HARDROCK PROJECT
Final Environmental Impact Statement / Environmental Assessment

Chapter 11.0:
Assessment of Potential Environmental Effects on Fish and Fish Habitat

Prepared for:
Greenstone Gold Mines GP Inc.
365 Bay St, Suite 500
Toronto ON M5H 2V1

Prepared by:
Stantec Consulting Ltd.
1-70 Southgate Drive
Guelph ON N1G 4P5

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11.0 ASSESSMENT OF POTENTIAL ENVIRONMENTAL EFFECTS ON FISH AND FISH HABITAT

For the purpose of this Final EIS/EA, the term 'fish' includes fish that are part of a commercial, recreational or Aboriginal (CRA) fishery and fish that support a CRA fishery (e.g., prey species), as defined in the *Fisheries Act*. Fish habitat means waters on which fish depend directly or indirectly in order to carry out their life processes. These include spawning, nursery, rearing, migration and feeding areas. Fish and fish habitat was selected as a Valued Component (VC) for assessment because fish and their habitats are key indicators of fisheries sustainability and productivity and are valued by agencies, the public, and Aboriginal communities for commercial, recreational, subsistence and cultural purposes and as a key component of biodiversity.

Fish and fish habitat is linked to other VCs, including:

- acoustic environment (Chapter 8.0) – vibration from blasting has the potential to affect fish due to changes in water pressure as a consequence of vibration generated from blasting (compressive shock waves)
- surface water (Chapter 10.0) – changes in surface water quantity and/or quality may affect fish and fish habitat and aquatic organisms
- land and resource use (LRU) (Chapter 16.0) and traditional land and resource use (TLRU) (Chapter 18.0) – may be influenced by changes in fish and fish habitat because fish are used for commercial (bait fishing), recreational (angling) and Aboriginal (sustenance and cultural) purposes
- human and ecological health (Chapter 19.0) – may be influenced by changes in fish and fish habitat because effluent discharge into Kenogamisis Lake and non-point sources of discharge from waste rock and tailings areas may result in changes in fish tissue metal concentrations. Since fish are captured and consumed by people, there is a link to human health. Likewise, fish may be consumed by other fauna. This Chapter discusses the fish tissue data and context for potential changes in fish tissue concentrations of mercury, while Chapter 19.0 (human and ecological health) assesses potential effects on humans from consumption of fish.

11.1 SCOPE OF ASSESSMENT

11.1.1 Regulatory and Policy Setting

11.1.1.1 Environmental Impact Statement Guidelines and Terms of Reference Requirements

The environmental effects assessment for fish and fish habitat has been prepared in accordance with the requirements of the federal Environmental Impact Statement (EIS) Guidelines (Appendix A1) and provincial Terms of Reference (ToR) (Appendix A2). Concordance tables, indicating how EIS Guidelines and ToR requirements have been considered, are provided in Appendix B.

11.1.1.2 Fisheries Act

The Government of Canada is responsible for the management of fisheries resources in Canada through the *Fisheries Act*, administered primarily by Fisheries and Oceans Canada (DFO) with some provisions administered by Environment and Climate Change Canada (ECCC, formerly Environment Canada [EC]). The *Fisheries Act* addresses national interests in marine and fresh waters. In June 2012, changes to the *Fisheries Act* came into force, including fisheries protection measures that have the goal of protecting the productivity and sustainability of CRA fisheries.

The *Fisheries Act* includes prohibitions against causing “serious harm” to fish that are part of or support a CRA fishery (Section 35) in addition to provisions for flow (Section 20), fish passage (Section 21), and deleterious substances (Section 36). Section 36 is administered by ECCC. When serious harm to fish cannot be avoided or mitigated, a subsection 35(2) authorization with appropriate offsetting of residual adverse effects is required. Section 6 of the *Fisheries Act* lists the factors taken into account by the Minister when considering the approval of an authorization, which are:

(a) contribution of the relevant fish to the ongoing productivity of a CRA fisheries

(b) fisheries management objectives

(c) whether there are measures and standards to avoid, mitigate or offset serious harm to fish that are part of a CRA fishery, or that support such a fishery

(d) the public interest.

The purpose of Section 35 and other provisions identified in Section 6 of the *Fisheries Act* relates to the sustainability and ongoing productivity of CRA fisheries. The *Fisheries Act* defines "serious harm to fish" as "the death of fish or any permanent alteration to, or destruction of, fish habitat". These are further defined in the *Fisheries Act* as follows:

- death of fish
- permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes
- destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes. For the purpose of this Final EIS/EA, destruction of fish habitat is referred to as loss of fish habitat.

Serious harm to fish can be offset, if approved by the Minister of Fisheries and Oceans, through the restoration and creation of fish habitat or other means that will replace the loss to fisheries productivity.

In support of the revised *Fisheries Act*, DFO has published a new policy statement and guidance documents. These include but are not limited to:

- Fisheries Protection Policy Statement (DFO 2013a)
- Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada (DFO 2013b)
- Fisheries Productivity Investment Policy: A Proponents Guide to Offsetting (DFO 2013c)
- a science-based interpretation and framework for considering the contribution of the relevant fish to the ongoing productivity of commercial, recreational or Aboriginal fisheries (Koops et al. 2013)
- science advice on a decision framework for managing residual impacts to fish and fish habitat (Bradford et al. 2015).

11.1.1.3 Fisheries Act - Metal Mining Effluent Regulations

The *Metal Mining Effluent Regulations* (MMER), developed under Section 36 of the *Fisheries Act* and administered by ECCC, regulates the deposit of mine effluent into natural waters frequented by fish. The listing of a natural waterbody frequented by fish for use as a tailings impoundment, under Schedule 2, would require compensation (MMER term for offsetting) for the loss of fish habitat. The regulations form the basis of the federal mine effluent standards by, among other requirements, defining authorized limits for releasing selected deleterious substances outlined in Schedule 4 of the Regulations (pH, total suspended solids [TSS], arsenic, copper, lead, nickel, zinc, radium-226, cyanide), from mining operations. In addition, environmental effects monitoring (EEM) requirements for mining operations are specified in Schedule 5 of the Regulations.

11.1.1.4 Species at Risk Act

The responsibility for aquatic species under the federal *Species at Risk Act* (SARA) is delegated to the Minister of Fisheries and Oceans by the Minister of Environment. SARA is intended to prevent extinction or extirpation of wildlife species and to assist in recovery of extirpated, threatened, or endangered species. SARA prohibits killing, harming, capturing, or harassing species listed as endangered, threatened, or extirpated (where introduction to the wild is recommended) and provides protection for habitat that supports these species. There are no known federally listed fish species at risk in the regional assessment area (RAA, defined in Section 11.1.4).

11.1.1.5 Endangered Species Act

The provincial *Endangered Species Act*, 2007 (ESA) is administered by the Ministry of Natural Resources and Forestry (MNRF) and has provisions for the protection of provincially listed species at risk. There are no known provincially listed fish species at risk in the RAA.

11.1.1.6 Lakes and Rivers Improvement Act

The *Lakes and Rivers Improvement Act* (LRIA) provides the MNRF with the legislative authority to govern the design, construction, operation, maintenance, and safety of dams in Ontario. Approval from the MNRF to construct, alter, improve, or repair water control infrastructure in Ontario is required under the LRIA, which has provisions for the protection of fish and fish habitat. One purpose of LRIA is to provide for the management, perpetuation, and use of the fish, wildlife, and other natural resources dependent on the lakes and rivers (MNR 2011).

Under the LRIA, approval must be obtained from the MNRF for:

- dams
- water crossings – bridges, culverts, and causeways
- river channels – channelization of rivers, including dredging, diverting, or enclosing a channel except for the installation or maintenance of a drain subject to the *Drainage Act*
- enclosures (e.g., pipe enclosures)
- buried pipelines and cables – installing cables and pipelines where they will hold back, forward or divert water
- municipal and other drains.

11.1.1.7 Fish and Wildlife Conservation Act

During the life of the Project, the Proponent will be required to collect fish for the purpose of monitoring potential adverse effects and to remove fish from in-water work areas. To conduct these works, authorization will be required from the MNRF under the provisions of the *Fish and Wildlife Conservation Act*. Section 39 of the *Fish and Wildlife Conservation Act* states that the Minister may authorize a person to capture, kill, or possess wildlife for educational or scientific purposes (S.O. 1997).

11.1.1.8 Ontario Provincial Fish Strategy– Fish for the Future

MNRF (2015a) states the following: *"This is a guiding document for managing fisheries resources in Ontario. It identifies provincial fisheries goals, objectives and tactics to achieve them. The main purposes of the strategy are to improve the conservation and management of Ontario's fisheries resources; and to promote, facilitate, and encourage fishing as an activity that contributes to the nutritional needs, and the social, cultural and economic wellbeing of individuals and communities in Ontario.*

The Provincial Fish Strategy provides management direction to MNRF staff and will better position the ministry to respond to evolving environmental, economic, social, technological and policy challenges facing fisheries in Ontario."

11.1.2 Influence of Consultation on the Identification of Issues and the Assessment Process

Consultation has been ongoing prior to and throughout the environmental assessment (EA) process, and will continue with government agencies, local Aboriginal communities, and stakeholders through the life of the Project. Chapter 3.0 (community and stakeholder consultation) provides more detail on the consultation process covering open houses, site visits, targeted meetings, newsletters, questionnaires, presentations, and capacity funding for technical reviews and community-based studies. The Record of Consultation (Appendix C) includes detailed comments received during the development of the Draft EIS/EA. As part of the information sharing throughout the consultation process, Project-related information was provided by Aboriginal communities in the form of traditional knowledge (TK)and traditional land and resource use (TLRU) studies and other forms of information sharing. This information was considered in the environmental effects assessment as described in Section 11.1.3.

Consultation feedback related to fish and fish habitat has been addressed through direct responses (in writing and follow up meetings), updates to baseline information, and in the Final EIS/EA, as appropriate. An overview of the key comments that influenced the fish and fish habitat effects assessment between the Draft and Final EIS/EA is provided below.

Blasting Effects on Fish

Aroland First Nation (AFN), Biigtigong Nishnaabeg, MNRF and the Canadian Environmental Assessment Agency (CEA Agency) requested additional information regarding potential effects on fish and fish habitat due to noise and vibration, including potential mitigation measures. In response, a blasting assessment on the effects to fish and fish habitat has been completed (Section 11.4.4). This assessment includes predictions of blast strength (instantaneous pressure change and peak particle velocity) in fish habitat compared to values that are known threshold values. Based on the results of the assessment, blasting in the central portion of the open pit will be below threshold levels but blasting in the eastern extension of the open pit has the potential to affect fish habitat. Therefore, a modified blasting pattern will be used in the east extension to achieve instantaneous pressure changes and Peak Particle Velocity (PPV) guidelines established for the protection of fish and fish habitat.

Goldfield Creek Diversion

The Ministry of the Environment and Climate Change (MOECC) and the MNRF provided comments regarding the location of the diversion in relation to Project infrastructure presented in the Draft EIS/EA. In particular, they noted potential effects on water quality and fish habitat offsetting due to seepage into the Southwest Arm Tributary. In response, GGM has increased the setbacks from the Southwest Arm Tributary to waste rock storage areas (WRSA) B and D. GGM has also completed additional field work and follow-up consultation, as a result, the Goldfield Creek diversion and the design was refined accordingly. GGM also incorporated the Goldfield Creek diversion in the “Technical Data Report: Hardrock Project – Assimilative Capacity Study of Southwest Arm of Kenogamisis Lake” (Assimilative Capacity TDR; Appendix F6), to better predict the anticipated changes to water quality in the new channel and completed flood line analysis used to refine the designs.

Animbiigoo Zaagi’igan Anishinaabek (AZA), AFN, Biinjitiwaabik Zaaging Anishinaabek, Long Lake #58 First Nation (LLFN), Red Sky Métis Independent Nation, ECCC, MNRF, MOECC and DFO requested further details on the channel design in the fisheries offsetting plan. LLFN noted the potential to form a focus group on Offsetting for work around Goldfield Creek and a workshop was carried out in December 2016. The MNRF noted the importance of considering provincial management objectives in developing offsetting. DFO noted the need to consider losses and gains in the offset plan and requested additional information on effects of bioaccumulation, determining fish use and habitat function of Goldfield Creek. In response, GGM conducted a fluvial geomorphological study to predict potential effects on the Southwest Arm Tributary and to evaluate options for managing flow and preventing erosion. The work optimized the design approach to reduce potential effects and provide opportunities for offsetting. GGM made presentations to agencies and Aboriginal groups to provide updated information, answered questions and considered additional input into the “Draft Hardrock Project: Fisheries Act, Paragraph 35(2)(b) Authorization and MMER Schedule 2 Draft Fisheries Offset Plan” (Draft Fisheries Offset Plan) (Appendix F10). The additional input received (discussed in Section 11.1.3) has been used to inform the design of the diversion channel (Draft Fisheries Offset Plan, Appendix F10).

In meetings with LLFN, community members expressed a desire that the Goldfield Creek diversion be designed so that it supports species that are currently present in Goldfield Creek and in the Southwest Arm Tributary. There was a common interest in using natural materials and implementing techniques that allow 'nature to take over'. GGM will use this information in developing the offsetting plan design, including the potential use of existing woody debris and seed banks.

Consultation input from AFN noted a concern that following the realignment of Goldfield Creek, fish from Kenogamisis Lake will be able to access Goldfield Lake, and that there is a perception that Goldfield Lake, and fish in Goldfield Lake, are cleaner than the fish and water in Kenogamisis Lake. The Baseline Report – Fish and Fish Habitat and Supplemental Baseline - Fish and Fish Habitat (Appendix E7) studies determined that the ability of fish to move from Kenogamisis Lake to Goldfield Lake may be inhibited by natural conditions (steep gradients). GGM has confirmed that this steeper gradient section of Goldfield Creek will remain as it exists during baseline and fish passage from Kenogamisis Lake to Goldfield Lake will be neither enhanced or inhibited by the Project.

Potential Effects to Aquatic Weed Beds

MNRF requested that GGM investigate macrophyte beds near the mouth of the existing Southwest Arm Tributary to assess potential effects of increased stream flow that would occur as a result of the Goldfield Creek diversion. GGM conducted aquatic macrophyte plot sampling in 2016 to further document baseline conditions. The data were collected to allow comparisons to pre and post-construction monitoring to assess changes in aquatic plant communities. Methods used are identified in the "Hardrock Project Conceptual Aquatic Management and Monitoring Plan" (Conceptual AMMP; Appendix M12).

