates are most representative for that pathway). Monitoring wells with unexpectedly low drawdown are indicative of limited hydraulic connection to the pumping well; therefore, hydraulic conductivity / transmissivity value estimates in these cases are not representative. An assessment of distance-drawdown has been conducted for monitoring wells for the long-term aquifer test, and is described in the Baseline Hydrogeology Report along with expanded discussion and interpretations of the pumping test (Appendix L-1, Section 5.2.2) of the EIS/EA.

IAAC requested a hydrogeological analysis be included as part of the detailed geotechnical design for the CDF to assess saturation conditions and predict groundwater levels and flow within the CDF, particularly for the post-closure phase. The CDF has been explicitly simulated with additional numerical layers in the Hydrogeological Modelling Report (Appendix L-2, Section 6.2) of the EIS/EA which is considered in the CDF design (Appendix V-2).

IAAC inquired how the groundwater model takes into account the ore stockpile design, and a description of the follow-up monitoring program for groundwater related to the ore stockpiles. Since the ore stockpile materials are expected to have high hydraulic conductivity, it has been assumed that percolation through / seepage from the ore stockpile would be similar to recharge through the existing baseline landscape (i.e., groundwater would not mound within the ore stockpile). As such, the ore stockpile was not explicitly modelled, Instead, the groundwater model budgets within the footprint of the proposed stockpile were used for analysis. In terms of the groundwater monitoring program, additional monitoring wells have been placed around the ore stockpiles in 2022 and have been incorporated into the Hydrogeological Modelling

Report (Appendix L-2, Section 3) of the EIS/EA. Additional information on the follow-up and monitoring program is provided in Section 12 of the EIS/EA.

CLFN and LSFN requested further information on the inflow volumes to the open pit. The determination of groundwater inflows to the open pit was conducted utilizing a calibrated 3D numerical model that has been developed for the mine site of the Project. Groundwater inflow rates to the open pit are included in the Hydrogeology Modelling Report (Appendix L-2, Section 6) of the EIS/EA. This Report includes an analysis of the sensitivity (Appendix L-2, Section 7) of inflows with changes in parameters for the bedrock layers, including the shallow bedrock.

Mitigation Measures

IAAC requested further discussion on additional seepage mitigation measures that might be considered best available technology that is economically achievable. Runoff water collection ditches will be constructed around the perimeter of key infrastructure, including the co-disposal facility and stockpiles, to collect overland flow and seepage and direct it to the central water storage pond during operations. The collected contact water not re-used in processing will be treated at the effluent treatment plant (ETP) as needed and discharged to the southeast arm of Springpole Lake. This information has been included in Section 6.5.4 of the EIS/EA.

MECP noted that assumptions made regarding capping of mine wastes must be clearly stated, to provided context to the assessment of changes to groundwater quality. A description of the measures to be implemented for the CDF at closure are described in Section 5.19.3.2. These measures include: continuing to direct runoff from the north cell to the south cell; deposit NAG tailings over the entire north cell surface to fully cover the PAG mine rock and limit oxygen ingress; vegetate the tailings or, if necessary, place and grade an erosion protection cover over the entire north cell surface and direct all runoff to the south cell; deposit NAG tailings or other suitable soil cover on the south cell to remove excess pond capacity and provide cover over PAG tailings; construct an overflow spillway at the south cell perimeter dam to safely pass the Inflow Design Flood to environment; and, decommission perimeter collection ponds and allow runoff and seepage water to report to environment once water quality requirements are met.

MECP inquired about the fate of water captured by the collection ditches during closure and any potential effects on water quality. The ETP will continue to be used if needed during the initial decommissioning / closure phase or will remain available for contingency use. Additional details on water management and associated infrastructure have been included in Section 6.5.4 of the EIS/EA.

Monitoring

NWOMC and MECP asked how seepage will be monitored to ensure that seepage is captured by the collection ditches before reaching surface water features, and what measures would be undertaken should seepage reach surface water features. Seepage quality monitoring requirements will be established for the construction, operations and closure phases of the Project as part of the provincial approvals process in consultation with MINES, MECP, and Indigenous communities. The monitoring of seepage from the co-disposal facility (CDF) will be primarily through regular sampling of groundwater monitoring wells that will be established between the CDF ditching and the surrounding environment. The foundation rock under the CDF is very competent with low hydraulic conductivity well suited for the CDF location, and in combination with the CDF design achieves highly effective seepage management and capture within the perimeter collection system. The potential presence of seepage in the monitoring wells will be determined by comparing results year after year to identify whether there are changes and/or trends in water quality that indicate the presence of seepage. Action will be taken if there are indications of potentially unexpected seepage in the monitoring well(s), beginning with an investigation to the cause and identification of mitigation measures if required. Contingency measures might include pump back wells whereby groundwater is pumped back into the CDF and/or grouting of bedrock to prevent seepage movement. Additional details on water monitoring have been included in Section 12.5.

Characterization of Residual Effects - Frequency

NWOMC requested clarification on the ranking of the frequency attribute for the characterization of residual effects on groundwater. Frequency is defined as the rate of occurrence for the residual effect and duration is defined as the length of time the residual effect is expected to occur. These attributes are assessed separately in the EIS/EA. The frequency of the residual effect on groundwater quantity from mine dewatering only occurs once during construction and therefore is low (Level I). However, since this effect will occur throughout operations, the duration is moderate (Level II). This detail has been included in Section 6.5.7 of the final EIS/EA.

Characterization of Residual Effects – Duration and Likelihood

MECP commented that the duration of residual effects to groundwater quality may need to be re-considered and requested further information to support the use of natural physical properties of the bedrock as opposed to a liner, a description of the mitigation measures and a description of the groundwater monitoring program.

Site hydrogeological characterization to date is advanced with over 220 measurements of bedrock hydraulic conductivity (excluding additional data from a long-term pumping test) as well as continuous groundwater level monitoring beginning in fall 2021. The current level of hydrogeological characterization and assessment of the Project is based on multiple lines of evidence that exceed the industry standard of assessment for this stage of Project development based on experience with environmental approvals and construction paths for similar projects. The hydrogeological characterization and assessment have been described in detail in the Baseline Hydrogeology Report (Appendix L-1, Section 5) and the Hydrogeological Modelling Report (Appendix L-2, Section 3.2), and summarized in Section 6.5.2.1. The Baseline Hydrogeology Report (Appendix L-1, Appendix A) includes an updated compilation of borehole logs that contain geological descriptions, and borehole logs for installations since 2019. Numerous borings, hydraulic test locations, and groundwater monitoring installations have been located within or directly adjacent to the proposed CDF footprint, including shallow bedrock conductivity testing inside and around of the proposed footprint of the CDF. The bulk hydraulic properties (i.e., the combined properties bedrock fractures and the bedrock matrix on a per volume basis) which are determined by hydraulic tests (such as rising falling head tests in monitoring wells and packer testing) will govern the overall flux of seepage emanating from the CDF to the surrounding receiver waterbodies. Forty-six measurements of hydraulic conductivity have been acquired in the area of the CDF, with 30 of those being conducted in the upper 25 metres. This is more than sufficient for the determination of hydraulic conductivities that are used in the hydrogeological numerical modelling of the CDF. Further, the conclusions drawn from these measured data are consistent with observations of groundwater levels / fluctuations discussed below and provide further lines of supporting evidence.

Given the relative difference between hydraulic conductivities of the shallow bedrock underlying the CDF (5.7×10^{-8} metres per second (m/s) for the upper 25 metres based on 30 measurements) and the value for tailings (approximately 10^{-7} m/s), flows will be primarily sub-lateral within the CDF and converge towards the perimeter embankments. This is supported by hydrogeological modelling as described in the final EIS/EA Hydrogeological Modelling Report (Appendix L-2, Section 3.2).

Data acquisition will, however, continue at site at various stages of Project development to meet requirements for detailed design, approvals, and permitting.

As part of detailed engineering design of the CDF, a supplemental geotechnical investigative program will be developed for specific areas of the CDF to in inform subsequent design stages and further ensure the design criteria are met. The specific engineering controls to manage seepage will be implemented during construction and include bedrock grouting, where required. The seepage collection ditches have been included and their implementation described in the Hydrogeological Modelling Report (Appendix L-2, Section 6) of the EIS/EA. This also includes a discussion of their effectiveness in intercepting groundwater from the CDF.

A supplemental hydrogeological characterization program is planned for 2024 based on feedback from the MECP. This program primarily focuses on the characterization of shallow bedrock hydrogeological conditions in the vicinity of the CDF as well as the establishment of additional long-term groundwater monitoring wells.

A groundwater monitoring program including overburden and bedrock monitoring wells is established for the site and will be refined and supplemented prior to construction reflecting conditions of approval to verify the groundwater flow and quality outside of the seepage collection ditches during all phases of the Project. A description of this program is provided in Section 12 of the final EIS/EA.

6.5.1.3 Spatial and Temporal Boundaries

The PDA is defined as the footprint of the Project including the mine site area, mine site access road and the transmission line corridor, as well as a buffer in order to allow for flexibility for design optimizations. The buffer includes approximately 250 metres (m) around the mine site area. The buffer for the transmission line is included within the 40 m wide corridor and within the 30 m wide corridor for the mine access road. Where the mine access road and transmission line are aligned together, the buffer is included within a 60 m wide corridor.

The spatial boundaries used for the assessment of groundwater are shown in Figure 6.5-1 and defined as follows:

- **LSA**: The LSA for groundwater extends from the PDA to the area encompassed by the natural groundwater boundary. Potential changes in groundwater to surface water interactions are typically focused at the shorelines of the nearest surrounding surface water bodies. The distribution of potential effects is bound by large surface water features surrounding the Project whose overall water budgets are orders of magnitude greater than the local contributions made by groundwater; these are Birch Lake and Springpole Lake.
- **Regional Study Area (RSA):** The groundwater model domain utilized in the analysis incorporates regional boundaries outside of which effects are negligible. As such, effects on groundwater are not expected to extend beyond the boundaries encompassed by the LSA. For the purposes of the effects assessment, a separate study area has not been defined and the RSA is considered the same as the LSA for this VC.

From a groundwater perspective, the construction of the mine access road, airstrip and transmission line is anticipated to occur during frozen conditions, above the water table, or will occur within a small area for a very short period of time. Therefore, there are no expected effects on groundwater due to the construction and operation of the mine access road, airstrip and transmission line. As a result, potential for effects to groundwater are limited to the mine site area of the PDA.

The temporal boundaries for the assessment of groundwater are defined as:

- **Construction Phase:** Years -3 to -1, representing the construction period for the Project.
- **Operations Phase:** Years 1 to 10, with the first year potentially representing a partial year as the Project transitions from construction into operations. Mining of the ore from the open pit will end in Year 10, at which time the pit will begin refilling with water; and
- **Decommissioning and Closure Phase:**
    - Active Closure: Years 11 and 15, when final decommissioning and the majority of active reclamation activities are carried out; and
    - Post-Closure: Years 16+, corresponding to the post-closure monitoring period and when the filled open pit basin will be reconnected to Springpole Lake.

Effects on the VC are assessed for each Project phase (i.e., construction, operations and closure).

6.5.1.4 Criteria and Indicators

In undertaking the assessment of groundwater effects, the following criteria were used:

- Change in groundwater quantity; and,
- Change in groundwater quality.

The specific criteria, measurable indicators and the rationale for the selection of criteria are described in Table 6.5-1.

6.5.1.5 Description of Residual Effect Attributes

The residual effects for groundwater are focused on the interactions with the surface water system VCs, and characterized in terms of the following attributes:

- Magnitude;
- Geographic Extent;
- Duration;
- Frequency; and
- Reversibility.

These attributes along with the rankings are further described in Table 6.5-2.

In addition, the residual effects for groundwater are characterized according to the ecological context within which the VC is found. This is a qualitative measure of the sensitivity and/or resilience of the VC is to potential change. The following ranking is applicable:

- **Level I:** The VC may or may not be sensitive but is capable of supporting the predicted change with typical mitigation measures.

- **Level II:** The VC is sensitive and requires special measures to support the predicted change.
- **Level III:** The VC is sensitive and unable to support the predicted change even with special measures.

As noted in Section 6.1, a residual effect is defined as significant if both of the following criteria are satisfied:

- A Level II or III rating is attained for all of the attributes involving magnitude, extent, duration, frequency and reversibility; and
- A Level II or III rating is attained for ecological context.

Conversely, if a Level I rating is achieved for any of the attributes involving magnitude, extent, duration, frequency or reversibility; or, if a Level I rating is achieved for the ecological and social context, then the residual effect is considered to be not significant.

In the event there is a significant adverse effect, the likelihood of occurrence is further described.

6.5.2 Existing Conditions

A description of the baseline conditions is presented below to characterize the existing conditions for groundwater and is based on several years of study that has resulted in a comprehensive groundwater dataset for this stage of project planning. The existing conditions are used to support the assessment of potential effects from the Project on groundwater and will support long-term monitoring for the Project. Further baseline information on the hydrogeological conditions can be found in the technical support documentation including the baseline hydrogeology (Appendix L-1) and hydrogeology modelling (Appendix L-2).

