5.4 Geology, Soil and Sediment

5.4.1 Rationale for Valued Component Selection

Geology, soil, and sediment are selected as a VC due to the potential for sediment laden runoff from Project infrastructure to be transported to nearby watercourses and wetlands, and due to the potential for ARD to be produced during exposure of sulphide-bearing bedrock to oxygen and surface water runoff. ARD is provincially regulated through the *Sulphide Bearing Material Disposal Regulations.*

Soil and sediment quality may facilitate exposure of birds, fauna, and fish to contaminants through ingestion. Mine tailings produced from historic mining operations between 1893 and 1958 are present in the sediments of Gold Brook and low-lying areas south of Gold Brook Lake. Contaminated soil and sediment are provincially regulated via the *Contaminated Sites Regulations*.

5.4.2 Baseline Program Methodology

5.4.2.1 Soil Sampling Program

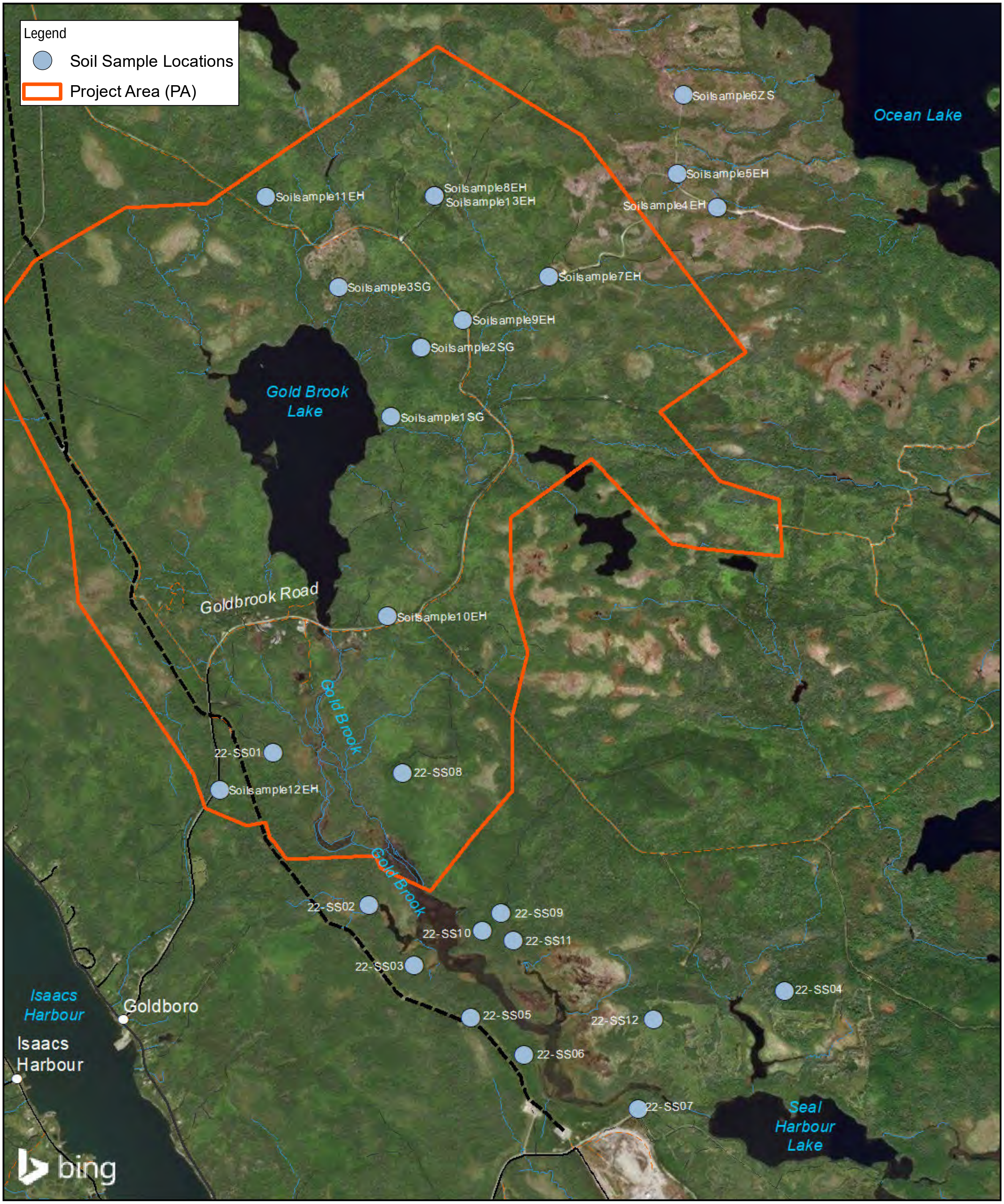
Soil samples were collected at 24 locations in the vicinity of the PA in 2021 and 2022 to provide baseline soil quality conditions. Samples were collected by McCallum Environmental Ltd. (MEL) between August 17 and September 1, 2021, by Signal Gold on October 14, 2021, and by GHD on March 10, 2022. Collected samples were placed in coolers with ice/cold packs until delivery to Bureau Veritas (BV Labs) in Bedford, NS, where they were analyzed for metals, mercury, and polycyclic aromatic hydrocarbons (PAHs). Baseline surface soil sample locations are shown in Figure 5.4-1. A summary of the baseline soil sampling program is provided in Table 5.4-1.

Table 5.4-1 Baseline Surface Soil Sampling Program

Sample ID	Company	Sample Depth (meters below ground surface (mbgs))	Analyses		
			Metals/Inorganics	Mercury	PAHs
SOIL SAMPLE 1 SG	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 2 SG	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 3 SG	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 4 EH	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 5 EH	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 6 ZS	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 7 EH	MEL	0 – 0.25	●	●	●
SOIL SAMPLE 8 EH	MEL/Signal Gold	0 – 0.25	●	●	●
SOIL SAMPLE 9 EH	MEL/Signal Gold	0 – 0.25	●	●	●
SOIL SAMPLE 10 EH	MEL/Signal Gold	0 – 0.25	●	●	●
SOIL SAMPLE 11 EH	MEL/Signal Gold	0 – 0.25	●	●	●
SOIL SAMPLE 12 EH	MEL/Signal Gold	0 – 0.25	●	●	●
22-SS01	GHD	0 – 0.25	●	●	●
22-SS02	GHD	0 – 0.25	●	●	●
22-SS03	GHD	0 – 0.25	●	●	●

Table 5.4-1 Baseline Surface Soil Sampling Program

Sample ID	Company	Sample Depth (meters below ground surface (mbgs))	Analyses		
			Metals/Inorganics	Mercury	PAHs
22-SS04	GHD	0 – 0.25	●	●	●
22-SS05	GHD	0 – 0.25	●	●	●
22-SS06	GHD	0 – 0.25	●	●	●
22-SS07	GHD	0 – 0.25	●	●	●
22-SS08	GHD	0 – 0.25	●	●	●
22-SS09	GHD	0 – 0.25	●	●	●
22-SS10	GHD	0 – 0.25	●	●	●
22-SS11	GHD	0 – 0.25	●	●	●
22-SS12	GHD	0 – 0.25	●	●	●



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0 300 600 900

Metres

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

GHD

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

SOIL SAMPLE LOCATIONS

Project No. 11222385
Revision No. -
Date 31/05/2022

FIGURE 5.4-1

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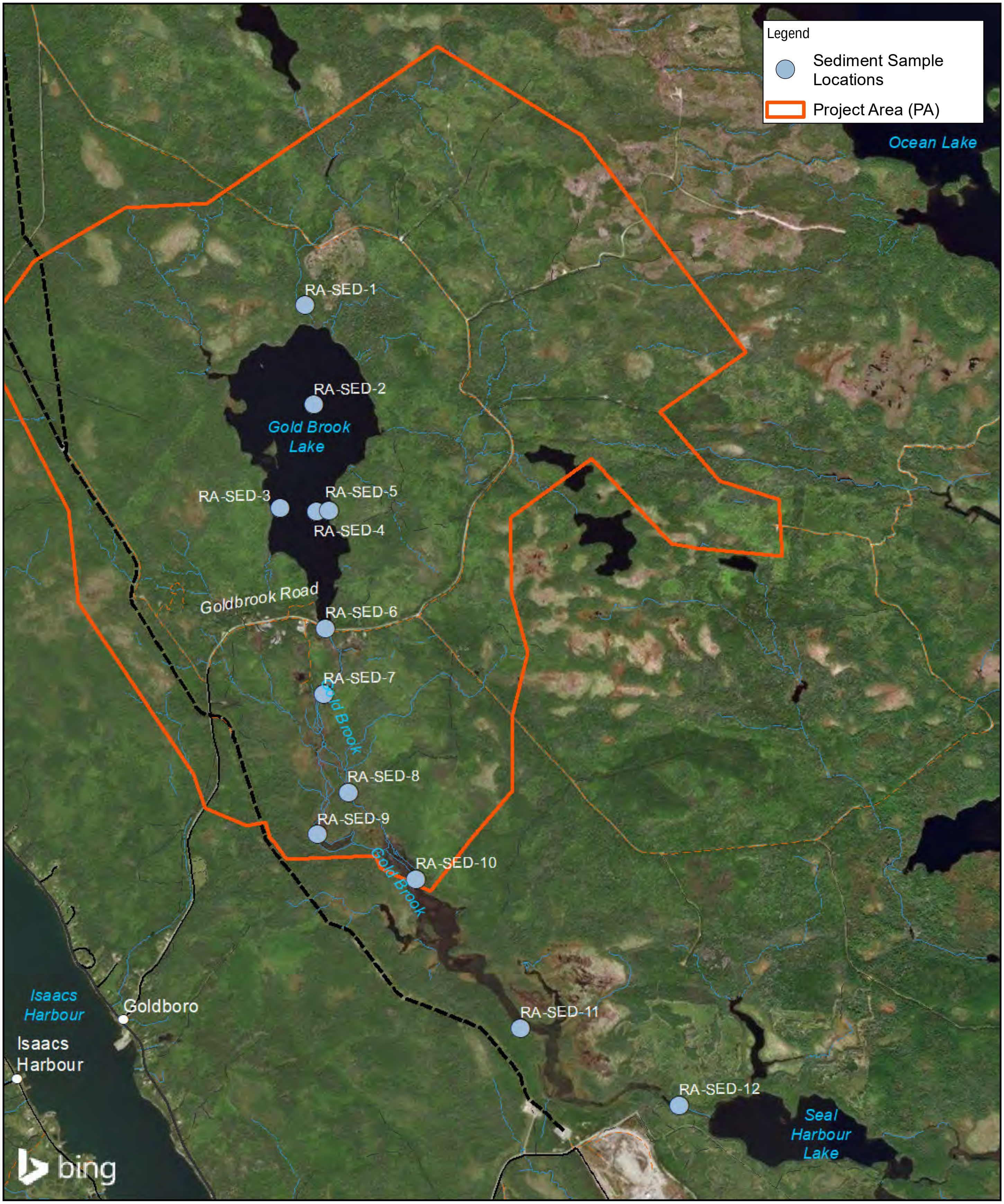
5.4.2.2 Sediment Sampling Program

Baseline sediment samples were collected at 12 locations in the vicinity of the PA by GHD on September 1 and 2, 2021. The samples were collected from 0 to 0.20 m below the sediment-water interface using a petite-ponar grab-sampler deployed from a boat and/or a stainless-steel trowel depending on sediment location. During sample collection, new gloves (e.g., disposable nitrile gloves) were worn for the collection of each sample. Between sample locations, the petite-ponar grab sampler and trowel were thoroughly cleaned to eliminate cross contamination. Sediment samples were collected commencing with the most downstream sample to avoid sediment interference with other downstream samples.

Collected samples were placed in coolers with ice/cold packs until delivery to BV Labs in Bedford, NS. Chemical analysis of sediments focused on inorganics, specifically metals. Baseline sediment sample locations are shown in Figure 5.4-2. A summary of the baseline sediment sampling program is provided in Table 5.4-2.

Table 5.4-2 Baseline sediment sampling program

Sample ID	Location	Analyses
		Metals/Inorganics
RA-SED-1	Watercourse (WC) 49	●
RA-SED-2	Gold Brook Lake	●
RA-SED-3	Gold Brook Lake	●
RA-SED-4	Gold Brook Lake	●
RA-SED-5	Gold Brook Lake	●
RA-SED-6	Gold Brook Lake	●
RA-SED-7	Gold Brook	●
RA-SED-8	Gold Brook	●
RA-SED-9	WC 64	●
RA-SED-10	Gold Brook	●
RA-SED-11	Gold Brook	●
RA-SED-12	Gold Brook	●



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Metres

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

SEDIMENT SAMPLE LOCATIONS

Project No. 11222385
Revision No. -
Date 31/05/2022

FIGURE 5.4-2

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5.4.2.3 Historic Tailings Assessment

Historic tailings in the vicinity of the PA were sampled and characterized in baseline studies conducted by the Geological Survey of Canada (GSC), Signal Gold, and others between 2003 and 2021. A limited Phase I and Phase II Environmental Site Assessment (ESA) was conducted in 2021 targeting historic tailings within the proposed mineral lease area for the Project. The Limited Phase I and Phase II ESA report is provided in Appendix E.2.

The Phase I ESA consisted of a records review, site visit observations, an evaluation of information available from previous site work, and a screening of known areas of historic tailings within the area of Upper Seal Harbour. The Phase II ESA included collection of samples from five previously identified historic tailings areas, a review of analytical data, and recommendations for further assessment.

To better define the potential impact of Project activities on historic tailings, a screening table was generated to summarize available information on 17 previously identified areas of historic tailings in the vicinity of Goldboro. Tailings areas labelled A through Q are shown in Figure 5.4-3. Based on a review of previous tailings delineations (produced using sampling completed by GSC, WSP, and Signal Gold), historic tailings areas F through Q are not anticipated to be directly or indirectly impacted by proposed Project infrastructure and were not retained for further investigation. Five tailings areas, A through E, are located in the vicinity of the Project and are likely to be disturbed by Project activities. These five areas were the focus of further investigation in the limited Phase II ESA.

To delineate the horizontal extent of these areas, a total of 272 delineation points were manually inspected, including descriptions of lithology and any historic tailings material encountered. Using a hand auger, the samples were collected from ground surface to a maximum depth of 1.5 m, or subject to refusal. A total of 84 delineation points were sampled for soil analysis and submitted to BV Labs in Bedford, NS, and to Eastern Analytical in Springdale, NL. Sample analysis was based on the field observations and included a combination of the following analyses: general chemistry and available metals, available mercury, total metals, leachable arsenic, total organic carbon (TOC), modified acid-base counting and grain size analysis. The locations of samples and delineation points collected as part of the limited Phase II ESA are shown in Figure 5.4-4.

Quality assurance/quality control (QA/QC) protocols were followed to ensure the integrity of the results. These included the in-house QA/QC programs implemented by the accredited laboratories and the collection of blind field duplicates for over 10% of parameters that were analyzed.

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

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ENVIRONMENTAL ASSESSMENT

HISTORIC TAILINGS AREAS

Project No. 11222385
Revision No. -
Date 31/05/2022

FIGURE 5.4-3

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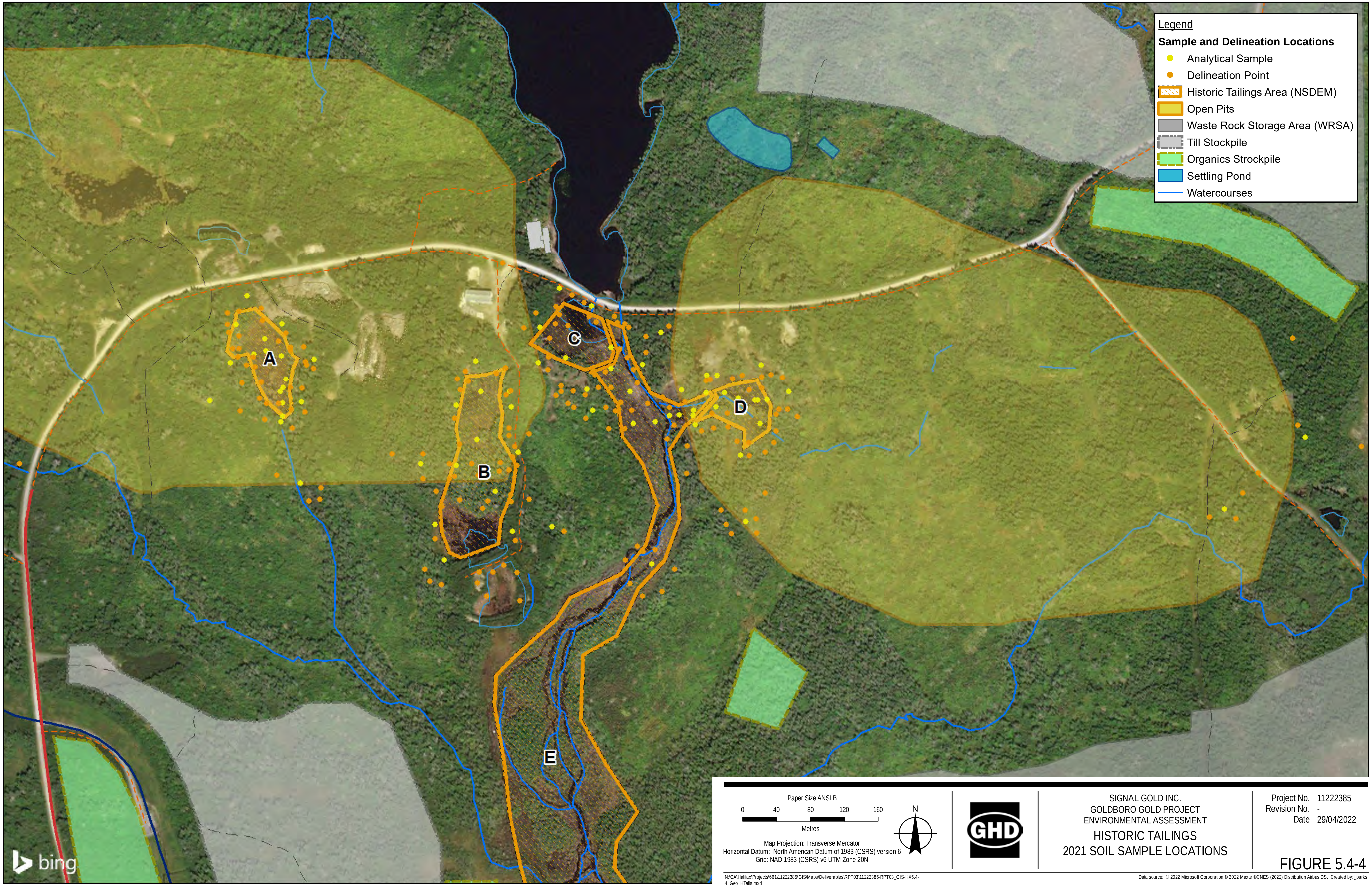

Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

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HISTORIC TAILINGS
2021 SOIL SAMPLE LOCATIONS

Project No. 11222385
Revision No. -
Date 29/04/2022

FIGURE 5.4-4

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5.4.2.4 Drilling Programs

A total of 682 surface and underground drill holes consisting of 121,776 m were completed between 1984 and 2021 (Nordmin, 2021) to confirm the geological interpretation of the ore deposit at the PA. A chronological summary of the drill programs is described in Table 5.4-3.

All drilling completed from 2017 to 2021 consisted of recovering NQ or HQ size core using conventional wireline drilling equipment. Core logging, geological interpretations and mineralogical/geochemical studies, core sampling, downhole surveying, and collar location surveying were also conducted for each drilling program during this period.

All programs between 1984 and 2017 were carried out to industry standards of their respective periods. They included detailed and systematic geological logging, sampling, and reporting procedures as well as systematic recording of downhole survey data (Nordmin, 2021).

Table 5.4-3 Drill Programs Summary

Years	Metres	No. Holes	Company
1984	529	1	Onitap Resources Inc.
1985	390	5	Onitap Resources Inc.
1987	13,545	40	Petromet Resources Ltd. and Greenstrike Gold Corp., Onitap Resources Inc.
1988	11,281	44	Orex
1988 to 1990	4,979	112	Orex
1989	2,811	26	Orex
1991	722	5	Minnova
1993	593	6	Orex
1995	1,263	7	Placer
2005	2,422	23	Orex
2008	12,065	45	Orex
2010	12,998	59	Osisko
2011	2,375	10	Osisko
2017	4,196	13	Signal Gold
2018	18,277	61	Signal Gold
2019	5,734	33	Signal Gold
2020	17,942	121	Signal Gold
2021	9,654	71	Signal Gold

5.4.2.5 Metal Leaching and Acid Rock Drainage Assessment

Lorax Environmental Services Ltd (Lorax) initiated a comprehensive ML/ARD program in 2020, considering the proposed dimensions of the East and West Pits, that included static and kinetic testing of waste rock, ore, tailings, and overburden (till and organic material).

A total of 188 rock samples (waste rock and ore) were collected in 2020 and submitted for static testing. All samples were submitted for acid-based accounting (ABA) and solid phase metals analysis, while a subset of samples underwent more advanced geochemical and mineralogical analyses. A total of eight tailings samples were submitted for geochemical test work, two of which represent “master” composite samples considered representative of bulk tailings material to be produced during operations. Six samples were collected from the historic tailing deposits south of Gold Brook Lake and were submitted for ABA and a subset of four samples was submitted for Shake Flask Extraction (SFE) testing. Finally, 28 overburden samples (16 till samples and 12 organic material samples) were collected and submitted for static testing consisting of ABA, solid phase metals analysis and SFE testing. A summary of the 2020-2021 static testing program is provided in Table 5.4-4.

Table 5.4-4 2020-2021 Static Testing Summary

Methods	Description	Number of Samples	Conducted By
Mineralogy	Quantitative Evaluation of Minerals by SCANning electron microscopy (QEMSCAN) analysis	14 (waste rock)	SGS Lakefield
	TESCAN Integrated Mineral Analyser (TIMA) analysis	1 (Tailings)	
	Optical microscopy inspection using a Nikon Optiphot polarizing microscope	14 (waste rock)	Lorax
Acid-Base Accounting	Analyses include paste pH, sulphur species, neutralization potential (NP), and acid potential (AP) NAG pH was also conducted on a sub-set of waste rock and tailings samples	174 (waste rock) 14 (ore) 8 (tailings) 28 (overburden)	SGS Lakefield (waste rock and ore) BV (tailings) SGS Canada (2021 Master Composite tailings and overburden)
Solid-Phase Elemental Abundance	Samples are acid digested and extract is diluted and analysed for metals by ICP-MS	174 (waste rock) 14 (ore) 8 (tailings) 28 (overburden)	SGS Lakefield (waste rock and ore) BV (tailings) SGS Canada (2021 Master Composite tailings and overburden)
Shake Flask Extraction	Sample is agitated in deionized water for 24h and leachate is analyzed for metals	36 (waste rock) 5 (ore) 4 (tailings) 14 (overburden)	SGS Lakefield (waste rock and ore) BV (tailings) SGS Canada (2021 Master Composite tailings and overburden)

On-going kinetic test programs were initiated in 2021 using representative sub-samples for a range of material types. A summary of the 2021 kinetic testing program is provided in Table 5.4-5.

Table 5.4-5 2021 Kinetic Testing Summary

Methods	Description	Number of Samples	Conducted By
Humidity Cells	Laboratory-based humidity cells are subject to several wet/dry cycles for six days. On day seven, the leachate is collected and analysed for pH, alkalinity, sulphate, and any solutes of interest, such as metals	6 (waste rock) 1 (tailings)	SGS Lakefield (waste rock) SGS Canada (tailings)
Field Bins	Natural precipitation was allowed to pass through field bins set up in the PA. Leachate was collected and analysed for water quality analysis, including pH, conductivity, alkalinity, acidity, hardness, sulphate, chloride, phosphorus, and dissolved metals	3 (waste rock) 1 (ore)	BV

Table 5.4-5 2021 Kinetic Testing Summary

Methods	Description	Number of Samples	Conducted By
Saturated Column	A saturated column was set up with tailings supernatant as influent. Influent and effluent were analyzed bi-weekly for conductivity, pH, and total alkalinity as well as sulphate, nitrogen species, cyanide species, dissolved organic carbon (DOC), and dissolved metals (accredited laboratory)	2 (tailings)	Lorax ALS Environmental Laboratories
Ore Stockpile Water Quality	Ore stockpile runoff is collected and analyzed for pH, conductivity, alkalinity, TSS, hardness, sulphate, chloride, nitrogen species, orthophosphate, total organic carbon, total metals, and dissolved metals	3 times per year (2018 to 2021)	BV

A laboratory and field QA/QC program was implemented including the collection of field blanks and duplicate samples. Samples collected for solid phase testing generally have a high degree of heterogeneity with the majority of the results within an RPD of 50%, with some exceptions (described in further detail in Appendix E.3). The QA/QC program for water sample data shows good data quality.

5.4.3 Baseline Conditions

5.4.3.1 Physiography

The Project is located in the Eastern and Atlantic Coastal Ecoregions of the Acadian Ecozone. Ecoregions are defined according to their ecological factors, including climate, physiography, vegetation, soil, water, fauna, and land use (Neily et al., 2017).

The Eastern Ecoregion is underlain by quartzite and slate of the Meguma Supergroup (Goldenville and Halifax Groups) with granitic intrusives throughout. A variety of landforms are found in this ecoregion, including rolling till plains, drumlin fields, extensive rockland, and wetlands. The bedrock is highly visible in those areas where the glacial till is very thin, exposing the ridge topography.

The Atlantic Coastal Ecoregion seldom exceeds 5 km in width from the coast. The inland boundary of the ecoregion is more defined by the absence of certain species of vegetation than by a geo-physical attribute. The underlying geology is variable due to the extent, however in the PA the bedrock is mainly of the Goldenville Group (greywacke and argillite).

Ecoregions are further subdivided into Ecodistricts, which reflect macro elements of the physical and biological attributes of ecosystems which will ultimately influence biodiversity. The PA is divided between the Eastern Interior and Eastern Shore Ecodistricts along the same boundaries as the ecoregions described above.

The Eastern Interior Ecodistrict is generally characterized by highly visibly bedrock where glacial till is very thin, exposing the ridge topography. Where till is thicker, ridged topography is masked and thick softwood forests occur as present in the PA. There are a few drumlins and hills scattered throughout the Ecodistrict and fine textured soils are derived from slates.

The Eastern Shore Ecodistrict spans a variety of landforms, geology and soils from Halifax to Canso; however, the classification is derived from the Atlantic Ocean which provides a consistent coastal climate that is reflected in the forests.

5.4.3.2 Topography

The topography of the area appears to be the result of glacial erosion and the deposition of glacial landforms. Regionally, the topography surrounding the PA slopes gently from a maximum level of approximately 110 masl in the northeast portion of the PA towards sea level to the southeast of the PA. Locally, the PA is in an area of low topographic relief at approximately 60 masl.

Gold Brook Lake is the dominant physiographic feature within the PA. Drainage from the Lake is to the southeast through Gold Brook, connected to a number of poorly drained streams, shallow lakes, and wetlands/marshes, emptying to Seal Harbour. Drainage can be limited by such factors as low topography and the silt content and degree of compactness of the underlying glacial till. Within the PA, the soils are either well or imperfectly drained. Peat deposits have developed in poorly drained topographic depressions located on the northwest shore of Gold Brook Lake, within the flood plain of Gold Brook, and on the eastern and western edges of the PA.

Local topography will be altered by the construction of Project infrastructure including the East and West Pits, WRSAs, till, and organic material stockpiles. In the final year of operations, the East and West Pits will be mined to elevations of approximately -128 and -184 masl, respectively, while the waste stockpiles are expected to reach elevations between 95 and 165 masl.

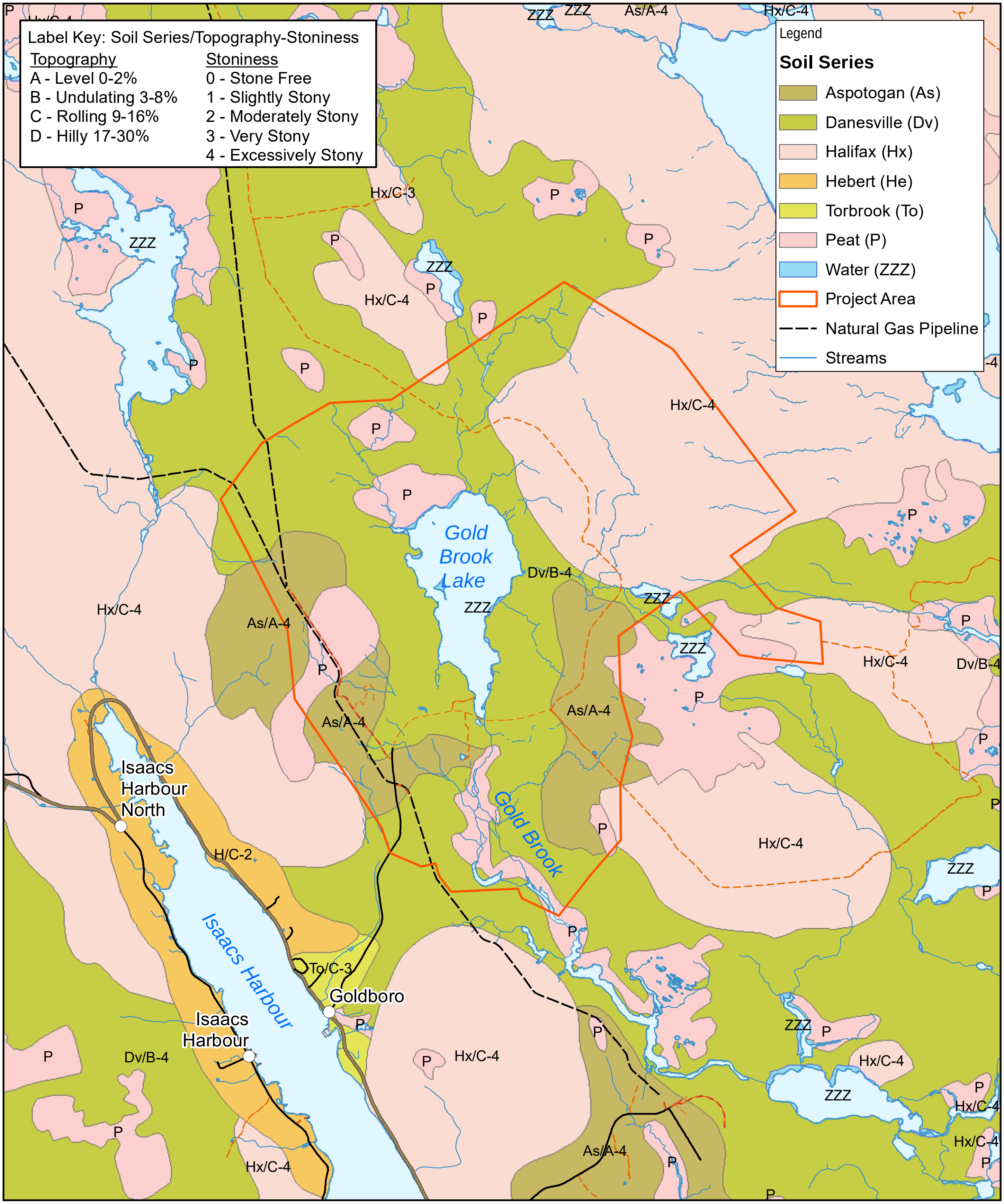
5.4.3.3 Soils

5.4.3.3.1 Soils Description

Soil mapped within the PA includes the Danesville, Aspotogan, Halifax, and Peat soil series, as shown in Figure 5.4-5. The PA is primarily underlain by Danesville and Halifax soils, with Aspotogan and Peat soils in the eastern and western extents of the PA (Hilchey et al., 1964).