Lake-wide Fish Community and Productivity Assessment

The MNRF requested that GGM collect productivity data for Kenogamisis Lake to support the Final EIS/EA, using methods similar to the MNRF Broadscale monitoring program. Concerns were also raised with respect to how a discharge in the Southwest Arm of Kenogamisis Lake might affect fish collected in other basins of the lake and beyond (i.e., farther downstream).

In response, GGM designed a monitoring program to evaluate pre-construction differences in fish communities between lake basins**.** A Conceptual AMMP has been provided in Appendix M12. The proposed program will be implemented as the Project progresses and will allow for pre- and post-construction comparison of the fish community in Kenogamisis Lake. The study design replicates the MNRF protocol for assessing fish communities in Ontario Lakes. In addition to the end points measured by the MNRF protocol (e.g., fish length and weight) additional EEM end points (e.g., gonad weight and liver weight) will be measured to assess the health and condition of fish in the various basins of Kenogamisis Lake.

Effects of Reduced Light Conditions

The CEA Agency conveyed concerns from Aboriginal communities related to fish and fish habitat. One such comment identified the following concern. *"Will the waste rock storage areas affect fish habitat because of changing light conditions? For example, certain fish species (e.g., walleye) feed and are more active at certain times of the day. Could the waste rock piles be located further away from the edge of the shore?"*

WRSAs are located along the northwest shore of the Southwest Arm of Kenogamisis Lake and are not anticipated to alter light conditions such that fish or fish habitat are effected. The average setback distance from WRSA D (the largest WRSA next to Kenogamisis Lake) to the high water mark of the lake is 150 m. The top of the pile is situated further from the water as the slopes of the waste rock pile will be benched. The average distance from the top of the WRSA pile to the high water mark is about 365 m. The setback distance and benching will minimize shading of the lake. Morning and mid-day light levels are not anticipated to change in Kenogamisis Lake. Direct sunlight to the Southwest Arm of Kenogamisis Lake may be reduced in the evening. Potential effects on fish habitat as a result of a change in light conditions are not predicted to be measurable. A program to monitor potential changes in primary production, phytoplankton and zoo plankton was initiated in Kenogamisis Lake in 2016. A Conceptual AMMP is provided in Appendix M12.

Contaminants in Fish Tissues

Aboriginal communities have indicated concern for the existing conditions of Kenogamisis Lake. AFN requested additional information on existing arsenic levels in fish, including human health risks from fish consumption and cyanide in historical tailings effects on fish. The Métis Nation of Ontario (MNO) noted the importance of characterizing and comparing historical concentrations of metals in water, sediment or fish tissue to indicate any temporal trends in contamination. Biigtigong Nishnaabeg requested rationale to support the assumption that the existing elevated mercury concentrations in Kenogamisis Lake are not related to historic mining, and also requested that GGM obtain fish tissue samples from species of importance to the Biigtigong Nishnaabeg. AFN, AZA, Constance Lake First Nation (CLFN), LLFN, and MNO raised concerns with regard to the potential environmental effects on fish related to health and toxicity levels from contamination-related metal loadings (particularly mercury and arsenic).

In response, GGM has included a more detailed description in the Final EIS/EA that describes the known historical contributions of mercury to Kenogamisis Lake (Section 11.2.2.1). Additional fish tissue collection was completed in 2016 to provide data to satisfy anticipated permitting and monitoring requirements. Walleye were used for tissue analysis in the Final EIS/EA because they are locally abundant and targeted for consumption by people. Walleye also occupy a relatively high trophic level in the aquatic environment and, as such, have a greater potential to bioaccumulate some parameters of potential concern (PoPCs) (like mercury) than fish of lower trophic level. Additional pre-construction fish collections are planned to obtain data on species Aboriginal communities have identified as being traditionally important (e.g., White Sucker). This will include whole body fish analysis to reflect the ways some Aboriginal people prepare and consume fish. A Conceptual AMMP is provided in Appendix M12.

Water Quality and Fish Habitat

The MOECC noted potential effects of effluent discharge on water quality and fish habitat. The MNRF and the CEA Agency noted potential effects from seepage (from tailings management facility (TMF) and WRSA), change in nutrient levels and trophic shifts. The CEA Agency requested clarification regarding mitigation measures for changes to fish and fish habitat at or around the discharge location due to temperature changes.

The Assimilative Capacity TDR (Appendix F6) has been updated for the Final EIS/EA and considers inputs from point (i.e., treated effluent discharge) and non-point sources (i.e., surface run-off, groundwater seepage and dust fall). Results demonstrate arsenic concentrations are expected to decrease from the PWQO (100 µg/L in effluent) to 20 µg/L within 30 m of the treated effluent discharge location, and to the Interim PWQO and CWQG-FAL (5 µg/L) within 2 km of the treated effluent discharge location. A residual effect on fish has been identified because there will be an increase in concentrations of PoPC within the mixing zone that will exceed guidelines established for the protection of aquatic life. However, this effect is not anticipated to adversely affect fisheries productivity and sustainability.

This prediction is based on:

- the conservative nature of the water quality guidelines, which are typically an order of magnitude lower than the lowest sub-lethal concentration
- supporting evidence from the Bioavailability Study (Appendix F7), which does not show biological impairment in concentrations similar to those expected in the mixing zone
- knowledge of local fish communities, which are mobile and unlikely to reside in the areas of highest effluent concentration for extended periods.

Similarly, there will be an increase in nutrients in Kenogamisis Lake that has the potential to alter components of the receiving environment that are considered fish habitat. However, the anticipated changes are small (i.e., 3 % increase in phosphorus in the Southwest Arm). Kenogamisis Lake supports a fish community reflective of mesotrophic conditions. When compared to baseline, nutrient concentrations during operation will remain within documented ranges of nutrients that support mesotrophic fish communities. Residual effects on fish habitat are therefore not predicted to adversely affect fisheries productivity and sustainability.

Changes in water temperature were assessed and indicate that the effluent temperature is either similar to or colder than that of the receiving environment. Water temperatures will rapidly equilibrate to ambient conditions and are not expected to appreciably alter fish habitat.

An assessment of potential effects on fish and fish habitat related to effluent discharge, including temperature and updated predictions of phosphorus and sulphate in the receiving environment are presented in Section 11.4.

11.1.3 Consideration of Aboriginal Information and Traditional Knowledge

GGM understands the importance of fish and fish habitat to Aboriginal communities through information sharing during the consultation process (Chapter 3.0). Project-specific TK and TLRU information (Appendix J) has been considered in Project planning including, baseline studies, alternatives assessment approach, mitigation and monitoring, where appropriate. However, only non-confidential TK and TLRU information is presented in the Final EIS/EA, where applicable to the Project, to respect the preferences of Aboriginal communities. An overview of the key Aboriginal information that influenced the fish and fish habitat effects assessment between the Draft and Final EIS/EA is summarized below.

Aboriginal communities have confirmed that Kenogamisis Lake has traditional use value. Consultation input received from AFN, Biigtigong Nishnaabeg, Biinjitiwaabik Zaaging Anishinaabek, CLFN, Eabametoong First Nation (EFN), Ginoogaming First Nation (GFN), LLFN and MNO identified the importance of recognizing Aboriginal fishing practices in their identified study areas.

Fish species identified as having traditional value or interest to Aboriginal communities are listed below. This information has been compiled from Project-specific TK studies and consultation input. Information on species caught or consumed by AFN is considered confidential and therefore detailed information from AFN was not listed in the table below, however it has been assumed that the species listed will also be of traditional value or interest to other Aboriginal communities.

Fish Species	Aboriginal Communities
Bass	MNO
Burbot (ling cod)	MNO
Northern Pike (jackfish)	CLFN, EFN, GFN, LLFN, MNO, Pays Plat First Nation (PPFN)
Yellow Perch (perch)	CLFN, GFN, MNO
Walleye (pickerel)	AFN, CLFN, EFN, LLFN, MNO, GFN, PPFN
Salmon	MNO
Rainbow Smelt (smelt)	LLFN, MNO
Lake Sturgeon	AFN, EFN, LLFN, MNO
Suckers (e.g. white suckers)	AFN, EFN, MNO
Trout (e.g. Brook Trout, Rainbow Trout, Splake)	AFN, CLFN
Trout (e.g. Lake trout)	LLFN, MNO
Lake Whitefish	AFN, CLFN, EFN, LLFN, MNO

NOTE:
*Aboriginal communities consulted on fish species of interest are provided in Chapter 3.0.

For the purposes of this assessment, all species that were identified during consultation or in TK and TLRU information have been considered to have value to Aboriginal communities and informed the understanding of what fish and fish habitat are like today and aligned with the potential Project interactions considered in this chapter.

Baseline studies suggest that Lake Sturgeon, Lake Trout, bass, smelt and salmon are not present in the local assessment area (LAA). The remaining species identified above are consistent with findings of the baseline field studies (Section 11.2.2). The Final EIS/EA recognizes the importance of these species and identifies measures to avoid significant residual effects.

The “Eabametoong First Nation Knowledge and Use Scoping Study for Greenstone Gold Mines GP Inc.’s Proposed Hardrock Project” (Appendix J5) noted that fishing continues to be practiced by EFN within the region and identified Kenogamisis Lake as an important fishing location. Fish were identified as an important part of many EFN members’ traditional diet. Fish species harvested within the PDA include Northern Pikeminnow[1] (also known as squaw fish), pickerel (also known as Walleye), and whitefish (EFN Knowledge and Use Study; Appendix J5). EFN members also noted a fish spawning area for both pickerel and sucker fish within the PDA (EFN Knowledge and Use Study; Appendix J5). Effects on traditional fishing is discussed further in Chapter 18.0 (traditional land and resource use VC).

The "Ginoogaming First Nation Social Impact Assessment" (Appendix J8) noted the importance of waterways, including Kenogamisis Lake, as habitat for harvested fish species. GFN reported irregularities, illnesses and worms in fish and noted the potential for the Project to reduce the health of fish populations. Lethal and sub-lethal effects on fish are discussed in Section 11.4.2. Human and ecological health is discussed in Chapter 19.0.

Results of the land use survey for LLFN indicated that fishing was the most popular use of the lakes, rivers and waterways within the "study area (either for food or recreational)." Fishing areas identified by individuals included "under the bridge, dump road, any lake except Long Lake, McKay Lake, all over, Long Lake, Fernow Lake, family trap ground, Long Lake #58, Nakina Lakes, Kenogamisis, Seagram Lake, Camp #20, Ranier Lake, by the river (Kenogamisis River), Suckle Creek, Fernel Lake. The popular fishing spots include Kenogamisis Lake, Kenogamisis River, lakes around Nakina, and Eldee Lake".

MNO provided information on fish species harvested and the number of "areas harvested" for each of the species identified. Species included bass, Burbot (ling cod), Northern Pike (jackfish), Yellow Perch (perch), Walleye (pickerel), Rainbow Smelt (smelt), sucker, trout, Lake Whitefish (whitefish), salmon, Lake Sturgeon and other non-commercial fish. The species with the greatest number of "areas harvested" were Walleye, Northern Pike and trout (MNO TKLU Study; Appendix J3). The presence, range and abundance of these species has been identified in the LAA, as have important spawning areas for these species. The effects assessment has identified mitigation measures for the protection of these and other important species present in the LAA.

Baseline studies confirmed a single adult Brook Trout, identified as a species of interest by MNO, in the LAA, in the Southwest Arm Tributary in May 2016. This fish was believed to be transient and not indicative of a resident population in the Southwest Arm Tributary because it was present during the spring, when water temperatures and dissolved oxygen conditions were favourable for Brook Trout. The absence of juvenile and young of the year fish in previous and subsequent fish community sampling events also indicates that there is not a resident population of Brook Trout in the Southwest Arm Tributary.

[1] The species range for Northern Pikeminnow (*Ptychocheilus oregonensis*) does not include Ontario and therefore this species is not directly assessed in this chapter; however, mitigation measures and offsetting is designed to protect habitat for all fish species that are present.

PPFN provided species information for Dickson Lake (located approximately 49 km south of the Project), Campsite Lake, Long Lake (located approximately 35 km downstream of Kenogamisis Lake), Aguasabon Lake (located approximately 125 km downstream of Kenogamisis Lake, Chorus Lake (located approximately 41 km south of Project) and Troupe Lake (located approximately 230 km south of the Project). For Dickson Lake, "the fish species present are white suckers, black nose shiner, northern pike, carp, and minnows." "Campsite Lake is a cool water regime with walleye and northern pike present." "Long Lake is a cool water regime with Lake trout, brook trout, walleye, northern pike, lake whitefish, yellow perch, burbot, and suckers present." "Northern pike, brook trout, smallmouth bass and walleye" were present in Aguasabon Lake." "Chorus Lake is a cool water regime with walleye, northern pike and suckers." Toupe Lake was described as a "cool water regime with walleye and northern pike present". None of the lakes identified by PPFN are located in the LAA or RAA, and are therefore not anticipated to be affected by the Project.

The Final EIS/EA identifies some habitat loss and alteration that will be offset through habitat creation in the Goldfield Creek diversion (Table 11-13). This chapter also discusses potential effects on fish and fish habitat that have the potential to occur as a result of effluent discharge to the Southwest Arm of Kenogamisis Lake. However, that assessment concludes that, although there may be localized effects on the most sensitive aquatic organisms (algae) in the immediate vicinity of the discharge (i.e., within 50 m), the anticipated changes in water quality will not result in an observable effect on fish. No serious harm to fish is anticipated within the Southwest Arm of Kenogamisis Lake. Water quality in the Central Basin of Kenogamisis Lake is also anticipated to improve because of excavation and removal of portions of the historical tailings to the new TMF. Therefore, potential effects on fish and fish habitat are limited to the LAA and are not anticipated farther downstream.

11.1.4 Selection of Potential Environmental Effects and Measurable Parameters

Table 11-1 summarizes the potential environmental effects of the Project on fish and fish habitat, the measurable parameters, and the rationale for their selection. These potential environmental effects and measurable parameters were selected based on professional judgment, recent EAs for mining projects in Ontario, and comments provided during consultation.

