Hardrock Project

Fish and Fish Habitat
Federal EIS Follow-Up Monitoring Plan

HP-MG003-EV-130-0008_0

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List of Abbreviations

ANCOVA	analysis of covariance
APV	Aquatic Protection Value
BACI	before-after-control-impact
BGS	below ground surface
CALA	Canadian Association for Laboratory Accreditation
CES	critical effect size
COC	chain of custody
CWQG-FAL	Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
EA	Environmental Assessment
EAC	Environmental Advisory Committee
ECA	Environmental Compliance Approval
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
ETP	effluent treatment plant
GFC	Goldfield Creek
GGM	Greenstone Gold Mines GP Inc.
IAA	Impact Assessment Agency
ICP-MS	inductively coupled plasma mass spectrometry
ISW	industrial sewage works
MDMER	Metal and Diamon Mining Effluent Regulations
MECP	Ministry of the Environment, Conservation and Parks

MHT	MacLeod high tailings
MNRF	Ministry of Natural Resources and Forestry
O.Reg.	Ontario Regulation
PDA	Project development area
PoPCs	parameters of potential concern
PTTW	Permit to Take Water
PWQO	Provincial Water Quality Objectives
QA/QC	quality assurance / quality control
STP	sewage treatment plant
SWAT	Southwest Arm Tributary
the Project	Hardrock Project
TMF	Tailings Management Facility
tpd	tonnes per day (tpd)
vibrations	peak particle velocity
WRSA	Waste Rock Storage Area
wwt	wet weight
YOY	young-of-the-year

1 Introduction

Greenstone Gold Mines GP Inc. (GGM) is in the process of permitting and developing the Hardrock Project (the Project), an open pit gold mine near Geraldton, Ontario. The Project's Environmental Impact Statement (EIS) (Stantec 2018a) was approved by the Canadian Environmental Assessment Agency (CEAA), as outlined in the Decision Statement issued under Section 54 of the *Canadian Environmental Assessment Act, 2012*. The federal Decision Statement contained various Conditions of Approval. This Fish and Fish Habitat Follow-up Monitoring Plan describes the plan to address federal Conditions of Approval related to fish and fish habitat. This Fish and Fish Habitat Follow-up Monitoring Plan addresses seven specific federal Conditions of Approval (Conditions 3.14, 3.15, 3.16, 3.17, 3.2, 5.4, and 5.5.1).

1.1 Mine Overview

The Hardrock deposit will be mined as an open pit. The process plant will operate 365 days per year with a Life of Mine of approximately 15 years. Mill throughput will range from 24,000 tonnes per day (tpd) increasing to 30,000 tpd as conditions warrant. The overall Project schedule will consist of the following phases:

- Construction: Years -3 to -1, with early ore stockpiling commencing after the first year of construction
- Operation: Years 1 to 15, with Year 1 representing a transition from construction to operation
- Closure: Years 16 to 20 for Active Closure and Years 21 to 36 for Post-Closure

Key mine components of the Project development area (PDA) are an open pit, waste rock storage areas, overburden storage areas, ore stockpile, ore crushing and mill feed ore storage activities, process plant, water management facilities, tailings management facility, power plant and associated infrastructure, and explosives facility. Ancillary Project components are buildings, service water supply and associated infrastructure, sewage and effluent treatment plants, site roads, watercourse crossings, realignments, and habitat compensation/offsets, onsite pipelines and piping, fuel and hazardous materials storage, aggregate sources, and a temporary camp. Existing infrastructure currently located within the PDA will be relocated, including a portion of Highway 11, a Ministry of Transportation Patrol Yard, and Hydro One Networks Inc. facilities.

1.2 Purpose

The purpose of this Fish and Fish Habitat Follow-up Monitoring Plan is to identify the monitoring and analysis that will be undertaken to verify the accuracy of the EIS as it pertains to federal Conditions of Approval related to fish and fish habitat (Conditions 3.15, 3.16, 3.17, 3.2, 5.4, and 5.5.1) and to determine the effectiveness of related mitigation measures. This Fish and Fish Habitat Follow-Up Monitoring Plan is a component of a broader monitoring framework, which is incorporated into a more

comprehensive Water Management and Monitoring Plan (GGM 2019a) and Aquatic Management and Monitoring Plan (GGM 2019b).

1.3 Objectives

This Fish and Fish Habitat Follow-up Monitoring Plan addresses seven specific federal Conditions of Approval (Conditions 3.14, 3.15, 3.16, 3.17, 3.2, 5.4, and 5.5.1). The overall objectives related to each condition are provided Table 1-1, which also lists the applicable section of this Fish and Fish Habitat Follow-up Monitoring Plan.

Table 1-1: Objectives for Federal Conditions of Approval Related to Fish and Fish Habitat

Federal Condition	Report Section	Objective (from federal Decision Statement, 9/4/2019)
3.14	2.1	*develop, prior to construction, and implement, during all phases of the Designated Project and in a manner consistent with the Fisheries Act and its regulations, measures to control erosion and sedimentation in the project development area. The Proponent shall submit these measures to the Agency before implementing them. Among other measures, the Proponent shall maintain stream bank stability using ditches and diversion berms.*
3.15	2.4	*determine the effectiveness of the mitigation measures as it pertains to the adverse environmental effects of blasting on fish and fish habitat*
3.16	2.2	*verify the accuracy of the environmental assessment and to determine the effectiveness of the mitigation measures as it pertains to adverse environmental effects on fish and fish habitat caused by changes in water quality in Kenogamisis Lake, Mosher Lake and the Southwest Arm Tributary*
3.17	2.3	*verify the accuracy of the environmental assessment and to determine the effectiveness of the mitigation measures as it pertains to the adverse environmental effects on fish and fish habitat of from changes in groundwater quality*
3.2	2.4	*develop, prior to the start of blasting activities in or near water, and implement, during blasting activities in or near water, mitigation measures to avoid or prevent adverse effect on fish and fish habitat from the use of explosives*
5.4	2.5 (water) 2.6 (fish tissue)	*verify the accuracy of the environmental assessment as it pertains to the adverse environmental effects on the health of Indigenous Peoples of changes in concentrations of contaminants in water and fish**

Federal Condition	Report Section	Objective (from federal Decision Statement, 9/4/2019)
5.5.1	2.7	*verify the accuracy of the environmental assessment and to determine the effectiveness of the mitigation measures as it pertains to the adverse environmental effects on the health of Indigenous Peoples of changes in concentrations of contaminants in fish tissue*

* Note that the objectives of this report are: This report describes methods to collect fish tissue data that will support the Indigenous Peoples Health Risk Assessment Follow-up Plan (GGM 2020). The Indigenous Peoples Health Risk Assessment Follow-up Plan will assess the accuracy of the environmental assessment as it pertains to the adverse environmental effects on the health of Indigenous Peoples.

2 Follow-up Monitoring Plan

This Fish and Fish Habitat Follow-up Monitoring Plan was developed for the Project based on Condition 2.4 of the Decision Statement. Under Condition 2.4 of the Decision Statement, " *a follow-up program is a requirement of a condition set out in this Decision Statement, determine, as part of the development of each follow-up program and in consultation with the party or parties being consulted during the development, the following information:*

2.4.1 the methodology, location, frequency, timing and duration of monitoring associated with the follow-up program;
2.4.2 the scope, content, and frequency of reporting of the results of the follow-up program.
2.4.3 the levels of environmental change relative to baseline conditions that would require the Proponent to implement modified or additional mitigation measure(s), including instances where the Proponent may require Designated Project activities to be stopped; and
2.4.4 the technically and economically feasible mitigation measures to be implemented by the Proponent if monitoring conducted as part of the follow-up program shows that the levels of environmental change referred to in condition 2.4.3 have been reached or exceeded."

Sections 2.1 through 2.6 provide a description of follow-up monitoring methods to satisfy Conditions 3.15, 3.16, 3.17, 3.2, 5.4, and 5.5.1. These plans approximately reflect years of ongoing consultation with Indigenous communities, local stakeholders, and government agencies. Continued community consultation will occur throughout the adaptive management process.

2.1 Erosion and Sediment Control

This section is intended to describe methods to meet the requirements of Federal condition 3.14.

2.1.1 Erosion Control

The following management practices for erosion control can be applied to various aspects of the work as defined by the Environmental Superintendent or designate. Actual practices chosen will vary according to site conditions, time of year, expected risk, substrate, weather related conditions, and construction timing (i.e., duration of expected exposure). Details on specific materials, placement and maintenance requirements will be defined in construction specifications and illustrated on For Construction Drawings.

The two main activities during the construction phase of the Project which have the immediate need for erosion control are activities related to clearing and grubbing, and activities related to soil transport and management, which includes historical tailings transport and management.

2.1.1.1 Clearing and Grubbing

Clearing and grubbing of areas for the purpose of site development will be one of the initial construction activities. Clearing and grubbing activities will be staged to limit the amount of area exposed for extended periods of time. Standard accepted forestry practices will be implemented along with elements of sediment controls and defined on construction drawings and in specifications. Typically, sediment controls will be established in defined areas, including the potential placement of culverts, berms, silt fencing, temporary ponds, ditches etc., prior to clearing and grubbing activities.

2.1.1.2 Soil Transport and Management

The soil handling (excavation, placement and compaction), and transport process is susceptible to erosion due to disturbance and the potential for site alteration of natural surface water flow pathways. Soil handling, storage and sequencing will occur with the intention to reuse soils during the restoration process. In order to achieve this, the handling of the soils (in particular topsoil) must be done with care to reduce the amount of disturbance or damage that is occurring to soil structures required for vegetation growth.

Sediment and erosion controls related to soil transport and management include:

- Liners or additional preventative measures may be used in the transportation of solid or liquid materials to mitigate fugitive releases outside of intended delivery locations.
- Stockpiles will be inspected regularly and maintained to promote stability.
- Stockpiles will be benched, where appropriate, and protected from natural weathering through covers, vegetation or other suitable materials.
- Check dams or velocity retarding objects will be placed along slopes where required.
- Construction activities will be planned, and work areas identified, prior to stripping surficial vegetation.

- Soil stripping and excavation will only be conducted when there is no precipitation occurring that is substantial enough to cause runoff and erosion.
- Water will be conveyed around work areas with ditching and appropriately sized culverts or sumps to reduce water velocity and limit the potential for erosion.
- Potential sources of erosion will be identified and stabilized prior to development using sediment fencing or alternative methods of natural material support.
- Site run off will be directed, via gravity, into sumps or sediment control ponds; and
- The flow of water will be throttled using check dams or semi-permeable materials, which will be routinely maintained.

2.1.2 Sediment Control

Sediment controls shall be implemented in accordance with the construction specifications, drawings and as directed by the Environmental Superintendent, or designate. Sediment control measures shall conform to:

- Ontario Provincial Standard Specifications for Temporary Erosion and Sediment Control Measures (OPSS 805 – November 2006) as amended; and,
- Ontario Provincial Standard Specifications. Construction Specification for Seed and Cover Measures (OPSS 804 – April 2014) as amended.

Typical measures for sediment control are outlined in the following sub-sections.

2.1.2.1 Siltation Control Fence

Silt fencing is the most commonly used sediment control measure. By design, it filters sediment laden overland flow and allows water to pass through woven and non-woven fabric fences, while retaining entrained sediments. Silt fencing will be installed along appropriate slopes or shoreline contours adjacent to active working areas, as defined on drawings prepared prior to ground disturbance. The fence is intended to act as temporary perimeter control to limit overland flows from exiting disturbed ground and entering undisturbed areas, water bodies, roadways etc. Silt fencing will be periodically inspected, specifically after rainfall events, and shall be maintained when retained sediments accumulate behind the structure as defined in the construction specifications. There is the expectation that silt fence will be repaired and replaced periodically throughout the lifecycle of construction activities. Silt fencing will remain in place and be maintained until such time as more permanent stabilization measures have been implemented.

2.1.2.2 Geotextile Mat

Geotextile mat is a woven geosynthetic material that is placed as a temporary measure to protect exposed waste material in excavated areas when directed by the Environmental Superintendent or designate. It is to be installed between waste materials or bare soils and rip rap in areas where erosion may occur, releasing sediment from beneath the rip rap due to runoff.

2.1.2.3 Drainage Ditches

Drainage ditches are to be used to intercept and direct surface runoff to a designated collection point (rock flow check dam/sediment trap) or discharge point (established vegetation area for overall filtration), but not directly into a watercourse or waterbody. Drainage ditches are to be implemented when required to reduce or prevent soil erosion, sedimentation, and to facilitate the establishment of vegetation. Drainage ditches will be required downgradient of roads associated with the Project within 30 meters of a watercourse or waterbody to capture and route potentially sediment laden waterflow. In some instances, due to excessive gradient, anticipated flow velocities and/or loose base materials, ditches may require lining (e.g., with rip rap materials underlain with geotextile mat).

2.1.2.4 Rock Check Dams

Temporary rock check dams are to be used when the velocity of concentrated flow in a drainage ditch is such that bed erosion within the ditch is witnessed or when there is a need to retain and trap sediment. Accumulated sediments shall be periodically removed when the depth of accumulation is one-third to one half the vertical height of the rock check dam at the center of the constructed features. Construction details (e.g., rock size, interval locations, core geotextile materials) will be outlined in construction specifications and may vary with site location.

2.1.2.5 Berms

Berms are water control structures used to direct or slow down water and protect water bodies from sediment laden run-off. Locations for installation of berms will typically be around material storage areas, or as otherwise directed or identified on construction drawings. Placement of berms is only intended to impede the movement of sediment, and typically will not exceed 1.0 meters in height. Berms may be constructed of compacted granular materials, sectional concrete barriers, stacked sandbags etc. In some instances, depending on the size of the berm, location, and duration of installation, shop drawings signed and sealed by a licensed Professional Engineer in Ontario may be required prior to installation as per Provincial Labour regulations.

2.1.2.6 Sediment Traps

Sediment traps may be utilized throughout the Project where there is a sub-catchment drainage area of less than two hectares, and where there is potential for the sediment laden waters to enter a

waterbody. They are to be constructed as shown on drawings or as directed by the Environmental Superintendent in accordance with OPSS 805.

2.1.2.7 Erosion Control Mat

Erosion control mats are biodegradable mats or woven blankets, which are placed and stapled directly on exposed soil surfaces that have been disturbed and graded. Their primary purpose is to stabilize finished surfaces and allow seeding or other plantings to establish and limit surface erosion primarily due to rainfall and minor sheet flow events. Blankets are to be installed and maintained as per OPSS 804.

2.1.2.8 Revegetation

Revegetation of disturbed lands, and areas of fill placement and grading, will help stabilize soil surfaces with natural vegetation and re-introduce biodiversity into the project site either temporarily or more permanently. Details on revegetation, progressive or final, will be outlined on construction drawings and specifications. Revegetation plans will be reviewed by Environmental Advisory Committees (EACs).

2.1.3 Routine Monitoring

Erosion and sediment controls will be regularly inspected throughout the duration of construction and operations phases to verify the effectiveness of mitigative measures and management practices implemented to protect the environment, and to determine whether new management strategies are required.

Depending on the structure or work area, inspections will be conducted on a daily basis to weekly basis. Inspection forms will be completed by qualified staff to record observations of various parameters such as slope stability indicators, development of rills, seeps, depth of sediment accumulation.

A GGM Environmental Supervisor, with assistance from GGM field staff and Environmental Monitors, will be responsible for the implementation of water quality monitoring in accordance the Water Management and Monitoring Plan and permit conditions.

The following activities will be undertaken as part of the surveillance inspections and monitoring:

- Inspect and monitor the work sites on an on-going basis for compliance with the Erosion and Sediment Control Plan
- Inspect earthworks daily to detect evidence of erosion and sedimentation; promptly apply appropriate corrective measures if necessary.
- As required, direct the implementation of incremental aspects of erosion and sediment control to improve control efficiency.

- If required, direct the cessation of work activities where control measures are not effectively controlling sediment transport and erosion.
- Silt fence barriers will be inspected daily and immediately following rainfall events.
- If gaps, tears, slumping, weathering or other visual failure of the materials are found, the silt fence will be immediately repaired, or the fabric replaced.
- In preparation for possible repairs, stand-by material of prefabricated silt fence barrier will be maintained on the construction site, and be available for rapid deployment.
- Sediment traps will be monitored, including monitoring for standing water, prior to forecasted rain, daily during extended rain events, and weekly during other periods.
- Sediment will be removed from sediment traps after each rainfall event or whenever sediment reaches one-third to one half of the trap capacity.
- Sediment removal may be required for collection ponds to maintain adequate storage capacity. This material will be removed, dewatered-stabilized and taken to the Tailings Management Facility (TMF).
- Erosion control structures will be reinforced when significant rainfall events are forecasted as per direction of the Environmental Superintendent, or designate; and
- A continual log of conditions and response actions will be maintained.

2.1.4 Adaptive Management

Adaptative Management is a planned and systematic process for continually improving environmental management practices by learning from outcomes. Adaptive management provides flexibility to address/accommodate new circumstances, to adjust monitoring, to implement new mitigation measures or to modify existing measures.

GGM will identify and correct incidents with appropriate measures aimed to prevent reoccurrence and/or similar occurrences. The Adaptive Management Framework provides a formalized approach to:

- Formally track and monitor activities
- Report and as needed investigate incidents, including non-conformance and non-compliant events.
- Develop and implement corrective and preventative actions; and,
- Continue monitoring and update relevant Environmental Management and Monitoring Plans (EMMPs)

2.1.5 Reporting

It is anticipated that those elements relevant to erosion and sediment control will be assembled into a formal summary report and issued annually during the Construction and Operations phases of the work. The report will form the basis of the Adaptative Management strategy and be utilized in the review process.

2.2 Water Quality

The following section describes the plan to satisfy federal Condition 3.16 of the EIS approval by presenting GGM's planned mitigation measures to reduce adverse effects on fish and fish habitat with respect to water quality. This follow-up program describes the plan to monitor water quality in Kenogamisis Lake, Mosher Lake, and the Southwest Arm Tributary (SWAT) (Condition 3.16). An Adaptive Management Plan (AMP) is presented to determine whether additional mitigation measures are required based on monitoring results to protect fish and fish habitat.

2.2.1 Routine Monitoring

The surface water monitoring locations, sampling frequency, sampling methods, and analytical parameters are presented in the following sections.

2.2.1.1 Location

Surface water quality in lakes and streams located downstream of the Project will primarily be affected through the sewage treatment plant (STP) and effluent treatment plant (ETP) discharges to the Southwest Arm of Kenogamisis Lake as well as groundwater seepage from the Waste Rock Storage Areas (WRSAs), TMF, and historical tailings.

The surface water quality sampling locations are presented in Figure 2-1. Surface water monitoring locations will be reviewed at regular intervals through the AMP presented in Section 2.2.2. Monitoring locations may be added or removed from the monitoring program in accordance with their utility in monitoring the effects of the Project on the environment or to account for modifications during detailed design.

2.2.1.2 Frequency

Table 2-1 presents the frequency of sampling and rationale for each monitoring station for surface water quality. Surface water quality monitoring will include:

- Water quality monitoring (monthly) of the Southwest Arm of Kenogamisis Lake to monitor the extent of the effluent mixing zones within the receiver as well as potential effects of the TMF on the Southwest Arm of Kenogamisis Lake.

- Water quality monitoring (monthly) of Barton Bay, Central Basin, and Outflow Basin of Kenogamisis Lake, and downstream of Kenogamisis Lake at the locations indicated on Figure 2-1 to document changes in water quality.
- Water quality monitoring (monthly) of Goldfield Creek (GFC) Tributary, GFC diversion channel, SWAT inflow to the Southwest Arm of Kenogamisis Lake, Magnet Creek, and Mosher Lake to document changes in water quality.

Twenty-two (22) surface water quality monitoring locations will be sampled. An additional surface water quality monitoring location will be added to monitor the mixing zone for the full scale ETP, after a plume delineation study is completed to determine the best location for the additional water quality monitoring station. The surface water quality monitoring locations will be monitored monthly, when safe to do so, to assess seasonal fluctuations in water quality. Monthly monitoring will allow a trend analysis in surface water quality and differentiate more accurately whether fluctuations in quality are due to sample variation, or the potential for a project related effect. The frequency of monitoring will be reduced to quarterly if there are no trigger thresholds exceeded during a two-year period (approximately 24 samples). The surface water quality monitoring stations are shown on Figure 2-1.

In addition, temperature and dissolved oxygen (DO) water column profile sampling will be completed at eight (8) surface water monitoring locations. Table 2-2 presents the location, frequency of profile sampling, and rationale for each temperature and DO water column profile sampling location. The temperature and DO water column profile sampling locations are presented on Figure 2-1.

Stantec

Legend

- Local Assessment Area
- Regional Assessment Area
- Discharge Location
- Routine Water Quality Monitoring
- Temperature/ DO Profile
- Mercury and Methylmercury Monitoring

Site Plan Revised Post Final EA/EIS

- New Highway 11 Alignment
- Diversion Channel
- Collection Ponds
- Open Pit- Full Extent
- Tailings Management Facility
- Grade Control Structure
- Inundated Area ; Backwater effect
- Waste Rock Storage Area

Existing Features

- Highway
- Major Road
- Local Road
- Existing SW Arm Tributary Channel
- Existing Portion of Goldfield Creek (to be overprinted)
- Watercourse
- Provincial Park
- Wetland (Eco-Site Based)
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

August 2020
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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
2-1

Title

Surface Water Quality Monitoring Locations

Goldfield Creek Confluence Detail

1:60,000 (0, 1,500, 3,000 m)

1:450,000 (0, 5, 10 km)

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Revised: 2020-08-07 By: dharvey

Table 2-1: Receiving Environment Surface Water Quality Monitoring Locations, Frequency, and Rationale

Station	Frequency	Rationale
1A	Monthly	Background station, upstream of Southwest Arm
4	Monthly	Monitor for potential effects of historical MacLeod tailings seepage discharge and Geraldton STP discharge on Barton Bay East
8	Monthly	Monitor for potential effects downstream of the Kenogamisis Lake Central Basin near the outlet to the Outlet Basin
11	Monthly	Monitor for potential effects midway through the Outlet Basin
17	Monthly	Kenogamisis Dam. End of Local Assessment Area
20	Monthly	Monitor for potential effects of the TMF on GFC, upstream of confluence of GFC and GFC Tributary and upstream of Kenogamisis Lake
20A	Monthly	Monitor for potential effects of the TMF on GFC, downstream of confluence of GFC and GFC Tributary and upstream of Kenogamisis Lake
21	Monthly	Monitor potential effects of TMF on Lake A-322.
22A	Monthly	Monitor for potential effects of the TMF on Goldfield Creek Tributary, upstream of confluence of GFC and GFC Tributary.
23	Monthly	Monitor for potential effects of the TMF on the Southwest Arm of Kenogamisis Lake
24	Monthly	Monitor for potential effects of the TMF and/or WRSA-D on the Southwest Arm of Kenogamisis Lake
25	Monthly	Monitor for potential effects of mining activities on the water at the mouth of the SWAT
26	Monthly	Monitor for potential effects of WRSA-C on Mosher Lake. Requirement of Condition 3.16 of CEAA Decision Statement.
28	Monthly	Background station. Magnet Creek, upstream of Barton Bay
38	Monthly	Downstream of Outlet Basin upstream of Long Lake
39	Monthly	Southwest Pond 3 (SWP3) of SWAT, downstream of Goldfield Creek Diversion
40	Monthly	Barton Bay East. Upstream of historical MacLeod tailings seepage discharge and Geraldton STP
46 (or equivalent)	Monthly	Monitor full scale ETP mixing zone; station location to be determined by plume delineation study
47	Monthly	Monitor for potential effects in the Central Basin
49	Monthly	Monitor for potential effects where Southwest Arm outlets to Central Basin
52	Monthly	Background station upstream of Goldfield Creek Diversion
53	Monthly	Monitor water quality to confirm the effluent discharge is meeting the Provincial Water Quality Objectives (PWQO) within the limits of the mixing zone for the temporary ETP.

Table 2-1: Receiving Environment Surface Water Quality Monitoring Locations, Frequency, and Rationale

Station	Frequency	Rationale
54	Monthly	Monitor for potential effects at the outlet of the Goldfield Creek Diversion Pond

Table 2-2: Dissolved Oxygen and Water Temperature Profile Monitoring Locations, Frequency, and Rationale

Station	Frequency	Rationale
21	Quarterly	Deepest point in Lake A-322
26	Quarterly	Deepest point in Mosher Lake
39	Quarterly	Deepest point in Southwest Pond 3 (SWP3) of SWAT
46	Quarterly	Southwest Arm near proposed effluent discharge location
47	Quarterly	Deepest point in Central Basin
48	Quarterly	Deepest point in Outlet Basin, Hardrock Bay
49	Quarterly	Deep location at narrows where Southwest Arm outlets to Central Basin
50	Quarterly	Gamsby Lake – Reference area, 25 km southwest of the Project, no known historical mine influences.

2.2.1.3 Methods

Surface water sampling will be collected by grab sample in laboratory provided bottles containing appropriate preservative, where required. Samples for dissolved forms of metals will be filtered using a 0.45 µm membrane filter. Water quality samples will be taken just below the surface of the water (0.1 m deep). Water quality samples will be collected by a qualified technician using suitable sampling equipment. Samples will be preserved (if applicable) and transported in appropriate containers to maintain the integrity of sample temperatures and hold times. Samples will be submitted to a Canadian Association for Laboratory Accreditation (CALA) accredited laboratory under chain of custody (COC) documentation. The accredited CALA laboratory will use the authorized analytical methods set out in the industrial sewage works (ISW) environmental compliance approvals (ECAs), permits to take water (PTTWs), and regulations (i.e., Metal and Diamond Mining Effluent Regulations [MDMER] and Ontario Regulation [O.Reg.] 560/94).

The surface water quality samples will be analyzed for general chemistry, nutrients, and total and dissolved metals (including arsenic), total suspended solids (TSS), nitrate (as N), total kjeldahl nitrogen (as N), pH, total phosphorus, and sulfate. Chlorophyll A will also be analyzed for samples collected at stations 25, 26, and 46. Unionized ammonia will be calculated based on total ammonia, and field pH and field temperature measurements.

Field parameters comprising temperature, pH, conductivity, turbidity, and DO will be measured during sample collection using a multi parameter water quality meter. A sample collection form will be used to record *in-situ* parameters and to record current weather (i.e. air temperature, raining, snowing) and flow conditions (i.e. low flows, high flows, ice cover conditions).

Quality assurance (QA) / quality control (QC) principles for sampling and laboratory analysis outlined in Environment Canada (2012) will be followed. Duplicate samples will be collected from a subset of samples collected to quantify environmental variability and analytical consistency, with a minimum of one duplicate for every 10 parent samples. A minimum of one travel and one field blank will be collected per sampling event to detect potential sources of contamination. Field instruments will be calibrated regularly according to the manufacturer's specifications and calibration logs will be maintained.

Water quality data will be entered into an electronic database and will be validated against the original laboratory certificate of analysis.

Dissolved Oxygen and Temperature Profile Sampling

Dissolved oxygen and temperature will be measured at 1 m intervals from the surface of the water column at the profile sampling locations (Figure 2-1). Dissolved oxygen and temperature will be measured using a handheld multi parameter water quality meter with an extended cable for the probe, sufficient to reach the intended depth of the water column. The meter will be calibrated prior to use according to the manufacturer's specifications using the appropriate calibration standards. The probe will be lowered with a graduated tape measure to confirm the depth of the probe. The probe will be allowed to equilibrate prior to taking a reading.

2.2.2 Adaptive Management

Surface water quality indicator parameters were chosen based on their relevance to the Project (i.e., parameters of potential concern [PoPCs]), permit requirements (e.g., ECAs), and regulatory criteria, particularly the PWQOs, Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-FAL), O.Reg. 560/94, and MDMER limits. The PoPCs for the Project were defined in the EIS/EA (Stantec 2018a). The PoPCs were reviewed with respect to baseline data, fate in surface water and sediments, and ability to consistently and reliably be quantified. In addition to the PoPCs, several other parameters typically indicative of mine operations and/or acid rock drainage were chosen as indicator parameters. The indicator parameters for surface water quality are the following:

- **Antimony:** defined as a PoPC for the Project. It was predicted to exceed the interim PWQO in pond M1 as well as in seepage from the WRSAs and ore stockpiles.
- **Arsenic:** Defined as a PoPC for the Project and a Ministry of the Environment, Conservation and Parks (MECP) Policy 2 parameter for Kenogamisis Lake. The concentration of arsenic in surface water consistently exceeds the Interim PWQO in Barton Bay and Central Basin under baseline conditions.
- **Cobalt:** defined as a PoPC for the Project. It was predicted to exceed the PWQO in Pond M1 as well in seepage from the WRSAs. It is a naturally occurring element in elevated concentrations in the Canadian Shield.

- **Uranium:** defined as a PoPC for the Project. It was predicted to exceed the interim PWQO in Pond M1 and in seepage from the WRSAs. It is a naturally occurring element in the Canadian Shield.
- **Cyanide (Free and Total):** Cyanide is a part of the processing of ore. A cyanide destruction circuit will be included in the mill process thereby limiting the amount of cyanide discharged with the tailings in the TMF. Cyanide is not commonly found in the natural environment and therefore provides an indication for the potential seepage from the TMF to the environment.
- **Phosphorous:** defined as a PoPC for the Project. It was predicted to exceed the interim PWQO in seepage from the WRSAs and is a MECP Policy 2 parameter for Kenogamisis Lake. Phosphorus is a naturally occurring element in some sedimentary rock such as apatite.
- **Copper:** It is predicted to exceed the Interim PWQO in TMF seepage. It is also a parameter listed in Schedule 4 of the MDMER and Schedule 1 of O.Reg. 560/94.
- **Mercury and Methyl Mercury:** Defined as a PoPC for the Project. Relevant for trigger threshold monitoring locations associated with the SWAT due to the potential for methylation processes that may result from flooding of vegetation and soils related to grade control structures.
- **Iron:** Defined as a policy 2 parameter for certain basins of Kenogamisis Lake. The 75th percentile concentration of iron in surface water exceeds the PWQO in Barton Bay under baseline conditions.

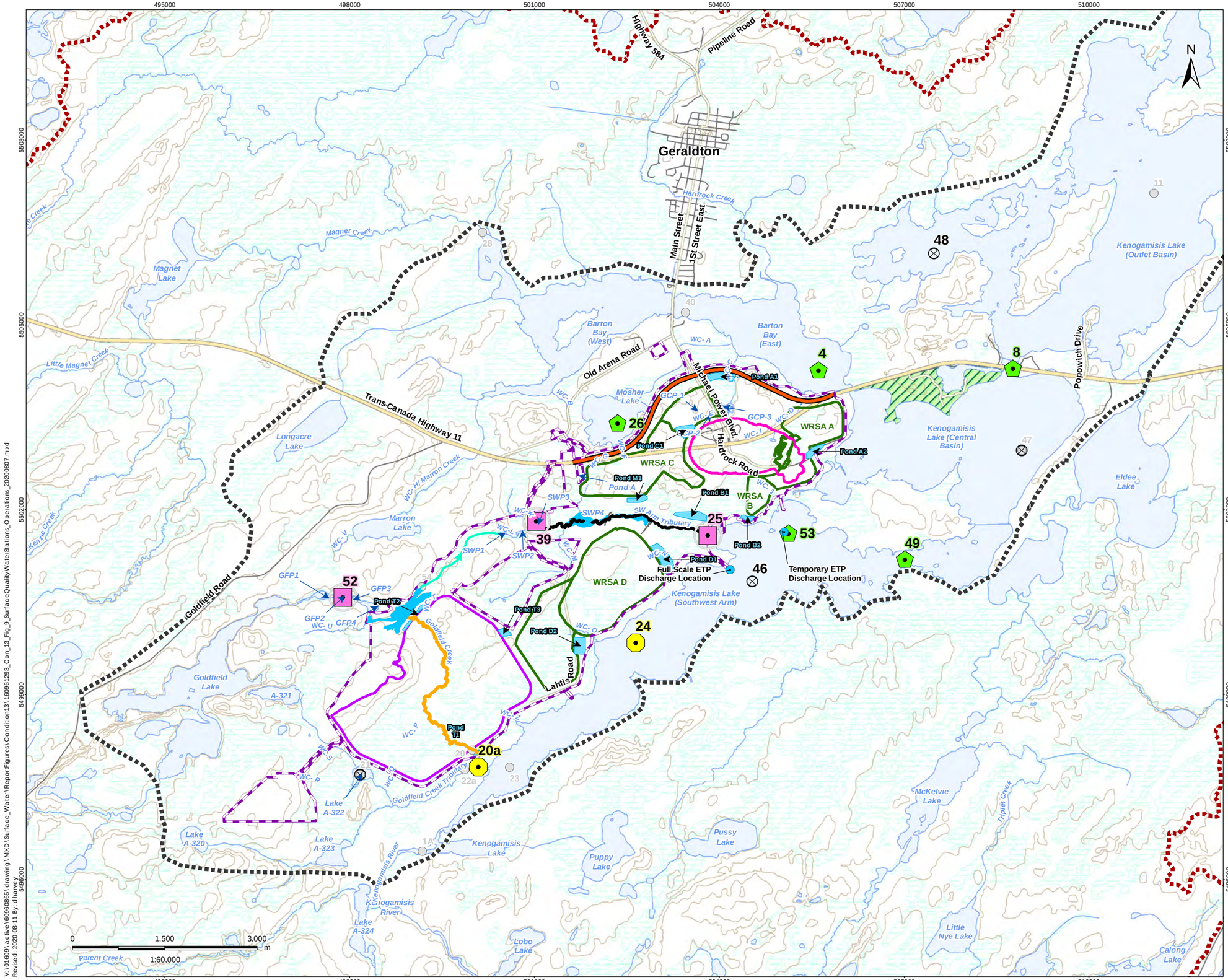
2.2.2.1 Surface Water Quality Trigger Threshold Monitoring Locations and Frequency

As presented in Section 2.1.1, 22 surface water quality monitoring locations are proposed during mine operations. Ten of the stations have been chosen as trigger threshold monitoring stations to alert to changing surface water quality downgradient of effluent discharge, downgradient of seepage collection systems associated with WRSAs, TMF, ore stockpile, and/or areas inundated by the GFC diversion. Monthly sampling of the trigger threshold monitoring stations will enable development of trigger threshold parameter trends in surface water quality and differentiate whether fluctuations in quality are due to sample variation, a single anomalous event such as a meteorological event, seasonal variation, or the potential for a project related effect. The surface water quality trigger threshold monitoring stations are shown on Figure 2-2. Table 2-3 presents a summary of surface water quality trigger threshold monitoring locations, associated parameters, frequency, and rationale.

Table 2-3: Surface Water Trigger Threshold Monitoring Stations

Trigger Threshold Monitoring Station	Frequency of Measurement	Trigger Threshold Parameter	Rationale
4	Monthly	As, Co, Fe, P, Sb, U	Monitor for potential effects of the historical tailings and WRSAs seepage and Geraldton STP discharge on Barton Bay East.
8	Monthly	As, Co, Fe, P, Sb, U	Monitor for potential Project effects downstream of the Kenogamisis Lake Central Basin near the outlet to the Outlet Basin.

Trigger Threshold Monitoring Station	Frequency of Measurement	Trigger Threshold Parameter	Rationale
20A	Monthly	As, Co, Cu, Fe, P, Sb, U, CN free & total	Monitor for potential effects of the TMF on GFC, downstream of confluence of GFC and GFC Tributary and upstream of Kenogamisis Lake
24	Monthly	As, Co, Cu, Fe, P, Sb, U, CN free & total	Monitor for potential effects of the TMF and/or WRSA-D on the Southwest Arm of Kenogamisis Lake
25	Monthly	As, Co, Fe, P, Sb, U, Hg, MeHg	Monitor for potential effects of mining activities on the water at the mouth of the SWAT
26	Monthly	As, Co, Fe, P, Sb, U	Monitor for potential effects of WRSA-C on Mosher Lake
39	Monthly	As, Co, Fe, P, Sb, U, Hg, MeHg	Monitor for potential effects of mining activities on SWAT, downstream of GFC Diversion
49	Monthly	As, Co, Fe, P, Sb, U	Monitor for potential effects where Southwest Arm outlets to Central Basin
52	Monthly	As, Co, Fe, P, Sb, U, Hg, MeHg	Background station upstream GFC Diversion
53	Monthly	As, Co, Fe, P, Sb, U	Monitor for potential effects beyond the temporary ETP mixing zone



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Revised: 2020-08-11 By: dharvey

Stantec

Legend

- Project Development Area
- Local Assessment Area
- Regional Assessment Area
- Discharge Location
- Temperature/ DO Profile
- Mercury and Methylmercury Monitoring
- Routine Water Quality Monitoring

Trigger Threshold Surface Water Quality Stations and Routine Monitoring

- Monthly Sampling for As, Co, P, Sb, U, Hg, Fe and MeHg
- Monthly Sampling for As, Co, Cu, Fe, P, Sb, U, CN Free and CN Total
- Monthly Sampling for As, Co, Fe, P, Sb, U

Site Plan Revised Post Final EA/EIS

- New Highway 11 Alignment
- Diversion Channel
- Collection Ponds
- Open Pit- Full Extent
- Tailings Management Facility
- Grade Control Structure
- Inundated Area ; Backwater effect
- Waste Rock Storage Area

Existing Features

- Highway
- Major Road
- Local Road
- Existing SW Arm Tributary Channel
- Existing Portion of Goldfield Creek (to be overprinted)
- Watercourse
- Provincial Park
- Wetland (Eco-Site Based)
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

August 2020
160961293

Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.

2-2

Title

Surface Water Quality Trigger Threshold Monitoring Locations

2.2.2.2 Surface Water Quality Trigger Threshold Monitoring Locations and Frequency

Two trigger thresholds for surface water quality have been defined, each with a varying level of sensitivity and associated level of response. If the trigger threshold has been exceeded, actions to determine if the exceedance is the result of an error in lab data, a result of sample variation, a single anomalous event such as a meteorological event, seasonal variation, or the potential for a project-related effect will be carried out, as described below. The next steps to be taken in the event of an exceedance are outlined below. The trigger thresholds are protective of the associated aquatic biota and/or wetland habitats while allowing for the possibility of natural fluctuations in surface water quality. An example of the preliminary trigger thresholds compared to baseline data for arsenic, antimony, cobalt, copper, iron, phosphorous, uranium, mercury, and methyl-mercury, are presented in Figure 2-3 to Figure 2-11, respectively. Free cyanide and total cyanide were observed to have sampled concentrations below the detection limits and therefore do not have associated seasonal 95th percentiles.