Danesville soils are derived from sandy loam quarzitic till and found on gentle to moderately undulating topography. Danesville soils provide imperfect drainage and are extremely stony and shallow. This soil is unsuitable for agriculture and generally supports forested land use. Halifax series soils are found on gently undulating to hilly topography, are well drained, and support fair to good stands of mixed forest. Aspotogan soils are similar in nature to the Danesville series except the topography is more level and drainage is poor. This series is comprised of medium and moderately coarse-textured glacial tills derived from granite or quartzite materials (Hilchey et al., 1964). Regionally, significant peat deposits have developed in poorly drained topographic depressions located on the northwest shore of Gold Brook Lake, to the west and east of the Site, and within the flood plain of Gold Brook.

The forest ecosystem classification soil type for Halifax, Danesville, and Aspotogan soils are ST2, ST3, and ST4, respectively. ST2 is mainly associated with fresh, coarse-loamy soils dominated by sandy loam texture. Coarse fragment content is generally low to moderate in surface horizons, but levels can be higher in soils derived from granite, quartzite, or sandstone tills. ST3 is mainly associated with moist, coarse-loamy soils dominated by sandy loam texture, but also includes moist sandy soils. Soils occurring on granite or quartzite derived tills tend to be stony with coarse fragments. Slope position causes the soils to be well to imperfectly drain. ST3 can be associated with all forest groups, except floodplain; however, spruce pine, spruce hemlock, intolerant hardwoods, mixed woods, coastal and highland vegetation types are dominant. ST4 is associated with wet, coarse-loamy soils dominated by sandy loam texture. The soil type is general poor to medium fertility – moisture levels are excessive during the growing season. Wet coniferous and deciduous vegetation types are associated with this type, but can also be found with some coastal, highland, and cedar vegetation types (Keys et al., 2011).



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GHD

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ENVIRONMENTAL ASSESSMENT

SOIL SERIES

Project No. 11222385
Revision No. -
Date 25/05/2022

FIGURE 5.4-5

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Data source: GeoNova, GHD, Anaconda . Created by: jjparks

5.4.3.3.2 Soil Quality

Background surface soil samples were collected at 24 locations in the vicinity of the PA in 2021 and 2022 to provide baseline soil quality conditions, as shown in Figure 5.4-1. Analytical results for metals, mercury, and PAHs were compared to the NS Pathway-Specific Standards (PSS) and Atlantic Risk-Based Corrective Action (RBCA) Ecological Tier 2 PSS for agricultural land use and soil contact and food ingestion pathways. Background surface soil results are presented in further detail in the HHERA provided in Appendix J.3 and are summarized in Table 5.4-6, below. Concentrations of PAHs in baseline soil samples collected were below laboratory detection limits.

Table 5.4-6 Summary of Analytical Results Exceedances in Background Soil Samples

Parameters	Units	NS PSS (agricultural, soil contact/ingestion)[a]	Atlantic RBCA Ecological Tier 2 PSS (agricultural, soil & food ingestion)[b]	Maximum Background Soil Concentration	Minimum Background Soil Concentration	% of Results Exceeding at Least One Guideline[c]
Aluminum (Al)	mg/kg	15,400	NG[d]	21,000	500	5%
Arsenic (As)	mg/kg	31	380	96	<2.0[e]	5%
Iron (Fe)	mg/kg	11,000	NG[d]	32,000	600	32%
Selenium (Se)	mg/kg	80	4.5	4.6	<0.50[e]	5%

a. Nova Scotia. 2021. Tier 2 Pathway-Specific Standards for Soil – Agricultural Land Use.
b. Atlantic RBCA. 2021. Ecological Tier 2 Pathway-Specific Standards for Soil – Agricultural Land Use.
c. 24 background soil samples analyzed. Field duplicates not included
d. No Guideline
e. Method detection limit

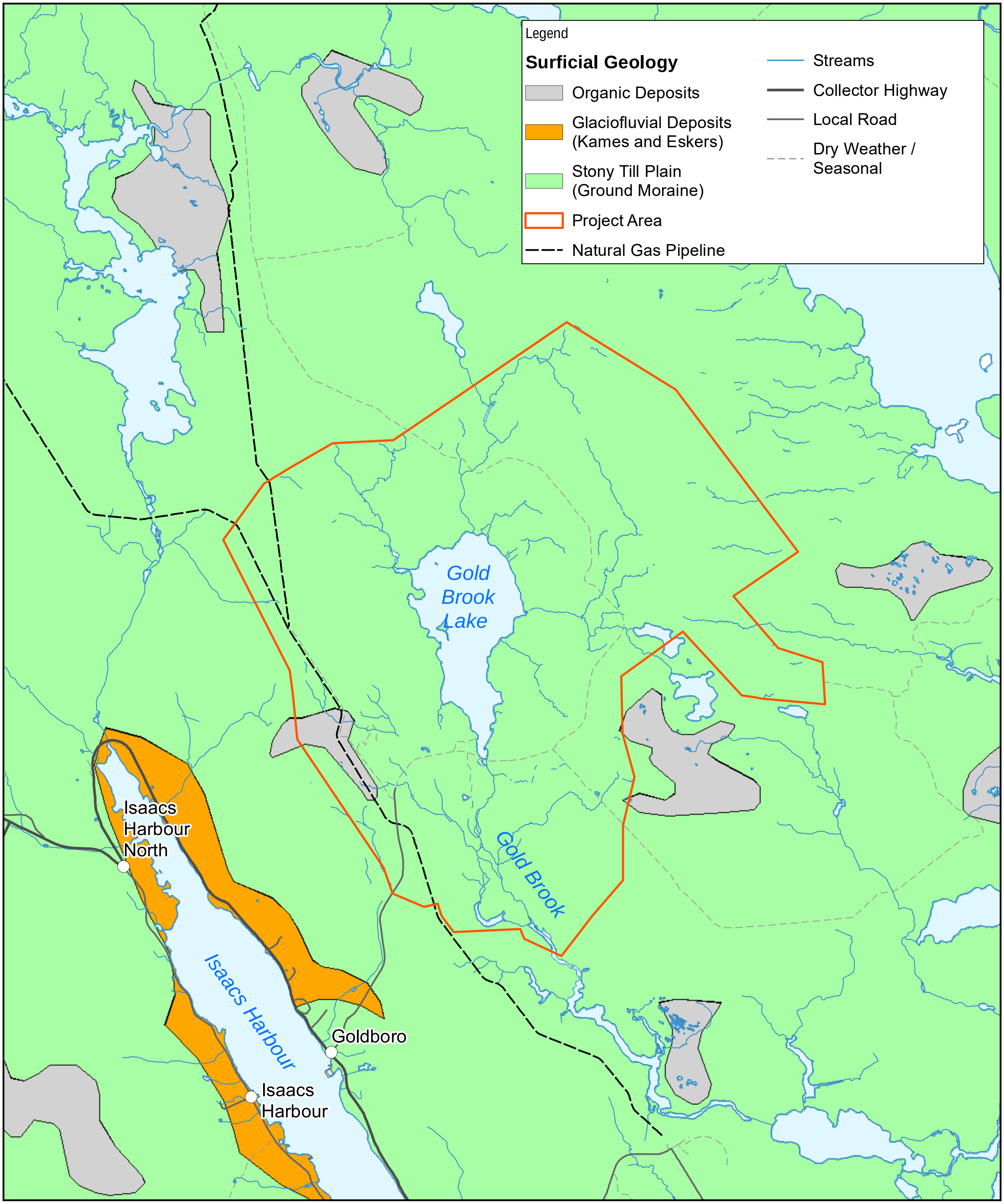
Elevated concentrations of certain metals parameters were identified in the soil samples as follows:

- Aluminum and arsenic concentrations exceeded applicable NS Tier 2 PSS in one sample only.
- Arsenic concentrations did not exceed Atlantic RBCA Ecological Tier 2 PSS.
- Iron concentrations exceeded NS Tier 2 PSS in seven samples.
- Selenium concentrations exceed Atlantic RBCA Ecological Tier 2 PSS in one sample only. Selenium concentrations did not exceed the NS Tier 2 PSS guideline.
- All other metals concentrations were less than the applicable guidelines.

5.4.3.4 Surficial Geology

The surficial unit in the PA is described as Stony Till Plain (Ground Moraine) with organic deposits at the eastern and western extents of the PA as shown in Figure 5.4-6 (Stea et al., 1992). Ground moraine is a non-linear, smooth to hummocky glacial drift cover, mostly composed of subglacial lodgment or melt out till (unsorted boulders, sand and mud). Stony till plain is developed over the Cambro-Ordivician Meguma Supergroup (Halifax and Goldenville Groups) greywacke and argillite.

Overburden thickness was estimated by first interpolating top of bedrock elevations then subtracting these elevations from ground surface elevations. Interpolating top of bedrock elevations was accomplished using kriging with locally varying mean methodologies as implemented in Stanford Geostatistical Modeling Software (SF)/PyKrige/Surfer Version 20.1.195/Leapfrog 2021.2.4 (Remy et al, 2009). This method involves implementing a regression function relating ground surface elevations with top of bedrock elevations. Regionally, the till deposit has a thickness ranging from approximately 2 m to 20 m (Stea et al., 1992). Glacial till deposits within the PA are on average approximately 6.5 m thick and range from 0.5 to over 18 mbgs.



Paper Size ANSI B

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Metres

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

GHD

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SURFICIAL GEOLOGY

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FIGURE 5.4-6

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Print date: 25 May 2022 - 17:14

Data source: GeoNova, GHD, Anaconda . Created by: jjparks

5.4.3.5 Bedrock Geology

5.4.3.5.1 Regional Geology

NS is divided into two distinct geologic regions, the northern Avalon Terrane and the southern Meguma Terrane separated by the Cobequid-Chedabucto Fault System. The Project is located within the northeastern portion of the Meguma Terrane. Greywackes and argillites of the Cambro-Ordovician aged Meguma Supergroup, which were intruded by granitic plutons during the Devonian Acadian Orogeny (Sangster and Smith, 2007).

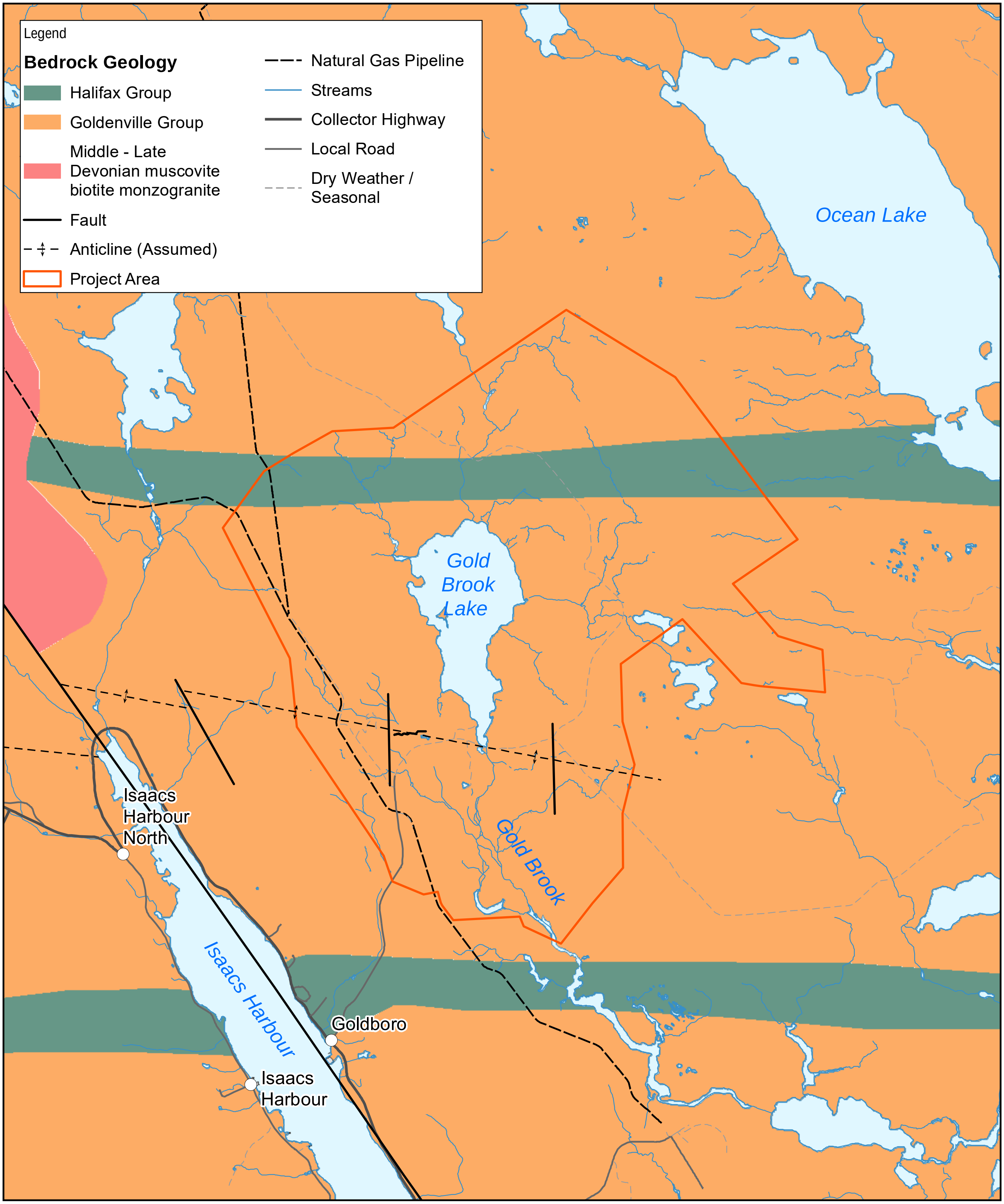
The turbiditic metasedimentary sequence of the Meguma Supergroup consists of two major stratigraphic units: the basal greywacke dominated Goldenville Group; and the overlying, finer-grained, argillite-dominated Halifax Group. The Goldenville Group is estimated to be approximately 6.7 km thick with an unknown base, while the overlaying Halifax Group is approximately 4.4 km thick in the northwest of Nova Scotia to 0.5 km thick to the south (Malcom, 1929; Taylor, 1967; Sangster and Smith, 2007). In one section near Halifax, the Halifax formation is 11.8 km thick (Sangster and Smith, 2007).

During the mid-Devonian Acadian Orogeny, approximately 400 million years ago (Ma), the sediments of the Goldenville and Halifax Groups were metamorphosed into greenschist-amphibolite faces grade and were subsequently intruded by peraluminous granite, granodiorite, and minor mafic intrusions of mid-Devonian to Carboniferous age (ca. 375 Ma). The main feature of the deformational history is a series of major east-west trending upright to slightly reclined asymmetric folds (Sangster and Smith, 2007).

5.4.3.5.2 Local Geology

The majority of the PA, including the proposed locations of the East and West Pits, is located within the Goldenville Group as shown in Figure 5.4-7. The Goldenville Group at the PA consists of alternating beds of greywacke and argillite with an approximate stratigraphic thickness of 950 m (Nordmin 2022). The beds at the PA are centered on the Upper Seal Harbour Anticline which trends approximately east west and can be traced for more than 13 km. The anticline plunges gently to the east and passes beneath the southern-most tip of the Gold Brook Lake.

Locally, structural geology is relatively complex. The bedrock is highly to intensely fractured near surface, with quartz vein intrusions along fault shear zones which crosscut the greywacke and slate strata (Orex, 1990). Three main faults have been identified and mapped in the PA as shown on Figure 5.4-7. Some faults are highly brecciated. Observations within historical mine workings have shown that some large faults have been made impervious by breccia fines and therefore will not conduct groundwater.



Paper Size ANSI B

0 400 800 1,200 1,600

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

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BEDROCK GEOLOGY

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FIGURE 5.4-7

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5.4.3.5.3 Ore Deposit Type

A detailed description of the geological setting and mineralization at the deposit was provided in the FS (Nordmin, 2021). The following information concerning the ore deposit was sourced from this study.

The deposit is a turbidite-hosted orogenic gold deposit hosted within a sequence of alternating argillites and greywacke metamorphosed to greenschist facies. These deposit types are typically characterized by the formation of gold bearing quartz veins within the argillite units, commonly referred to as mineralized belts (belts), that are interbedded with greywacke units. There are currently 68 stacked mineralized belts ranging in thickness from 1 m to 20 m in the Deposit. The metasedimentary units are folded into the tight, gently east-plunging Upper Seal Harbour Anticline and gold mineralization has typically been deposited at various positions and times during the fold formation process. Veins, which form during deformation, occur in three major geometries commonly referred to as reefs: saddle reefs, leg reefs, and spur reefs. Saddle reefs occur about the apex of the fold and are the dominant vein types within some deposits. Leg reefs extend down the limbs of the fold, beyond the saddle reef, and are generally parallel with the metasedimentary layers. These are also commonly termed bedding parallel (BP) veins. Spur reefs are veins that cross between layers and may be in the apex of the fold or on its limbs. This style of vein is in part captured under the term “angular” veins.

The Deposit contains all three types of reefs outlined above but is also characterized by mineralization within the argillite forming the Belts. Because the Deposit contains saddle, leg, and spur reefs, and often has gold mineralization within the argillite hosting the veins, it has the potential to contain significantly more gold resources than deposits of a similar style that contain gold only within the quartz veins (reefs) themselves. The trace of the Upper Seal Harbour Anticline transects the PA and is found near the Dolliver Mountain prospect 2 km to the west of the Deposit, demonstrating that the structure which hosts gold continues for at least several kilometres.

5.4.3.6 Sediment Quality

Baseline sediment samples were collected at 12 locations in the vicinity of the PA by GHD on September 1 and 2, 2021. Sediment samples were collected from WC 49, WC 64, Gold Brook, and Gold Brook Lake as shown in Figure 5.4-2. Analytical results for metals were compared to the NS Tier 1 EQS for Sediment (freshwater) and the CCME Sediment Quality Guidelines for the Protection of Aquatic Life (Freshwater Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL)).

Sediment quality results are included in the 2021 Surface Water Monitoring Report provided in Appendix F.3 and are summarized in Table 5.4-7 below.

Table 5.4-7 Summary of Analytical Results Exceedances in Sediment Samples

Parameters	Units	NS Tier 1 EQS[a]	CCME PEL[b]	CCME ISQG[c]	Maximum Sediment Concentration	Minimum Sediment Concentration	% of Results Exceeding at Least One Guideline[d]
Antimony (Sb)	mg/kg	25	NG[e]	NG[e]	81	<2.0[f]	17%
Arsenic (As)	mg/kg	17	17	5.9	110,000	9.1	100%
Copper (Cu)	mg/kg	197	197	35.7	36	<2.0[f]	8%
Iron (Fe)	mg/kg	43766	NG[e]	NG[e]	120,000	3,500	17%
Lead (Pb)	mg/kg	91.3	91.3	35	120	4.5	33%
Mercury (Hg)	mg/kg	0.486	0.486	0.17	11	0.16	92%
Nickel (Ni)	mg/kg	75	NG[e]	NG[e]	210	2.7	17%

Table 5.4-7 Summary of Analytical Results Exceedances in Sediment Samples

Parameters	Units	NS Tier 1 EQS[a]	CCME PEL[b]	CCME ISQG[c]	Maximum Sediment Concentration	Minimum Sediment Concentration	% of Results Exceeding at Least One Guideline[d]
Selenium (Se)	mg/kg	2	NG[e]	NG[e]	2.5	<0.50[f]	17%
Silver (Ag)	mg/kg	0.5	NG[e]	NG[e]	3.4	<0.50[f]	17%

a. Nova Scotia. 2021. Tier 1 EQS
b. CCME Interim Probable Effect Limit
c. CCME Interim Sediment Quality Guidelines (Freshwater)
d. 12 sediment samples analyzed. Field duplicate not included
e. No Guideline
f. Method detection limit

Elevated concentrations of certain metals parameters were identified in the sediment samples collected from Gold Brook Lake, Gold Brook, WC 49 and WC 64 are as follows:

- Arsenic concentrations exceeded CCME ISQG in all 12 samples. The concentrations also exceeded CCME PEL and NS Tier 1 EQS in 10 samples.
- Mercury concentrations exceeded CCME ISQG in 11 samples. The concentrations also exceeded CCME PEL and NS Tier 1 EQS in 9 samples.
- Antimony, iron, nickel, selenium, and silver exceeded applicable NS Tier 1 EQS in 2 samples.
- Lead concentrations exceeded CCME ISQG in 4 samples. The concentrations also exceeded CCME PEL and NS Tier 1 EQS in 1 sample only.
- Copper concentrations exceeded CCME ISQG in 1 sample only. The concentrations did not exceed CCME PEL and NS Tier 1 EQS guidelines.
- All other metals concentrations were less than the applicable guidelines.

The GSC reported on the geochemistry of historic tailings, sediments and surface water collected from historic gold mining areas throughout NS. Sediment samples were collected from approximately 60 sites within a 20 km radius of the Upper and Lower Seal Harbour gold districts. The objective of the sampling was to collect information on regional and background concentrations for arsenic and mercury in mineralized and unmineralized areas for comparison with waters and sediments that have been impacted by mining activity (Parsons et al., 2012). Arsenic concentrations in streambank sediments ranged from 370 – 6500 mg/kg in these areas, while mercury ranged from 300-3900 µg/kg, which is consistent with those observed in other gold mining districts throughout the Meguma Terrane in NS (Parsons et al., 2012).

5.4.3.7 Historic Tailings

The primary goal of the limited Phase I and Phase II ESA conducted in 2021 was to further understand the extent of the historic tailings and elevated metal concentrations in soils resulting from historic mining. Analytical results of soil samples collected during the Phase II ESA from 84 delineation points were compared against the NS Tier 1 EQS for an industrial site with potable groundwater and coarse-grained soil, as well as the CCME Canadian Soil Quality Guidelines for the Protection of Environmental (SQG_E) and Human Health (SQG_{HH}), industrial land use.

Soil and historic tailings quality results are included in the limited Phase I and Phase II ESA Report provided in Appendix E.2 and are summarized in Table 5.4-8.

Table 5.4-8 Summary of Analytical Results Exceedances in Soil and Historic Tailings Samples

Parameters	Units	NS Tier 1 EQS (Potable, Industrial, Coarse Grained)[a]	CCME SQG_{HH} (Industrial)[b]	CCME SQG_E (Industrial)[b]	Upper Value	Lower Value	% of Results Exceeding at Least One Guideline[c]
Arsenic (As)	mg/kg	10	31[d]	26	28,000	3	85%
Selenium (Se)	mg/kg	1	1135	2.9	3.7	<0.50[e]	19%
Zinc (Zn)	mg/kg	200	140000	410	280	<5.0[e]	2%

a. Nova Scotia. 2021. Tier 1 EQS for Soil at a Potable Site (Industrial land use and coarse grained soil).
b. CCME. 2021. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.
c. Field duplicates not included
d. Value has been adjusted from its original jurisdictional value to reflect a 1 x 10-05 Target Cancer Risk Level.
e. Method detection limit

Concentrations of arsenic, selenium, and zinc in exceedance of the NS Tier 1 EQS were present in the historic tailings areas assessed. The results indicate that:

- Arsenic exceedances (53 samples including 5 field duplicates) were present in each of the historic tailings areas assessed. Available arsenic also exceeded CCME SQG_{HH} in 39 samples (including four field duplicates) and SQG_E in 41 samples (including four field duplicates).
- Selenium exceedances (12 samples) were also present in each of the historic tailing areas assessed. Available selenium also exceeded CCME SQG_E in 2 samples.
- Only one zinc exceedance was recorded, in historic tailings area B. Available zinc did not exceed SQG_E or SQG_{HH}.
- None of the other parameters analyzed during this study exceeded applicable criteria.

The exceedances can be attributed to the historic tailings in the area, and to naturally occurring background metals concentrations. Arsenic, selenium, and zinc are listed as substances potentially considered as background occurrences in the NS Notification of Contamination Protocol (NSECC, 2021).

5.4.3.8 Metal Leaching and Acid Rock Drainage

ML/ARD occurs when naturally occurring sulphide minerals in rock and overburden are exposed to oxygen and water, resulting in sulphide mineral oxidation. This reaction produces iron-oxides, sulphide minerals, and sulphuric acid which are released into contact water. The acidic runoff can mobilize metals including iron, arsenic, manganese, and copper from the surrounding bedrock, releasing them into the environment as well.

The preliminary ML/ARD program completed for the Project included 86 rock samples collected in 2017 and 2019 and submitted for static test analyses to characterize the waste rock and mineralized material of the Boston-Richardson, West Goldbrook, and East Goldbrook gold systems. These initial characterizations indicated that the waste rock was generally expected to be NPAG with lesser PAG material, while the ore was characterized as PAG. However, changes in the mine plan and open pits designs resulted in the majority of these samples falling outside of the targeted zones and thereby rendering these investigations somewhat unrepresentative. To refine understanding of the geochemical character of the local host rock, Lorax initiated a comprehensive ML/ARD program in 2020, considering the proposed dimensions of the East and West Pits and associated sampling gaps, that included static and kinetic testing of 229 samples comprising waste rock, ore, tailings, and overburden (till and organic material). The complete results of the ML/ARD assessment completed for the Project are presented in the Geochemical Characterization and Source Terms Report provided in Appendix E.3.

Operationally, the distinction and quantification of PAG and NPAG material is important for mine planning since the exposure of PAG mine rock or tailings is expected to have negative impacts on contact water quality. Waste rock and ore ARD characteristics were defined through a ratio of the Neutralizing Potential (NL) relative to Acid Potential (AP_ whereby the Net Potential Ratio (NPR = NP/AP) is characterized as follows:

- PAG1 – NPR < 1 or 1 ≤ NPR ≤ 2 and total sulphur ≥ 0.2 wt. %
- PAG2 – 1 ≤ NPR ≤ 2 and total sulphur < 0.2 wt. %
- NPAG – NPR > 2

The evaluation of ARD potential was carried out via ABA testing, which is a screening procedure whereby the acid generation and neutralization potential of samples are determined. ABA consists of a series of static tests including paste pH, sulphur species, NP, and AP. The results of ABA testing are summarised in Table 5.4-9.

Table 5.4-9 Summary of ABA results

Sample Type	Paste pH		Total S (wt. %)		NPR[a]		PAG[b]		NPAG[b]
	Min	Max	Min	Max	Min	Max	PAG1[b]	PAG2[b]	
Waste Rock (n = 174)	7.9	10	<0.005	1.7	0.076	32	26%	11%	63%
Ore (n = 14)	8.1	9.7	0.16	0.95	0.087	3.3	93%	0%	7%
Tailings (n = 8)	8.4	8.9	0.16	0.57	0.27	1.1	100%		0%
Historic Tailings (n = 6)	4.3	6.4	0.02	0.48	-0.82	4.3	83%		17%
Overbuden – Soil (n = 12)	3.2	5.7	0.02	0.24	-176	-5.1	100%		0%
Overbuden – Till (n = 16)	4.8	7.2	<0.005	0.34	-39	5.6	88%		13%

a. NPR: Net Potential Ratio.
b. PAG: Potentially Acid Generating; NPAG: Non-Potentially Acid Generating

A kinetic test program comprising humidity cell, saturated column, and field-scale experiments using PA waste and ore materials was also initiated in 2021 and is currently on-going. These tests allow for the evaluation of pH, metal mobility and mineral reaction rates contributing to ML/ARD for a range of conditions. To date, pH in kinetic test leachates from waste rock, ore, and tailings samples have remained circumneutral. Under these conditions, release rates of sulphate and most pH-sensitive metals are relatively low in waste rock and ore. Tailings are an exception where fine grain size and residual mill process reagents cause elevated concentrations of multiple species including sulphate, cyanide, iron, copper, and cobalt. Arsenic was identified as the main parameter of concern for the Project. It is enriched across the Deposit and is expected to be mobile under a range of geochemical conditions including neutral pH. In waste rock and ore, arsenic was found to be primarily hosted in arsenopyrite which is susceptible to dissolution under oxic conditions. Long-term pH and its effects on ML rates is being investigated through ongoing testing.

The results of static ML/ARD analyses and kinetic tests results received to date are summarized according to material type in the following sections.

5.4.3.8.1 Waste Rock and Ore

174 waste rock samples and 14 ore samples were submitted for ML/ARD analyses:

- Total sulphur contents for waste rock range from <0.005% to 1.7% with a relatively low median value of 0.05%. Mineralogical investigations identified pyrite, pyrrhotite, and arsenopyrite as being the most common sulphide minerals. Ore samples are relatively enriched in total sulphur compared with the waste rock population with a median content of 0.51%.

- Among the static test population, the majority of waste rock was classified as NPAG (63%), while 37% of samples were deemed PAG. Ore materials were predominantly PAG1 (93%).
- Solid phase metals analysis results were compared to Average Upper Continental Crustal Abundance (AUCCA). Arsenic exceeds 3x the AUCCA in the majority of waste rock and ore samples and is commonly elevated by more than 10x the AUCCA.
- All waste rock SFE leachates had circumneutral to slightly alkaline pH. Solute concentrations were compared to NS Tier 1 EQS for Surface Water and Groundwater Discharging to Surface Water. Leachate concentrations in contact with waste rock were generally low (commonly below the detection limit). Arsenic concentrations range from 0.057 to 4.9 mg/L for waste rock samples, which were at least 10 times above the Tier 1 EQS value of 0.005 mg/L. The elevated concentrations confirm arsenic as a parameter of concern for the PA even under neutral drainage conditions. Aluminum concentrations were also elevated for all samples; however, in SFE tests, these high values are usually the result of colloids passing through the filter due to the high TSS generated by stirring a crushed sample. Copper, lead, and zinc were occasionally above their respective Tier 1 EQS in field bin leachates and runoff from the bulk sample stockpile, indicating that there is some potential for elevated concentrations in contact water.

5.4.3.8.2 Tailings

Eight tailings samples and six historic tailings samples were submitted for ML/ARD analyses:

- All tailings and historic tailings samples are relatively enriched in total sulphur with median contents of 0.27% and 0.29%, respectively, compared to 0.05% for the waste rock samples.
- Tailings and historic tailings materials were dominantly classified as PAG1 (100% and 83%, respectively).
- All tailings samples had arsenic concentrations above 10x the AUCCA.
- Arsenic exceeds 3x the AUCCA in the majority of historic tailings samples and is commonly elevated by more than 10x the AUCCA.
- Tailings SFE leachates had slightly alkaline pH. Leachate concentrations in contact with the samples were generally low (commonly below the detection limit), except for aluminum and arsenic concentrations which are above their respective Tier 1 EQS in the majority of samples. Cobalt, copper, and iron concentrations were above their respective Tier 1 EQS in one or more tailings samples which is likely an artifact of mill processes such as cyanidation. Arsenic is the primary parameter of concern for leaching from tailings, as indicated by the elevated SFE concentrations (0.40 to 2.2 mg/L). Elevated dissolved aluminum concentrations in SFE leachate may be attributed to the high TSS of SFE samples. The other parameters above their Tier 1 EQS are considered to be of lower concern.
- Historic tailings SFE leachates had slightly acidic pH (<6.5), with several metal concentrations above their respective Tier 1 EQS. This indicates that there is some leaching potential from historic tailings under mildly acidic conditions.

5.4.3.8.3 Overburden

28 overburden samples (12 organic material samples and 16 till samples) were submitted for ML/ARD analyses:

- Total sulphur contents for overburden show a relatively low median value of 0.041%; however due to the high organics inventory in soil materials in particular, the speciation of sulphur in these materials is likely less straightforward as for bedrock.
- Overburden was generally classified as PAG, although further characterization is recommended due to the unique geochemical characteristics of these oxidized materials.
- Arsenic contents in overburden are lower relative to waste rock; however, the maximum arsenic values for both organic material and till samples were above 10x the AUCCA. Metal contents were generally lower in the overburden samples.
- Overburden SFE leachates had slightly acidic pH (<6.5), with several metal concentrations above their respective Tier 1 EQS. This indicates that there is some leaching potential from overburden under mildly acidic conditions.

5.4.3.9 Seismic Activity

The North American Plate has a stable interior but along the edges more seismic activity is likely to occur. Eastern Canada is part of the stable interior; however, unlike the subduction zone on the west coast of North where plates are colliding, crustal stresses on the east coast are more difficult to explain and likely depend on their local tectonic context.

Although seismic activity is unpredictable, all of NS is in a moderately low hazard zone. The southern Bay of Fundy is a moderate hazard zone. The Laurentian Slope is a moderate to high hazard zone (NRCAN, 2015). Figure 5.4-8 displays the relative seismic hazards across Canada as determined by the GSC (NRCAN, 2015).