Table 11-1: Potential Environmental Effects and Measurable Parameters for Fish and Fish Habitat

Potential Environmental Effect	Measurable Parameter(s) and Units of Measurement	Notes or Rationale for Selection of the Measurable Parameter
Lethal and sub-lethal effects on fish	Direct mortality of fish measured by species, numbers and age classes killed.	Work in or around water can cause direct mortality of fish, which are protected by Section 35 (1) of the *Fisheries Act* and valued locally for recreational purposes and sustenance.
	Peak particle velocity (PPV)	PPV >13 mm/sec through the use of explosives can cause lethal or sub-lethal effects on fish eggs and larval fish.
	Instantaneous pressure	Instantaneous pressure change > 50 KPa can cause internal injury to fish including damage to their organs and swim airbladders and can be lethal.
	Chronic toxicological effects on fish and other biota as measured by PoPC (e.g., mercury and arsenic) in water (mg/L) or body tissue (µg/g) and by toxicity testing (% mortality, % inhibition, and lethal body concentrations in µg/g). EEM regulated end- points including Condition Factor (CF), Gonadal Somatic Index (GSI), and Liver Somatic Index (LSI).	The Project may result in increased levels of PoPCs in the environment, some of which may bioaccumulate in fish tissue and affect fish health (e.g., condition and reproductive success), thereby affecting fishery productivity. EEM endpoints for toxicity and fish community monitoring have been established to a national standard to assess potential effects on fish health.
Permanent Alteration of Fish Habitat	Fish habitat quality as prescribed in the Ontario Stream Assessment Protocol, including stream morphology (e.g., percent riffle, percent pool), substrate types (e.g., percent detritus, percent gravel), and percent cover.	The Project has the potential to affect the quality of fish habitat by altering characteristics such as sediment composition, riparian vegetation, and in-stream cover. These parameters are important for assessing the suitability of habitat for various species and evaluating fisheries productivity. Changes to fish habitat directly influence fisheries, which are protected by Section 35 (1) of the *Fisheries Act*.
	Water quantity as measured by lake levels (m amsl) and stream discharge (m^3/s).	Water diversion or withdrawal can directly alter habitat quality and availability and influence temperature and dissolved oxygen (DO) levels.
	Water quality parameters that influence fish habitat including water temperature (^oC), dissolved oxygen (DO) (mg/L), TSS (mg/L), pH (pH units), nutrients and chlorophyll *a* (mg/L).	Changes in water quality can affect the health of fish as well as fish habitat. The quality of surface water can affect the trophic status of lakes due to the addition of nutrients and alteration of nutrient cycling within the aquatic system. Other parameters may directly affect the suitability of habitat (e.g., changes in TSS may affect feeding success for visual predators). Changes in water temperature may influence oxygen levels and changes in habitat suitability for some species.

Table 11-1: Potential Environmental Effects and Measurable Parameters for Fish and Fish Habitat

Potential Environmental Effect	Measurable Parameter(s) and Units of Measurement	Notes or Rationale for Selection of the Measurable Parameter
	Concentration of PoPC in sediment (typically µg/g)	Project input of metals can alter sediment chemistry, leading to altered benthic invertebrate communities, which are an important component of aquatic food webs.
	Benthic invertebrate abundance (number of organisms per m^2), species diversity (number of species per m^2) and chlorophyll *a* concentrations in water (µg/L)	Project-related changes in water and sediment quality can affect aquatic communities. Planktonic and benthic organisms form the base of the aquatic food web, providing food for higher trophic levels, and common monitoring tools for aquatic effects.
	Changes in bank composition or stability as indicated by bank slope (% slope)	Works in and around water can lead to changes in bank composition through deposition of materials and bank instability leading to slumping or increased erosion.
	Presence (presence/ absence) and abundance (catch per unit effort) of fish	Changes in fish habitat may result in a shift in fish community structure or relative abundance of fish species that are valued from a CRA perspective.
	Estimate of lost productivity based on fish condition factor (length/ weight relationship), growth (age/length relationship), and reproductive condition (gonad weight and fecundity)	The Project may result in alteration of fish habitat or quality that can affect life history characteristics, leading to reduced fisheries productivity.
Loss of Fish Habitat	Fish habitat type and quantity as measured by aerial extent of loss (m^2)	The Project will result in the direct loss of habitat through infilling. Fish habitat quantity is an important factor linked to fisheries productivity. Loss of fish habitat directly influences fisheries, which are protected under Section 35 (1) of the *Fisheries Act.*

11.1.5 Boundaries

11.1.5.1 Spatial Boundaries

The areas applied for the assessment of potential environmental effects on fish and fish habitat are described below and shown in Figure 11-1 and Figure 11-2.

Project Development Area

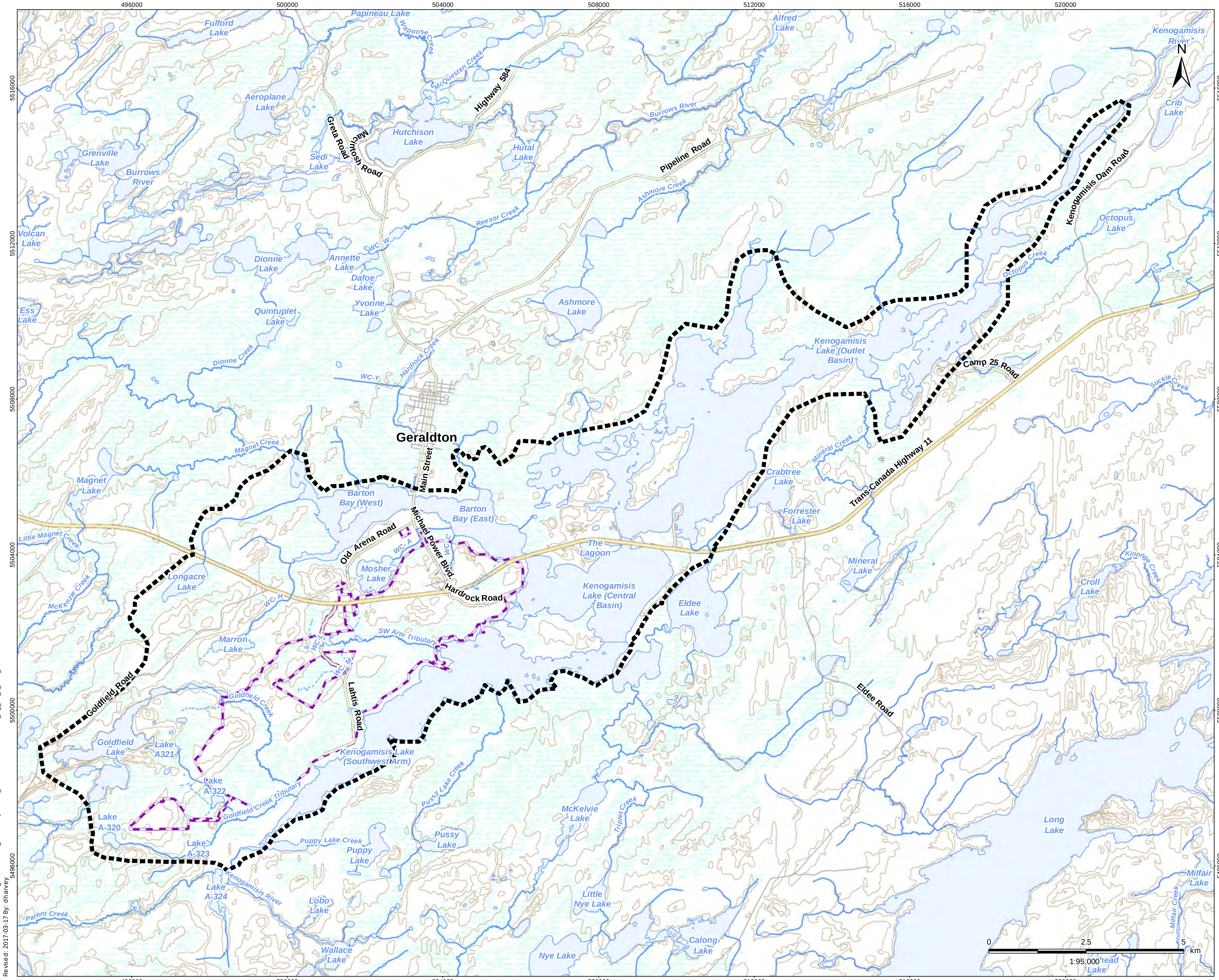
The Project development area (PDA) encompasses the Project footprint and is the anticipated area of physical disturbance associated with the construction, operation and closure of the Project (Figure 11-1). The PDA is approximately 2,200 ha in size.

Local Assessment Area

The LAA for fish and fish habitat encompasses the PDA, Kenogamisis Lake, creeks, and watercourses that flow into the northwest side of the Southwest Arm (including Goldfield Creek and its tributaries), Goldfield Lake, Marron Lake, Mosher Lake, Lake A-320, Lake A-321, Lake A-322, and Lake A-323. Based on the Provincial Water Quality Guidelines for the protection of aquatic life and conservative water quality predictions, potential effects are limited to the treated effluent mixing zone within the Southwest Arm of Kenogamisis Lake. The LAA was extended to the outlet of Kenogamisis Lake because fish have the potential to move throughout the entire lake. The LAA is shown in Figure 11-1. The LAA is approximately 14,100 ha in size and includes the PDA.

Regional Assessment Area

The regional assessment area (RAA) encompasses the LAA, the upstream drainage area of Barton Bay and the upstream drainage area of the Southwest Arm of Kenogamisis Lake. It also includes all of Kenogamisis Lake and extends downstream along the Kenogamisis River to the reservoir created by the Kenogami Control Dam. To consider potential cumulative effects on water quality, the RAA boundary was extended southward along the Kenogamisis River (which now flows south as a result of historical water diversions) to Crib Road. Compared to the LAA, the RAA boundary was further extended to the Kenogami Diversion Reservoir, which is approximately 30 km downstream of the LAA. The RAA includes the drainages of the LAA, plus the Burrows River and some smaller, unnamed tributaries to the Kenogami River downstream of Kenogamisis Lake. The RAA is shown in Figure 11-2. The RAA is used to provide regional context for the significance of residual effects and is also the area within which potential for cumulative effects of the Project in combination with other past, present or reasonably foreseeable projects or activities are considered. The RAA is approximately 133,800 ha in size and includes the LAA.



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Revised: 2017-03-17 By: dharvey

Stantec

Legend

- Local Assessment Area
- Project Development Area

Existing Features

- Contour Line (10m intervals)
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody

Notes

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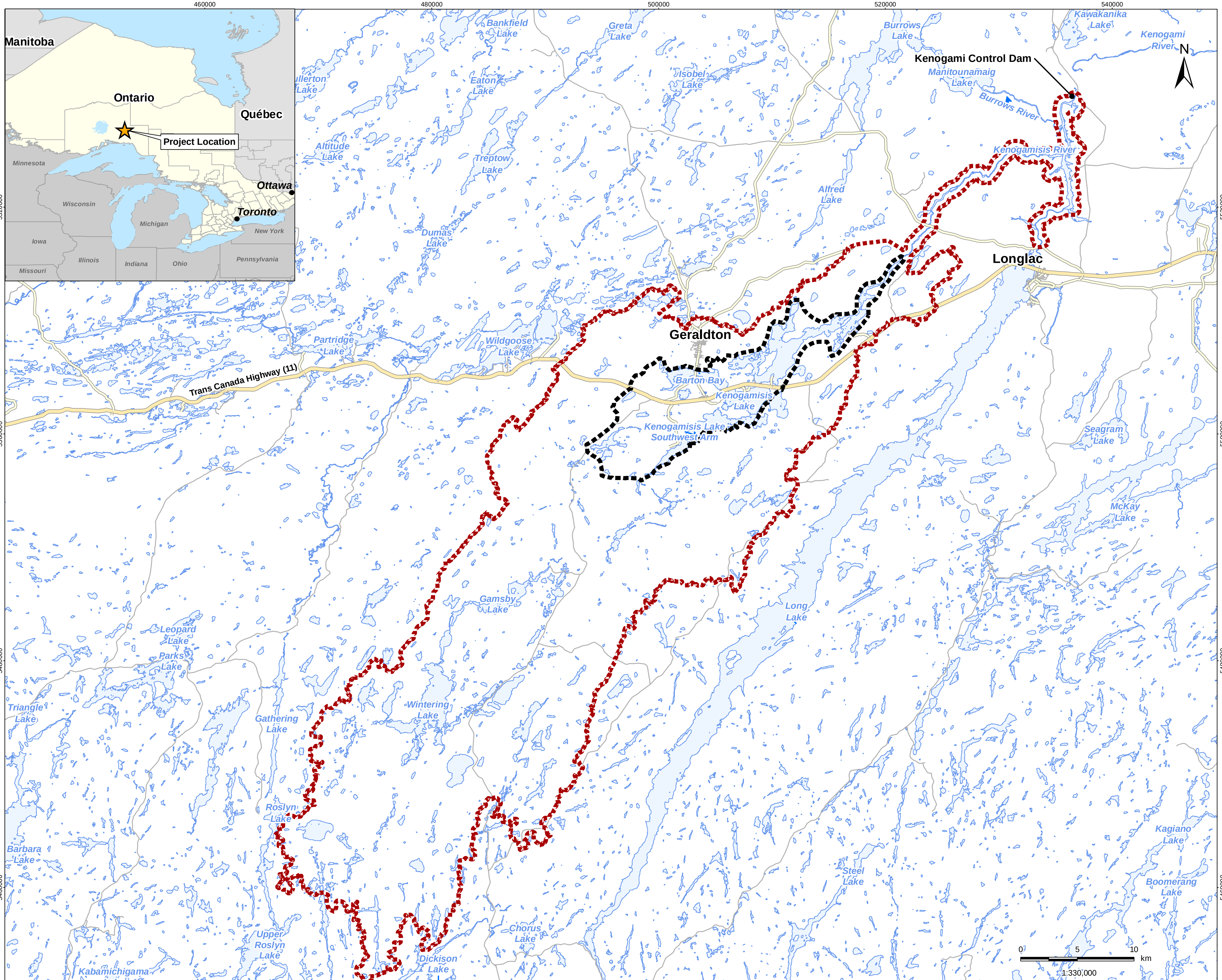
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

11-1

Title

Spatial Boundaries (LAA) For Fish and Fish Habitat



Stantec

Legend

- Regional Assessment Area
- Local Assessment Area

Existing Features

- Highway
- Major Road
- Local Road
- Waterbody

Notes

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Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-2

Title

Spatial Boundaries (LAA)
For Fish and Fish Habitat

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Revised: 2017-03-17 By: dharvey

11.1.5.2 Temporal Boundaries

Temporal boundaries are as follows:

- Construction: Years -3 to -1 with early ore stockpiling commencing after the first year of construction.
- Operation: Years 1 to 15, with the first year representing a partial year as the Project transitions from construction to operation.
- Closure:
  - Active Closure: Years 16 to 20, corresponding to the period when primary decommissioning and rehabilitation activities are carried out.
  - Post-Closure: Years 21 to 36, corresponding to a semi-passive period when the Project is monitored and the open pit is allowed to fill with water creating a pit lake.