6.5.2.1 Hydrogeological Setting

The Project is located in a remote area of northwestern Ontario and there are no nearby industrial or commercial developments. The MECP Water Well Information System shows the monitoring wells installed at the Project site are for the purpose of monitoring. There are no other wells listed within the MECP database that are within the PDA and LSA, including along the proposed transmission line. All of the communities within the region are located far from any potential effects to groundwater and no groundwater sources or uses have been identified at the Project site during consultation to date.

The proposed mine site area is situated within the western Superior Province of the Canadian Shield physiographic region where the landscape is dominated by recent glacial activity. The undulating and subdued topography clearly shows the effects of glaciation, whereby cyclical ice advances and retreats eroded ancient mountain ranges and generally deposited and reworked sediment in low-lying areas. Site topography is shown in Figure 6.5-2. The Project is situated between Birch Lake and Springpole Lake, where topographic relief in the PDA and LSA is approximately 35 m and elevations range from 390 to 425 masl (Figure 6.5-3). Bathymetric mapping of Springpole Lake in the area of the ore zone has shown a lake depth of up to approximately 40 m. Most of the smaller inland waterbodies near the mine site are several metres deep; however, unnamed small waterbodies L-2 and L-16 have a moderate depth of greater than 20 m and 10 m, respectively.

The surface water divide between the northern basin of Springpole Lake and Birch Lake runs south and east of Lake L-3, and then along the narrow (about 250 m at its narrowest) east-west strip of land. The elevation of Birch Lake is approximately 2 m to 4 m above Springpole Lake depending on the season. On the

Springpole Lake side of this flow divide, the area is drained by small ponds and tributaries which discharge into Springpole Lake. L-3, which is located within the footprint of the proposed CDF, drains into Birch Lake.

Site bedrock lithologies are shown in Figure 6.5-3. Lithologies of the host bedrock consist primarily of mafic to felsic metavolcanic rock and metasedimentary rock with various intrusions, the primary rock type in the area of the CDF being competent andesite, which is highly favourable for CDF foundation conditions. Generally, there is a small zone of weaker bedrock in the immediate vicinity of the open pit associated with the ore zone (i.e., the Portage Zone) and the surrounding host bedrock consists of metasedimentary and metavolcanic rock, as well as intrusions. The Portage Zone is further divisible between a zone of unconsolidated granular material, termed the 'UGM' zone, and the adjacent rock which has low rock quality designation (RQD), called the 'Low RQD' zone. Several bedrock structures have been mapped in the area of the ore zone. The primary feature of interest is an east-west trending fault (SW-2) which intersects the open pit and correlates to a topographic lineament that underlies the CDF. This feature, if hydraulically transmissive, is expected to divert potential bypass seepages towards the open pit but is not expected to increase the overall seepage rate from the CDF south cell. This is primarily due to limiting factor governing seepage being the permeability of tailings.

The overburden geology in the Project area generally consists of surficial organics (i.e., peat) underlain by glacial sediments. On land, overburden is generally quite thin and discontinuous at site, with thicknesses being 2.2 m on average (excluding bedrock outcrop mapping, which would result in a much lower value), and values exceeding 5 m being atypical. The thickest overburden deposits are located under Springpole Lake and are confined to a narrow corridor within the footprint of the open pit (i.e., within Springpole Lake). This material will be removed as part of open pit development (Appendix L-1). Overburden is frequently absent along the shoreline of Springpole Lake and Birch Lake, possibly due to erosion by wave and ice action on the lake shore. Due to these characteristics, overburden is of limited influence to the hydrogeology assessment compared to bedrock. Further discussion of this is provided in Appendix L-1.

Hydraulic testing has been conducted at site as part of numerous investigation programs and includes a total of 218 unique measurements of bedrock hydraulic conductivity from rising / falling head tests in monitoring wells and packer tests in boreholes (i.e., excluding measurements from a 30-day pumping test). The locations of these hydraulic tests are shown in Figure 6.5-4. Hydraulic conductivity data show that the Low RQD and UGM zones have consistently and markedly higher permeabilities (2.8×10^{-6} m/s and 5.0×10^{-6} m/s, respectively) compared to the surrounding host bedrock (2.2×10^{-7} m/s). The Low RQD and UGM hydraulic conductivities show minimal consistent variability with depth, while the host bedrock shows a tendency for a decrease in hydraulic conductivity with depth. Host bedrock hydraulic conductivities near the area of the proposed CDF are lower as compared to the rest of the proposed mine site area, which are otherwise similar (i.e., 3.2×10^{-8} m/s versus $4.0. \times 10^{-7}$ m/s, respectively). This is consistent with observations at the mine site area, which demonstrate that the bedrock in the area of the CDF is more competent compared to other areas of site. Hydraulic conductivity values for overburden and overburden/bedrock interface materials (excluding the lakebed organics) show a relatively narrow range, with values ranging from 1.0×10^{-6} m/s to 6.0×10^{-5} m/s, with an overall geometric mean of 5.9×10^{-6} m/s based on 12 measurements. This contrasts with the values for lakebed organics obtained from laboratory tests, which both yielded very low values (1.7×10^{-9} m/s and 3.0×10^{-10} m/s).

The locations of groundwater monitoring installations are shown in Figure 6.5-5. Groundwater level monitoring in these wells and vibrating wire piezometers (VWP) shows two archetypal water level responses: zones which are connected to Springpole Lake and zones whose water levels are driven by infiltration and recharge. Locations of shallow groundwater levels close to the surface at topographic highs, as typically observed in the area of the CDF, demonstrates that the local bedrock does not readily drain and having low permeability / limited fracture connectivity.

Baseline groundwater quality results are summarized in Table 6.5-3. Baseline groundwater quality is circumneutral to slightly alkaline pH, with higher pH values associated with monitoring in the northwest area of the proposed open pit. Overall, groundwater has high hardness and alkalinity, with low sulfate and chloride values which is typical of bedrock groundwater quality of areas in northern Ontario. For the purposes of summary here, groundwater quality data are additionally benchmarked against surface WQG for the protection of aquatic life. Surface water quality guidelines are not directly applicable to groundwater quality and are provided for benchmarking purposes only. Concentrations of dissolved metals are low for most parameters, with the exception of dissolved iron, which is slightly elevated across the PDA (>1.5 mg/L). Elevated concentrations of arsenic, cobalt, copper and zinc were also observed in some wells (Table 6.5-3).

6.5.2.2 Hydrogeological Model

A hydrogeological model was developed to support the effects assessment (Appendix L-2). Under existing conditions, most of the local groundwater flow will be driven by recharge in higher elevation areas and subsequent discharge to surface water features in low-lying areas. Thin pockets of overburden overlying the fractured rock are likely to act as recharge buffers, whereby shallow infiltration is stored in porous overburden following rainfall/snowmelt events and slowly percolates into the fractured rock system which will have comparatively little storage. The limited groundwater flow that exists will be preferential through the overburden and shallow fractured bedrock, towards surface water features such as Birch Lake and Springpole Lake. The degree of hydraulic connectivity between the groundwater flow system and surface water features will be largely site specific. Groundwater levels in the immediate vicinity of Springpole Lake, for example, are shown to be very well connected to the lake due to the prevalence of fracturing in the Low RQD zone. Conversely, groundwater levels away from the Low RQD zone show little relation to the levels in Springpole Lake or local surface water features and generally remain much higher than local surface water features.

A transverse stratigraphic section to the open pit, showing bedrock zones is illustrated in Figure 6.5-6 and shows the open pit has markedly higher hydraulic conductivity than the surrounding host bedrock. Hydraulic conductivity within the open pit area (Low RQD and UGM zones) does not decrease with depth in the same manner that is seen in surrounding host rock. Higher permeabilities in the Low RQD and UGM zones reflect the presence of weaker rock in this zone, which is more prone to fracturing and weathering than either the metavolcanic (andesite) host rock to the southwest (CDF area), or the metasediment to the northeast of the proposed open pit (process plant area). The fracturing within this zone is focused on several structural features identified by SRK (2013). The initial structures might have allowed for greater fluid movement, resulting in higher alteration in the core of the UGM zone. The fracturing within low RQD zone, which surrounds the UGM, likely developed in response to the rock within the UGM becoming weaker due to the alteration progressed over time in the geologic past and the surrounding rock in what is now the Low RQD zone lost confining support from the UGM zone. The conceptual hydrogeological model (CHM) described above forms the basis for the construction of the numerical groundwater flow model described in Section 6.5.5 and detailed in Appendix L-2. The numerical model is used to assess potential changes in the groundwater flow system resulting from Project development.

6.5.2.3 Traditional Knowledge

As part of the Project, all eight Indigenous communities were contacted to participate in the EA process, and to provide Traditional Knowledge and Traditional Land Use (TK/TLU) information. To date, six Indigenous communities, Cat Lake First Nation, Lac Seul First Nation, Mishkeegogamang Ojibway Nation, Slate Falls Nation, Wabauskang First Nation and the Northwestern Ontario Métis Community, have provided Traditional Knowledge and Traditional Land Use information. Specific TK/TLU information relevant to groundwater is described below.

CLFN noted that there are spring water collection sites adjacent to the proposed Project footprint, although these appear to be further southeast and away from the CDF. Further, CLFN noted there are spring water sites and drinking water collection sites in the local study area for their TK study, but the exact location and frequency of use were also not specified.

LSFN emphasized the importance of the English River water system in the territory for the ability to collect drinking water safely, and for supporting healthy fish habitats. LSFN members felt the waters of northern lakes closer to the Project were important and valued as places where water was cleaner, compared to waterbodies closer to their community. LSFN noted the importance of wild rice harvesting in waterbodies adjacent to Lac Seul communities, where flooding had historically occurred due to hydroelectric development. LSFN noted a spring water site within the Project footprint, which appears to be upstream of the proposed treated effluent discharge location. Spring water sites were also observed in the local and regional study areas for their TK study, but the exact locations and frequency of use was not described. As the spring water sites are not located near the mine site, there are no anticipated interactions anticipated with the Project.

6.5.3 Identification of Pathways to Potential Effects

The initial step in the assessment process is to identify interactions between the Project and groundwater that can result in pathways to potential effects. These potential effects may be direct, indirect and/or positive effects, where applicable. Table 6.5-4 includes the potential interactions of the Project with groundwater, prior to the application of the mitigation measures. The professional judgement of technical experts experienced with mining projects in Ontario and Canada as well as input from Indigenous communities, government agencies and the public informed the identification of those interactions that are likely to result in a pathway to a potential effect due to a measurable change on groundwater. These pathways to potential effects are further described below for each phase of the Project, along with the rationale for those interactions excluded from further assessment. Section 6.5.4 and Table 6.5-5 provide a description of the mitigation measures applied to during all phases of the Project. The residual effects, after the application of the mitigation measures, are then described and further evaluated in Section 6.5.6, using the criteria and indicators identified in Section 6.5.1.4.

Construction Phase

The construction phase of the Project is expected to occur over a three-year period and will include preparation of the site and the construction of mine infrastructure. The following interactions with the Project result in pathways to potential effects on groundwater as described below. After mitigation is applied to each pathway, as described in Table 6.5-5, the residual effects are assessed using the criteria identified for each pathway:

- Site preparation activities for the mine site, including clearing, grubbing and bulk earthworks, interacts with groundwater. These activities result in a pathway to a potential effect on groundwater due to the change in surface water catchment areas contributing to groundwater. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity.
- The construction of the central water storage pond, mine site water management infrastructure, fish habitat development area and CDF interacts with groundwater. These activities result in a pathway to a potential effect on groundwater due to the requirement for excavation below the groundwater table and the associated water management. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity.
- The controlled dewatering of the mining area to safely access the ore body interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due to the requirement to manage surface water that contributes to groundwater. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity.
- The initiation of the development of the open pit in rock interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due to the requirement for excavation below the groundwater table and the associated water management. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity.
- The initiation of ore stockpiling interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due to the change in surface water catchment areas and the requirement to manage surface water that contributes to groundwater. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity.

The construction of the mine access road, airstrip and the transmission line is anticipated to occur during frozen conditions, above the water table, or within a small area for a very short period of time. These activities will be effectively managed with standard best practices, such as limiting the active construction area to the extent possible, and having spill contingency plans. Similarly, the development and operation of aggregate resources is not planned below the water table, and potential effects will be effectively managed with best practices during operations including surface water management and progressive rehabilitation. As a result, there is unlikely to be potential effects on groundwater.

The construction of the two dikes will occur in-water using appropriate isolation measures to manage surface water effects. There are no anticipated effects on groundwater from this activity. The controlled dewatering of the open pit basin can only occur once the dikes are completed. Once the controlled dewatering of the open pit basin is completed, the stripping of lakebed sediment and overburden in the open pit area will occur and there is unlikely to be potential effects on groundwater from this activity.

The construction of the temporary construction camp, buildings and other onsite infrastructure as well as the commissioning of the process plant will not result in a potential effect to groundwater as excavation below the water table is not anticipated.

There is no plausible interaction between the employment and expenditures activities and groundwater during any Project phase.

Operations Phase

The operations phase is anticipated over a 10-year period. The following interactions with the Project result in pathways to potential effects on groundwater as described below. After mitigation is applied to each pathway, as described in Table 6.5-5, the residual effects are assessed using the criteria identified for each pathway:

- Operation of the open pit interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due to the requirement to manage groundwater and surface water that collects in the open pit. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity and quality.
- Operation of the overburden stockpile, ore stockpile and CDF interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due the requirement to collect and manage runoff and groundwater seepage. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity and quality.
- Operation of water management and treatment facilities interacts with groundwater. This activity results in a pathway to a potential effect on groundwater due the requirement to collect and manage runoff and groundwater seepage. The assessment of potential effects on groundwater from this pathway includes the evaluation of changes in groundwater quantity and quality.