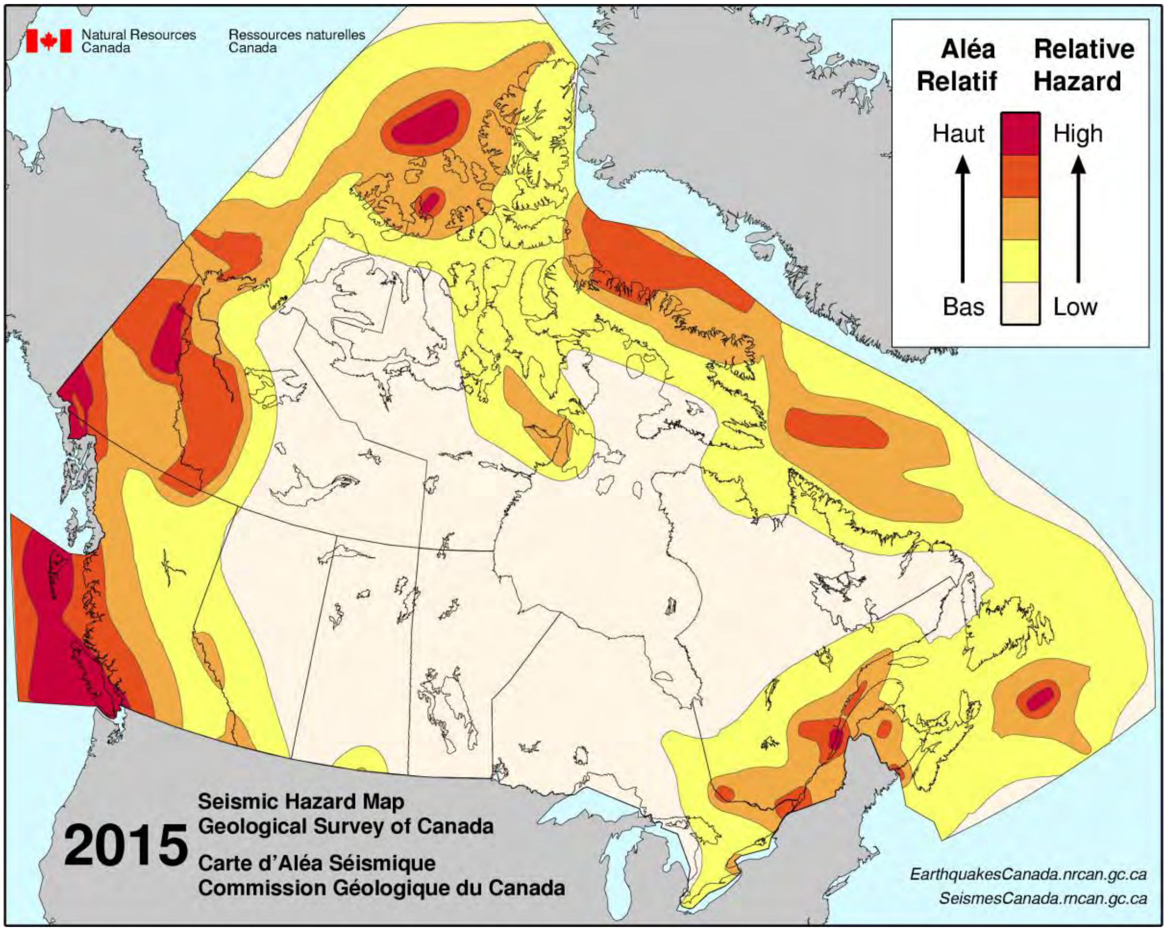


Figure 5.4-8 Relative Seismic Hazard Map of Canada

Each year, approximately 450 earthquakes occur in eastern Canada, of which four will exceed magnitude 4, 30 will exceed magnitude 3, and 25 events will be reported as felt. A decade will likely include three events greater than magnitude 5. NS has low seismic activity with records (since 1925) showing a max magnitude of 3.5, which occurred in Yarmouth in 2015, and most of the activity occurring in southwest NS.

The Northern Appalachian Seismic Zone is located in southwest NS. The Project is located east of this zone. Goldboro does not fall within a designated seismic zone and the closest recorded seismic event in NS in the last 10 years (2012 to 2022), a magnitude 2.2 earthquake southwest of Truro (NRCan, 2016), was 136 km from the Project. Magnitudes of intensity less than 3.0 are not felt by people except under favourable conditions and cause no damage to buildings. The global frequency of earthquakes with magnitude 2.0 to 2.9 is over one million per year.

If an earthquake occurs, seismic activity may affect the Project through primary impacts such as infrastructure damage facilitated by ground vibrations and secondary impacts such as fires caused by damaged infrastructure. Tsunamis, should they be created offshore earthquakes, are unlikely to impact the Project. The PA is located approximately 1.2 km from the coast at an elevation of approximately 60 masl.

Given that NS is located in a low hazard zone and the limited extent and duration of the Project, the potential risk of seismic activity affecting the Project is very low.

5.4.4 Consideration of Consultation and Engagement Results

Signal Gold has undertaken an engagement and consultation program with the Mi’kmaq of Nova Scotia, stakeholders, regulators, and the public. These activities are described in more detail in Section 3. Throughout this process, various issues, concerns, and opportunities have been identified in relation to the Project. These matters have been considered within the context of this VC to help understand potential effects of the Project on the biophysical and socioeconomic environment and inform consideration of possible mitigation measures. For the geology, soil, and sediment VC, identified concerns include:

- Management of historic tailings

5.4.5 Effects Assessment Methodology

5.4.5.1 Boundaries

This section describes the boundaries of the effects assessment and the thresholds for determination of significance for sediment quality and potential effects of the Project. The effects of ML/ARD are evaluated in the Sections 5.5 (Groundwater Resources) and 5.6 (Surface Water Resources).

Spatial Boundaries

The spatial boundary used for the assessment of effects to geology, soil, and sediment are defined below:

- The PA encompasses the immediate area in which Project activities may occur and includes the infrastructure associated with the mine site plus a buffer of 100 – 200 m.
- The LAA encompasses the Gold Brook catchment area and portions of the Isaacs Harbour River (1EP-1), Isaacs Harbour Shore-Direct (1EP-SD1), New Harbour River (1EQ-4), and Coddles Harbour Shore-Direct (1EQ-SD29) watersheds.
- The RAA encompasses shore direct watershed 1EQ-SD31, which begins at the headwaters to Gold Brook Lake and extends to the Atlantic Ocean, and portions of the Isaacs Harbour River (1EP-1), Isaacs Harbour Shore-Direct (1EP-SD1), New Harbour River (1EQ-4), and Coddles Harbour Shore-Direct (1EQ-SD29) watersheds.
- As the Project has the potential to cause direct and indirect impacts to geology, soil, and sediment outside of the PA, the LAA is considered the most appropriate spatial boundary for this assessment. Spatial boundaries defined for the geology, soil, and sediment effects assessment are presented in Figure 5.4-9.

Temporal Boundaries

The temporal boundaries used for the assessment of effects to geology, soil, and sediment are the construction, operations, and closure phases of the Project.

Technical Boundaries

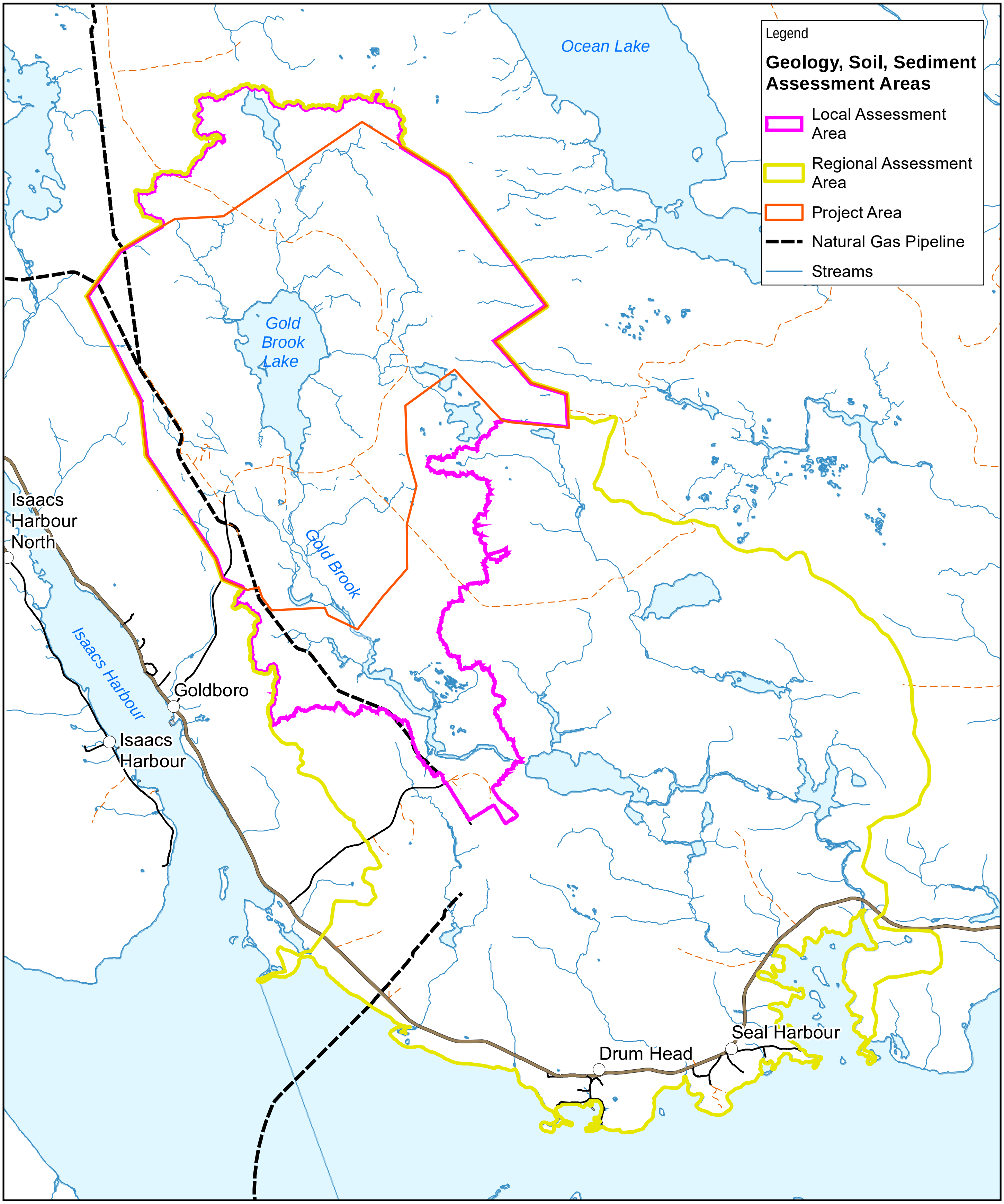
No technical boundaries were identified for the effects assessment of geology, soil, and sediment.

Administrative Boundaries

ARD is provincially regulated through the *Sulphide Bearing Material Disposal Regulations*.

Contaminated soil and sediment are provincially regulated via the *Contaminated Sites Regulations*. Specifically, the assessment of soil and sediment quality included comparison to the following criteria:

- NS Tier 1 EQS for an industrial site with potable groundwater and coarse-grained soil (NSECC, 2021)
- NS Tier 1 EQS for sediment (freshwater) (NSECC, 2021)



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Metres

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

SPATIAL BOUNDARIES -
GEOLOGY, SOIL, SEDIMENT

Project No.	11222385
Revision No.	-
Date	25/05/2022

FIGURE 5.4-9

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Data source: GeoNova, GHD, Anaconda . Created by: jjparks

5.4.5.2 Geological Source Term Development

Geochemical source terms, or contact water chemistry predictions, were developed as inputs into the predictive water quality assessment and groundwater contaminant transport model completed for the Project. Further detail on the application of these source terms is provided in Sections 5.5 (Groundwater Resources) and 5.6 (Surface Water Resources). Source terms were developed for the short-term operations condition prior to the onset of acidic drainage and for the long-term closure condition following the onset of acidic drainage. Both base case and upper-case source terms were developed.

The contact water chemistry was modelled for mine components containing waste rock, ROM material, overburden, and tailings, and was largely based on the results from static and kinetic test programs described in the ML/ARD assessment (Appendix E.3). Where applicable, the scaling of humidity cell data was undertaken with reliance on analogue mine site information for which both kinetic test and operational water quality monitoring data are available. This approach is thought to result in a drastic increase of model confidence as it relates to parameter specific humidity cell scaling.

The modelled Project infrastructure components included:

- WRSAs
- Till and organic material stockpiles
- East Pit backfill
- Pit walls
- ROM material stockpile
- TMF embankments
- PAG1 exposures in TMF (temporary)
- TMF closure cover

Nitrogen leaching predictions associated with the flushing of explosives residue from blasted materials were based on the Project schedule, site analogue, and explosive type and characteristics.

Source terms for tailings contact water were developed using representative tailings supernatant samples produced during bench-scale metallurgical testing. TMF seepage chemistry predictions relied on results from saturated column testing, while overburden runoff chemistry was conservatively predicted using material-specific SFE data.

For the WRSAs and pit walls, base case source terms were estimated based on humidity cell loadings and scaled using the 75th percentile of a representative site analogue water quality database. Source term output concentrations were then capped using the greater of the maximum value observed in drainage data from the PA (including the field barrel leachate and bulk sample drainage chemistry database) and the 75th percentile of all SFE tests. Iron and aluminum were excluded from the SFE adjustment as results were unrealistically high. One half of the detection limit values were applied as the base case cap for beryllium and mercury. Upper case source terms for the WRSAs and pit walls were estimated based on humidity cell loadings and scaled using maximum observed concentrations in the site analogue water quality database. Caps applied represent two times the base case cap to maintain conservatism.

Base case and upper-case source terms for tailings were equal to the average and maximum, respectively, of the 2020 and 2021 master composite tailings supernatant. Base case source terms for TMF seepage correspond to the median leachate concentration from the last eight saturated column cycles collect between October 2021 and February 2022, while upper case source terms were the 90th percentile values from the same dataset.

Base case source terms were not developed for overburden (including till and organic material) as scaling of kinetic test data was not conducted. Upper case source terms were developed for overburden using SFE data alone. Short-term upper case source terms for overburden were derived from the median of SFE data, with the exception of aluminum. Aluminum in SFE data was found to be artificially high when compared to baseline concentrations of comparable pH. Therefore, Al was set to the 95th percentile of 2021 baseline database. Long-term upper case short terms for overburden were derived from the 95th percentile of 2021 baseline database with the exception of antimony, beryllium, fluoride, mercury, silver, and tin where the detection limit would result in artificially high source terms.

5.4.5.3 Thresholds for Determination of Significance

There are no regulated or proposed thresholds for geology for the Project. The characterization criteria applied in the soil and sediment quality effects assessment are detailed in Table 5.4-10, below.

Table 5.4-10 Characterization Criteria for Residual Effects on Soil and Sediment Quality

Characterization	Quantitative Measure or Definition of Qualitative Categories
Magnitude	**N** – contaminant concentrations are elevated above baseline (<10%) and below the applicable guidelines (CCME ISQG/PEL and NS Tier 1 EQS) **L** – contaminant concentrations are elevated above baseline (>10%) and below the applicable guidelines (CCME ISQG/PEL and NS Tier 1 EQS) **M** – contaminant concentrations are marginally (<10%) greater than the applicable guidelines (CCME ISQG/PEL and NS Tier 1 EQS) **H** – contaminant concentrations are greater (>10%) than the applicable guidelines (CCME ISQG/PEL and NS Tier 1 EQS)
Geographic Extent	**PA** – direct and indirect effects from Project activities are restricted to the PA **LAA** – direct and indirect effects from Project activities are restricted to the LAA **RAA** – direct and indirect effects from Project activities are restricted to the RAA
Timing	**N/A** — seasonal aspects are unlikely to affect soil and/or sediment quality **A** — seasonal aspects may affect soil and/or sediment quality
Duration	**ST** – effects are limited to the construction phase or operations phase **MT** – effects occur in the construction phase and operations phase **LT** – effects occur in the construction phase and operations phase and persist in closure **P** – soil and/or sediment quality unlikely to recover to baseline conditions
Frequency	**O** – effects occur once **S** – effects occur at irregular intervals throughout the Project **R** – effects occur at regular intervals throughout the Project **C** – effects occur continuously throughout the Project
Reversibility	**RE** – soil and/or sediment quality will recover to baseline conditions before or after Project activities have been completed. **PR -** mitigation cannot guarantee a return to baseline conditions **IR** – effects to soil and/or sediment quality are permanent and will not recover to baseline conditions

A significant adverse effect to soil and sediment quality from the Project is defined as:

- Residual effects have high magnitude, potential for regional geographic extent and for medium to long term duration, occur at any frequency, and are partially reversible to irreversible.

5.4.6 Project Interactions and Potential Effects

Potential Project interactions with geology, soil, and sediment are presented in Table 5.4-11, below.

Table 5.4-11 Project Activities and Geology, Soil, and Sediment Interactions

Project Phase	Duration	Relevant Project Activity
Construction	2 years	– Clearing, grubbing, and grading – Drilling and rock blasting – Topsoil, till, and waste rock management – Surface infrastructure installation and construction – Haul road construction – TMF construction – Collection ditch and settling pond construction – Watercourse and wetland alteration – General waste management
Operations	11 years	– Drilling and blasting – Open pit dewatering – Ore management – Waste rock management – Surface water management – Reagent management – Petroleum products management – Site maintenance and repairs – Tailings management – Water treatment – General waste management
Closure	24 years	– Demolition – Earthworks – Water treatment – General waste management

Project activities have the potential to result in impacts to geology by ML/ARD. Geochemical source terms generated in the ML/ARD assessment completed for the Project were used as inputs to the predictive water quality assessment and groundwater contaminant transport model. Effects to surface water and groundwater quality are described in Sections 5.5 (Groundwater Resources) and 5.6 (Surface Water Resources).

Effects to soil and sediment may result from Project activities in the construction, operations, and closure phases. Pre-stripping material from the pit areas, mill area, TMF area, WRSAs, and stockpile pads during construction has the potential to mobilize sediment laden runoff if not adequately controlled. Dust particulates generated during drilling, blasting, crushing, and haul road traffic, among other activities in the operations phase, have the potential to be deposited as sediments if they are transported to watercourses and wetlands. Sediment releases may also occur during closure activities, including re-contouring WRSAs, installation of the TMF closure cover, and pit rehabilitation.

Historic tailings deposited in low-lying areas south of Gold Brook Lake and in portions of Gold Brook are likely to be disturbed by proposed Project activities and will require remedial action prior to Project development. Historic tailings within the footprint of Project infrastructure, including the East Pit, West Pit, and haul road, will be removed via excavator and transported to the TMF for long-term storage. Further discussion of potential effects to historic tailings within Gold Brook is provided in Section 5.6.6.1.5.

5.4.7 Mitigation

Project mitigation measures protective of geology, soil, and sediment are detailed in Table 5.4-12 below.

Table 5.4-12 Geology, Soil, and Sediment Mitigation Measures

Project Phase	Mitigation Measure
Construction	Project infrastructure was micro-sited to avoid known areas of historic tailings where possible.
	Excavation, transport, and long-term storage of historic tailings within the footprint of Project infrastructure will be completed as per the Historic Tailings Management Plan provided in Appendix E.2.
	Disturbed areas will be limited to the extent practical.
	Clearing associated with road construction will be limited, where possible, to the width required for the road embankment and drainage areas.
	Erosion and sediment control measures will be established around all disturbed areas as per the Erosion and Sediment Control Plan provided in Appendix F.10.
	Disturbed areas will be monitored to ensure erosion and sediment control measures are maintained/effective and to identify if additional mitigation is required.
	Road and site grading will be directed away from wetlands and watercourses, where possible.
	Organic material and till will be separated and stockpiled separately during stripping activities.
	Organic material and till will be separated from grubbed material and stored for use during progressive reclamation and closure.
	Organic and till stockpiles will be developed with appropriate buffers (30 m) to wetlands and watercourses where practical. Ditching around stockpiles will collect all run-off for treatment of TSS prior to discharge.
	Sediment control fences will be installed in areas (e.g., slopes and embankments) where organic materials and till are exposed to potential erosion and siltation. Sediment control fences will be inspected and maintained until the disturbed areas have stabilized and revegetation has occurred.
	Duration of instream work will be minimized. Any instream work will be completed free of flowing water (i.e., temporary cofferdam to allow for work in the dry) to minimize TSS. When possible, machinery will be operated above the high-water mark or inside isolated areas.
	Instream historic tailings excavation work will be conducted in accordance with the Nova Scotia *Activities Designation Regulations* and the *Nova Scotia Watercourse Alterations Standard* and will be limited to the low flow period between June 1st and September 30th.
Construction and Operations	Surfaces of organic material and till stockpiles will be stabilized during extended periods between usage by means of vegetating or covering exposed surfaces.
	Settling ponds will be utilized to treat surface runoff and pit water for TSS. Treated water will be discharged to the environment.
	All the settling pond outlet structures will be equipped with emergency shut-off valves that can be closed if any water quality parameter exceedances are triggered
	All surface water discharges from settling ponds to the natural environment will be sampled as per requirements listed in IA and MDMER to ensure water quality conforms to applicable regulations and guidelines.
	Design of stockpiles will include perimeter ditches to direct water to settling ponds prior to discharge.
	Precipitation runoff from WRSA, developed areas and mine pits will be collected via lined ditches and directed to the associated water treatment unit (if required) and settling ponds.
	All ditching will be designed to reduce erosion and sedimentation through use of rock check dams, silt fences, plunge pools, and grading as appropriate. All contact water ditching will be lined to mitigate contaminant leaching into the receiving environment.
	A maintenance schedule will be developed and implemented to provide for regular maintenance and inspection of Project mine water management infrastructure.
	ROM material and waste rock will managed in accordance with the MI/ARD Management Plan provided in Appendix E.4.

Table 5.4-12 Geology, Soil, and Sediment Mitigation Measures

Project Phase	Mitigation Measure
	Disposal/storage of PAG bedrock, if encountered, will be conducted in compliance with the *Sulphide Bearing Material Disposal Regulations.*
Closure	Disturbed areas will be graded and/or scarified, covered with organic material and till, where required, and seeded with native seed mix to promote natural plant colonization and succession.
	Passive water quality treatment technologies, including engineered wetlands to treat site seepage and runoff, will be employed as required for closure.
	The volume of organic material and till required for rehabilitation will be tracked to ensure sufficient material is available for reclamation.

5.4.8 Monitoring and Follow-up

A robust monitoring program of erosion and sedimentation control measures will be required to measure the effectiveness of mitigation activities. Proposed monitoring and maintenance of erosion and sediment controls are described in the Erosion and Sediment Control Plan provided in Appendix F.10. Potential effects of siltation on watercourses will also be monitored as per the Water Monitoring Plan provided in Appendix F.11 and discussed in Section 5.6 (Surface Water Resources).

Historic tailings that are not directly disturbed by Project infrastructure will remain in place in the low-lying areas south of Gold Brook Lake and in Gold Brook. Surface water and groundwater in the vicinity of the historic tailings areas will be monitored over the duration of the Project as detailed in the Water Monitoring Plan developed for the Project (GHD, 2022a). Groundwater elevations will be monitored in existing wells located between the open pits and the historic tailings areas to provide an early indicator of potential reduction of groundwater contribution to Gold Brook and surrounding wetlands. If a reduction in groundwater elevations is observed that is greater than minimum predicted groundwater elevations, and there is an increase in constituent concentrations in surface water approaching applicable regulatory standards (CCME WQGs for the Protection of FWAL, NS Tier 1 EQS, or Site-Specific Water Quality Guidelines (SSWQG)), Signal Gold will implement an adaptive management approach. Additional mitigation measures that could be undertaken include excavation and transportation of dewatered tailings material to the TMF and covering disturbed tailings with a low permeability cover.

Signal Gold will regularly test mine rock and tailings to monitor the ML/ARD potential and inform material handling and storage strategies. Water quality from groundwater and surface water locations will be monitored for the potential for migration of ML/ARD affected water quality (pH, SO4 or specific trace metals identified during the course of the operations phase).

5.4.9 Company Commitments

NSLI is currently undertaking a Phase I and Phase II ESA and remedial action plan for all historic tailings located on Crown land within the Upper Seal Harbour Gold District and Lower Seal Harbour Gold District, including the PA. Signal Gold is part of a historic tailings working group with NSLI and has provided the data and findings of the limited Phase I and Phase II ESA completed for the Project to assist with their assessment. Signal Gold is committed to further discussion and cooperation with NSLI as they advance their Phase I and Phase II ESA and remedial action plan.

5.4.10 Residual Effects and Significance

There are no regulated or proposed thresholds of significance for geology related to the Project. A significant adverse effect on soil and sediment quality was defined in Section 5.4.6 as:

- Project-related residual effects having high magnitude, potential for regional geographic extent and for medium to long term duration, occurring at any frequency, and partially reversible to irreversible.

The predicted residual environmental effects of the Project on sediment are assessed to be both positive and adverse, but not significant. However, after appropriate mitigation measures have been implemented, the overall residual effect of the Project on geology, soil and sediment is assessed as not likely to have significant adverse effects, as summarized in Section 5.4.7. Residual effects to sediment are summarized in Table 5.4-13 and are further addressed in Sections 5.6 (Surface Water Resources).

Table 5.4-13 Residual Effects on Sediment

Project Phase	Mitigation and Compensation Measures	Nature of Effect	Residual Effects Characteristics						Residual Effect	Significance
			Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility		
Construction – Excavation and long-term storage of historic tailings	In-stream excavation completed according to *Nova Scotia Watercourse Alterations Standard*. Downstream migration of sediments controlled by best management practices. Long-term storage of the historic tailings in the lined TMF. TMF WTS and seepage collection system	P	L Permanent removal of contaminant source.	PA	N/A	P Source of contamination removed.	C Potential for continuous water quality improvement.	IR	Removal of historic tailings Potential improvement of surface water quality	Not significant
Construction, Operations, and Closure – Discharge of sediment laden runoff to watercourses and wetlands	Erosion and sediment controls Water management infrastructure Progressive reclamation of WRSAs and stockpiles	A	L Erosion and sediment controls are expected to minimize impacts to receiving waterbodies.	LAA	N/A	LT Potential for sediment laden runoff during all phases of the Project	S With the implementation of proper mitigations, the effects occur at irregular intervals throughout the Project.	PR	Watercourse siltation	Not significant

Legend (refer to Table 5.4-10 for definitions)

Nature of Effect	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility
A – Adverse	N – Negligible	PA – Project Area	N/A – Not Applicable	ST – Short-Term	O – Once	RE – Reversible
P – Positive	L – Low	LAA – Local Assessment Area	A – Applicable	MT – Medium-Term	S – Sporadic	IR – Irreversible
	M – Moderate	RAA – Regional Assessment Area		LT – Long-Term	RE – Regular	PR – Partially Reversible
	H – High			P – Permanent	C – Continuous	

5.5 Groundwater Resources

5.5.1 Rationale for Valued Component Selection

Groundwater resources was selected as a VC for its significance to ecological, and socioeconomic systems. Groundwater resources provide ecological value by supporting surface water flows and wetlands providing habitat for aquatic and terrestrial species that rely on accessible water sources for their survival. Socially and economically, groundwater resources can provide a source of water, potable or otherwise, to municipal agricultural, industrial, and recreation sectors, among others. Groundwater quantity and/or quality may be changed due to the activities associated with Project construction, operations, and closure. Groundwater quality is provincially regulated via many legislative avenues within the NS *Environment Act* and several of its regulations. The regulations are protective of ecological receptors, as well as the health of the general public.

During various Project activities, there is a potential for direct adverse effects to groundwater quantity and quality. Project activities such as dewatering the proposed pits, have the potential to drawdown (lower) the groundwater table adversely impacting the quantity of groundwater available for use (e.g., potable consumption). Project activities including construction of WRSA and blasting to develop the open pits have the potential to increase concentrations of metals and nitrogen species in groundwater which may adversely impact groundwater quality. There is also a potential for impacts to groundwater quantity and quality to indirectly impact other VCs including surface water, wetlands, fish and fish habitat, terrestrial, and Indigenous Peoples. Where impacts to groundwater may affect other VCs, the impacts to those VCs are discussed in the section of the impacted VC (i.e., groundwater impacts are incorporated into the surface water assessment as discussed in Section 5.6 (Surface Water Resources)).

5.5.2 Baseline Program Methodology

To assess baseline groundwater quantity and quality conditions, GHD developed an understanding of the regional and Project-specific hydrologic, geologic, and hydrogeologic conditions through the review and compilation of publicly available and Project-specific hydrologic, geologic, and hydrogeologic information and through Project-specific hydrogeologic investigations. Project-specific investigations included monitoring well installation, groundwater elevation monitoring, hydraulic conductivity testing, and groundwater quality sampling. The review and compilation of regional and Project-specific data forms the basis for developing a hydrogeologic Conceptual Site Model (CSM) to describe the key components of the hydrogeologic system with respect to groundwater quantity and quality under baseline conditions. Based on the hydrogeologic CSM, GHD developed a 3D numerical groundwater flow model to represent baseline Project conditions and to provide a basis of comparison for predicted Project impacts on groundwater resources.

5.5.2.1 Review and Compilation of Regional and Project-Specific Hydrologic, Geologic, and Hydrogeologic Data

GHD reviewed historical and recent data to develop an understanding of the regional and Project-specific hydrologic, geologic, and hydrogeologic conditions. Reviewed publicly available data included

- Surficial soil and geologic mapping developed for NS
- Regional recharge and baseflow mapping
- Reports on regional groundwater quality
- Reports on regional groundwater quantity
- Climatic data
- Historical investigations and studies conducted for the Project including but not limited to:
  - Goldboro Project Hydrogeological Investigation – Updated (WSP, 2019b)
  - Hydrogeological Modeling Study Goldboro Project (WSP, 2019c)

- Environmental Assessment Report for A Proposed Gold Mine Project at Goldboro Guysborough County, Nova Scotia (Orex, 1990)

In addition to the above-mentioned data sources, GHD reviewed the NS Well Logs Database (NSECC, nd) to identify water supply wells and private wells located within or in the vicinity of the PA. The NS Well Logs Database also provided information on geologic conditions, groundwater elevations and well yields.

5.5.2.2 Project-Specific Hydrogeologic Investigation

In addition to the historical hydrogeologic investigations completed by WSP and others, GHD conducted a Project-specific hydrogeologic investigation within the PA to collect detailed geologic and hydrogeologic information. Borehole/monitoring well locations were selected to provide broad spatial coverage over the PA and to focus on collecting detailed geologic and hydrogeologic information near the proposed pits and TMF which are most significant from a hydrogeologic perspective. Borehole/monitoring well locations are constrained by property access agreements, Crown land use permits, and offsets from environmentally sensitivity areas.

Borehole drilling and monitoring well installation was completed by Logan Drilling Group (Logan) with supervision from Terrane Geoscience (Terrane) and technical direction from GHD. Drilling and monitoring well installation commenced in 2021 and is ongoing in 2022. GHD completed baseline groundwater monitoring events from July 19 to 22, October 25 to 27, and December 13 to 17, 2021 at installed monitoring well locations. Groundwater monitoring has been ongoing for the Project since August 2018 at monitoring well locations installed by WSP. The 2021 Baseline Groundwater Program (Appendix F.1) presents the detailed methodology and results of 2021 hydraulic testing, groundwater elevation monitoring and groundwater quality sampling that are summarized in the following sections. Groundwater quantity and quality monitoring at the Project is ongoing.

5.5.2.2.1 Monitoring Well Locations

Boreholes were drilled at 19 locations throughout the PA in 2021. Between two and three monitoring wells were installed at each drilling location within individual boreholes advanced to different depths. Monitoring wells labelled ‘A’ and ‘ ’ were installed to approximately 5 and 30 mbgs, respectively, and wells labelled ‘C’ were installed to depths ranging from 41.1 to 196.6 mbgs. The screened intervals of the A, B, and C series were installed targeting permeable units or fractures within the overburden, shallow fractured bedrock, and deep more competent bedrock. Monitoring wells monitored in 2021 are shown in Figure 5.5-1 and listed in Table 5.5-1, below. Drilling is ongoing within the PA and will be completed in 2022.