Trigger Threshold 1 Action Plan

The goal of Trigger Threshold 1 is to obtain more information about the PoPC, identify the source of the trigger threshold exceedance, and increase attention, information, and awareness of the PoPC before it has the potential to have an adverse effect on the environment. Trigger Threshold 1 is defined as three consecutive monthly parameter concentration exceedances above the seasonal 95th percentile baseline concentration and five times the detection limit, with the exception of the stations identified in Table 2-4.

At a few surface water quality stations, the 95th percentile is less than the predicted surface water quality concentrations from the EIS/EA (Stantec 2018a). Despite a greater predicted concentration than baseline conditions, no significant effect was determined through the EIS/EA for the receiver. Therefore, for the stations and parameters indicated in Table 2-4, Trigger Threshold 1 will be defined as 10% above the predicted surface water quality concentration from the EIS/EA (Stantec 2018a) for the surface water feature at a given monitoring station, and five times the detection limit. The water quality predictions in the EIS/EA were normalized for seasons and across each basin and therefore, to account for natural seasonal variability and natural variation through basins, a 10% variance above the predicted water quality value is included in the trigger threshold definition.

Table 2-4: Surface Water Quality Stations and Parameters Above 95th Percentile

Station	Parameters
20A	Antimony, Arsenic, Cobalt, Copper, Iron, Uranium, Free cyanide, Total cyanide
24	Free cyanide, Total cyanide
25	Antimony
26	Antimony

If Trigger Threshold 1 is exceeded, then the following actions will be undertaken:

- **Confirm the Result** – Complete a QA/QC review of the sampling methods, laboratory report, and COC. If the original sample is available and within the hold time, the sample will be re-run to determine whether the exceedance was due to a potential laboratory error. In addition, the surface water monitoring station may be resampled within one month of the original exceedance to confirm the indicator parameter concentration.
    - If the QA/QC review and/or resampling finds that the parameter concentration is less than five times the detection limit, below the seasonal 95th percentile, or <10% above the predicted surface water quality concentration from the EIS/EA (Stantec 2018a) for the surface water feature, then no action is required and the monitoring plan continues as prescribed with documentation of the Trigger Threshold 1 exceedance and evaluation in the annual report (refer to Section 2.1.3).
    - If two exceedances of Trigger Threshold 1 are observed and validated, the MECP will be notified each month the exceedance is observed. Notification will be given to the MECP to indicate whether the subsequent sample did or did not exceed the trigger thresholds presented for Trigger Threshold 1.
    - If three consecutive monthly samples are confirmed to exceed Trigger Threshold 1, then move to Action 2.
- **Review previous data for trends** – Review of available data to determine if exceedance is a result of sample variation, a single anomalous event such as a meteorological event, seasonal variation (e.g., Kenogamisis Dam operation), or the potential for a project-related effect (Mine operation). Ongoing trend analysis will be completed using the Mann-Kendall test (Mann 1945; Kendall 1970; Walker and Harrison 2013). The Mann-Kendall test has been found to be a simple effective way to measure whether an indicator parameter is rising or falling. The test can be applied to as few as four points. For this application, the Mann-Kendall test will be applied to a maximum of the last three complete years and a minimum of one complete year of data. Using the method cited by Walker and Harrison (1970), the Mann-Kendall test statistic (S) and the coefficient of variation will be calculated and applied using the 90% confidence level chart.
    - If there is no statistically significant increasing or decreasing trend in the parameter concentration, then no action is required and the monitoring plan continues as prescribed with documentation of the Trigger Threshold 1 exceedance and evaluation in the annual report (refer to Section 2.1.3).
    - If there is a statistically significant increasing trend in the parameter data, then move to refer to Trigger Threshold 2 action plan.

Trigger Threshold 2 Action Plan

The goal of Trigger Threshold 2 is to identify potential issues associated with the Project before they have the potential to result in a significant adverse effect on the environment. Trigger Threshold 2 is

defined as an exceedance of Trigger Threshold 1 and a statistically significant upward trend for a given indicator parameter or, for stations that have a statistically significant upward trend in the baseline data, an increase in the magnitude of the trend compared to baseline. If Trigger Threshold 2 is exceeded, then the following actions will be undertaken:

1. Notify Impact Assessment Agency Canada (IAA, formerly CEAA), MECP, and the EACs of the trigger threshold exceedance and that an investigation will be completed.

2. Complete an investigation – to assess whether the exceedance is Project related. The investigation will be designed, implemented, and interpreted by a qualified person. The investigation may include the following key aspects:

    - Spatial extent of PoPC: assess whether the exceedance event is isolated to one monitoring station or to stations located upstream and downstream.

    - Investigate potential sources of contamination (e.g., ETP/ STP discharge, groundwater seepage, GFC Diversion-Southwest Arm tributary, seasonal variations such as extended dry or wet weather conditions, forest fire in the Kenogamisis Lake watershed).

    - Parameter(s) of potential concern: assess whether there are changing trends associated with other parameters at the given sampling location or whether changes in other parameters are “forcing” PoPC concentration changes.

    - Magnitude of exceedance above the trigger threshold: assess whether the exceedance represents a minor or significant deviation from the trigger threshold. Compare the concentration of the source of the exceedance to predicted concentrations to assess the potential for the parameter to further degrade surface water quality.

    - Based on parameter concentration and flow, estimate the contaminant loading to the receiver.

    - If required, augment the monitoring network by adding more stations or increase sampling frequency.

3. **Undertake Quantitative Risk Evaluation**: Based on the information derived from the Trigger Threshold 1 action plan and/or Trigger Threshold 2 investigation, the potential relevance of the exceedance event to surface water quality or ETP/STP effluent will be evaluated through a qualitative risk evaluation. A quantitative risk evaluation is a conceptual evaluation and comparison of concentrations, loads, exceedances and trends and conclusions drawn from such analysis. At this time, more rigorous monitoring may be recommended for neighbouring stations (e.g., increased sampling frequency, increased number of sample locations, additional parameters).

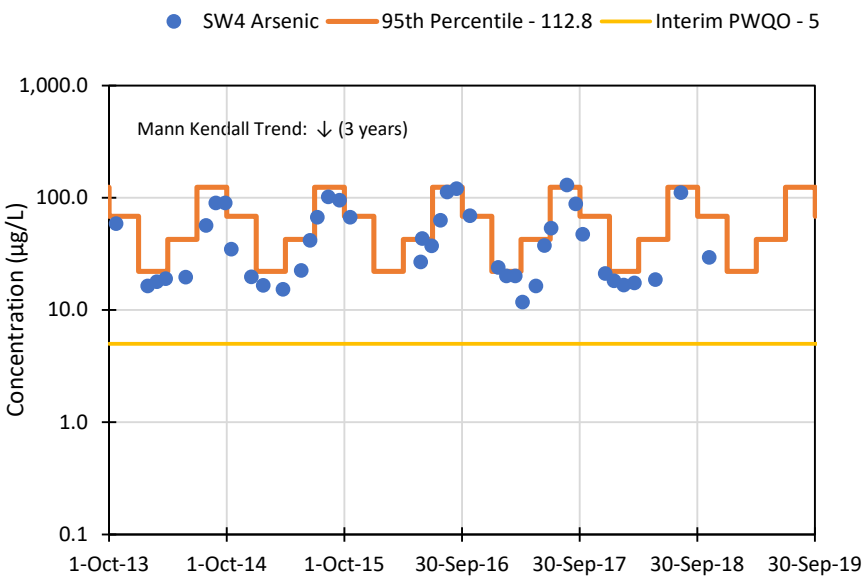
4. **Identify Exceedance Source**: Conclude whether exceedance is related to external activities, seasonal or natural phenomenon, or Project and if Project related whether it is incidental (accident/malfunction), operational (related to an operational procedure that may be mitigated

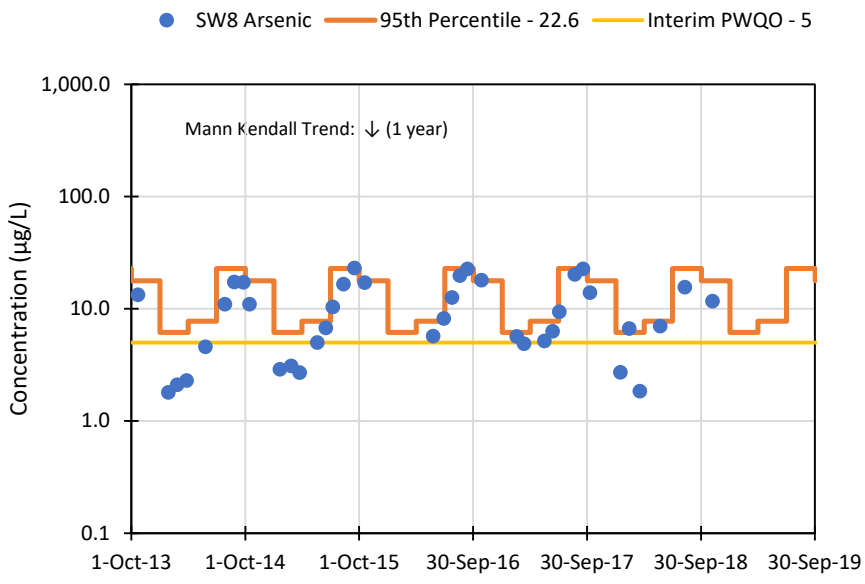
relatively easily, e.g., increase treatment reagent use, change in pumping procedures, revise operational procedures) or a change in operation plans (i.e., change processing rate; change in open pit footprint, dimensions and mine plan; change in WRSA footprint, elevation or shape)

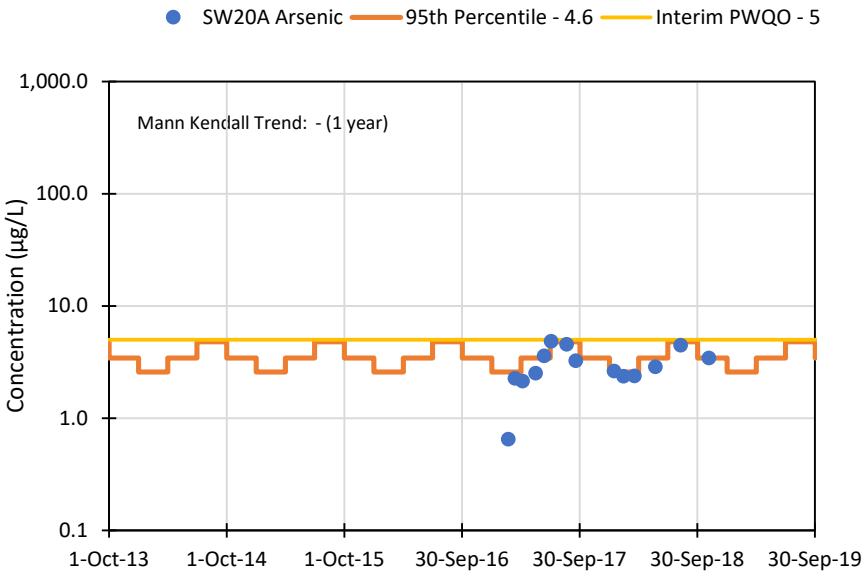
- If exceedance is not related to the Project continue with the monitoring plan with modifications to the plan as recommended by the Qualified Person based on the outcomes of the investigation and document the assessment in the annual report (refer to Section 5.0). Notify IAA, MECP, and the EACs of the outcome of the investigation and that the details of the investigation would be documented in the annual report.
- If the exceedance is deemed related to the Project, refer to Action 5

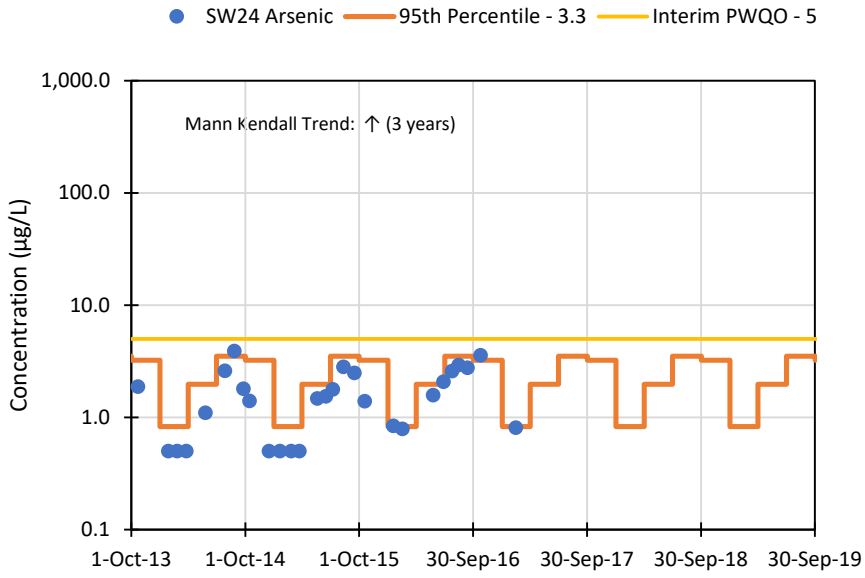
5. **Mitigate effects of the Project:** If mitigation is deemed necessary, options designed to reduce contaminant load to surface water will be implemented and could include, but is not limited to:

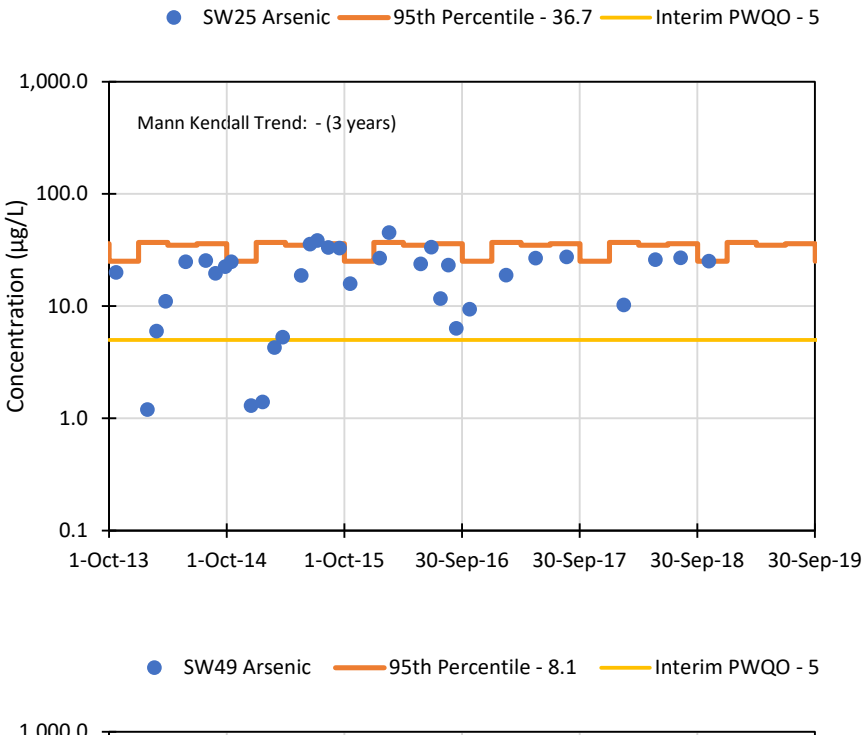
- Improve water treatment at STP/ETP.
- Reduce Project effluent discharge, if feasible.
- Reduce inflow of contact water to Pond M1 by limiting Project development area (PDA) footprint to the extent practicable.
- Implement measures to reduce groundwater seepage into the receiver.
- Numerical modelling to better quantify the contaminant loading and contaminant transport.

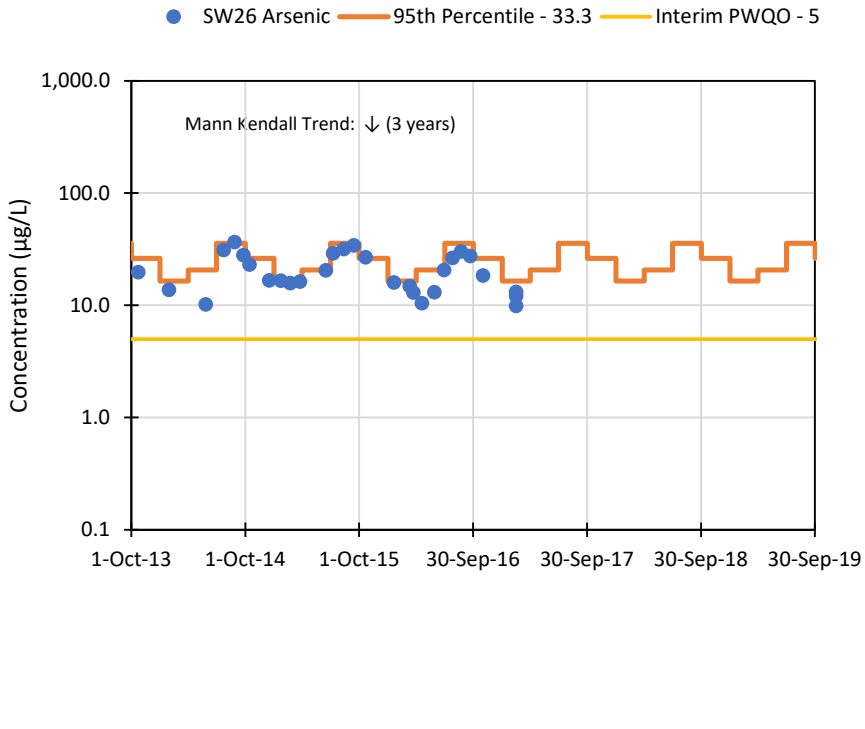












Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

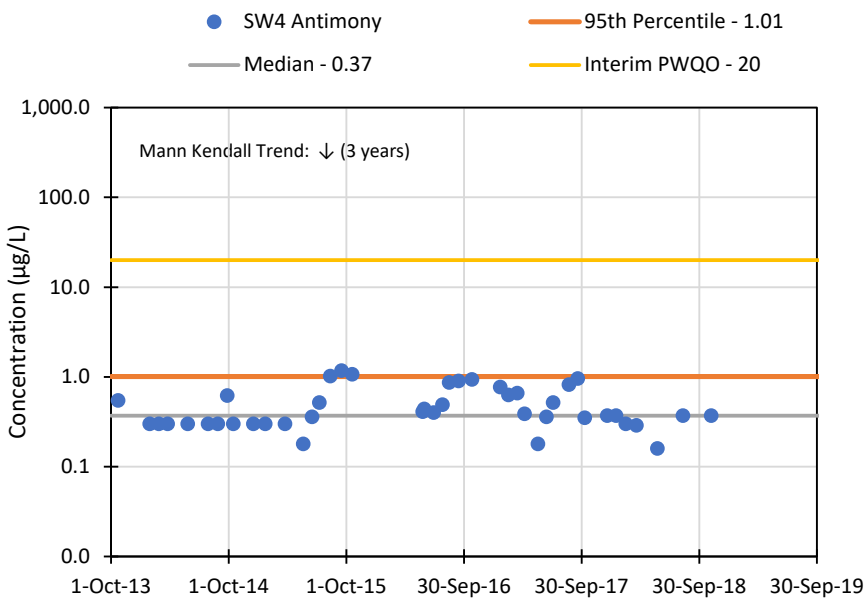
Figure No.

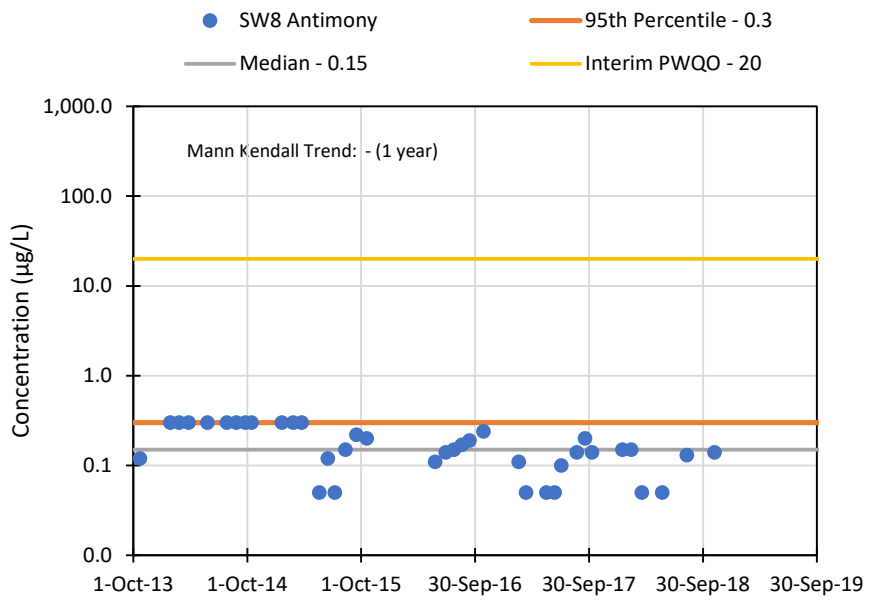
2-3

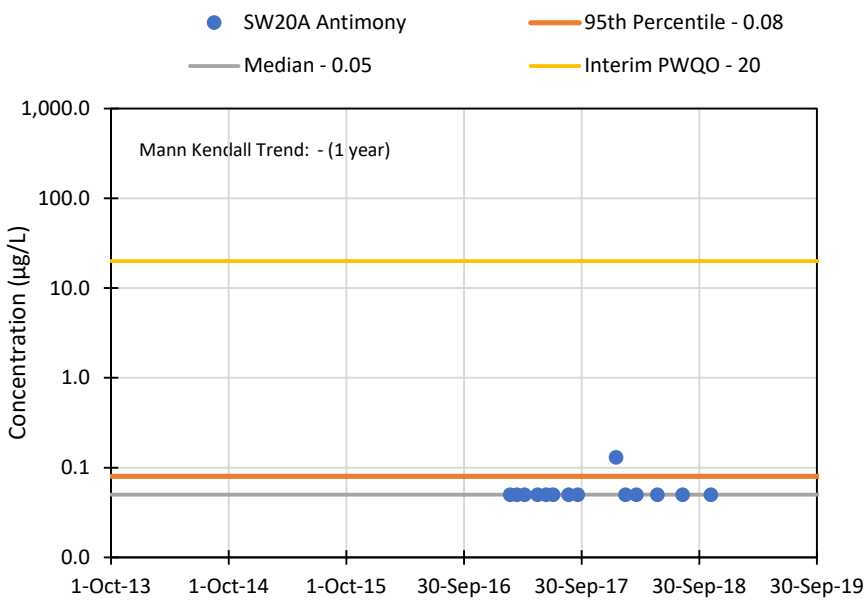
Title

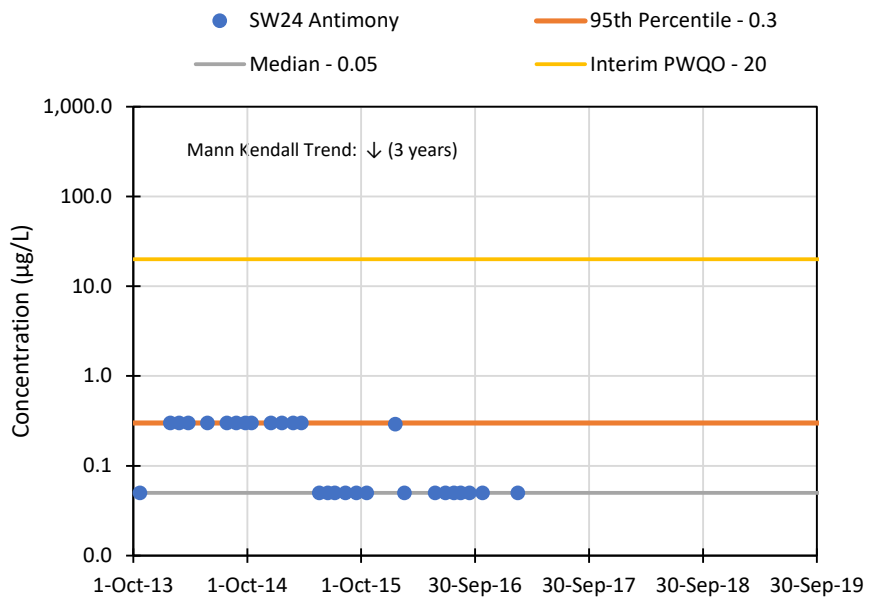
Total Arsenic Concentrations
Surface Water

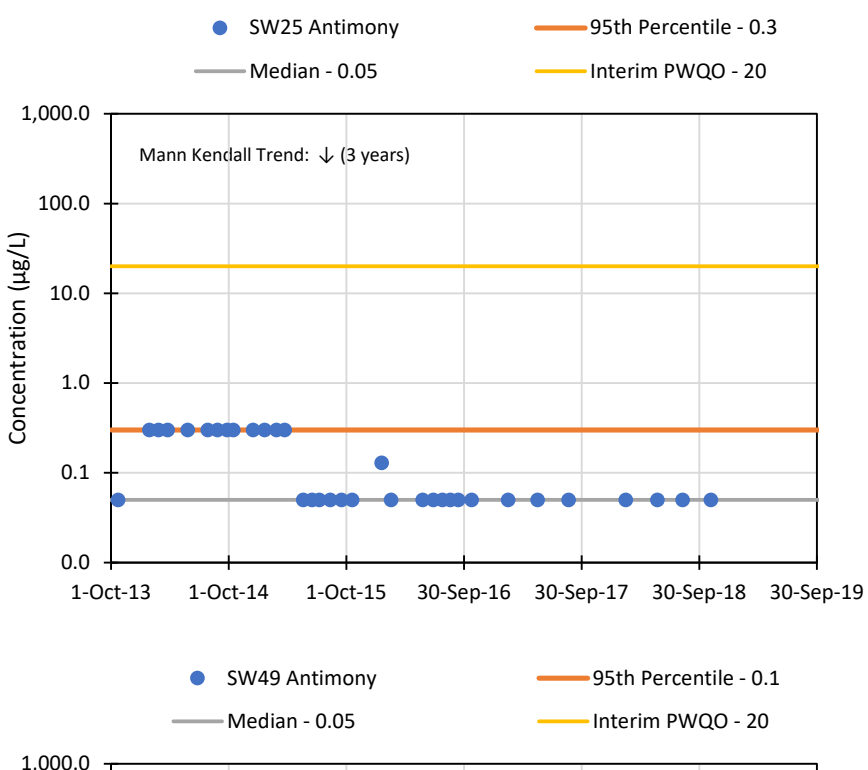
Stantec

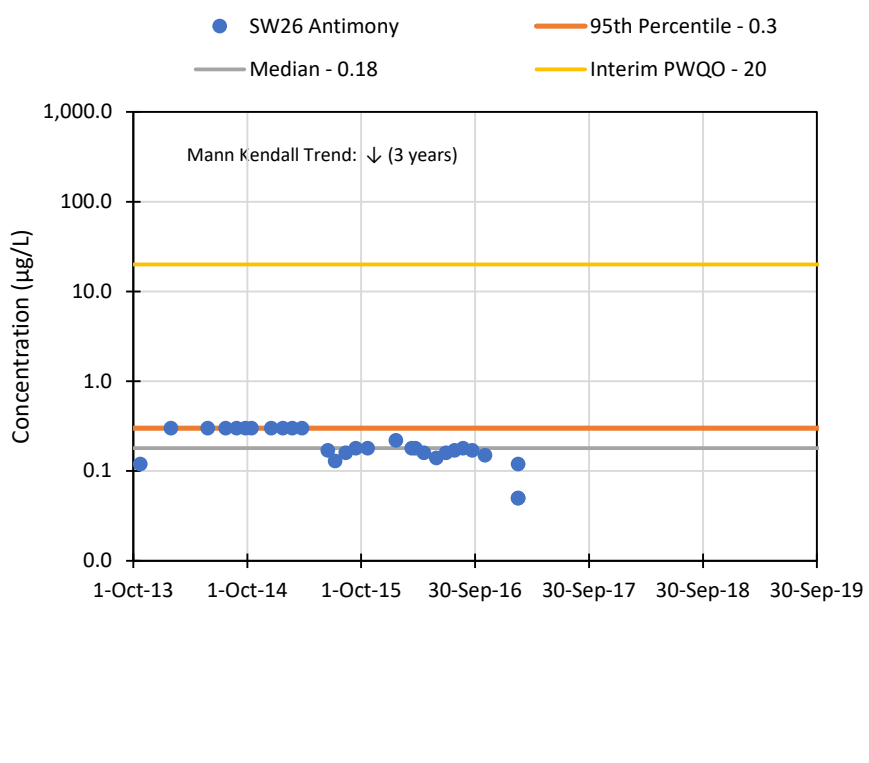


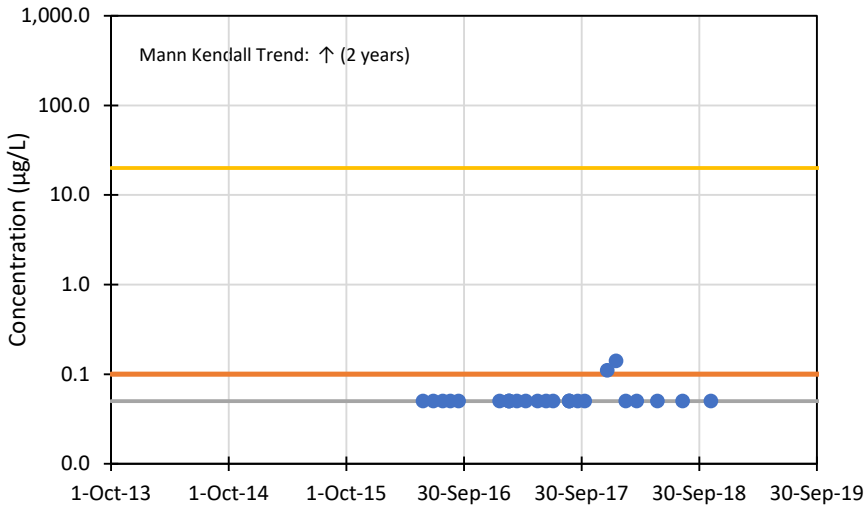












Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

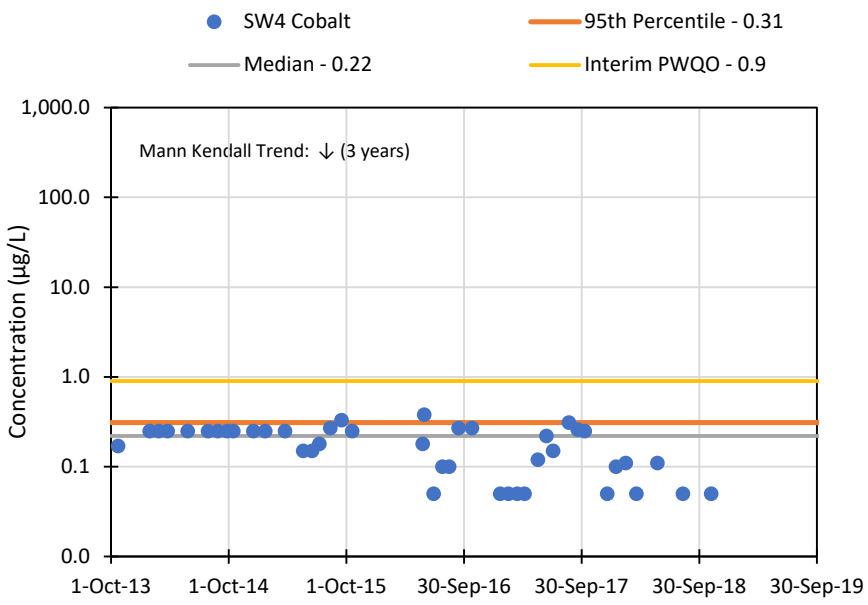
Figure No.

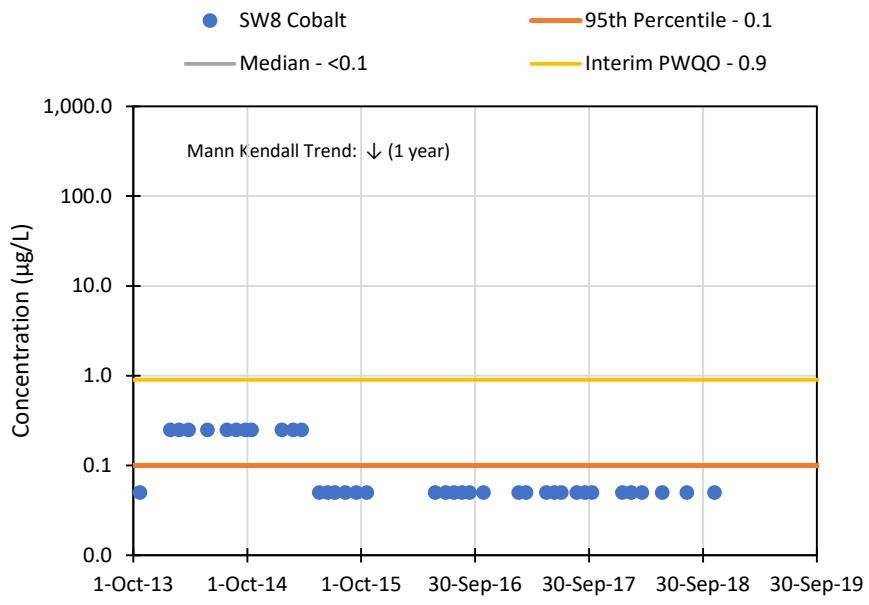
2-4

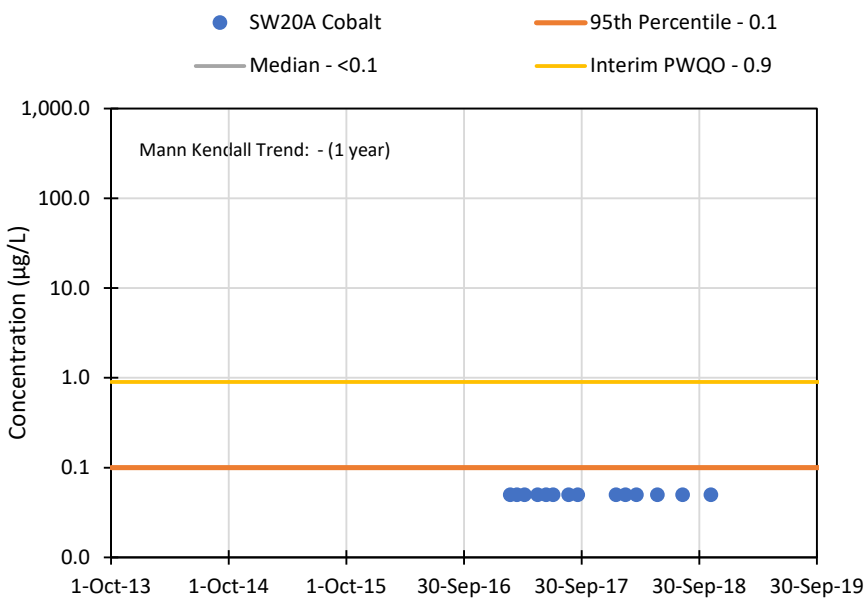
Title

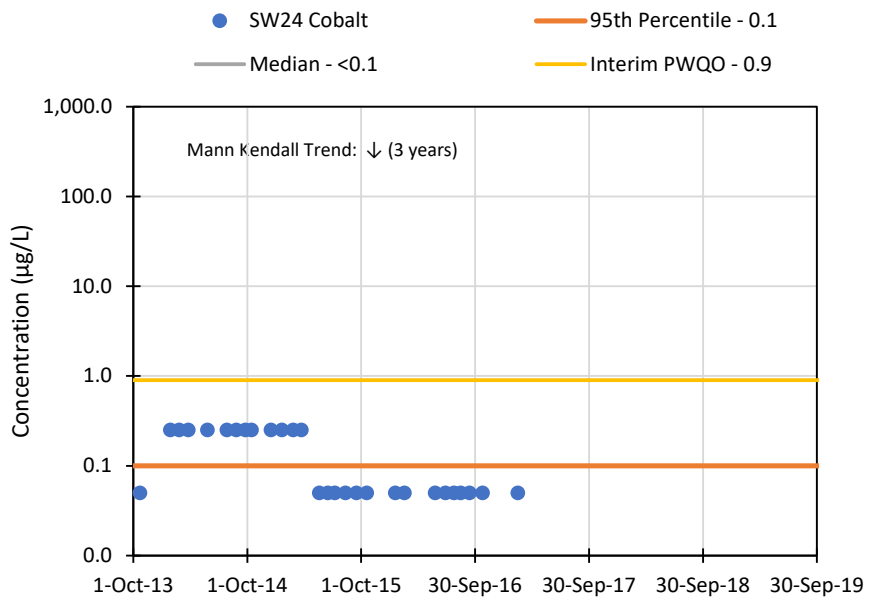
Total Antimony Concentrations
Surface Water