11.1.6 Residual Environmental Effects Description Criteria

Table 11-2 summarizes how residual environmental effects are characterized in terms of direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological and socio-economic context.

Table 11-2: Characterization of Residual Environmental Effects on Fish and Fish Habitat

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The relative change compared to baseline conditions.	**Positive** — an increase in baseline fisheries productivity. **Adverse** — a decline in baseline fisheries productivity.
Magnitude	The amount of change in measurable parameters or the VC relative to baseline conditions.	**Low** — a measurable change to fish or fish habitat that is less than applicable guidelines, legislated requirements and/or federal and provincial management objectives, or that does not affect sustainability and productivity of CRA fisheries. **Moderate** — a measurable change in fish or fish habitat that is not within applicable guidelines, legislated requirements and/or federal and provincial management objectives but does not affect sustainability and productivity of CRA fisheries. **High** — a measurable change in fish or fish habitat that is not within applicable guidelines, legislated requirements and/or federal and provincial management objectives, and that is likely to affect sustainability and productivity of CRA fisheries.

Table 11-2: Characterization of Residual Environmental Effects on Fish and Fish Habitat

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Geographic Extent	The geographic area in which the residual environmental effect occurs.	**PDA** — the residual environmental effect is limited to the PDA. **LAA** — the residual environmental effect extends into the LAA. **RAA** — the residual environmental effect extends into the RAA.
Timing	Considers when the residual environmental effect is expected to occur. Timing considerations are noted in the evaluation of the residual environmental effect, where applicable or relevant.	**Not Applicable (N/A)** — seasonal aspects are unlikely to affect existing fisheries productivity. **Applicable** — seasonal aspects may affect existing fisheries productivity.
Frequency	Identifies how often the residual environmental effect occurs within a given time.	**Single Event** — the residual environmental effect occurs only once. **Multiple Irregular Event (no set schedule)** — the residual environmental effect occurs sporadically, at irregular intervals, without any predictable pattern. **Multiple Regular Event** — the residual environmental effect occurs on a regular basis and at regular intervals. **Continuous** — the residual environmental effect occurs continuously.
Duration	The length of time required until the residual environmental effect can no longer be measured or otherwise perceived.	**Short-term** — the residual environmental effect is limited to construction or active closure. **Medium-term** — the residual effect extends throughout construction, operation and active closure. **Long-term** — the residual environmental effect extends beyond active closure.
Reversibility	Pertains to whether a measurable parameter or the VC can return to baseline condition or other target (such as an offsetting target) after the Project activity ceases.	**Reversible** — the residual environmental effect is likely to be reversed after activity completion. **Irreversible** — the residual environmental effect is permanent and the VC is unlikely to return to baseline conditions or other target.
Ecological and Socio-economic Context	Considers uncommon characteristics of the area, a community and/or ecosystems that may be affected by the Project and/or whether the VC or measurable parameter is important to the functioning of an ecosystem or community of people.	**Typical** — fish species or fish habitat are considered common. **Atypical** — fish species or fish habitat are considered rare.

11.1.7 Significance Thresholds for Residual Environmental Effects

In consideration of the criteria presented in Section 11.1.5, the following threshold has been established to define a significant adverse residual environmental effect on fish and fish habitat:

- A significant residual environmental effect is one that is not authorized under the *Fisheries Act*, or one that, despite authorization and associated mitigation and offsetting, affects the productivity and sustainability of a CRA fishery.

This significance threshold considers the characterizations described in Table 11-2 when making a determination of significance. Direction is addressed in this significance threshold because, by definition, a decline in fisheries productivity relates to an adverse condition. Magnitude is addressed when considering whether the residual environmental effect on fish or fish habitat is within applicable guidelines, legislated requirements, and/or federal and provincial management objectives and whether the sustainability or productivity of CRA fish populations are adversely affected. Ecological and socio-economic context is addressed as the significance threshold considers traditional knowledge (TK) and local baseline conditions and how a Project-related change in fish and fish habitat may affect a CRA fishery. A conservative estimation of what constitutes CRA fisheries has been made, where all fish bearing waters connected to known CRA fisheries are also considered CRA fisheries.

Timing is not directly addressed by this significance threshold, as the Final EIS/EA is concerned primarily with environmental effects caused by the Project and not by natural variations in baseline conditions that may be associated with seasonality or other timing considerations. Where such natural seasonal variations are expected to affect fish and fish habitat, they are mentioned in the environmental effects assessment, but these variations would not be considered to cause a significant adverse residual environmental effect by the Project.

The remaining characterizations (i.e., geographic extent, frequency, duration, and reversibility) inform the determination of significance in terms of understanding when, how often, and the length of time the residual effect on fish and fish habitat is anticipated to occur and whether fish habitat will return to baseline conditions once the Project activity has ceased.

11.2 EXISTING CONDITIONS FOR FISH AND FISH HABITAT

This section provides a summary of existing conditions for fish and fish habitat and the methods used to characterize baseline conditions. Additional details are provided in Appendix E7. Locations of waterbodies and watercourses referenced in this chapter are shown on Figure 11-3. In addition to assessing streams shown on existing mapping (i.e., NTS topographic series), smaller intermittent and ephemeral steams were identified, delineated and assessed based on multiple site visits between 2013 and 2016.

11.2.1 Methods

Fish and fish habitat were characterized by obtaining existing information and supplementing it with field studies. Several data sources were incorporated into the description of existing habitat.

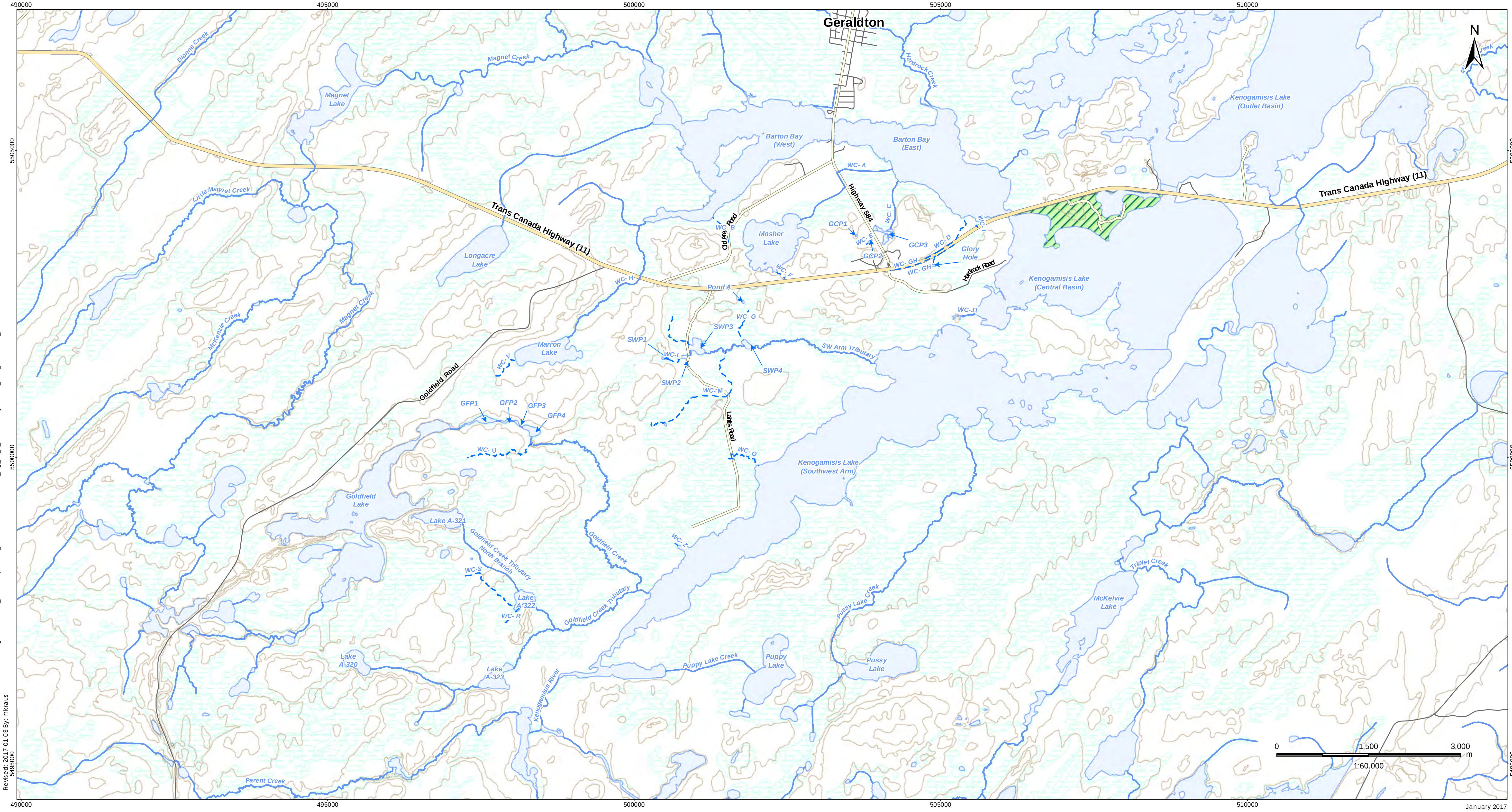
11.2.1.1 Existing Data

The following studies were reviewed and summarized prior to field investigations:

- Land Information Ontario (LIO) database
- topographic maps, aerial photography, and satellite imagery
- MOECC Fish Tissue Database
- MNRF Fish ON-Line website containing Broad-scale Fisheries Monitoring Bulletins "Kenogamisis Lake – FMZ 7 – 2008-2012" and "Kenogamisis Lake – FMZ 7 – 2013-2017" (MNRF 2015b)
- email correspondence between MNRF biologist Evan Armstrong, Senior MNRF Technical Specialist Gerald Abraham and Stantec Staff (June 30, 2015.)
- previous monitoring studies near the Hardrock site including:
  - Hardrock Mine Project Pond A-323, Pond A-322, and Pond A-320 Aquatic Habitat Assessment (Parks 2013a)
  - Premier Gold Ltd. Ecological Constraint Mapping: Hardrock Project Memo (Parks 2013b)
  - A Spatial and Temporal Assessment of Metal/Metalloid Concentrations in Kenogamisis Lake Sediments (Parks 2012a)
  - A Geographical and Temporal Assessment of Metal/Metalloid Concentrations in Fish in Kenogamisis Lake from 1977-2011 with Comparisons to Other Ontario Waters (Parks 2012b)
  - Premier Gold Mines Ltd. Benthic Invertebrate Baseline Report (Salter 2010)
  - MacLeod Provincial Park Management Plan (MNR 1987)

11.2.1.2 Environmental Monitors

An environmental program was initiated with local Aboriginal groups in 2012 to support the collection of environmental data for the Project. The process was community-driven and intended to provide transparency and increase community capacity in technical aspects of environmental monitoring. Local Environmental Monitors contributed to the success of the baseline programs. Aboriginal communities that participated in field programs in 2014 included AFN, GFN, and LLFN.



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Revised: 2017-01-03 By: mkraus

Stantec

Legend

- Highway
- Major Road
- Local Road
- Contour Line (10m intervals)
- Provincial Park
- Waterbody

Watercourses

- Permanent
- Intermittent
- Wetland (Eco-site Based)

Notes

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Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

11-3

Title

Names and Locations of Local Lakes, Ponds and Streams

11.2.1.3 Field Studies

GGM conducted field studies (discussed in more detail below) to supplement existing fish and fish habitat characterization data during the following periods:

- fall 2013: September 21 through October 2
- spring 2014: May 12 through May 25
- summer 2014: September 18 through September 21
- fall 2014: September 22 through September 26 and October 17 through October 30
- spring 2015: May 19 to May 30
- summer 2015: July 19 to 28
- spring 2016: May 10 to June 10
- summer 2016: August
- fall 2016: September

The field program involved assessment of fish community, fish tissue, fish habitat, sediment quality and benthic invertebrate conditions, as outlined below.

Detailed methods are described in the Baseline Report – Fish and Fish Habitat (Appendix E7). Extensive water quality sampling was also completed and is described in the Baseline Report – Surface Water Quality (Appendix E4). Key information collected in 2016 has been incorporated into the effects assessment (e.g., the identification of new species, critical habitats, or revisions to the known range of fish within the LAA, consideration of toxicity testing results).