The commissioning and operation of the process plant, accommodation complex and the maintenance of ancillary mine site infrastructure is not anticipated to have potential effects on groundwater as excavation below the water table is not anticipated. Similarly, progressive reclamation activities are not anticipated to affect groundwater during operations.

Decommissioning and Closure Phase

Activities occurring during the active closure phase, which is expected to occur over a five-year period, are similar to those that occur during the construction phase, and use similar mining equipment but generally on a smaller scale. The following interactions with the Project result in pathways to potential effects on groundwater as described below. After mitigation is applied to each pathway, as described in Table 6.5-5, the residual effects are assessed using the criteria identified for each pathway:

- Closure and restoration of the open pit basin will commence with the termination of water management within the open pit at the end of the mine life and the recovery of water levels through groundwater infiltration and precipitation runoff. During this time, the local groundwater levels will gradually recover until the open pit basin fills to the natural elevation of Springpole Lake, at which time groundwater levels will stabilize at their final post closure level similar to levels at baseline. This activity interacts with groundwater and results in pathways to potential effects on groundwater due to changes in water management, and changes in water quality from the exposed pit walls and associated seepage quality. The assessment of potential effects on groundwater from these pathways includes the evaluation of changes in groundwater quantity and quality.
- The reclamation of impacted areas includes stabilizing disturbed areas, such as by re-grading, placement of an appropriate cover to facilitate revegetation, if needed, and revegetation (active or passive) of the site. In addition, the closure of the CDF will change catchment areas for groundwater. These activities interact with groundwater and results in pathways to potential effects on groundwater due to changes in water management from altered catchment areas, and changes in

water quality from seepage. The assessment of potential effects on groundwater from these pathways includes the evaluation of changes in groundwater quantity and quality.

During decommissioning and closure, the removal of assets, demolition of remaining materials, disposal of demolition-related wastes and monitoring are not expected to have an interaction with groundwater as excavation below the water table is not anticipated.

6.5.4 Mitigation Measures

Measures to be implemented to avoid or minimize the effects of the Project on groundwater include:

- Development of a compact mine site to limit the areal extent of disturbance, and to limit the overall areas of contact water that requires management.
- Locating the CDF on favourable geologic conditions at the Project site to support long-term stability and effective seepage management.
- Strategic placement of the open pit dikes which limit and isolate the open pit basin and maintain 94% of Springpole Lake untouched by the Project.
- During construction, operation and active closure, an integrated water management system will be operated to collect and control contact water from the stockpiles, CDF and plant site areas. Collected contact water that is not used in ore processing will be treated at the effluent treatment plant (ETP) and discharged to the southeast arm of Springpole Lake in accordance with permitting requirements.
- During construction, operation and active closure, contact water collection ditches will be constructed and operated around the perimeter of key infrastructure, including the CDF and stockpiles, to collect overland flow and seepage and direct it to the integrated water management system.
- During construction and operation, best management practices will be implemented for the use of explosives (such as following approved blasting plans, and using appropriate drilling, explosive handling and loading procedures) to reduce the potential presence of blasting residuals on mine rock stored in the CDF that could otherwise infiltrate into groundwater.
- During construction, a geosynthetic clay liner will be installed on the upstream side of the perimeter embankment of the CDF south cell (specifically the south, west, and east sides) to mitigate seepage potential during the operation and closure phases.
- During operation and closure phases, revegetation and encouragement of natural revegetation / recolonization of disturbed areas, will be undertaken as part of progressive and final reclamation to minimize the length of time disturbed areas are exposed to reduce infiltration.
- During the filling of the open pit basin, accelerate the return of groundwater levels to baseline conditions, by transferring water from Springpole Lake in a controlled manner while maintaining lake water levels in Springpole Lake within natural variation.

The application of mitigation measures for the pathways of potential effects is illustrated in Table 6.5-5. Mitigation measures described in this section are expected to be effective for their intended purposes given their effective implementation at similar projects.

Monitoring programs will be implemented to verify the accuracy of the predicted effects, assess the effectiveness of the implemented mitigation measures and may be further optimized in response to monitoring data. Monitoring programs are in place for the Project with previous data collection completed. Monitoring for the Project going forward is further described in Section 12 and will be further refined during the permitting phase to incorporate conditions of approvals and permits. Consultation on the monitoring programs is expected to continue through all phases of the Project.

6.5.5 Analytical Methodology

The assessment of the groundwater effects has been completed in accordance with generally and widely accepted assessment methodologies. The prediction and assessment of effects involved the following steps:

- Determine baseline conditions in the area of the Project;
- Identify the key pathways of interaction of the Project with groundwater through development of the site CHM;
- Construct and calibrate a numerical groundwater model utilizing baseline conditions data that can subsequently be used to simulate future conditions;'
- Identify the relevant regulatory standards and criteria, and establish the appropriate assessment criteria for a site in Ontario, noting that there may be more than one applicable criterion for some of the parameters;
- Predict changes to groundwater using appropriate modelling methods and established data sources; and
- Compare the groundwater modelling outputs to the assessment criteria, comparing effects with the corresponding applicable criteria.

As described in Section 6.5.2 and Appendix L, there are no potential effects to groundwater users from the Project and effects to groundwater users are not further assessed. Groundwater is, however, a key component of the surface water environment and thus potential effects to groundwater, including predictions of changes in groundwater quantities and quality, are evaluated herein as a pathway to effects of the Project on other VCs.

In order to support the effects on groundwater that ultimately discharges to surface water, WQG for the Protection of Aquatic Life were selected as a basis of comparison for predicted groundwater quality. A list of WQG used in this assessment are provided in Table 6.5-3.

The analytical methodology, including quantitative hydrogeological modelling, used to support the assessment of groundwater flows is presented in Appendix L-2 and is summarized herein. The specific objectives of the hydrogeological modelling were to:

- Calculate the groundwater discharge to the open pit during mine operations;
- Calculate seepage rates from key site infrastructure / facilities to nearby surface water receivers during mining operations and under long-term post-closure conditions; and
- Calculate the effects of open pit mining activities on the local groundwater - surface water interaction during late mine operations and under long-term post-closure conditions.

Similarly, changes in groundwater quality due to Project development are assessed via characterization of changes to groundwater and surface water interactions (including seepage), as determined by the surface water models developed for the Project (Appendix M-3 and Appendix N-2) and further discussed in surface water system VC effects assessment sections (Section 6.6 through 6.9).

6.5.5.1 Site CHM

The subsurface flow pathways for end of mine operations conditions is depicted in Figure 6.5-7, where the CDF is at full development and the open pit is at the maximum extent and is fully dewatered. This diagram illustrates an east-west cross-section transecting the CDF south cell and open pit, with the surface water feature on the left side representing a nearby surface water receiver (best represented by Birch Lake in this case). Within the diagram, overburden is differentiated from the bedrock, which is sub-divided between host rock, the Low RQD zone, and the UGM zone. The construction of the CDF shown includes tailings that is overlain by a cover and surrounded by the perimeter embankments, which include a geosynthetic liner on the upstream face of the south cell embankment (specifically the south, west, and east embankments), based on the proposed design of the facility. The CDF is surrounded by a seepage collection system. In this diagram, the open pit is shown in its fully operational state. The water table is shown as very shallow within the south cell of the CDF.

Potential residual effects represented in this diagram for end of mine operations conditions include:

- A drawdown cone will emanate radially from the open pit. Drawdowns will be largest within the Low RQD zone (and UGM zone), as this zone is expected to drain readily due to its relatively high permeability.
- Contact water (seepage) from the CDF may follow three main pathways - 1) direct leakage through the perimeter liner into the embankments; 2) upwelling under the liner through the shallow bedrock into the perimeter embankments, or 3) diffuse seepage/percolation into the bedrock underlying the CDF. Flows within the embankments accumulate and converge towards topographic low points within the embankments, at which point flows would seep / discharge from the embankment toes and runoff to the seepage collection system.

Flows within the shallow rock move sub-laterally within the most permeable zone of rock. Depending on local conditions, a component of this flow may discharge to the surrounding seepage collection system. It is expected that the total amount of seepage bypassing the system would be quite low due to generally low permeability of bedrock underlying the CDF, which results in a preference for flow to move laterally above the bedrock interface towards the surrounding perimeter embankments. Otherwise, minimal flows bypassing the seepage collection system would eventually discharge to the surrounding surface water features. For the end of mine operations conditions, the primary pathway for seepage bypass would be the open pit, due to the large drawdown cone imposed by the dewatered open pit.

6.5.5.2 Numerical Hydrogeological Model

Using the CHM as a basis, the numerical groundwater flow modelling was conducted in FEFLOW 8.0 for three mine development conditions, corresponding to key hydrogeological conditions during the lifespan of the mine, specifically:

- **Baseline:** existing (baseline) site conditions were simulated first for model development and calibration purposes.

- **End of mine operations Phase:** this represents conditions where the CDF is constructed to its maximum elevation, the open pit is developed to its maximum depth, the central water storage pond is in operation, and the open pit is fully dewatered.
- **Post Closure Phase:** this case represents conditions long after closure, where the open pit has fully re-saturated and the groundwater levels in the vicinity of site have recovered to their long-term state.

The hydrogeological model calculates the effects of mining on the local groundwater regime for mine development with respect to groundwater flow. Detailed descriptions of the development of the numerical groundwater model are provided in Appendix L-2 and are summarized below.

The numerical groundwater flow model represents a three-dimensional (3D) steady-state flow condition, with the bedrock represented using an Equivalent Porous Media approach. Conditions are simulated for baseline and development conditions to focus the assessment on incremental changes predicted to occur specifically as a result of Project development.

The groundwater model domain is shown in Figure 6.5-8 and is inclusive of surface water features within and adjacent to the Project footprint. Subsurface hydrostratigraphy in the model is simulated as six primary units: the UGM zone, the Low RQD zone, host bedrock in area of the CDF, host bedrock outside of the CDF area, lakebed organics, and overburden (i.e., other overburden excluding the lakebed sediments). Host bedrock layers are also further demarcated with respect to depth. Boundary conditions in the numerical model were assigned for the various lakes/ponds and streams at site based on measured data, as available, and groundwater recharge was assigned based on ranges determined from local flow monitoring and regional studies. A layout view of the operations phase model is shown in Figure 6.5-9. Additional details on model development and calibration are provided in the Hydrogeology Modelling TSD (Appendix L-2).

Following base case simulations for end of mine operations and post-closure conditions, a series of sensitivity simulations was conducted to assess variability of key model outputs (i.e., groundwater budgets and CDF seepage distributions) to model inputs. Only variants expected to result in increased environmental effects were selected for simulation. Model outputs for sensitivity simulations were selected based on the sensitivity case (i.e., End of mine operations operations cases focused on open pit groundwater inflows and post-closure cases focused on long-term seepage rates). In addition to the 11 3D model variants, a simplified 2D cross-sectional model for the CDF south cell was run to simulate the effects of varying embankment liner performance on the distribution of seepage (Variant 11). A summary of predictive simulations conducted as part of the model assessment is provided in Table 6.5-5.

6.5.5.3 Assumptions and the Use of the Conservative Approach

Conservative approaches are defined as those that provide predictions that will tend to be higher than expected, as a means to ensure that potential effects from the Project will not be underestimated and feasible mitigation measures will not be overlooked. For groundwater, those approaches include the following:

- Operations phase is conservatively restricted to the final year of mining (i.e., end of mine operations or maximum build-out). In contrast, concentrations of water quality parameters in contact water as well as drawdown effects of open pit dewatering are expected to increase over time to these maximum levels, coincident with mining of the open pit and expansion of corresponding facilities.

- The model simulates steady state conditions, which assumes that there is infinite time for drawdown to develop and for groundwater travel between sources and receptors. In reality, these conditions will not completely develop over the life of the mine and actual changes during mine operations from drawdown and seepage will be less than predicted by the model.
- The potential influence of seepage quality on surface water is modelled as a strict mass balance and does not account for any natural attenuation of concentrations along the groundwater flow path.
- With respect to seepage, flow and mass load reporting to model nodes from various input sources were assumed to mix instantaneously. Ponds were assumed to empty each month such that loads were not retained in ponds from month to month.

6.5.6 Characterization of Potential Residual Effects

Residual effects of the Project on groundwater, after the application of mitigation, were subsequently characterized using both quantitative modelling as well as qualitative methods. The discussion is focused on the predicted residual groundwater effects on surface water features in the PDA and LSA.

After the application of mitigation measures, predicted changes to groundwater are driven by:

- Changes to local groundwater catchment area and flow regime as a result of the development of mine site infrastructure, including open pit development and dewatering activities. These changes are further considered for the potential to affect the water quantity of surface water features in the PDA and LSA.
- Changes in groundwater quality due to seepage from Project components. These changes are further considered for the potential to affect water quality of surface water features in the PDA and LSA.

Residual effects to groundwater identified and discussed below have been integrated into the surface water modelling for the Project (Appendix M and Appendix N) and the associated residual effects assessment for surface water system VCs (Sections 6.6 through 6.9).