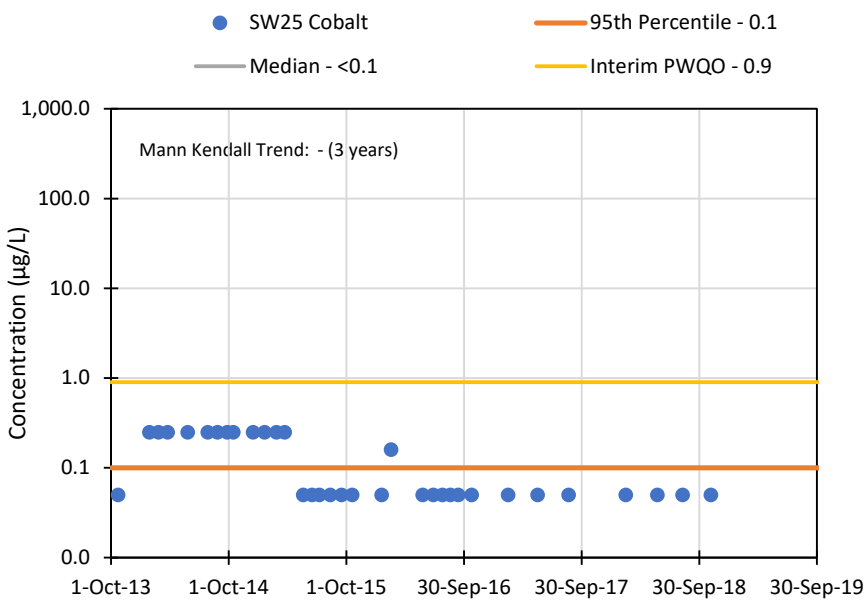
Stantec

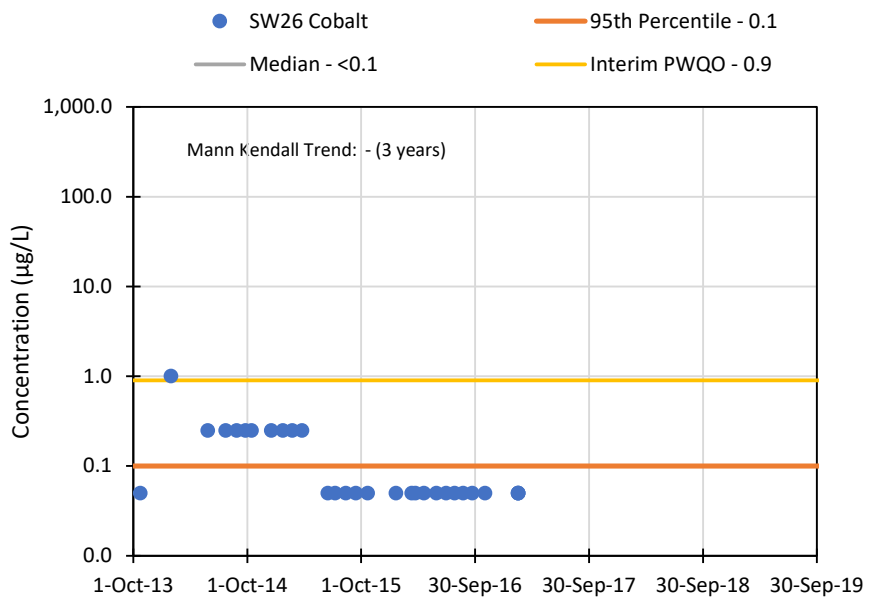


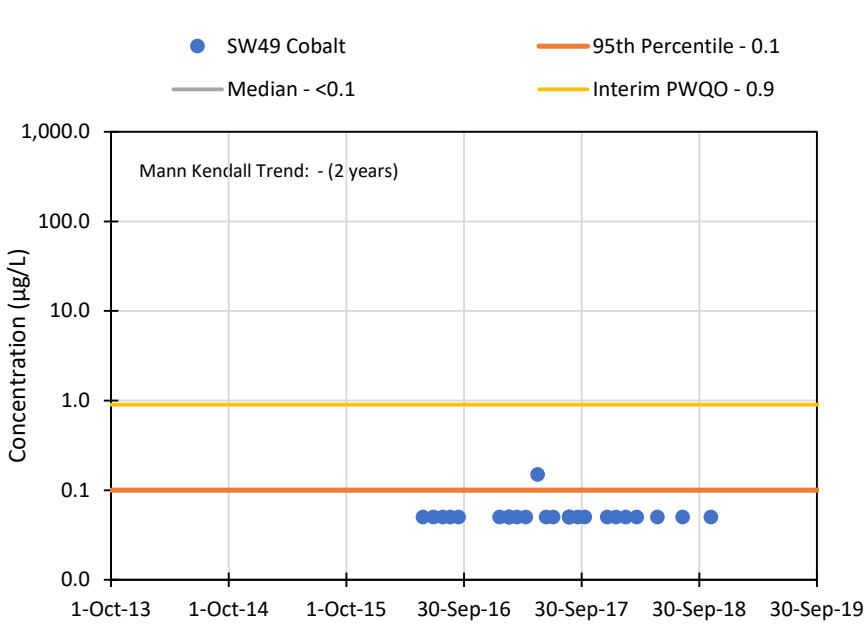












Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

2-5

Title

Total Cobalt Concentrations
Surface Water

Stantec

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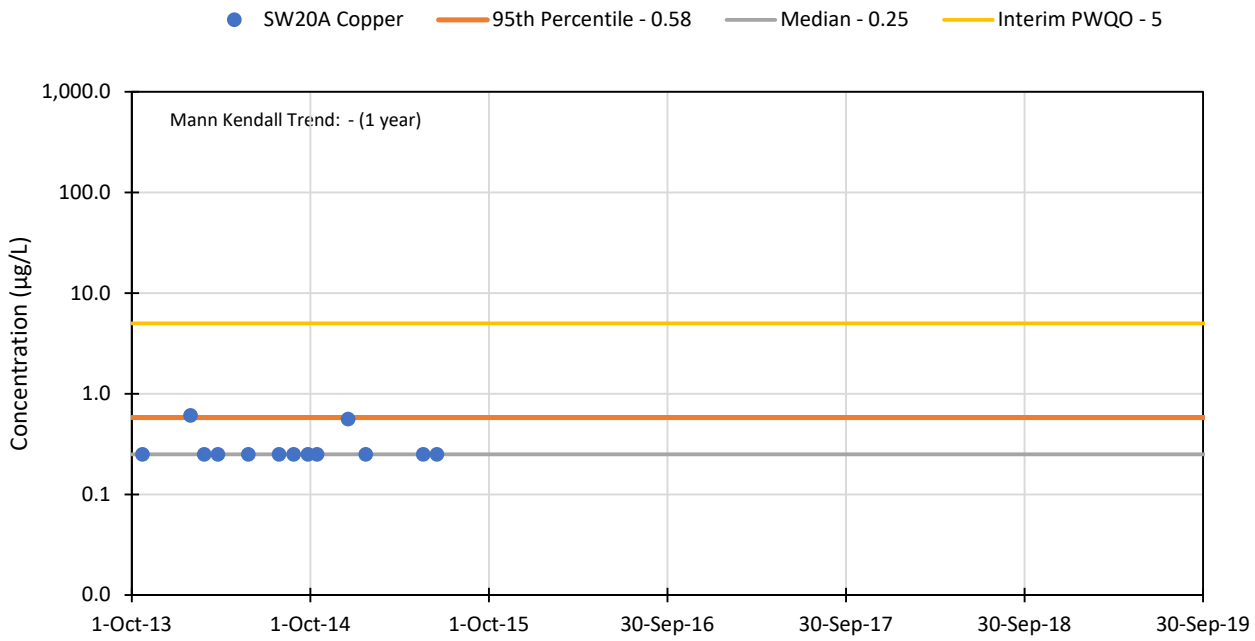

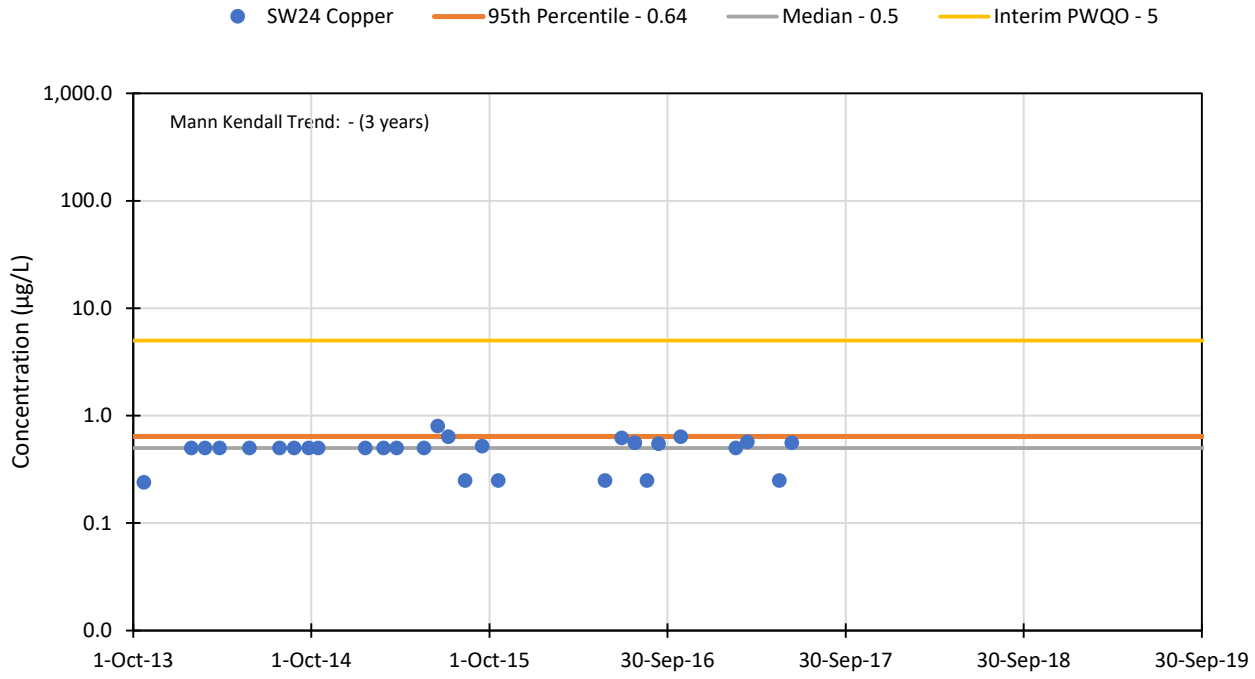

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-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

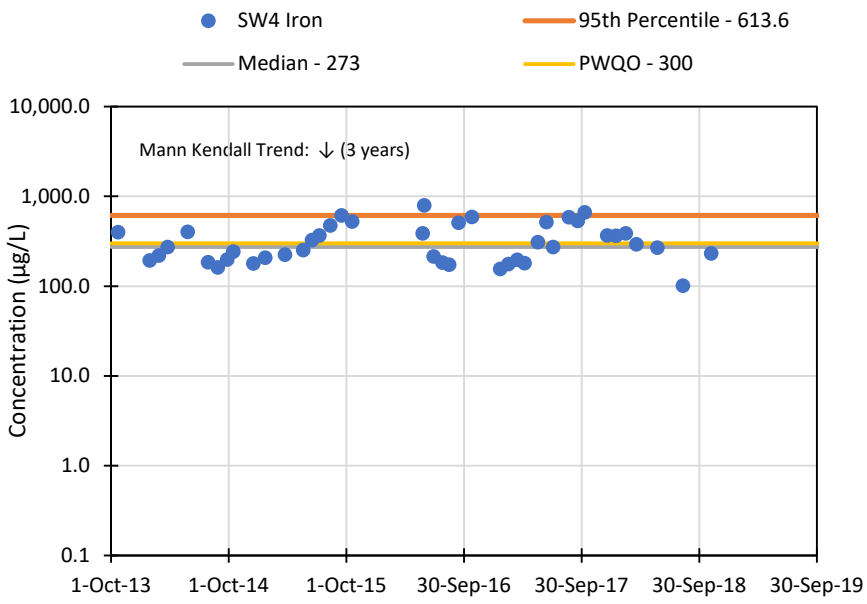
2-6

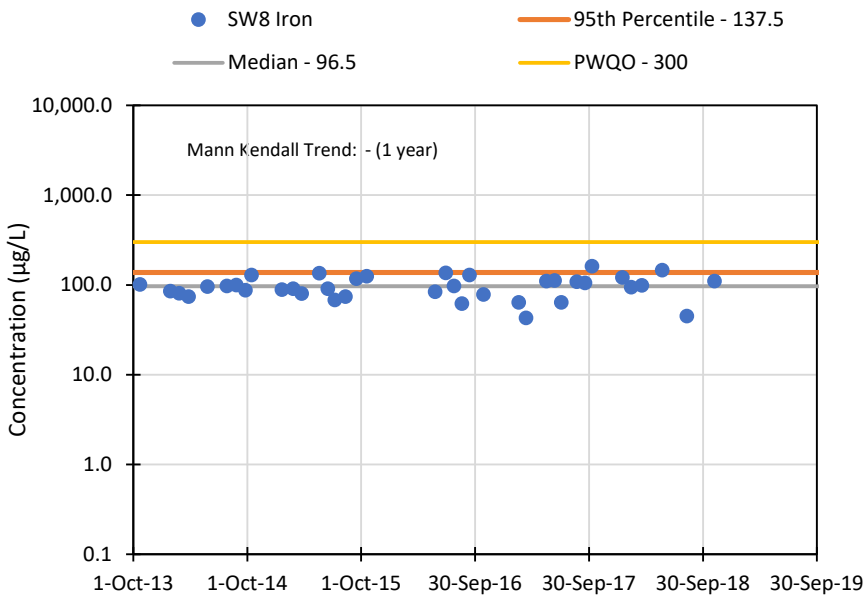
Title

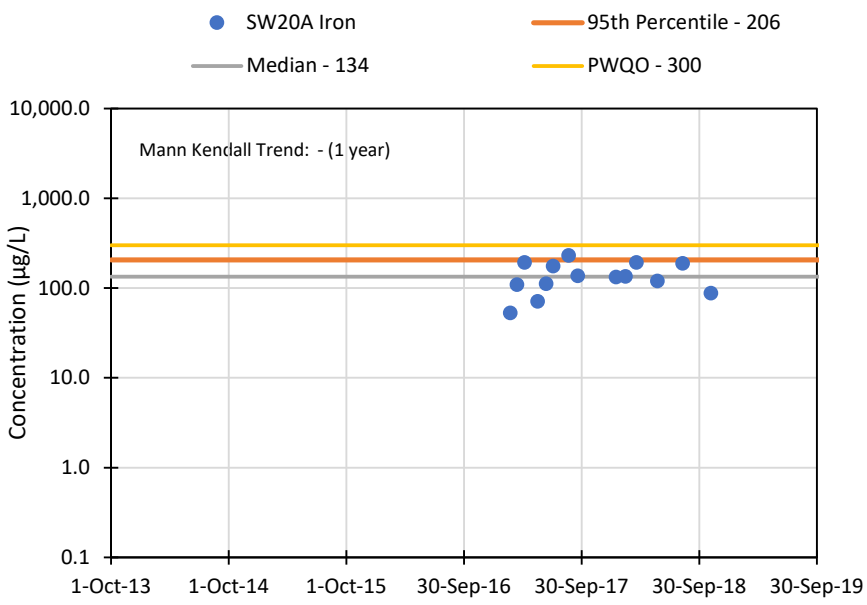
Total Copper Concentrations
Surface Water

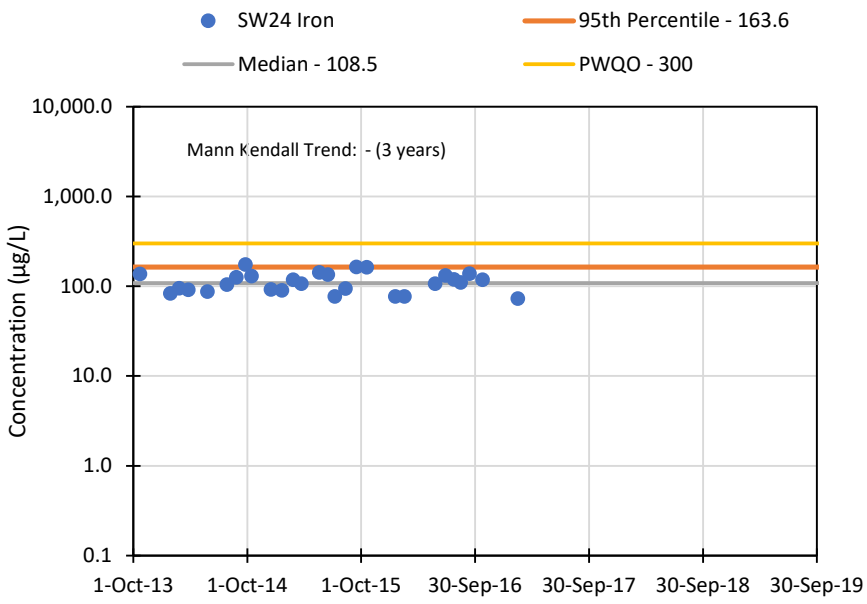
Stantec

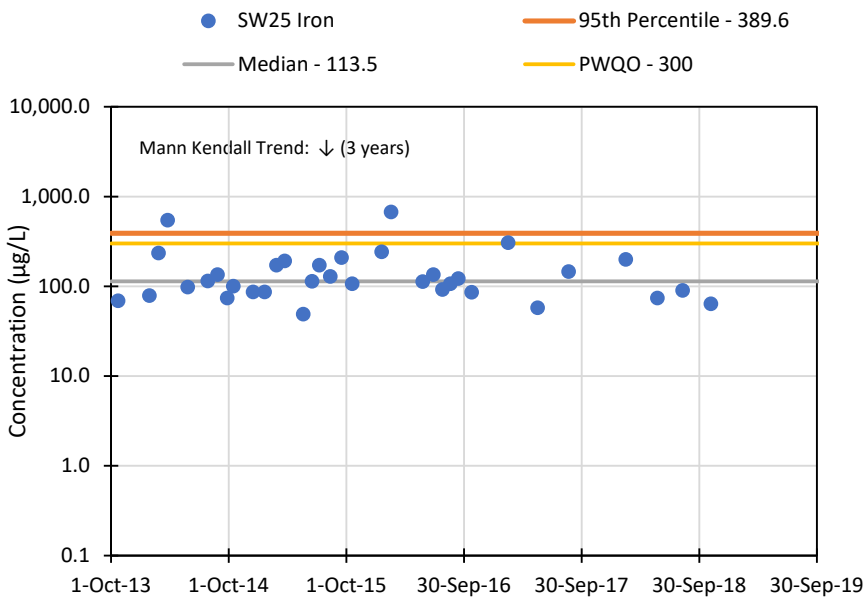
\\cd1220-f02\work_group\01609\active\160961293\07_disciplines\Hydrogeology\Analysis\Surface_Water_Quality\tbl_WMMP_SW_WQ_Charts_withTriggers_2013_to_2018_20200622.xlsx

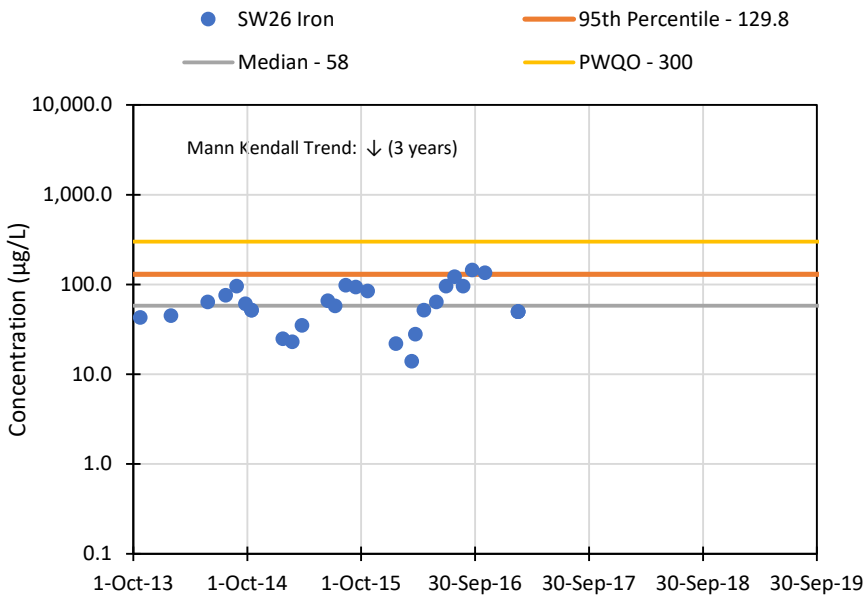


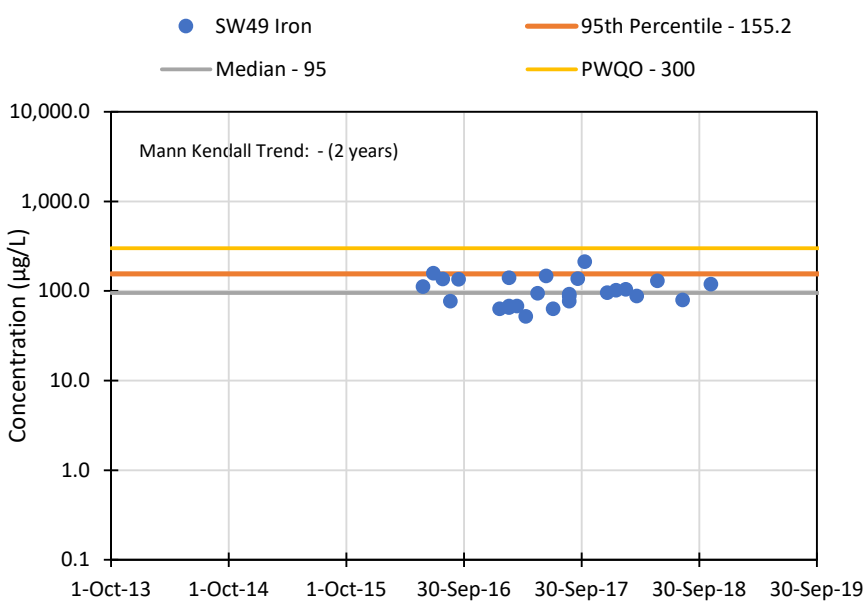












Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

2-7

Title

Total Iron Concentrations
Surface Water

Stantec

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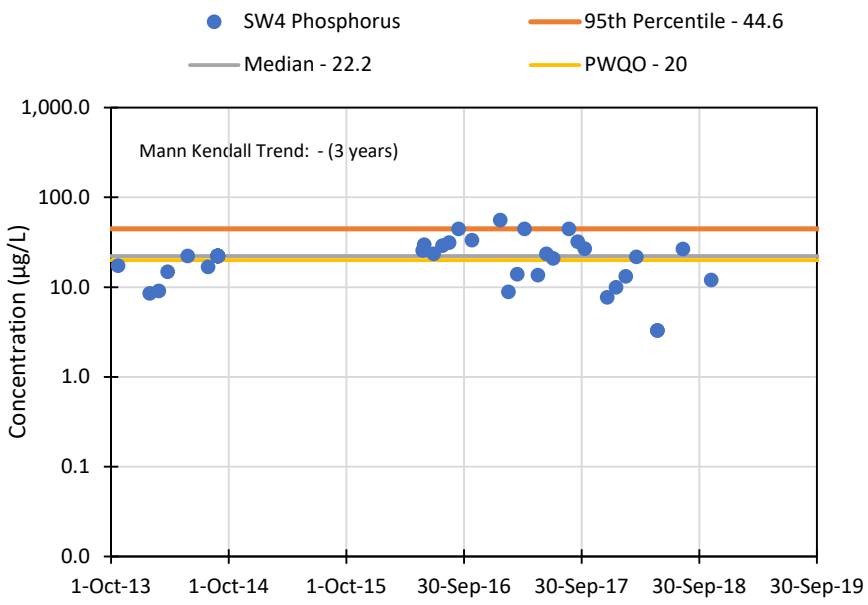
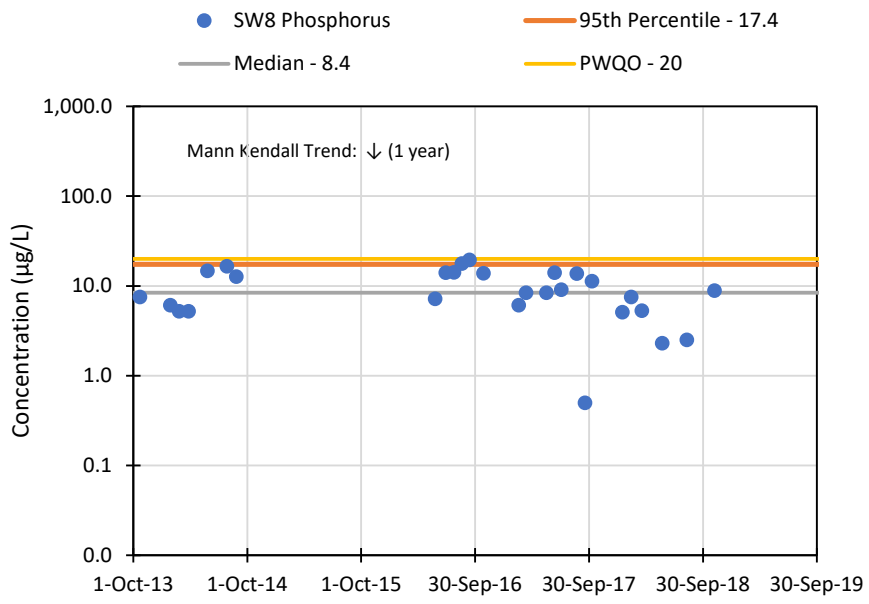
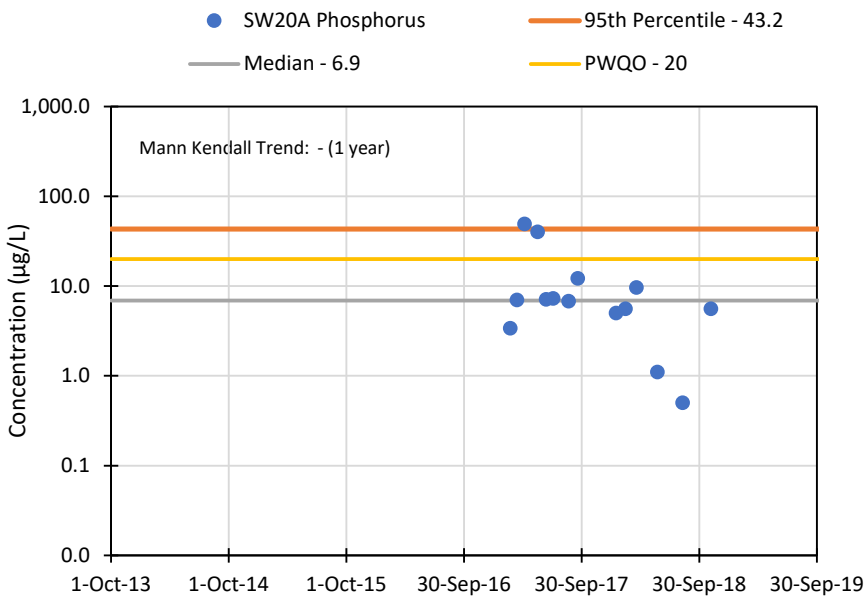
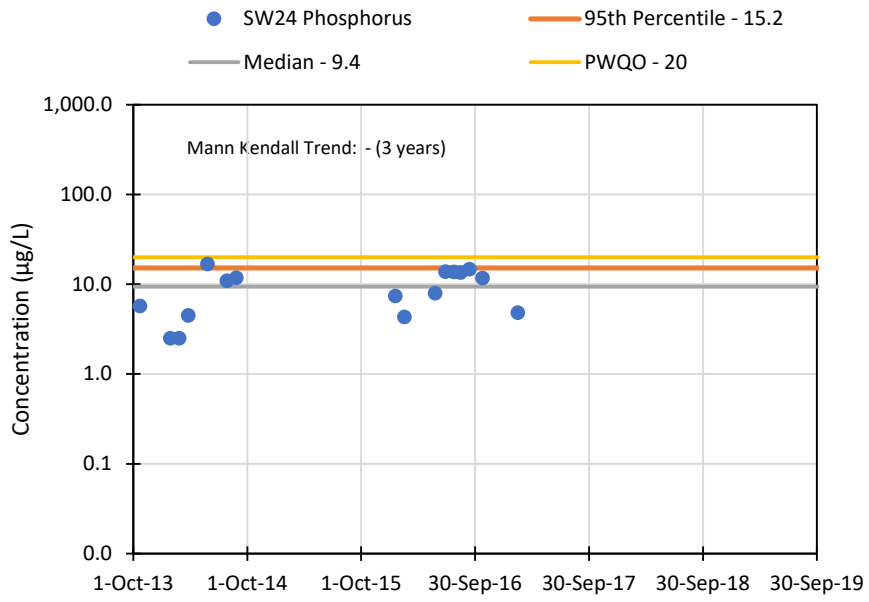
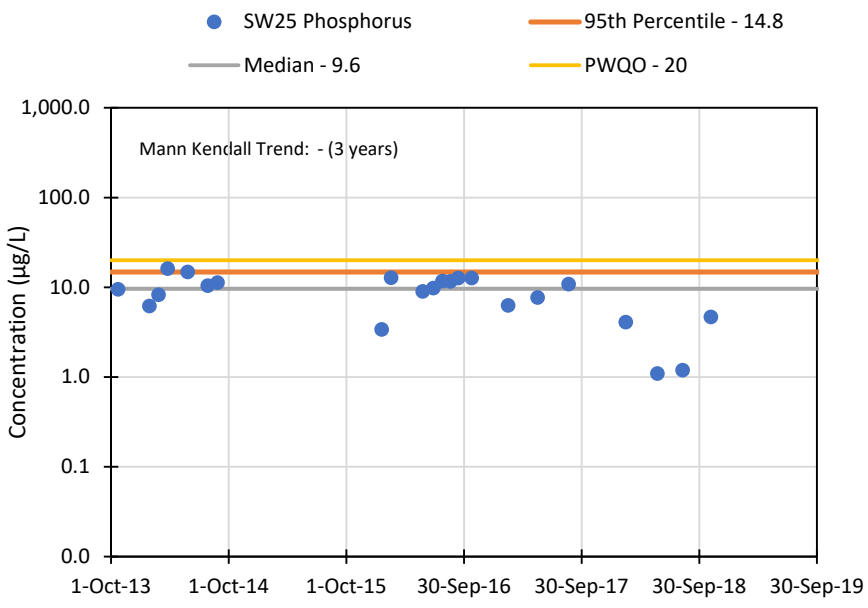
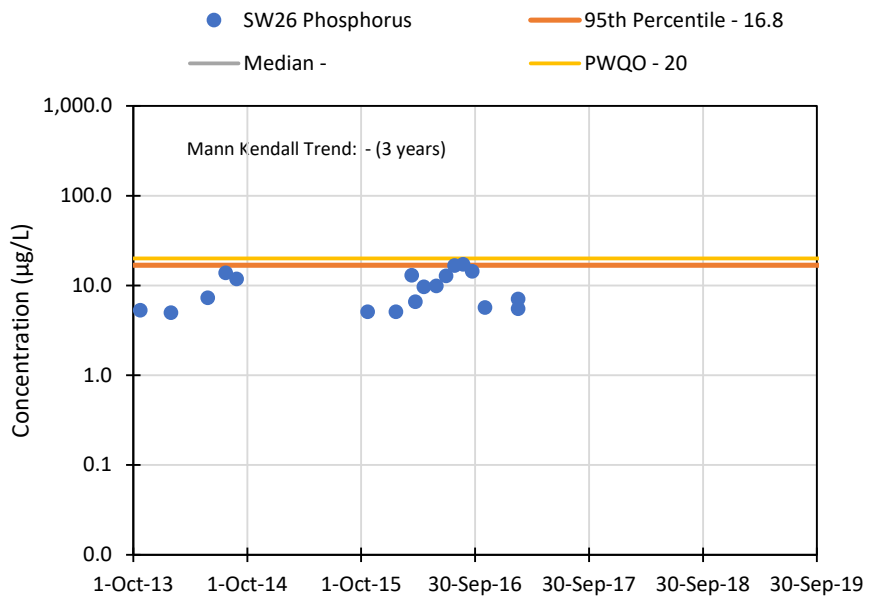


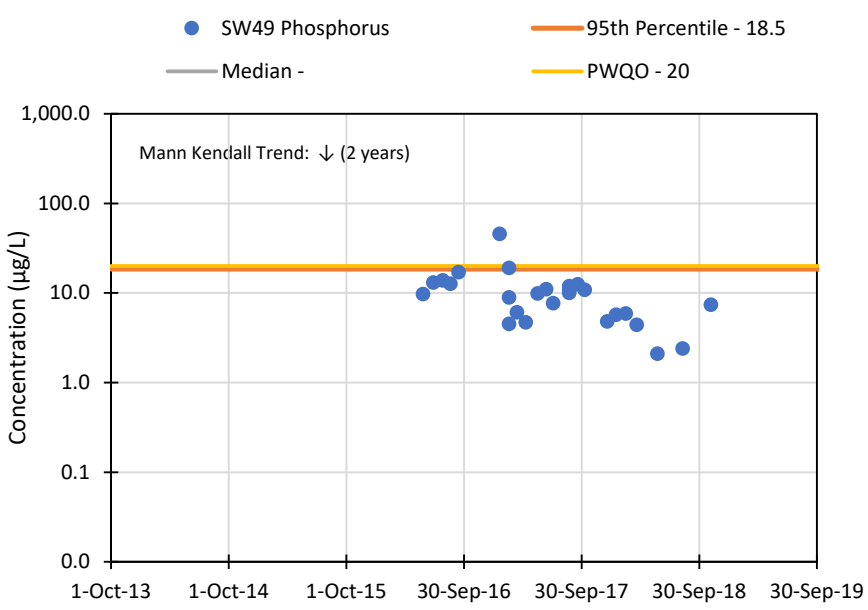












Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

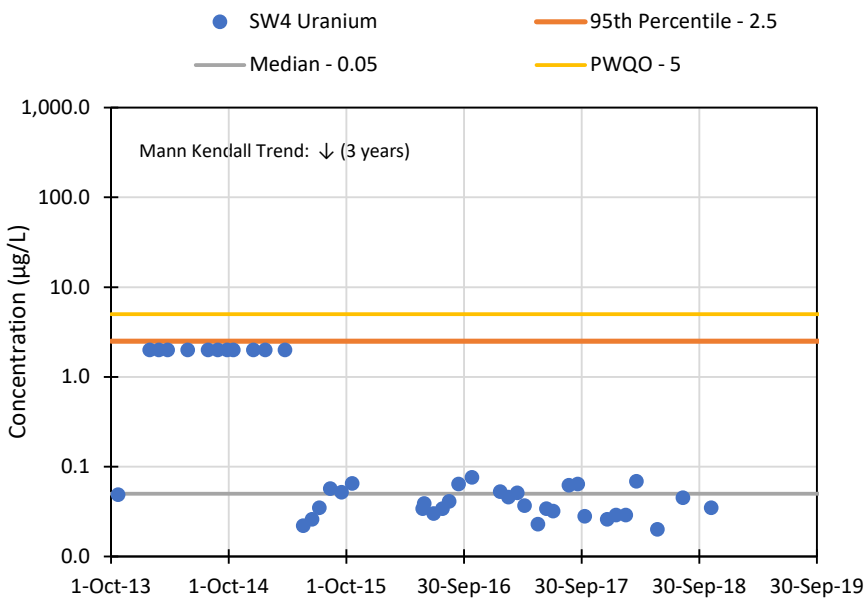
Figure No.