Fish Habitat

Fish habitat assessments were completed in lotic (flowing water) and lentic (still water such as lakes) habitats throughout the LAA. Fish habitat surveys in lakes and ponds included assessment and documentation of:

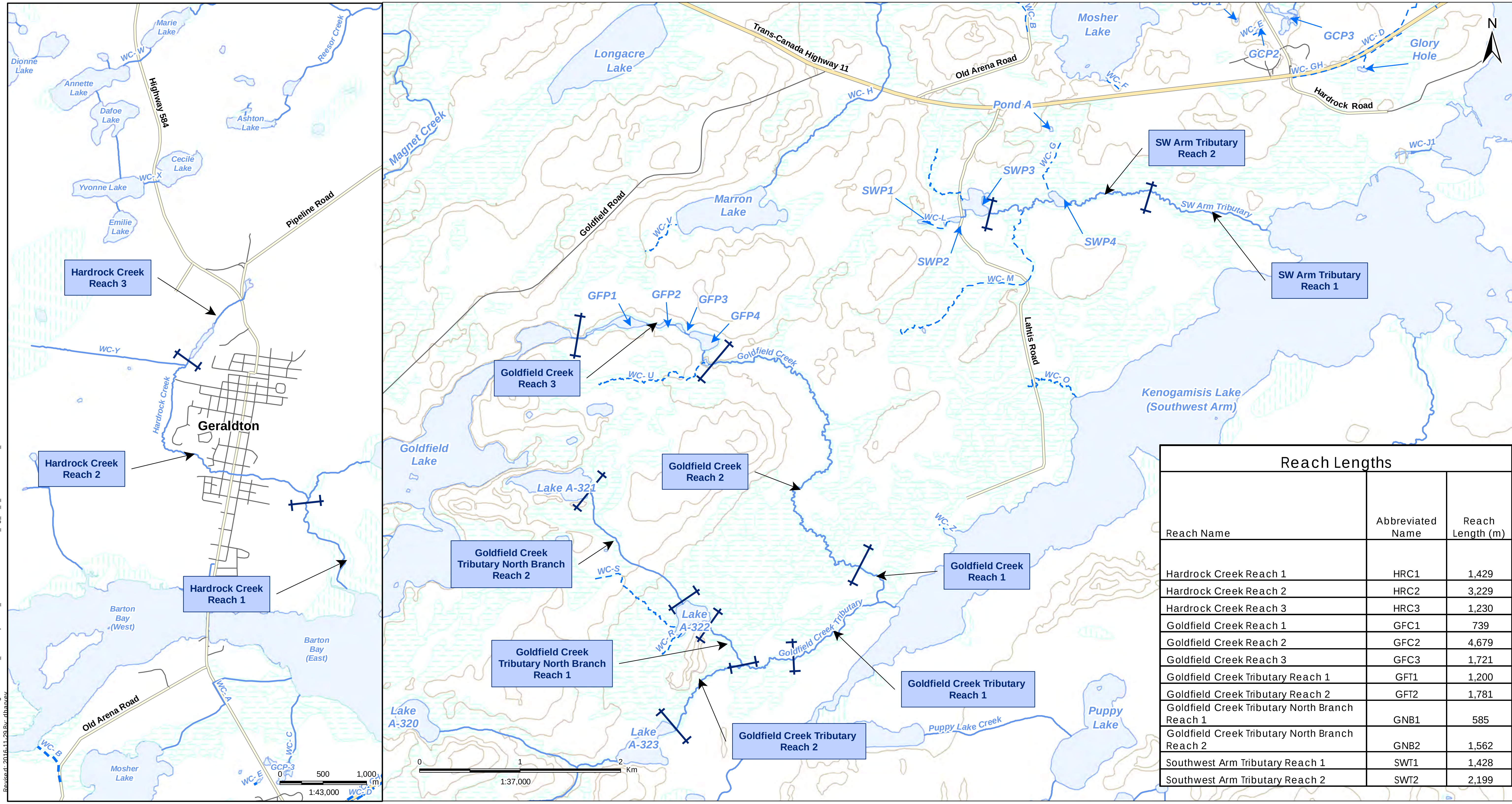
- substrate characteristics
- riparian vegetation
- aquatic vegetation
- lake bathymetry
- critical habitats, including potential spawning areas.

Fish habitat surveys in streams included the assessment and documentation of:

- in-stream cover
- substrate characteristics
- riparian vegetation
- aquatic vegetation
- stream dimensions, including bank full width, wet width and maximum pool depth
- stream gradient
- stream morphology
- barriers to fish passage
- spawning potential.

To identify spawning habitat, visual observations were made to document spawning activity. Where spawning activity was not observed, potential spawning habitats were identified and, for the purpose of the Final EIS/EA, considered as spawning habitat. Spawning habitat characteristics identified in Scott and Crossman (1973) were used to identify potential spawning areas.

In situ measurements of temperature, DO, pH, and conductivity were made at the water surface at each habitat assessment site. *In situ* profiles were also completed in the deepest basin of lakes within the LAA. Habitat in first order streams was characterized for the entire length of the stream. Larger streams such as Goldfield Creek and the Southwest Arm Tributary were divided into homogeneous reaches of similar habitat, with habitat assessments conducted within each reach. Stream reaches and watercourses assessed are shown in Figure 11-4. Qualitative assessments were completed in most watercourses, with quantitative assessments completed in watercourses potentially affected by overprinting or water diversions. Quantitative assessments documented specific, measurable parameters following the Ontario Stream Assessment Protocol (MNR 2012) such that potential losses can be quantified and offset if required. Photographs were taken of sampling locations and are provided in the Baseline Report – Fish and Fish Habitat (Appendix E7).



Reach Lengths

Reach Name	Abbreviated Name	Reach Length (m)
Hardrock Creek Reach 1	HRC1	1,429
Hardrock Creek Reach 2	HRC2	3,229
Hardrock Creek Reach 3	HRC3	1,230
Goldfield Creek Reach 1	GFC1	739
Goldfield Creek Reach 2	GFC2	4,679
Goldfield Creek Reach 3	GFC3	1,721
Goldfield Creek Tributary Reach 1	GFT1	1,200
Goldfield Creek Tributary Reach 2	GFT2	1,781
Goldfield Creek Tributary North Branch Reach 1	GNB1	585
Goldfield Creek Tributary North Branch Reach 2	GNB2	1,562
Southwest Arm Tributary Reach 1	SWT1	1,428
Southwest Arm Tributary Reach 2	SWT2	2,199

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Stantec

Legend
- Contour Line (10 m intervals)
- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody
- Reach Break

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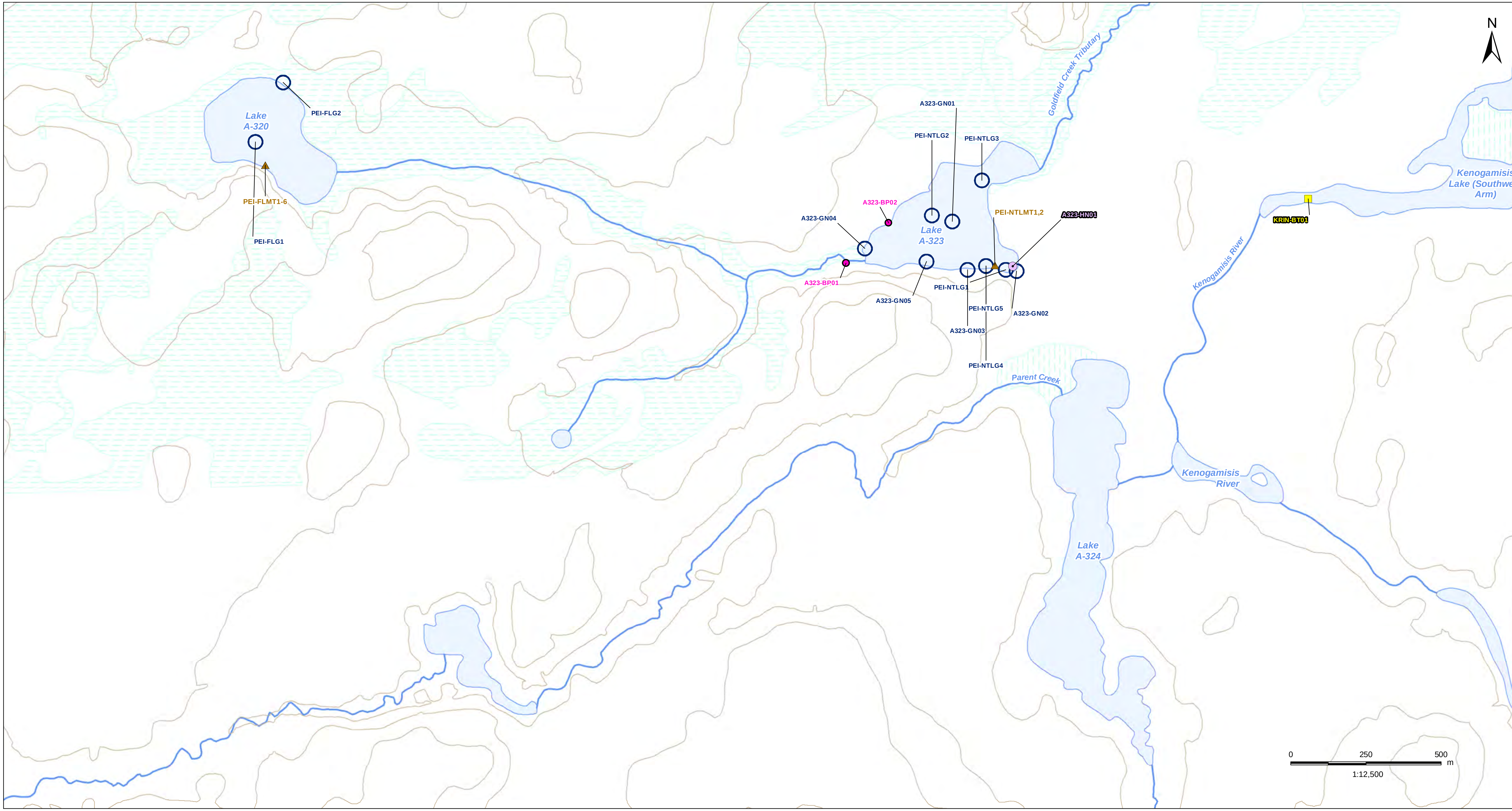
Client/Project
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-4

Title
Stream Reaches

Fish Community

Fish community assessments in the LAA were completed using a variety of sampling methods to target a wide range of fish species, sizes, and age classes. Gear types were selected that were most effective for the type of habitat sampled. These included large mesh experimental gill nets, small mesh experimental gill nets, backpack electrofishing, boat electrofishing, seine nets, minnow traps, box traps, and fyke nets. Gear types, methods and catch per unit effort were documented, with appropriate effort expended to document the species present, relative abundance, and life stages of the populations present in each waterbody sampled. The location of fish collections is summarized by collection method in Figure 11-5. This figure includes collections completed by Stantec and in previous studies. Supporting environmental measurements (i.e., DO, temperature, pH, conductivity) were obtained near the water surface at each fish sampling location. Morphometric data (i.e., length, weight and external condition) for fish from each waterbody were collected. Tissue samples were also collected from representative fish throughout the LAA and analyzed for metals and percent moisture. Fish ageing structures were collected and age was estimated for fish used for tissue sampling.



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Revised: 2016-11-30 By: mkraus

November 2016
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Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

Notes

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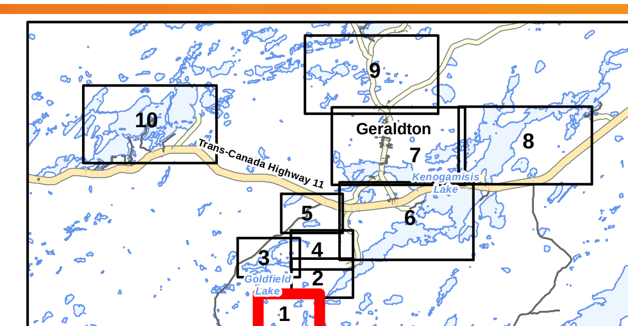

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Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

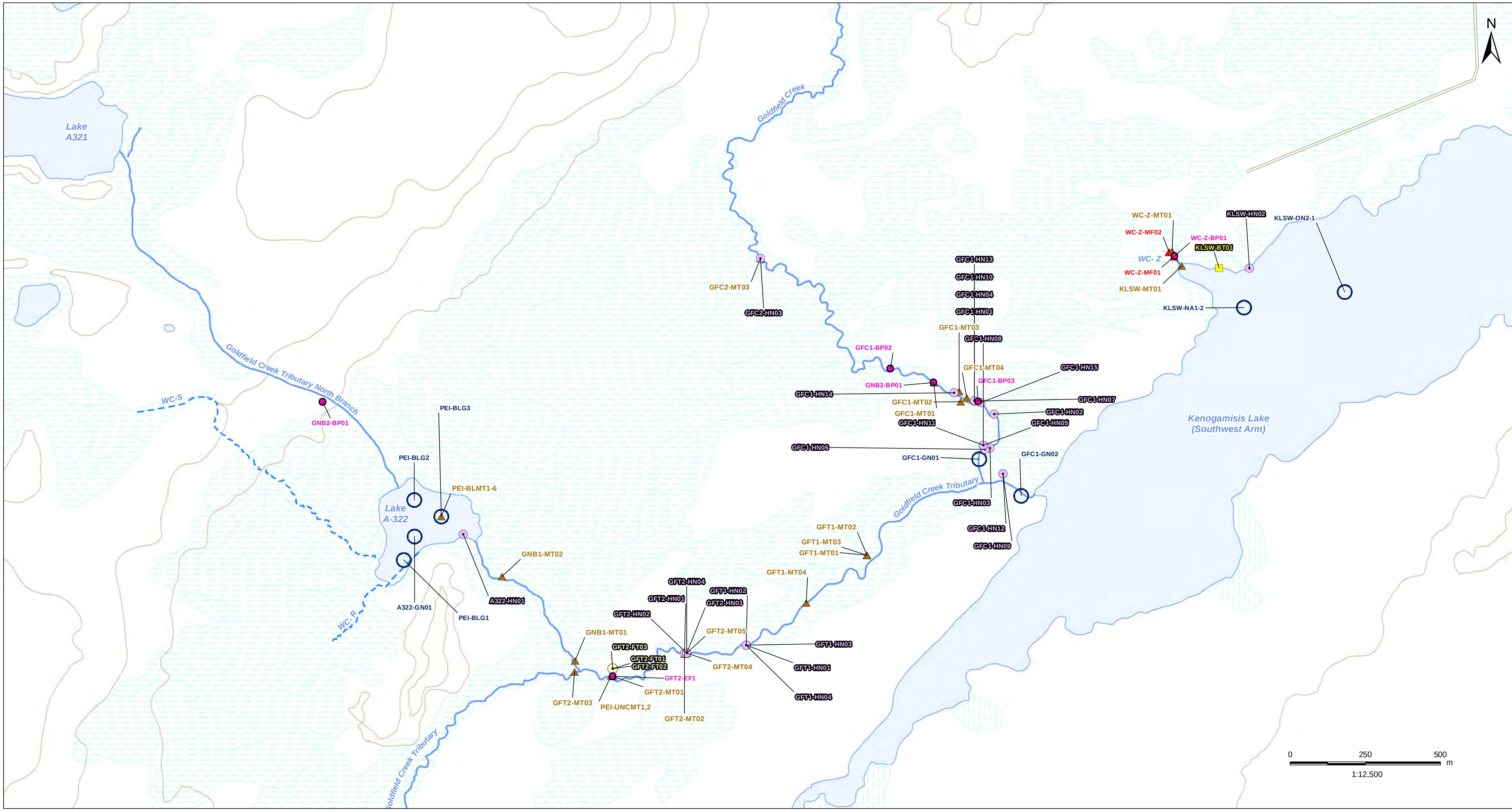
Figure No.