Groundwater monitoring has been ongoing since August 2018 as part of the monitoring program for the Goldboro Bulk Sample Site IA (Approval No. 2018-101368-02). The following five monitoring wells are included in the IA monitoring program: Domestic Well (Station #8), MW17-1, MW17-2, MW17-3S, and MW17-3D.

Paper Size ANSI B

0 125 250 375 500

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

GROUNDWATER
MONITORING LOCATIONS

Project No. 11222385
Revision No. -
Date 25/05/2022

FIGURE 5.5-1

N:\CA\Halifax\Projects\661\11222385\GIS\Maps\Deliverables\RPT03\11222385-RPT03_GIS-HX5.5-1_GW_Monitor.mxd
Print date: 26 May 2022 - 14:44

Data source: GHD, Anaconda, © 2022 Microsoft Corporation © 2022 Maxar ©CNES (2022) Distribution Airbus DS. Created by: jjparks

Table 5.5-1 ***Monitoring Well Locations and Elevations***

Monitoring Well ID	Coordinates (UTM Zone 20, NAD83 [CSRS])		Recorded Drilled Depth[1] (mbgs[2])	Screened Interval (mbgs)	Reference Elevation (masl[3])
	Northing (m)	Easting (m)			
MW1-A	5008839	608216	6.5	3.4 – 6.4	111.366
MW1-B	5008840	608218	30.3	19.9 – 22.8	111.297
MW5-A	5007231	606591	4.7	1.7 – 4.7	58.691
MW5-B	5007231	606592	31.1	28.0 – 31.1	58.795
MW6-A	5006806	606654	4.3	0.7 – 3.8	63.691
MW6-B	5006807	606654	30.2	26.5 – 29.6	63.771
MW7-A	5006845	605953	5.5	2.4 – 5.5	86.541
MW7-B	5006845	605952	30.5	27.5 – 30.5	86.632
MW15-A	5006593	605912	5.5	2.4 - 5.5	80.868
MW15-B	5006593	605911	30.2	24.0 – 27.0	80.906
MW15-C	5006595	605910	251.6	185.2 – 189.8	80.851
MW16-A	5006087	606366	14.0	11.2 – 14.0	64.619
MW16-B	5006090	606367	30.5	26.1 – 29.0	64.609
MW16-C	5006087	606371	101.0	38.2 – 41.1	64.118
MW20-A	5006226	606170	5.6	2.6 – 5.6	71.955
MW20-B	5006225	606169	30.2	26.8 – 29.8	71.931
MW20-C	5006224	606171	251.6	97.7 – 101.5	71.916
MW21-A	5005735	606440	9.2	6.3 – 9.2	59.837
MW21-B	5005734	606442	30.3	18.5 – 21.4	59.582
MW23-A	5006474	606971	7.2	4.1 – 7.1	58.447
MW23-B	5006473	606973	30.3	27.4 – 30.3	57.869
MW26-A	5006677	606402	6.8	3.9 – 6.8	72.239
MW26-B	5006676	606403	30.0	22.8 – 25.7	72.384
MW26-C	5006680	606397	251.4	149.8 – 152.6	71.306
MW29-A	5006140	606754	5.0	2.1 – 4.9	57.294
MW29-B	5006138	606752	30.5	6.4 – 7.6	57.272
MW30-A	5006720	606608	6.2	3.3 – 6.2	67.486
MW30-B	5006717	606613	30.4	15.5 – 18.4	66.984
MW30-C	5006715	606610	251.3	193.7 – 196.6	66.271
MW42-A	5007032	606657	5.1	1.8 – 4.6	59.620
MW42-B	5007030	606659	30.3	21.1 – 24.0	59.580
MW43-A	5007474	606424	12.3	9.3 – 12.2	61.801
MW43-B	5007475	606423	30.3	16.8 – 19.8	61.816
MW46-A	5006747	606390	6.1	3.3 – 6.1	76.047

Table 5.5-1 Monitoring Well Locations and Elevations

Monitoring Well ID	Coordinates (UTM Zone 20, NAD83 [CSRS])		Recorded Drilled Depth[1] (mbgs[2])	Screened Interval (mbgs)	Reference Elevation (masl[3])
	Northing (m)	Easting (m)			
MW46-B	5006748	606391	30.1	19.4 – 22.2	76.042
MW46-C	5006741	606389	149.6	110.3 - 113.6	74.822
MW51-A	5008623	607378	4.6	1.7 – 4.5	83.408
MW51-B	5008625	607379	30.5	8.0 – 10.9	83.507
MW54-A	5007673	607449	4.8	2.8 – 4.8	58.021
MW54-B	5007674	607449	30.3	7.9 – 10.8	58.154
MW55-A	5007525	607760	7.6	4.6 – 7.6	71.892
MW55-B	5007523	607758	30.5	11.5 – 14.3	71.899
MW56-A	5007455	608337	7.8	4.9 – 7.8	74.600
MW56-B	5007455	608337	30.5	25.7 – 28.6	74.230

Note: Monitoring wells were surveyed by Terrane and Signal Gold in 2021.

[1] Borehole depths taken from borehole logs completed by Terrane

[2] metres below ground surface (mbgs)

[3] metres above sea level (masl)

5.5.2.2.2 Hydraulic Conductivity Testing

Logan and Terrane completed packer tests in 2021 to determine the hydraulic conductivity of the bedrock encountered during the investigation. A total of 47 packer tests (between two and five per borehole) were carried out between January 24 and December 1, 2021.

The packer tests were completed using the Lugeon test method, which consists of isolating a section of the previously drilled borehole using inflatable packers, and injecting water in the rock under 5 pressures for 10 minutes each. The pressures correspond to 50%, 75%, 100%, 75% and 50% of the maximum test pressure. The maximum test pressure was determined based on the depth of the test, the overburden pressure, and the quality of the bedrock. The average hydraulic conductivity of the rock mass was determined using the average values of water pressure and flow rate measured at each stage of the packer test.

5.5.2.2.3 Groundwater Elevation Monitoring

Groundwater static water levels were measured relative to surveyed referenced points (top of polyvinyl chloride [PVC] casing) with an electric water level probe. All monitoring wells also have transducers (Leveloggers) installed to automatically record hourly water levels.

The Leveloggers are removed from the monitoring well and data is downloaded in the field. Data is also retrieved from a Barologger, which is used to compensate the transducer data for the effects of atmospheric pressure. Transducers were re-installed following each sampling event.

5.5.2.2.4 Groundwater Quality Sampling

Groundwater quality sampling has been ongoing in the PA since December 2017. WSP collected 8 sampled in December 2017, and Signal Gold collected groundwater samples during dewatering of the Orex mine workings from August 2018 through January 2019. As part of the IA, groundwater monitoring has also been completed since August 2018 at five groundwater monitoring stations including: Domestic Well (#8), MW17-1, MW17-2, MW17-3S, and MW17-3D.

To assess groundwater quality conditions in the PA, GHD reviewed groundwater sampling conducted by Signal Gold as part of the IA and completed comprehensive groundwater quality sampling at monitoring wells installed in 2021. The methodology applied to collect and analyse the 2021 groundwater samples is described below.

Except as noted below, groundwater samples were collected from all available monitoring wells in July, October, and December 2021. Borehole drilling and monitoring well installation continued in 2022, and subsequent sampling events will be expanded to include all available wells. The monitoring network will continue to be modified over time as the Project enters different stages of its lifecycle.

Prior to collecting groundwater samples, the depth to water and total depth of the well were measured and used to calculate the volume of standing water in the well. Monitoring wells were purged prior to sampling and stabilization parameters were measured after every purged well volume until pH readings were within 1 standard unit and conductivity and temperature readings were within ten percent for three consecutive readings or a minimum of three well volumes were purged. The water level in each of the monitoring wells was allowed to recover (24 hours) to its approximate static water level prior to collecting groundwater samples. This approach allowed any silt in the water column to settle to the bottom of the well and avoid it from becoming entrained in the groundwater sample. This is intended to reduce the amount of turbidity, and associated filtering, required to prepare the groundwater samples collected for metals analysis. The samples were collected from the well with a bottom loading bailer and decanted into the laboratory supplied sample containers.

Samples for dissolved metals (including mercury) and DOC analysis were filtered using dedicated Waterra tubing and in-line filters. The groundwater samples were placed directly in new laboratory supplied sample bottles and placed in coolers with ice immediately after they were collected. The samples were maintained in cool storage until delivery to BV Labs in Bedford, NS. All waste generated from the sampling program was collected and disposed off-site, in accordance with provincial and municipal legislation.

The groundwater samples collected from the monitoring wells were submitted for the following analysis: total and dissolved mercury, general chemistry, dissolved metals, dissolved phosphorous, chemical oxygen demand (COD), DOC, TSS, and benzene, toluene, ethylbenzene, xylenes (BTEX)/modified total petroleum hydrocarbons (mTPH). Groundwater samples collected as part of IA monitoring were analyzed for general chemistry, dissolved metals, and TSS.

A minimum of one field duplicate sample for every 10 samples (at least 10%) was collected in accordance with QA/QC protocols. The results of the QA/QC sampling were used to evaluate the reliability of the sampling and analysis methods.

5.5.2.3 Methodology for Hydrogeologic CSM Development

The hydrogeologic CSM forms the working basis for understanding the hydrogeologic conditions at the Project. The CSM includes:

- The extent, geometry, and composition of the hydrostratigraphic units
- Groundwater flow characteristics of each hydrostratigraphic unit
- Groundwater flow interactions between the units
- Groundwater/surface water interactions

The CSM facilitates selecting model domain limits for the numerical groundwater flow model, as well as hydrostratigraphic unit representation and boundary conditions taking into consideration the observed Project-specific and regional hydrogeologic conditions. The CSM then forms the basis for constructing the numerical groundwater flow model. GHD developed the hydrogeologic CSM for the project through the review and compilation of hydrologic, geologic and hydrogeologic data collected through the review of publicly available information, historical investigations in the PA and the Project-specific hydrogeologic investigation.

5.5.2.4 Methodology for Development of 3D Numerical Groundwater Flow Model

To develop the 3D numerical groundwater flow model, GHD selected a simulation program based on the following:

- The ability of the program to represent key components of the CSM
- The demonstration that the program correctly represents the hydrogeologic processes being considered
- The proven acceptance of the program by regulatory agencies and the scientific/engineering community
- The ability of the program to represent the proposed Project design
- The ability of the program to provide a reasonable numerical solution in consideration of the complexity of the hydrogeologic conditions at in the PA and their interaction with the proposed Project infrastructure

GHD developed a 3D numerical groundwater flow model to represent the hydrogeologic conditions observed at and surrounding the PA based on available hydrologic, geologic and hydrogeologic data and the hydrogeologic CSM. GHD calibrated the groundwater flow model to represent baseline Project conditions through achieving a reasonable representation of measured groundwater elevations and estimated based flow. The model was further evaluated against historical inflow volumes to the Orex and Boston-Richardson underground mine workings. The reasonable representation of baseline hydrogeologic conditions, as demonstrated through model calibration and evaluation, provides the basis against which to compare predicted impacts from Project development.

5.5.3 Baseline Conditions

This section provides a summary of the existing or baseline conditions for groundwater resources (i.e., quantity and quality) based on a review of publicly available regional and Project-specific hydrologic, geologic, and hydrogeologic information and Project-specific hydrogeologic investigations. A summary of the hydrogeologic CSM and development of the 3D numerical groundwater flow model to represent baseline conditions is also provided. Detailed drilling, monitoring well installation details groundwater levels and groundwater quality monitoring results from the 2021 hydrogeologic investigations is presented in the 2021 Groundwater Monitoring Report provided in Appendix F.1. The Groundwater Modelling Report (Appendix F.2) provides a detailed description of the 3D numerical groundwater flow model development, calibration, and application to predict potential impacts of Project development.

5.5.3.1 Summary of Hydrologic, Geologic, and Hydrogeologic Conditions

GHD reviewed the regional and site-specific hydrologic, geologic, and hydrogeologic conditions at the Project. This analysis forms the basis for developing a comprehensive CSM that characterizes key groundwater flow conditions, including groundwater sinks (i.e., conditions that remove groundwater from the groundwater flow system) and groundwater sources (i.e., conditions that introduce/recharge groundwater into the groundwater flow system) at/near the Project. Understanding these groundwater flow conditions allows for the development of a groundwater flow model that can be applied to make predictions of groundwater flow, groundwater/surface water interactions, and potential COC migration. An overview of the regional and Project-specific hydrologic, geologic, hydrogeologic conditions are summarized below.

5.5.3.1.1 Hydrologic Conditions

The hydrologic conditions are affected by regional physiography, topography, and surface water features. Section 5.4 provides a detailed description of the Project physiography and topography. Section 5.6 provides a detailed description the Project surface water features. In general, the physiographic province containing the Project is characterized by rolling hills, drumlin fields and smooth ridges with intervening lakes, streams, and wetlands. The maximum elevation in the PA is approximately 110 masl northeast of Gold Brook Lake and the land topography slopes gently towards sea level to the southeast of the Project. The proposed open pits are locating in an area of low topographic relief at approximately 60 masl.

Regional surface water drainage is predominantly to the southeast along several stream channels and shallow lakes, and there are several low-lying wetlands across the PA. The most significant surface water body in the PA is Gold Brook Lake. The southern end of Gold Brook Lake is located approximately 100 m north of the proposed pits. Gold Brook Lake drains southeastward to Seal Harbour Lake and finally discharges to the Atlantic Ocean. Gold Brook Lake likely is a location of groundwater discharge (i.e., a groundwater sink).

In addition to Gold Brook Lake, the most significant surface water bodies near the PA include Rocky Lakes, Oak Hill Lake, Ocean Lake, and Meadow Lake.

5.5.3.1.2 Geologic Conditions

Surficial geology is described in Section 5.4.3.4 and bedrock geology is described in Section 5.4.3.5.

5.5.3.1.3 Hydrogeologic Conditions

The hydrogeologic and groundwater flow conditions in and surrounding the PA are informed by the review of publicly available information and through hydrogeologic investigations conducted in the PA, including the review and compilation of measured groundwater elevations and hydraulic conductivity testing data.

In general, groundwater flow systems in NS are relatively shallow, with the majority of groundwater flow occurring in the upper 150 m. Large-scale groundwater flow between watersheds has not been observed, likely due to the geology present throughout NS (i.e., low permeability faulted/folded bedrock) that does not lend itself to the development of large regional aquifer systems (Kennedy et al., 2010). Collected groundwater elevation measurements help provide an understanding of groundwater flow conditions within the PA. Groundwater elevations have been collected in the PA by Signal Gold since August 2018 at five monitoring well locations installed by WSP in December 2017. WSP conducted a single synoptic round of groundwater monitoring at 62 borehole locations and five monitoring well locations in June 2019. As described in Section 5.5.2.2, the installation of comprehensive monitoring network consistent with the scope of the Project began in 2021 and is ongoing in 2022. Throughout the three monitoring events in 2021, conducted at monitoring well locations installed in 2021, the depth to groundwater ranged from 0.84 metres below top of riser (mbtr) (MW20-A, October 1, 2021) to 46.28 mbtr (MW26-C, October 1, 2021), with most of the static water levels ranging from approximately 1.0 – 4.0 mbtr. Groundwater elevations collected at monitoring wells installed in 2021 are summarized in Table 5.5-2. Groundwater elevations collected as part of the existing IA monitoring program are presented in Appendix F.1.

Table 5.5-2 Groundwater Monitoring Levels

Monitoring Well ID	Date	Reference Elevation (m CGVD28)	Static Water Level (mbtr[1])	Groundwater Elevation (masl)
MW1-A	15-Dec-21	111.366	1.11	110.26
MW1-B	15-Dec-21	111.297	6.52	104.78
MW5-A	29-Jul-21	58.691	1.095	57.60
	1-Oct-21		0.890	57.80
	25-Oct-21		0.914	57.78
	13-Dec-21		0.950	57.74
MW5-B	29-Jul-21	58.795	1.545	57.25
	1-Oct-21		1.300	57.50
	25-Oct-21		1.405	57.39
	13-Dec-21		1.470	57.33
MW6-A	29-Jul-21	63.691	1.895	61.80
	1-Oct-21		1.040	62.65
	25-Oct-21		1.721	61.97
	13-Dec-21		1.050	62.64

Table 5.5-2 Groundwater Monitoring Levels

Monitoring Well ID	Date	Reference Elevation (m CGVD28)	Static Water Level (mbtr[1])	Groundwater Elevation (masl)
MW6-B	29-Jul-21	63.771	4.820	58.95
	1-Oct-21		4.780	58.99
	25-Oct-21		5.170	58.60
	13-Dec-21		4.635	59.14
MW7-A	29-Jul-21	86.541	1.991	84.55
	1-Oct-21		1.320	85.22
	26-Oct-21		1.480	85.06
	14-Dec-21		1.355	85.19
MW7-B	29-Jul-21	86.632	2.441	84.19
	1-Oct-21		1.960	84.67
	26-Oct-21		2.120	84.51
	14-Dec-21		1.906	84.73
MW15-A	29-Jul-21	80.868	1.305	79.56
	1-Oct-21		0.980	79.89
	26-Oct-21		1.054	79.81
	14-Dec-21		1.005	79.86
MW15-B	29-Jul-21	80.906	1.365	79.54
	1-Oct-21		1.15	79.76
	26-Oct-21		1.251	79.66
	14-Dec-21		1.158	79.75
MW15-C	29-Jul-21	80.851	5.475	75.38
	1-Oct-21		5.28	75.57
	26-Oct-21		5.233	75.62
	14-Dec-21		4.975	75.88
MW20-A	29-Jul-21	71.955	1.114	70.84
	1-Oct-21		0.840	71.12
	26-Oct-21		0.985	70.97
	14-Dec-21		0.905	71.05
MW20-B	29-Jul-21	71.916	1.280	70.64
	1-Oct-21		1.170	70.75
	26-Oct-21		1.242	70.67
	14-Dec-21		1.251	70.67

Table 5.5-2 Groundwater Monitoring Levels

Monitoring Well ID	Date	Reference Elevation (m CGVD28)	Static Water Level (mbtr[1])	Groundwater Elevation (masl)
MW20-C	29-Jul-21	71.931	6.085	65.85
	1-Oct-21		1.380	70.55
	26-Oct-21		1.402	70.53
	14-Dec-21		1.290	70.64
MW21-A	15-Dec-21	59.837	1.285	58.55
MW21-B	15-Dec-21	59.582	1.125	58.46
MW23-A	14-Dec-21	58.447	2.756	55.69
MW23-B	14-Dec-21	57.869	2.655	55.21
MW26-A	26-Oct-21	72.239	0.963	71.28
	14-Dec-21		0.835	71.40
MW26-B	26-Oct-21	72.238	1.388	70.85
	14-Dec-21		1.150	71.09
MW26-C	29-Jul-21	71.306	44.820	26.49
	1-Oct-21		46.280	25.03
	26-Oct-21		40.409	30.90
	14-Dec-21		37.100	34.21
MW29-A	15-Dec-21	57.294	2.135	55.16
MW29-B	15-Dec-21	57.272	2.206	55.07
MW30-A	26-Oct-21	67.486	1.904	65.58
	13-Dec-21		1.143	66.34
MW30-B	26-Oct-21	66.984	9.367	57.62
	13-Dec-21		9.676	57.31
MW30-C	29-Jul-21	66.271	11.445	54.83
	1-Oct-21		8.615	57.66
	26-Oct-21		8.362	57.91
	13-Dec-21		9.016	58.26
MW42-A	26-Oct-21	60.582	1.792	58.79
	13-Dec-21		1.811	58.771
MW42-B	26-Oct-21	60.527	3.632	56.895
	13-Dec-21		3.299	57.228
MW43-A	25-Oct-21	61.801	1.823	59.98
	13-Dec-21		1.953	59.85
MW43-B	25-Oct-21	61.816	3.070	58.75
	13-Dec-21		3.105	58.71

Table 5.5-2 Groundwater Monitoring Levels

Monitoring Well ID	Date	Reference Elevation (m CGVD28)	Static Water Level (mbtr[1])	Groundwater Elevation (masl)
MW46-A	26-Oct-21	76.047	0.525	75.52
	14-Dec-21		0.531	75.52
MW46-B	26-Oct-21	76.042	1.123	74.92
	14-Dec-21		1.043	75.00
MW46-C	29-Jul-21	74.822	3.140	71.68
	1-Oct-21		2.990	71.83
	26-Oct-21		2.893	71.93
	14-Dec-21		2.756	72.07
MW51-A	15-Dec-21	83.408	0.754	82.65
MW51-B	15-Dec-21	83.507	0.735	82.77
MW54-A	15-Dec-21	58.021	0.94	57.08
MW54-B	15-Dec-21	58.154	1.189	56.97
MW55-A	15-Dec-21	71.892	2.285	69.61
MW55-B	15-Dec-21	71.899	3.449	68.45
MW56-A	14-Dec-21	75.631	2.292	73.339
MW56-B	14-Dec-21	75.124	2.515	72.609

Groundwater elevations measured in December 2021 range from 110.256 masl (MW1-A) to 34.206 masl (MW26-C). The difference in groundwater elevations in the A series wells versus the B series wells range from 0.06 m to 8.53 m. The vertical hydraulic gradient is directed downward in all monitoring well nests except MW30, where the groundwater elevation in MW30-C is higher than in MW30-B. The difference in groundwater elevations in the B series wells versus the C series wells range from 0.160 m to 45.130 m. Monitoring wells are still being added to the network and are included in groundwater elevations monitoring events as they become available.

To further improve the understanding of groundwater flow conditions in the PA and to increase the resolution of interpreted groundwater elevations, GHD developed an average static groundwater elevation dataset by combining average observed groundwater elevations at monitoring well locations installed by Terrane in 2021 with the June 2019 monitoring event conducted by WSP that included groundwater elevations measured at 62 boreholes and five monitoring wells installed by WSP in 2017. Table 5.5-3 presents the combined average static groundwater elevation dataset.

Table 5.5-3 Average Static Groundwater Elevations

Observation Location Name	Groundwater Elevation (masl)	Observation Location Name	Groundwater Elevation (masl)
BR_91_110	58.63	BR-17-MET-7	54.24
BR_95_124	61.8	BR-17-MET-8	54.85
BR_18_47	62.95	BR-17-MET-9	54.81
BR_88_45	58.95	BR-17-MET-10	58.60
BR_18_45	58.78	BR-17-MET-11	60.10
BR_18_46	61.47	BR_18_69	52.00

Table 5.5-3 Average Static Groundwater Elevations

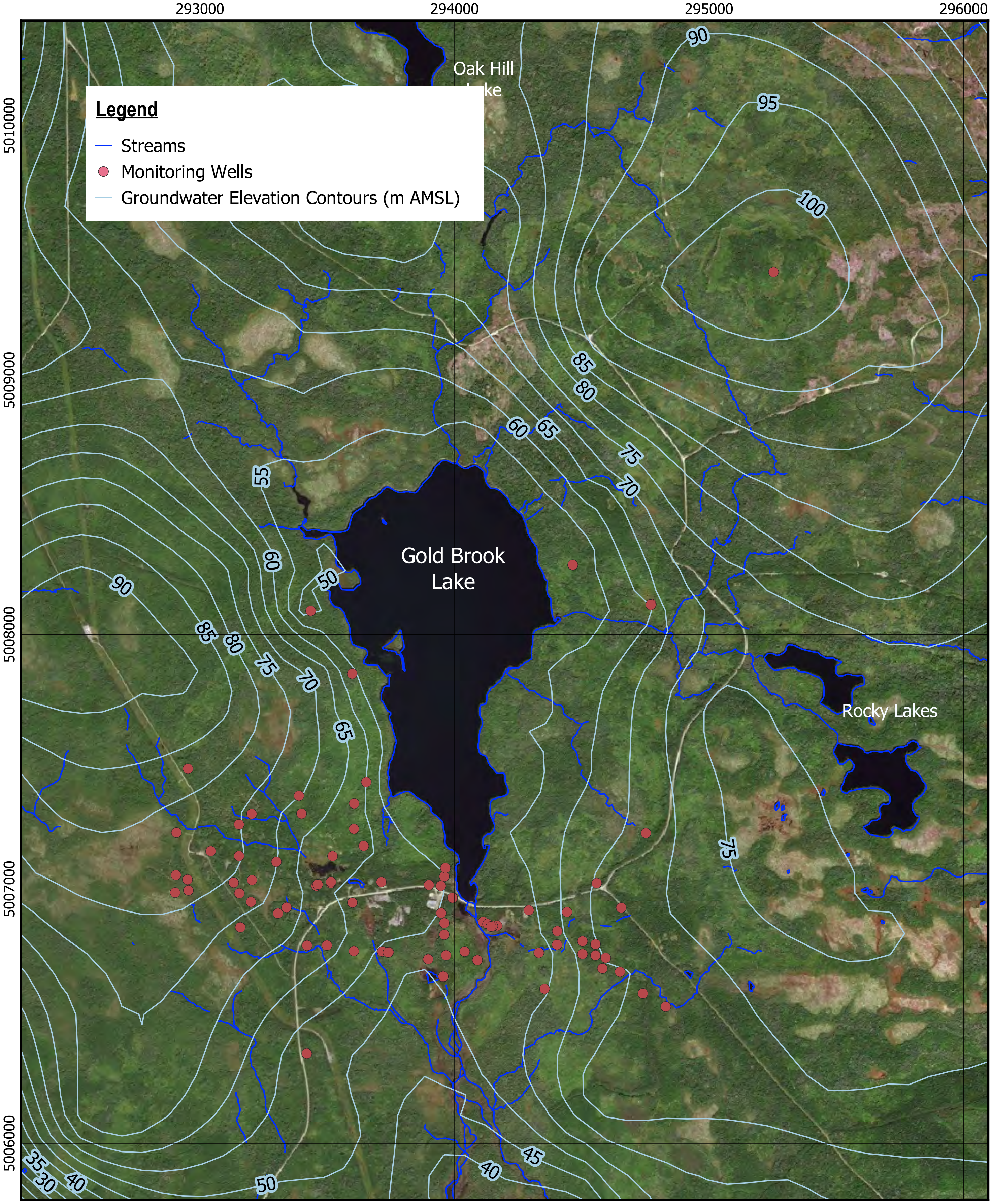
Observation Location Name	Groundwater Elevation (masl)	Observation Location Name	Groundwater Elevation (masl)
BR_18_43	68.58	BR_18_70	52.21
BR_18_44	55.23	BR_19_88	64.41
BR_18_48	52.04	BR_19_91	54.70
BR_18_49	63.24	BR_19_92	54.56
BR_18_50	76.88	BR_19_99	54.00
BR_18_51	76.23	MW17-01	59.29
BR_18_52	76.84	MW17-02	52.11
BR_18_53	77.13	MW17-02S	50.21
BR_18_54	74.99	MW17-03D	50.43
BR_18_55	74.93	MW17-03S	52.41
BR_18_56	71.26	MW15-C	75.61
BR_18_57	73.37	MW15-B	79.68
BR_18_58	73.02	MW15-A	79.78
BR_18_59	75.39	MW7-B	84.53
BR_18_60	73.39	MW7-A	85.00
BR_18_61	71.44	MW20-B	70.68
BR_18_62	75.49	MW20-A	70.99
BR_18_63	76.3	MW20-C	69.39
BR_18_64	61.31	MW46-C	71.88
BR_18_65	65.97	MW46-A	75.52
BR_18_66	63.68	MW46-B	74.96
BR_18_67	63.92	MW26-A	71.34
BR_18_68	51.94	MW26-B	70.97
BR_18_71	51.99	MW21-A	58.55
BR_19_100	56.48	MW21-B	58.46
BR_19_101	63.87	MW43-B	58.73
BR_19_102	66.76	MW43-A	59.91
BR_19_72	66.31	MW5-A	57.73
BR_19_73	68.25	MW5-B	57.37
BR_19_74	66.40	MW30-A	65.96
BR_19_75	66.73	MW30-C	57.16
BR_19_76	61.25	MW30-B	57.46
BR_19_87	51.47	MW6-A	62.26
BR_19_93	57.19	MW6-B	58.92
BR_19_94	59.50	MW29-B	55.07

Table 5.5-3 Average Static Groundwater Elevations

Observation Location Name	Groundwater Elevation (masl)	Observation Location Name	Groundwater Elevation (masl)
BR_19_95	62.55	MW29-A	55.16
BR_19_96	65.81	MW23-A	55.69
BR_19_97	65.56	MW23-B	55.21
BR_19_98	52.83	MW54-A	57.08
BR-17-MET-1	64.07	MW54-B	56.97
BR-17-MET-2	64.72	MW55-B	68.45
BR-17-MET-3	62.24	MW55-A	69.61
BR-17-MET-4	51.47	MW1-A	110.26
BR-17-MET-5	55.06	MW1-B	104.78
BR-17-MET-6	54.54		

As shown in Tables 5.5-2 and 5.5-3, the water table at the PA is typically close to ground surface (i.e., averaging 1.9 m below ground surface, in shallow monitoring wells measured in 2021). The bedrock forms a fractured rock aquifer system, which is overlain by a thin overburden aquifer. The groundwater flow system is strongly influenced by topography such that recharge occurs in areas of high elevation and discharge is to low lying streams, rivers, and bogs. Interpreted groundwater elevation contours are presented on Figure 5.5-2 for the overburden/shallow bedrock flow system. Figure 5.5-2 shows that in general groundwater elevations mimic topographic relief and locally groundwater discharges to low-lying surface water features. Gold Brook Lake is likely the most significant surface water body receiving groundwater discharge.

Regional groundwater flow in the fractured crystalline bedrock is controlled by secondary permeability and fracturing. The rock matrix permeability is believed to be generally low. Fracture density is high in the weathered shallow bedrock and decreases with depth (WSP, 2019b). Therefore, most bedrock flow is expected to occur in shallower depth intervals and will decrease with depth, consistent with the understanding presented by Kennedy et al. (2010). Regionally groundwater flow is expected to be towards the Atlantic Ocean; however, groundwater flow at depth is likely minimal due to the low permeability of the deeper bedrock is discussed in the following section.



Paper Size ANSI A

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

OBSERVED GROUNDWATER ELEVATION CONTOURS

Project No.	**11222385**
Revision No.	**-**
Date.	**April 2022**

FIGURE 5.5-2

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Data Source: Bing Aerial (http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1)

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Hydrostratigraphic Units and Hydraulic Properties

Two major hydrostratigraphic units are defined near the PA consisting of the overburden and weathered bedrock hydrostratigraphic units. The overburden is further divided into two main units. These include the upper unit, which is more transmissive to groundwater, and the lower silt-dominated unit, which is less transmissive to groundwater. The identified faults are not considered separate hydrostratigraphic units as discussed below. The hydraulic properties (i.e., hydraulic conductivity) of each of these major aquifer units are summarized below. Hydraulic conductivity values are based on a pumping test conducted by WSP (2019), packer tests and slug tests conducted by WSP, and packer tests analysed by GHD. Table 5.5-4 presents slug test results and Table 5.5-5 presents hydraulic conductivity testing results for the bedrock.