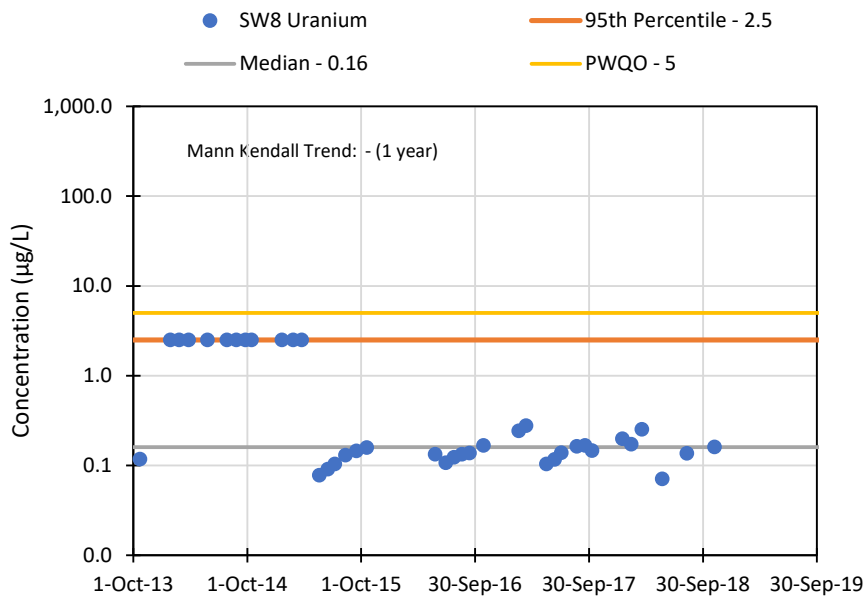
2-8

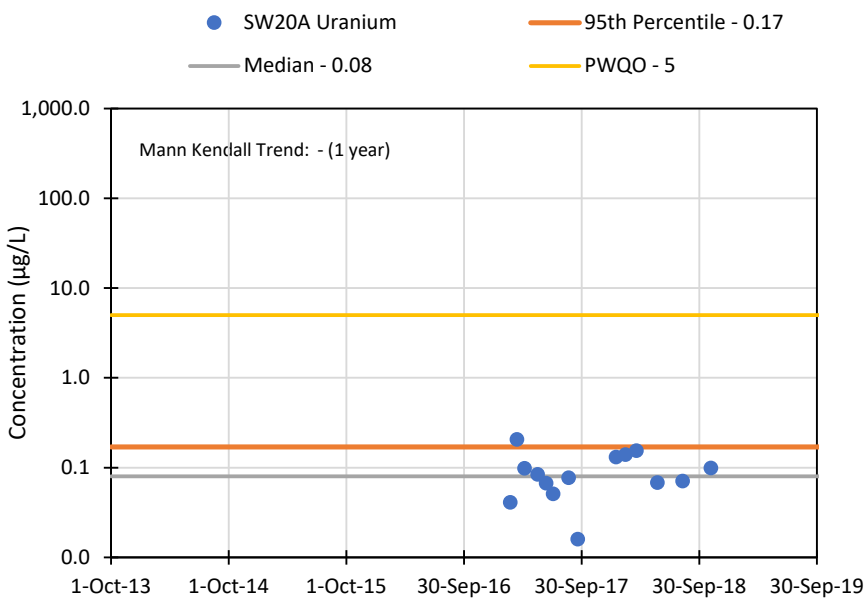
Title

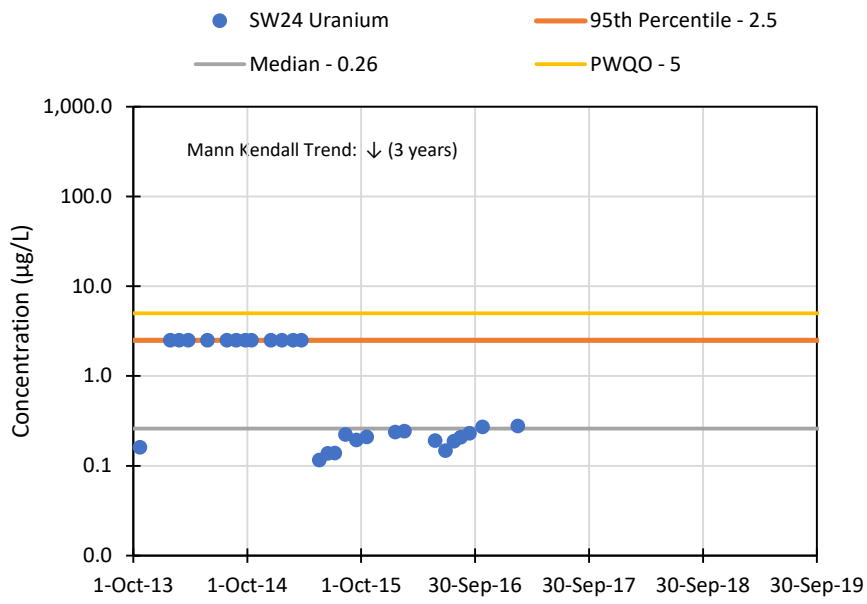
Total Phosphorous Concentrations
Surface Water

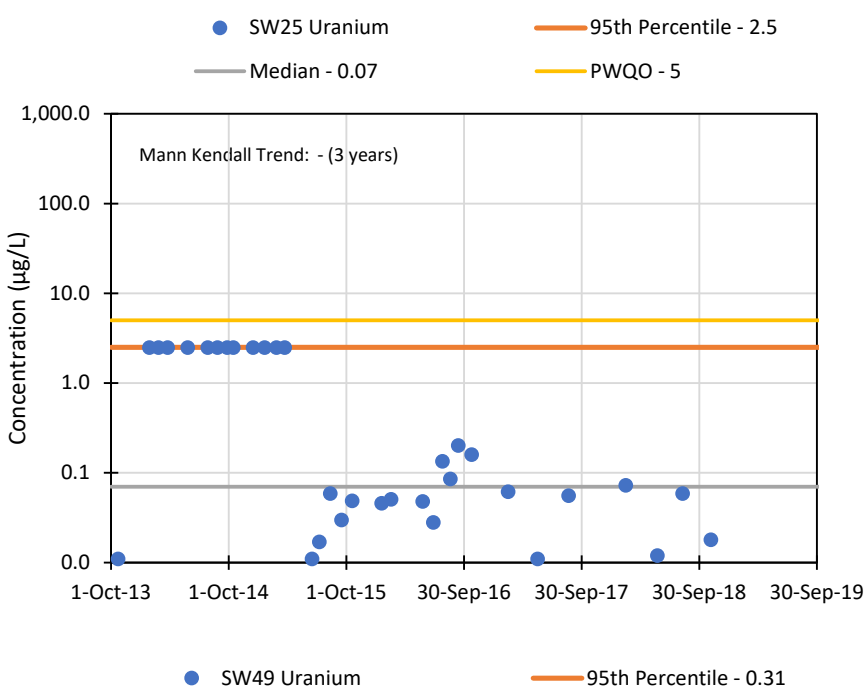
Stantec

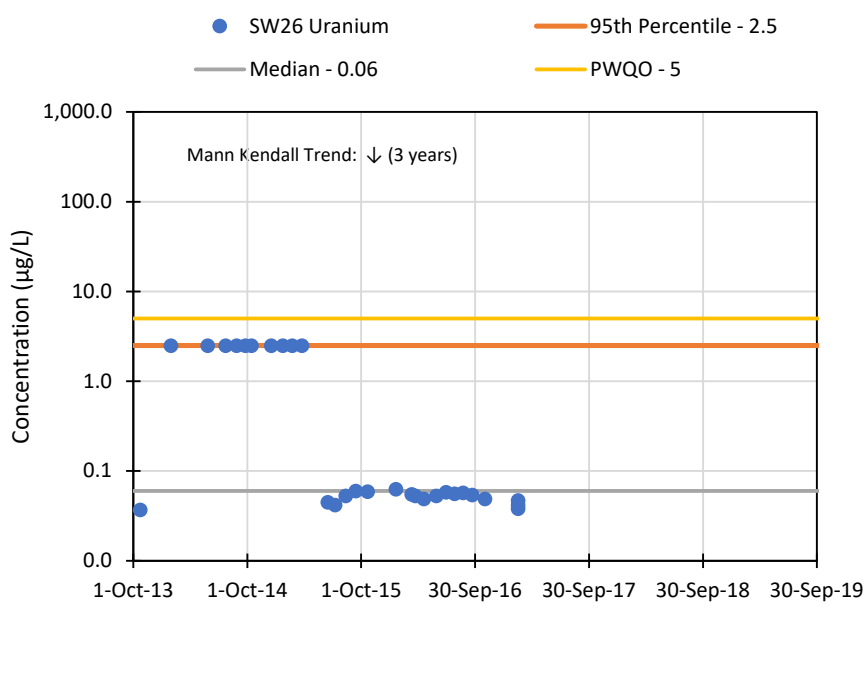


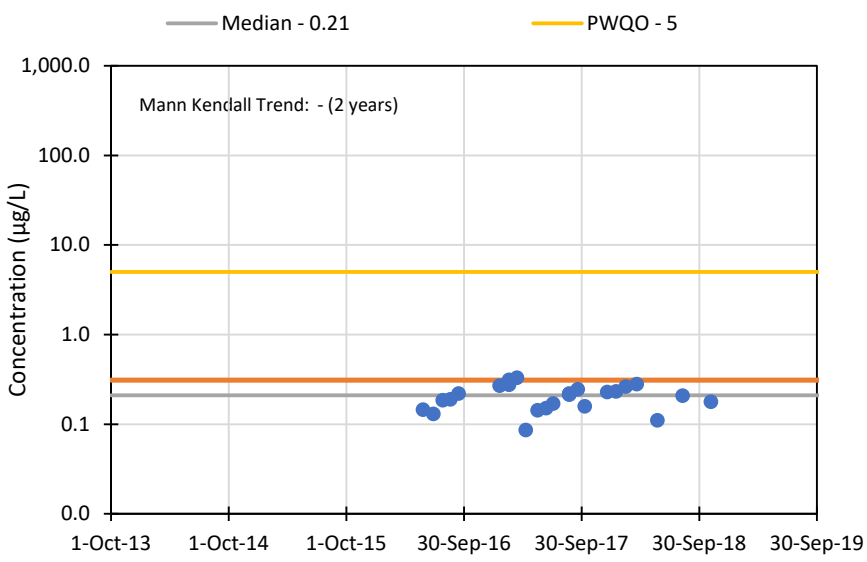












Notes:

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-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

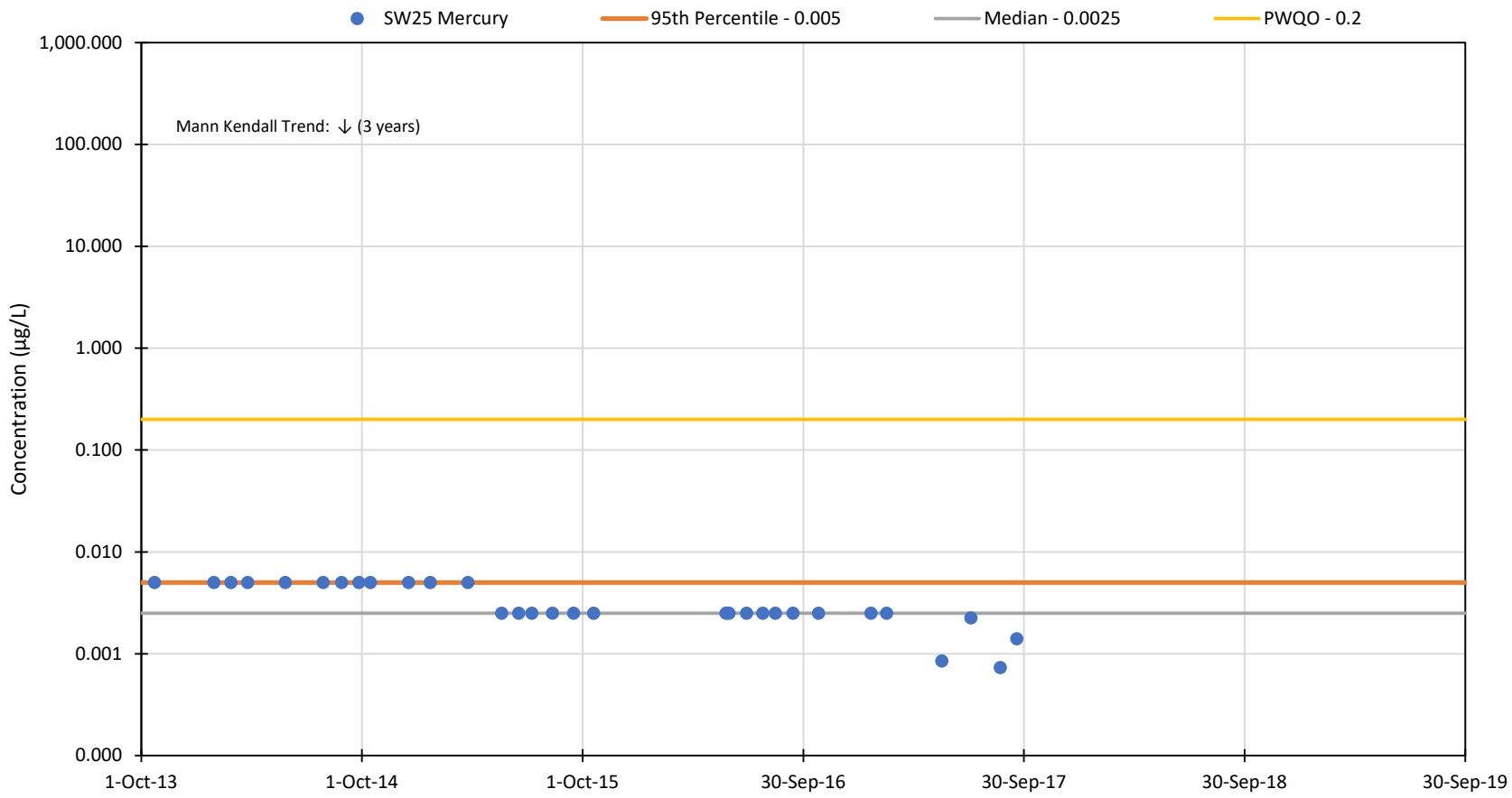
Figure No.

2-9

Title

Total Uranium Concentrations
Surface Water

Stantec



Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

2-10

Title

Total Mercury Concentrations
Surface Water

Stantec

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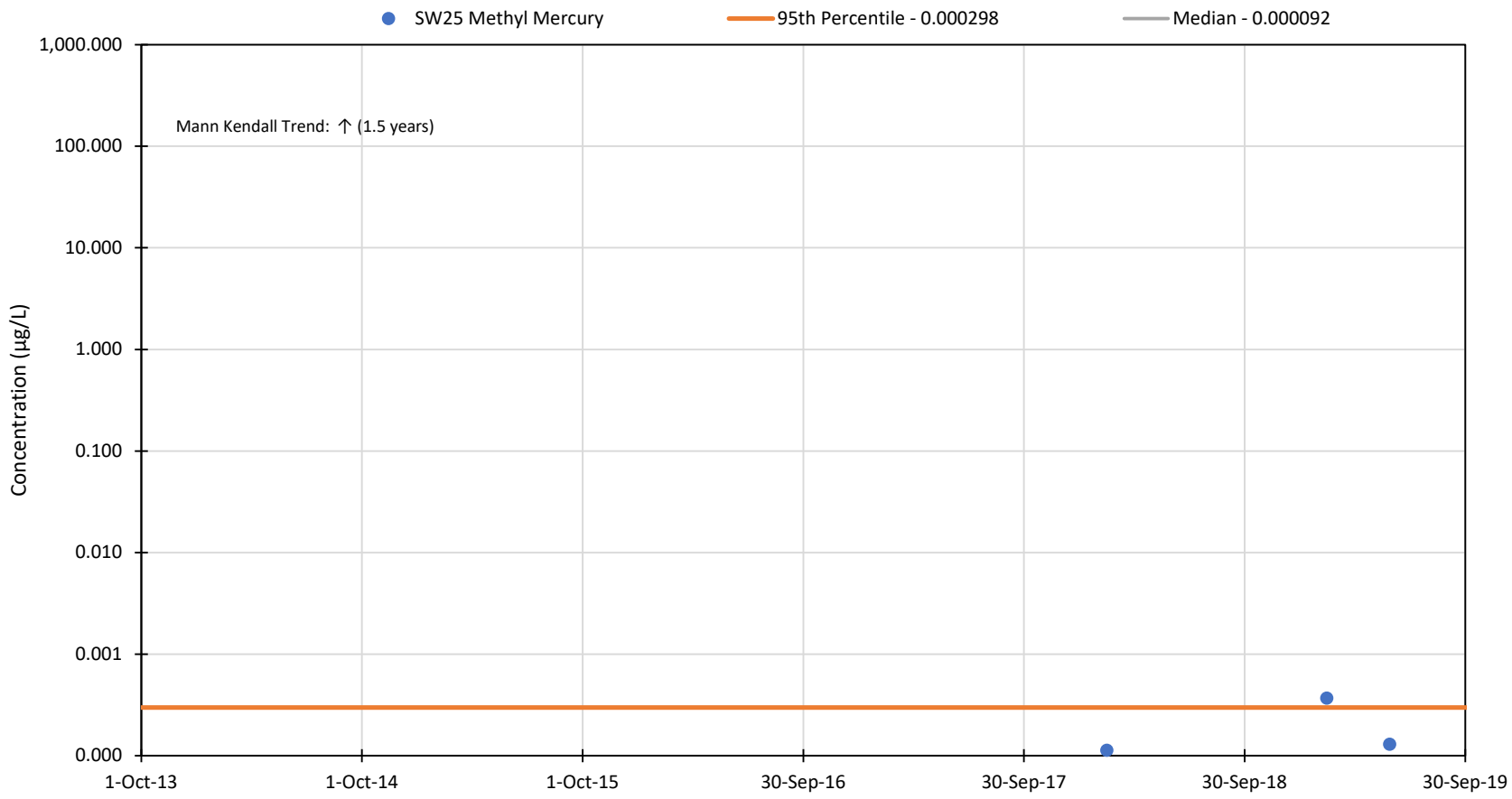


Notes:

↑: Increasing Mann Kendall trend analysis for years indicated

↓: Decreasing Mann Kendall trend analysis for years indicated

-: Negligable Mann Kendall trend analysis for years indicated

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

2-11

Title

Total Methyl-Mercury Concentrations
Surface Water

Stantec

\\cd1220-f02\work_group\01609\active\160961293\07_disciplines\Hydrogeology\Analysis\Surface_Water_Quality\tbl_WMMP_SW_WQ_Charts_withTriggers_2013_to_2018_20200622.xlsx

2.2.3 Reporting

For this Fish and Fish Habitat Monitoring Plan, each reporting year will be from October 1 of a calendar year through September 30 of the subsequent calendar year (as stated in Condition 1.3). GGM will prepare an annual report no later than December 31 following the reporting year to which the annual report applies. The content of the report is expected to vary each year, depending on the monitoring activities that are planned and available results for a given year. The annual report will be factual, presenting the monitoring data with limited interpretation of results.

As applicable, the annual report may include the following:

- Summary of monitoring activities which were conducted in the previous year and monitoring components that are planned in the given year
- Tabulated results of the surface water quality monitoring program, as available (i.e., results of laboratory analyses)
- Comparison of results to predictions from the EIS/EA
- Comparison of data to trigger thresholds, as data is available, identification if a trigger threshold was exceeded, and mitigation and/or adaptive management that was implemented, if required.

More detailed interpretation and analysis of the results will be completed as part of reporting requirements under the MDMER, Environmental Effects Monitoring (EEM), and applicable permit conditions.

2.3 Groundwater

The following section describes the plan to satisfy federal Condition 3.17 of the EIS approval by presenting GGM's planned mitigation measures to reduce adverse effects on fish and fish habitat with respect to groundwater. This follow-up program describes the plan to monitor groundwater quantity and quality within the Project area (Condition 3.17). An AMP is presented to determine whether additional mitigation measures are required to protect fish and fish habitat.

2.3.1 Routine Monitoring

The groundwater monitoring locations, sampling frequency, and sampling methods are presented in the following sections.

2.3.1.1 Location

Groundwater levels and quality within the vicinity of the open pit, TMF, WRSAs, aggregate pits, Kenogamisis Lake, Southwest Arm Tributary, and Goldfield Creek will be monitored to assess potential effects of the Project on groundwater quantity and quality. In addition, the water pumped from the

open pit, Mosher No. 1 Shaft, Hardrock No. 2 Shaft, MacLeod Seepage Collection System, and aggregate pits and quarry will be measured. Figure 2-12 shows the groundwater level monitoring locations, while Figure 2-13 presents the groundwater quality monitoring locations. A summary of the groundwater quantity and quality monitoring locations are presented in Table 2-5. The monitoring well completion table is presented in Table 2-6 for reference.

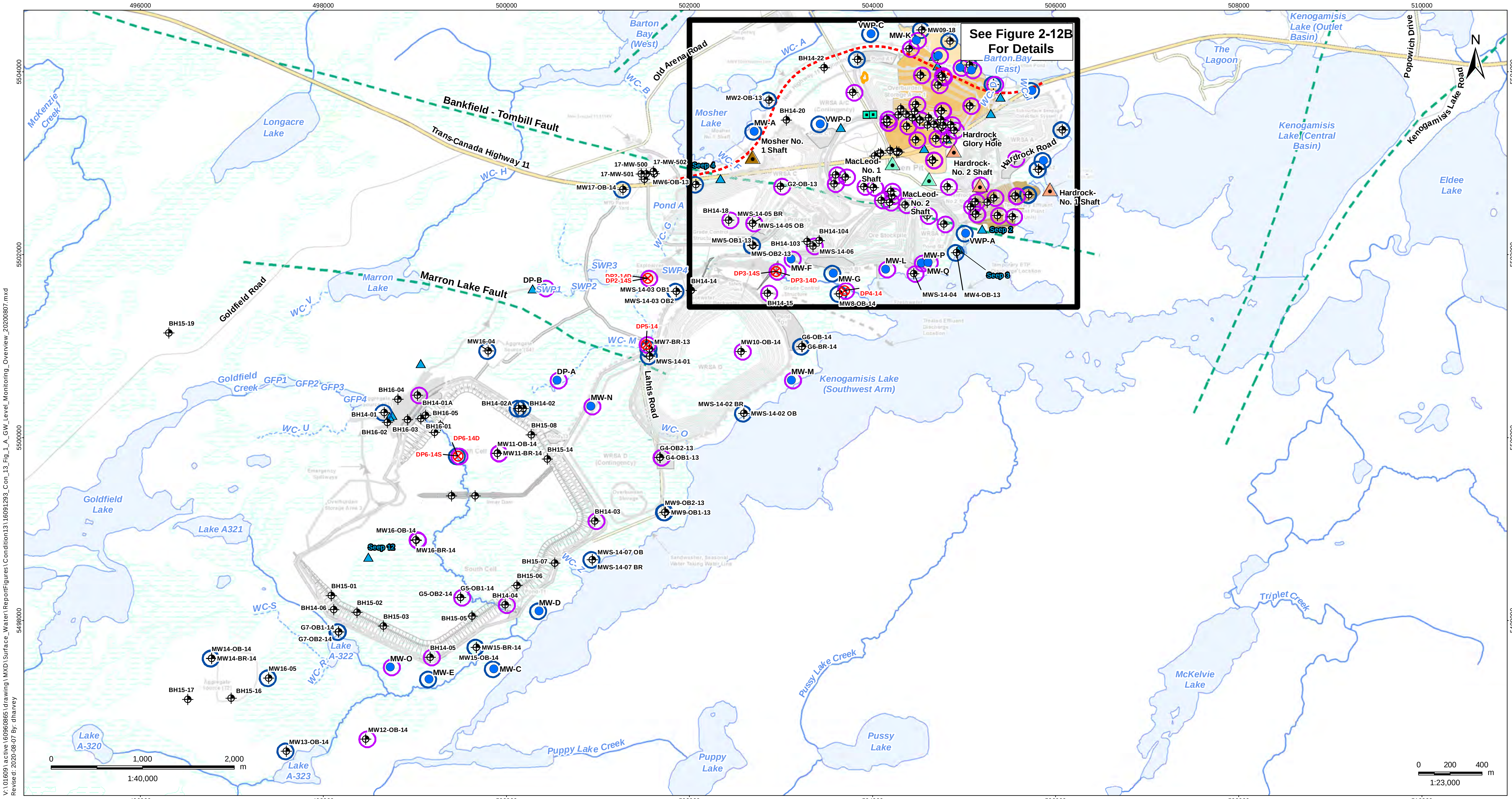
Groundwater level monitoring will be completed at up to 136 existing monitoring wells (91 locations) as well as 43 proposed monitoring wells, drive-point piezometers, and/or vibrating wire piezometers (23 locations) for a total of 179 monitoring points (114 locations). Groundwater quality monitoring will be completed at up to 82 existing monitoring wells (50 locations) as well as 21 proposed monitoring wells (13 locations) for a total of 103 monitoring points (63 locations). The proposed new monitoring well locations for groundwater quantity and quality are described as follows:

- Four new vibrating wire piezometers are proposed to be installed around the open pit (proposed locations VWP-A to VWP-D on Figure 2-12a). Each vibrating wire piezometer will consist of four sensors installed at depths ranging from the shallow bedrock (about 50 m below ground surface [BGS]) to deep bedrock corresponding with the base of the open pit at 570 m BGS. The vibrating wire piezometers will be installed in conjunction with geotechnical monitoring requirements for stability of the open pit and the data from the vibrating wire piezometers will be used to confirm the water level response in deep bedrock as a result of open pit dewatering.
- Four (4) new monitoring wells (Proposed MW-H through MW-K on Figure 2-12b) are proposed to monitor groundwater levels in the vicinity of the MHT seepage collection system.
- Twenty-one (21) monitoring wells (13 locations) (Proposed MW-A through MW-G and MW-L through MW-Q on Figure 2-13) are proposed primarily for monitoring groundwater quality downgradient, cross gradient, and upgradient of mine infrastructure but will also be used to monitor the effect of open pit dewatering and mounding associated with the TMF on groundwater levels.
- New drive-point piezometers are proposed to monitor groundwater levels associated with a sensitive (but not provincially designated as significant) wetland located within the central portion of the site (proposed location DP-A on Figure 2-12a) and a sparse treed fen (ecosite B136) located near the headwaters of the SWAT (proposed location DP-B Figure 2-12a).

The proposed new monitoring locations are based on the current design details and subject to change based on field observations. The intent of the proposed new monitoring wells is to install them in a location where they will not be overprinted by future mine infrastructure so that a long-term data set can be developed. The majority of proposed monitoring wells will be installed during construction to allow sufficient time to assess current conditions prior to commencement of mining activities. Groundwater monitoring at the proposed locations shall begin up to one (1) month prior to dewatering activities associated with construction and shall continue throughout mine operation except for the locations associated with the MacLeod high tailings (MHT) seepage collection system drain (Proposed MW-H to MW-K). The proposed MHT monitoring well locations will be installed after the construction of the MHT seepage collection system due to site access constraints. There is sufficient baseline data in the

vicinity of the proposed drain to understand groundwater flow directions and horizontal hydraulic gradients prior to installation of the proposed monitoring wells.

Groundwater monitoring locations will be reviewed at regular intervals through the AMP presented in Section 2.3.2 of this Fish and Fish Habitat Follow Up Program. Monitoring locations may be added or removed from the monitoring program in accordance with their utility in monitoring the effects of the Project on the environment or to account for modifications during detailed design (i.e., actual existing monitoring wells that may be overprinted by Project components and as a result new replacement wells may be required). Monitoring locations will be maintained until the location is no longer required. If a monitoring location is no longer required but is identified as part of a regulatory approval, it will only be removed from the monitoring program once the required amendments are approved.



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Revised: 2020-08-07 By: dharvey

August 2020
160961293

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Legend

- Monitoring Well
- Drive Point
- Proposed Monitoring Location
- Manual Groundwater Level Measurement
- Data Logger
- Seep
- Former Gas Station
- Faults
- New Highway 11 Alignment
- Watercourse- Permanent
- Watercourse- Intermittent
- Former Macleod Landfill Site
- Wetland (Eco-Site Based)

Historic Tailings Areas

- Hardrock Tailings
- Hardrock Reactive Tailings Area
- MacLeod High Tailings
- MacLeod Low Tailings

Historical Tailings Areas Mine Shafts

- Consolidated Mosher Long Lac Shaft
- Hard Rock Gold Mine Shaft
- Little Longlac Mine Shaft
- MacLeod-Cockshutt Mine Shaft

Notes

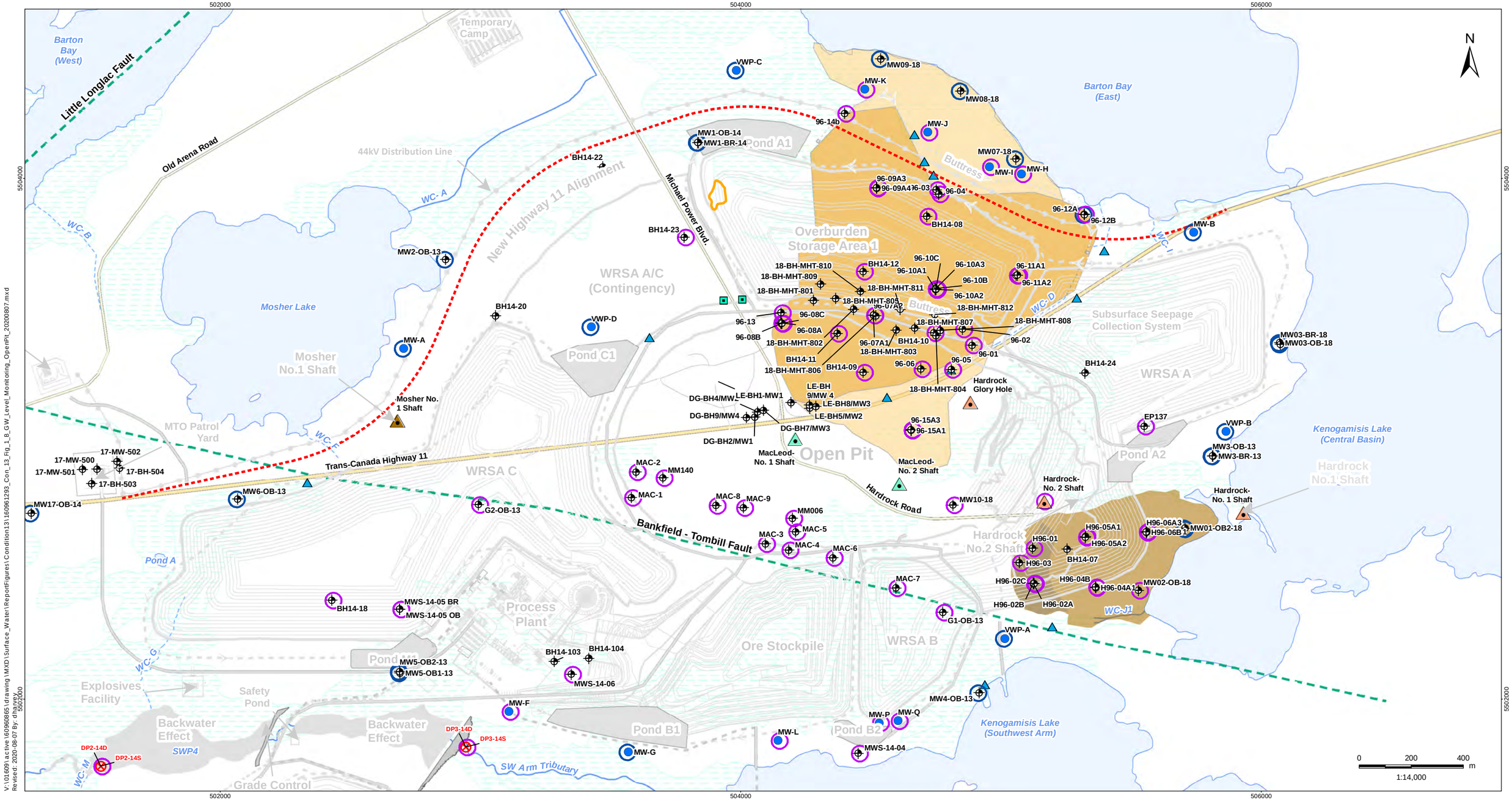
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
2-12A

Title
Groundwater Quantity Monitoring Locations (Overview)



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Revised: 2020-08-07 By: dharvey

August 2020
160961293

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Legend

- Monitoring Well
- Drive Point
- Proposed Monitoring Location
- Manual Groundwater Level Measurement
- Data Logger
- Seep
- Former Gas Station
- Faults
- New Highway 11 Alignment
- Watercourse- Permanent
- Watercourse- Intermittent
- Former Macleod Landfill Site
- Wetland (Eco-Site Based)

Historic Tailings Areas

- Hardrock Tailings
- Hardrock Reactive Tailings Area
- MacLeod High Tailings
- MacLeod Low Tailings

Historical Tailings Areas Mine Shafts

- Consolidated Mosher Long Lac Shaft
- Hard Rock Gold Mine Shaft
- Little Longlac Mine Shaft
- MacLeod-Cockshutt Mine Shaft

Client/Project

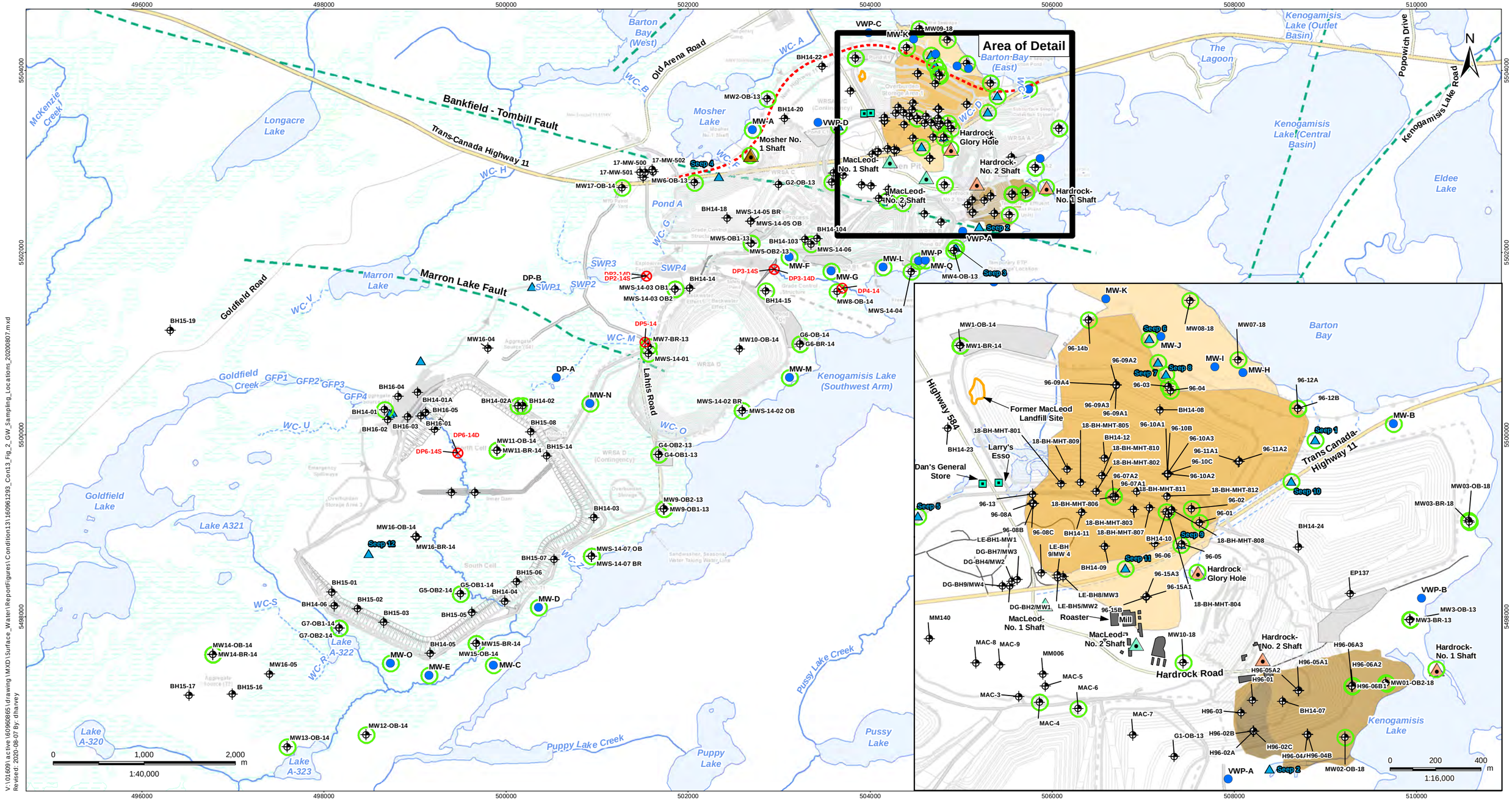
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

2-12B

Title

Groundwater Quantity Monitoring Locations (Open Pit Area)



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Revised: 2020-08-07 By: dharvey

August 2020
160961293

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Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Legend

- Monitoring Well
- Drive Point
- Proposed Monitoring Location
- Groundwater Sampling Location
- Seep
- Former Gas Station
- Faults
- New Highway 11 Alignment
- Watercourse- Permanent
- Watercourse- Intermittent
- Former Macleod Landfill Site
- Wetland (Eco-Site Based)

Historic Tailings Areas

- Hardrock Tailings
- Hardrock Reactive Tailings Area
- MacLeod High Tailings
- MacLeod Low Tailings

Historical Tailings Areas Mine Shafts

- Consolidated Mosher Long Lac Shaft
- Hard Rock Gold Mine Shaft
- Little Longlac Mine Shaft
- MacLeod-Cockshutt Mine Shaft

Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

2-13

Title

Groundwater Quality Monitoring Locations

Table 2-5
Groundwater Monitoring Plan Summary
Hardrock Project

Monitoring Well	Level		Total Daily Volume	Sample (General Chemistry, Dissolved Metals)	Sample (VOCs, BTEX, and PHCs)	Location
	Manual	Data Logger				
Monitoring Wells						
17-MW-500						Within Footprint of Proposed MTO Patrol Yard
17-MW-501						Within Footprint of Proposed MTO Patrol Yard
17-MW-502						Within Footprint of Proposed MTO Patrol Yard
BH2/MW1 - TBT Dan's General Store						Dan's General Store, HWY 11 and Micheal Power Boulevard
BH4/MW2 - TBT Dan's General Store						Dan's General Store, HWY 11 and Micheal Power Boulevard
BH7/MW3 - TBT Dan's General Store						Dan's General Store, HWY 11 and Micheal Power Boulevard
BH9/MW4 - TBT Dan's General Store						Dan's General Store, HWY 11 and Micheal Power Boulevard
BH1/MW1 - TBT Former Larry's Esso						Former Larry's Esso, HWY 11 and Micheal Power Boulevard
BH5/MW2 - TBT Former Larry's Esso						Former Larry's Esso, HWY 11 and Micheal Power Boulevard
BH8/MW3 - TBT Former Larry's Esso						Former Larry's Esso, HWY 11 and Micheal Power Boulevard
BH9/MW4 - TBT Former Larry's Esso						Former Larry's Esso, HWY 11 and Micheal Power Boulevard
BH14-01	X	X		X		Adjacent to Borrow Area S1 and TMF West Dam
BH14-01A	X					Within Footprint of TMF West Dam
BH14-02	X	X		X		Adjacent to TMF Northeast Dam
BH14-02A	X	X		X		Adjacent to TMF Northeast Dam
BH14-03	X*					Within Footprint of TMF Northwest Dam
BH14-04	X*					Within Footprint of TMF Southwest Dam
BH14-05	X*					Within Footprint of TMF Southwest Dam
BH14-06						Within Footprint of TMF
BH14-08	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
BH14-09	X*					Within Footprint of Open Pit and Historical MacLeod Tailings
BH14-10	X			X*		Between Overburden Storage Area 1 and Open Pit and within Footprint of Historical MacLeod Tailings
BH14-11	X*					Within Footprint of Open Pit and Historical MacLeod Tailings
BH14-12	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
BH14-14						Downgradient of WRSA D and South of SW Arm Tributary
BH14-15	X			X		Between WRSA D and SW Arm Tributary
BH14-18	X*					Within Footprint of WRSA C
BH14-20						Downgradient of WRSA C and South of HWY 11 Realingment
BH14-22						Downgradient of WRSA A/C (Contingency) and South of HWY 11 Realignment
BH14-23	X					Within Footprint of WRSA A/C (Contingency)
BH14-24						Within Footprint of WRSA A
BH14-103						Within Footprint of Process Plant
BH14-104						Within Footprint of Process Plant
BH15-01						Within Footprint of TMF Southwest Dam
BH15-02						Within Footprint of TMF Southwest Dam
BH15-03						Within Footprint of TMF Southwest Dam
BH15-05						Within Footprint of TMF Southeast Dam
BH15-06						Within Footprint of TMF Southeast Dam
BH15-07						Within Footprint of TMF Southeast Dam
BH15-08						Within Footprint of TMF Northeast Dam
BH15-14						Within Footprint of TMF Northeast Dam
BH15-16						Within Footprint of Aggregate Source T2
BH15-17						Within Footprint of Aggregate Source T2
BH15-19						Within Footprint of Aggregate Source T1
BH16-01						Within Footprint of TMF Northwest Dam
BH16-02						Within Footprint of TMF Northwest Dam
BH16-03						Within Footprint of TMF Northwest Dam
BH16-04						Within Footprint of Aggregate Source S1
BH16-05						Within Footprint of TMF Northwest Dam
G1-OB-13	X*					Within Footprint of WRSA B
G2-OB-13	X*					Within Footprint of WRSA C
G4-OB1-13	X			X		Within Footprint of Contingency WRSA D and Pond D2
G4-OB2-13	X			X		Within Footprint of Contingency WRSA D and Pond D2
G5-OB1-14	X*			X*		Within Footprint of TMF
G5-OB2-14	X*			X*		Within Footprint of TMF
G6-BR-14	X	X		X		Downgradient of WRSA D and Adjacent to Southwest Arm
G6-OB-14	X	X		X		Downgradient of WRSA D and Adjacent to Southwest Arm
G7-OB1-14	X	X		X		Adjacent TMF Southwest Dam and Lake A-322
G7-OB2-14	X	X		X		Adjacent TMF Southwest Dam and Lake A-322
MAC-1	X			X		West of Open Pit
MAC-2	X*					Within Footprint of Open Pit
MAC-3	X*					Within Footprint of Open Pit
MAC-4	X*			X*		South of Open Pit
MAC-5	X*					Within Footprint of Open Pit
MAC-6	X*			X*		Between Open Pit and Ore Stockpile
MAC-7	X*					Within Footprint of WRSA B
MAC-8	X*					Within Footprint of Open Pit
MAC-9	X*					Within Footprint of Open Pit
MW1-BR-14	X	X		X		Downgradient of Overburden Storage Area 1
MW1-OB-14	X	X		X		Downgradient of Overburden Storage Area 1
MW2-OB-13	X	X		X		Downgradient of WRSA A/C (Contingency) and Adjacent to Mosher Lake
MW3-BR-13	X	X		X		Downgradient of WRSA A and Adjacent to Central Basin
MW3-OB-13	X	X		X		Downgradient of WRSA A and Adjacent to Central Basin
MW4-OB-13	X	X		X		Downgradient of WRSA B and Adjacent to Southwest Arm
MW5-OB1-13	X	X		X	X	Downgradient of WRSA C and Process Plan
MW5-OB2-13	X	X		X	X	Downgradient of WRSA C and Process Plan
MW6-OB-13	X	X		X		Downgradient of WRSA C and Adjacent to HWY 11
MW7-BR-13	X	X		X		Downgradient of WRSA D (northwest)
MW8-OB-14	X	X		X		Downgradient of WRSA D and Adjacent to SW Arm Tributary
MW9-OB1-13	X	X		X		Downgradient of Contingency WRSA D (Contingency) and Overburden Storage Area 2
MW9-OB2-13	X	X		X		Downgradient of Contingency WRSA D (southeast)
MW10-OB-14	X*					Within Footprint of WRSA D
MW11-BR-14	X*			X*		Within Footprint of TMF
MW11-OB-14	X*			X*		Within Footprint of TMF
MW12-OB-14	X			X		Background - South of TMF and Goldfield Creek Tributary
MW13-OB-14	X	X		X		Background - South of TMF and Adjacent to Lake A-323
MW14-BR-14	X	X		X		Background - Southwest of TMF and Within Footprint of Aggregate Source T2
MW14-OB-14	X	X		X		Background - Southwest of TMF and Within Footprint of Aggregate Source T2
MW15-BR-14	X	X		X		Downgradient of TMF and north of Goldfield Creek Tributary
MW15-OB-14	X	X		X		Downgradient of TMF and north of Goldfield Creek Tributary
MW16-BR-14	X*					Within Footprint of TMF
MW16-OB-14	X*					Within Footprint of TMF
MW17-OB-14	X	X		X		Southeast Corner of HWY 11 and Lahitis Road
MW16-04	X	X				Within Footprint of Aggregate Source S4
MW16-05	X	X				Adjacent to Aggregate Source T2
MW03-BR-18	X	X		X		East of WRSA A, Adjacent to Central Basin
MW03-OB-18	X	X		X		East of WRSA A, Adjacent to Central Basin
MW10-18	X*			X*		Within Footprint of Open Pit, South of Historical MacLeod Tailings
MWS-14-01	X	X		X		Downgradient of WRSA D (Northwest)
MWS-14-02 BR	X	X		X		Downgradient of WRSA D and Adjacent to Southwest Arm
MWS-14-02 OB	X	X		X		Downgradient of WRSA D and Adjacent to Southwest Arm
MWS-14-03 OB1	X	X		X		Downgradient of WRSA D and South of SW Arm Tributary
MWS-14-03 OB2	X	X		X		Downgradient of WRSA D and South of SW Arm Tributary
MWS-14-04	X			X		Downgradient of WRSA B and Adjacent to Southwest Arm
MWS-14-05 BR	X*					Within Footprint of WRSA C
MWS-14-05 OB	X*					Within Footprint of WRSA C
MWS-14-06	X			X		Adjacent to Process Plant
MWS-14-07 BR	X	X		X		Downgradient of TMF and Adjacent to Soutwest Arm