6.5.6.1 Changes in Groundwater Flow Regime

The modelled potential effects of the Project on groundwater flow for mine operations and post-closure are that:

- Groundwater will mound in the vicinity of the CDF during mine operations and post-closure. This is expected and typical of all similar mine facilities as they are built up over time.
- The open pit will generally act as a sink to groundwater flow (i.e., hydraulic low), drawing groundwater into the pit from areas immediately adjacent during mine operations. This is expected and typical of all open pit mining operations and reversible at closure.

The management of groundwater inflows to the open pit include pumping water from the open pit to the central water storage pond at surface, which will be used as make-up for the process plant or will be treated at the ETP. This will commence during the construction phase and continue as needed until the development of the ultimate pit extent in Year 10 (i.e., as modelled for end of mine operations). After mining ceases, the groundwater system will recover towards its post-closure state, which is similar to the baseline condition.

A base case and sensitivity analyses were conducted to assess the variability of the modelled open pit groundwater inflow rate, and groundwater-surface water interactions at other surface water bodies. Sensitivity analysis was done to illustrate how variation in input parameters could affect the results for the modelling and result in an increased environmental effect (e.g., increased groundwater inflow rates to the open pit). Predicted open pit groundwater inflow rates and groundwater budgets for end of mine operations phase for the base case and identified sensitivity variants, as well as the base case for post-closure conditions, are provided in Table 6.5-6. Changes in the interaction between groundwater and surface water as a result of open pit inflows, as well as related water management activities at site, were assessed in the groundwater model by analyzing water budgets at surface water features (i.e., changes in simulated groundwater discharge to surface water features; Appendix L-2). The water budgets from the baseline calibration model were compared to the operations phase model to determine the effects of mining operations on the groundwater budget for each feature.

The groundwater inflow rate to the open pit for the base-case is 3,034 cubic metres per day (m^3/day) in sensitivity analyses, with the greatest value corresponding to the case where the Low RQD zone is increased in spatial extent by 200 m.

Water budget analysis shows that the largest sources of water to open pit inflows are Springpole Lake and Birch Lake, which represent the closest major surface water features (i.e., boundary conditions). The largest relative changes in groundwater budgets are generally for the smaller inland waterbodies / ponds proximal to the open pit. These effects on groundwater budgets will be relatively short-term and rebound readily as the open pit re-saturates at the end of operations, as shown by the post-closure water budgets in Table 6.5-6. During open pit operations, the groundwater model indicates that most proximal surface water features experience an overall reduction in groundwater contributions compared to baseflow, which return to baseline conditions in the closure phase. The modelled changes in water budgets from baseline conditions are provided in Table 6.5-6.

Although Table 6.5-6 shows there is a net reduction in groundwater contribution to L-1 (node 1), L-2 (becomes the central water storage pond), L-16 (node 4), and L-19 (node 2) compared to the pre-mining water budget., the fish habitat in these small waterbodies will be compensated for, as described in the draft Fish Habitat Offsetting and Compensation Plan (Appendix F) and are not assessed further.

Table 6.5-7 also demonstrates that given the large size of Birch Lake (nodes 6, 7 and 8) and Springpole Lake (node 5), these predicted changes in groundwater discharge represent a negligible component of the contribution to overall the lake water balance (i.e., less than 0.2%; Appendix L-2). Lake L-20 experiences a negligible change in groundwater discharge that is not measurable. Effects on these surface water features as a result of these identified changes in groundwater regime are further discussed in Section 6.6 through Section 6.9.

6.5.6.2 Seepage Predictions

Seepage analysis was conducted for the two stages of the CDF and ore stockpile development to predict the volume and direction of seepage emanating from each of these facilities. Seepage analysis was conducted by performing reverse particle-tracking from the various potential surface water receivers of seepage surrounding the CDF and ore stockpiles to delineate their respective source zones (Appendix L-2). Water balances at the source zones were then analyzed to determine the seepage rate corresponding to the receivers. The simulated seepages to surface water receivers for mine operations and final closure from mine source zones to surface water features are provided in Table 6.5-8 and Table 6.5-9, respectively. A summary of modelled seepages from the CDF for sensitivity variants, which focused on the post-closure conditions, is provided in Table 6.5-10. Sensitivity analysis was done to illustrate how variation in parameters effects the results for variants that were expected to result in an increased environmental effect (e.g., increased seepages from the CDF). It should be noted, however, that it is equally probable for most simulated sensitivity variants that conditions exist that would result in reduced environmental effects.

For operations, the model results demonstrate highly effective capture with more than 90% of seepages emanating from both the north and south cell of the CDF reporting to the seepage collection system, which is then routed to the internal pond of the CDF south cell, for use as reclaim water in the process plant. Excess water in the internal pond will be directed to the central water storage pond for use as make-up water in the process plant or sent to the ETP for treatment before discharge to the southeast arm of Springpole Lake (Section 6.7). The primary receiver of the excess bypass seepage is the open pit, which is fully dewatered in this scenario and represents a large sink local to groundwater flow. This seepage to the open pit will be managed as contact water onsite. The minimal remaining seepage bypass is predicted to discharge to Birch Lake, which is further assessed in Section 6.6 with respect to water quality.

Seepage from the ore stockpiles (both the low grade stockpile and medium-high grade stockpile) will also primarily report to the open pit, with a small amount from the low grade stockpile (10 m^3/day, representing approximately 0.002% of the overall average Birch Lake flow) reporting to Birch Lake (node 8).

For the active closure model base case (Table 6.5-11), approximately 90% of the seepage from both the north and south cells of the CDF discharge at the downstream toe of the CDF perimeter embankment where it will be collected by the seepage collection system and sent to the ETP for treatment before discharge to the southeast arm of Springpole Lake. The remaining 10% discharges to the adjacent surface waters surrounding the CDF. In all sensitivity variants, the total amount of seepage bypassing of the ditches was less than 225 m^3/day, which represents a negligible contribution (approximately 0.02% for Springpole Lake) to the overall water balance for Springpole and Birch Lakes (e.g., average flow of 13.65 m^3/s [approximately 1.2 million m^3/day] at the outflow of Springpole Lake). The primary receiver of the seepage from the north cell of the CDF is Birch Lake (i.e., nodes 6, 7 and 8). Similar to the north cell, approximately 91% of the total seepage from the south cell of the CDF discharges to the perimeter embankment toes (and subsequently the seepage collection system) in the base-case. Once water quality meets acceptable conditions, the seepage collection system will be reclaimed, and shallow seepage will flow to the receiver waterbodies during post-closure.

Geochemical characterization studies for the Project (Appendix K) indicate that seepage from the CDF will be circumneutral to slightly alkaline pH (e.g., pH 7 to 9). The predicted quality of seepage from the CDF and ore stockpile area during the operation phase is presented in Table 6.5-9. Results indicate that concentrations of aluminum, antimony, boron, cobalt, mercury, silver, thallium and uranium are greater than baseline groundwater quality and the identified WQG in operation,.

In final closure, the design of the CDF includes a low permeability cover placed on top of the south cell (Appendix L-2). The corresponding model results determined that concentrations of water quality parameters in seepage improve, with the exception of arsenic and phosphorus and concentrations of aluminum, arsenic, mercury, phosphorus, selenium, silver and vanadium are determined to be both greater than baseline groundwater and the identified WQG (Table 6.5-3) .

The potential for changes to surface water quality as a result of these identified changes to groundwater, including seepage, are quantitatively assessed by predictive water quality modelling (Appendix N-2). The corresponding effects assessment is presented in Sections 6.6 through 6.9. Surface water quality modeling results show that, after implementation of mitigation measures, concentrations of the above-identified parameters are less than WQG and there are no significant adverse effects to water quality (Section 6.6, Section 6.7, Section 6.8, Section 6.9). These results demonstrate long-term protection of surface waters and aquatic environment. Seepage effects to groundwater quality will be constrained to the LSA, based on the hydrogeological model (Appendix L-2). As discussed in Section 6.5.1, there are no groundwater wells within the LSA that are used as a source of drinking water, nor are there any known springs use within the PDA that are used as a source of drinking water and effects to groundwater users are therefore not expected.

6.5.7 Significance of Residual Effects

The groundwater VC is no sensitive and is capable of supporting the predicted residual effects, which are localized and minimized with proven mitigation measures, and therefore the ecological and social context is considered low (Level I).

6.5.7.1 Changes in Groundwater Flow Regime

With the implementation of the identified mitigation measures, the residual effect on groundwater quantity (flow) is that during open pit operations, several surface water features immediately adjacent to the open pit experience an overall reduction in groundwater contributions to baseflow as the open pit acts as a local sink for groundwater. Given the large size of Birch Lake and Springpole Lake, the predicted change in groundwater discharge represents a negligible component of the overall lake water balance (e.g., <0.2% for Springpole Lake) and will not affect surface water quantity or lake water levels. Further, the groundwater flow is also expected to return to near baseline conditions in the post-closure phase, after cessation of open pit operations, and the filling of the open pit basin. Given the relative size of L-20, the predicted changes in groundwater discharge are not measurable. As a result, the magnitude of the residual effect on groundwater flow are considered to be moderate (Level I) as the change in groundwater flow is less than 15% and unlikely to result in an adverse effect to a surface water system VC. The geographic extent of the residual effect is low (Level I), as predicted effects are within the LSA. The frequency of the residual effects is low (Level I) as it will only occur once. However, the duration of the residual effect is moderate (Level II), as the effects could occur throughout the operations phase of the Project. The residual effects are predicted to be effectively fully reversible (Level I) during the closure phase once the open pit basin is filled with water.

As a result, the adverse residual effect on groundwater due to a change in groundwater flow regime is predicted to be not significant.

6.5.7.2 Seepage Predictions

With the implementation of the identified mitigation measures, the residual effect on local groundwater quality will a change due to seepage from Project components during operations within the PDA. The seepage rate and quality, are predicted to improve during the final closure phase with the exception of arsenic and phosphorus. The magnitude of the residual effect on groundwater quality is considered to be low (Level I) as the change in groundwater quality will no result in an exceedance of surface water guidelines in the receiving water and there is unlikely to be an adverse effect to a surface water system VC. The geographic extent of the residual effect is low (Level I), as predicted effects are discrete within the PDA. The duration of the residual effects is potentially long-term (Level III), as the effects could occur throughout the operation phase and closure phases of the Project on a frequent basis (Level III). The residual groundwater quality effects for the CDF are not reversible (Level II) but can be partially mitigated through the use of a liner on the embankment of CDF south cell (south, west, and east sides) and operation of the perimeter collection ditches. The ore stockpiles will be consumed during mining, and therefore the effect on groundwater quality is reversible in this area in the long term (Level I). The groundwater VC is capable of supporting the predicted residual effects with proven measures and therefore the ecological and social context is considered low (Level I).

As a result, the adverse residual effect on groundwater due to a change in seepage quality is predicted to be not significant.

6.5.8 Confidence Prediction

There is high confidence in the results of this residual effects assessment for groundwater effects. The predicted effects are determined using well-established models and do not consider supplemental contingency mitigation factors (e.g., bedrock grouting), lag and travel times or naturally occurring attenuation processes and therefore likely over predict effects. Input data used in predictive modelling are of high quality, and the range of existing and projected variability in both the existing regime and the mine influenced regime have been considered in the model sensitivity cases that have been applied (Appendix L-2). The conservative approach of the assessment demonstrates that predicted effects on groundwater as well as surface - groundwater interactions are not underestimated, and with the application of mitigation measures, there will be reliable environmental protection. Groundwater and surface water monitoring will be ongoing in the construction, operations and closure phases and will support the validation of the predictions.

Table 6.5-1: Groundwater Criteria, Indicators and Rationale

Criteria	Indicators	Rationale
Change in groundwater quantity	• Flow volumes at groundwater discharge locations (cubic metres per day; m^3/day) • Groundwater levels in local wells (metres above sea level; masl)	• Groundwater to surface water interactions a key factor of environmental importance for groundwater, as they relate to both groundwater-surface water balance effects due to open pit development dewatering, and seepage management for site infrastructure to the receiving environment via subsurface pathways. • Groundwater levels are the most reliable indicator of Project effects on the local groundwater system as it is readily measured and provides an assessment of the effects on groundwater flows.
Change in groundwater quality	• Concentrations of dissolved metals (mg/L) • Concentrations of anions and nutrients (mg/L) • pH	• Groundwater-surface water interactions are the primary factor of environmental importance for groundwater, as they relate to both groundwater-surface water quality and seepage.