Table 5.5-4 Slug Test Results

Monitoring Well	Hydraulic Conductivity (m/s)	Analysis Method	Slug Test Method	Lithology
MW 17-01	9.00E-07	Hvorslev	Falling Head	Till (SM) (80%) and Bedrock (fractured greywacke) (20%)
MW 17-01	5.00E-07	Hvorslev	Rising Head	Till (SM) (80%) and Bedrock (fractured greywacke) (20%)
MW 17-02	5.00E-06	Hvorslev	Falling Head	Bedrock (fractured greywacke) (80%) and Till (SM) (20%)
MW 17-02	6.00E-06	Hvorslev	Rising Head	Bedrock (fractured greywacke) (80%) and Till (SM) (20%)
MW 17-02	6.00E-06	Hvorslev	Rising Head	Bedrock (fractured greywacke) (80%) and Till (SM) (20%)
MW 17-03D	8.00E-06	Hvorslev	Falling Head	Bedrock (fractured greywacke)
MW 17-03D	8.00E-06	Hvorslev	Rising Head	Bedrock (fractured greywacke)
MW 17-03S	3.00E-06	Hvorslev	Falling Head	Till (SM)

Table 5.5-5 Bedrock Hydraulic Conductivity Test Results

Borehole ID	Hydraulic Conductivity (m/s)	Test Midpoint Below Top of Bedrock (m)	Hydraulic Test Method/Type	Overburden Thickness (m)
MW17-02	6.00E-06	1.00	Slug test rising head	6.0
MW17-03D	8.00E-06	1.00	Slug test rising head	9.0
BR-17-MET-2	9.00E-07	4.00	Packer test	7.8
MW42B	2.73E-06	4.03	Packer test	5.0
MW51B	9.38E-06	4.21	Packer test	5.2
MW21B	1.15E-05	4.49	Packer test	4.7
MW23B	1.30E-05	4.98	Packer test	11.7
MW7B	1.43E-05	5.95	Packer test	3.8
MW5B	9.94E-08	6.02	Packer test	4.0
MW6B	4.56E-08	6.06	Packer test	2.7
BR-17-MET-2	7.00E-08	7.00	Packer test	7.8
MW16B	5.85E-06	8.89	Packer test	9.5

Table 5.5-5 Bedrock Hydraulic Conductivity Test Results

Borehole ID	Hydraulic Conductivity (m/s)	Test Midpoint Below Top of Bedrock (m)	Hydraulic Test Method/Type	Overburden Thickness (m)
MW1B	4.59E-05	9.13	Packer test	1.6
MW15B	2.89E-06	12.81	Packer test	7.0
BR-17-MET-2	1.00E-07	13.00	Packer test	7.8
MW20B	6.09E-08	14.36	Packer test	4.0
MW21B	3.23E-05	14.98	Packer test	4.7
BR-17-MET-2	9.00E-08	15.00	Packer test	7.8
MW26B	1.72E-06	15.57	Packer test	2.5
MW56B	8.05E-05	15.84	Packer test	0.7
MW23B	1.12E-05	16.00	Packer test	11.7
MW42B	6.66E-06	17.27	Packer test	5.0
MW16B	1.83E-05	17.88	Packer test	9.5
MW46B	5.70E-07	19.12	Packer test	1.8
MW51B	4.65E-06	19.19	Packer test	5.2
MW1B	2.82E-04	19.62	Packer test	1.6
MW7B	2.62E-06	19.67	Packer test	3.8
MW5B	9.99E-08	19.77	Packer test	4.0
BR-17-MET-3	1.00E-06	20.00	Packer test	9.0
MW26B	7.37E-06	21.57	Packer test	2.5
MW15B	6.16E-06	21.96	Packer test	7.0
BR-17-MET-2	8.00E-08	23.00	Packer test	7.8
MW6B	2.26E-07	23.30	Packer test	2.7
BR21-270	3.10E-07	25.06	Packer test	3.9
MW56B	2.12E-04	26.30	Packer test	0.7
BR21-274	4.21E-07	28.61	Packer test	2.6
BR21-271	8.29E-07	32.71	Packer test	7.5
BR-17-MET-3	9.50E-07	37.00	Pumping Test	9.0
BR-17-MET-3	2.00E-07	39.00	Packer test	9.0
BR-17-MET-2	6.00E-08	40.00	Packer test	7.8
BR-17-MET-2	2.00E-08	44.00	Packer test	7.8
BR-17-MET-3	3.00E-07	48.00	Packer test	9.0
BR-17-MET-1	5.00E-08	51.62	Pumping Test	7.1
BR21-273	2.44E-07	52.51	Packer test	2.5
BR-17-MET-2	1.00E-07	64.00	Packer test	7.8
BR21-274	2.72E-07	85.61	Packer test	2.6
BR-17-MET-2	9.00E-08	88.00	Packer test	7.8

Table 5.5-5 Bedrock Hydraulic Conductivity Test Results

Borehole ID	Hydraulic Conductivity (m/s)	Test Midpoint Below Top of Bedrock (m)	Hydraulic Test Method/Type	Overburden Thickness (m)
BR21-270	1.99E-07	94.07	Packer test	3.9
BR-17-MET-2	7.00E-08	100.00	Packer test	7.8
BR21-272	1.88E-07	100.51	Packer test	2.4
BR21-274	4.33E-07	109.61	Packer test	2.6
BR-17-MET-5	1.80E-07	114.91	Pumping Test	12.6
BR21-272	2.39E-07	115.51	Packer test	2.4
BR21-270	1.82E-07	123.46	Packer test	3.9
BR21-271	2.14E-07	134.71	Packer test	7.5
BR21-273	2.34E-07	148.51	Packer test	2.5
BR21-271	9.61E-08	149.71	Packer test	7.5
BR21-272	1.99E-07	166.51	Packer test	2.4
BR21-271	3.54E-07	179.71	Packer test	7.5
BR-17-MET-2	3.00E-08	189.00	Pumping Test	7.8
BR21-272	2.56E-07	193.51	Packer test	2.4
BR21-273	1.02E-07	193.51	Packer test	2.5
BR21-270	9.43E-08	199.06	Packer test	3.9
BR21-273	2.26E-07	217.51	Packer test	2.5
BR21-271	3.04E-07	218.71	Packer test	7.5
BR21-272	1.09E-07	223.51	Packer test	2.4

Overburden

WSP conducted slug testing in three monitoring well nests having screens installed in the overburden, at the contact between till, and fractured bedrock, and in the fractured bedrock (WSP, 2019b). The upper till layer identified at MW17-03S had a hydraulic conductivity of 3 × 10^{-6} m/s. MW17-03S has greater amounts of gravel in the till matrix that likely contributed to the relatively transmissive hydraulic conductivity value. The lower till unit had a hydraulic conductivity of 6 × 10^{-7} m/s (average of two tests in MW17-1). The slug tests results are presented in Table 5.5-4. Table 5.5-4 includes slug test results for MW17-03D and MW17-02, which are screened in fractured bedrock and in the fractured bedrock/till interface, respectively, and as such are not summarized in this section.

Bedrock

Measured hydraulic conductivities in the bedrock are presented in Tables 5.5-4 and 5.5-5. As presented in Table 5.5-5, bedrock hydraulic conductivity at the Project has been observed to decrease with depth consistent with the observation of weathered fractured bedrock at shallow depths grading into less fractured and more competent bedrock at depth. In general, the highest hydraulic conductivity values, on the order of 1 × 10^{-6} m/s to 1 × 10^{-3} m/s occur within the upper 30 m of bedrock while hydraulic conductivity values on the order of 1 × 10^{-8} m/s to 1 × 10^{-6} m/s occur at depths greater than 30 m below the top of bedrock. Several empirical equations have been developed by researchers to describe this trend. One of the most frequently-used equations is the model developed by Wei et al. (1995).

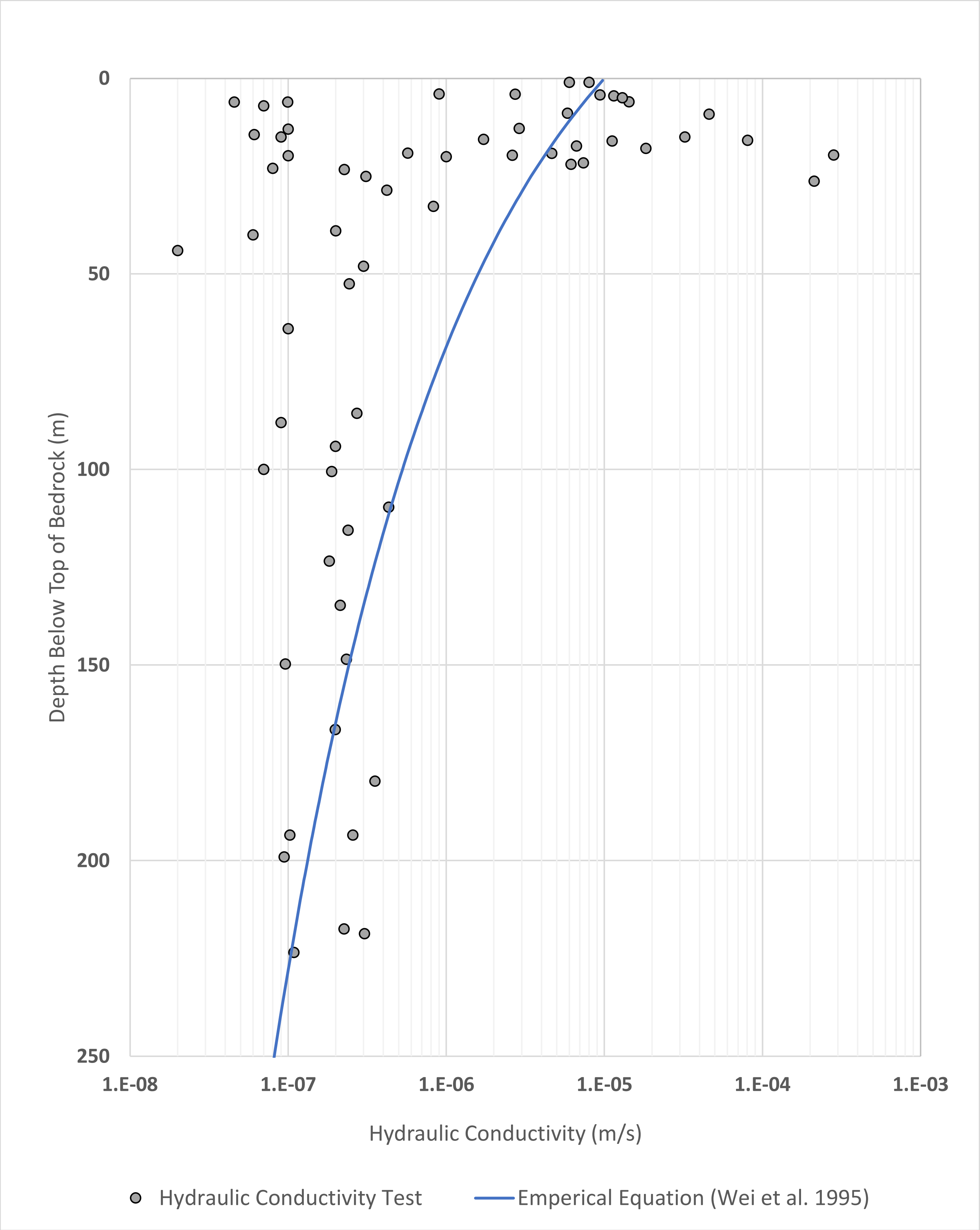
$$K = K_i \left[\frac{1 - Z}{58 + 1.02 \times Z}\right]^3$$

Where:

Z = Depth below ground surface (m)

K_i = Hydraulic conductivity near ground surface

Figure 5.5-3 illustrates the relationship between hydraulic conductivity values measured, from Table 5.5-5, and measurement depth. The hydraulic conductivity versus depth relationship developed using Wei et al. (1995) is also shown on Figure 5.5-3. As illustrated on Figure 5.5-3, the model developed by Wei et al. (1995) provides a reasonable representation of the observed pattern in measured hydraulic conductivity values with increasing depth. It should be noted that the packer tests were typically selected at the intervals with perceived higher fracture densities and secondary permeabilities (which would correspond with greater hydraulic conductivity values) based on the Rock Quality Designation (RQD) of each interval. Consequently, the estimated hydraulic conductivity values, especially at depth, were biased towards higher values and representative of zones conducting groundwater flow. In general, groundwater flow in the bedrock is controlled by the fracturing and secondary permeability, which is greater in the shallow zones and decreases with depth. Hydraulic conductivity testing demonstrates that the hydraulic conductivity of the bedrock decreases with depth.



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GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

HYDRULIC CONDUCTIVITY VERSUS DEPTH

Project No. **11222385**
Date **May 2022**

FIGURE 5.5-3

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Faults

Three main faults have been identified in the PA. Some of these large faults have been observed to be filled will breccia fines, indicating that they will likely not conduct water. Packer testing and pumping testing in borehole BR-17-MET-1, which appears to intercept the New Belt Fault, showed that the fault had low hydraulic conductivity comparable to other bedrock zones (WSP, 2019b). This is consistent with observations made at other gold deposits within the Meguma group where large faults were filled with breccia fines or a clay like gouge and demonstrated similar permeability to the surrounding formation (Jacques and Whitford, 1986). Therefore, the faults observed in the PA are assumed to behave similarly to the surrounding bedrock formation and are not considered as a distinct hydrostratigraphic unit.

Groundwater Sinks

A groundwater sink is any feature that removes groundwater from the groundwater flow system. Within the PA, the primary groundwater sinks correspond to groundwater discharge to surface water features. Groundwater discharge to surface water features is discussed in more detail in the following section.

Discharge to Surface Water Features

Locally, groundwater flow typically follows topographic relief, moving towards surface water features and low-lying areas. During some times of the year, when surface water stage elevations are lower than surrounding groundwater elevations, the linear/flowing surface water features (i.e., rivers, creeks, and channels) will receive groundwater discharge as baseflow. On an average annual basis, baseflow within the primary watersheds containing the Project is estimated to range from approximately 17 to 21 percent of average annual precipitation (Kennedy et al, 2010).

The proposed open pits are located approximately 100 m south of Gold Brook Lake. Gold Brook Lake is the primary surface water feature in the area and is likely an area of groundwater discharge. Gold Brook Lake is approximately 1,700 m long with a maximum width of approximately 790 m at its northern end and 110 m at its southern end. Gold Brook Lake has a maximum depth of approximately 3.0 m and a mean depth of 1.7 m. Gold Brook Lake is drained from its southern end by Gold Brook which flows in a southerly to southeasterly direction ultimately discharging into Seal Harbour Lake and the Atlantic Ocean.

Groundwater Sources

A groundwater source is any feature that contributes water to the groundwater flow system. At the Project, the primary groundwater source is from groundwater recharge through precipitation infiltration. In some areas it is expected that groundwater will receive recharge from surface water features; however, surface water features overall are expected to receive net discharge from the groundwater flow system.

Recharge Through Precipitation Infiltration

Groundwater near the Project area receives precipitation at a reported average annual rate of approximately 1,409.2 mm/yr (Water Balance Analysis Summary Report provided in Appendix F.5 and discussed in section 5.6). The amount of precipitation reaching the groundwater table is typically considered to range from approximately 10 to 40 percent of the average annual precipitation (Arnold et al., 2000; Rushton and Ward, 1979).

Project-specific average baseflow was estimated using the chloride mass-balance (CMB) method (Healy, 2010). The CMB method is widely used to estimate groundwater recharge. In this method, groundwater recharge is estimated using the following equation:

$$R = \frac{Cl_p}{Cl_{gw}} \times P$$

Where R is recharge in mm, Cl_p is chloride concentration in precipitation, Cl_{gw} is chloride concentration in groundwater, and P is average annual precipitation. Chloride concentration in groundwater was estimated from 4 monitoring wells (MW17-1, MW17-2, MW17-3D, and MW17-3S) in the PA. GHD estimated the precipitation chloride concentration from the publicly available data for Sherbrook Station (approximately 27 km east of the site) collected from 2008 to 2018. GHD estimated that the site specific average annual recharge is 18.5 percent of average annual precipitation or approximately 260 mm/year. The lower and upper quartiles of the percentages of precipitation contributing to recharge are 17 and 23 percent, respectively. The Project-specific average groundwater recharge estimates of 17 to 23 percent of average annual precipitation corresponds well with the estimated baseflow range of 17 to 21 percent of average annual precipitation presented by Kennedy et al. (2010).

Baseflow often is used to estimate recharge rates, with the caveats that: 1) baseflow probably represents some amount less than that which recharges the aquifer; and 2) baseflow is best applied to provide a reasonable estimate of recharge occurring over long time periods (1 year or more) (Risser et al., 2005). Therefore, the recharge estimates developed by Kennedy et al. (2010) through annual baseflow analysis and those developed by GHD using the CMB method are applicable to determine the potential range of groundwater recharge values for the PA. As such the average annual recharge within the Project area likely ranges from approximately 220 to 340 mm/yr.

Recharge from Surface Water Features

While surface water features are expected to be a net groundwater sink, there will be losing reaches (i.e., sections where surface water recharges groundwater) along some surface water features. Surface water features will recharge groundwater in areas where groundwater levels fall below adjacent surface water elevations.

5.5.3.2 Hydrogeologic CSM

Understanding the general hydrogeologic characteristics of the groundwater flow system for the Project is fundamental to developing a representative CSM and guides the development of the numerical groundwater flow model. Based on the available regional and Project-specific information, the hydrogeologic characteristics presented in Section 5.5.3.1 are summarized as follows:

- Based on the available monitoring well installation borehole records, exploratory geologic drillhole records, regional well records, and regional geology reports the geologic conditions at the Project consist of fractured interbedded argillite and greywacke bedrock overlain by a thin till overburden layer. The overburden consists of a silty sand and gravel containing cobbles and boulders.
- Groundwater flow at the Project occurs primarily in the till overburden layer and the shallow weathered fractured bedrock zone. Bedrock permeability decreases with depth indicating that groundwater flow rates also are expected to decrease with depth.
- Groundwater flow directions in the till overburden typically follow topographic relief, and the groundwater table is expected to mimic ground surface, with recharge occurring in upland areas, and discharge occurring to surface water bodies in low lying areas.
- Groundwater flow in the bedrock is controlled by secondary permeability and fracturing, and more so in the weathered shallow bedrock than in the more competent deep bedrock. Hydraulic conductivity in the bedrock declines with depth.
- Identified faults have a similar hydraulic conductivity to the surrounding bedrock formation.
- The linear surface water features near the Project predominantly are groundwater sinks, removing water from the groundwater flow system.
    - Water from losing reaches of the linear surface water features may contribute to the groundwater flow system as groundwater sources.
- Regionally, groundwater discharges to Gold Brook Lake, Ocean Lake, and Isaacs Harbour.
- At depth within the deep bedrock, the permeability becomes sufficiently low such that vertical groundwater flow is negligible.

5.5.3.3 3D Numerical Groundwater Flow Model Development

As described in Section 5.5.2, GHD developed a 3D numerical groundwater flow model to provide a reasonable representation of observed baseline conditions in at the Project for the specific purpose of providing a basis of comparison against which predicted impacts to groundwater quantity can be compared. This section briefly described the development of 3D groundwater flow model to represent observed baseline conditions. Additional details of the development of the 3D groundwater flow model are provided in Appendix F.2.

GHD selected MODFLOW-NWT (Niswonger, 2011) to simulate groundwater flow for this modelling study due to its ability to efficiently solve complex groundwater flow simulations characterized by drying and rewetting of model cells such as that encountered in the simulation of dewatering scenarios, including the proposed dewatering of the open pits during Project construction and operations. MODFLOW-NWT has been extensively verified and is readily accepted by many regulatory agencies throughout North America and Europe. MODFLOW-NWT can represent the hydrogeologic components of the CSM for the Project.

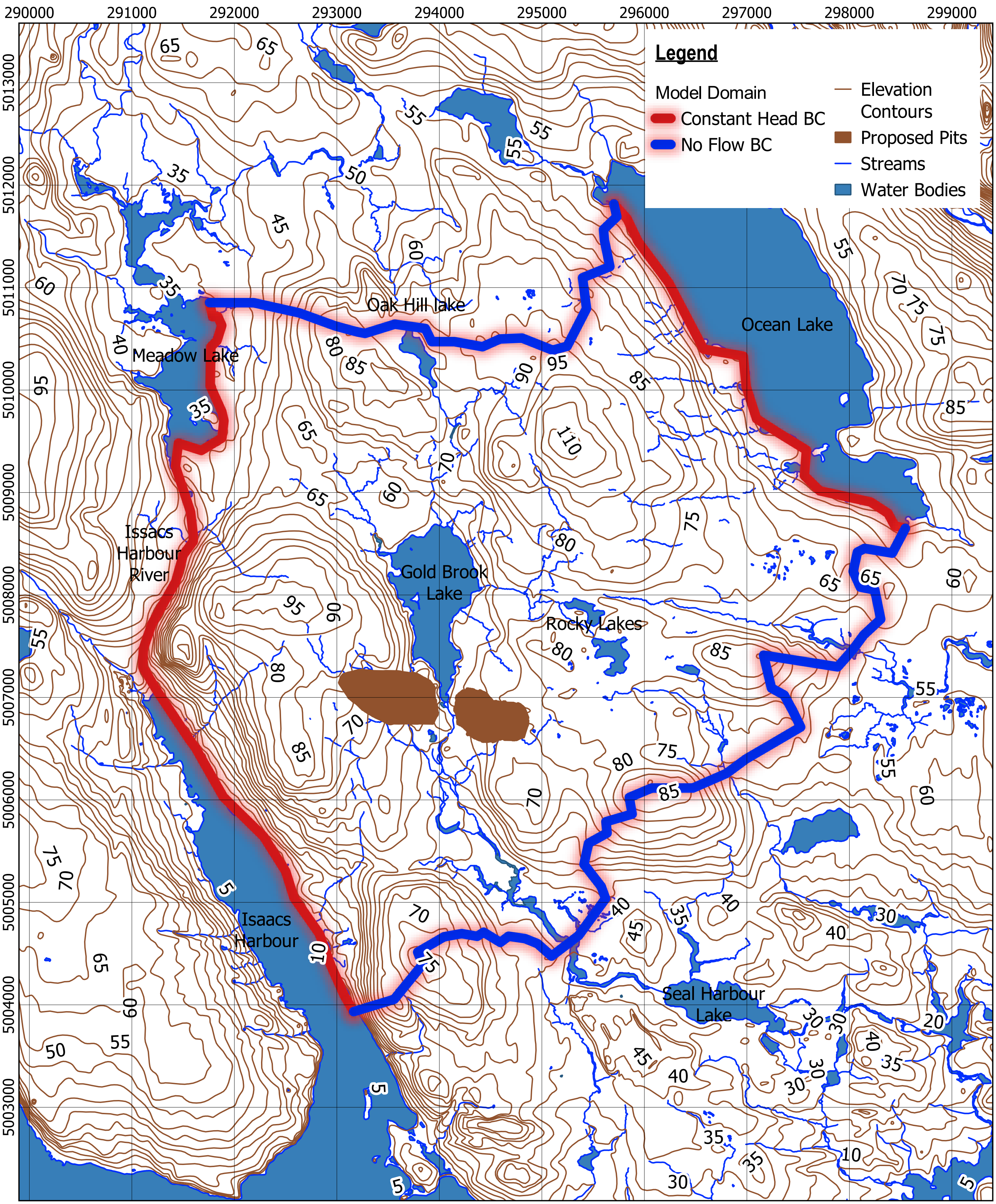
GHD selected a model domain and associated boundary conditions representative of observed conditions at the Project and reasonably expected conditions regionally. The selected model domain and boundary conditions assigned at the model domain limits are illustrated on Figure 5.5-4, and are described in general terms as follows:

- North: The northern model domain limit is aligned with an expected groundwater flow divide located near the New Harbour Salmon basin watershed divide and along topographic highs from Meadow Lake towards the watershed divide near Oak Hill Lake. A no-flow boundary condition is assigned to the nodes along this limit of the model.
- West: The western model domain boundary was selected to correspond with surface water bodies along Meadow Lake, Isaacs Harbour River, and Isaacs Harbour. Constant head boundary conditions are assigned to represent these surface water bodies.
- South and Southeast: The southeastern model domain limit corresponds to groundwater flow divides along topographic highs and the flow lines adjacent to three creeks that have been crossed by the model domain. It is assumed that water flows from the high lands toward these creeks. This boundary condition was selected to be a sufficient distance from the Project area to avoid undue bias on predictive simulations while maintaining a reasonable model size to maintain computational efficiency. A no flow boundary condition is assigned to all the nodes along this boundary.
- Northeast: The northeastern boundary condition corresponds to surface water along the margins of Ocean Lake. Constant head boundary conditions were assigned to simulate the interaction between lake water and groundwater.

Vertically, the model domain extends from ground surface, where a recharge boundary condition is applied, to approximately 600 m below the bottom of bedrock surface where a horizontal no-flow boundary is inferred. At this depth, the permeability of the deep bedrock becomes sufficiently low such that active vertical groundwater flow is considered negligible. The bottom of the model domain was also set to provide sufficient vertical separation between the bottom of the model domain and the proposed open pits to avoid unduly biasing predictive simulations.

The hydraulic conductivity zones were assigned in the model to represent each of the major hydrogeologic units identified in the CSM: the overburden unit and the bedrock unit. The overburden unit is further subdivided into an upper and lower overburden unit, represented by Model Layers 1 and 2, respectively. The upper overburden unit is subdivided into 5 hydraulic conductivity zones based on the surficial geology presented on Figure 5.5-5. A single hydraulic conductivity value is assigned to layer 2, representative of the lower overburden unit. Model Layers 3 to 24 represent bedrock. Bedrock is subdivided into 5 different conductivity zones based on observed hydraulic conductivity values and the relationship defining the decrease of hydraulic conductivity values with depth as described in Section 5.5.3.1.3. The hydraulic conductivity zones specified in Model Layers 3 to 24 are presented on Figure 5.5-6 along with hydraulic conductivity testing results and the calculated geometric mean of the hydraulic conductivity test results within each hydraulic conductivity zone. As shown on Figure 5.5-6, five hydraulic conductivity zones are assigned to represent the bedrock and the geometric mean of the hydraulic conductivity decreases with the depth of each hydraulic conductivity zone. The hydraulic conductivity value for each hydraulic conductivity zone was adjusted within reasonable bounds during model calibration. The ranges of the reasonable bounds were assessed based on the results of the hydraulic conductivity testing within each hydrogeologic unit, as well as published literature values.

GHD calibrated the groundwater flow model to provide a reasonable representation of the static water levels present in Table 5.5-5 and the estimated baseflow values/groundwater recharge. GHD further evaluated the calibrated model against observed inflow rates into the historical Orex and Boston-Richardson mine workings. The inflow rate predicted by the calibrated model is comparable with the inflow rates reported for the Orex and Boston-Richardson mine workings. The model input parameters (e.g., hydraulic conductivity and recharge) applied in the calibrated model are consistent with observed Project conditions. GHD conducted a sensitivity analysis on the model calibration to identify sensitive model parameters to apply in predictive uncertainty analysis as discussed further in Section 5.5.5.2. The model calibration to static water levels and baseflow, evaluation against historical inflow rates into the Orex and Boston-Richardson mine and application of parameter values consistent with observed parameter value ranges demonstrates that the calibrated model provides a reasonable representation of baseline Project conditions as understood from available hydrogeologic data and is suitable for the specific purpose of predicting Project impacts to groundwater impacts relative to simulated baseline condition.



Paper Size ANSI A

0 0.5 1 1.5 km

N

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

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GROUNDWATER MODEL DOMAIN

FIGURE 5.5-4

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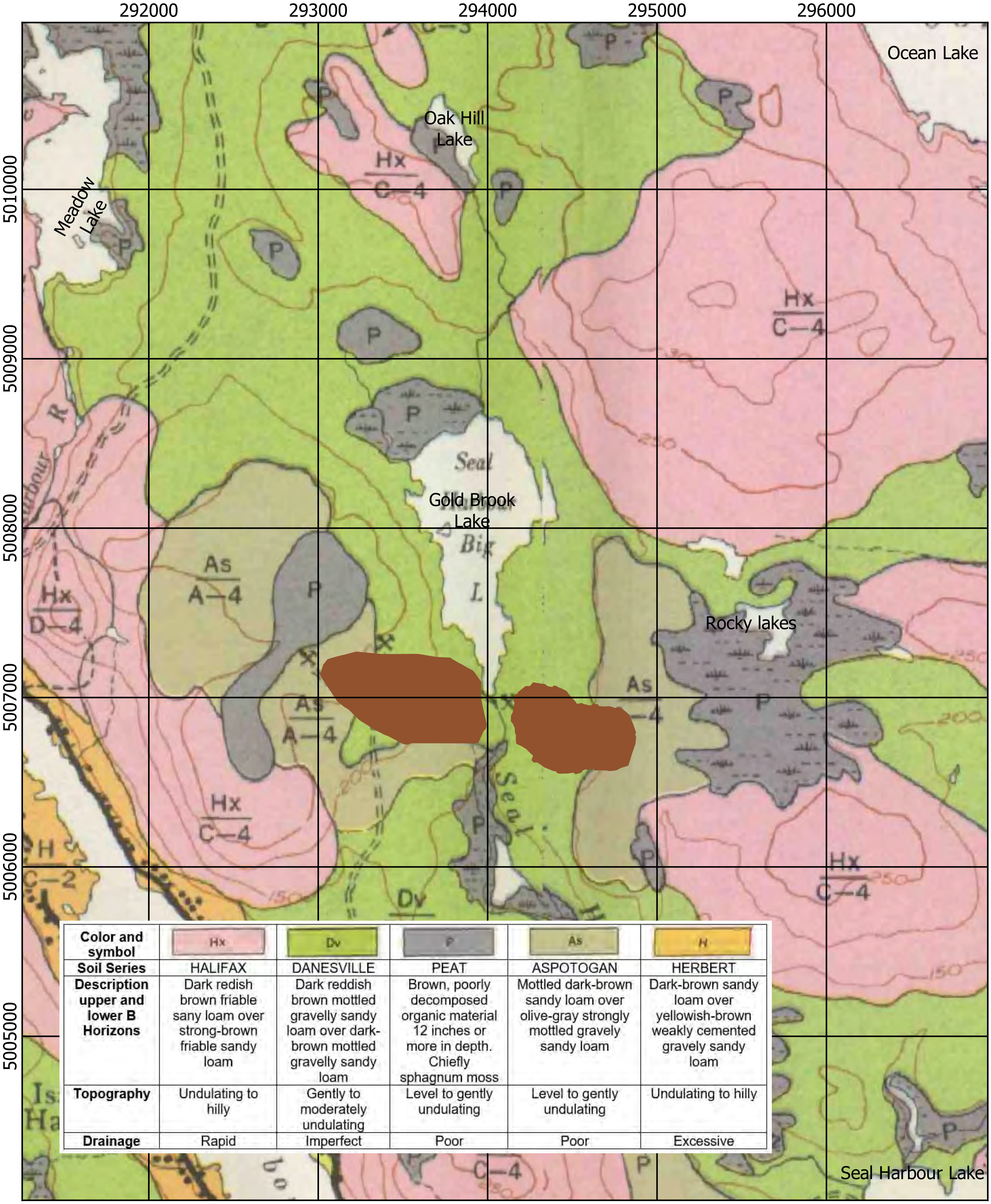
Print Date: 2022-05-30

Created By: Amir Niazi



Color and symbol	Hx	Dv	P	As	H
Soil Series	HALIFAX	DANESVILLE	PEAT	ASPOTOGAN	HERBERT
Description upper and lower B Horizons	Dark redish brown friable sany loam over strong-brown friable sandy loam	Dark reddish brown mottled gravelly sandy loam over dark-brown mottled gravelly sandy loam	Brown, poorly decomposed organic material 12 inches or more in depth. Chiefly sphagnum moss	Mottled dark-brown sandy loam over olive-gray strongly mottled gravely sandy loam	Dark-brown sandy loam over yellowish-brown weakly cemented gravely sandy loam
Topography	Undulating to hilly	Gently to moderately undulating	Level to gently undulating	Level to gently undulating	Undulating to hilly
Drainage	Rapid	Imperfect	Poor	Poor	Excessive

Paper Size ANSI A

0 0.3 0.6 0.9 km

N

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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GOLDBORO GOLD PROJECT
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FIGURE 5.5-5

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Data Source: Soil Map of Guysborough County, Soil Research Institute, Ottawa, 1963

Print Date: 2022-05-30

Created By: Amir Niazi

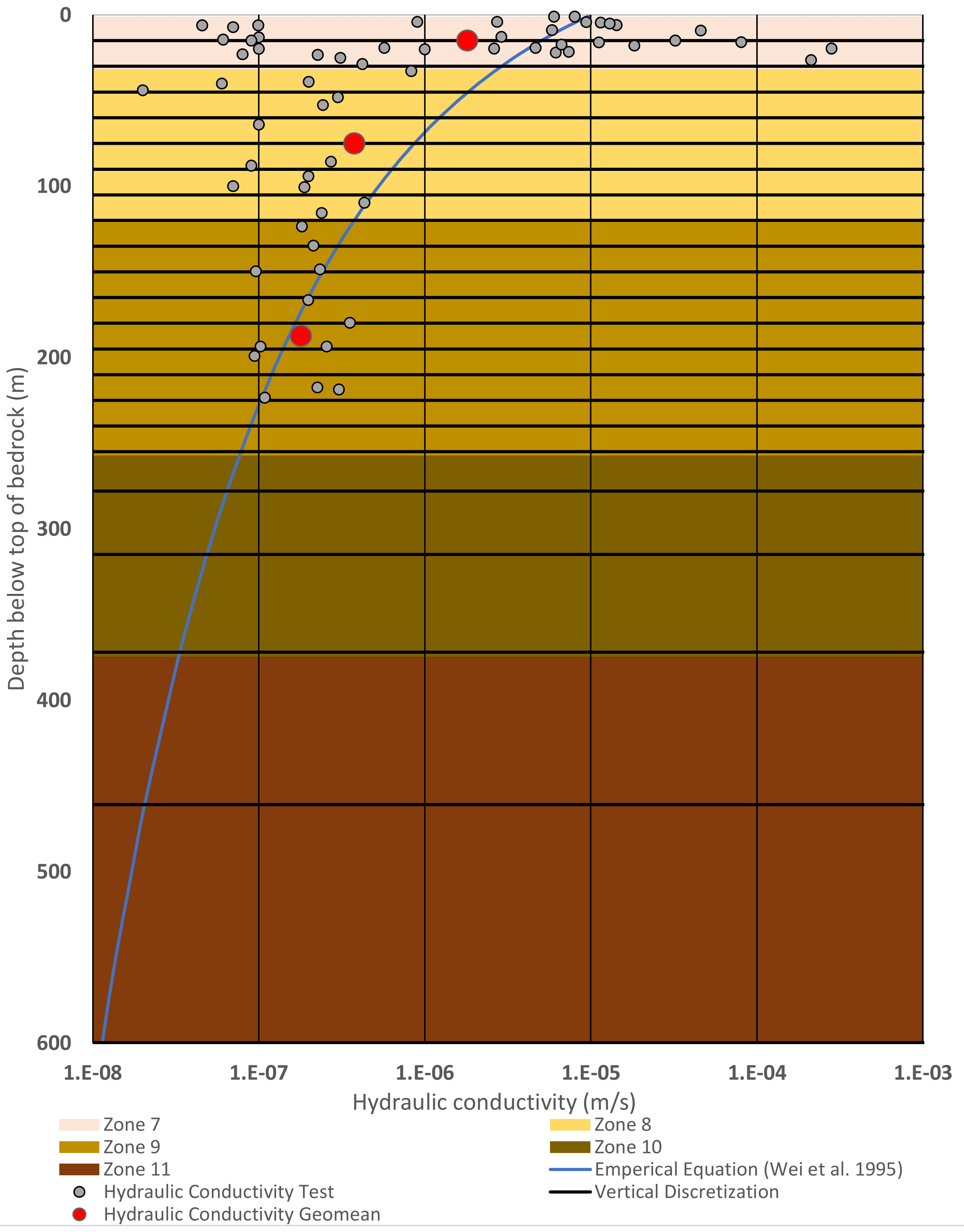


Figure 5.5-6 ***Bedrock Hydraulic Conductivity Zones***

5.5.3.4 Groundwater Quality Results

Groundwater samples were collected from available monitoring wells in July, October, and December 2021. This section provides an overview of the 2021 groundwater monitoring program analytical results. The complete comparison of 2021 groundwater quality samples are presented in 2021 Groundwater Monitoring Report (Appendix F.2) including Laboratory certificates of analysis and groundwater quality sampling completed for the IA. Groundwater quality samples collected by WSP are presented in WSP (2019a) and are discussed in this section to provide additional context for the 2021 groundwater monitoring program analytical results.