Table 2-5
Groundwater Monitoring Plan Summary
Hardrock Project

Monitoring Well	Level		Total Daily Volume	Sample (General Chemistry, Dissolved Metals)	Sample (VOCs, BTEX, and PHCs)	Location
	Manual	Data Logger				
MWS-14-07 OB	X	X		X		Downgradient of TMF and Adjacent to Soutwest Arm
WP791/14-FL-MW1 - landfill						Former MacLeod Landfill Site, West of Historical MacLeod Tailings
WP792/14-FL-MW2 - landfill						Former MacLeod Landfill Site, West of Historical MacLeod Tailings
Historical MacLeod Tailings Monitoring Wells						
96-01	X*			X*		Between Overburden Storage Area 1 and Open Pit, Within Footprint of Historical MacLeod Tailings
96-02	X*			X*		Between Overburden Storage Area 1 and Open Pit, Within Footprint of Historical MacLeod Tailings
96-03	X			X		Downgradient of Overburden Storage Area 1 and Within Footprint of Historical MacLeod Tailings
96-04	X			X		Downgradient of Overburden Storage Area 1 and Within Footprint of Historical MacLeod Tailings
96-05	X*					Within Footprint of Open Pit
96-06	X*					Within Footprint of Open Pit
96-07A1	X*			X*		Between Overburden Storage Area 1 and Open Pit, Within Footprint of Historical MacLeod Tailings
96-07A2	X*			X*		Between Overburden Storage Area 1 and Open Pit, Within Footprint of Historical MacLeod Tailings
96-08A	X*					Within Footprint of Open Pit
96-08B	X*					Within Footprint of Open Pit
96-08C	X*					Within Footprint of Open Pit
96-09A1	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-09A2	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-09A3	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-09A4	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-10A1	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-10A2	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-10A3	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-10B	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-10C	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-11A1	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-11A2	X*					Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-12A	X			X		Downgradient of WRSA A and Within Footprint of Historical MacLeod Tailings
96-12B	X	X		X		Downgradient of WRSA A and Within Footprint of Historical MacLeod Tailings
96-13	X*					Between Overburden Storage Area 1 and Open Pit, Within Footprint of Historical MacLeod Tailings
96-14b	X			X		Within Footprint of Overburden Storage Area 1 and Historical MacLeod Tailings
96-15A1	X*					Within Footprint of Open Pit
96-15A3	X*					Within Footprint of Open Pit
96-15B	X*					Within Footprint of Open Pit
MW07-18	X	X		X		Within Footprint of Historical MacLeod Low Tailings, Adjacent to Barton Bay
MW08-18	X	X		X		Within Footprint of Historical MacLeod Low Tailings, Adjacent to Barton Bay
MW09-18	X	X		X		Within Footprint of Historical MacLeod Low Tailings, Adjacent to Barton Bay
Historical Hardrock Tailings Monitoring Wells						
BH14-07						Within Footprint of WRSA A and Historical Hardrock Tailings
H96-01	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-02A	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-02B	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-02C	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-03	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-04A1	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-04B	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-05A1	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-05A2	X*					Within Footprint of WRSA A and Historical Hardrock Tailings
H96-06A1	X*			X*		Within Footprint of WRSA A and Historical Hardrock Tailings
H96-06A2	X*			X*		Within Footprint of WRSA A and Historical Hardrock Tailings
H96-06A3	X*			X*		Within Footprint of WRSA A and Historical Hardrock Tailings
H96-06B	X*			X*		Within Footprint of WRSA A and Historical Hardrock Tailings
MW01-OB1-18	X	X		X		Within Footprint of Historical Hardrock Tailings, Adjacent to Central Basin
MW01-OB2-18	X	X		X		Within Footprint of Historical Hardrock Tailings, Adjacent to Central Basin
MW02-OB-18	X			X		Within Footprint of Historical Hardrock Tailings, Adjacent to Central Basin
Drive-Point Piezometers						
DP2-14D	X					Downgradient of WRSA D and South of SW Arm Tributary
DP2-14S	X					SW Arm Tributary
DP3-14D	X					SW Arm Tributary
DP3-14S	X					SW Arm Tributary
DP4-14	X					SW Arm Tributary
DP5-14	X					WC-M
DP6-14D	X*	X*				Goldfield Creek
DP6-14S	X*					Goldfield Creek
Seeps						
Seep 1				X		Downgradient of WRSA A and Historical MacLeod Tailings
Seep 3				X		Downgradient of WRSA B and Adjacent to Southwest Arm
Seep 4						Downgradient of WRSA C and South of HWY 11 Realingment, Dry
Seep 5				X		Within Footprint of WRSA A/C (Contingency)
Seep 6				X		Downgradient of Overburden Storage Area 1, within Footprint of Historical MacLeod Tailings
Seep 7				X		Downgradient of Overburden Storage Area 1, within Footprint of Historical MacLeod Tailings
Seep 8				X		Downgradient of Overburden Storage Area 1, within Footprint of Historical MacLeod Tailings
Seep 9				X		Within Footprint of Open Pit and Historical MacLeod Tailings
Seep 10				X		Within Footprint of WRSA A and Adjacent to HWY 11
Seep 11				X		Within Footprint of Open Pit and Historical MacLeod Tailings
Exploration Boreholes and Historical Shafts						
Hardrock Shaft 1				X		Downgradient of WRSA A and Adjacent to Central Basin
Hardrock Shaft 2	X**		X	X*		Within Footprint of WRSA A and Adjacent to Historical Hardrock Tailings
Hardrock Glory Hole				X		Within Footprint of Open Pit and Adjacent to Historical MacLeod Tailings
MacLeod Shaft 1						Within Footprint of Open Pit and Adjacent to Historical MacLeod Tailings
MacLeod Shaft 2						Within Footprint of Open Pit and Adjacent to Historical MacLeod Tailings
Mosher Shaft 1	X	X	X	X***		Adjacent to WRSA C and Mosher Lake
EP137	X*					Within Footprint of WRSA A
MM006	X*					Within Footprint of Open Pit
MM140	X*					Within Footprint of Open Pit
Total Existing Monitoring Locations:	**136**	**45**	**2**	**82**	**2**	
Proposed Monitoring Locations						
MHT SCS East Chamber			X			MHT Seepage Collection System, located between MHT and Kenogamisis Lake
Open Pit			X			Northern Portion of Project Development Area
Aggregate Pit S1			X			Northeast of the TMF, Headwaters of the Goldfield Creek Diversion
Aggregate Pit T2			X			Southwest of the TMF
Aggregate Pit S4			X			Northeast of the TMF
Construction Dewatering (various)			X			Associated with Construction of the Process Plant, TMF, Goldfield Creek Diversion, Culvert Crossings, Water Management Ponds
Proposed Monitoring Well MW-A (Ob)	X	X		X		Downgradient of WRSA C, Adjacent to Mosher Lake, overburden
Proposed Monitoring Well MW-A (Bdrk)	X	X		X		Downgradient of WRSA C, Adjacent to Mosher Lake, bedrock
Proposed Monitoring Well MW-B (Ob)	X	X		X		Downgradient of WRSA A, Adjacent to Barton Bay, overburden
Proposed Monitoring Well MW-B (Bdrk)	X	X		X		Downgradient of WRSA A, Adjacent to Barton Bay, bedrock
Proposed Monitoring Well MW-C (Ob)	X	X		X		Downgradient of TMF and Goldfield Creek Tributary, adjacent to Southwest Arm, overburden
Proposed Monitoring Well MW-C (Bdrk)	X	X		X		Downgradient of TMF and Goldfield Creek Tributary, adjacent to Southwest Arm, bedrock
Proposed Monitoring Well MW-D (Ob)	X	X		X		Downgradient of TMF, adjacent to Southwest Arm, overburden
Proposed Monitoring Well MW-D (Bdrk)	X	X		X		Downgradient of TMF, adjacent to Southwest Arm, bedrock
Proposed Monitoring Well MW-E (Ob)	X	X		X		Downgradient of TMF, adjacent to Goldfield Creek Tributary, overburden
Proposed Monitoring Well MW-E (Bdrk)	X	X		X		Downgradient of TMF, adjacent to Goldfield Creek Tributary, bedrock
Proposed Monitoring Well MW-F	X	X		X	X	Downgradient of Process Plant, overburden
Proposed Monitoring Well MW-G	X	X		X	X	Downgradient of Process Plant and Pond B1, overburden
Proposed Monitoring Well MW-H	X					Downgradient of MHT Seepage Collection System
Proposed Monitoring Well MW-I	X	X				Downgradient of MHT Seepage Collection System
Proposed Monitoring Well MW-J	X					Downgradient of MHT Seepage Collection System
Proposed Monitoring Well MW-K	X					Downgradient of MHT Seepage Collection System
Proposed Monitoring Well MW-L (Ob)	X			X		Between WRSA D and Kenogamisis Lake to the northeast of MWS-14-02 and southwest of G6-14

Table 2-5
Groundwater Monitoring Plan Summary
Hardrock Project

Monitoring Well	Level		Total Daily Volume	Sample (General Chemistry, Dissolved Metals)	Sample (VOCs, BTEX, and PHCs)	Location
	Manual	Data Logger				
Proposed Monitoring Well MW-L (Bdrk)	X			X		Between WRSA D and Kenogamisis Lake to the northeast of MWS-14-02 and southwest of G6-14
Proposed Monitoring Well MW-M	X			X		Between the Ore Stockpile and Kenogamisis Lake, to the West of MWS-14-04 and East of Proposed Monitoring Well MW-G
Proposed Monitoring Well MW-N (Ob)	X			X		Between the TMF and Goldfield Creek Tributary, Northwest of Proposed Monitoring Well MW-E and Southeast of G7-14
Proposed Monitoring Well MW-N (Bdrk)	X			X		Between the TMF and Goldfield Creek Tributary, Northwest of Proposed Monitoring Well MW-E and Southeast of G7-14
Proposed Monitoring Well MW-O (Ob)	X			X		Monitoring well northwest of WRSA D contingency to be installed once access roads have been constructed
Proposed Monitoring Well MW-O (Bdrk)	X			X		Monitoring well northwest of WRSA D contingency to be installed once access roads have been constructed
Proposed Monitoring Well MW-P	X			X		Monitoring well downgradient of WRSA B and the construction and demolition landfill
Proposed Monitoring Well MW-Q	X			X		Monitoring well downgradient of WRSA B and the construction and demolition landfill
Proposed Drive-Point Piezometer DP-F	X					Within the footprint of the sparse treed fend located east of the TMF
Proposed Drive-Point Piezometer DP-G	X					Within wetland located at the headwaters of SWAT and confluence with Goldfield Creek Diversion
Vibrating Wire Piezometer VWP-A-A	X	X				Between the Open Pit and Southwest Arm, shallow bedrock
Vibrating Wire Piezometer VWP-A-B	X	X				Between the Open Pit and Southwest Arm, intermediate bedrock
Vibrating Wire Piezometer VWP-A-C	X	X				Between the Open Pit and Southwest Arm, intermediate bedrock
Vibrating Wire Piezometer VWP-A-D	X	X				Between the Open Pit and Southwest Arm, deep bedrock
Vibrating Wire Piezometer VWP-B-A	X	X				Between the Open Pit and Central Basin, shallow bedrock
Vibrating Wire Piezometer VWP-B-B	X	X				Between the Open Pit and Central Basin, intermediate bedrock
Vibrating Wire Piezometer VWP-B-C	X	X				Between the Open Pit and Central Basin, intermediate bedrock
Vibrating Wire Piezometer VWP-B-D	X	X				Between the Open Pit and Central Basin, deep bedrock
Vibrating Wire Piezometer VWP-C-A	X	X				Between the Open Pit and Barton Bay, shallow bedrock
Vibrating Wire Piezometer VWP-C-B	X	X				Between the Open Pit and Barton Bay, intermediate bedrock
Vibrating Wire Piezometer VWP-C-C	X	X				Between the Open Pit and Barton Bay, intermediate bedrock
Vibrating Wire Piezometer VWP-D-D	X	X				Between the Open Pit and Barton Bay, deep bedrock
Vibrating Wire Piezometer VWP-D-A	X	X				West of Open Pit, shallow bedrock
Vibrating Wire Piezometer VWP-D-B	X	X				West of Open Pit, intermediate bedrock
Vibrating Wire Piezometer VWP-D-C	X	X				West of Open Pit, intermediate bedrock
Vibrating Wire Piezometer VWP-D-D	X	X				West of Open Pit, deep bedrock
Total Proposed Monitoring Locations:	**43**	**29**	**0**	**21**	**2**	
Total Proposed and Existing Monitoring Locations:	**179**	**74**	**2**	**103**	**4**	

Notes:

* Monitoring requirements to be re-evaluated once construction starts. Majority of locations will be removed from program but select locations will require replacement wells to be constructed outside of infrastructure footprint.
** Monthly manual water level monitoring to commence once pumping from shaft has started.
*** Mosher Shaft 1 is sampled at 5 different depth intervals (21 m, 122 m, 244, 396 m and 512 m)
MHT MacLeod High Tailings
Ob/Bdrk Nested monitoring well with one screen in overburden and one screen in shallow bedrock.
VOCs Volatile organic compounds
BTEX Benzene, Toulene, Ethylbenzene, Xylene
PHCs Petroleum hydrocarbons
Manual water level measurements to be collected in spring, summer and fall
Groundwater sampling for general chemistry and dissolved metals to be conducted annually except at groundwater quality trigger locations which will be conducted in spring, summer, and fall. Groundwater sampling for analysis of VOCs, BTEX, and PHCs to be conducted every year with the first sample collected once fuel is stored on site.

TABLE 2-6
Well Completion Details
Hardrock Project

Name	Coordinates UTM NAD 83 Zone 16 Easting	Coordinates UTM NAD 83 Zone 16 Northing	Top of Casing Elevation	Stick-up	Ground Elevation	Total Depth Drilled	Azimuth	Dip	Top of Sand	Bottom of Sand	Top of Screen	Bottom of Screen	Screen Material Description	Hydrostratigraphic Unit
	m	m	m AMSL	m	m AMSL	m	degrees	degrees	m BGS	m BGS	m BGS	m BGS		
Monitoring Wells														
17-MW-500	501527	5502884	-	0.82	341.80	3.20			1.40	3.20	1.70	3.20	SAND AND SILT	GLACIOFLUVIAL SEDIMENT
17-MW-501	501471	5502883	-	0.80	341.60	2.90			1.10	2.90	1.40	2.90	SAND	GLACIOFLUVIAL SEDIMENT
17-MW-502	501488	5502837	-	-	341.50	4.90			1.20	4.90	1.80	4.90	SAND	GLACIOFLUVIAL SEDIMENT
BH2/MW1 - TBT Dan's General Store	504048	5503087	99.75	0.00	99.75	4.40	-	-	0.60	4.40	1.00	3.80	SAND, silt, fill	GLACIOFLUVIAL SEDIMENT
BH4/MW2 - TBT Dan's General Store	504058	5503100	99.53	0.00	99.53	3.60	-	-	0.60	3.60	0.90	3.00	SAND, organics, fill	GLACIOFLUVIAL SEDIMENT
BH7/MW3 - TBT Dan's General Store	504082	5503112	99.02	0.00	99.02	3.00	-	-	0.60	3.00	0.90	3.00	SAND, ORGANICS, FILL	GLACIOFLUVIAL SEDIMENT
BH9/MW4 - TBT Dan's General Store	504019	5503087	100.13	0.00	100.13	3.60	-	-	0.60	3.60	0.90	3.00	SAND, fill	GLACIOFLUVIAL SEDIMENT
BH1/MW1 - TBT Former Larry's Esso	504192	5503140	100.00	0.79	99.21	3.60	-	-	0.60	3.60	0.90	3.00	SAND, silt, fill	GLACIOFLUVIAL SEDIMENT
BH5/MW2 - TBT Former Larry's Esso	504265	5503119	100.41	0.65	99.76	2.70	-	-	0.60	2.70	1.20	2.70	SILT and ROCK FILL	FILL
BH8/MW3 - TBT Former Larry's Esso	504288	5503124	99.98	0.73	99.25	4.40	-	-	0.60	3.60	0.90	3.00	SAND FILL, organics	FILL and GLACIOFLUVIAL
BH9/MW4 - TBT Former Larry's Esso	504019	5503087	100.41	0.78	99.63	3.10	-	-	0.60	3.10	0.90	3.00	ROCK FILL, SAND	FILL
BH14-01	498663	5500278	339.61	0.81	338.80	25.10	-	-	4.57	19.50	16.45	19.50	SAND and GRAVEL	GLACIOFLUVIAL SEDIMENT
BH14-01A	499026	5500466	338.74	0.34	338.40	19.80	-	-	1.82	3.66	2.14	3.66	SAND and GRAVEL TILL	TILL
BH14-02	500179	5500320	337.66	0.96	336.70	17.00	-	-	0.61	1.98	0.61	1.22	SILTY SAND	GLACIOFLUVIAL SEDIMENT
BH14-02A	500131	5500322	337.96	1.26	336.70	4.66	-	-	2.80	4.60	3.10	4.60	BEDROCK	SHALLOW BEDROCK
BH14-03	500966	5499090	334.10	0.80	333.30	37.80	-	-	6.10	10.97	7.62	10.67	SILTY SAND TILL	TILL
BH14-04	499984	5498174	336.22	0.92	335.30	39.80	-	-	18.90	24.19	19.58	22.63	SILTY SAND TILL	TILL
BH14-05	499167	5497601	333.18	0.98	332.20	22.80	-	-	1.83	4.70	2.21	3.37	SILT	GLACIOFLUVIAL SEDIMENT
BH14-06	498112	5498123	338.19	0.69	337.50	30.80	-	-	4.27	7.92	4.57	7.62	SAND	GLACIOFLUVIAL SEDIMENT
BH14-07	504511	5503474	337.42	1.12	336.30	12.00	-	-	6.30	11.30	8.20	11.20	TAILINGS	TAILINGS
BH14-08	504714	5503856	339.69	0.89	338.80	26.20	-	-	5.90	10.10	6.80	9.80	TAILINGS	TAILINGS
BH14-09	504470	5503256	346.03	0.93	345.10	20.70	-	-	13.40	17.70	13.70	16.70	SILTY SAND TO SANDY SILT TILL	TILL
BH14-10	504741	5503408	342.37	0.97	341.40	36.30	-	-	6.90	10.80	7.40	10.50	TAILINGS	TAILINGS
BH14-11	504370	5503406	343.86	0.96	342.90	19.20	-	-	7.90	12.20	8.90	11.90	TAILINGS	TAILINGS
BH14-12	504470	5503644	341.55	0.95	340.60	30.20	-	-	6.40	10.70	7.40	10.40	TAILINGS	TAILINGS
BH14-14	502017	5501611	332.77	0.77	332.00	33.50	-	-	3.80	7.90	4.60	7.60	SILT to silty SAND TILL	TILL
BH14-15	502851	5501580	331.37	0.77	330.60	14.30	-	-	4.90	9.10	6.10	9.10	SILTY SAND TILL	TILL
BH14-18	502429	5502380	338.30	0.90	337.40	4.30	-	-	0.50	1.70	0.80	1.40	SAND and GRAVEL	GLACIOFLUVIAL SEDIMENT
BH14-20	503058	5503473	341.96	0.96	341.00	4.40	-	-	0.61	2.20	1.30	1.90	SILTY SAND	GLACIOFLUVIAL SEDIMENT
BH14-22	503469	5504045	337.25	0.85	336.40	8.00	-	-	2.20	4.60	2.80	4.30	SILTY SAND	GLACIOFLUVIAL SEDIMENT
BH14-23	503782	5503775	342.14	0.94	341.20	8.90	-	-	2.40	6.40	3.30	6.30	SILTY SAND TO GRAVELLY SAND	GLACIOFLUVIAL SEDIMENT
BH14-24	505322	5503254	335.40	1.00	334.40	14.30	-	-	9.00	14.00	10.00	13.00	SAND and SILT TILL	TILL
BH14-103	503284	5502145	-	-	334.60	5.90			0.90	3.40	1.80	3.40	SAND AND GRAVEL	GLACIOFLUVIAL SEDIMENT
BH14-104	503416	5502157	-	-	334.50	7.50			0.90	3.60	1.80	3.40	SANDY SILTY CLAY TILL	TILL
BH15-01	498087	5498274	339.42	0.86	338.56	20.90	-	-	2.80	7.60	2.90	7.47	SANDY SILT and SILT	GLACIOFLUVIAL SEDIMENT
BH15-02	498365	5498092	336.30	0.90	335.40	15.10	-	-	2.74	6.10	3.05	6.10	SILTY SAND and SILT	GLACIOFLUVIAL SEDIMENT
BH15-03	498656	5497942	335.05	0.92	334.13	23.60	-	-	3.80	4.30	4.30	7.30	SAND to SILT	GLACIOFLUVIAL SEDIMENT
BH15-05	499622	5498052	332.65	0.84	331.81	19.30	-	-	5.33	8.53	5.33	8.38	SAND to SILT	GLACIOFLUVIAL SEDIMENT
BH15-06	500113	5498387	334.76	0.88	333.88	14.60	-	-	1.93	6.10	2.54	5.59	SILT	GLACIOFLUVIAL SEDIMENT
BH15-07	500528	5498632	332.03	0.89	331.14	12.00	-	-	2.44	6.10	3.00	6.04	SILT	GLACIOFLUVIAL SEDIMENT
BH15-08	500270	5500032	340.53	0.89	339.64	18.30	-	-	3.56	6.55	4.17	5.69	BEDROCK	SHALLOW BEDROCK
BH15-14	500447	5499767	343.07	0.90	342.17	14.90	-	-	2.74	7.19	3.10	6.20	SILTY SAND TILL	TILL
BH15-16	496992	5497153	356.01	0.81	355.20	24.30	-	-	20.30	22.70	20.80	22.40	SAND TILL	TILL
BH15-17	496518	5497141	363.31	0.91	362.40	25.90	-	-	9.14	13.11	10.67	12.19	SANDY SILT TILL	TILL
BH15-19	496310	5501148	376.77	0.91	375.86	12.10	-	-	5.50	7.80	6.30	7.80	SANDY SILT TILL	TILL
BH16-01	499063	5500209	-	0.76	336.00	27.30	-	-	5.18	7.93	6.10	7.62	SILT	GLACIOFLUVIAL SEDIMENT
BH16-02	498700	5500169	-	0.76	342.00	12.40	-	-	5.48	7.62	6.10	7.62	SAND AND GRAVEL	GLACIOFLUVIAL SEDIMENT
BH16-03	498917	5500199	-	0.96	337.00	27.10	-	-	5.18	7.93	6.10	7.62	SILT	GLACIOFLUVIAL SEDIMENT
BH16-04	498812	5500421	-	0.76	339.20	5.90	-	-	1.67	3.50	1.98	3.50	SAND	GLACIOFLUVIAL SEDIMENT
BH16-05	499115	5500246	-	0.76	336.03	5.30	-	-	2.43	4.57	3.04	4.57	BEDROCK	SHALLOW BEDROCK
G1-OB-13	504776	5502334	332.04	0.91	331.13	6.96	-	-	2.84	4.65	3.33	4.85	SAND to SILTY SAND	GLACIOFLUVIAL SEDIMENT
G2-OB-13	502992	5502748	344.16	0.87	343.29	4.24	-	-	1.17	3.51	1.54	3.07	CLAY	CLAY
G4-OB1-13	501679	5499784	333.69	0.91	332.78	12.19	-	-	9.91	12.19	10.67	12.19	SANDY SILT TILL	TILL
G4-OB2-13	501677	5499784	333.68	0.91	332.77	5.49	-	-	4.11	5.49	4.57	5.18	SANDY SILT	GLACIOFLUVIAL SEDIMENT
G5-OB1-14	499499	5498253	333.32	1.07	332.25	12.80	-	-	10.36	12.19	10.67	12.19	SILT TILL	TILL
G5-OB2-14	499499	5498254	333.38	1.05	332.33	5.18	-	-	3.05	5.19	3.67	5.19	SILT to SAND	GLACIOFLUVIAL SEDIMENT
G6-BR-14	503229	5500999	331.89	0.87	331.02	15.65	-	-	10.67	12.75	10.92	12.44	BEDROCK	SHALLOW BEDROCK
G6-OB-14	503227	5500998	331.68	0.64	331.04	3.05	-	-	1.22	3.05	1.52	3.05	SILT to CLAYEY SILT	GLACIOFLUVIAL SEDIMENT
G7-OB1-14	498165	5497879	334.39	0.88	333.51	15.24	-	-	13.41	15.24	13.72	15.24	SILT to SAND and GRAVEL	GLACIOFLUVIAL SEDIMENT
G7-OB2-14	498166	5497878	334.24	0.74	333.50	5.85	-	-	3.35	5.85	3.56	5.18	SAND	GLACIOFLUVIAL SEDIMENT
MAC-1	503580	5502775	344.14	0.39	343.75	2.00	-	-	-	-	2.54	4.98	BEDROCK	SHALLOW BEDROCK
MAC-2	503597	5502873	342.27	0.57	341.70	2.00	-	-	-	-	2.46	3.99	BEDROCK	SHALLOW BEDROCK
MAC-3	504094	5502597	339.35	0.91	338.44	2.00	-	-	-	-	1.68	4.72	BEDROCK	SHALLOW BEDROCK
MAC-4	504184	5502573	338.02	0.48	337.54	2.00	-	-	-	-	1.78	4.83	BEDROCK	SHALLOW BEDROCK
MAC-5	504210	5502643	337.81	0.70	337.11	2.00	-	-	-	-	1.70	4.75	BEDROCK	SHALLOW BEDROCK
MAC-6	504354	5502544	336.96	0.73	336.23	2.00	-	-	4.00	6.78	2.80	6.20	BEDROCK	SHALLOW BEDROCK
MAC-7	504595	5502427	335.03	0.94	334.09	2.00	-	-	3.43	6.40	6.40	2.80	BEDROCK	SHALLOW BEDROCK
MAC-8	503905	5502744	342.83	0.81	342.02	-	-	-	0.90	4.85	1.50	4.85	BEDROCK	SHALLOW BEDROCK
MAC-9	504010	5502736	342.15	0.83	341.32	-	-	-	0.70	4.88	1.50	4.50	BEDROCK	SHALLOW BEDROCK
MW1-BR-14	503837	5504139	332.68	0.72	331.96	14.15	-	-	9.60	11.43	9.91	11.43	BEDROCK	SHALLOW BEDROCK
MW1-OB-14	503835	5504139	332.70	0.71	331.99	3.05	-	-	1.22	3.05	1.52	3.05	SAND to SILT to SILTY-CLAY	GLACIOFLUVIAL SEDIMENT
MW2-OB-13	502866	5503690	334.31	0.77	333.54	4.11	-	-	3.05	4.11	3.20	4.11	SILTY SAND	GLACIOFLUVIAL SEDIMENT
MW3-BR-13	505814	5502934	331.19	0.80	330.39	14.91	-	-	13.03	14.91	13.39	14.91	BEDROCK	SHALLOW BEDROCK
MW3-OB-13	505812	5502935	331.23	0.91	330.32	10.52	-	-	8.63	10.52	8.99	10.52	SILTY SAND	GLACIOFLUVIAL SEDIMENT
MW4-OB-13	504915	5502024	330.77	0.78	329.99	7.26	-	-	2.63	4.46	2.94	4.46	SILT to SILTY CLAY	CLAY
MW5-OB1-13	502691	5502101	333.11	1.04	332.07	13.01	-	-	9.32	12.11	10.59	12.11	HARD TILL	TILL
MW5-OB2-13	502690	5502106	333.09	0.96	332.13	6.35	-	-	4.57	6.35	4.88	5.79	HARD TILL	TILL
MW6-OB-13	502067	5502769	337.01	0.90	336.11	3.25	-	-	1.68	3.25	2.34	3.25	SAND	GLACIOFLUVIAL SEDIMENT
MW7-BR-13	501560	5500971	335.49	0.80	334.69	12.18	-	-	9.45	12.18	9.85	12.18	BEDROCK	SHALLOW BEDROCK
MW8-OB-14	503637	5501573	330.69	0.64	330.05	9.75	-	-	3.66	6.40	4.57	6.10	SANDY SILT	GLACIOFLUVIAL SEDIMENT
MW9-OB1-13	501735	5499186	333.06	0.78	332.28	12.29	-	-	10.06	12.29	10.77	12.29	SANDY SILT to SILTY SAND TILL	TILL
MW9-OB2-13	501731	5499185	333.32	0.72	332.60	4.57	-	-	2.87	4.57	3.35	4.27	SANDY SILT to SILTY SAND TILL	TILL
MW10-OB-14	502563	5500943	333.64	0.81	332.83	5.18	-	-	3.35	5.18	3.66	5.18	SILTY SAND	GLACIOFLUVIAL SEDIMENT
MW11-BR-14	499902	5499832	337.70	0.66	337.04	7.92	-	-	4.57	6.40	4.88	6.40	BEDROCK	SHALLOW BEDROCK
MW11-OB-14	499901	5499831	337.69	0.66	337.03	2.13	-	-	0.61	2.13	0.91	2.13	SANDY SILT	GLACIOFLUVIAL SEDIMENT
MW12-OB-14	498460	5496708	336.22	0.78	335.45	4.57	-	-	2.74	4.57	3.05	4.57	SAND and SILT	GLACIOFLUVIAL SEDIMENT
MW13-OB-14	497596	5496576	343.67	0.85	342.82	7.62	-	-	5.79	7.62	6.10	7.62	SILT to SILTY CLAY	CLAY
MW14-BR-14	496777	5497590	358.91	0.70	358.21	25.68	-	-	22.56	24.69	22.86	24.38	BEDROCK	SHALLOW BEDROCK
MW14-OB-14	496777	5497587	359.04	0.87	358.17	6.10	-	-	2.74	6.10	3.05	6.10	SILTY SAND to SANDY SILT TILL	TILL
MW15-BR-14	499671	5497708	330.52	0.57	329.95	13.72	-	-	11.28	13.72	12.19	13.72	BEDROCK	SHALLOW BEDROCK
MW15-OB-14	499670	5497709	330.53	0.55	329.98	6.10	-	-	4.11	6.10	4.57	6.10	SAND	GLACIOFLUVIAL SEDIMENT
MW16-BR-14	499012	5498878	338.18	0.76	337.42	19.71	-	-	15.24	17.37	15.54	17.07	BEDROCK	SHALLOW BEDROCK
MW16-OB-14	499009	5498884	337.91	1.05	336.86	13.41	-	-	2.74	4.88	3.05	4.88	SILT	GLACIOFLUVIAL SEDIMENT
MW17-OB-14	501274	5502714	339.81	0.72	339.09	3.81	-	-	1.83	3.81	2.13	3.65	SAND	GLACIOFLUVIAL SEDIMENT
MW16-04	499800	5500949	349.16	0.76	348.40	13.70	-	-	5.48	7.62	6.10	7.62	SILT	GLACIOFLUVIAL SEDIMENT
MW16-05	497400	5497375	-	0.76	341.10	7.30	-	-	4.87	7.01	5.48	7.01	SILT and SAND	GLACIOFLUVIAL SEDIMENT
MW03-BR-18	506073	5503364	332.40	1.20	331.20	25.80	-	-	22.00	24.30	22.70	24.30	BEDROCK	SHALLOW BEDROCK
MW03-OB-18	506070	5503370	332.38	1.18	331.20	6.00	-	-	-	6.00	4.50	6.00	SILT	GLACIOLACUSTRINE SEDIMENT
MW10-18	504815	5502746	337.93	1.03	336.90	3.30	-	-	1.80	3.30	1.80	3.30	SAND AND SILT	GLACIOFLUVIAL SEDIMENT
MWS-14-01	501564	5500893	336.70	0.90	335.80	12.20	-	-	4.30	6.50	4.60	6.10	SILTY SAND TILL	TILL
MWS-14-02 BR	502592	5500266	331.94	0.64	331.30	13.40	-	-	7.60	9.50	7.90	9.40	BEDROCK	SHALLOW BEDROCK