Table 6.5-2: Significance Determination Attributes and Rankings for Groundwater

Attribute	Description	Category
Magnitude	A qualitative or quantitative measure to describe the size or degree of the residual effects relative to baseline conditions	**Level I:** A change in groundwater quality or quantity of a magnitude that does not result in exceedance of surface water quality guidelines in the receiver or the change in surface water quantity is less than or equal to 15% of seasonal norms, and is protective of aquatic life, **Level II:** A change in groundwater quality or quantity of a magnitude that exceeds surface water quality guidelines in the receiver for limited parameters or the change in surface water quantity is greater than 15% of seasonal norms, but does not affect the aquatic ecosystem. **Level III:** A change in groundwater quality or quantity of a magnitude that exceeds surface water quality guidelines in the receiver for several parameters leading to effects on the aquatic ecosystem, or the change in surface water quantity is greater than 15% of seasonal norms and the effect to the aquatic ecosystem can not be compensated for or offset.
Geographic Extent	The spatial extent over which the residual effect will take place	**Level I:** Effect is restricted to the LSA. **Level II:** Effect extends beyond the LSA. **Level III:** Effect extends beyond the RSA.
Duration	The time period over which the residual effect will or is expected to occur	**Level I:** Effect occurs over the short term: less than or equal to 3 years. **Level II:** Effect occurs over the medium term: more than 3 years but less than 20 years. **Level III:** Effect occurs over the long term: greater than 20 years.
Frequency	The rate of occurrence of the residual effect	**Level I:** Effect occurs once, infrequently or not at all. **Level II:** Effect occurs intermittently or with a certain degree of regularity. **Level III:** Effect occurs frequently or continuously.
Reversibility	The extent to which the residual effect can be reversed	**Level I:** Effect is fully reversible. **Level II:** Effect is partially reversible or potentially reversible with difficulty. **Level III:** Effect is not reversible.

Table 6.5-3: Summary of Baseline Groundwater Quality

Parameter	Units	Water Quality Guideline (1)		25th Percentile	Mean	75th Percentile
Conductivity	umhos/cm	-	-	338	429	532
Hardness (as $CaCO_3$)	mg/L	-	-	146	204	277
Alkalinity, Total (as $CaCO_3$)	mg/L	-	-	170	251	296
Ammonia, Total (as N)	mg/L	-	-	0.028	0.283	0.261
Chloride	mg/L	120	CWQG	0.24	3.12	1.48
Fluoride	mg/L	0.12	CWQG	0.0365	0.0796	0.109
Nitrate-N	mg/L	13	CWQG	0.01	0.141	0.103
Nitrite-N	mg/L	0.06	CWQG	0.005	0.00624	0.005
Sulphate	mg/L	-	-	5.73	24.4	24.9
Aluminum, Dissolved	mg/L	0.075	iPWQO	0.00425	0.0397	0.0428
Antimony, Dissolved	mg/L	0.02	iPWQO	0.00005	0.000343	0.00038
Arsenic, Dissolved	mg/L	0.005	CWQG	0.000395	0.00243	0.00221
Beryllium, Dissolved	mg/L	1.1	PWQO	0.00001	0.0000683	0.00005
Boron, Dissolved	mg/L	0.2	PWQO	0.005	0.0151	0.0135
Cadmium, Dissolved	mg/L	0.00029	CWQG	0.0000025	0.0000136	0.0000143
Chromium, Dissolved	mg/L	0.0078	CWQG	0.000145	0.00051	0.000405
Cobalt, Dissolved	mg/L	0.0009	iPWQO	0.00005	0.000611	0.00066
Copper, Dissolved	mg/L	0.004	CWQG	0.000465	0.00329	0.00356
Iron, Dissolved	mg/L	0.3	CWQG	0.03	1.58	1.9
Lead, Dissolved	mg/L	0.005	iPWQO	0.000025	0.000074	0.0000545
Mercury, Dissolved	mg/L	0.000026	CWQG	0.0000025	0.00000776	0.0000025
Molybdenum, Dissolved	mg/L	0.04	iPWQO	0.000703	0.00453	0.00289
Nickel, Dissolved	mg/L	0.025	PWQO	0.000525	0.00169	0.00194
Phosphorus, Dissolved	mg/L	0.02 / 0.03	iPWQO	0.025	0.0326	0.025
Selenium, Dissolved	mg/L	0.002	CWQG	0.0000585	0.000242	0.000183
Silver, Dissolved	mg/L	0.0001	PWQO	0.000005	0.000007	0.000005
Strontium, Dissolved	mg/L	-		0.111	0.334	0.408000
Thallium, Dissolved	mg/L	0.0003	iPWQO	0.000005	0.00000742	0.000005
Titanium, Dissolved	mg/L	-	-	0.00015	0.00155	0.000885
Tungsten, Dissolved	mg/L	-	-	0.00005	0.00319	0.00246
Uranium, Dissolved	mg/L	0.015	CWQG	0.000142	0.000897	0.000828
Vanadium, Dissolved	mg/L	0.006	iPWQO	0.00025	0.000899	0.000935
Zinc, Dissolved	mg/L	0.02	iPWQO	0.0005	0.0165	0.0036

Note:

(1) Surface water quality guidelines are not directly applicable to groundwater quality and are here provided for benchmarking / comparison purposes only. Water quality guidelines represent both federal and provincial criteria. Where applicable, guideline values are calculated here using average baseline groundwater hardness (204 mg $CaCO_3$/L), and average pH (7.64).

Grey highlighted numbers are greater than the identified surface water quality guideline.

CWQG: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life

PWQO: Ontario Provincial Water Quality Objectives

iPWQO: Ontario Interim Provincial Water Quality Objectives

Table 6.5-4: Potential Interactions of Project Components on Groundwater

Project Component / Activity	Groundwater
Construction Phase	
Site preparation activities including clearing, grubbing and bulk earthworks	Yes
Construction of the mine access road and airstrip, including the development and operation of aggregate resource areas	-
Development of temporary construction camp and staging areas	-
Construction of the fish habitat development area	Yes
Construction of the transmission line to the Project site	-
Construction of the onsite haul and access roads	-
Construction of dikes in the north basin of Springpole Lake	-
Construction of buildings and onsite infrastructure	-
Construction of the central water storage pond	Yes
Controlled dewatering of the open pit basin	Yes
Construction of the starter embankments for the CDF	Yes
Stripping of lakebed sediment and overburden at the open pit	-
Development of the surficial soil stockpile	-
Initiation of pit development in rock	Yes
Initiation of stockpiling of ore	Yes
Establishment and operation of water management and treatment facilities	Yes
Commissioning of the process plant	-
Employment and expenditures	-
Operations Phase	
Operation of the process plant	-
Operation of open pit mine	Yes
Management of overburden, mine rock, tailings and ore in designated facilities	Yes
Operation of water management and treatment facilities	Yes
Accommodations complex operations	-
Operation and maintenance of ancillary mine site infrastructure	-
Progressive reclamation activities	-
Employment and expenditures	-
Decommissioning and Closure Phase	
Removal of assets that can be salvaged	-
Demolition and recycling and/or disposal of remaining materials	-
Removal and disposal of demolition-related wastes in approved facilities	-
Reclamation of impacted areas, such as by regrading, placement of cover and revegetation	Yes
Filling the open pit basin with water	Yes
Monitoring and maintenance	-
Employment and expenditures	-

Note:
(-) The interaction is not expected, and no further assessment is warranted.

Table 6.5-5: Proposed Mitigation Measures for Potential Groundwater Effects

	Phase			
Pathways to potential effect	**Con.**	**Op.**	**Cl.**	**Proposed Mitigation Measure**
Change in groundwater quantity	•	•	–	Development of a compact mine site to limit the areal extent of disturbance, and to limit the overall areas of contact water that requires management.
	•	–	–	Strategic placement of the open pit dikes which limit and isolate the open pit basin and maintain 94% of Springpole Lake untouched by the Project.
	•	•	•	An integrated water management system will be operated to collect and control contact water from the stockpiles, CDF and plant site areas. Collected contact water that is not used in ore processing will be treated at the effluent treatment plant (ETP) and discharged to the southeast arm of Springpole Lake in accordance with permitting requirements.
		•	•	A geosynthetic clay liner will be installed on the upstream side of the perimeter embankment of the CDF south cell (specifically the south, west, and east sides) to mitigate seepage potential during the operation and closure phases.
	•	–	•	Revegetation and encouragement of natural revegetation / recolonization of disturbed areas, will be undertaken as part of progressive and final reclamation to minimize the length of time disturbed areas are exposed to reduce infiltration.
	–	–	•	During the filling of the open pit basin, accelerate the return of groundwater levels to baseline conditions, by transferring water from Springpole Lake in a controlled manner while maintaining lake water levels in Springpole Lake within natural variation.
Change in groundwater quality	•	•	–	Development of a compact mine site to limit the areal extent of disturbance, and to limit the overall areas of contact water that requires management.
	•	•	•	Locating the CDF on favourable geologic conditions at the Project site to support long-term stability and effective seepage management.
	•	•	•	An integrated water management system will be operated to collect and control all contact water from the stockpiles, CDF and plant site areas. Collected contact water that is not used in ore processing will be treated at the effluent treatment plant (ETP) and discharged to the southeast arm of Springpole Lake in accordance with permitting requirements.
	•	•	–	Water collection ditches will be constructed and operated around the perimeter of key infrastructure, including the CDF and stockpiles, to collect overland flow and seepage and direct it to the integrated water management system.

Table 6.5-5: Proposed Mitigation Measures for Potential Groundwater Effects

	Phase			
Pathways to potential effect	**Con.**	**Op.**	**Cl.**	**Proposed Mitigation Measure**
	●	●	–	Best management practices (such as following approved blasting plans, and using appropriate drilling, explosive handling and loading procedures) will be implemented for the use of explosives to reduce the potential presence of blasting residuals on mine rock stored in the CDF that could otherwise infiltrate into groundwater.
	●	–	–	A geosynthetic clay liner will be installed on the upstream side of the perimeter embankment of the CDF south cell (specifically the south, west, and east sides) to mitigate seepage potential during the operation and closure phases.
	●	–	●	Revegetation and encouragement of natural revegetation / recolonization of disturbed areas, will be undertaken as part of progressive and final reclamation to minimize the length of time disturbed areas are exposed to reduce infiltration.
	–	–	●	During the filling of the open pit basin, accelerate the return of groundwater levels to baseline conditions, by transferring water from Springpole Lake in a controlled manner while maintaining lake water levels in Springpole Lake within natural variation.

Notes:
Con: Construction Op: Operation Cl: Closure
● Mitigation is applicable
– Mitigation is not applicable

Table 6.5-6: Summary of Predicted CDF Seepage Water Quality

Parameter	Baseline Groundwater Quality (1)	Water Quality Guideline (2)	Seepage Quality Operations (3)		Seepage Quality Initial Closure		Seepage Quality Final Closure (4)	
			Base Case	Conservative Case	Base Case	Conservative Case	Base Case	Conservative Case
Sulphate	24.9	-	2200	2200	2200	2200	27	111
Aluminum, Dissolved	0.0428	0.075	0.637	0.82	0.637	0.82	0.58	0.97
Antimony, Dissolved	0.00038	0.02	0.553	0.551	0.553	0.551	0.012	0.021
Arsenic, Dissolved	0.00221	0.005	0.0000236	0.0000507	0.00002	0.00005	0.0121	0.0203
Beryllium, Dissolved	0.00005	1.1	0.0000000174	0.0000000231	0.0000000174	0.0000000231	0.00000768	0.0000221
Boron, Dissolved	0.0135	0.2	0.325	0.354	0.325	0.354	0.035	0.098
Cadmium, Dissolved	0.0000143	0.00029	0.000109	0.000275	0.000109	0.000275	0.0000277	0.00207
Chromium, Dissolved	0.000405	0.0078	0.00432	0.00695	0.00432	0.00695	0.0051	0.0057
Cobalt, Dissolved	0.00066	0.0009	0.0569	0.0666	0.0569	0.0666	0.000696	0.0397
Copper, Dissolved	0.00356	0.004	0.000765	0.000811	0.000765	0.000811	0.00264	0.00316
Iron, Dissolved	1.9	0.3	0.0000479	0.0000444	0.0000479	0.0000444	0.000044	0.00005
Lead, Dissolved	0.0000545	0.005	0.000000435	0.000000492	0.000000435	0.000000492	0.00018	0.000162
Mercury, Dissolved	0.0000025	0.000026	0.000138	0.000149	0.000138	0.000149	0.0000489	0.0000568
Molybdenum, Dissolved	0.00289	0.04	0.03	0.03	0.03	0.03	0.0045	0.071
Nickel, Dissolved	0.00194	0.025	0.00378	0.00418	0.00378	0.00418	0.00295	0.0205
Phosphorus, Dissolved	0.025	0.02 / 0.03	0.00535	0.013	0.00535	0.013	0.16	0.398
Selenium, Dissolved	0.000183	0.002	0.0358	0.038	0.0358	0.038	0.0012	0.0041
Silver, Dissolved	0.000005	0.0001	0.000523	0.000675	0.000523	0.000675	0.00013	0.00056
Thallium, Dissolved	0.000005	0.0003	0.00442	0.00472	0.00442	0.00472	0.00016	0.00042
Tungsten, Dissolved	0.00246	-	0.03	0.03	0.03	0.03	0.00239	0.00367
Uranium, Dissolved	0.000828	0.015	0.0932	0.0937	0.0932	0.0937	0.0022	0.0028
Vanadium, Dissolved	0.000935	0.006	0.00000272	0.00000474	0.00000272	0.00000474	0.00927	0.00969
Zinc, Dissolved	0.0036	0.02	0.00281	0.00434	0.00281	0.00434	0.0104	0.0435

Notes:

All units are mg/L.

(1) Equivalent to 75th percentile baseline groundwater quality (Table 6.5-1).

(2) Surface water quality guidelines are not directly applicable to groundwater quality and are here provided for benchmarking / comparison purposes only. Water quality guidelines represent both federal and provincial criteria. Where applicable, guideline values are calculated here using average baseline groundwater hardness (204 mg $CaCO_3$/L), and average pH (7.64).