All groundwater analytical results collected in 2021 were compared to Potable Water Criteria (defined as the lowest of the Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ) Maximum Acceptable Concentrations (MAC) and the NSECC Tier I EQS for potable groundwater, residential land use, and coarse-grained soils, the CCME WQGs for the Protection of FWAL, and the NS Pathway Specific Standards (PSS) for groundwater discharging to surface water (>10 m from a freshwater body). Concentrations that are greater than these criteria are flagged in Table 5.5-6 (General Chemistry), Table 5.5-7 (Metals), and Table 5.5-8 (BTEX/mTPH).

QA/QC sampling indicated that duplicate results agree closely with the corresponding sample and confirm the representativeness of the sampling procedures. 330 out of 332 constituents analyzed have relative percent differences (RPDs) of less than 40% between field duplicates and original samples.

Table 5.5-6 2021 Groundwater Exceedances – General Chemistry

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW1-A	17-Dec-21	--	pH	--
MW1-B	17-Dec-21	--	--	--
MW5-A	21-Jul-21	--	--	--
	26-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	--	--
MW5-B	21-Jul-21	--	--	--
	26-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	--	--
MW6-A	21-Jul-21	--	--	--
	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	pH	--
MW6-B	21-Jul-21	--	Ammonia Nitrogen	--
	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	Ammonia Nitrogen	--
MW7-A	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
MW7-A	16-Dec-21	--	pH	--
MW7-B	21-Jul-21	--	Ammonia Nitrogen	--
	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	--	--

Table 5.5-6 2021 Groundwater Exceedances – General Chemistry

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW15-A	21-Jul-21	--	Ammonia Nitrogen	--
	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	Ammonia Nitrogen, pH	--
MW15-B	21-Jul-21	--	Ammonia Nitrogen	--
	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	Ammonia Nitrogen	--
MW16-A	16-Dec-21	--	Ammonia Nitrogen	--
MW16-B	16-Dec-21	--	--	--
MW20-A	21-Jul-21	--	--	--
	27-Oct-21	--	Ammonia Nitrogen, Total Cyanide	--
	16-Dec-21	--	--	--
MW20-B	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW21-A	13-Dec-21	--	--	--
MW21-B	13-Dec-21	--	Ammonia Nitrogen	--
MW23-A	14-Dec-21	--	pH	--
MW23-B	14-Dec-21	--	Ammonia Nitrogen	--
MW26-A	27-Oct-21	--	Ammonia Nitrogen	--
	15-Dec-21	--	--	--
MW26-B	27-Oct-21	--	Ammonia Nitrogen	--
	15-Dec-21	--	Ammonia Nitrogen	--
MW29-A	17-Dec-21	--	--	--
MW29-B	17-Dec-21	--	--	--
MW30-A	27-Oct-21	--	--	--
	16-Dec-21	--	pH	--
MW30-B	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	--	--
MW42-A	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	--	--
MW42-B	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	Ammonia Nitrogen	--

Table 5.5-6 2021 Groundwater Exceedances – General Chemistry

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW43-A	27-Oct-21	--	Ammonia Nitrogen	--
	16-Dec-21	--	Ammonia Nitrogen	--
MW43-B	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW46-A	27-Oct-21	--	--	--
	15-Dec-21	--	--	--
MW46-B	27-Oct-21	--	Ammonia Nitrogen	--
	15-Dec-21	--	--	--
MW51-A	17-Dec-21	--	pH	--
MW51-B	17-Dec-21	--	--	--
MW54-A	17-Dec-21	--	--	--
MW54-B	17-Dec-21	--	--	--
MW55-A	17-Dec-21	--	--	--
MW55-B	17-Dec-21	--	--	--
MW56-A	17-Dec-21	--	--	--
MW56-B	17-Dec-21	--	--	--

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW1-A	17-Dec-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Copper	Dissolved Manganese
MW1-B	17-Dec-21	--	Dissolved Copper	Dissolved Cobalt
MW5-A	21-Jul-21	--	Dissolved Iron	Dissolved Manganese
	26-Oct-21	Dissolved Aluminum, Dissolved Iron	Dissolved Iron, Dissolved Zinc	Dissolved Manganese
	13-Dec-21	Dissolved Iron	Dissolved Aluminum, Dissolved Iron	Dissolved Manganese

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW5-B	21-Jul-21	--	Dissolved Iron, Dissolved Zinc	--
	26-Oct-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Iron	--
	16-Dec-21	Dissolved Aluminum	Dissolved Copper, Dissolved Iron, Dissolved Zinc	Dissolved Manganese
MW6-A	21-Jul-21	--	Dissolved Aluminum, Dissolved Cadmium, Dissolved Copper, Dissolved Nickel, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	27-Oct-21	Dissolved Aluminum, Dissolved Copper	Dissolved Aluminum, Dissolved Arsenic, Dissolved Cadmium, Dissolved Copper, Dissolved Iron, Dissolved Lead, Dissolved Zinc	Dissolved Cobalt, Dissolved Lead
	16-Dec-21	Dissolved Aluminum, Dissolved Copper	Dissolved Aluminum, Dissolved Copper, Dissolved Zinc	--
MW6-B	21-Jul-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Aluminum, Dissolved Arsenic	Dissolved Antimony, Dissolved Arsenic
	27-Oct-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic
	16-Dec-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic
MW7-A	21-Jul-21	Dissolved Copper	Dissolved Aluminum, Dissolved Copper, Dissolved Manganese, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	27-Oct-21	Dissolved Aluminum, Dissolved Copper	Dissolved Aluminum, Dissolved Copper, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	16-Dec-21	Dissolved Aluminum, Dissolved Copper	Dissolved Aluminum, Dissolved Copper, Dissolved Zinc	Dissolved Cobalt
MW7-B	21-Jul-21	--	Dissolved Arsenic, Dissolved Manganese	Dissolved Arsenic, Dissolved Manganese
	27-Oct-21	--	Dissolved Arsenic, Dissolved Manganese, Dissolved Zinc	Dissolved Arsenic, Dissolved Manganese
	16-Dec-21	--	Dissolved Arsenic	Dissolved Arsenic, Dissolved Manganese

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW15-A	21-Jul-21	Dissolved Aluminum, Dissolved Iron	Dissolved Aluminum, Dissolved Arsenic, Dissolved Iron, Dissolved, Dissolved Manganese	Dissolved Arsenic, Dissolved Manganese
	27-Oct-21	Dissolved Aluminum, Dissolved Iron	Dissolved Arsenic, Dissolved Iron, Dissolved, Dissolved Manganese, Dissolved Zinc	Dissolved Arsenic, Dissolved Manganese
	16-Dec-21	Dissolved Aluminum, Dissolved Iron	Dissolved Arsenic, Dissolved Iron, Dissolved Manganese	Dissolved Arsenic, Dissolved Manganese
MW15-B	21-Jul-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic	Dissolved Arsenic, Dissolved Manganese
	27-Oct-21	Dissolved Arsenic	Dissolved Arsenic, Dissolved Manganese, Dissolved Zinc	Dissolved Arsenic, Dissolved Manganese
	16-Dec-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Aluminum, Dissolved Arsenic, Dissolved Manganese	Dissolved Arsenic, Dissolved Manganese
MW16-A	16-Dec-21	Dissolved Arsenic	Dissolved Arsenic, Dissolved Copper, Dissolved Manganese	Dissolved Arsenic, Dissolved Manganese
MW16-B	16-Dec-21	--	Dissolved Arsenic, Dissolved Manganese	Dissolved Manganese
MW20-A	21-Jul-21	Dissolved Iron	Dissolved Aluminum, Dissolved Iron, Dissolved Manganese	Dissolved Manganese
	27-Oct-21	Dissolved Iron	Dissolved Arsenic, Dissolved Iron, Dissolved Manganese, Dissolved Zinc	Dissolved Arsenic, Dissolved Cobalt, Dissolved Manganese
	16-Dec-21	Dissolved Iron	Dissolved Arsenic, Dissolved Iron, Dissolved Manganese, Dissolved Zinc	Dissolved Manganese
MW20-B	21-Jul-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic, Dissolved Iron	Dissolved Arsenic, Dissolved Manganese
MW20-B	27-Oct-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic, Dissolved Iron, Dissolved Zinc	Dissolved Arsenic, Dissolved Manganese
	16-Dec-21	Dissolved Arsenic	Dissolved Arsenic	Dissolved Arsenic, Dissolved Manganese
MW21-A	16-Dec-21	--	Dissolved Manganese	Dissolved Cobalt, Dissolved Manganese
MW21-B	16-Dec-21	--	Dissolved Copper	--

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW23-A	16-Dec-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Zinc	Dissolved Manganese
MW23-B	16-Dec-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Arsenic, Dissolved Copper, Dissolved Iron, Dissolved Lead, Dissolved Zinc	Dissolved Arsenic
MW26-A	27-Oct-21	--	Dissolved Arsenic, Dissolved Cadmium, Dissolved Copper, Dissolved Manganese, Dissolved Zinc	Dissolved Arsenic, Dissolved Cobalt, Dissolved Manganese
	15-Dec-21	--	Dissolved Cadmium, Dissolved Copper	--
MW26-B	27-Oct-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Aluminum, Dissolved Arsenic, Dissolved Copper, Dissolved Lead	Dissolved Arsenic
	15-Dec-21	Dissolved Aluminum, Dissolved Arsenic	Dissolved Aluminum, Dissolved Arsenic	Dissolved Arsenic
MW29-A	17-Dec-21	Dissolved Cobalt	Dissolved Aluminum, Dissolved Copper, Dissolved Iron, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW29-B	17-Dec-21	--	Dissolved Aluminum	Dissolved Manganese
MW30-A	27-Oct-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	16-Dec-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Copper, Dissolved Iron, Dissolved Zinc	--
MW30-B	27-Oct-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Arsenic	Dissolved Manganese
	16-Dec-21	--	Dissolved Arsenic	Dissolved Manganese
MW42-A	27-Oct-21	Dissolved Aluminum, Dissolved Copper, Dissolved Zinc	Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Nickel, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	16-Dec-21	Dissolved Iron	Dissolved Iron, Dissolved Manganese, Dissolved Nickel, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW42-B	27-Oct-21	Dissolved Aluminum	Dissolved Arsenic	Dissolved Arsenic
	16-Dec-21	--	Dissolved Arsenic	Dissolved Arsenic
MW43-A	27-Oct-21	Dissolved Aluminum	Dissolved Manganese, Total Mercury, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
	16-Dec-21	--	Dissolved Copper, Dissolved Iron, Dissolved Manganese, Total Mercury, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW43-B	27-Oct-21	--	Dissolved Iron, Dissolved Zinc	Dissolved Manganese
	16-Dec-21	--	Dissolved Zinc	--
MW46-A	27-Oct-21	--	Dissolved Copper, Dissolved Iron, Total Mercury, Dissolved Zinc	--
	16-Dec-21	--	Dissolved Aluminum, Dissolved Copper	--
MW46-B	27-Oct-21	Dissolved Aluminum	Dissolved Aluminum, Dissolved Arsenic, Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Selenium, Dissolved Uranium	Dissolved Arsenic, Dissolved Manganese, Dissolved Uranium
	16-Dec-21	Dissolved Aluminum	Dissolved Arsenic, Dissolved Uranium	Dissolved Arsenic, Dissolved Manganese, Dissolved Uranium
MW51-A	17-Dec-21	Dissolved Cobalt, Dissolved Copper	Dissolved Aluminum, Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Silver, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW51-B	17-Dec-21	--	--	Dissolved Manganese
MW54-A	17-Dec-21	--	Dissolved Cadmium, Dissolved Copper, Dissolved Manganese, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW54-B	17-Dec-21	--	--	--
MW55-A	17-Dec-21	--	Dissolved Copper, Dissolved Iron, Dissolved Manganese, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW55-B	17-Dec-21	Dissolved Aluminum	Dissolved Copper, Dissolved Manganese	Dissolved Manganese

Table 5.5-7 2021 Groundwater Exceedances – Metals

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW56-A	17-Dec-21	--	Dissolved Copper, Dissolved Manganese, Dissolved Nickel, Dissolved Zinc	Dissolved Cobalt, Dissolved Manganese
MW56-B	17-Dec-21	--	Dissolved Copper, Dissolved Manganese	Dissolved Manganese

Table 5.5-8 2021 Groundwater Exceedances – BTEX/mTPH

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW1-A	17-Dec-21	--	--	--
MW1-B	17-Dec-21	--	--	--
MW5-A	21-Jul-21	--	--	--
	26-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW5-B	21-Jul-21	--	--	--
	26-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW6-A	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW6-B	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW7-A	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
MW7-A	16-Dec-21	--	--	--
MW7-B	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW15-A	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	mTPH	--	--

Table 5.5-8 2021 Groundwater Exceedances – BTEX/mTPH

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW15-B	21-Jul-21	--	Toluene	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW16-A	16-Dec-21	--	--	--
MW16-B	16-Dec-21	--	--	--
MW20-A	21-Jul-21	--	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW20-B	21-Jul-21	mTPH	--	--
	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW21-A	13-Dec-21	--	--	--
MW21-B	13-Dec-21	--	--	--
MW23-A	14-Dec-21	--	--	--
MW23-B	14-Dec-21	--	--	--
MW26-A	27-Oct-21	--	--	--
	15-Dec-21	--	--	--
MW26-B MW26-B	27-Oct-21	--	Toluene	--
	15-Dec-21	--	--	--
MW29-A	17-Dec-21	--	--	--
MW29-B	17-Dec-21	--	--	--
MW30-A	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW30-B	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW42-A	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW42-B	27-Oct-21	--	--	--
	16-Dec-21	--	--	--
MW43-A	27-Oct-21	--	--	--
	16-Dec-21	--	Toluene	--
MW43-B	27-Oct-21	--	--	--
	16-Dec-21	--	--	--

Table 5.5-8 2021 Groundwater Exceedances – BTEX/mTPH

Monitoring Well ID	Date	NS Tier II PSS for Groundwater Discharging to Surface Water (>10m)	CCME WQGs for the Protection of FWAL	Potable Water Criteria (Lowest of GCDWQ MAC and NSECC Tier 1 EQS)
MW46-A	27-Oct-21	--	--	--
	15-Dec-21	--	--	--
MW46-B	27-Oct-21	--	--	--
	15-Dec-21	--	--	--
MW51-A	17-Dec-21	--	--	--
MW51-B	17-Dec-21	--	--	--
MW54-A	17-Dec-21	--	--	--
MW54-B	17-Dec-21	--	--	--
MW55-A	17-Dec-21	--	--	--
MW55-B	17-Dec-21	--	Toluene	--
MW56-A	17-Dec-21	--	--	--
MW56-B	17-Dec-21	--	--	--

In total, 67 groundwater quality samples, excluding duplicates, were collected across three monitoring events completed in July 2021, October 2021 and December 2021. The results of the laboratory analysis are summarized as follows:

- Number of samples exceeding CCME guidelines
  - pH – 6 samples
  - ammonia nitrogen – 28 samples
  - total cyanide – 1 sample
  - Aluminum – 25 samples
  - Arsenic – 30 samples
  - Copper – 30 samples
  - Iron – 28 samples
  - Zinc – 32 samples
  - Nickel – 4 samples
  - Cadmium – 5 samples
  - Lead – 3 samples
  - Manganese – 28 samples
  - Total mercury – 3 samples
  - Selenium – 1 sample
  - Toluene – 4 samples
- Number of samples exceeding NS Tier II PSS for groundwater discharging to surface water (>10 m)
  - Aluminum – 31 samples
  - Iron – 9 samples
  - Copper – 7 samples

  - Arsenic – 7 samples
  - Cobalt – 2 samples
  - Zinc – 1 sample
  - mTPH – 2 samples
- Number of samples exceeding Potable Water Criteria
  - Manganese – 47 samples
  - Cobalt – 19 samples
  - Lead – 1 sample
  - Antimony – 1 sample
  - Arsenic – 25 samples
  - Uranium – 2 samples

As described above and shown in Tables 5.5-6, 5.5-7 and 5.5-8, a significant number of samples (28) exceed CCME guidelines for ammonia nitrogen and there are a significant number of metals exceedances of CCME guidelines in groundwater and only two samples do not exceed CCME guidelines for metals. 41 of 67 samples exceed the exceed the NS Tier II PSS for groundwater discharge to surface water (>10m). 51 of 67 samples exceed Potable Water Criteria, mostly for manganese (47 exceedances) and arsenic (25 exceedances). This is consistent with the samples collected by WSP (2019a) that detected arsenic in all four of their bedrock monitoring wells.

The groundwater sampling program demonstrates that many metals, including aluminum, arsenic, copper, iron, zinc, nickel, cadmium, lead, manganese, total mercury and selenium are either naturally elevation relative to NS Tier II PSS, CCME, or Potable Water Criteria or are impacted by the historic tailings where monitoring wells are installed near the historic tailings. Metals including arsenic and manganese are often naturally elevated relative to NS Tier II PSS, CCME, or Potable Water Criteria in NS (Kennedy, 2021; Kennedy and Drage, 2017).

Arsenic is considered the most prevalent naturally occurring groundwater contaminant in NS and significant research over the past four decades has indicated that bedrock geology is the most important control on arsenic concentrations in groundwater. NS has completed extensive surveys of arsenic in various media (till, sediment, bedrock, groundwater), primarily in areas underlain by bedrock related to the Goldenville and Halifax Groups (i.e., the formations underlying the Project) and has compiled arsenic concentration data from water wells across NS (Kennedy and Drage, 2016; Kennedy and Drage, 2017). The Project is located in an area of high risk for arsenic, with high risk defined as more than 15 percent of well water samples exceeding the Portable Criteria for arsenic (Kennedy and Drage, 2016).

5.5.3.4.1 Industrial Approval Monitoring Results

Groundwater quality monitoring has been completed since August 2018 at 5 groundwater monitoring stations as part of the monitoring program for the Goldboro Bulk Sample Site IA (Approval No. 2018-101386-02). The results of the IA groundwater monitoring program are provided in detail in Appendix F.1. The results of the 2021 quarterly groundwater quality monitoring program at the Domestic Well (Station #8), MW17-1, MW17-2, MW17-3S, and MW17-3D are summarized below.

Groundwater quality results were compared to the Health Canada GCDWQ, where criteria exist. For areas where discharge of groundwater to surface water (as defined by upward hydraulic gradients) is occurring or may occur seasonally, the results were also compared to the CCME WQGs for the Protection of FWAL. The 95th percentile of the baseline dataset collected in 2018 was selected as the screening criteria in cases these values were greater than GCDWQ and CCME.

Domestic Well (Station #8)

Manganese was the only parameter present at concentrations greater than the GCDWQ value (0.12 mg/L) in the samples collected from the Domestic Well (Station #8) in 2021, with concentrations ranging from 0.123 mg/L to 0.216

mg/L. Concentrations of dissolved manganese in 2021 samples were generally less than previous results and are not attributable to bulk sample site activities.

MW17-1

The pH value of the samples collected from monitoring well MW17-1 ranged from 6.28 to 6.52 in 2021. pH values were outside of the CCME FWAL acceptable range of 6.5-9, with the exception of the February 9, 2021 sample (6.52) which was within the CCME FWAL acceptable range. The 2021 pH values were consistent with previous results.

Concentrations of dissolved aluminum ranged from 0.0233 mg/L to 0.0475 mg/L in 2021 and all results were greater than the applicable 95th percentile value (0.012 mg/L) and CCME FWAL value (0.005 mg/L to 0.100 mg/L, pH dependent), with the exception of the February 9, 2021 sample (0.031 mg/L, pH of 6.52). This is consistent with previous results.

Concentrations of dissolved cadmium ranged from 0.00023 mg/L to 0.000055 mg/L and all results were greater than the CCME FWAL criteria value (0.00004 mg/L), but less than the GCDWQ criteria (0.007 mg/L). This is consistent with previous results. The concentrations of dissolved copper ranged from 0.00215 mg/L to 0.00414 mg/L and all results were greater than the CCME FWAL threshold concentration (0.002 mg/L to 0.004 mg/L, hardness dependent) but less than the GCDWQ criteria (2 mg/L). This is consistent with previous results. The concentrations of dissolved zinc ranged from less than the laboratory detection limit (0.0050 mg/L) to 0.0133 mg/L and exceeded the 95th percentile value (0.0058 mg/L) on June 28, 2021 (0.0098 mg/L) and September 20, 2021 (0.0133 mg/L). All concentrations of dissolved zinc were less than the GCDWQ criteria of 5 mg/L. This is consistent with previous results.

MW17-2

The pH value of the samples collected from monitoring well MW17-2 in 2021 ranged from 5.42 to 5.68. All measured pH values were outside of the CCME FWAL acceptable range of 6.5 to 9. This is consistent with the previous monitoring data.

Concentrations of dissolved aluminum ranged from 0.483 mg/L to 0.635 mg/L and all results were greater than 95th percentile (0.09 mg/L), This is consistent with previous monitoring data. All other groundwater quality data from monitoring well MW17-2 are less than the applicable criteria, which is consistent with previous results.

MW17-3S

The pH value of the samples collected from monitoring well MW17-3S in 2021 ranged from 6.01 to 6.29. All measured pH values were outside of the CCME FWAL acceptable range of 6.5 to 9. This is consistent with the previous monitoring period.

Concentrations of dissolved cadmium ranged from 0.000019 mg/L to 0.000032 mg/L and were less than the GCDWQ (0.005 mg/L). Cadmium concentrations were also less than the 95th percentile (0.000031 mg/L), except for the November 29, 2021 sample (0.000032 mg/L). This is consistent with the previous monitoring results.

MW17-3D

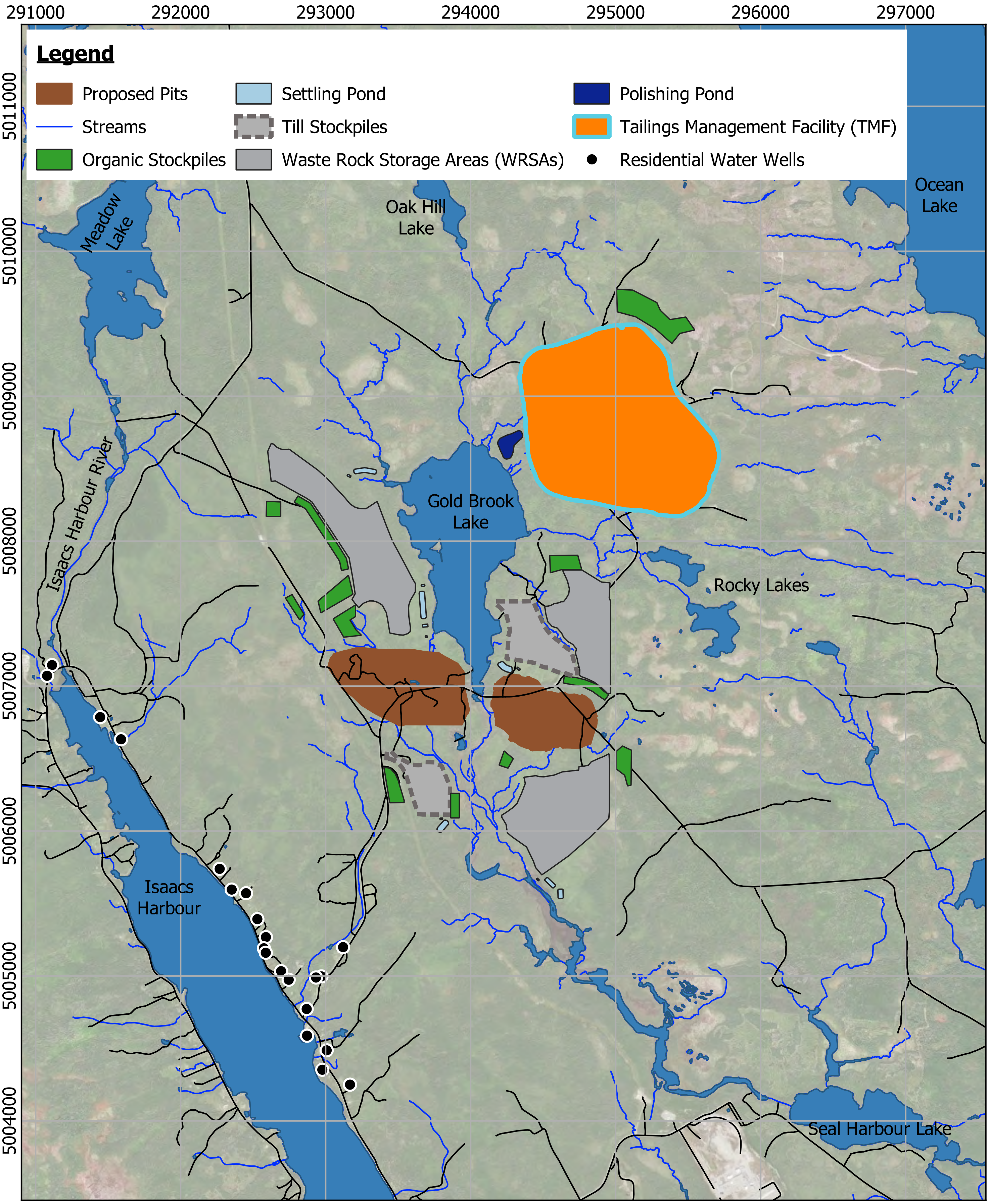
Concentrations of dissolved arsenic ranged from 0.066 mg/L to 0.202 mg/L in 2021. All measured concentrations of arsenic were greater than the 95th percentile (0.062 mg/L). This is consistent with previous monitoring data.

5.5.3.5 Residential Well Survey

Signal Gold conducted a residential well survey to identify and document groundwater users near the Project. The residential well survey included 21 residences on the eastern side of Isaacs Harbour. Isaacs Harbour was selected as a boundary for the extent of the survey because it is a distinct divide for the watershed catchments recharge and is a barrier to groundwater within the overburden and more permeable shallow bedrock zones. Signal Gold staff visited each residence and documented existing well conditions, water usage and existing concerns about well yield and/or quality. Raw water (untreated) samples were collected from each residence and submitted to Maxxam laboratory (now BV) for analysis of general chemistry and metals (WSP, 2019b). Four wells exceeded Potable Water Criteria for

Manganese, one exceeded Potable Water Criteria for cobalt and one exceeded Potable Water Criteria for lead. Residential well locations are shown on Figure 5.5-7.

Of the 21 identified residential wells, 18 were dug wells and 3 were drilled wells. Dug wells generally provide adequate yield but are susceptible to water quantity shortages during summer months. The drilled wells in the area are between 35 m and 95 m deep (WSP, 2019b).



Paper Size ANSI A

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

SURVEYED RESIDENTIAL WATER WELL LOCATIONS

Project No.	**11222385**
Revision No.	**-**
Date.	**May 2022**

FIGURE 5.5-7

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Data Source: 1:10,000 watersheds for Nova Scotia. primary watersheds. https://data.novascotia.ca/Environment-and-Energy/1-10-000-Nova-Scotia-Primary-Watersheds/569x-2wnq

Print Date: 2022-05-30

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5.5.4 Consideration of Consultation and Engagement Results

Signal Gold has undertaken an engagement and consultation program with the Mi’kmaq of Nova Scotia, stakeholders, regulators, and the public. These activities are described in more detail in Section 3. Throughout this process, various issues, concerns, and opportunities have been identified in relation to the Project. These matters have been considered within the context of this VC to help understand potential effects of the biophysical and socioeconomic environment and inform consideration of possible mitigation measure. For the groundwater VC, identified concerns include:

- Changes to groundwater levels potentially affecting groundwater availability as residential water well locations
- Potential contamination of residential water wells from Project activities
- Changes to groundwater discharge to surface water
- Changes in the quality of groundwater discharge to surface water

The results of the public and Mi’kmaq engagement have been considered in the environmental effects assessment, including the Signal Gold’s commitments to mitigation and monitoring measure as described in Sections 5.5.7 and 5.5.8, respectively.