TABLE 2-6
Well Completion Details
Hardrock Project

Name	Coordinates UTM NAD 83 Zone 16 Easting	Coordinates UTM NAD 83 Zone 16 Northing	Top of Casing Elevation	Stick-up	Ground Elevation	Total Depth Drilled	Azimuth	Dip	Top of Sand	Bottom of Sand	Top of Screen	Bottom of Screen	Screen Material Description	Hydrostratigraphic Unit
	m	m	m AMSL	m	m AMSL	m	degrees	degrees	m BGS	m BGS	m BGS	m BGS		
MWS-14-02 OB	502592	5500266	331.83	0.53	331.30	5.80	-	-	4.00	5.30	4.30	5.80	SILTY SAND TILL	TILL
MWS-14-03 OB1	501856	5501600	332.76	0.86	331.90	45.00	-	-	41.60	43.74	42.22	43.74	SILTY SAND TILL	TILL
MWS-14-03 OB2	501856	5501600	332.83	0.93	331.90	5.33	-	-	3.51	5.33	3.81	5.33	SILT TO SILTY SAND TILL	TILL
MWS-14-04	504451	5501792	331.90	0.90	331.00	7.50	-	-	5.00	7.50	5.90	7.50	BEDROCK	SHALLOW BEDROCK
MWS-14-05 BR	502689	5502346	340.50	0.90	339.60	7.30	-	-	3.70	6.30	4.60	6.10	BEDROCK	SHALLOW BEDROCK
MWS-14-05 OB	502689	5502346	340.45	0.85	339.60	1.50	-	-	0.50	1.50	0.80	1.40	SAND and GRAVEL	GLACIOFLUVIAL SEDIMENT
MWS-14-06	503349	5502096	334.37	0.87	333.50	6.60	-	-	4.20	6.60	5.10	6.60	BEDROCK	SHALLOW BEDROCK
MWS-14-07 BR	500938	5498669	332.05	0.85	331.20	12.10	-	-	7.60	11.00	9.10	10.70	BEDROCK	SHALLOW BEDROCK
MWS-14-07 OB	500938	5498669	332.01	0.81	331.20	6.10	-	-	4.40	6.10	4.60	6.10	SAND and GRAVEL TILL	GLACIOFLUVIAL SEDIMENT
WP791/14-FL-MW1 - landfill	-	-	-	1.10	-	-	-	-	0.20	1.80	0.20	1.80	ORGANICS, SAND	GLACIOFLUVIAL SEDIMENT
WP792/14-FL-MW2 - landfill	-	-	-	1.10	-	-	-	-	0.20	1.90	0.20	1.90	Organics, SILT	GLACIOFLUVIAL SEDIMENT
Historical MacLeod Tailings Monitoring Wells														
96-01	504888	5503361	334.67	0.22	334.45	2.00	-	-	12.90	15.00	13.40	14.60	Fine SAND	GLACIOFLUVIAL SEDIMENT
96-02	504852	5503422	341.32	0.35	340.97	0.00	-	-	8.30	10.36	8.90	10.00	TAILINGS	TAILINGS
96-03	504751	5503958	333.39	0.65	332.74	0.00	-	-	10.1	12.19	10.80	11.90	Fine SAND / Silty Sand TILL	GLACIOFLUVIAL SEDIMENT / TILL
96-04	504760	5503941	331.54	0.10	331.44	2.00	-	-	7.30	10.36	7.80	9.00	TAILINGS	TAILINGS
96-05	504809	5503267	335.25	1.50	333.75	0.00	-	-	0.70	2.43	1.00	2.24	TAILINGS	TAILINGS
96-06	504691	5503269	342.98	1.56	341.42	2.00	-	-	8.20	14.38	10.60	11.60	TAILINGS / SILT	TAILINGS / TILL
96-07A1	504509	5503476	343.45	1.03	342.42	2.00	-	-	6.30	11.25	8.20	11.25	TAILINGS	TAILINGS
96-07A2	504510	5503475	343.73	1.33	342.40	2.00	-	-	6.38	7.80	7.05	7.80	TAILINGS	TAILINGS
96-08A	504157	5503443	342.33	1.13	341.20	-	-	-	2.95	7.00	3.95	7.00	TAILINGS	TAILINGS
96-08B	504157	5503443	342.51	1.55	340.96	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
96-08C	504157	5503443	342.59	1.60	340.99	1.50	-	-	-	-	-	-	TAILINGS	TAILINGS
96-09A1	504522	5503964	339.36	1.09	338.27	2.00	-	-	2.98	9.40	6.30	9.40	TAILINGS	TAILINGS
96-09A2	504522	5503966	339.63	1.32	338.31	1.50	-	-	8.70	9.66	9.10	9.66	TAILINGS	TAILINGS
96-09A3	504522	5503964	339.67	1.35	338.32	1.50	-	-	1.97	5.49	2.40	5.40	TAILINGS	TAILINGS
96-09A4	504521	5503965	339.60	1.33	338.27	1.50	-	-	1.00	4.57	1.50	4.57	TAILINGS	TAILINGS
96-10A1	504747	5503574	341.86	1.45	340.41	2.00	-	-	9.60	10.86	7.70	10.50	TAILINGS	TAILINGS
96-10A2	504749	5503574	341.79	1.40	340.39	1.50	-	-	9.40	10.90	9.98	10.90	TAILINGS	TAILINGS
96-10A3	504748	5503576	341.75	1.36	340.39	1.50	-	-	1.92	5.49	2.40	5.40	TAILINGS	TAILINGS
96-10B	504746	5503577	341.63	1.17	340.46	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
96-10C	504749	5503576	341.48	1.23	340.25	1.50	-	-	-	-	-	-	TAILINGS	TAILINGS
96-11A1	505058	5503628	339.26	1.13	338.13	-	-	-	2.60	7.1	4.05	7.1	TAILINGS	TAILINGS
96-11A2	505062	5503630	339.18	1.33	337.85	0.00	-	-	-	-	3.00	4.57	TAILINGS	TAILINGS
96-12A	505318	5503864	332.57	1.65	330.92	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
96-12B	505320	5503862	332.42	1.70	330.72	1.50	-	-	-	-	-	-	TAILINGS	TAILINGS
96-13	504154	5503485	335.65	1.16	334.49	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
96-14b	504399	5504251	333.02	1.78	331.24	1.50	-	-	-	-	-	-	TAILINGS	TAILINGS
96-15A1	504655	5503033	336.10	1.05	335.05	0.00	-	-	1.26	3.80	2.1	3.80	TAILINGS	TAILINGS
96-15B	504653	5503033	336.86	1.80	335.06	0.00	-	-	-	-	-	-	TAILINGS	TAILINGS
96-15A3	504653	5503036	336.09	1.17	334.92	-	-	-	-	-	0.4	1.98	TAILINGS	TAILINGS
MW07-18	505057	5504076	331.28	1.18	330.10	7.60	-	-	1.20	2.90	1.4	2.90	SAND AND SILT	GLACIOLACUSTRINE SEDIMENT
MW08-18	504845	5504337	331.41	1.21	330.20	17.10	-	-	1.50	3.30	1.80	3.30	TAILINGS	TAILINGS
MW09-18	504537	5504460	331.52	1.32	330.20	8.40	-	-	1.00	2.70	1.20	2.70	TAILINGS	TAILINGS
Historical Hardrock Tailings Monitoring Wells														
H96-01	505121	5502580	334.67	0.22	334.45	2.00	-	-	0.60	1.80	1.10	1.70	TAILINGS	TAILINGS
H96-02A	505124	5502443	332.85	0.80	332.05	2.00	-	-	0.20	1.20	0.60	1.10	TAILINGS	TAILINGS
H96-02B	505123	5502445	332.62	0.40	332.22	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
H96-02C	505126	5502445	333.63	1.44	332.19	1.50	-	-	-	-	-	-	TAILINGS	TAILINGS
H96-03	505070	5502525	334.32	1.42	332.90	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
H96-04A1	505363	5502429	333.15	1.86	331.29	2.00	-	-	1.20	3.10	1.50	2.70	TAILINGS	TAILINGS
H96-04B	505362	5502431	332.68	1.42	331.26	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
H96-05A1	505324	5502625	335.67	1.17	334.50	2.00	-	-	1.90	4.80	3.30	4.50	TAILINGS	TAILINGS
H96-05A2	505323	5502622	335.76	1.34	334.42	-	-	-	test pit	test pit	0.80	2.40	TAILINGS	TAILINGS
H96-06A1	505560	5502644	332.65	1.40	331.25	2.00	-	-	1.20	3.40	1.80	3.00	TAILINGS	TAILINGS
H96-06A2	505559	5502645	332.78	1.54	331.24	1.50	-	-	2.60	3.20	2.90	3.20	TAILINGS	TAILINGS
H96-06A3	505558	5502641	332.39	1.16	331.23	1.50	-	-	test pit	test pit	0.40	1.80	TAILINGS	TAILINGS
H96-06B	505557	5502643	332.67	1.41	331.26	2.00	-	-	-	-	-	-	TAILINGS	TAILINGS
MW01-OB1-18	505710	5502654	332.08	1.38	330.70	26.70	-	-	18.40	18.20	16.70	18.20	SAND AND SILT	GLACIOFLUVIAL SEDIMENT
MW01-OB2-18	505706	5502658	332.13	1.23	330.90	4.20	-	-	2.40	4.20	2.70	4.20	TAILINGS AND SAND	TAILINGS
MW02-OB-18	505528	5502418	331.60	1.30	330.30	12.80	-	-	1.20	3.00	1.50	3.00	TAILINGS	TAILINGS
Drive Point Piezometers														
DP2-14D	501541	5501743	331.58	0.86	330.72	2.19	-	-	-	-	-	-	-	-
DP2-14S	501541	5501743	331.42	0.59	330.83	1.54	-	-	-	-	-	-	-	-
DP3-14D	502943	5501816	330.50	1.22	329.28	1.83	-	-	-	-	-	-	-	-
DP3-14S	502943	5501816	330.64	1.35	329.29	0.78	-	-	-	-	-	-	-	-
DP4-14	503689	5501608	330.10	0.96	329.14	1.17	-	-	-	-	-	-	-	-
DP5-14	501523	5501019	333.18	0.53	332.65	1.60	-	-	-	-	-	-	-	-
DP6-14D	499468	5499799	334.64	1.54	333.10	-	-	-	-	-	-	-	-	-
DP6-14S	499468	5499798	334.67	1.57	333.10	0.56	-	-	-	-	-	-	-	-
Seeps														
Seep 1	505396	5503722	-	-	-	-	-	-	-	-	-	-	-	-
Seep 2	505195	5502277	-	-	-	-	-	-	-	-	-	-	-	-
Seep 3	504937	5502054	-	-	-	-	-	-	-	-	-	-	-	-
Seep 4	502334	5502831	-	-	-	-	-	-	-	-	-	-	-	-
Seep 5	503648	5503387	-	-	-	-	-	-	-	-	-	-	-	-
Seep 6	504667	5504167	-	-	-	-	-	-	-	-	-	-	-	-
Seep 7	504705	5504064	-	-	-	-	-	-	-	-	-	-	-	-
Seep 8	504740	5504012	-	-	-	-	-	-	-	-	-	-	-	-
Seep 9	504807	5503263	-	-	-	-	-	-	-	-	-	-	-	-
Seep 10	505290	5503541	-	-	-	-	-	-	-	-	-	-	-	-
Seep 11	504561	5503159	-	-	-	-	-	-	-	-	-	-	-	-
Historical Mine Shafts														
Hardrock Shaft 1	505162	5502761	-	-	331.73	174.27	-	-	-	-	-	-	-	DEEP BEDROCK
Hardrock Shaft 2	505927	5502717	-	-	341.86	446.01	-	-	-	-	-	-	-	DEEP BEDROCK
Hardrock Glory Hole	504877	5503143	-	-	225.64	127.62	-	-	-	-	-	-	-	DEEP BEDROCK
MacLeod Shaft 1	504206	5503001	-	-	340.45	776.91	-	-	-	-	-	-	-	DEEP BEDROCK
MacLeod Shaft 2	504605	5502828	-	-	336.91	792.31	-	-	-	-	-	-	-	DEEP BEDROCK
Mosher Shaft 1	502678	5503070	-	-	348.92	756.88	-	-	-	-	-	-	-	DEEP BEDROCK
Monitored Exploration Holes														
EP137	505550	5503049	-	-	338.85	300.00	1.07	-54.77	-	-	-	-	-	DEEP BEDROCK
MM006	504199	5502695	-	-	339.85	201.00	354.56	-42.03	-	-	-	-	-	DEEP BEDROCK
MM140	503700	5502851	-	-	343.16	450.00	356.00	-49.31	-	-	-	-	-	DEEP BEDROCK

Notes:
TOC - Top of Casing
UTM - Universal Transverse Mercator
NAD - North American Datum
1. Exploration hole data provided by Premier
2. Ground and depth elevations for shafts estimated using Premier Wireframe - Hardrock Glory Hole elevation appears erroneous
3. Screen information from historical wells estimated using available borehole logs

2.3.1.2 Frequency

The frequency of sampling for each of the groundwater monitoring locations presented in Table 2-5 is described as follows:

- Water quantity (flow rate and total daily volume) pumped from Mosher No. 1 Shaft and Hardrock No. 2 Shaft during dewatering of historical underground workings and open pit.
- Water quantity (flow rate and total daily volume) pumped from the MHT seepage collection system (east pumping chamber discharge).
- Water quantity (flow rate and total daily volume) pumped from the aggregate pits (S1 and T2) and TMF Quarry.

Groundwater level monitoring will be completed in spring, summer, and fall at 179 monitoring wells (114 locations) (existing and proposed) with 74 of these monitoring wells (42 locations) (existing and proposed) instrumented with data loggers (set to record at 1 hour intervals). Sixty-eight (68) of these monitoring wells (43 locations) will be monitored throughout construction until such time they will be overprinted by mine infrastructure. The need to drill a replacement well close to, but outside the mine infrastructure footprint for groundwater monitoring will be evaluated in the year prior to abandoning the monitoring well. Manual water level measurements in the winter is not recommended as the majority of monitoring wells are frozen and safe access to the monitoring wells is an issue. The data loggers installed in select monitoring wells for continuous water level monitoring will capture the groundwater level fluctuations in the winter provided the monitoring well does not freeze.

Groundwater quality sampling of 65 monitoring wells (41 locations) (existing and proposed) annually (fall) and 38 monitoring wells (22 locations) (existing and proposed) in spring, summer, and fall. Groundwater quality monitoring wells are located upgradient, cross gradient, and downgradient of the TMF, WRSAs, and historical MacLeod and Hardrock tailings to monitor for changes in groundwater quality due to Project development. Monitoring wells sampled in spring, summer, and fall are associated with trigger threshold monitoring locations as indicated in Section 2.3.2. Some of the locations will be monitored throughout construction until such time they will be overprinted by mine infrastructure. The need to drill a replacement well close to, but outside the mine infrastructure footprint for groundwater monitoring will be evaluated in the year prior to abandoning the monitoring well. Newly installed monitoring wells for groundwater quality will be sampled in spring, summer, and fall until 10 sampling events are completed then sampling frequency will change to fall, unless the new monitoring well is associated with a trigger threshold monitoring location (as per section 2.3.2.1) then frequency will remain as spring, summer, and fall.

2.3.1.3 Methods

Pumped Volume

The pumped volume from Mosher Shaft No. 1, Hardrock Shaft No. 2, the open pit, and the aggregate pits will be monitored using a flow meter or totalizer so that the pumped volume may be measured or calculated based on flow rate and duration of pumping on a daily basis. For construction dewatering from excavations, the pumped volume may be estimated based on pump capacity and daily run times.

Water Level Monitoring

Water levels at the monitoring wells and drive-point piezometers will be monitored using a combination of manual and automated techniques. Manual water level measurements will be collected using a battery-operated probe and calibrated tape, water depths will be measured in meters below the top of casing (BTOC) and recorded.

Select monitoring wells will be instrumented with a data logger that records either pressure or frequency. If the data logger is not vented, then the atmospheric pressure will be recorded at the site so that the data logger readings may be corrected for atmospheric pressure to obtain the actual height of water above the data logger. The data loggers should be set to record at a frequency that is sufficient to understand the variability in the groundwater level at the given monitoring well (minimum 1 hour intervals).

Water Quality Monitoring

Groundwater quality sampling for general chemistry and metals analysis will be completed by purging the monitoring wells prior to sample collection. If feasible, the monitoring wells will be purged by removing a minimum of three well casing volumes of water or until the well is purged dry three times. Monitoring wells will be sampled using dedicated high density polyethylene (HDPE) tubing and inertial lift foot valves (e.g., Waterra). Field parameters comprising temperature, pH, conductivity, oxidation-reduction potential (ORP), and DO will be measured during purging using a multi parameter water quality meter and flow through cell where feasible. The meter will be calibrated prior to use according to the manufacturer's specifications using the appropriate calibration standards.

Groundwater quality sampling for organic parameters will be conducted using low flow sampling techniques. A peristaltic or bladder pump will be used and set to a maximum flow rate of 1 L/min, but ideally less than 0.5 L/min to avoid aerating the water. Field measurements including conductivity, temperature, DO and pH will be measured during purging using a multi-parameter water quality meter and flow through cell where feasible. Field parameters will be allowed to stabilize prior to sampling. Stabilization for low flow sampling is defined as three successive readings within ±0.1 pH units, ±3% for specific conductance, ±10 mV for ORP, and ±10% for turbidity and DO.

Dedicated equipment will be used when possible and reusable equipment will be decontaminated between sampling locations using phosphate free detergent, deionized water, and methanol or isopropyl rinse. Groundwater samples will be collected in laboratory supplied bottles containing

appropriate preservative. Samples that require filtering (e.g., samples for metals analysis) will be filtered in the field using a dedicated 0.45 µm filter.

QA/QC samples will be collected as a check on the field methodology, laboratory analytical methods, and on sample precision in accordance with Environment Canada (2012). A minimum one field blank and trip blank will be collected per sampling event in addition to one field duplicate for approximately 10% of groundwater samples per sampling event.

Groundwater quality samples will be placed on ice and sent, under COC documentation, to an analytical laboratory that is accredited under CALA. Groundwater quality samples collected as part of this monitoring program will be analyzed for general chemistry, nutrients, and metals as listed in Table 2-7. Table 2-7 is consistent with the parameters presented in Table 9-20 of the EIS/EA (Stantec 2018a) with additional parameters included. In addition, two monitoring wells located downgradient of the fuel storage location and the two proposed monitoring wells downgradient of the process plant (MW-F and MW-G) will be monitored annually for organic parameters listed in Table 2-7.

Dissolved metals analysis is considered more appropriate for groundwater samples and is more representative of metals chemistry in the aquifer since the suspended solids are generally not transported through aquifer materials and water supply wells are typically designed and developed to a state to reduce the potential for sediment in the pumped water. Therefore, it is recommended that the dissolved metals fraction is analyzed and compared to regulatory criteria and/or the trigger thresholds presented in the AMP (Section 2.3.2).

Table 2-7: Summary of Analytical Parameters for Groundwater Quality Samples

Parameter	
Alkalinity	Cobalt
Ammonia (as N)	Copper
Chloride	Iron
Electrical Conductivity	Lead
Cyanide (free and total)	Magnesium
Fluorine	Manganese
Hardness	Mercury
Nitrite (as N)	Molybdenum
Nitrate (as N)	Nickel
pH	Potassium
Phosphorus	Selenium
Sulfate	Silver
Total Dissolved Solids (TDS)	Sodium
Total Suspended Solids	Thallium
Total Suspended Solids	Tungsten
Turbidity	Uranium
Aluminum	Vanadium
Antimony	Zinc
Arsenic	Zirconium
Beryllium	Benzene *
Boron	Toluene *
Calcium	Ethylbenzene *
Cadmium	Xylenes *
Chromium (total)	Petroleum Hydrocarbons (PHCs) Fraction 1 (F1) to 4 (F4) *

* Benzene, Toluene, Ethylbenzene, Xylenes and PAHs sampled only at monitoring wells located downgradient of fuel storage locations (MW5-OB1-13, MW5-OB2-13 and proposed new monitoring wells MW-F and MW-G)

2.3.2 Adaptive Management

The following section describes the groundwater AMP trigger threshold monitoring locations, frequency of evaluation, parameters, trigger thresholds, and associated response plan. Due to the rural location of the Project, the main receptor for change in groundwater quantity and/or quality are the ecosystems associated with the receiving water bodies, predominantly Kenogamisis Lake. Therefore, the trigger

threshold locations and trigger thresholds defined for the groundwater AMP are focused on alerting to changing conditions in groundwater that have the potential to affect surface water and the associated aquatic biota and/or wetlands.

Groundwater Quantity Indicator Parameters

The pumped volume from the open pit can be compared to the predicted dewatering rate to assess whether there is potential for drawdown greater than that predicted in the EIS/EA (Stantec 2018a). For example, if the pumping rate is greater than that predicted in the EIS/EA (Stantec 2018a) then the resulting drawdown may be greater than predicted in the EIS/EA (Stantec 2018a), which can potentially result in changes in baseflow in nearby surface water features.

The groundwater levels in monitoring wells can be compared to baseline conditions and those predicted in the EIS/EA (Stantec 2018a) to assess whether there is potential for a change in associated baseflow to nearby surface water features that is greater than that predicted in the EIS/EA (Stantec 2018a) and to confirm the reversal of the horizontal hydraulic gradient between the historical MacLeod and Hardrock tailings and Kenogamisis Lake.

Groundwater Quality Indicator Parameters

Groundwater quality indicator parameters were chosen based on their relevance to the Project and regulatory criteria, particularly the MECP Aquatic Protection Values (APVs). The PoPCs for the Project were defined in the EIS/EA (Stantec 2018a). The PoPCs were reviewed with respect to baseline data, fate in groundwater, and ability to consistently and reliably quantify to determine which PoPCs would be defined as indicator parameters as part of the AMP. In addition to the PoPCs, parameters typically indicative of mine operations and/or acid rock drainage were chosen as indicator parameters. The indicator parameters for groundwater quality are defined as follows including rationale:

- **Antimony:** Defined as a PoPC for the Project. Was predicted to exceed the interim PWQO in seepage from the WRSAs and ore stockpiles. There is no APV for antimony.
- **Arsenic:** Defined as a PoPC for the Project. Was the only parameter that consistently exceeded the APV and PWQO in groundwater associated with the historical MacLeod and Hardrock tailings. Was predicted to exceed the interim PWQO in at source seepage associated with the TMF, WRSAs, and ore stockpile.
- **Cobalt:** Defined as a PoPC for the Project. Was predicted to exceed the APV and PWQO in seepage from the WRSAs. Cobalt is naturally elevated above the PWQO in bedrock.
- **Iron:** Defined as a policy 2 parameter for certain basins of Kenogamisis Lake. The 75th percentile concentration of iron in surface water exceeds the PWQO in Barton Bay under baseline conditions.
- **Uranium:** Defined as a PoPC for the Project. Was predicted to be less than the APV but to exceed the interim PWQO in seepage from the WRSAs.
- **Cyanide:** Sodium cyanide (NaCN) is a part of the processing of ore. A cyanide destruction circuit will be included in the mill process thereby limiting the amount of cyanide discharged with the

tailings in the TMF. Cyanide is not commonly found in the natural environment and therefore provides an indicator parameter for the potential of seepage from the TMF to the environment.

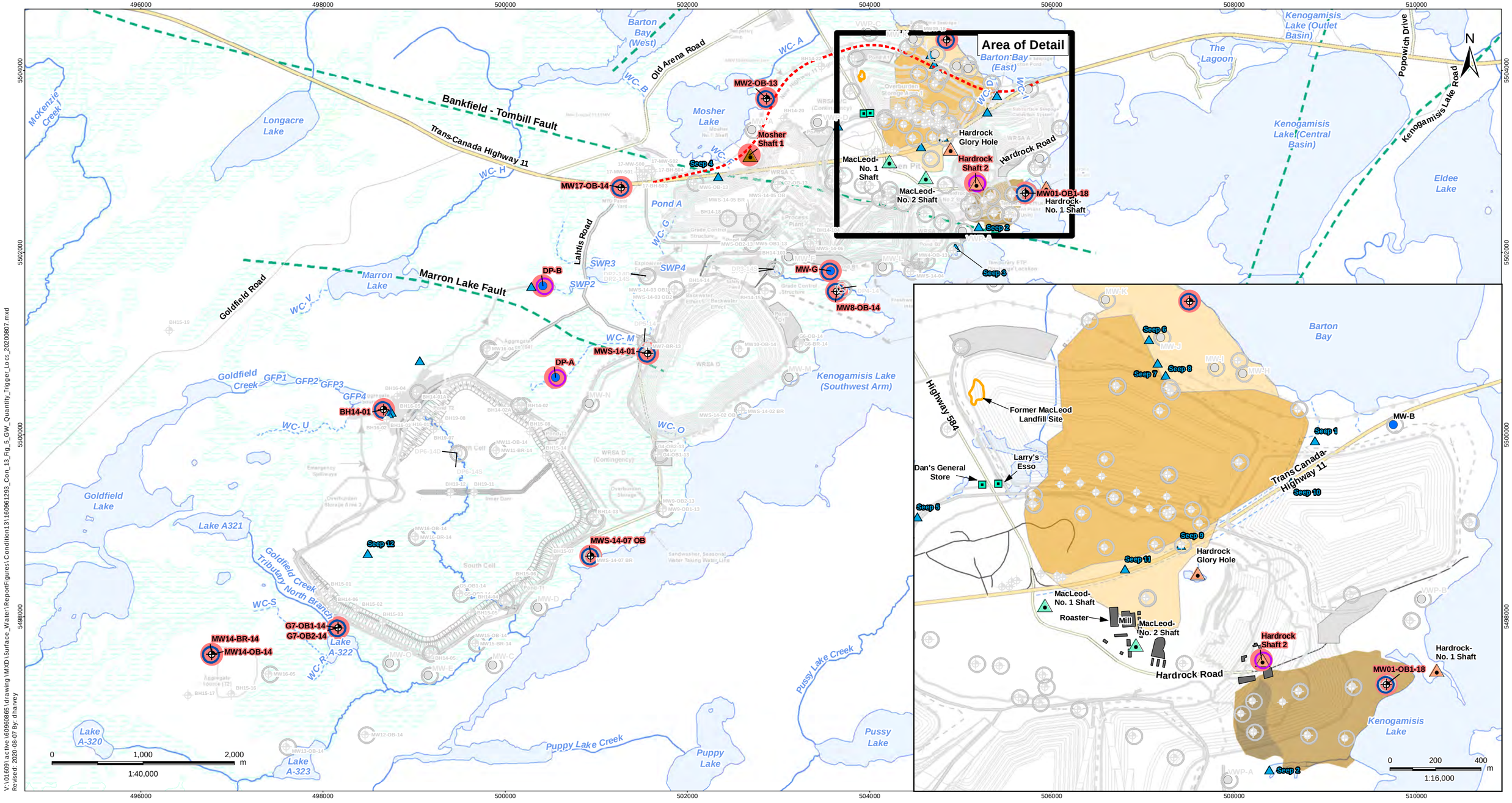
- **Sulphate:** Was predicted to be elevated above baseline groundwater concentrations in source seepage by an order of magnitude. A common indicator of acid rock drainage. There is no APV or PWQO for sulphate.

2.3.2.1 Groundwater Trigger Threshold Monitoring Locations and Frequency

Water level monitoring at up to 179 monitoring points (114 locations) is proposed at the start of the groundwater monitoring program. Twelve monitoring wells (9 locations) in addition to two proposed drive-point piezometers, two proposed monitoring wells, the hydraulic gradient around the MHT seepage collection system drain, and pumping from the open pit, Mosher shaft, aggregate pits, and Hardrock No. 2 shaft have been chosen as trigger threshold monitoring locations for groundwater quantity. A key finding of the EIS/EA was the reversal in the horizontal hydraulic gradient between the historical Hardrock and MacLeod tailings and Kenogamisis Lake that resulted in the reduction of mass loading of contaminants from the tailings to the lake. The reversal in horizontal hydraulic gradient was defined using the original steady state groundwater flow model built for the Project. As the steady state groundwater flow model was based on average annual conditions, the timing of the reversal of the hydraulic gradient is unknown. The steady state groundwater flow model is being updated to transient and will be used to assess the timing of the reversal of the horizontal hydraulic gradient between the historical tailings and Kenogamisis Lake. A trigger threshold to confirm the reversal and timing of reversal of the horizontal hydraulic gradient between the historical tailings and Kenogamisis lake will be defined once the updated groundwater flow modelling is completed. Figure 2-14 presents the groundwater quantity monitoring network and groundwater quantity trigger threshold monitoring locations. Trigger threshold monitoring locations were chosen to alert for changing groundwater quantity associated with the effect of dewatering the open pit and aggregate pits on nearby surface water features and wetlands. The frequency of monitoring the groundwater quantity trigger threshold locations is consistent with the rational presented in Section2.3.1, Routine Monitoring, which is manual measurements in spring, summer, and fall with data loggers set to record at 1 hr intervals.

Groundwater quality monitoring is proposed at up to 103 monitoring points (63 locations) at the start of the groundwater monitoring program. Nineteen (19) existing monitoring wells (11 locations) in addition to 19 proposed monitoring wells (11 locations) for a total of 38 monitoring wells (22 locations) have been chosen as trigger threshold monitoring locations for groundwater quality. Figure 2-15 presents the groundwater quality monitoring network and groundwater quality trigger threshold monitoring locations. Trigger threshold monitoring locations were chosen to alert for changing groundwater quality downgradient of the TMF, WRSAs, and ore stockpile prior to discharge to surface water features. The groundwater quality trigger threshold locations will be monitored in spring, summer, and fall and are consistent with those presented in Section 2.3.1.

Table 2-8 presents a summary of the groundwater quality and quantity trigger threshold monitoring locations, parameters, and associated rationale. The groundwater quantity data for trigger threshold monitoring locations will be reviewed with respect to the trigger thresholds in spring, summer, and fall of a given year as per the sampling frequency. The frequency of monitoring should be reviewed as the hydraulic gradients associated with open pit and aggregate pit dewatering are developed and the effects of dewatering are confirmed.



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Revised: 2020-08-07 By: dharvey

August 2020
160961293

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Legend

Groundwater Quantity Trigger **Threshold** Monitoring Locations
- Monitoring Well
- Proposed Monitoring Location
- Manual Groundwater Level Measurement
- Data Logger
- Groundwater Quantity Trigger Threshold Monitoring Locations

Other Features
- Drive Point
- Other Groundwater Level Monitoring Locations
- Seep
- Former Gas Station
- Faults
- New Highway 11 Alignment
- Watercourse- Permanent
- Watercourse- Intermittent
- Former Macleod Landfill Site
- Wetland (Eco-Site Based)

Historic Tailings Areas
- Hardrock Tailings
- Hardrock Reactive Tailings Area
- MacLeod High Tailings
- MacLeod Low Tailings

Historical Tailings Areas Mine Shafts
- Consolidated Mosher Long Lac Shaft
- Hard Rock Gold Mine Shaft
- Little Longlac Mine Shaft
- MacLeod-Cockshutt Mine Shaft

Client/Project

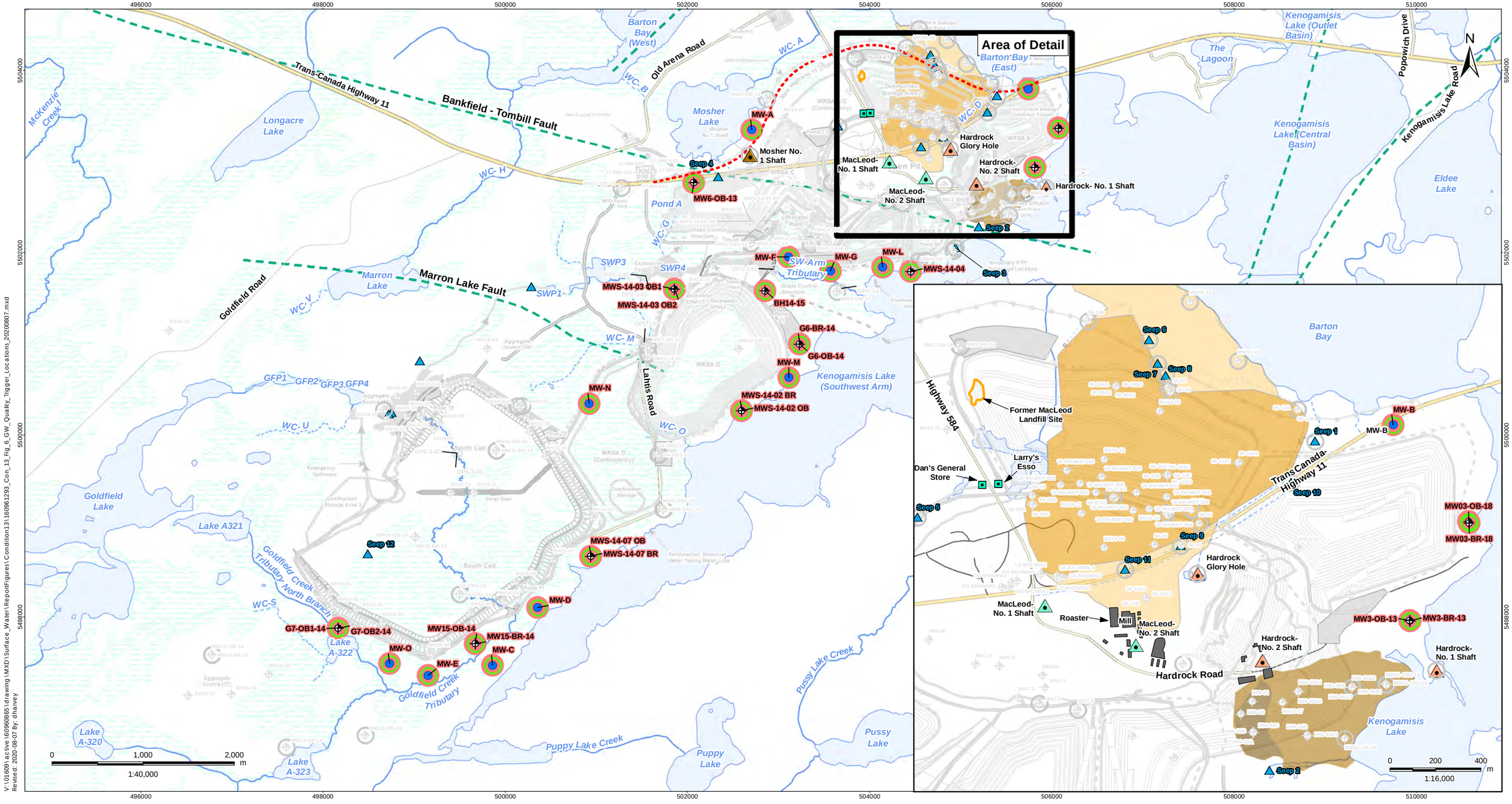
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

2-14

Title

Groundwater Quantity **Trigger Threshold** Monitoring Locations



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Revised: 2020-08-07 By: dharvey

August 2020
160961293

Stantec

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

Legend

Groundwater Quality Trigger **Threshold** Monitoring Locations
- Monitoring Well
- Proposed Monitoring Location
- Groundwater Sampling Location
- Trigger Threshold Groundwater Quality Monitoring Location

Other Features
- Drive Point
- Other Groundwater Sampling Location
- Seep
- Former Gas Station
- Faults
- New Highway 11 Alignment
- Watercourse- Permanent
- Watercourse- Intermittent
- Former Macleod Landfill Site
- Wetland (Eco-Site Based)

Historic Tailings Areas
- Hardrock Tailings
- Hardrock Reactive Tailings Area
- MacLeod High Tailings
- MacLeod Low Tailings

Historical Tailings Areas Mine Shafts
- Consolidated Mosher Long Lac Shaft
- Hard Rock Gold Mine Shaft
- Little Longlac Mine Shaft
- MacLeod-Cockshutt Mine Shaft

Client/Project
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
2-15

Title
Groundwater Quality **Trigger Threshold** Monitoring Location**s**

Table 2-8: Groundwater Trigger Threshold Monitoring Locations, Frequency, Parameters, and Rationale

Trigger Threshold Monitoring Location	Frequency of Measurement and Comparison to Trigger Threshold	Trigger Threshold Parameter	Rationale
Groundwater Quantity			
Mosher and Hardrock No. 2 Shafts	Daily Compared to Trigger Threshold – Quarterly	Pumped Volume	Indirectly monitor potential effects of dewatering the open pit on groundwater levels.
Open Pit	Compared to Trigger Threshold – Quarterly	Pumped Volume	
Aggregate Pit S1	Daily Compared to Trigger Threshold - Quarterly	Pumped Volume	Indirectly monitor potential effects of dewatering the aggregate pits on groundwater levels.
Aggregate Pit T2	Daily Compared to Trigger Threshold - Quarterly	Pumped Volume	
Aggregate Pit S4	Daily Compared to Trigger Threshold - Quarterly	Pumped Volume	
BH14-01 G7-OB1-14 G7-OB2-14 MW14-OB-14 MW14-BR-14 MWS-14-01 MWS-14-07 OB Proposed Drive-Point Piezometer DP-A (Central Wetland)	Manual - Spring, Summer, and Fall Data Logger – 1 hour Intervals Compare to Trigger Threshold – Spring, Summer, and Fall	Water Level	Monitor potential changes in groundwater levels associated with the TMF and/or dewatering of the aggregate pits to be protective of wetlands and baseflow to surface water features.
Proposed Drive-Point Piezometer DP-B (GFC Diversion)	Manual - Spring, Summer, and Fall Data Logger – 1 hour Intervals	Water Level	Monitor potential changes in groundwater levels associated with the GFC diversion on a wetland located in the upper reaches of the SWAT.

Table 2-8: Groundwater Trigger Threshold Monitoring Locations, Frequency, Parameters, and Rationale

Trigger Threshold Monitoring Location	Frequency of Measurement and Comparison to Trigger Threshold	Trigger Threshold Parameter	Rationale
	Compare to Trigger Threshold – Spring, Summer, and Fall		
MW2-OB-13 MW8-OB-14 MW17-OB-14 MW01-OB2-18 MW08-18	Manual - Spring, Summer, and Fall Data Logger – 1 hour Intervals Compare to Trigger Threshold – Spring, Summer, and Fall	Water Level	Monitor potential changes in groundwater levels associated with dewatering the open pit to be protective of wetlands and baseflow to surface water features.
Proposed Monitoring Well MW-F Proposed Monitoring Well MW-G	Manual - Spring, Summer, and Fall Data Logger – 1 hour Intervals Compare to Trigger Threshold – Monthly during Construction Dewatering of Process Plant	Horizontal Hydraulic Gradient toward the SWAT	Monitor potential changes in groundwater levels associated with temporary construction dewatering of the process plant area to be protective of wetlands and baseflow to surface water features. Confirm there is a horizontal hydraulic gradient toward the SWAT.
MHT Seepage Collection Drain (via drain manholes, 96-03, 96-04, 96-09A1, 96-09A2, 96-09A3, 96-09A4, 96-11A1, 96-11A2, 96-12A, 96-12B, 96-14B, MW07-18, MW08-18, MW09-18, MW-H, MW-I, MW-J, and/or MW-K)	Manual - Spring, Summer, and Fall Data Logger – 1 hour Intervals Compared to Trigger Threshold – Spring, Summer, and Fall	Horizontal Hydraulic Gradient	Confirm that an inward horizontal hydraulic gradient is maintained toward the MHT seepage collection drain and/or toward the open pit.
To Be Determined (will be based on updated groundwater flow modelling)	To Be Determined (will be based on updated groundwater flow modelling)	Horizontal Hydraulic Gradient	Monitor timing of reversal in hydraulic gradient between historical tailings and the open pit to reduce mass loading from historical tailings to Kenogamisis Lake.

Table 2-8: Groundwater Trigger Threshold Monitoring Locations, Frequency, Parameters, and Rationale

Trigger Threshold Monitoring Location	Frequency of Measurement and Comparison to Trigger Threshold	Trigger Threshold Parameter	Rationale
Groundwater Quality			
G7-OB1-14 G7-OB2-14	Spring, Summer, and Fall	CN- (free), SO4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from the TMF on Lake A-322
MW15-OB-14 MW15-BR-14 Proposed Monitoring Well MW-E and MW-N	Spring, Summer, and Fall	CN- (free), SO4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from the TMF prior to discharge to GFC Tributary
MWS-14-07 OB MWS-14-07BR Proposed Monitoring Wells MW-C and MW-D*	Spring, Summer, and Fall	CN- (free), SO4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from the TMF prior to discharge to Southwest Arm
MWS-14-02 OB MWS-14-02-BR G6-BR-14 G6-OB-14 Proposed Monitoring Well MW-L	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from WRSA D prior to discharge to Southwest Arm
BH14-15 MWS-14-03 OB1 MWS-14-03 OB2	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from WRSA D prior to discharge to Southwest Arm Tributary
MWS-14-04 Proposed Monitoring Well MW-M and MW-O	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from WRSA B and/or Ore Stockpile prior to Discharge to Southwest Arm
Proposed Monitoring Well MW-A MW6-OB-13	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effect of seepage from WRSA C prior to discharge to Mosher Lake
Proposed Monitoring Well MW-B (north of WRSA A) MW3-OB-13 MW3-BR-13 MW03-OB-18 MW03-BR-18	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, and Ur	Monitor for potential effects of seepage from WRSA A prior to discharge to Central Basin and Barton Bay

Table 2-8: Groundwater Trigger Threshold Monitoring Locations, Frequency, Parameters, and Rationale

Trigger Threshold Monitoring Location	Frequency of Measurement and Comparison to Trigger Threshold	Trigger Threshold Parameter	Rationale
Proposed Monitoring Well MW-F Proposed Monitoring Well MW-G	Spring, Summer, and Fall	SO_4, and dissolved Sb, As, Co, Fe, Ur, BTEX, and PHCs	Monitor for potential effects of the process plant and associated facilities (fuel storage) on groundwater quality as well as potential effects of seepage from upgradient WRSAs.

2.3.2.2 Groundwater Trigger Thresholds and Response Plans

Groundwater Quantity

Adaptive management with respect to groundwater quantity would be initiated in the event of one of the following trigger thresholds:

1. The groundwater level declines below the predicted minimum groundwater level elevation (based on observed minimum groundwater elevation from baseline data and maximum predicted drawdown over the life of the Project). At monitoring well BH14-01, drawdown is predicted to occur in relation to aggregate pit S1 dewatering as well as subsequent mounding is predicted to occur in relation to the TMF; therefore, a minimum and maximum trigger threshold has been defined for BH14-01 (refer to Table 2-9). The groundwater levels will be compared to the trigger thresholds in spring, summer, and fall.