(3) Operations seepage predictions represent average and maximum monthly concentrations for Year 10 of mining (maximum extent of mine operations).

(4) Final closure represents the future condition where residual pore water has been completely released from the tailings pile, and the only loading sources are the covered tailings and mine rock.

Grey highlighted numbers are higher than the identified surface water quality guideline.

Table 6.5-7: Groundwater model Simulations

Simulation ID	Model Configuration	Sensitivity Parameter	Parameter Change
Baseline	Premining Conditions	-	-
End of mine operations	End of Mine Operations	-	-
Final Closure	Post-Closure	-	
Variant 0	End of Mine Operations	Groundwater Recharge	Increase by 50%
Variant 1	End of Mine Operations	'Other' Host Rock K	Increase ×3.2 (half-order)
Variant 2	End of Mine Operations	CDF Rock K	Increase ×3.2 (half-order)
Variant 3(1)	End of Mine Operations	E-W Fault SW-2	Impermeable to Manufacturer Specific Upper Limit (2)
Variant 4	End of Mine Operations	Low RQD Zone Extent	Increase Extent by 200 m
Variant 5	End of Mine Operations	Lakebed Sediment K	Increase ×3.2 (half-order)
Variant 6	Post-Closure	CDF Shallow Rock K	Increase ×3.2 (half-order)
Variant 7	Post-Closure	Overburden K	Increase ×3.2 (half-order)
Variant 8	Post-Closure	South Cell Tailings K	Increase ×3.2 (half-order)
Variant 9	Post-Closure	North Cell Recharge	Increase to 300 mm/year
Variant 10(1)	Post-Closure	E-W Fault SW-2	Introduced to Model
Variant 11	2D South Cell Post-Closure	Liner K	Impermeable to Manufacturer Specific Upper Limit (2)

Note:

(1) Fault SW-2 simulated as an approximately 40 m width feature with a hydraulic conductivity of 2×10^{-6} m/s (i.e., the same as the Low RQD zone). This superseded bedrock layers from surface to the bottom of the model.

(2) Manufacturer specifications for the liner indicate a maximum liner permeability of 5×10^{-11} m/s (Terrafix, 2023).

Table 6.5-8: Predicted Groundwater Budgets and Open Pit Inflow Rates(1)

Variant	Groundwater Budget (m^3/day)	Hydrological Node Groundwater Budget (m^3/day)								
		L-1	L-19	L-20	L-16	Springpole Lake	Birch Lake			-
		Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Open Pit
Premining	**Net**	54	9	-10	61	1,031	234	179	672	
End of mine operations (2)	**Net**	-235	-49	-13	42	-657	-2	134	566	3,034
	Change	-289	-58	-3	-19	-1,688	-236	-45	-106	-
Variant 0	**Net**	-189	-10	9	54	-503	57	155	853	3,162
	Change	-243	-19	19	-7	-1,534	-177	-24	181	-
Variant 1	**Net**	-751	-294	-129	37	-2,368	-245	107	367	6,628
	Change	-805	-303	-119	-24	-3,399	-479	-72	-305	-
Variant 2	**Net**	-271	-49	-13	53	-985	-135	162	615	4,161
	Change	-325	-58	-3	-8	-2,016	-369	-17	-57	-
Variant 3	**Net**	-236	-50	-14	54	-826	-3	127	460	3,524
	Change	-290	-59	-4	-7	-1,857	-237	-52	-212	-
Variant 4	**Net**	-473	-87	-17	39	-7,308	-206	108	482	10,630
	Change	-527	-96	-7	-22	-8,339	-440	-71	-190	-
Variant 5	**Net**	-238	-50	-15	38	-790	-11	114	562	3,095
	Change	-292	-59	-5	-23	-1,821	-245	-65	-110	-
Post-Closure	**Net**	54	-2	-9	38	628	164	113	641	-
	Change	0	-11	1	-23	-403	-70	-66	-31	-
Average Annual Surface Flow – Baseline (m^3/day)		294	518	-	725	1,030,000	587,520			-

Note:
(1) Groundwater model domain does not completely encapsulate the watershed for several large features. As such, the 'Net' values in Table 6.5-5 should only be considered for relative differences between model variants. The 'Change' values, however, are representative for groundwater budget changes.
(2) End of Mine Operations.

Table 6.5-9: Simulated Seepage to Receivers for Mine Operations

Receiver	Hydrological Node	Seepage from CDF North Cell (m³/day)	Seepage from CDF South Cell (m³/day)	Seepage from Low Grade Ore Stockpile (m³/day)	Seepage from Medium-High Grade Ore Stockpile (m³/day)
L-1	1	0	0	0	0
L-19	2	0	0	0	0
L-20	3	0	0	0	0
L-16	4	3	5	0	0
Springpole Lake	5	0	12	0	0
Birch Lake	6	5	0	0	0
	7	50	0	0	0
	8	28	0	10	0
Open Pit	-	167	134	66	30
Seepage Collection System Capture(1)		694	372	-	-
Total2		947	523	76	30

Note:

(1) Includes portion discharging at downstream outer embankment toes.

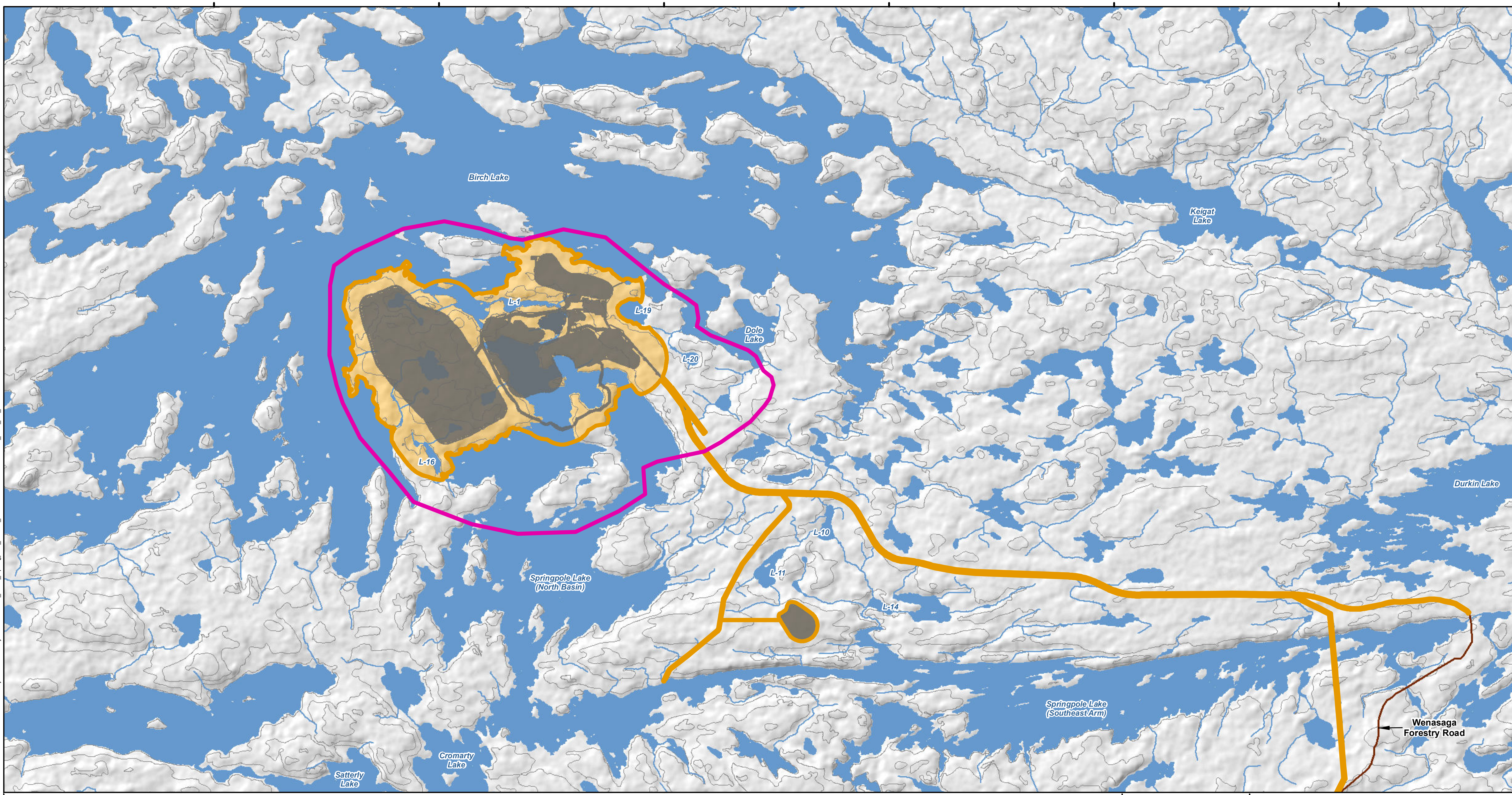
(2) The total represents the amount of seepage entering the model at the CDF boundary conditions.

Table 6.5-10: Simulated Seepage to Receivers for Post Closure

Receiver	Hydrological Node	Seepage from CDF North Cell (m³/day)	Seepage from CDF South Cell (m³/day)
L-1	1	0	0
L-19	2	0	0
L-20	3	0	0
L-16 + L-6	4	0	5
Springpole Lake	5	0	24
Birch Lake	6	19	0
	7	26	0
	8	26	0
Open Pit Area(1)	-	21	19
Shallow Seepage		855	475
Total		948	523

Table 6.5-11: Summary of Post-Closure Variant Seepages

Variant	South Cell Seepage (m³/day)			North Cell Seepage (m³/day)		
	Total	Capture	Bypass	Total	Capture	Bypass
Post-Closure[(1)]	523	475	48	947	855	92
Variant 6	790	746	44	947	835	112
Variant 7	545	491	54	947	827	120
Variant 8	866	814	52	947	866	81
Variant 9	509	463	46	1423	1297	126
Variant 10	526	404	122	947	844	103



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LEGEND

- Proposed Mine Feature
- Project Development Area
- Local Study Area for Groundwater
- Existing Road
- Watercourse
- Waterbody
- Contour (10 m intervals)

0 1 2 4 6 8 10 Kilometres

NOTES:
- Topographic information extracted from LIO, MNRF.
- Proposed site plan provided by Ausenco, drawing number 104496-GX-03000-31344-003, Rev 1. 26 June 2023 and modified by WSP July 2023.

Datum: NAD83
Projection: UTM Zone 15N

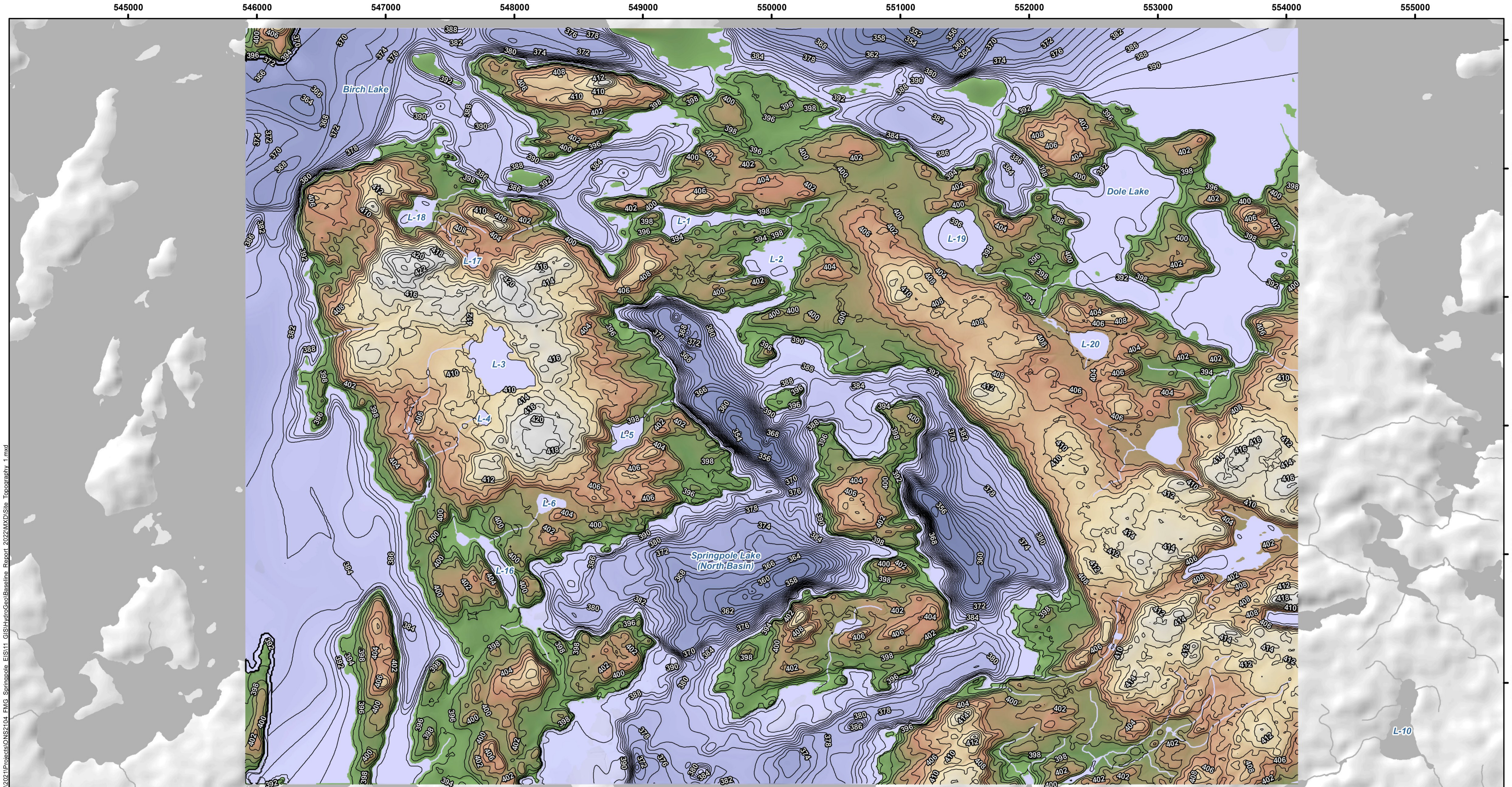
FIRST MINING GOLD

WSP

SPRINGPOLE GOLD PROJECT

Local Study Area for Groundwater

PROJECT N°: ONS2104	**FIGURE: 6.5-1**
SCALE: 1:65,000	DATE: February 2024



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LEGEND

—— Contours (2 metre interval)