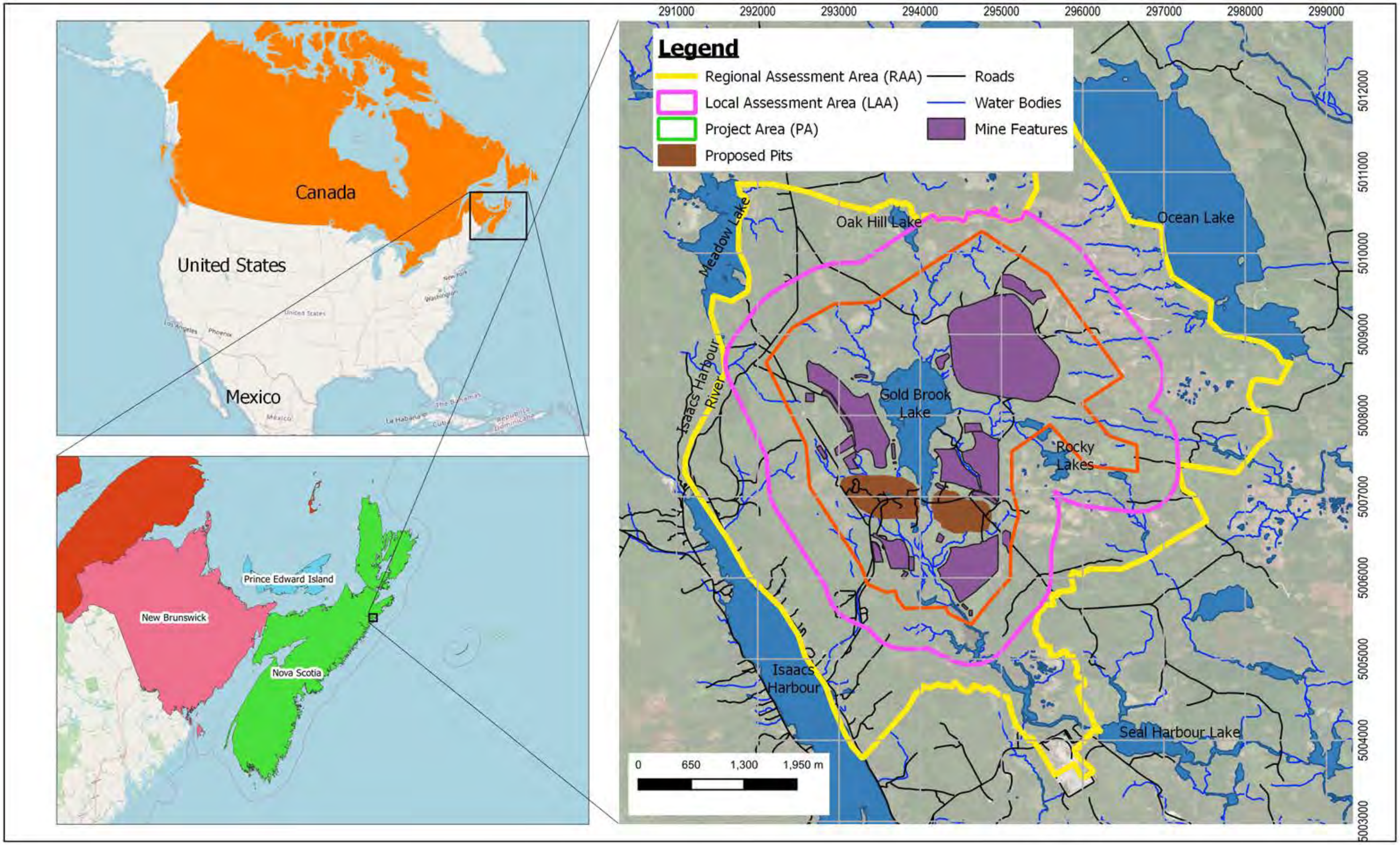
5.5.5 Effects Assessment Methodology

5.5.5.1 Spatial Boundaries

The spatial boundaries used for the assessment of effects on groundwater are defined below:

- The PA encompasses the immediate area in which Project activities may occur and includes the infrastructure associated with the Project plus a buffer of 100 – 200 m.
- The LAA encompasses a 500 m buffer surrounding the PA or extends to the groundwater flow model domain where the groundwater flow model domain is located within 500 m of the PA. The LAA was selected encompass expected direct or indict impacts between the PA and nearest identified residential water well. The boundary of the LAA provides a 250 m buffer from the LAA to the nearest identified residential well.
- The RAA corresponds to the groundwater flow model domain. The groundwater flow model domain corresponds to physically based boundaries of the groundwater flow system surrounding the PA where practical and was selected to provide sufficient separation between Project infrastructure and model domain boundaries as to not unduly bias predicted impacts. Therefore, RAA encompasses all Project and groundwater VC interactions.

As the Project has the potential to cause direct and indirect effects on groundwater quantity and quality outside of the PA, the LAA is considered the most appropriate spatial boundary for this assessment because groundwater impacts contained within the LAA will not impact residential well locations. Spatial boundaries defined for the groundwater effects assessment are presented in Figure 5.5-8.



Paper Size ANSI A

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

SPATIAL BOUNDARIES GROUNDWATER EFFECTS ASSESSMENT

Project No. **11222385**
Revision No. **-**
Date. **April 2022**

FIGURE 5.5-8

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Data Source: Bing Aerial (http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1)

Print Date: 2022/04/07

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5.5.5.1.1 Temporal Boundaries

The temporal boundaries are related to the duration of each phase of the Project. The duration of each phase is provided in the Table 5.5-9.

Table 5.5-9 Project Timeline

Project Phase	Duration
Construction	2 years
Operations	11 years
Closure	24 years

Relative to the operations and closure phases, the construction phase will have not have significant impacts on the groundwater VC as the organics, till, and waste rock piles will not be developed during the construction phase thereby limiting the potential for groundwater quality impacts and the pits will not be excavated thereby limiting the potential for groundwater quantity impacts.

To provide a conservative, worst-case evaluation of the operations and closure phases three temporal boundaries were selected to evaluate groundwater quantity and quality impacts. Temporal boundaries for the groundwater were selected as follows:

- Operations
  - East Pit End of Mine (EOM) corresponding approximately to Year 8 of operations when the East Pit is excavated to its maximum depth. East Pit EOM provides a conservative, worst-case evaluation of groundwater quantity impacts from the extraction of the East Pit to its maximum depth.
  - West Pit EOM corresponding approximately to Year 11 of operations when the West Pit is excavated to its maximum depth and the East Pit has partially filled to an elevation of approximately 32 masl. East Pit EOM provides a conservative, worst-case evaluation of groundwater quantity impacts from the extraction of the East Pit to its maximum depth and groundwater quality impacts during operations.
- Closure
  - Post-Closure (PC) corresponding to the long-term steady-state reclamation condition once the East Pit and West Pit are filled. The PC scenario provides a conservative, worst-case evaluation of the groundwater quantity and quality impacts for the long-term closure condition.

5.5.5.1.2 Technical Boundaries

No technical boundaries are identified for the effects assessment of groundwater quality and quantity.

5.5.5.1.3 Administrative Boundaries

Groundwater quality with be compared against the lower of NS Tier 1 EQS for potable groundwater and GCDWQ MAC, herein referred to as Potable Criteria. Groundwater quality is also compared against the NS Tier II EQS for groundwater discharging to surface water (>10 m). No administrative boundaries are identified for the effects assessment.

5.5.5.2 Modelling of Groundwater Quantity and Quality Impacts

As described in Section 5.5.3.3, GHD developed and calibrated a 3D numerical groundwater flow model that provides a reasonable representation of observed Project baseline conditions based on available hydrogeologic data. The groundwater flow model is suitable for the specific purpose of providing a basis of comparison against which to compare predicted Project impacts. The groundwater flow model was applied to estimate the following impacts at East Pit EOM, West Pit EOM, and PC:

- The rate of groundwater inflow into the open pits

- Changes in groundwater elevations
- Changes in baseflow to surface water bodies
- Changes in groundwater quality

East Pit EOM was evaluated in the model as follows:

- The East Pit is fully extracted to a depth of -128 masl.
- The West Pit is partially extracted to an elevation of -72 masl.
- The TMF is fully developed and the bottom of the TMF is lined with a geosynthetic membrane.
- The simulation is conservatively run at steady-state to predict the maximum potential extent of groundwater quantity impacts.
- The organics, till, and waste stockpiles are fully developed and it is conservatively assumed that constituents have been seeping through the piles to groundwater at the short-term source term concentrations (see Section 5.4.5.2) from year zero of operations to East Pit EOM (approximately Year 8 of operations).

West Pit EOM was evaluated in the model as follows:

- The East Pit is fully extracted to a depth of -128 masl and has partially filled to an elevation of 32 masl.
- The West Pit is fully extracted to an elevation of -184 masl.
- The TMF is fully developed the bottom of the TMF is lined with a geosynthetic membrane.
- The simulation is conservatively run at steady-state to predict the maximum potential extent of groundwater quantity impacts.
- The organics, till, and waste stockpiles are fully developed and it is conservatively assumed that constituents have been seeping through the piles to groundwater at the short-term source term concentrations (see Section 5.4.5.2) from year zero of operations to West Pit EOM (approximately Year 11 of operations).

For East-Pit EOM and West-Pit EOM, it is assumed that the infiltration rate over the footprint of the organics, till, and waste stockpiles is unchanged. It is assumed that any surplus infiltration in these areas would be collected by the perimeter drainage system and not report to groundwater. The bottom of the TMF will be lined. Therefore, it is assumed that there is no groundwater recharge beneath the TMF which is conservative with respect to the prediction of groundwater drawdown and baseflow impacts.

PC was evaluated as follows:

- The East Pit is fully extracted to a depth of -128 masl and is completely filled with water to an elevation of 50.24 masl.
- The West Pit is fully extracted to an elevation of -184 masl and is completely filled with water to an elevation of 51.7 masl.
- The TMF is reclaimed and the bottom of the TMF is lined with a geosynthetic membrane and the top of the TMF is covered.
- The simulation is run at steady-state to predict the maximum potential extent of groundwater quantity impacts.
- The organics and till piles have been removed for use in reclamation.
- The WRSA are covered and it is assumed that constituents have been seeping through the WRSAs to groundwater as the long-term source term concentrations (see Section 5.4.5.2) for 500 years to approximate a steady-state condition representing the maximum extent and magnitude of potential groundwater quality impacts for the PC condition. It is further assumed that constituent migration is conservative and that constituent concentrations are not reduced through sorption or degradation in the subsurface.
- For PC, it is assumed that the infiltration rate over the footprint of the waste piles is unchanged. It is assumed that any surplus infiltration in these areas would be collected by the perimeter drainage system which is left in place following reclamation, and will not report to groundwater. The bottom of the TMF will be lined. Therefore, it is assumed that there is no groundwater recharge beneath the TMF which is conservative with respect to the prediction of groundwater drawdown and baseflow impacts.

The groundwater flow and transport results presented above are based on currently available best-estimates and assumptions of the input parameters and processes affecting groundwater flow and solute transport. Selected assumptions were made to provide a conservative bias in the prediction of potential groundwater quality and quantity impacts. The sensitivity analysis conducted on the calibrated model identified that the recharge rates applied over the model are the most sensitive model parameters to the observed data. Therefore, GHD varied the recharge rates and corresponding surface water elevations to evaluate uncertainty in groundwater quantity predictions related to seasonal changes in recharge rates and surface water elevations. Uncertainty in groundwater quality predictions related to seasonality was not evaluated because constituent transport occurs over large timescales (i.e., was simulated over 8 years [East Pit EOM], 11 years [West Pit EOM], and 500 years [PC]) and is therefore less likely to be impacted by seasonal changes in groundwater recharge and surface water elevations. In general, the effects of groundwater were not sensitive to the range of scenarios evaluate in the uncertainty analysis (refer to the modelling report in Appendix F.2 for additional details).

5.5.5.3 Thresholds for Determination of Significance

5.5.5.3.1 Groundwater Quantity

The characterization criteria applied in the groundwater quantity effects assessment are defined in Table 5.5-10, below.

Table 5.5-10 Characterization Criteria for Residual Effects on Groundwater Quantity

Characterization	Quantitative Measure or Definition of Qualitative Categories
Magnitude	**N** – Simulated drawdown is less than 0.5 m **L** – Simulated drawdown greater than 0.5 but less than 1 m **M** – Simulated drawdown greater than 1 but less than 5 m **H** – Simulated drawdown greater than 5 m
Geographic Extent	**PA** – direct and indirect effects from Project activities are restricted to the PA **LAA** – direct and indirect effects from Project activities are restricted to the LAA **RAA** – direct and indirect effects from Project activities are restricted to the RAA
Timing	**N/A** — seasonal aspects are unlikely to affect VCs **A** — seasonal aspects may affect VCs
Duration	**ST** – effects are limited to the construction phase or operations phase **MT** – effects occur in the construction phase and operations phase **LT** – effects occur in the construction phase and operations phase and persist in closure **P** – valued component unlikely to recover to baseline conditions
Frequency	**O** – effects occur once **S** – effects occur at irregular intervals throughout the Project **R** – effects occur at regular intervals throughout the Project **C** – effects occur continuously throughout the Project
Reversibility	**RE** – VCs will recover to baseline conditions before or after Project activities have been completed. **PR** - mitigation cannot guarantee a return to baseline conditions **IR** – effects to VCs are permanent and will not recover to baseline conditions

A significant adverse effect to groundwater quantity from the Project is defined as:

- Residual effects have low magnitude, occur beyond the LAA, occur sporadically or more frequently and are only partially reversible to irreversible.

5.5.5.3.2 Groundwater Quality

The characterization criteria applied in the groundwater quality effects assessment are defined in Table 5.5-11, below.

Table 5.5-11 Characterization Criteria for Residual Effects on Groundwater Quality

Characterization	Quantitative Measure or Definition of Qualitative Categories
Magnitude	**N** – Predicted maximum concentrations are below the 95th percentile baseline concentration and the applicable guideline (GCDWQ or NS Tier 1 EQS for potable groundwater) **L** – Predicted maximum concentrations are greater than the 95th percentile baseline concentration but lower than the applicable guideline (GCDWQ or NS Tier 1 EQS for potable groundwater) **M** – Predicted maximum concentrations in the upper-case scenario are greater than the 95th percentile baseline concentration and greater than the applicable guideline (GCDWQ or NS Tier 1 EQS for potable groundwater) **H** – Predicted maximum concentrations in the base case scenario are greater than the 95th percentile baseline concentration and greater than the applicable guideline (GCDWQ or NS Tier 1 EQS for potable groundwater)
Geographic Extent	**PA** – direct and indirect effects from Project activities are restricted to the PA **LAA** – direct and indirect effects from Project activities are restricted to the LAA **RAA** – direct and indirect effects from Project activities are restricted to the RAA
Timing	**N/A** — seasonal aspects are unlikely to affect VCs **A** — seasonal aspects may affect VCs
Duration	**ST** – effects are limited to the construction phase or operations phase **MT** – effects occur in the construction phase and operations phase **LT** – effects occur in the construction phase and operations phase and persist in closure **P** – valued component unlikely to recover to baseline conditions
Frequency	**O** – effects occur once **S** – effects occur at irregular intervals throughout the Project **R** – effects occur at regular intervals throughout the Project **C** – effects occur continuously throughout the Project
Reversibility	**RE** – VCs will recover to baseline conditions before or after Project activities have been completed. **PR** - mitigation cannot guarantee a return to baseline conditions **IR** – effects to VCs are permanent and will not recover to baseline conditions

A significant adverse effect to groundwater quality from the Project is defined as:

- Residual effects have moderate or higher magnitude, occur beyond the LAA, are of any duration, occur at any frequency and are only partially reversible to irreversible.

5.5.6 Project Interactions and Potential Effects

Project activities during construction, operations, and closure have the potential to interact with groundwater resources, both directly within the PA and potentially indirectly outside the PA. Potential Project interactions with groundwater are presented in Table 5.5-12, below.

Table 5.5-12 Project Activities and Surface Water Interactions

Project Phase	Duration	Relevant Project Activity
Construction	2 years	- Clearing, grubbing, and grading - Drilling and rock blasting - Topsoil, till, and waste rock management - Surface infrastructure installation and construction - Haul road construction - TMF construction - Collection ditch and settling pond construction - Petroleum products management - Environmental Monitoring - Watercourse and wetland alteration - General waste management
Operations	11 years	- Drilling and blasting - Open pit dewatering - Waste rock management - Surface water management - Cyanide and reagent management - Petroleum products management - Site maintenance and repairs - Tailings management - Environmental Monitoring - Water treatment - General waste management
Closure	24 years	- Demolition - Earthworks - Water treatment - General waste management - Environmental Monitoring

These interactions have the potential to change groundwater quantity and quality from baseline conditions as outlined below.

Changes in groundwater quantity may be caused by:

- Compaction of surfaces thereby reducing recharge: earth works including construction of the haul road, buildings, and waste rock management may lead to the compaction of subsurface soils. This may reduce the area in the PA that is available for groundwater recharge and cause a temporary lowering of the groundwater table relative to baseline conditions.
- Clearing and grubbing increasing recharge: clearing and grubbing will take place during construction. Removal of vegetation may temporarily increase recharge thereby potentially causing a small increase in local groundwater levels.
- Open pit dewatering: open pit dewatering will cause a lowering of the groundwater table and will reduce the quantity of groundwater available to surface water resources and potentially to residential water wells.
- Blasting: blasting has the potential to increase fracture frequency in the bedrock near blast holes thereby increasing the permeability of the rock to groundwater flow.

Changes in groundwater quality may be caused by:

- Topsoil, till and rock interactions with water: precipitation falling on topsoil, till and rock stockpiles may leach potential constituents of concern from the stockpiles and that water may infiltrate into the subsurface and impact groundwater quality.
- Incomplete combustion of blast materials: Use of ammonium nitrate type explosives during construction and operations has the potential to affect groundwater quality because the incomplete combustion of the explosive can leave nitrogen residual substances that can leach into groundwater.

The potential impacts on groundwater quantity and quality within the PA, LAA, and RAA as predicted by the numerical groundwater flow model are outlined below. Potential impacts not directly addressed through the numerical groundwater flow modelling assessment are addressed through mitigation measures described in Section 5.5.7. The groundwater quantity and quality assessments are summarized below.

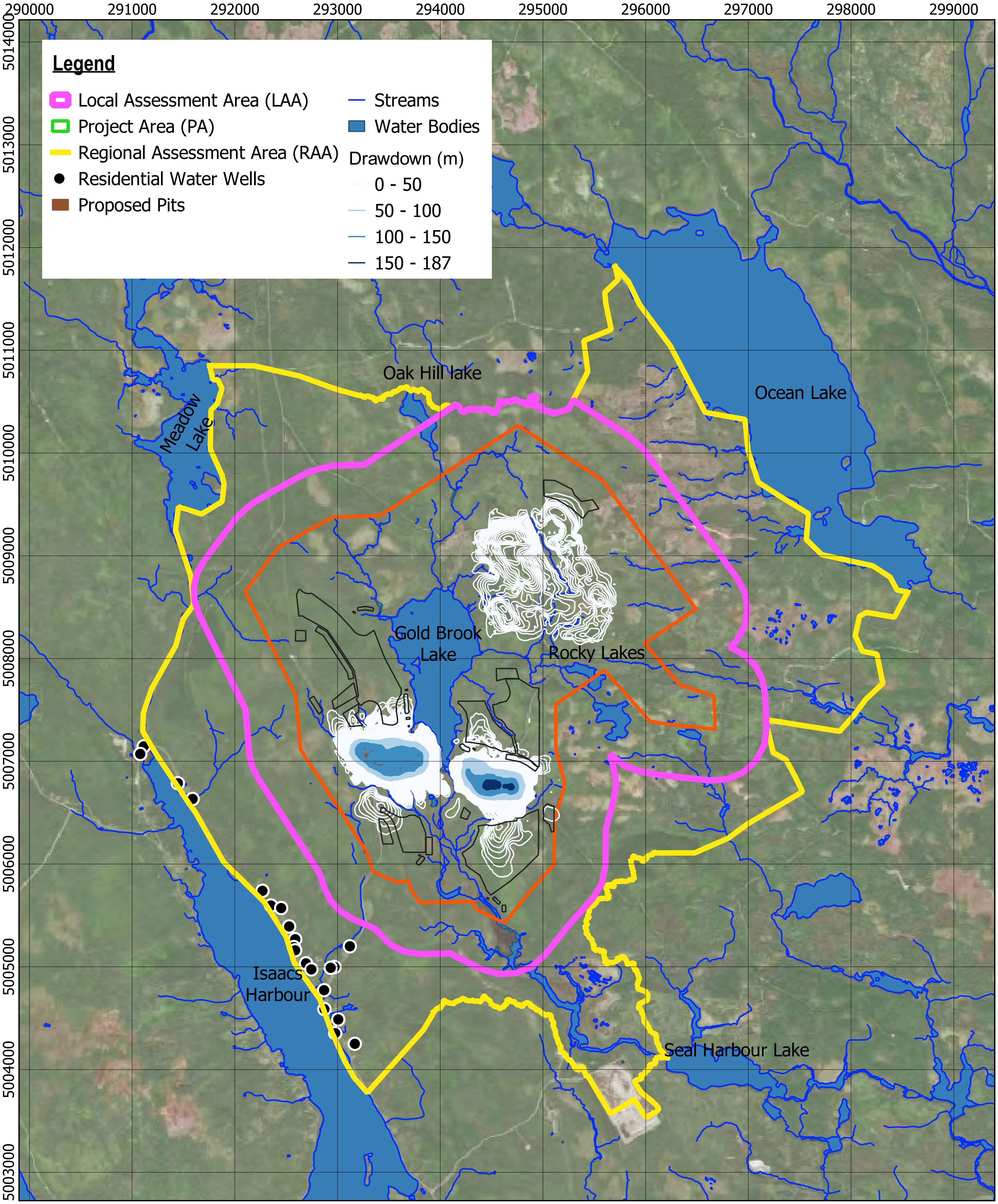
5.5.6.1 Simulated Pit Inflow Rates

Groundwater inflow rates into the open pit are simulated at East Pit EOM, West Pit EOM, and PC. The simulated volumetric flow from the pit drain cells is summed over the entire East and West Pits to estimate the potential groundwater inflow rates into the open pits. At East Pit EOM the simulated groundwater inflow rates are 1,811 and 1,874 m^3/day for the East and West Pits, respectively. At West Pit EOM the simulated groundwater inflow rates are 950 and 2,168 m^3/day for the East and West Pits, respectively. At PC the simulated groundwater inflow rates are 474 and 524 m^3/day for the East and West Pits, respectively.

The simulated pit inflow rates were completed to support the effects assessment for Surface Water Resources (Section. 5.6).

5.5.6.2 Simulated Change in Groundwater Table

Figures 5.5-9, 5.5-10, and 5.5-11 show simulated drawdown (i.e., change in groundwater table elevation) at East Pit EOM, West Pit EOM, and PC, respectively. As shown on Figures 5.5-9 and 5.5-10, the greatest extent of drawdown is simulated at West Pit EOM and East Pit EOM. This is expected as West Pit EOM and East Pit EOM correspond to the maximum extraction and dewatering of the East and West Pits, respectively. Maximum simulated drawdown at East Pit EOM and West Pit EOM is contained inside the PA. There is also groundwater table drawdown under the TMF which is due to a reduction in groundwater recharge associated with lining the TMF. Figure 5.5-11 shows that simulated drawdown decreases at PC relative to East Pit EOM and West Pit EOM. Under all three scenarios, East Pit EOM, West Pit EOM, and PC, the predicted drawdown or radius of influence (ROI) does not reach the nearest residence. The maximum predicted extent of drawdown, defined as 0.5 m of drawdown, extends approximately 500 m from the open pits, and the nearest residential water well is located approximately 1.4 km from the pits.



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Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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EAST PIT EOM DRAWDOWN

FIGURE 5.5-9

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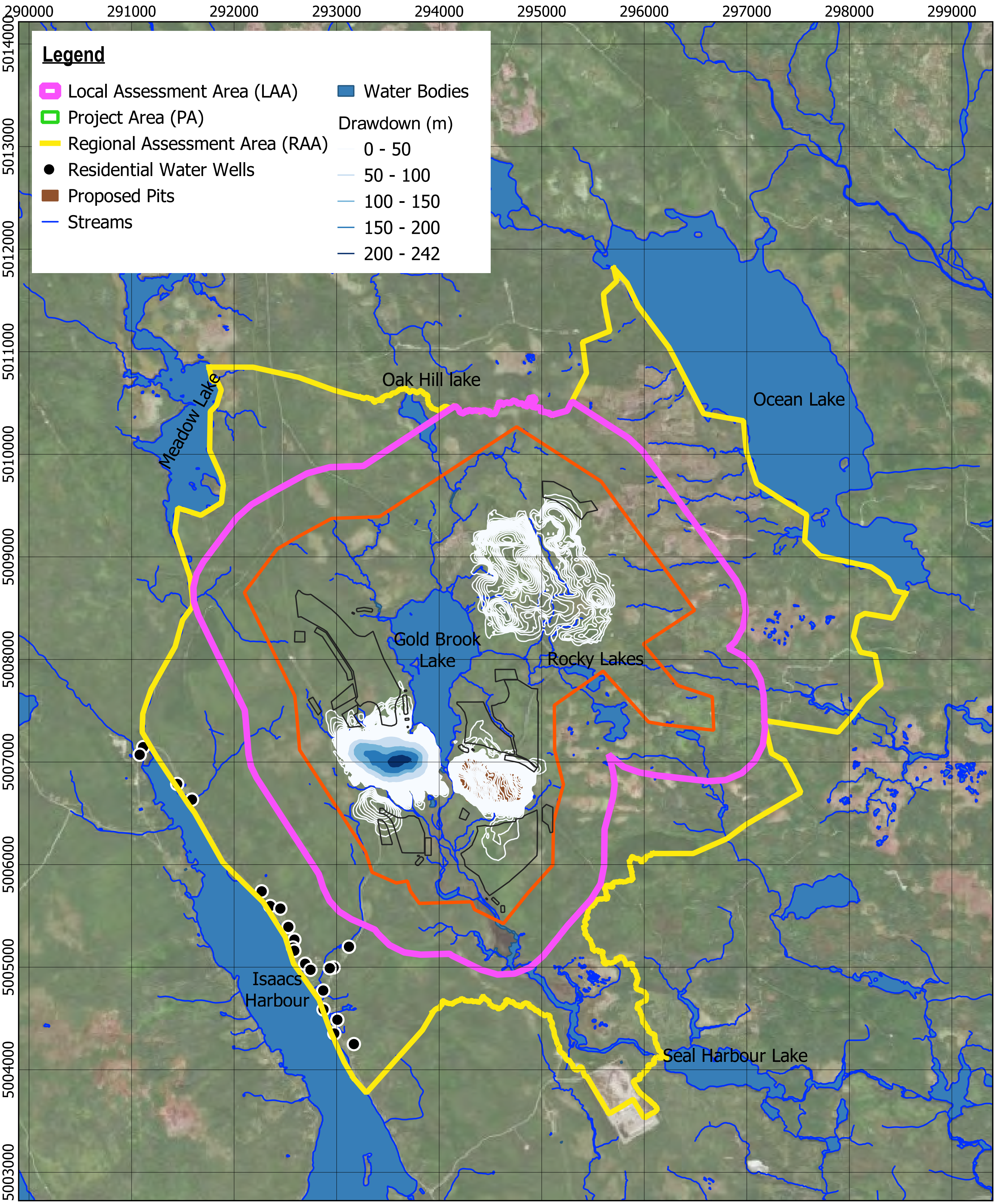
Data Source: Bing Aerial (http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1)

Print Date: 2022-05-30

Created By: Amir Niazi



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Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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WEST PIT EOM DRAWDOWN

FIGURE 5.5-10

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Data Source: Bing Aerial (http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1)

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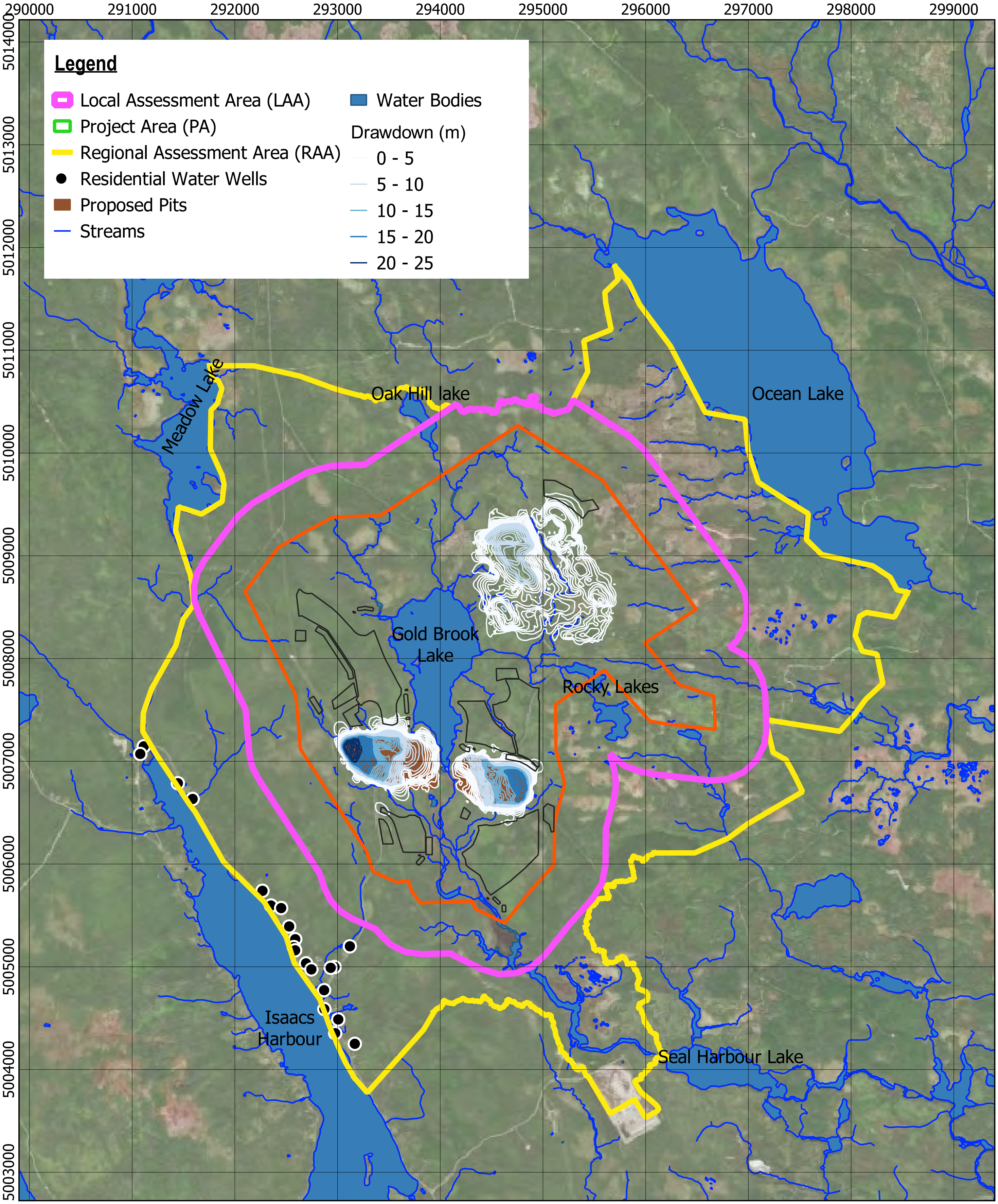
Created By: Amir Niazi



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Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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PC DRAWDOWN

FIGURE 5.5-11

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Data Source: Bing Aerial (http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1)

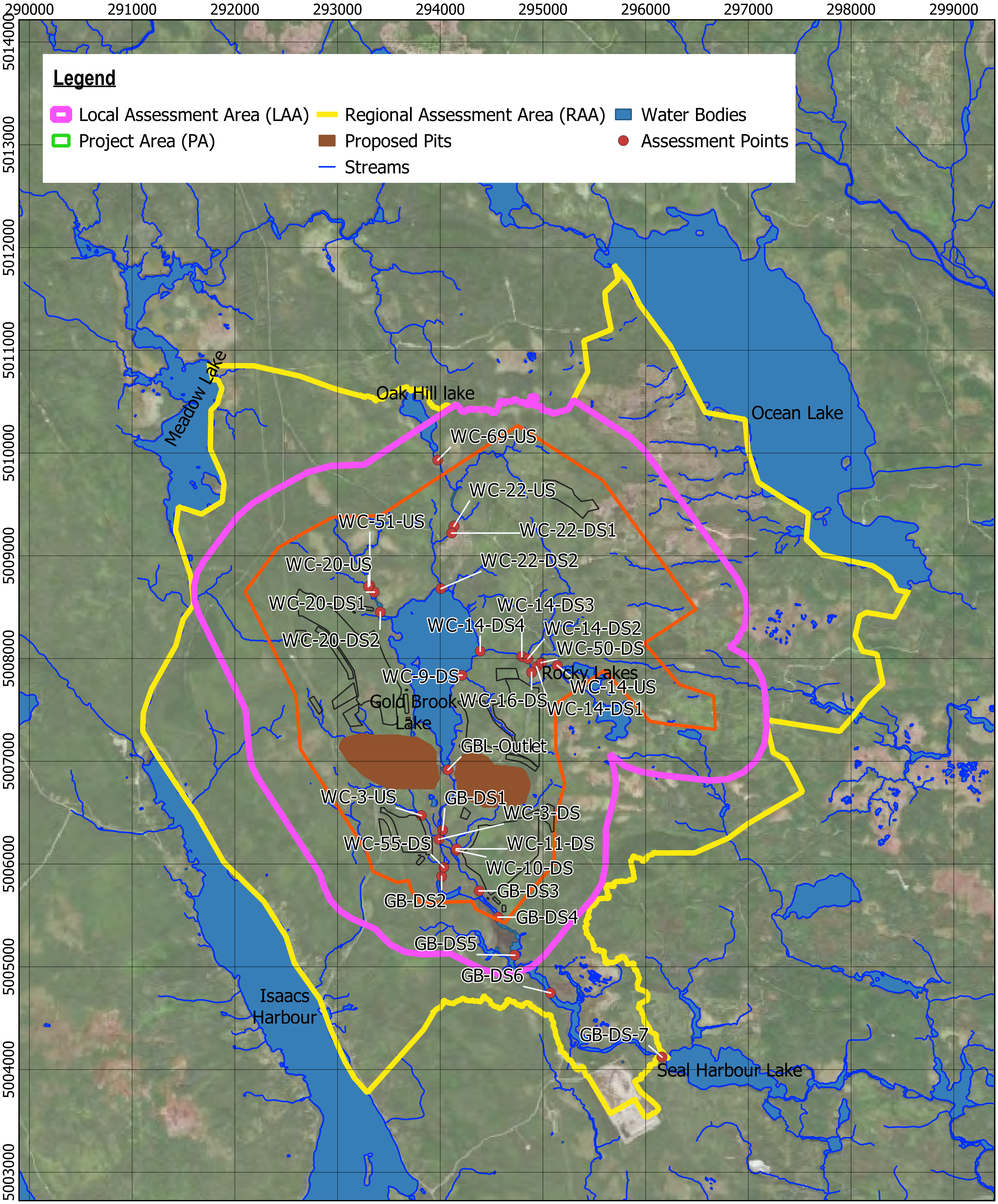
Print Date: 2022-05-30

Created By: Amir Niazi

5.5.6.3 Simulated Change in Baseflow

The numerical groundwater flow model simulated the potential changes in baseflow that may occur within and surrounding the PA under East Pit EOM, West Pit EOM, and PC conditions. The simulated change in baseflow is assessed at select assessment points down-gradient of Gold Brook Lake. Changes to baseflow under East Pit EOM, West Pit EOM, and PC conditions were completed to support the effects assessment for Surface Water Resources (Section. 5.6), Wetlands (Section 5.7) and Fish and Fish Habitat (Section 5.8). The simulated change in baseflow and the percent change at the surface water assessment points are presented in Table 5.5-13.