2. The average daily pumped volume determined on a quarterly basis exceeds the predicted dewatering rate presented in the EIS/EA (Stantec 2018a) for the open pit, historical shafts, and/or aggregate pits (Refer to Table 2-10).

3. Prior to the diversion of GFC, a horizontal hydraulic gradient toward the SWAT from proposed Monitoring Wells MW-F and MW-G is not observed during construction dewatering associated with the process plant (e.g., the water level at MW-F and MW-G is less than the surface water level of the SWAT). The data will be compared to the trigger threshold on a monthly basis while construction dewatering associated with the process plant is occurring.

4. An inward horizontal hydraulic gradient is not maintained toward the MHT seepage collection drain and/or the open pit. The data will be compared to the trigger threshold in the spring, summer, and fall.

5. A trigger threshold to confirm the reversal and timing of reversal of the horizontal hydraulic gradient between the historical tailings and Kenogamisis Lake as a result of open pit dewatering will be defined once updated groundwater flow modelling is completed.

If one of the trigger threshold criteria is identified, then the following actions will be completed:

1. **Confirm the result** – remeasure the water level or pumped volume to confirm the indicator parameter value. Confirm the equipment used to make the measurement is operating as intended by the manufacture.

    - If remeasuring indicates a value that meets the defined groundwater quantity trigger threshold then no action is required and continue with the monitoring plan.

    - If the original measurement is validated, then complete an evaluation of the data.

2. **Evaluate the dataset**:

    - Compare the groundwater level or pumping volume to meteorological data and groundwater and surface water quantity data for the Project to determine if the exceedance is related to a single anomalous event such as a meteorological event, seasonal variation, or the potential for a project related effect.

    - If the trigger threshold exceedance is not Project related, then continue with ongoing monitoring. Otherwise proceed to Action 3.

3. **Complete an investigation** to determine if an adverse effect is occurring in the receiving environment. Based on the information derived from the investigation, the potential relevance of the exceedance event to surface water features, aquatics, and wetlands will be evaluated through a qualitative risk evaluation. At this time, more rigorous monitoring may be recommended for the nearby surface water features, aquatics, and/or wetlands. Notify IAA, MECP, and EAC if new mitigation is required. Document the results of the assessment in the annual report (refer to Section 2.3.3).

Table 2-9: Preliminary Groundwater Level Trigger Thresholds

Trigger Threshold Monitoring Location	Minimum Groundwater Level (m AMSL)	Date Observed	Predicted Drawdown (m)	Groundwater Level Trigger Threshold (m AMSL)
BH14-01*	337.2	4/3/2018 7:00	-7.51 and 1.76	<344.7 and >335.4
G7-OB1-14	333.7	9/4/2014 11:32	1.76	> 332.6
G7-OB2-14	332.7	4/3/2018 7:00	1.04	> 331.6
MW2-OB-13	332.7	4/12/2015 16:00	0.63	>332.0
MW8-OB-14	329.1	9/4/2014 11:00	0.70	> 328.4
MW14-OB-14	355.1	4/8/2014 18:00	0.27	> 354.8
MW14-BR-14	354.1	4/16/2014 6:00	1.93	>352.1
MW17-OB-14	337.0	4/1/2017 19:00	0.68	>336.3
MW08-18	328.6	8/26/2018 23:30	0.95	>327.6
MW01-OB2-18	329.8	06/27/2018 10:40	1.53	>328.2
MWS-14-01	335.1	8/2/2016 11:30	1.68	> 333.4
MWS-14-07 OB	329.2	10/17/2016 10:55	1.63	> 327.5

NOTES:

AMSL: above mean seal level

>: greater than

<: less than

*: Drawdown is predicted in relation to S1 pit dewatering followed by mounding associated with the TMF, therefore a minimum and maximum trigger threshold has been defined for BH14-01.

Once proposed monitoring locations DP-A and DP-B are installed and a minimum of one year of monthly water level data is collected, the minimum groundwater level for the purpose of the groundwater quantity trigger threshold will be assigned for these wells.

Table 2-10: Pumping Rate Trigger Thresholds

Trigger Threshold Monitoring Location	Maximum Groundwater Pumping Rate (m^3/day)
Aggregate Pit S1	1,979 (Stantec 2019a)
Aggregate Pit S4*	Negligible (Stantec 2019b)
Aggregate Pit T2	569 (Stantec 2019c)
Combined Pumping from Open Pit and Historical Underground Workings (via Mosher and Hardrock No. 2 Shafts)	14,860 (Stantec 2017)
Notes: *: The S4 pit is predicted to be an above water table aggregate extraction. Trigger thresholds may be updated as groundwater and water balance modelling updates are made over the life of the Project.	

Groundwater Quality

Trigger thresholds have been defined as concentrations for key indicator parameters that would initiate specific adaptive management actions depending on the severity of the action level triggered. Two trigger thresholds for groundwater quality have been defined each with a varying level of sensitivity and associated level of response. The purpose of establishing multiple action levels is to identify potential groundwater issues as soon as possible through routine screening, and to identify the appropriate action level to address potential impacts to groundwater resources as a result of the Project. The following section describes the two trigger thresholds and the rational for their selection. An example of the preliminary trigger thresholds compared to baseline data for arsenic is presented in Figure 2-16.

Trigger Threshold 1

The early identification of increasing trends in the concentration of indicator parameters, prior to guideline exceedance, is a primary component of the groundwater AMP. Trigger Threshold 1 is meant to identify potential issues associated with the Project before they have the potential to result in a significant adverse effect on the environment. The goal of Trigger Threshold 1 is to obtain more information about potential seepage, identify the source of the trend, if possible, and generally provide increase attention, information, and awareness of potential seepage before it reaches a trigger threshold concentration. Trigger Threshold 1 is defined as a statistically significant upward trend for a given indicator parameter or for stations that have a statistically significant upward trend in the baseline data, an increase in the magnitude of the trend compared to baseline.

Ongoing trend analysis will be completed using the Mann-Kendall test (Mann 1945; Kendall 1970, Walker and Harrison 2013). The Mann-Kendall test has been found to be a simple effective way to measure whether an indicator parameter is rising or falling. The test can be applied to as few as four points. For this application, the Mann-Kendall test will be applied to the last ten monitoring events.

Using the method cited by Walker and Harrison (2013), the Mann-Kendall test statistic (S) and the coefficient of variation will be calculated and applied using the 90% confidence level chart.

If Trigger Threshold 1 is exceeded the following actions will be undertaken:

1. **Quality Review of the data** – Complete a QA/QC review of the sampling methods, laboratory reports, and COC. Assess the validity of outliers that may be biasing the trend analysis. Resample the well and/or re-run the laboratory sample (if the sample is within hold time) to confirm the recent water quality data.
    - If QA/QC review indicates sampling or laboratory error and the applicable trigger threshold is not exceeded, then continue with monitoring.
    - If QA/QC review confirms trigger threshold is exceeded, then proceed to Action 2.
2. **Complete a physical inspection of the identified monitoring well and associated area**.
    - If the monitoring well is compromised, contract a licensed well contractor to repair the well and complete resampling of the well once repaired and re-developed to confirm if applicable Trigger Threshold is exceeded.
    - If the monitoring well is in good condition and there is no obvious reason for the exceedance of the applicable Trigger Threshold, then proceed to Action 3.
3. **Review available data** – Review available data to determine if a cause for the trigger threshold exceedance can be determined. For example, is the exceedance related to a single anomalous event such as a meteorological event, seasonal variation, or the potential for a project-related effect.
    - If review indicates the occurrence is anomalous or may subside, such as for non-Project related effects, document the assessment in the annual report (refer to Section 5) and continue monitoring to confirm reduction.
    - If review suggests concentrations are increasing or remaining elevated above predictions for extended periods and/or has the potential to be related to the Project, go to Action 4.
4. Refer to Trigger Threshold 2 action plan.

Trigger Threshold 2

Trigger Threshold 2 is defined as an exceedance of Trigger Threshold 1 and an exceedance of predicted source concentrations for the mine component located upgradient of the trigger threshold monitoring well location (TMF, WRSA, Ore Stockpile, etc.) as defined in the EIS/EA (Stantec 2018a) or exceeding the APV, whichever concentration is lower except for cobalt and uranium. The predicted concentration of cobalt and uranium in seepage from the TMF is less than the 95th percentile for baseline data. Therefore, in these instances the APV will be used as Trigger Threshold 2. Trigger Threshold 2 is defined to alert to

the need for additional investigation prior to the potential to significantly affect the receiving surface water quality. The EIS/EA was completed assuming at source seepage concentrations discharging from groundwater to surface water with no attenuation along the groundwater flow path. The APVs are considered conservative as they are the established water quality criteria in surface water and are used to determine the acceptable concentrations in groundwater (GW-3 values) by back-calculation through a defined modelling process that considers a ten times dilution in the receiving environment. If an indicator parameter exceeds Trigger Threshold 2, the following actions will be undertaken.

1. **Notify IAA, MECP, and the EACs of the trigger threshold exceedance and that an investigation will be completed.**

2. **Complete an investigation** – to assess whether the exceedance is Project-related. The investigation will be designed, implemented, and interpreted by a Qualified Person. The investigation may include the following key aspects:

    - Lateral and vertical extent of contamination: assess whether the exceedance event is isolated to one well or several wells, and whether the exceedance is limited to one or both of the shallow and deep wells at a given location.

    - Contaminant Pathway: based on the well interval(s) showing the exceedance and on borehole logs for the well installations, define the geological properties and hydrostratigraphic unit(s) of the seepage pathway.

    - Parameter(s) of concern: assess whether there are changing trends associated with other parameters at the given monitoring well.

    - Magnitude of exceedance above the trigger threshold: assess whether the exceedance represents a minor or significant deviation from the trigger threshold. Review the concentration of the source of the exceedance to predicted concentrations to assess the potential for the parameter to further degrade groundwater quality.

    - If required, augment the monitoring network to delineate source of seepage or increase sample frequency.

3. Based on the information derived from the Trigger Threshold 1 action plan and/or Trigger Threshold 2 investigation, the potential relevance of the exceedance event to surface water quality in the receiving surface water feature will be evaluated through a qualitative risk evaluation. At this time, more rigorous monitoring may be recommended for the downgradient surface water features (e.g., increased sampling frequency, increased number of sample locations, additional parameters).

4. Conclude whether exceedance is related to Project and if so whether it is incidental (accident/malfunction), operational (related to an operational procedure that may be mitigated relatively easily, e.g., pumping configuration), and/or effects of seepage from mine components (e.g., TMF, WRSA).

- If exceedance is not related to the Project continue with the monitoring plan with modifications to the plan as recommended by the Qualified Person based on the outcomes of the investigation and document the assessment in the annual report (refer to Section 2.2.3). Notify IAA, MECP, and the EACs of the outcome of the investigation and that the details of the investigation would be documented in the annual report.

- If the exceedance is deemed related to the Project, refer to Action 5

5. **Mitigate effects of the Project:** If mitigation is deemed necessary, options designed to reduce the seepage flow reporting to groundwater could include, but is not limited to:

    - Persistent seepage flows detected in the seepage collection ditches that cannot be adequately captured by existing sump stations will be addressed by the installation of larger seepage collection pumps, where necessary, to direct seepage to the appropriate facility (e.g., pumped back to TMF or ETP).

    - Modifications to the existing ditch system to increase seepage collection efficiency (e.g., modification of ditch geometry, alignment, or construction materials).

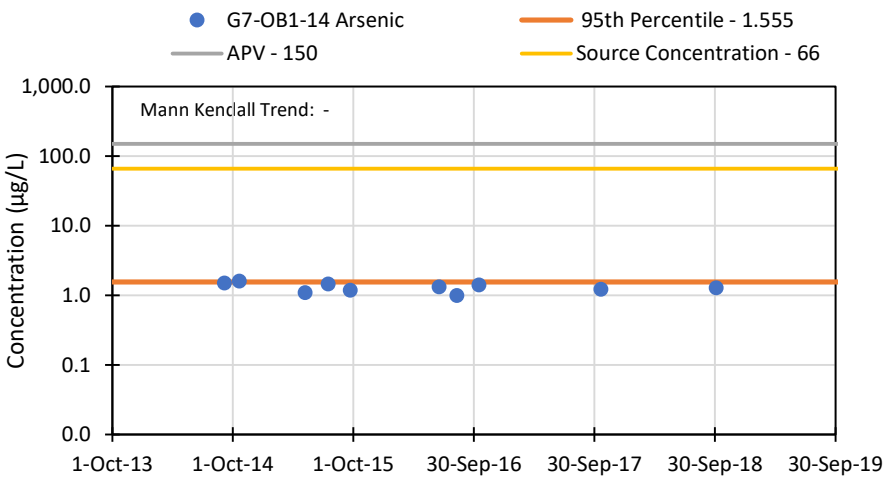
    - Installation of one or multiple groundwater pump-back wells that could serve as a hydraulic barrier (i.e., collection of plume waters and pump back to TMF).

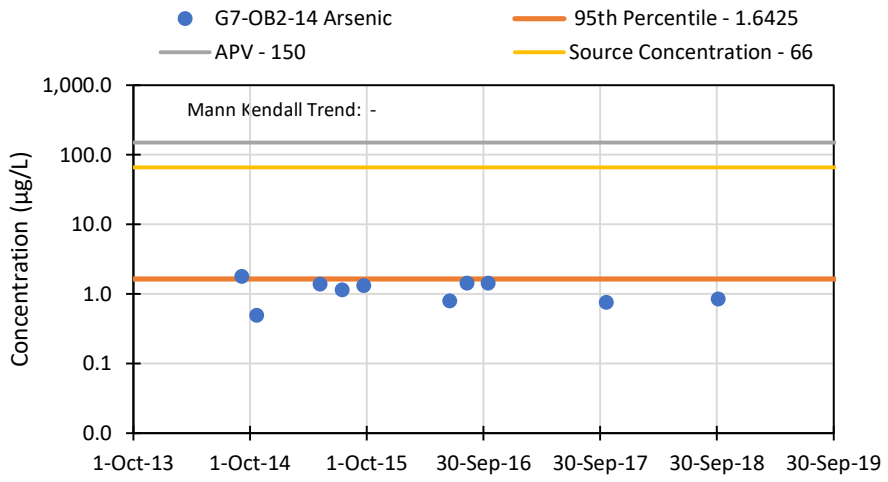
    - Installation of a barrier wall that could include sheet pile, grout curtain or localized grouting of bedrock.

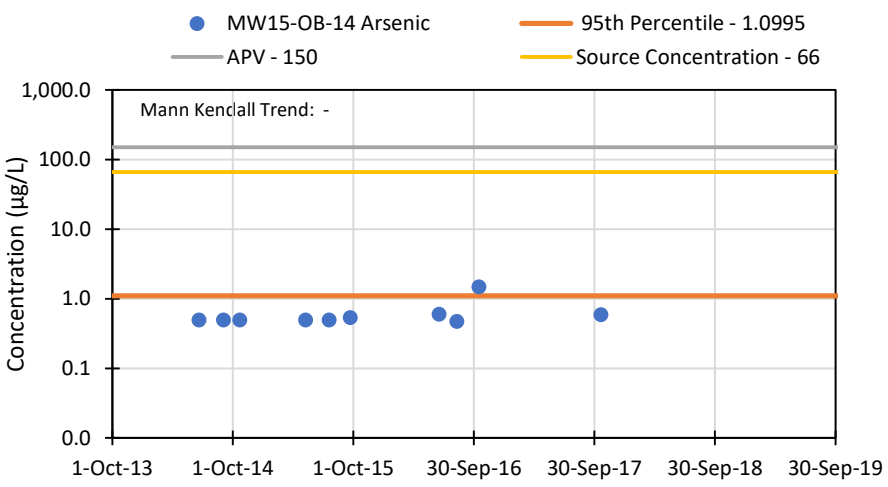
    - For some parameters and flow paths, passive treatment options may offer a viable alternative to other contingency measures. These could include permeable reactive barriers or other forms of seepage interception systems designed to passively treat groundwater plumes *in situ*.

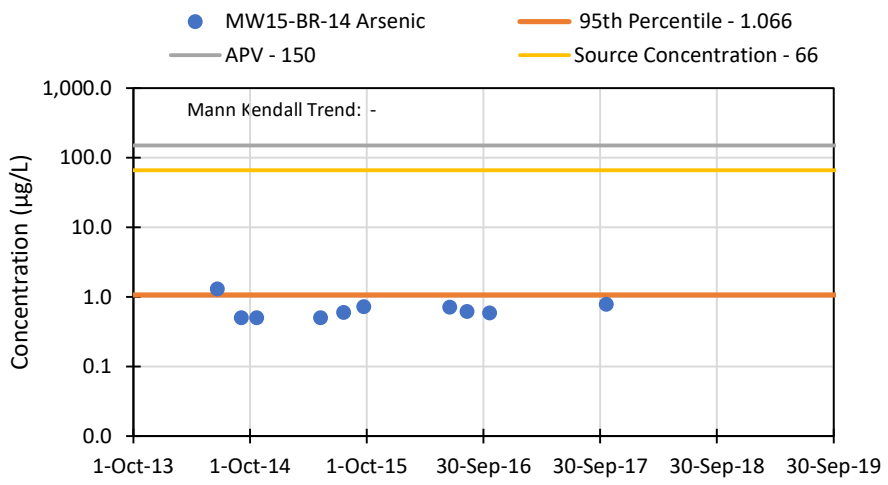
    - Based on consideration to the primary investigation described as part of Trigger Threshold 1, secondary evaluation measures may be proposed to better define the source, extent and/or pathway of the contaminant plume. This may include: installation of additional monitoring wells to better constrain the seepage pathway (nature of conductive unit and vertical/lateral extent of the plume); hydraulic testing and discrete interval sampling to better determine whether the seepage plume is isolated to discrete units or fracture zones or distributed over a wider area.

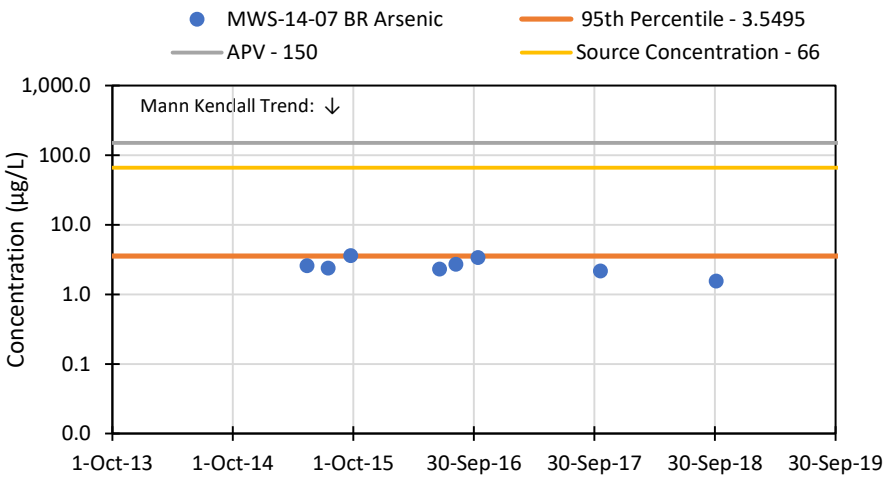
    - Numerical modelling to better quantify the contaminant flux to local watercourses.

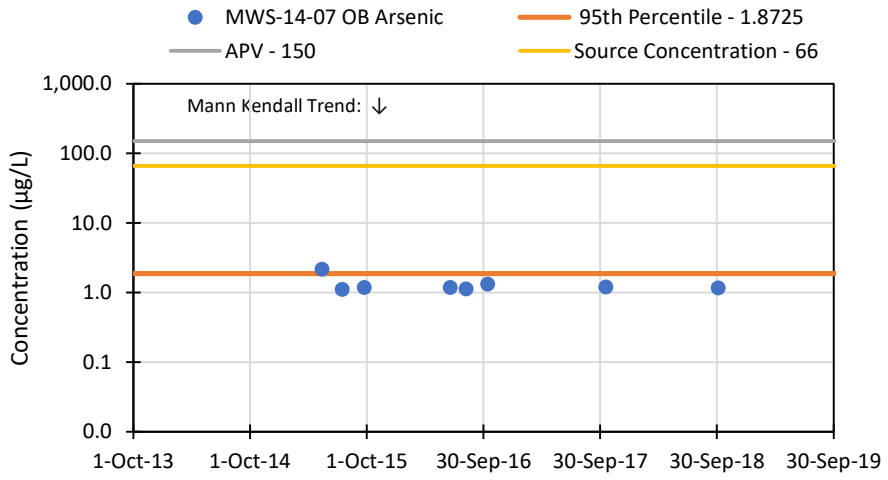


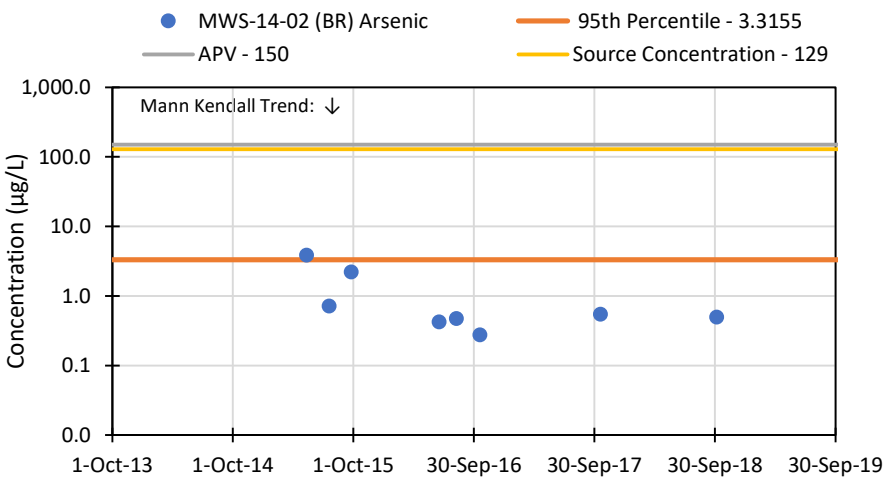


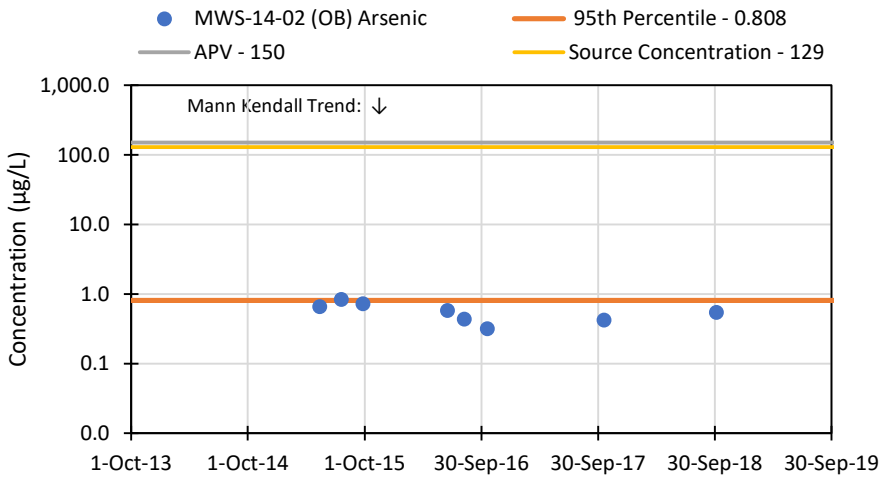


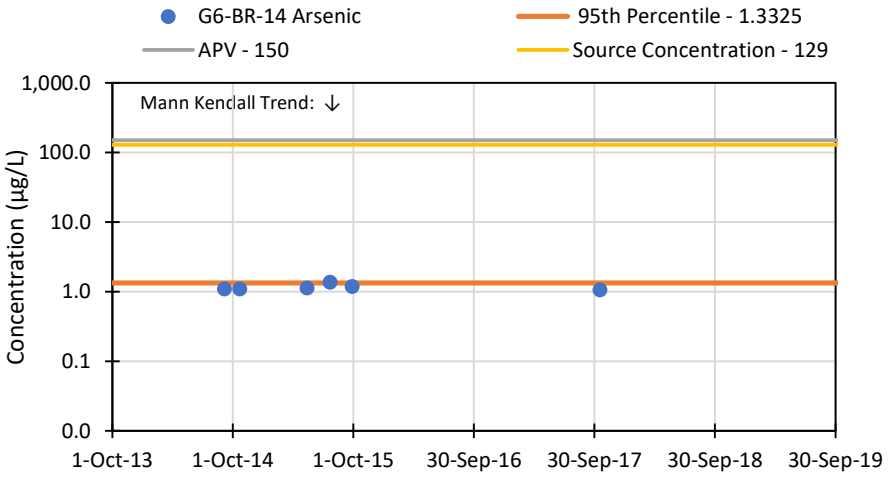


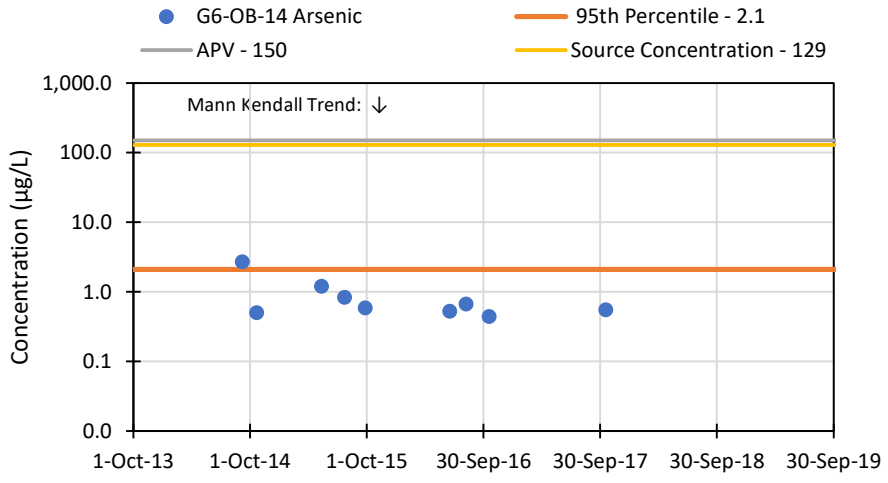












Notes:

↑: Increasing Mann Kendall trend analysis for last 10 sampling points

↓: Decreasing Mann Kendall trend analysis for last 10 sampling points

-: Negligable Mann Kendall trend analysis for last 10 sampling points

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

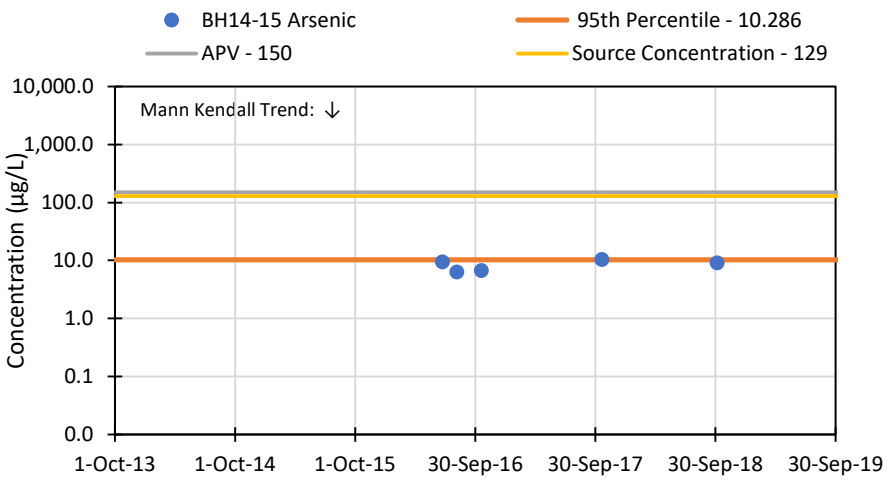
Figure No.

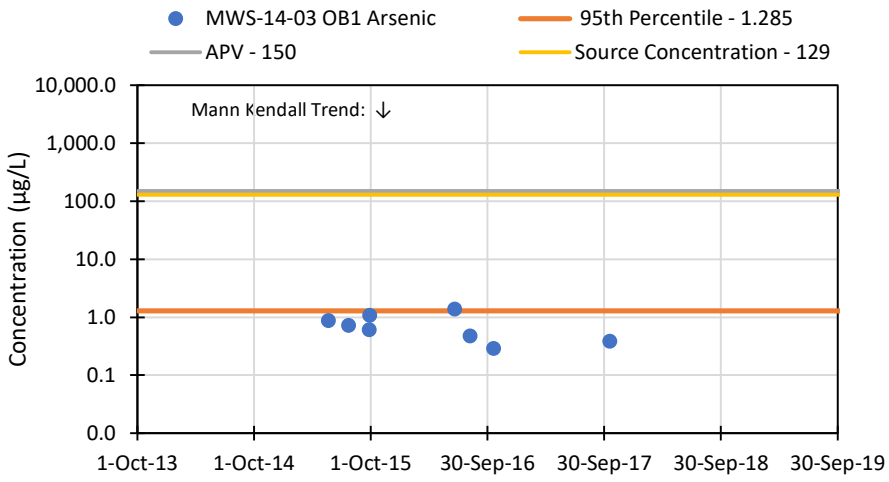
2-16A

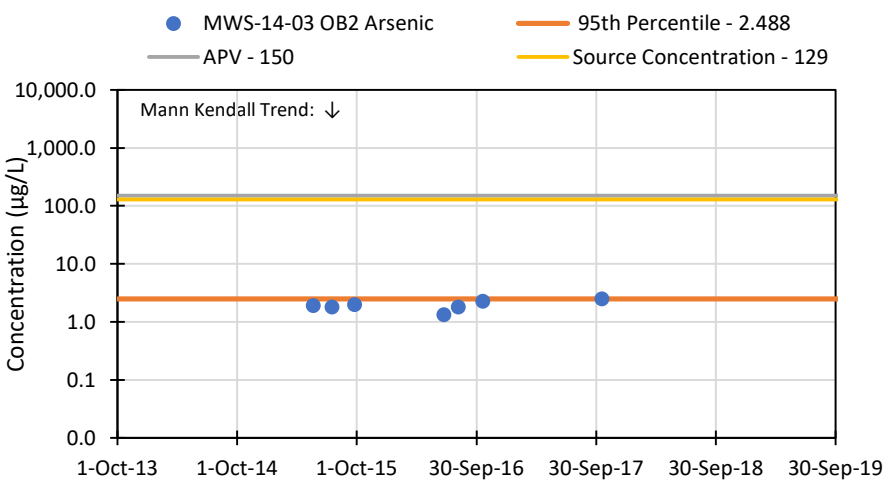
Title

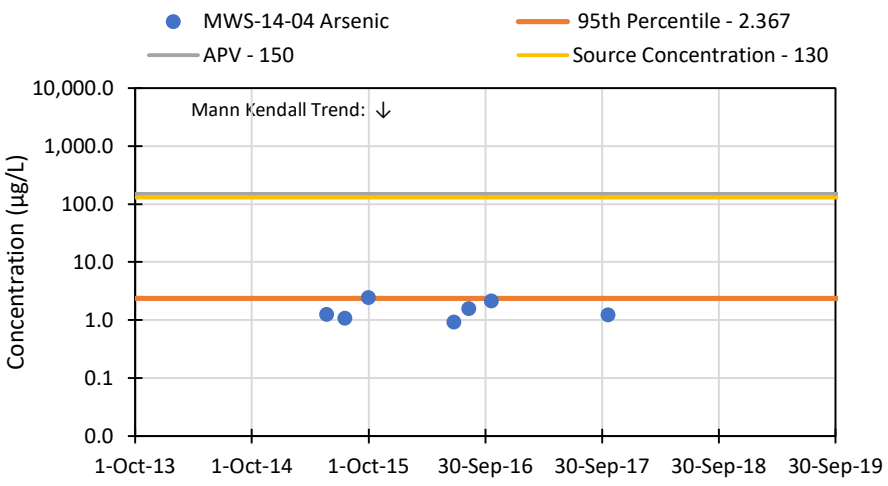
Dissolved Arsenic Concentrations (Groundwater)

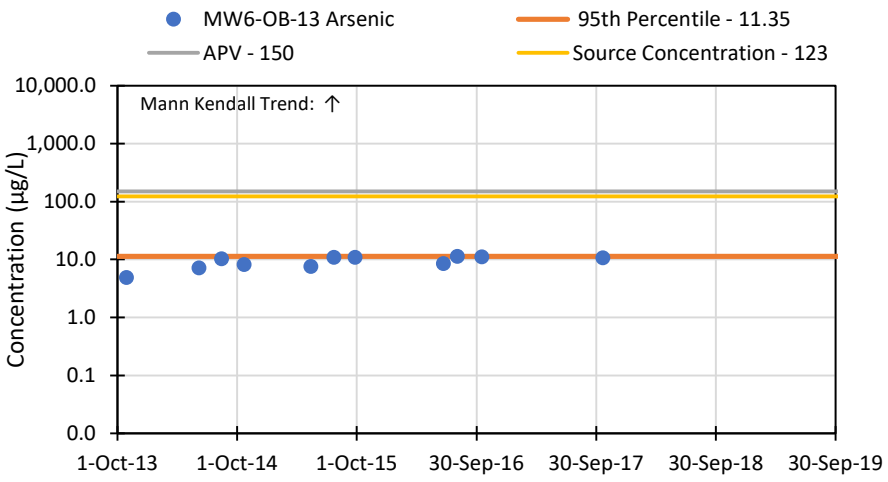
Stantec

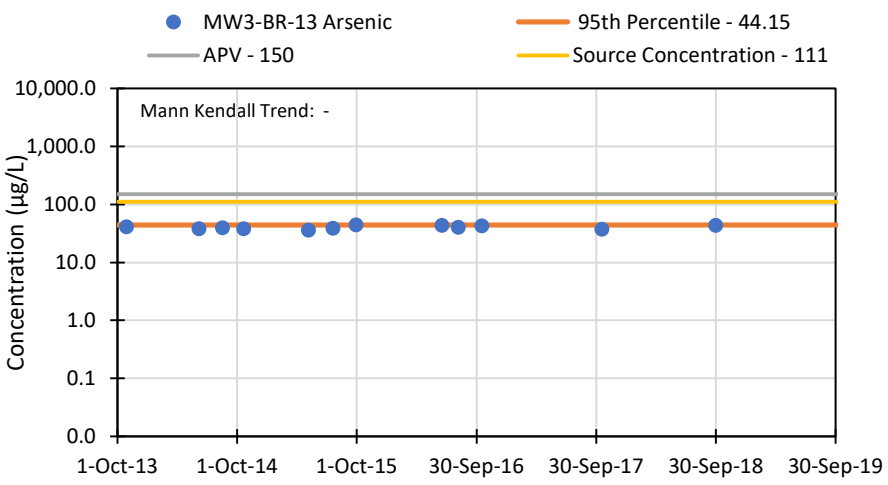


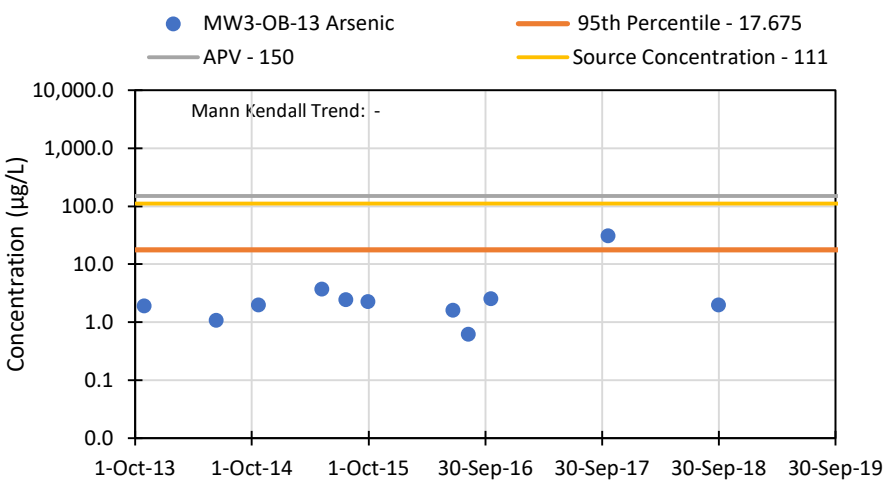


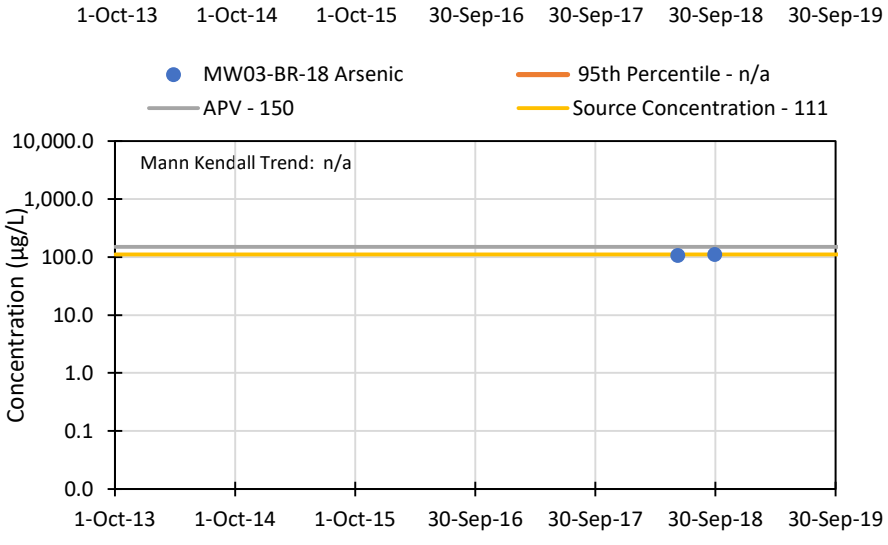


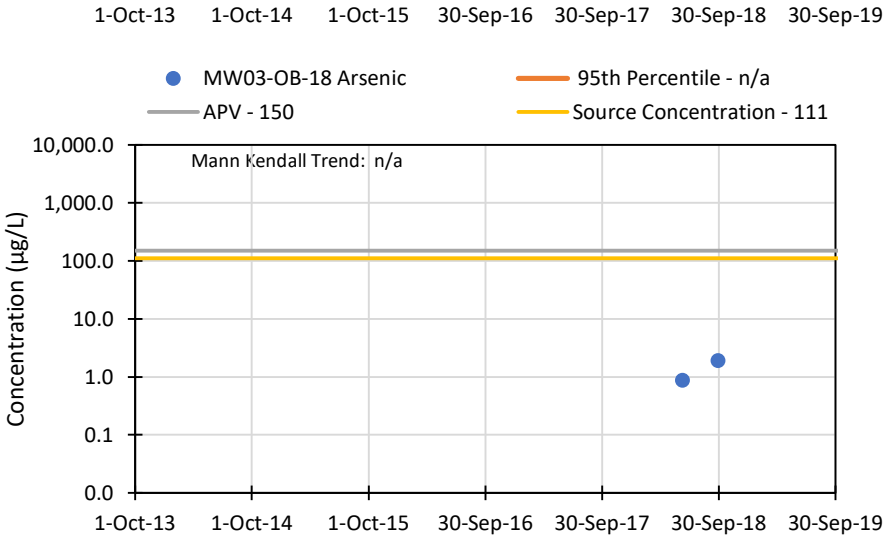












Notes:

↑: Increasing Mann Kendall trend analysis for last 10 sampling points

↓: Decreasing Mann Kendall trend analysis for last 10 sampling points

-: Negligable Mann Kendall trend analysis for last 10 sampling points

Client/Project

Fish and Fish Habitat Follow-Up Monitoring Plan
Hardrock Project
Greenstone Gold Mines

Figure No.