Elevation (masl)

424

352

NOTES:

Datum: NAD83
Projection: UTM Zone 15N

FIRST MINING GOLD

wsp

SPRINGPOLE GOLD PROJECT

Site Topography

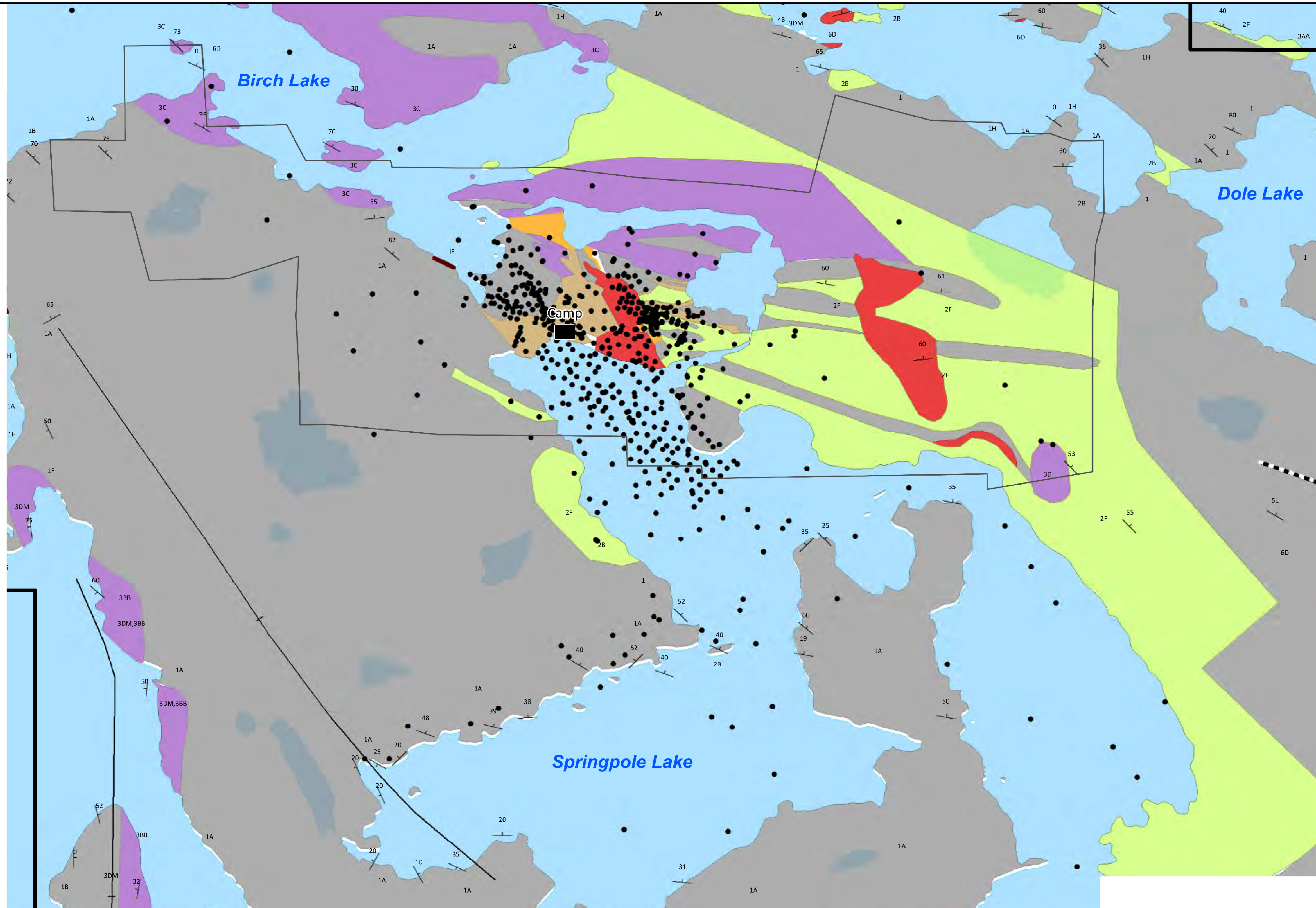
PROJECT N°: ONS2104

FIGURE: 6.5-2

SCALE: 1:28,000

DATE: July 2023

0 0.5 1 2 3 4 5 Kilometres



LEGEND

- Drillhole Collar
- Camp
- Property Outline
- Patents Outline

Geology Mapping 20k Scale

- 1-Mafic to Intermediate Metavolcanics; 1A-Massive Lava
- 2-Intermediate to Felsic Metavolcanics; 2B-Intermediate to Felsic Tuff
- 2A-Rhyolite
- 3AA-Clastic Sediment; 3C-Conglomerate; 3DM-Metasediments; 3BB-Siltstone and Greywacke; 3
- 6B-Quatz Porphyry
- 6D-Feldspar Porphyry
- B
- O
- Lithology Observation
- Structure Strike/Dip
- BIF
- Shear
- Anticline
- Syncline

NOTES:
- Site bedrock geology provided by FracFlow Consultants Inc., Hydrogeology Baseline Report 19 February 2021.

First Mining Gold

wsp

SPRINGPOLE GOLD PROJECT

Local Geologic Setting

Datum: NAD83
Projection: UTM Zone 15N

PROJECT N°: ONS2104	**FIGURE: 6.5-3**
SCALE: 1:21,000	DATE: October 2023

Kilometres

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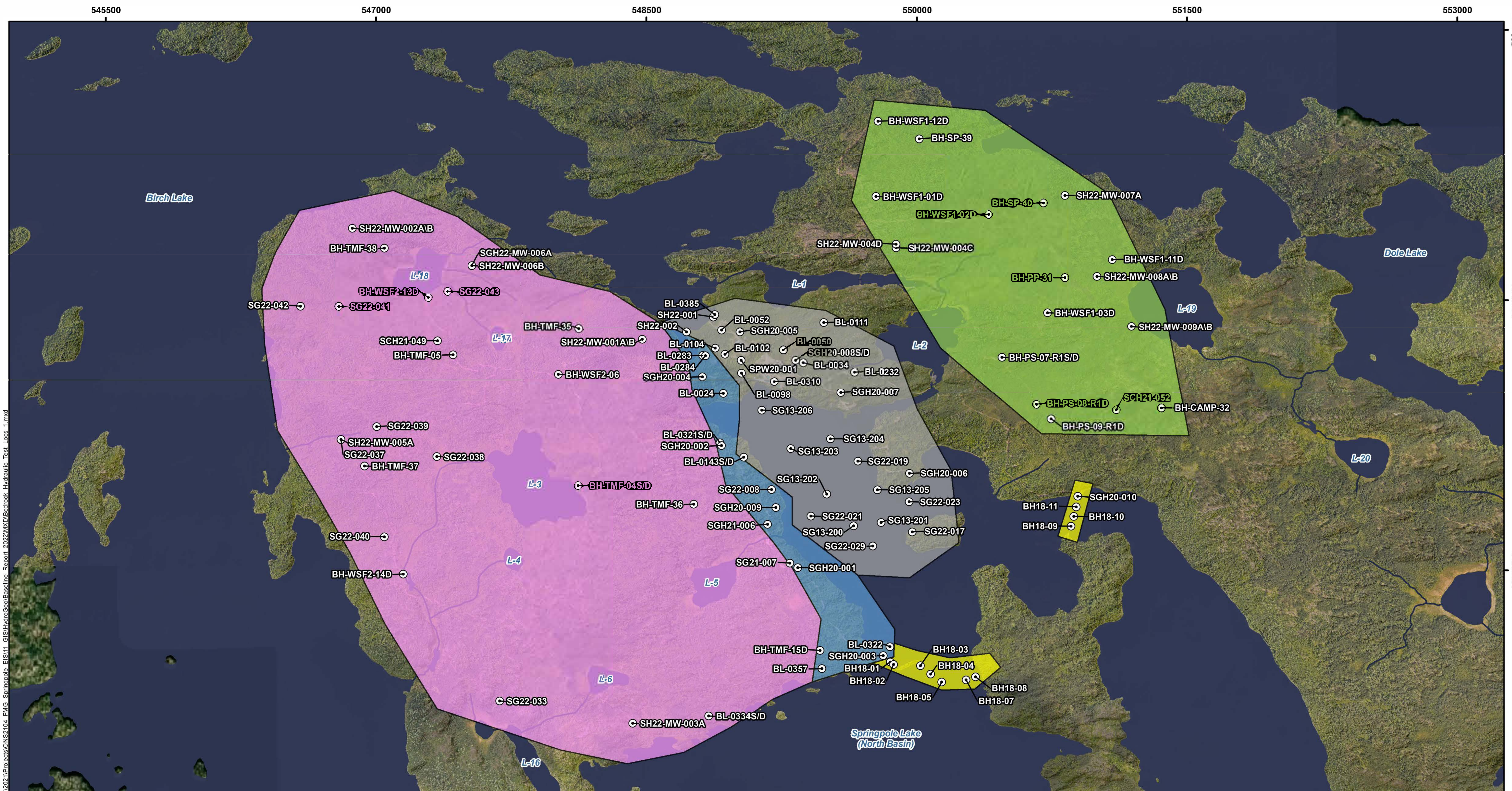

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LEGEND

- Watercourse
- Waterbody
- Hydraulic Test Location

Host Rock Locations

- Co-Disposal Facility
- Open Pit
- Open Pit / Co-Disposal Facility
- Dike
- East

NOTES:
- Topographic information extracted from LIO, MNRF.
- Aerial imagery provided by First Mining Gold, August 2020.

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 5 Kilometres

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SPRINGPOLE GOLD PROJECT

Bedrock Hydraulic Test Locations

PROJECT N°: ONS2104	FIGURE: 6.5-4
SCALE: 1:20,000	DATE: July 2023

LEGEND

- Monitoring Well
- Monitoring Well with Transducer
- Vibrating Wire Piezometer
- Watercourse
- Waterbody

NOTES:
- Topographic information extracted from LIO, MNRF.
- Aerial imagery provided by First Mining Gold, August 2020.