GBL-Outlet, located downstream of Gold Brook Lake (see Figure 5.5-12) measures surface water runoff and baseflow from Gold Brook Lake and its tributaries. Each assessment point downstream of GBL-Outlet represents the Gold Brook watershed area between the assessment point and GBL-Outlet. Assessment point GBL-Outlet includes the simulated change in baseflow for Gold Brook Lake and all contributing drainage areas upstream. As shown in Table 5.5-13, the simulated baseflow reduction ranges from 53 to 320% at East Pit EOM, from 50 to 254% at West Pit EOM, and from 34 to 86% at PC. Simulated changes in baseflow are incorporated into the site water balance assessment (discussed in section 5.6) to assess the impact of baseflow change on surface water flows. During mine operations, all groundwater discharge to the open pits and to the surface water management ditches will be managed and discharged to Gold Brook Lake and Gold Brook. Once the East Pit Lake has reached 50.24 masl (Year 19) and West Pit has reached 51.74 masl (Year 35), the pit lakes will naturally discharge to Gold Brook Lake.



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Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS98 MTM Zone 4

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SURFACE WATER ASSESSMENT POINTS

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FIGURE 5.5-12

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Print Date: 2022-05-30

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Table 5.5-13 Simulated Change in Baseflow

Assessment Point	Baseline	East Pit EOM		West Pit EOM		PC	
	m^3/day	m^3/day	% change	m^3/day	% change	m^3/day	% change
GBL-Outlet	-4,932	-2,344	-52%	-2,450	-50%	-3,233	-34%
GB-DS1	-215	472	-320%	331	-254%	-31	-86%
GB-DS2	-550	553	-201%	226	-141%	-185	-66%
GB-DS3	-341	65	-119%	-36	-90%	-241	-29%
GB-DS4	-1,084	444	-141%	7	-101%	-617	-43%
GB-DS5	-1,645	-115	-93%	-552	-66%	-1,177	-28%
GB-DS6	-1,990	-458	-77%	-897	-55%	-1,522	-24%

5.5.6.4 Simulated Constituent of Concern Transport

GHD conducted COC transport simulations to estimate the location and significance of potential COC impacts to surface water and the extent of impacts to groundwater quality. Simulated COC mass loadings were assessed at four assessment points downstream of Gold Brook Lake: GBL-Outlet, GB-DS2, GB-DS4, and GB-DS6. Simulated COC mass loadings at each assessment point are incorporated into the predictive water quality assessment (discussed in Section 5.6) to predict the potential cumulative impact, from groundwater discharge and surface water runoff, of the Project on surface water quality and to determine water treatment requirements.

To assess the potential impact of the Project on groundwater quality, the predicted concentrations for each COC are compared against Potable Criteria using upper case source terms for East Pit EOM, West Pit EOM and PC. Simulated COC concentrations and exceedances of Potable Criteria are described and illustrated in detail in the groundwater modelling report provided in Appendix F.2. The results show that with the exception of arsenic at PC, any predicted increase in COC concentrations above Potable Criteria is contained within the PA at East Pit EOM, West Pit EOM, and PC condition. The predicted increase in arsenic concentrations above Potable Criteria only extends a small distance (approximately 100 m) southeast of the PA. Predicted COC concentration increases above Potable Criteria do not extend to within 1 km of the nearest residential well.

To aid in the effects assessment of Wetland (Section 5.7) and Fish and Fish Habitat (Section 5.8), GHD also compared simulated COC concentrations against NS Tier 2 PSS for groundwater discharging to surface water (>10 m). Simulated COC concentrations and exceedances of NS Tier 2 PSS are described and illustrated in detail in the groundwater modelling report provided in Appendix F.2.

5.5.7 Mitigation

Proposed mitigation measures for groundwater quantity and quality are presented in Table 5.5-14

Table 5.5-14 Groundwater Quantity and Quality Mitigation Measures

Project Phase	Mitigation Measure
Construction and Operations	Blasting will be conducted by a certified contractor who will develop a Blast Management Plan and Blast Designs for review and approval prior to carrying out the work. Blasts will be designed to meet vibration and overpressure limits at appropriate distances from any existing structures (i.e., pipeline, residential receptors), Project infrastructure, and fish habitat. A monitoring plan will be implemented to record vibration and overpressure for each blast. Blasting will be carried out according to good practices in order to limit the fracturing of the rock and thus disturbance of groundwater resources.
	Explosive materials storage will meet government regulations including required separation distances as regulated by the Explosives Regulatory Division of Natural Resources Canada (NRCAN).
Operations	Runoff from mine pit walls and groundwater seepage will be collected, with water pumped to the water treatment unit associated with the northwest WRSA prior to entering the settling pond and discharging.
Construction, Operations, and Closure	A maintenance schedule will be developed and implemented to provide for regular maintenance and inspection of Project mine water management infrastructure.
	Reagents will be stored and handled within designated containment areas. Where required, reagent storage will be located within a designated containment area to avoid mixing of incompatible chemicals. Storage tanks will be equipped with level indicators, instrumentation, and alarms to prevent spills.
	Petroleum products (hydrocarbons) will be handled in such a way as to prevent and control leaks and spills. At all times, hydrocarbon absorbents will be kept on the premises where the storage or use of oil products occurs.
	Fuel will be obtained from a licensed contractor who will be required to comply with federal and provincial regulations.
	Disposal and handling of waste oils and hazardous waste will be as recommended by the suppliers and/or manufacturers in compliance with federal and provincial regulations.
	An Emergency Response and Spill Contingency Plan will include information on incident prevention, response procedures, and response training in the case of accidental spills.
Closure	Passive water quality treatment technologies, including engineered wetlands to treat site seepage and runoff, will be employed as required for closure.

5.5.8 Monitoring and Follow-up

A Water Monitoring Plan (Appendix F.11) has been developed for the Project. The proposed Water Monitoring Plan includes groundwater quality and elevations monitoring wells. Monitoring will be completed within the PA to evaluate potential impacts of proposed mining operations on the surrounding groundwater resources. The results from the monitoring will be used to inform adaptive water management practices to mitigate any adverse impacts that may result from the Project. The objectives of this Water Monitoring Plan are to:

- Identify any long-term groundwater quality trends and potential cumulative effects from current and future development of the Project
- Detect any potential groundwater quality and quantity impacts
- Increase understanding of background conditions
- Gain further understanding of groundwater/surface water interaction
- Identify high risk areas that may require further monitoring

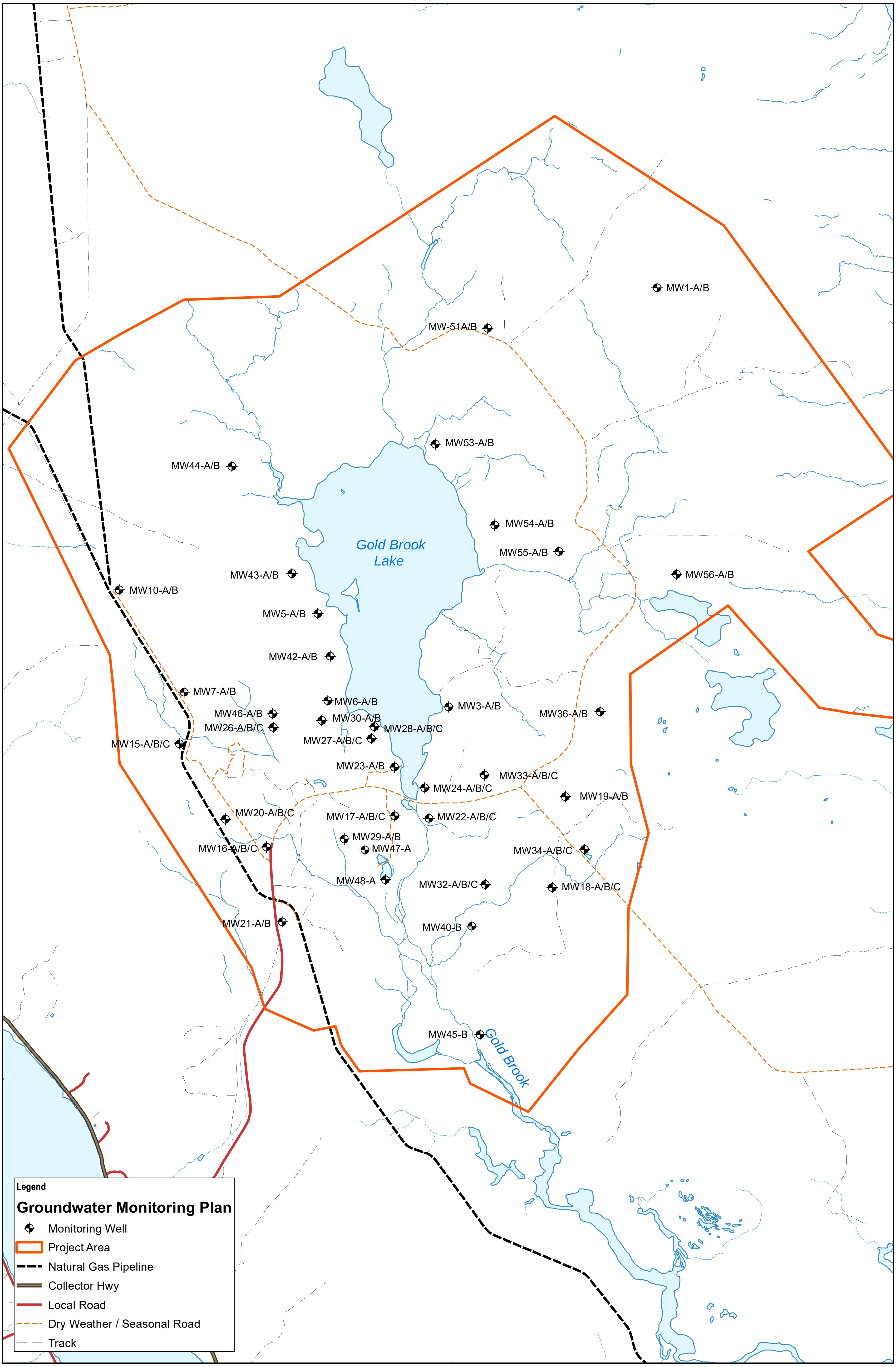
- Refine the list of analytes based on a review of long-term trends

In addition to introducing additional monitoring locations as necessary, this Water Monitoring Plan recommends using existing groundwater monitoring wells to establish a network of monitoring sites to permit the collection of groundwater data to geographically cover the extents of the Project activities. Existing and proposed monitoring sites are located adjacent to key infrastructure that has the potential to affect groundwater conditions.

Monitoring groundwater and surface water elevations, and surface water flows will document potential impact of Project activities on groundwater elevations and flow directions as well as on surface flow and baseflow conditions in nearby watercourses. Routine groundwater sampling and analysis will provide data to evaluate changes in groundwater quality, especially with respect to baseline conditions prior to active mining.

Effective water management requires a clear understanding of the interaction between groundwater and surface water. Therefore, to better assess this interaction, the surface water monitoring is coordinated with the groundwater monitoring and both groundwater and surface water monitoring programs are designed to complement each other.

As previously mentioned, 91 nested monitoring wells at 38 locations have been installed in the PA. Groundwater quantity and quality monitoring proposed for all phases of the Project is outlined in the Water Monitoring Plan provided in Appendix F.11 and in Figures 5.5-13 through 5.5-15.



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Map Projection: Transverse Mercator
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Grid: NAD 1983 CSRS MTM 4

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GROUNDWATER MONITORING LOCATIONS EXISTING

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FIGURE 5.5-13

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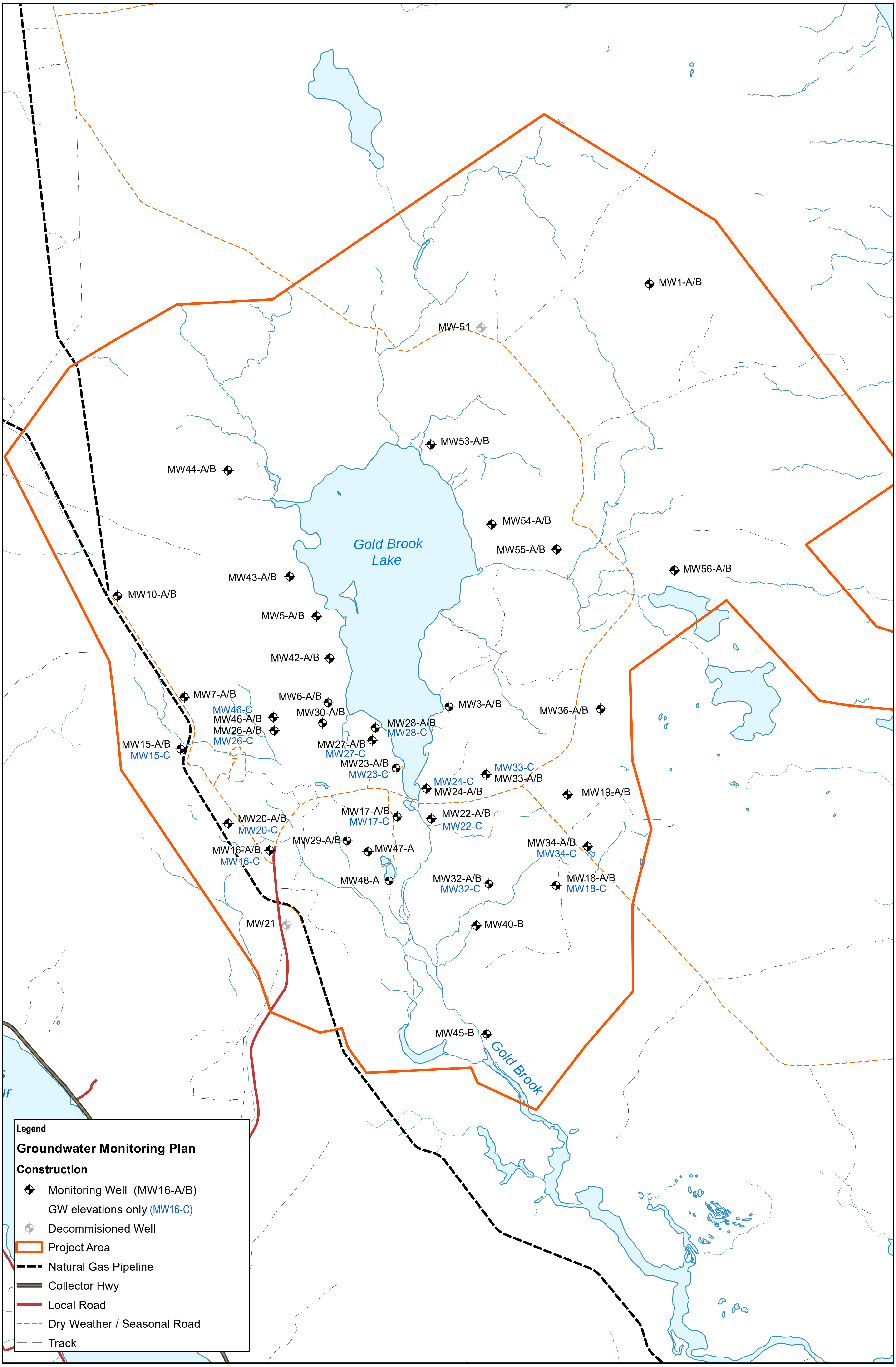

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Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

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GROUNDWATER MONITORING LOCATIONS CONSTRUCTION

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FIGURE 5.5-14

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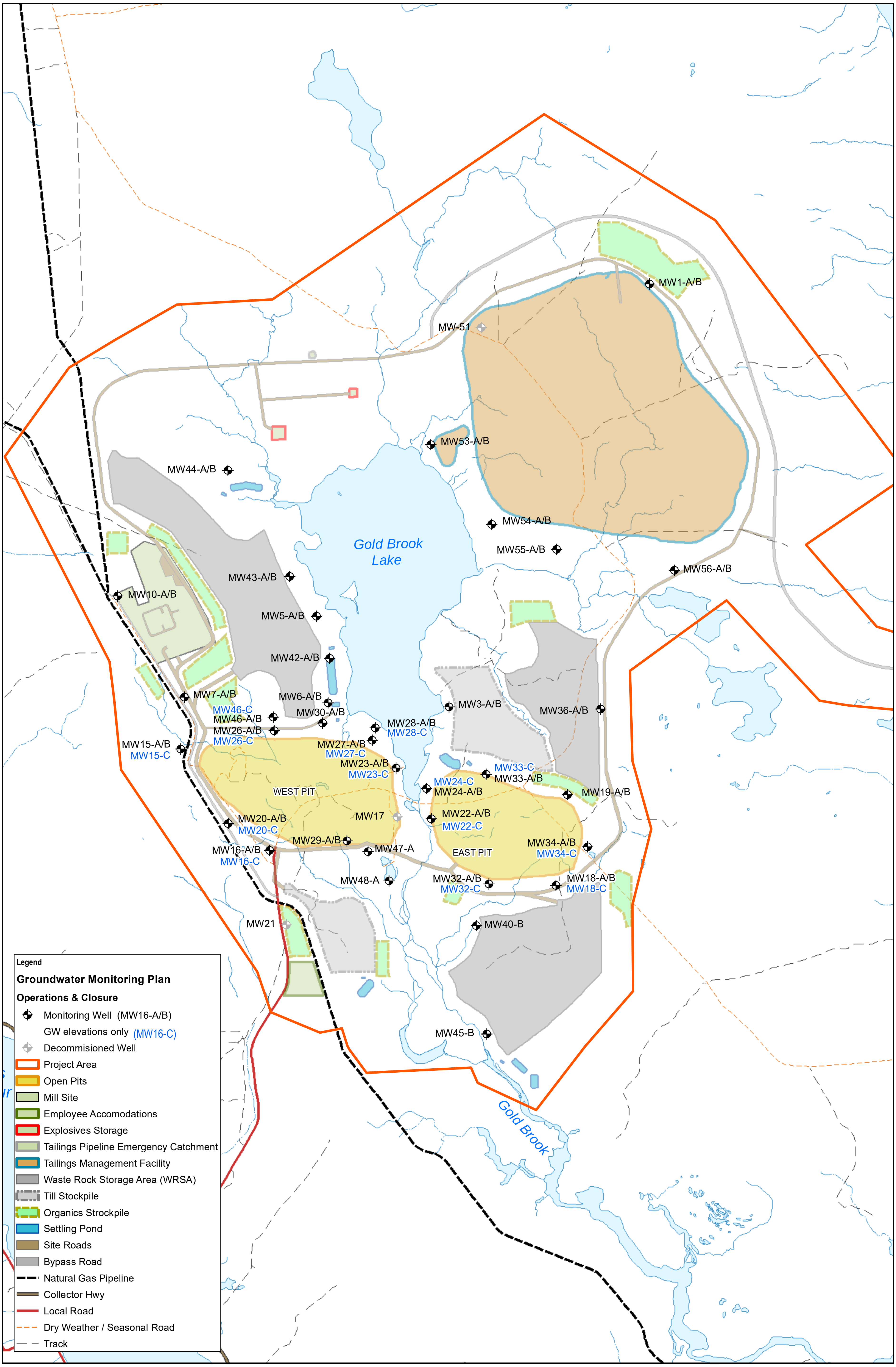

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Map Projection: Transverse Mercator
Horizontal Datum: North American Datum of 1983 (CSRS) version 6
Grid: NAD 1983 (CSRS) v6 UTM Zone 20N

GHD

SIGNAL GOLD INC.
GOLDBORO GOLD PROJECT
ENVIRONMENTAL ASSESSMENT

GROUNDWATER MONITORING LOCATIONS OPERATIONS & CLOSURE

Project No. 11222385
Revision No. -
Date 25/05/2022

FIGURE 5.5-15

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Data source: GeoNova, GHD, Anaconda . Created by: jparks

Groundwater quantity (elevation) and quality monitoring will be conducted consistent with the methodology described for the baseline Project-specific hydrogeologic investigations.

Groundwater data will be collected on a quarterly basis to sample during each season and to determine if there are cyclic changes in groundwater quality related to weather/climate. As more groundwater data is collected and evaluated, it may be appropriate to reduce the monitoring frequency. More frequent monitoring may be implemented to monitor trends or mine infrastructure changes over shorter durations that may have a potential impact to groundwater.

Table 5.5-15 provides the recommended groundwater quality monitoring parameters throughout the lifecycle of the Project. Parameters may be adjusted from time to time to meet the needs of the Project, as determined from analysis of the analytical data and in consultation with regulators.

Table 5.5-15 Groundwater Quality Monitoring Parameters

Phase	Monitoring Parameters
Pre-Construction	- BTEX/mTPH - Total and Dissolved Cyanide - Total and Dissolved Mercury - Dissolved Metals - Dissolved Phosphorus - COD - DOC - TSS
Construction, Operations, and Closure	- BTEX/mTPH (construction/operations only) - Total and Dissolved Cyanide - Total and Dissolved Mercury - Dissolved Metals - Dissolved Phosphorus - COD - DOC - TSS

The existing monitoring well network was established to document baseline groundwater conditions prior to Project development. The monitoring network will be modified over time as the Project enters different stages of its life cycle.

During pre-construction, the existing monitoring well network will be utilized during this stage of the Project life cycle. Groundwater elevation and quality monitoring will continue at all existing monitoring well nests (Figure 5.5-13).

During construction, GHD assumes existing monitoring well nests MW21 and MW51 will be decommissioned to facilitate construction of the pits and WRSAs (Figure 5.5-14). Routine groundwater quality monitoring at all 'C' wells (MW15-C, MW16-C, MW18-C, MW20-C, MW22-C, MW23-C, MW24-C, MW26-C, MW27-C, MW28-C, MW30-C, MW32-C, MW33-C, MW34-C, and MW46-C) will cease, but groundwater elevation monitoring is proposed to continue.

During the operations phase, monitoring well nest MW17 will be decommissioned as the West Pit development will gradually impact the well nest. Routine groundwater quality and elevation monitoring is proposed to continue at all remaining monitoring wells on a quarterly basis (Figure 5.5-15). Should any significant changes in the mine operations, groundwater quality or levels occur during the operational phase, additional monitoring wells may be added or removed.

During the first three years of the Project's closure phase, earthworks and demolition activities will take place to return the PA to a safe, stable, and vegetated state, and the pits will commence filling with water from both ground and surface sources. Quarterly groundwater monitoring will continue at all remaining monitoring wells.

Following demolition and earthworks activities, groundwater quality and elevation monitoring are proposed on a bi-annual basis for 22 years (i.e., from Year 16 to 37), during which time the East and West Pits will be allowed to flood creating two open waterbodies. Groundwater monitoring may be further reduced over this period as the mine stabilizes. Termination of the groundwater monitoring program would be expected following a satisfactory review of the monitoring data collected during all Project phases and as directed by and/or in consultation with NSECC.

5.5.9 Company Commitments

Signal Gold will undertake a survey of residential wells near the PA prior to Project construction to document baseline well conditions. Signal Gold will maintain a complaints line to allow residents to report any issues with their wells including changes in water quantity and quality. Signal Gold will investigate all complaints and will be responsible for replacement of impacted wells if it is determined the impacts were caused by Project activities.

5.5.10 Residual Effects and Significance

A significant adverse effect on the Groundwater Resources VC was defined in Section 5.5.6 as:

- Groundwater Quantity: Residual effects have low magnitude, occur beyond the LAA, occur sporadically or more frequently and are only partially reversible to irreversible.
- Groundwater Quality: Residual effects have moderate or higher magnitude, occur beyond the LAA, are of any duration, occur at any frequency and are only partially reversible to irreversible.

The predicted residual environmental effects of the Project on groundwater resources are assessed to be adverse, but not significant. However, after appropriate mitigation measures have been implemented, the overall residual effect of the Project on groundwater is assessed as not likely to have significant adverse effects, as summarized in Table 5.5-14. Residual effects to groundwater resources are summarized in Table 5.5-16 and are further addressed in Section 5.6 (Surface Water Resources), Section 5.7 (Wetlands) and Section 5.8 (Fish and Fish Habitat) as they pertain to the impact of groundwater alterations on the Surface Water Resources, Wetlands, Fish and Fish Habitat VCs.

Table 5.5-16 Residual Effects on Groundwater Quantity and Quality

Project – VC Interaction	Mitigation and Compensation Measures	Nature of Effect	Residual Effects Characteristics						Residual Effect	Significance
			Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility		
Construction/Operation Increased permeability in the bedrock around the blast holes use to create the open pits	Blasting will be conducted using best management practices to limit fracturing of the rock and disturbance of the groundwater flow system. Groundwater collected in the open pit due to enhanced permeability is conveyed away and treated as necessary through the water management system.	A	H The increased permeability in the bedrock around the blast hole may extend out less than 10m for a well executed blast. This contributed to a simulated drawdown greater than five metres immediately adjacent to the pit walls.	PA	N/A	MT	C	IR	Enhanced permeability of the rock immediately adjacent to the open pits	Not Significant Predicted impacts do not extend beyond the LAA
Operations Precipitation falling on uncovered waste rock, topsoil and till stockpiles may leach COCs from the piles which then may infiltrate into groundwater impacting groundwater quality	Runoff from pit walls and groundwater seepage will be collected, with water pumped to the water treatment unit associated with the northwest WRSA prior to entering the settling pond and discharging.	A	H COC concentrations in groundwater may exceed Potable Criteria beneath and near the waste rock, topsoil and till stockpiles.	PA Predicted COC exceedances of Potable Criteria are limited to within the PA during Operations.	N/A	MT	C	PR Groundwater quality impacts will naturally attenuate once the till and topsoil stockpiles are removed and used for reclamation.	Elevated COC concentrations in groundwater within the PA	Not Significant Predicted impacts do not extend beyond the LAA
Closure Precipitation falling on reclaimed waste rock, stockpiles may leach COCs from the stockpiles which then may infiltrate into groundwater impacting groundwater quality	Passive water quality treatment technologies, including engineered wetlands to treat site seepage and runoff, will be employed as required for closure.	A	H COC concentrations in groundwater may exceed Potable Criteria beneath and near the waste rock, stockpiles.	LAA Predicted COC exceedances of Potable Criteria are limited to within the PAA during Closure.	N/A	LT	C	PR	Elevated COC concentrations in groundwater within the LAA	Not Significant Predicted impacts do not extend beyond the LAA
Construction/Operations There is a potential for spills of petroleum products associate with the use of machinery and handling/storage of petroleum products	Contingency plans, including spill prevention and response, training, outline of roles and responsibilities, clean-up equipment and materials, and contact and reporting procedures, will be implemented.	A	H Mitigation measures will contain and reduce the potential impact of a spill; however, there is potential for limited exceedance of Portable Criteria.	PA	N/A	MT	S	RE The source of potential impacts will be removed the any remaining COCs will naturally degrade over time.	A spill of hazardous material could potentially result in elevated COC concentrations in groundwater	Not Significant Impacts will not extend beyond the LAA, duration is MT, may occur sporadically and the impact is reversible.

Table 5.5-16 Residual Effects on Groundwater Quantity and Quality

Project – VC Interaction	Mitigation and Compensation Measures	Nature of Effect	Residual Effects Characteristics						Residual Effect	Significance
			Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility		
Operations Dewatering of the open pits will reduce groundwater elevations thereby reducing available groundwater for potable use and for discharge to surface water bodies	Water pumped to dewater the open pits will be treated and discharged to Gold Brook Lake to mitigate surface water flows	A	H Drawdown greater than 5 m is simulated immediately adjacent to the open pits.	PA	A	MT	C	PR Filling of the open pits will partially reverse drawdown that occurs during operations.	Reduction in groundwater quantity	Not Significant Predicted impacts do not extend beyond the LAA
Closure The pit lakes will act as an area of groundwater discharge thereby reducing natural groundwater elevations and available groundwater for potable use and for discharge to surface water bodies	None	A	H Drawdown greater than 5 m is simulated immediately adjacent to the pit lakes.	PA	A	LT	C	IR	Reduction in groundwater quantity	Not Significant Predicted impacts do not extend beyond the LAA
Legend (refer to Table 5.10 and 5.11 for definitions)										

Nature of Effect	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility
A – Adverse P – Positive	N – Negligible L – Low M – Moderate H – High	PA – Project Area LAA – Local Assessment Area RAA – Regional Assessment Area	N/A – Not Applicable A – Applicable	ST – Short-Term MT – Medium-Term LT – Long-Term P – Permanent	O – Once S – Sporadic R – Regular C – Continuous	RE – Reversible IR – Irreversible PR – Partially Reversible