2-16B

Title

Dissolved Arsenic Concentrations (Groundwater)

Stantec

2.3.3 Reporting

For this Fish and Fish Habitat Monitoring Plan, each reporting year will be from October 1 of a calendar year through September 30 of the subsequent calendar year (as stated in Condition 1.3). GGM will prepare an annual report no later than December 31 following the reporting year to which the annual report applies. The content of the report is expected to vary each year, depending on the monitoring activities that are planned and available results for a given year. The annual report will be factual, presenting the monitoring data with limited interpretation of results.

As applicable, the annual groundwater report may include the following:

1. Summary of monitoring activities which were conducted in the previous year and monitoring components that are planned in the given year
2. Tabulated results of the groundwater monitoring program, as available (i.e., results of laboratory analyses)
3. Comparison of data to predictions from the EIS/EA
4. Comparison of data to trigger thresholds, as data is available, identification if a trigger threshold was exceeded, and mitigation and/or adaptive management that was implemented, if required.

More detailed interpretation and analysis of the results will be completed as part of reporting requirements under the MDMER, EEM, and permit conditions.

2.4 Use of Explosives in or Near-Water

The following section describes GGM's planned mitigation measures to mitigate potential adverse effects on fish and fish habitat from the use of explosives near water to satisfy federal Condition 3.2 and 3.15 of the EIS. There will be no use of explosives in water. GGM has taken into account Fisheries and Oceans Canada's (DFO) Measures to avoid causing harm to fish and fish habitat including aquatic species at risk as it pertains to the use of explosives in or near water.

This follow-up program describes the plan to monitor instantaneous pressure and peak particle velocity during the first blasting event (Condition 3.15.1) and throughout the life of the project. This follow-up program also describes measures that will be taken if the results of the monitoring demonstrate that modified or additional mitigation measures are required to protect fish and fish habitat (Condition 3.15.2) and provides a commitment to implement modified or additional mitigation measures during subsequent blasting events as required.

2.4.1 Routine Monitoring

The open pit is generally set back a sufficient distance from fish and fish bearing habitat to limit potential effects to fish and fish habitat due to the use of explosives, except in the area of the eastern extension. The edge of the eastern extension of the open pit is located approximately 220 m of the high-water level mark of Kenogamisis Lake. However, predicted overpressure and peak particle velocity (vibrations) in fish habitat were less than federal guidelines (Stantec 2017) and therefore impacts to fish or fish habitat as a result of blasting were deemed not significant in the EIS.

DFO guidance for protecting fish from blasting overpressure (instantaneous pressure change) and vibrations are used for the follow-up monitoring. An overpressure threshold of 50 kPa (in the water) is used for the Project. The vibration threshold is 13 mm/sec within the substrate of the waterbody.

The monitoring locations, sampling frequency, sampling methods, and parameters related to the use of explosives near water are presented in the following sections.

2.4.1.1 Location

Two fish habitat monitoring locations (FH01 and FH02) have been identified at the high-water mark of Kenogamisis Lake for the open pit blasting monitoring program (Figure 2-17). The water level of Kenogamisis Lake may be below these monitoring locations during dry periods, and therefore, these locations may potentially be moved out to the active shoreline, depending on the level of water during monitoring.

504000

WC-G
WC-E
WC-I
Trans-Canada Highway 11
WC-D
WC-GH
Hardrock Road
FH01
FH02
Kenogamisis Lake (Central Basin)
WC-J1
Kenogamisis Lake (Southwest Arm)
N
bing

504000

V:\01609\active\160960865\drawing\MXD\Noise\Report_Figures\Noise _and_Vibration_MMP\160961293_Fig_7_3_FishBlastMonitoringLocations_20200714.mxd
Revised: 2020-07-14 By: dharvey

Stantec

Legend

- Fish Blasting Monitoring Location
- Kenogamisis Lake High Water Mark (330 masl)
- Kenogamisis Lake Conservative High Water Mark (330 masl)
- Open Pit- Full Extent
- Contour Line (10m intervals)
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody

0 100 200 m
1:8,000

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N

2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

3. Orthographic Imagery Source: © 2020 Microsoft Corporation © 2020 Maxar ©CNES (2020) Distribution Airbus DS

July 2020
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Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

2-17

Title

Receptor Locations Monitoring Potential Effects on Fish

2.4.1.2 Frequency

As required by Federal Condition 3.15.1, instantaneous pressure change, and vibration will be monitored during the first blasting event. Blasting vibration monitoring will also occur during blasting events that occur within the restrictive timing window for work in and around water (i.e., April 1 to June 20). Blast monitoring may be discontinued after monitoring three consecutive blasting events only if 1) thresholds are not exceeded, 2) subsequent blasting uses an equal or lesser blast charge and/or 3) the blasting occurs farther away from fish habitat. Blast monitoring will be re-initiated if there is potential to exceed the threshold.

Similarly, overpressure monitoring may be discontinued if 1) thresholds are not exceeded, 2) subsequent blasting uses an equal or lesser blast charge and/or 3) the blasting occurs farther away from fish habitat. Blast monitoring will be re-initiated if there is potential to exceed the threshold.

Water quality monitoring of total suspended sediments (TSS) and pH in Kenogamisis Lake as described in Section 2.4 will address water quality monitoring needs associated with the use of explosives in the eastern extension of the open pit. Measurements of TSS will be conducted during the initial blasting event.

2.4.1.3 Methods

The monitors selected for installation should be capable of recording overpressure and vibration levels simultaneously. The units will be connected with a hydrophone to measure overpressure in KPa in the waterbody and a geophone capable of monitoring vibration levels in mm/sec in three axes (e.g., transverse, vertical, and longitudinal). The calibrated hydrophones will be deployed in shallow water (0.5 to 2 m depth). Hydrophones would be set on tripods, suspended approximately 15 to 20 cm from the surface of the water.

Mitigation applied to the use of explosives in the open pit, including selection of blast charges and delays, is expected adequately address potential effects on fish and fish habitat and therefore no other monitoring is recommended.

2.4.2 Adaptive Management

The application of hydrophone and geophone monitoring is both economically and technically feasible and has been used in other blasting applications in North America. Overpressure in water should not exceed 100 KPa although 50 KPa is recommended. Vibration levels should not be greater than 13 mm/sec. These thresholds are recommended by DFO to prevent harm to fish. If overpressure or vibration thresholds are exceeded, the charge/delay per Kg or number of blast holes should be lowered and/or the distance of blasting to fish bearing waters could be increased until thresholds are met. Based on predicted overpressure or vibrations, effects on fish are not anticipated. If overpressure or vibration values are predicted to exceed the thresholds, the use of fish deterrents such as bubblers in the nearshore area adjacent to the eastern extension of the open pit would be considered, pending approval from DFO and the Ministry of Natural Resources and Forestry (MNRF).

The use of explosives in the eastern extension of the open pit should not occur during the restricted activity period of April 1 to June 30 to be protective of Yellow Perch and Northern Pike which may spawn in adjacent waters of the eastern extension. If the use of explosives is required in the eastern extension during the restricted activity period, the charge/delay per Kg and/or the number of blast holes will be reduced to meet overpressure and vibration thresholds to limit the potential to impact fish. To maintain the production capacity and alleviate economical impact during this restricted period, additional blasting may be required during weekdays and weekends.

If the concentration of TSS and pH (Section 2.4) conducted in Kenogamisis Lake exceeds 15 mg/L and 9, respectively, and cannot be sourced to elevated effluent discharge or natural background conditions, then blasting should cease in the eastern extension until appropriate mitigation measures are put in place.

If death of fish is observed immediately after the use of explosives, further use of explosives will be halted until causes of the death of fish is determined and appropriate mitigation measures are put in place.

2.4.3 Reporting

Reporting to DFO for the overpressure and vibration values will be completed once the results are analyzed to demonstrate the level of compliance. The report will include a description of observed exceedances (if exceedances are identified during the monitoring period). Should an exceedance occur, the recorded overpressure or vibration values will be reported, along with monitoring location, blasting location, and blasting charge size. There will be one report per year unless compliance cannot be achieved, and additional monitoring is required. Additional reporting would also be required if effects such as death of fish are observed, at which time the DFO would be notified within 24 hours. In the event dead fish are observed, blasting of the eastern extension of the open pit would cease immediately until discussions with DFO were conducted and further mitigation applied. In the absence of such exceedances, a monitoring report will be submitted to Environment and Climate Change Canada (ECCC) no later than December 31 following the reporting year to which the annual report applies. For this Fish and Fish Habitat Monitoring Plan, each reporting year will be from October 1 of a calendar year through September 30 of the subsequent calendar year (as stated in Condition 1.3).

2.5 Concentration of Mercury and Methylmercury in Water

2.5.1 Routine Monitoring

The realignment of GFC is planned to facilitate siting of the TMF and to offset for predicted effects on fish and fish habitat. GFC will be diverted into the existing SWAT, which will increase flow in the SWAT and result in an increase of the permanently inundated area by approximately 15 ha. The management and monitoring measures identified in this section deal specifically with potential effects related to changes in mercury concentrations and methylmercury generation in the GFC diversion. The surface water monitoring locations, sampling frequency, and sampling methods as it pertains to mercury and methylmercury are presented in the following sections.

2.5.1.1 Location

Surface water at stations 25, 39, and 52 presented in Figure 2-1, will be monitored monthly to assess for potential changes to mercury and methylmercury as a result of the GFC diversion and associated inundated areas. Surface water monitoring locations will be reviewed at regular intervals through the AMP presented in Section 2.2.2. Monitoring locations may be added or removed from the monitoring program in accordance with their utility in monitoring the effects of the Project on the environment or to account for modifications during detailed design.

2.5.1.2 Frequency

Table 2-11 presents the frequency of sampling and rationale for each monitoring station for surface water quality. Three (3) surface water monitoring locations will be monitored monthly for mercury and methylmercury, when safe to do so, to assess seasonal fluctuations in water quality. Monthly monitoring data will be used to conduct trend analysis of surface water quality to differentiate whether observed fluctuations in quality are due to natural/seasonal sample variation, or if they may indicate a project related effect. The frequency of monitoring will be reduced to quarterly if there are no trigger thresholds exceeded during a two-year period (approximately 24 samples). The surface water quality monitoring stations are shown in Figure 2-1.

Table 2-11: Receiving Environment Surface Water Quality Monitoring Locations, Frequency, and Rationale

Station	Frequency	Rationale
25	Monthly	Monitor potential effects of the Project, including the GFC diversion, on mercury and methylmercury concentrations in surface water at the downstream end of the GFC diversion
39	Monthly	Monitor potential effects of the Project, including the GFC diversion, on mercury and methylmercury concentrations in surface water in SWP3 and the middle section of the channel diversion
52	Monthly	Document background mercury and methylmercury concentrations in surface water upstream of the GFC diversion

2.5.1.3 Methods

Surface water grab samples will be collected using laboratory-provided bottles, containing appropriate preservative. Samples for dissolved forms of metals will be filtered using a 0.45 µm membrane filter. Water quality samples will be taken just below the surface of the water (0.1 m deep). Water quality samples will be collected by a qualified technician using suitable sampling equipment. Samples will be preserved (if applicable) and transported in appropriate containers to maintain the integrity of sample temperatures and hold times. Samples will be submitted to a CALA accredited laboratory under COC documentation. The accredited CALA laboratory will use the authorized analytical methods set out in the industrial sewage works (ISW) Environmental Compliance Approval (ECAs), permits to take water (PTTWs), and regulations (i.e., MDMER and Ontario Regulation 560/94).

The method detection limits (MDLs) used by the CALA laboratory for mercury and methylmercury have been revised since the beginning of the baseline monitoring program. MDLs for mercury and methylmercury are currently 0.0001 µg/L and 0.00002 µg/L, respectively. The current MDLs are capable of detecting the concentrations of mercury of methylmercury in surface water and have been used to develop baseline and 95th percentile concentrations for surface water quality stations 25, 39, and 52.

QA/QC principles for sampling and laboratory analysis outlined in Environment Canada (2012) will be followed. Duplicate samples will be collected from a subset of samples collected to quantify environmental variability and analytical consistency, with a minimum of one duplicate sample in approximately 10 surface water samples per sample set. A minimum of one travel and one field blank will be collected per sampling event to detect potential sources of contamination. Field instruments will be calibrated regularly according to the manufacturer's specifications and calibration logs will be maintained.

Water quality data will be entered into an electronic database and will be cross-checked against the original laboratory certificate of analysis and validated.

2.5.2 Adaptive Management

The AMP for surface water quality presented in Section 2.2.2 defines mercury and methylmercury as indicator parameters and has defined trigger thresholds for adaptive management. The AMP in Section 2.2.2 should be referred to for the mercury and methylmercury adaptive management.

A summary of the mitigation measures and strategies that will be carried out to address possible changes to the concentrations of mercury and methylmercury as a result of the Project are as follows:

- Clearing and grubbing of organic vegetation prior to inundation to reduce potential mercury methylation. This is particularly relevant for the aggregate pit area in the GFC diversion pond and the diversion channel from the pond to Lahtis Road.
- Removal and collection of organic soils, where feasible, for subsequent use in progressive rehabilitation to reduce potential mercury methylation. This is most feasible in the upper section of the realignment and aggregate pit area.
- The proposed inundation areas specifically reduce shoreline erosion, which is otherwise known to accelerate potential mercury methylation release.
- The proposed inundation zones are riverine in the upper stream realignment and more lacustrine in the Southwest Arm Tributary lowland. The diversion increases the catchment area of Southwest Arm Tributary by more than 200% and will flush more water through the system than under baseline conditions, reducing the potential for concentration increase over time under static or low flow conditions.
- Defining of trigger thresholds to alert to changing conditions for surface water quality, soil and sediment quality, and fish tissue that, if exceeded, will trigger adaptive management that may include investigation of cause or corrective action.

2.5.3 Reporting

Mercury and methylmercury are both parameters included in the water quality monitoring plan presented in Section 2.1. As such, Section 2.2.3 annual reporting should be referred to for federal Condition 5.4 of the EIS reporting.

2.6 Fish Tissue Monitoring - SWAT

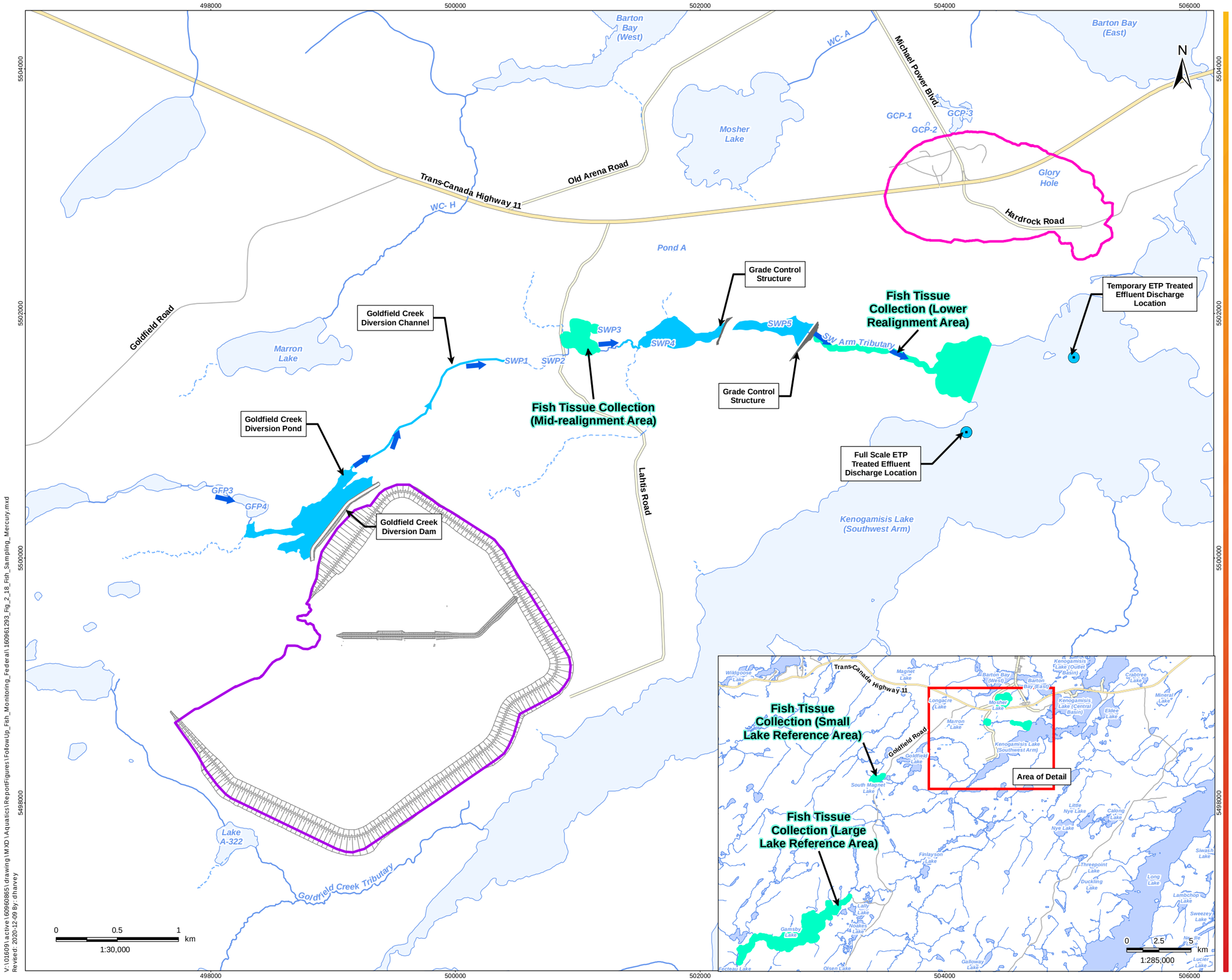
2.6.1 Routine Monitoring

The realignment of GFC is planned to facilitate siting of the TMF and to offset for predicted effects on fish and fish habitat. GFC will be diverted into the existing SWAT, which will increase flow in the SWAT and result in an increase of the permanently inundated area by approximately 15 ha. The management and monitoring measures identified in this section deal specifically with potential effects related to changes in mercury concentrations and methylmercury generation in the GFC diversion.

The purpose of fish tissue sampling as part of the Fish and Fish Habitat Follow-Up Plan will be to monitor potential changes in the concentration of mercury and methylmercury in fish tissue and, if changes are observed, to determine if there is an adverse effect on fish health or an increased risk to human and wildlife consumers. A BACI study design will be implemented, examining potential changes in mercury and methylmercury concentrations in fish tissue along the Goldfield Creek realignment. Yellow Perch (*Perca flavescens*) will be used at the sentinel species for mercury monitoring, as they may be consumed by humans and by wildlife and are the only species that are abundant enough in each test areas to achieve a reasonable sample size.

2.6.1.1 Location

Yellow Perch fish tissue will be collected from two test areas, one in the middle of the realignment (SWP3), and one at the downstream end of the realignment (downstream of both grade control structures) (Figure 2-18). Fish tissue collection efforts at the downstream end of the realignment will first be focused within the realigned channel, between the grade control structures and Kenogamisis Lake. Sampling efforts will only be extended into Kenogamisis Lake if the required number of fish cannot be captured after triple pass electrofishing effort within the stream channel. If sampling in Kenogamisis Lake occurs, fish tissue collections will be limited to the small bay at the outlet of the stream realignment. Reference sampling areas will include a small lake reference and a large lake reference, to account for potential variability in natural systems and to reflect the varying conditions that test fish may inhabit. The small lake reference area will be South Magnet Lake and the large lake reference area will be Gamsby Lake (Figure 2-18).



Legend

- Fish Tissue Collection Area
- Flow Direction
- Diffuser Location
- Tailings Management Facility
- Open Pit- Full Extent
- Diversion Channel
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

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Figure No.

2-18

Title

Sampling Areas for Monitoring Mercury and Methylmercury in Fish Tissue

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Revised: 2020-12-09 By: dharvey

2.6.1.2 Frequency

The frequency for fish tissue monitoring is provided in Table 2-12. The need for continued fish tissue monitoring as part of the Mercury Monitoring and Management Plan will be re-assessed after the first three years of monitoring.

Table 2-12: Anticipated Timing for Fish Tissue Collection in SWAT

Sampling Location	Sampling Year[1]										
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Reference Area (GMBY and SMLK)			✓	✓	✓	[2]					
Mid-Realignment (SWP3)			✓	✓	✓	[2]					
Lower realignment or Southwest Arm of Kenogamisis Lake			✓	✓	✓	[2]					

Notes: [1] Sampling years based on the start of construction as Year 1, with creek diversion occurring in Year 2.
[2] The need for continued fish tissue monitoring will be re-assessed after the first three years of monitoring

2.6.1.3 Methods

It is anticipated that, if they were to occur, changes in methylmercury in water and fish would be most pronounced shortly after construction and then return to near-baseline conditions over time (St. Louis 2004). This would make young-of-the-year (YOY) fish suitable for monitoring change in the first few years following construction because they are representative of conditions in a given sampling year. YOY fish are also preferred because they presumably have a smaller geographic range than their adult counterparts and are, therefore, more representative of the site from which they are collected. YOY Yellow Perch (age 1) will be preferentially targeted for the mercury monitoring study. Age 2+ Yellow Perch may also be collected if sufficient age 1 Yellow Perch cannot be captured.

Fish may be collected using a variety of methods, but it is anticipated that electrofishers, gill nets and minnow traps will be the main collection tools.

Composite samples will be created by combining whole Yellow Perch into a single sample (the anticipated minimum sample mass is 10 g wet weight). To minimize fish handling and help to acquire sufficient sample mass, age structures will not be collected from age 1 Yellow Perch submitted for tissue analysis. Rather, age will be estimated in two ways. Firstly, fish lengths will be plotted into length frequency histograms to identity seasonal growth trends and age/length relationships. Secondly, a separate sample of Yellow Perch otoliths will be submitted for age estimation to establish length at age relationships for each species from each waterbody.

If age 2+ Yellow Perch are needed for the study, skinless boneless tissue samples will be collected, and a regression method may be used during data analysis. It is anticipated that an entire fillet may be needed

to obtain the necessary tissue mass from individual fish (i.e., rather than collecting tissue from only above the lateral line). A wide size range of fish (i.e., from all age classes present) will be sampled to establish a relationship between mercury and methylmercury concentration and fish length. If age 2+ Yellow Perch are sampled, age structures (otoliths) will be collected from individual fish.

Total length, fork length and weight will be measured and recorded from fish collected for tissue analysis Sex will be determined for age 2+ fish. Methods used during operations will be consistent with pre-construction methods to allow for meaningful data comparison. Data collected from reference locations South Magnet Lake (sampled in 2016) and GMBY (sampled in 2018) will support a BACI design.

Muscle tissue will be sent to a CALA laboratory for analysis of metals, mercury, methylmercury and the supporting parameters percent lipid and percent moisture. The laboratory will follow the MOECC (2014) "Protocol for the Collection of Fish Samples for Contaminant Analyses" and Environment Canada (2012) "Metal Mining Technical Guidance for Environmental Effects Monitoring" during tissue preparation. Where method requirements differ, the more rigorous method will be used. Muscle samples will be analyzed for total mercury using cold vapour atomic spectrophotometry, which achieves a lower detection limit than inductively coupled plasma mass spectrometry (ICP-MS). The detection limit for mercury will be 0.001 µg/g wet weight. The detection limit for methylmercury will be 0.0001 mg/kg wet weight.

Summary statistics will be provided to describe key aspects of the data, including central tendency, variation and overall shape. Specifically, mean, median, minimum, maximum, standard deviation and standard error estimates will be calculated for mercury and methylmercury by species and location. Data will also be presented in summary figures, such as boxplots, bar-and-error graphs or histograms. Finally, federally advocated critical effect sizes (CES) will be calculated based on a 25% difference from reference conditions (expressed as ±25% of the change observed in reference conditions).

Formal comparisons between reference and exposure sites will be conducted in accordance with methods recommended by Environment Canada (2012). Specifically, the BACI design will analyze changes over time at the exposure sites relative to changes at the reference sites. A general linear model will be developed that compares changes in a species' elemental tissue concentrations between 'before' and 'after' time periods at both 'control' and 'impact' locations. Analytical methods will account for confounding variables such as sex and age/weight/length. This framework includes classic analysis of covariance (ANCOVA) designs, but also other statistical designs that accommodate statistical nuances that ANCOVAs do not permit (e.g., inconsistent relationships between sites with confounding variables). Non-parametric alternatives may be used if data distributions preclude parametric methods using methods such as those described by Environment Canada (2012).

Retrospective and prospective power analyses will be completed to, respectively, determine whether non-significant results arose due to insufficient statistical power to detect critical effects, and estimate minimum sample sizes required to detect critical effects in the future. Analyses will either use standard power calculations (e.g., Cohen 1988), adjusting for non-parametric tests using asymptotic relative efficiency ratios (if necessary), or Monte-Carlo simulations to analyse given effect sizes.

2.6.2 Adaptive Management

The identification of biologically significant changes to the concentration of mercury in fish tissue will be used to trigger adaptive management. A biologically significant change is defined as a statistically significant difference (i.e., increase) in fish tissue mercury concentration with a CES ≥ 25%. For individual fish samples, regression analysis will be used to account for mercury concentration at fish length. For whole body composite samples, a comparison of means will be completed. The fish tissue study will be designed using a recommended power level of 0.90 (1-β).

The surface water adaptive management plan (Section 2.2.2) identifies two trigger thresholds for surface water quality, each with a varying level of sensitivity and associated level of response. The trigger thresholds are meant to be protective of the associated aquatic biota and/or wetland habitats while allowing for the possibility of natural fluctuations in surface water quality. Additional fish tissue monitoring may be required if triggered by the findings of the surface water adaptive management plan and if:

- Ongoing fish tissue monitoring plans do not adequately monitor changes where the surface water Trigger Threshold 2 is exceeded.
- The change has the potential to adversely affect fish health or the usability of fish by human or wildlife consumers (i.e., exceeds guidelines), and
- The change is likely caused by Project activities.

Additional fish tissue studies may also be required, to determine the magnitude and extent of changes, if fish tissue monitoring activities demonstrate an effect on fish tissue in two consecutive fish tissue studies that are conducted as part of routine monitoring. The scope of additional fish tissue monitoring, if required, will be based on the area where water quality exceedances may occur and will include reference area sampling. If contaminant levels in fish tissue are below Canadian Council of Ministers of the Environment (1998) guideline levels and/or MECP (Nilima et al. 2017) guidelines and water quality levels are no longer in exceedance of regulatory requirements, then no further monitoring would be required.

Confirmed effects on fish tissue may trigger the need for one of more of the following responses:

- Investigation of cause (i.e., determining the cause of the observed effect)
- Additional project mitigation (i.e., improve treatment, revise operational procedures)
- Remedial actions.

Response actions will be dictated by the nature of the observed effect, if any, and developed in consultation with relevant governing agencies.

2.6.3 Reporting

GGM will prepare an annual Fish and Fish Habitat Follow-Up Monitoring Report beginning after the first year of implementation of the monitoring plan. The report will be submitted to ECCC no later than December 31 following the reporting year to which the annual report applies. For this Fish and Fish Habitat Monitoring Plan, each reporting year will be from October 1 of a calendar year through September 30 of the subsequent calendar year (as stated in Condition 1.3).

The content of the report is expected to vary with each monitoring year, depending on the monitoring activities that are planned that year. The report will be summitted to ECCC following the calendar year in which monitoring occurred. Reporting will include a detailed description of methods and results. Supporting raw data will also be provided in appendices to the report, as appropriate.

2.7 Fish Tissue Monitoring - Kenogamisis Lake

The following section describes the plan to satisfy Condition 5.5.1 of the federal EIS approval, which requires GGM to monitor, at least every two years, during the first six years of operation, mercury, methylmercury, and arsenic concentrations in Walleye (*Sander vitreus*) tissue. The sampling plan presented below has been developed in consultation with Indigenous groups and relevant authorities (MNRF, MECP). GGM will continue to engage Indigenous groups and relevant authorities throughout the adaptive management process. Section 5.5.1 identifies the need to monitor country foods. For the purpose of this Fish and Fish Habitat Follow-Up Monitoring Plan, 'country foods' includes only fish. Monitoring methods for other country foods are described in a separate Health of Indigenous Peoples Follow-up Monitoring Plan (GGM 2020).

2.7.1 Routine Monitoring

The purpose of fish tissue monitoring will be to assess potential changes in the concentration of mercury, methylmercury, and arsenic in fish tissue and, if changes are observed, to determine if there is an adverse effect on fish health or an increased risk to human and wildlife consumers. A before-after-control-impact (BACI) design will be used to monitor potential changes in metal concentrations.

2.7.1.1 Location

Walleye will be sampled from the exposure and reference areas shown in Table 2-13 and in Figure 2-19.

2.7.1.2 Frequency

Fish tissue sampling will be completed in late summer or early fall and in keeping with the seasonal timing of pre-construction data collection. Monitoring will commence within 24 months of when the mine begins discharging effluent via the temporary ETP. An approximate schedule of monitoring and reporting is provided in Table 2-13. The monitoring cycle is scheduled for every two years for the first six years of operation. Sampling methods and frequencies will be reviewed after the third cycle of sampling to assess whether additional monitoring is required after the first six years of operation and, if required,

at what frequency this additional monitoring will occur. Adaptive management will allow for changes to the Study Design and frequency of sampling, depending on the results of previous studies.

Table 2-13: Anticipated Walleye Muscle Tissue Monitoring Schedule

Location	Year 1	Year 2	Year 3	Year 4	Year5	Year 6	Year 7	Post Year 7
Kenogamisis Lake (KLSW) (Test Area)	-	-	✓	-	✓	-	✓	TBD
Gamsby Lake (GMBY) (Reference Area)	-	-	✓	-	✓	-	✓	TBD

TBD = To be determined

Stantec

Legend

- Walleye Tissue Collection (Exposure Area)
- Walleye Tissue Collection (Reference Area)
- Diffuser Location
- Open Pit- Full Extent
- Contour Line (10m intervals)
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthographic Imagery Source: © 2020 Microsoft Corporation © 2020 Maxar ©CNES (2020) Distribution Airbus DS

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Hardrock Project

Figure No.

2-19

Title

Walleye Tissue Monitoring Locations

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Revised: 2020-12-10 By: dharvey

2.7.1.3 Methods

As required by Condition 5.5.1 of federal EA approval, Walleye will be used for fish tissue monitoring. Walleye are abundant in the target sampling areas and are an important local human food source. Sample preparation and tissue removal methods will follow MECP Protocol for the Collection of Fish Samples for Contaminant Analyses (MOE 2014), however, sample sizes will be based on the analysis of existing Walleye muscle tissue data from Kenogamisis Lake (i.e., rather than the target sample size range of 10 to 20 samples identified in the MECP protocol). A CES of 25% will be used to detect changes in fish tissue total mercury concentrations, as per the MDMER Technical Guidance Document (TGD) (Environment Canada 2012). Table 2-14 identifies predicted minimum sample sizes required to detect significant differences greater than the CES in the concentration of total mercury in male and female Walleye muscle tissue, should they exist, using an ANCOVA with fork length as a covariate. Based on a CES of 25%, 17 male and 16 female Walleye would be required to detect biologically significant differences in the concentration of total mercury in Walleye muscle tissue (Table 2-14). Fish tissue will be analyzed for an ICP-MS metals, with adequate detection limits for comparison to baseline data and applicable tissue guidelines (MECP 2016). A summary of the MDLs for arsenic, mercury, and methylmercury to be measured in fish tissue are provided in Table 2-15.

Table 2-14: Estimated Sample Sizes Required to Detect Changes in Fish Tissue Mercury Concentrations based on Pre-Construction Data

Species	Parameter	Sex	Model	Mean Square Error	Estimated Sample Size Required (number of fish per sampling area)			
					CES-10%	CES-20%	CES-25%	CES-30%
Walleye	**Total Mercury (mg/kg wet weight)**	Male	ANCOVA*	0.042	81	24	17	13
		Female	ANCOVA*	0.040	77	23	16	12
* Natural log-transformation of independent variable ANCOVA = analysis of covariance, CES = Critical Effect Size								

Table 2-15: Key Fish Tissue Parameters and Detection Limits

Metals (Tissue)	Detection Limit (MDL)	Units
Arsenic (As)-Total	0.004	mg/kg wwt
Mercury (Hg)-Total	0.001	mg/kg wwt
Speciated Metals	-	-
Methylmercury	0.0001	mg/kg wwt
Aggregate Organics (Tissue)	-	-
Lipid Content	0.5	% wwt
Physical Tests (Tissue)	-	-
% Moisture	0.5	%

2.7.2 Adaptive Management

Fish tissue monitoring locations and methods focus on the areas that will experience change in habitat or water quality as a result of the Project (i.e., effluent discharge area). The methods and schedule set out in this plan may be modified to address concerns that may arise over the life of the Project or to improve upon scientific defensibility (e.g., data examination may reveal that a larger or smaller sample size is required).

Extensive baseline fish tissue data have been collected that will support broader studies, if required. For example:

- The use of Walleye as sentinel species is planned to monitor fish muscle tissue in Kenogamisis Lake. Sampling has been completed for Walleye with enough replication to provide a robust baseline dataset (Stantec 2020).
- This plan describes fish tissue monitoring methods that focus on the treated effluent mixing zone in Kenogamisis Lake, but fish tissue data are also available for each basin of Kenogamisis Lake, so that comparisons between basins, or lake-wide comparisons can be made, if necessary (Parks 2012, Stantec 2015a, Stantec 2015b, Stantec 2018b, Stantec 2020).
- Historical fish tissue data from MECP provide additional baseline data for Kenogamisis Lake and for potential reference lakes. The MECP data were summarized by Parks (2012). These pre-construction data will provide additional data for comparison to conditions during operations.
- This plan for monitoring Walleye fish tissue in Kenogamisis Lake will be completed in conjunction with other fish tissue and fish health monitoring programs including more focused studies along the GFC Diversion and fish tissue sampling for Walleye, White Sucker and Yellow Perch in Kenogamisis Lake and Mosher Lake that will occur every three years.

The surface water AMP (Section 2.2.2) identifies two trigger thresholds for surface water quality, each with a varying level of sensitivity and associated level of response. The trigger thresholds are meant to be protective of the associated aquatic biota and/or wetland habitats while allowing for the possibility of natural fluctuations in surface water quality. Additional fish tissue monitoring may be required if triggered by the findings of the surface water AMP (Section2.2.2) and if:

- Ongoing fish tissue monitoring plans do not adequately monitor changes where the surface water Trigger Threshold 2 is exceeded.
- The change has the potential to adversely affect fish health or the usability of fish by human or wildlife consumers (i.e., exceeds guidelines), and
- The change is likely caused by Project activities.

Additional fish tissue studies may also be required, to determine the magnitude and extent of changes, if fish tissue monitoring activities demonstrate an effect on fish tissue in two consecutive fish tissue studies that are conducted as part of routine monitoring.

The scope of additional fish tissue monitoring, if required, will be based on the area where water quality exceedances occurred and would include reference area sampling. If contaminant levels in fish tissue are below MECP tissue residue guidelines (MECP 2106) and water quality levels are no longer in exceedance of regulatory requirements, then additional monitoring would not be recommended.

Confirmed effects on fish tissue may trigger the need for one of more of the following responses:

- Investigation of cause (i.e., determining the cause of the observed effect)
- Additional project mitigation (i.e., improve treatment, revise operational procedures)
- Remedial actions.

Response actions will be dictated by the nature of the observed effect, if any, and developed in consultation with relevant governing agencies.

2.7.3 Reporting

The results of fish tissue monitoring in Kenogamisis Lake will be reported following each of the monitoring years (every two years). The report will present monitoring data and an interpretation of results in relation to current guidelines, baseline values and trends.

As applicable, the biennial Report will include the following:

1. Summary of monitoring activities which were conducted that year and monitoring components that are planned within the next two years.
2. Tabulated results of the monitoring presented in Section 2.7.1, as available (i.e., results of laboratory analyses)
3. Comparison of data to trigger thresholds, as data is available, identification if a trigger threshold was exceeded, and mitigation and/or adaptive management that was implemented, if required.

Raw field data will be provided along with summary statistics for morphometric parameters (Table 2-16). Means will be statistically compared between reference and exposure areas to determine whether there are significant differences ($p<0.05$) between areas. The probability of correctly detecting an effect of a pre-defined size and the degree of confidence that can be placed in the calculations will also be reported. If effects are observed, the magnitude of effects will also be reported relative to the reference mean.

Table 2-16: Fish Morphometric Data Reporting Requirements

Measurement	Reporting of Summary Statistics
Length (fork, total or standard)	Mean, median, SD, SE, minimum, maximum values for sampling areas
Total body weight (fresh)	Mean, median, SD, SE, minimum, maximum values for sampling areas
Age	Mean, median, SD, SE, minimum, maximum values for sampling areas
Arsenic (As)-Total	Mean, median, SD, SE, minimum, maximum values for sampling areas

Table 2-16: Fish Morphometric Data Reporting Requirements

Measurement	Reporting of Summary Statistics
Mercury (Hg)-Total	Mean, median, SD, SE, minimum, maximum values for sampling areas
Methylmercury	Mean, median, SD, SE, minimum, maximum values for sampling areas
Lipid Content	Mean, median, SD, SE, minimum, maximum values for sampling areas
% Moisture	Mean, median, SD, SE, minimum, maximum values for sampling areas

SD = standard deviation; SE = standard error

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