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 5 Kilometres

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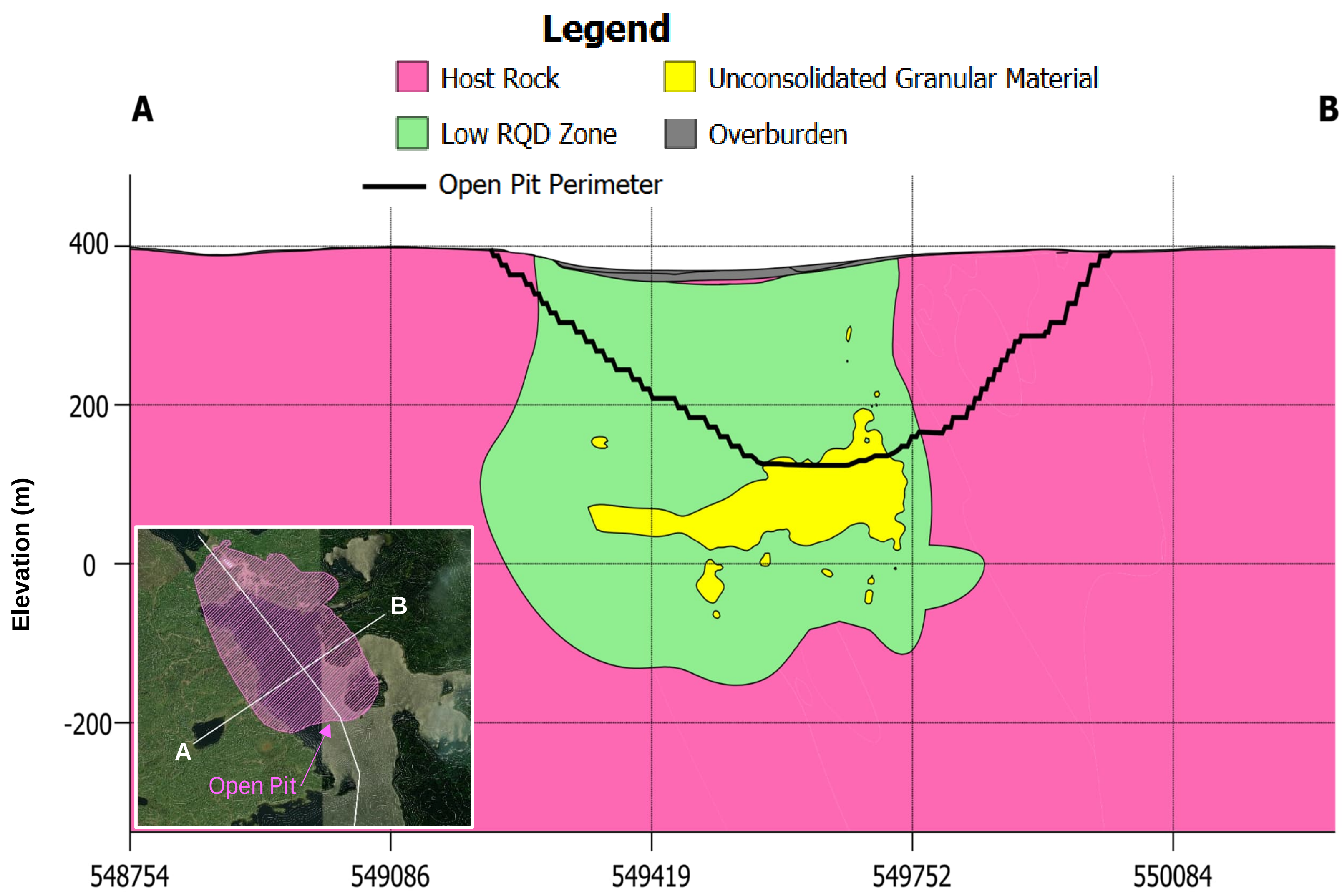
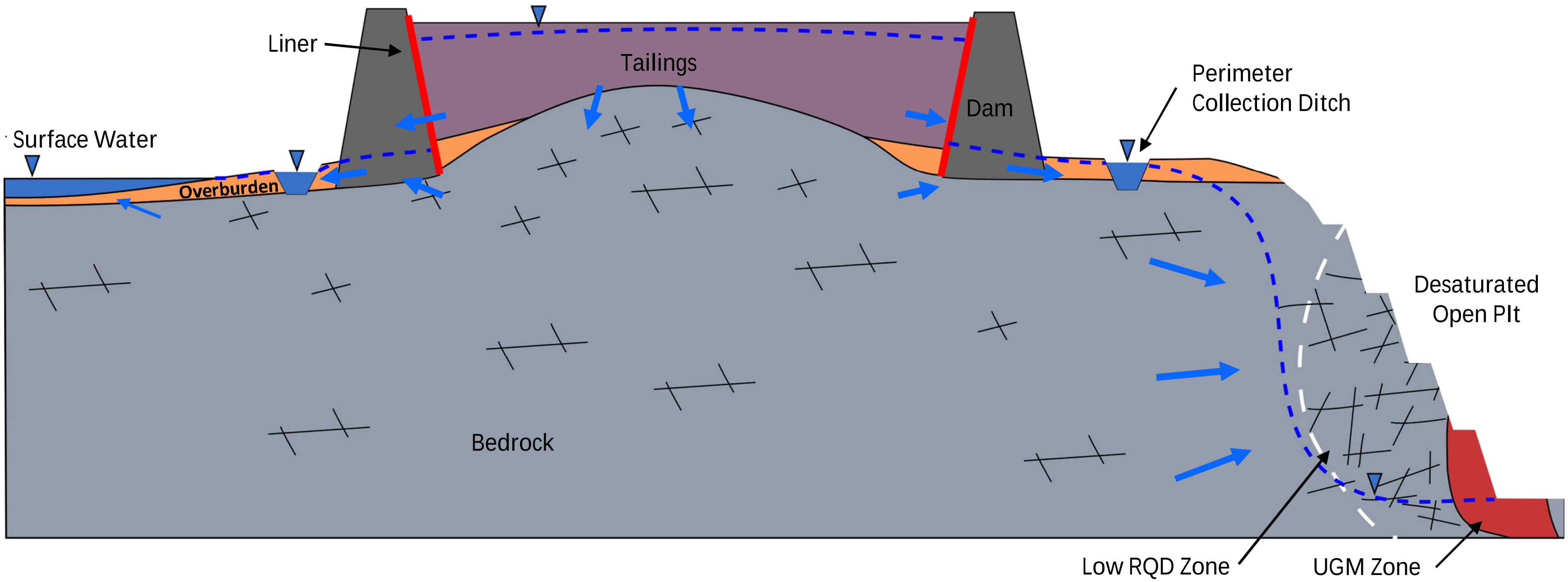
SPRINGPOLE GOLD PROJECT

Groundwater Monitoring Installation Locations

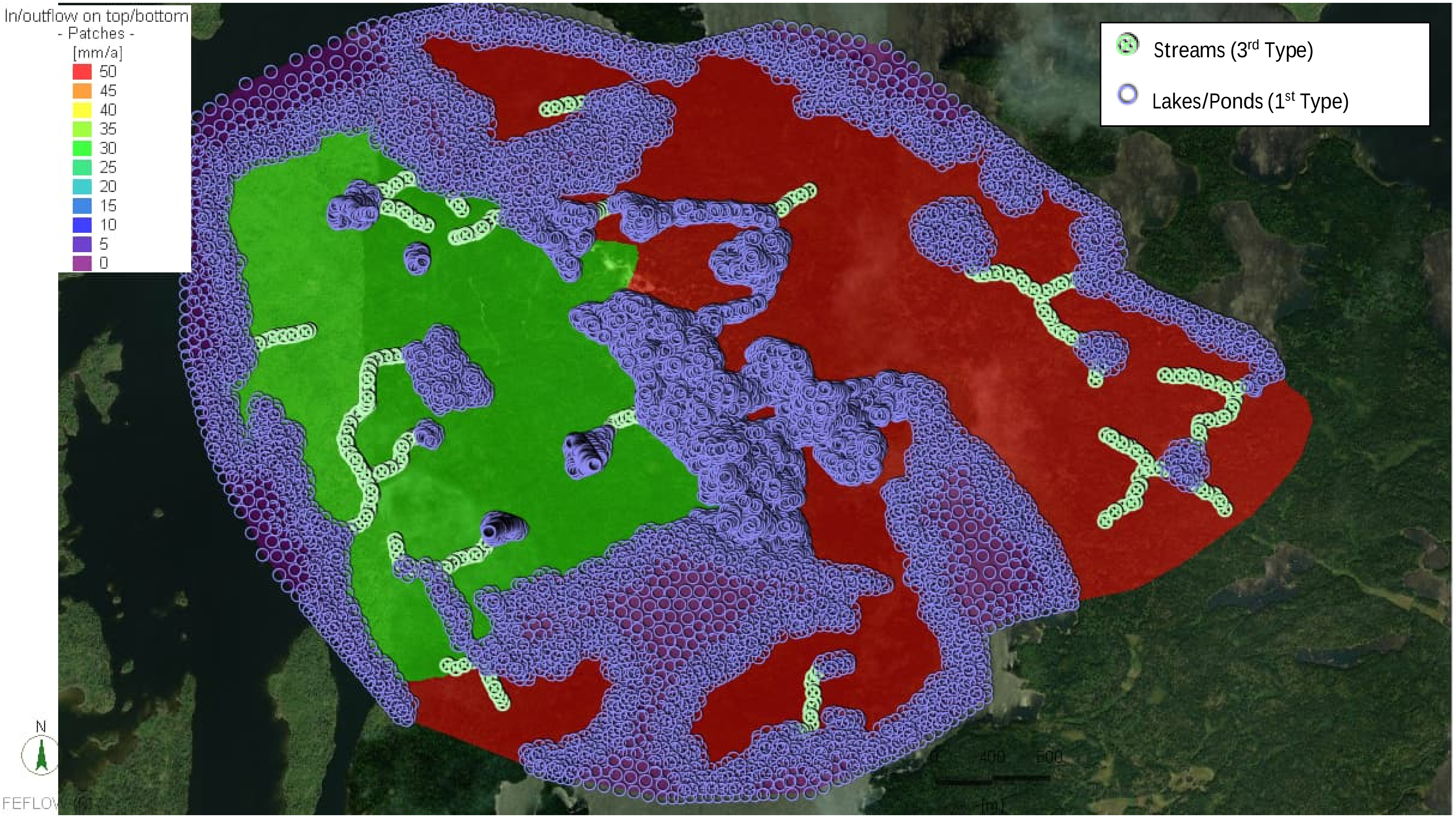
PROJECT N°: ONS2104	FIGURE: 6.5-5
SCALE: 1:20,000	DATE: July 2023



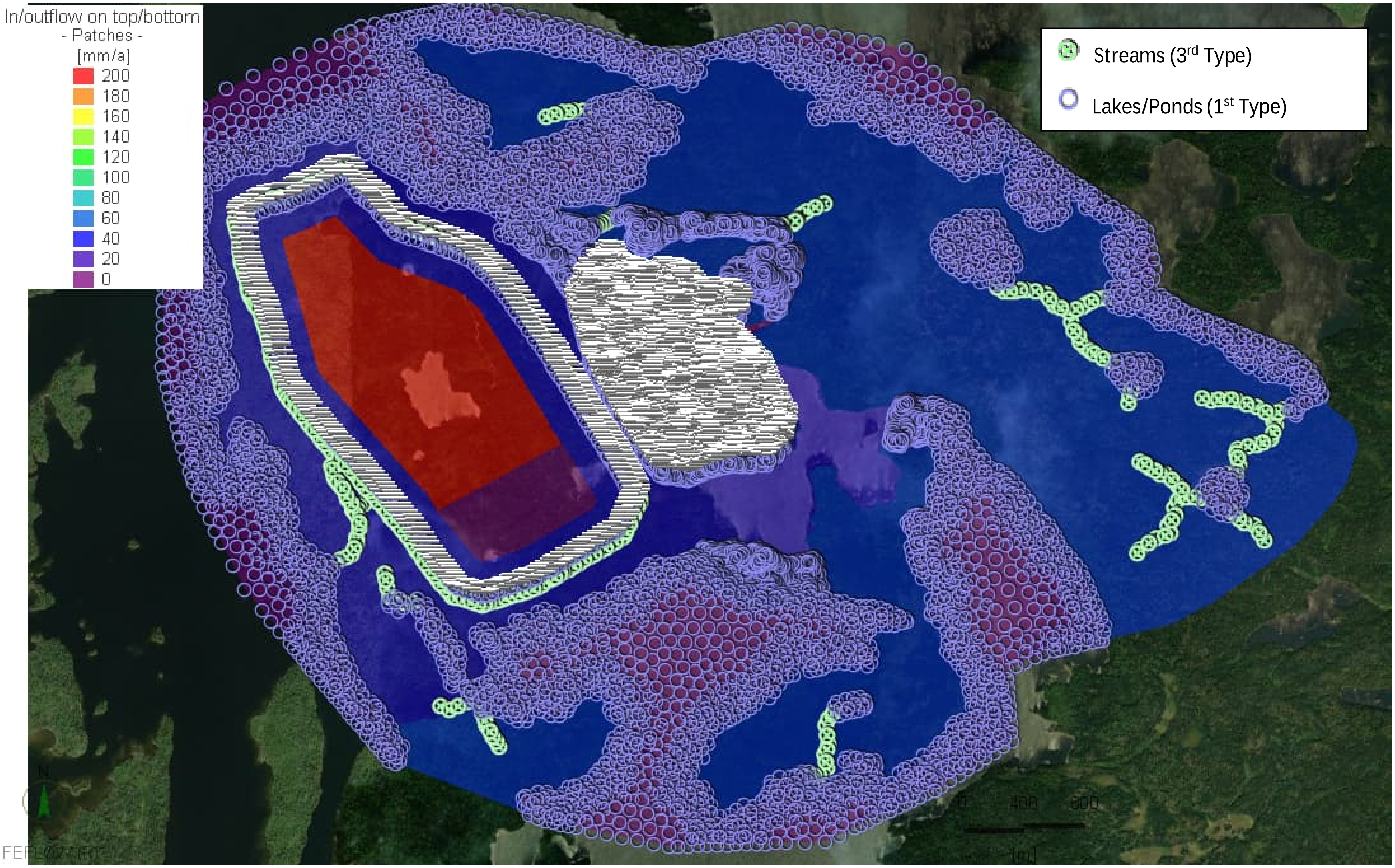
First Mining Gold	Figure No: 6.5-6	Springpole Gold Project
	Project No: ONS2104	
wsp	Date: 29-Jun-23	Hydrostratigraphic Model Section – Transverse to Open Pit
	Rev: 0	



FIRST MINING GOLD	Figure No:6.5-7	Springpole Gold Project
	Project No: ONS2104	
WSP	Date: 29-Jun-23	Conceptual Diagram for End of Mine Operations Conditions
	Rev: 0	



FIRST MINING GOLD	Figure No: 6.5-8	Springpole Gold Project
	Project No: ONS2104	
WSP	Date: 24-Oct-23	Pre-mining Model Boundary Conditions
	Rev: 0	



First Mining Gold	Figure No: 6.5.-9	Springpole Gold Project
	Project No: ONS2104	
wsp	Date: 24-Oct-23	End of Operations Mining Phase Boundary Conditions
	Rev: 0	