11-5

Title

Fish Collection Locations and Methods

Tile- 1



November 2016
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Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
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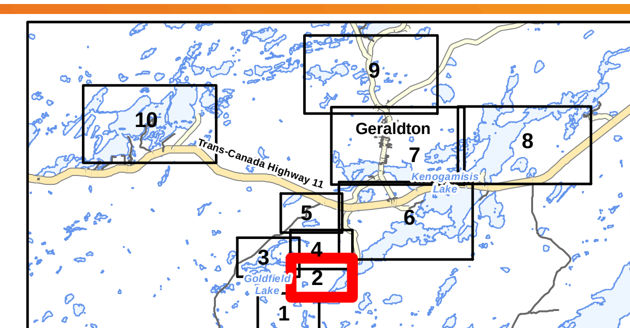
- MNRF Broadscale Netting
- Seine Net



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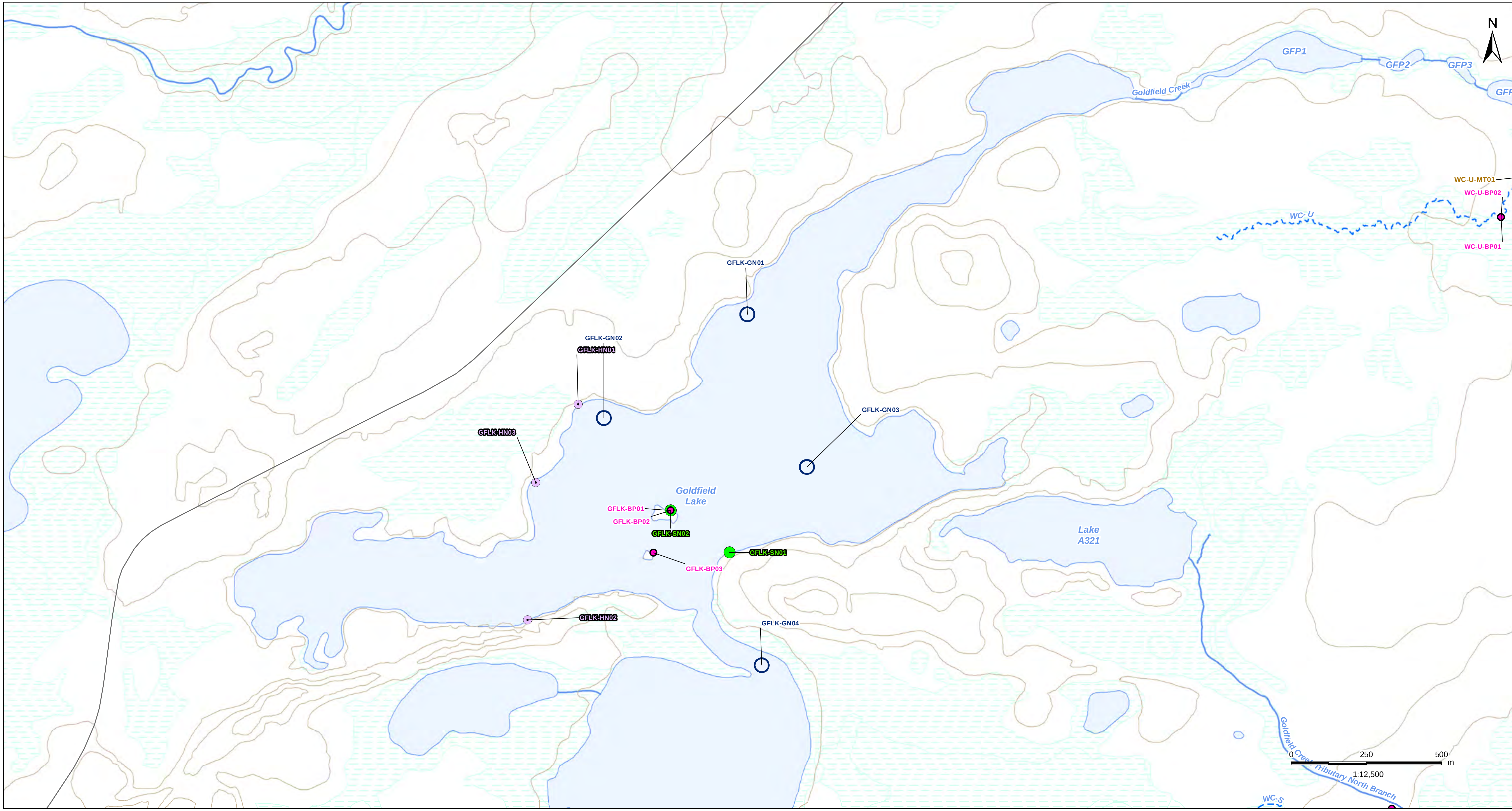
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

11-5

Title

Fish Collection Locations and Methods
Tile- 2



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Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
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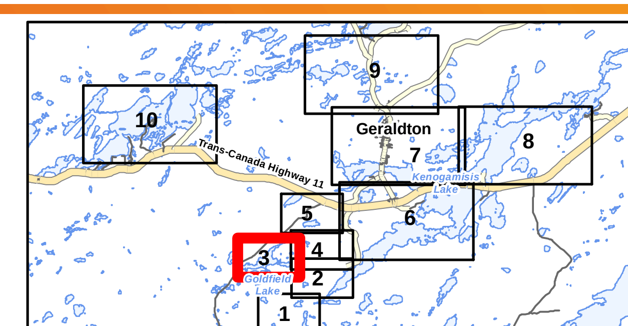
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net



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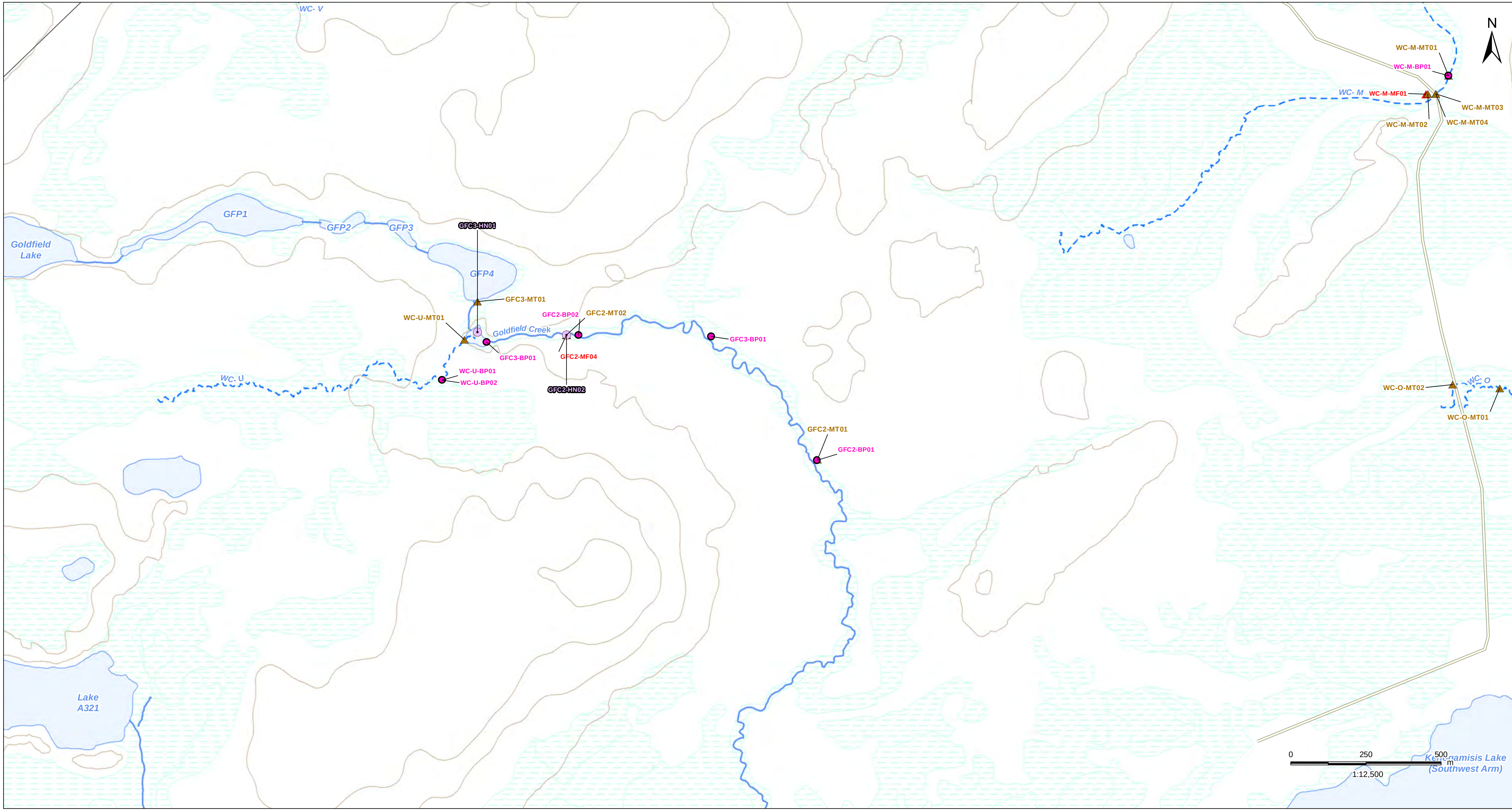
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-5

Title
Fish Collection Locations and Methods
Tile- 3



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November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

Notes

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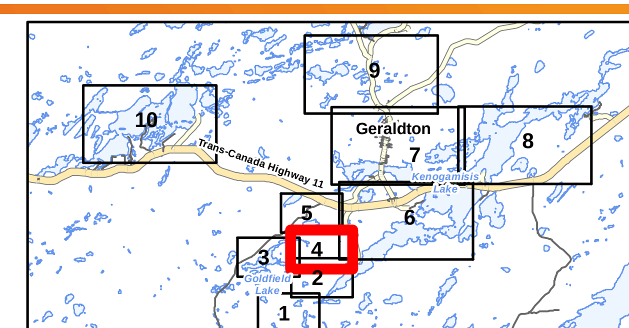

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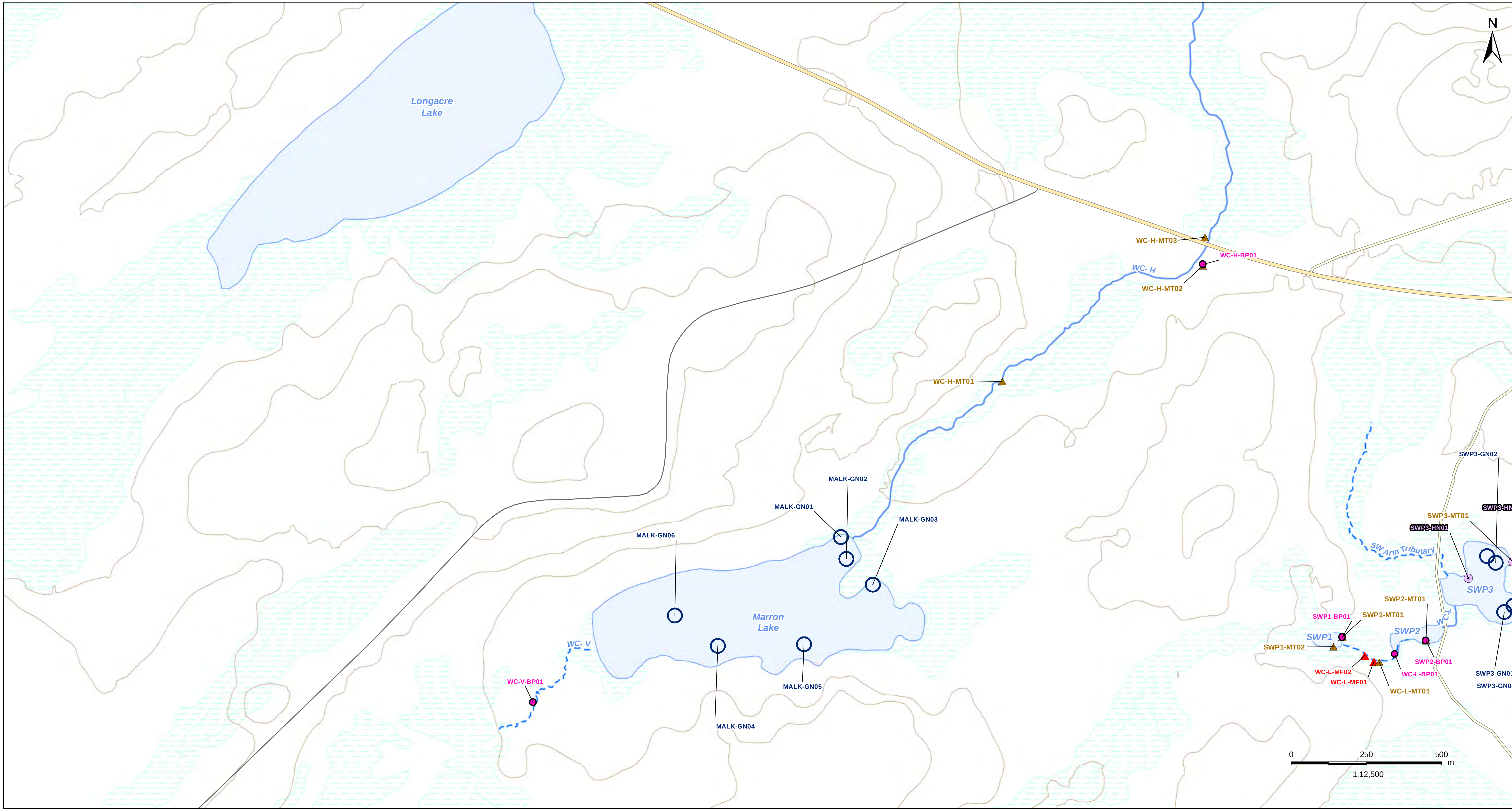
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

11-5

Title

Fish Collection Locations and Methods
Tile- 4



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Revised: 2016-11-30 By: mkraus

November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

Notes

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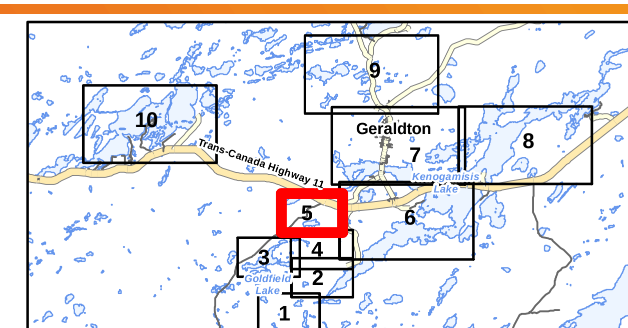


Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

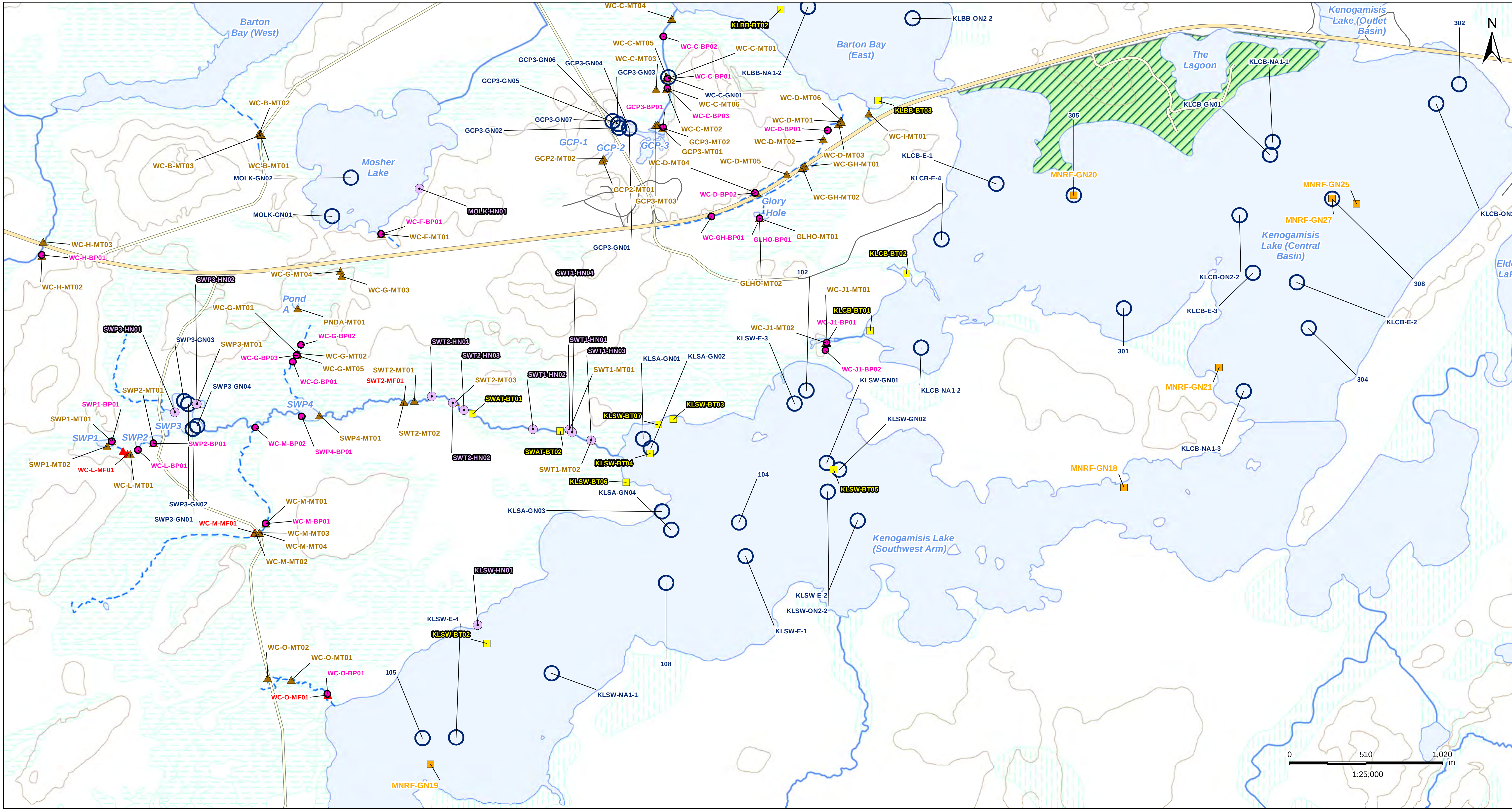
Figure No.

11-5

Title

Fish Collection Locations and Methods

Tile- 5



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Revised: 2017-01-03 By: mkraus

January 2017
160961111

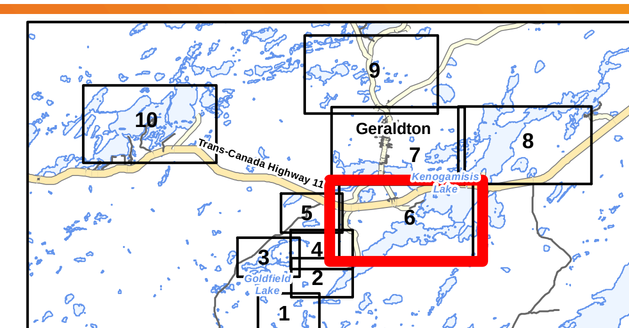
Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net



Notes

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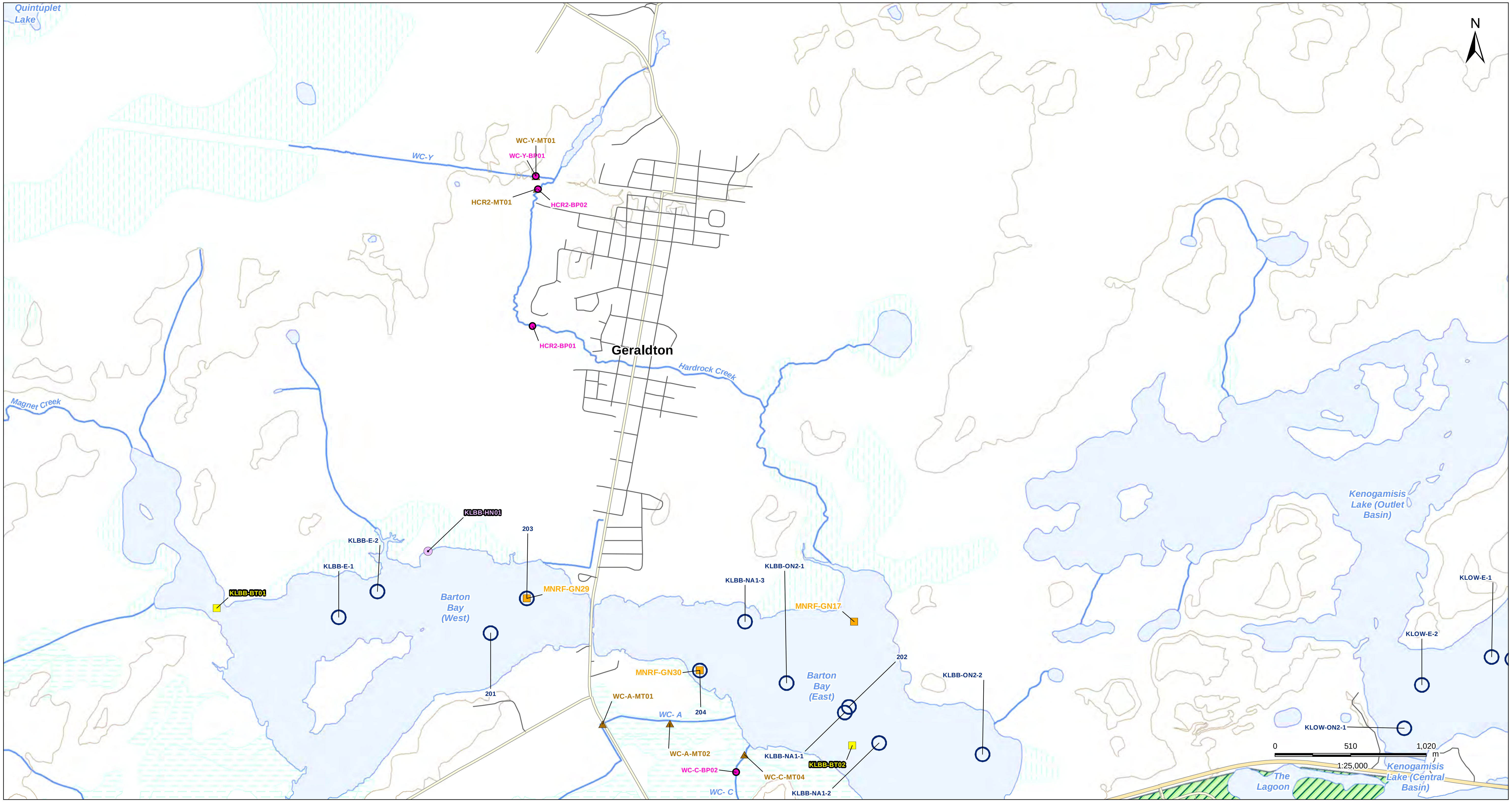
Client/Project
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-5

Title
Fish Collection Locations and Methods
Tile- 6



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Revised: 2016-11-30 By: mkraus

November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

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- Fish Trap
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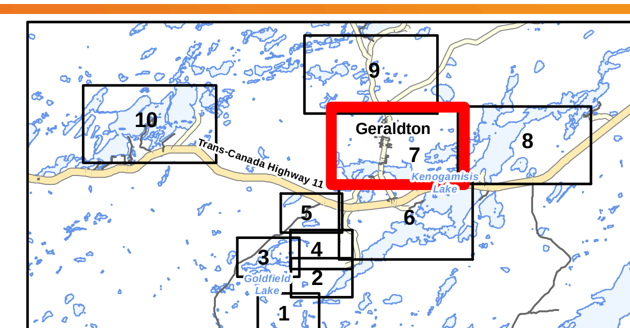
- MNRF Broadscale Netting
- Seine Net



Notes

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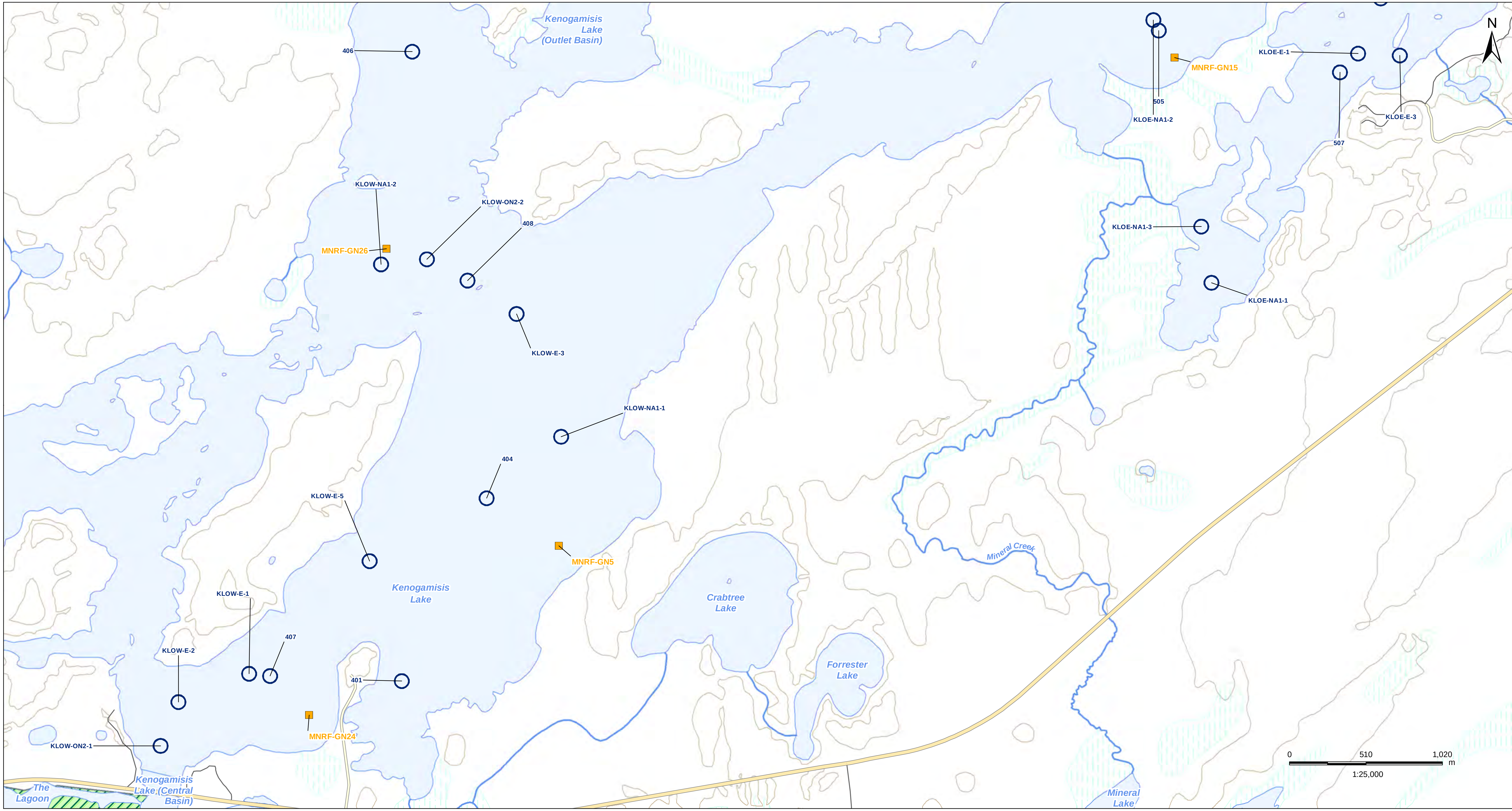
Client/Project
Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-5

Title
Fish Collection Locations and Methods
Tile- 7



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Revised: 2016-11-30 By: mkraus

November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
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- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

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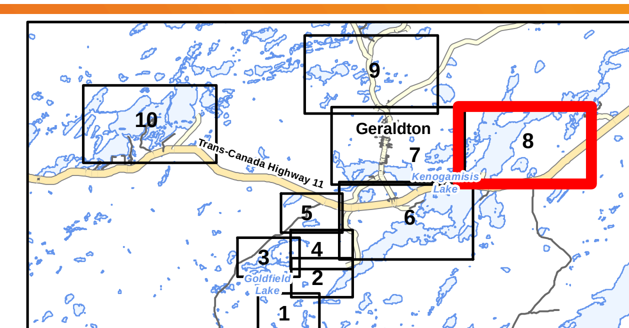


Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

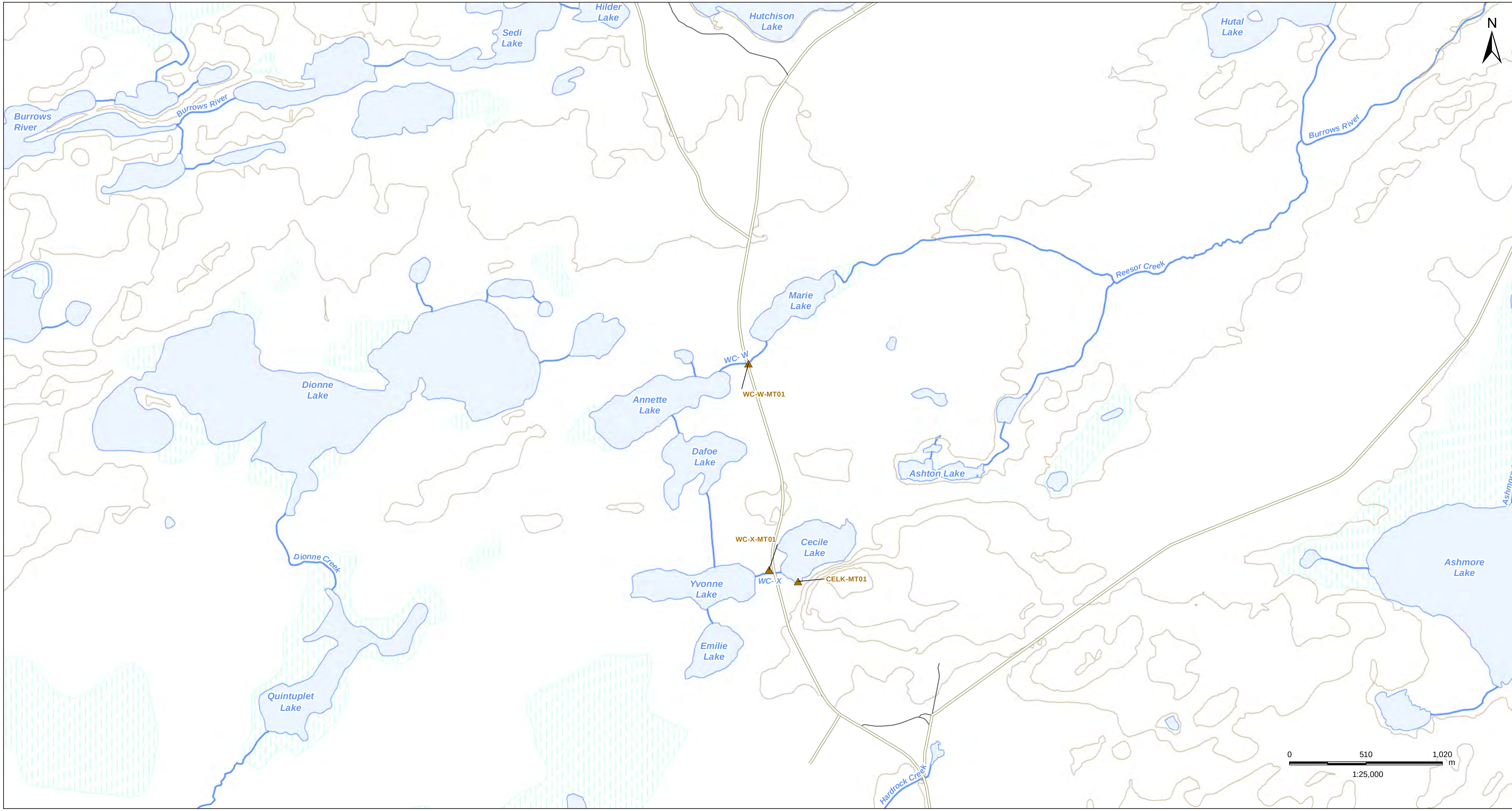
Figure No.

11-5

Title

Fish Collection Locations and Methods

Tile- 8



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Revised: 2016-11-30 By: mkraus

November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

Notes

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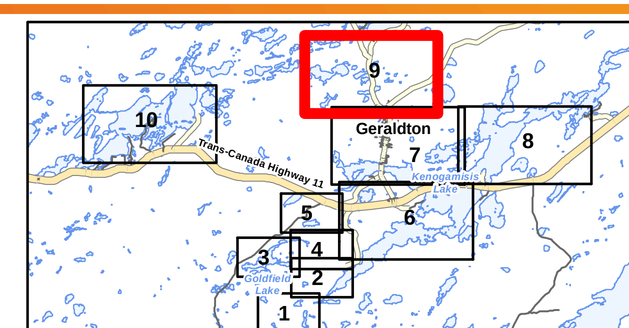
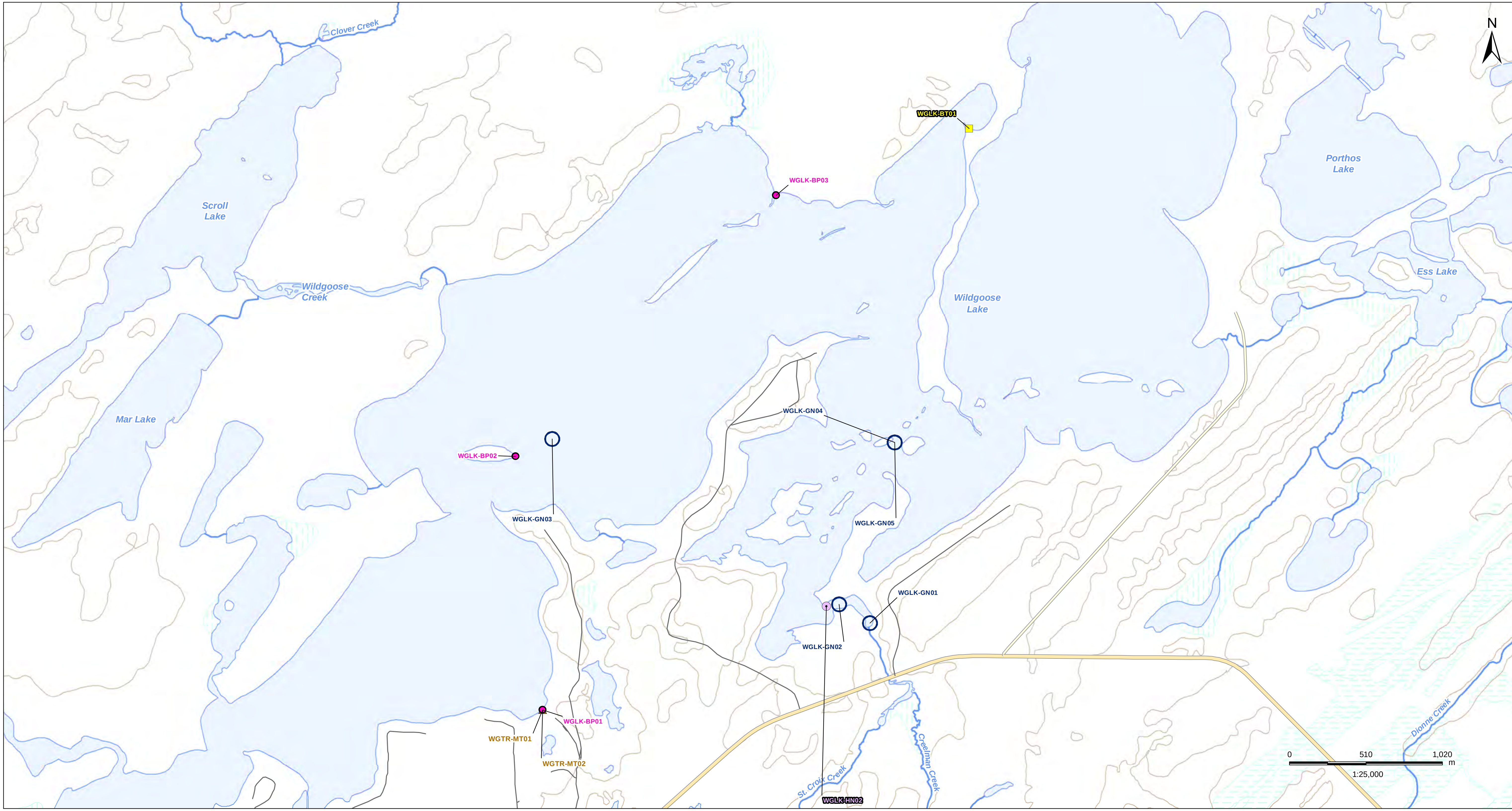


Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
11-5

Title
Fish Collection Locations and Methods
Tile- 9



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Revised: 2016-11-30 By: mkraus

November 2016
160961111

Stantec

Legend

- Highway
- Major Road
- Local Road
- Permanent
- Intermittent
- Provincial Park
- Wetland (Eco-Site Based)
- Wetland (Unevaluated- MNRF Data)
- Waterbody

Fishing Methods

- Minnow Trap
- Backpack Electrofishing
- Boat Electrofishing
- Fish Trap
- Fyke Net
- Gill Net
- Hoop Net
- MNRF Broadscale Netting
- Seine Net

Notes

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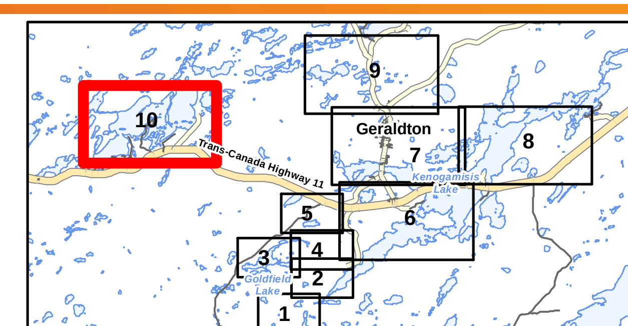


Client/Project

Greentsone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.

11-5

Title

Fish Collection Locations and Methods
Tile- 10

Fish Tissue Analysis and Metal Bioavailability

Fish tissue was sampled to build upon the historical data set managed by MOECC and summarized by Parks (2012b). Both large-bodied and small-bodied fish in Kenogamisis Lake were targeted for tissue analysis. Large bodied fish were selected for comparison to historical data and because of their importance as a human food source. Small-bodied fish were also selected because they tend to occupy a smaller geographic home range throughout their life cycle; therefore, they are more representative of local conditions and can be more useful for long-term monitoring. For smaller lakes that will not receive effluent discharges, one or more representative species of fish have been selected for tissue monitoring.

Walleye were the preferred large-bodied fish species for tissue analysis wherever data were available because they are frequently targeted for consumption and because they are a top aquatic predator, so are more likely to show effects of bioaccumulation than most other species. Consultation and TK input has identified that Walleye are of traditional importance to Aboriginal people (Traditional Knowledge Assessments/Information) (Appendix J)). Where Walleye were not present, an alternative species was selected for monitoring. Yellow Perch were widely distributed in the LAA and were often used when Walleye were not present. For tissue studies of small bodied fish, Spottail Shiner was selected as the preferred species because it is widely distributed in the LAA, has a small home range, and could be captured in adequate numbers to satisfy sample size objectives. They are also likely an important prey species for piscivorous fish in Kenogamisis Lake. Species sampled for each sampling area and numbers of samples collected are summarized in Table 11-3.

Table 11-3: Species, Methods and Sample Sizes used for Fish Tissue Analysis, Stantec Studies 2013 to 2016

Waterbody Name	Date Sampled	Sampling Methods	Species Selected	Tissue Type [A]	Number of Replicate Samples (n)	Number of Fish per Replicate Sample
Lake A-321	August 2016	Hoop Netting & Gill Netting	White Sucker	fillet	24	1
Lake A-321	August 2016	Minnow Traps	Fine Scale Dace	whole	5	3-6
Lake A- 322	October 2013	Gill Netting	Northern Pike	fillet	5	1
Lake A- 322	August 2016	Hoop Netting & Gill Netting	Yellow Perch	fillet	24	1
Lake A-323	October 2013	Gill Netting and Backpack Electrofishing	Yellow Perch	fillet	15	1

Table 11-3: Species, Methods and Sample Sizes used for Fish Tissue Analysis, Stantec Studies 2013 to 2016

Waterbody Name	Date Sampled	Sampling Methods	Species Selected	Tissue Type [A]	Number of Replicate Samples (n)	Number of Fish per Replicate Sample
Goldfield Lake (GFLK)	May 2014	Backpack Electrofishing	Spottail Shiner	whole	7	4 - 8
Goldfield Lake (GFLK)	May 2014	Gill Netting	Walleye	fillet	21	1
Goldfield Creek (GFCR-1)	May 2014	Gill Netting	Trout-perch	whole	10	4
Kenogamisis Lake (Southwest Arm)	October 2014	Gill Netting	Walleye	fillet	24	1
Kenogamisis Lake at main inlet (KRIN)	May 2014	Boat Electrofishing	Walleye	fillet	12	1
Southwest Arm Tributary Mouth (SWAT)	May 2014	Boat Electrofishing	Spottail Shiner	whole	7	4 - 6
Kenogamisis Lake –Barton Bay (McLeod Tailings)	May 2014	Boat Electrofishing	Spottail Shiner	whole	7	4 - 6
Kenogamisis Lake Central Basin (Hardrock)	May 2014	Boat Electrofishing	Spottail Shiner	whole	7	4 - 6
Marron Lake (MOLK)	August 2016	Hoop Netting and Gill Netting	Yellow Perch	fillet	22 [B]	1-2
Mosher Lake (MOLK)	October 2013	Gill Netting	Northern Pearl Dace	whole	10	1
Mosher Lake (MOLK)	October 2013	Gill Netting	Yellow Perch	fillet	7	1 - 3
Mosher Lake (MOLK)	August 2016	Hoop Netting and Gill Netting	Yellow Perch	fillet	16 [B]	1-2
South Magnet Lake (SMLK)	August 2016	Hoop Netting and Gill Netting	White Sucker	fillet	4 [B]	1
South Magnet Lake (SMLK)	August 2016	Hoop Netting and Gill Netting	Yellow Perch	fillet	25 [B]	1
South Magnet Lake (SMLK)	August 2016	Minnow Trapping	Finescale Dace	whole	5 [B]	3-6
Southwest Pond 3 (SWP3)	August 2016	Hoop Netting & Gill Netting	Yellow Perch	fillet	20 [B]	1

Table 11-3: Species, Methods and Sample Sizes used for Fish Tissue Analysis, Stantec Studies 2013 to 2016

Waterbody Name	Date Sampled	Sampling Methods	Species Selected	Tissue Type A	Number of Replicate Samples (n)	Number of Fish per Replicate Sample
Wildgoose Lake (WGLK)	May 2014	Backpack Electrofishing	Spottail Shiner	whole	6	4 - 6
Wildgoose Lake (WGLK)	May 2014	Minnow Trapping	Trout-perch	whole	6	4
Wildgoose Lake (WGLK)	May 2014	Gill Netting	Walleye	fillet	12	1
Wildgoose Lake (WGLK)	May 2014	Gill Netting and Boat Electrofishing	Yellow Perch	fillet	11	1

NOTES:
A tissue type: fillet denotes boneless skinless fillet; whole indicates whole body composite of several fish
B lab results for tissues collected in 2016 were not yet available at time of report production

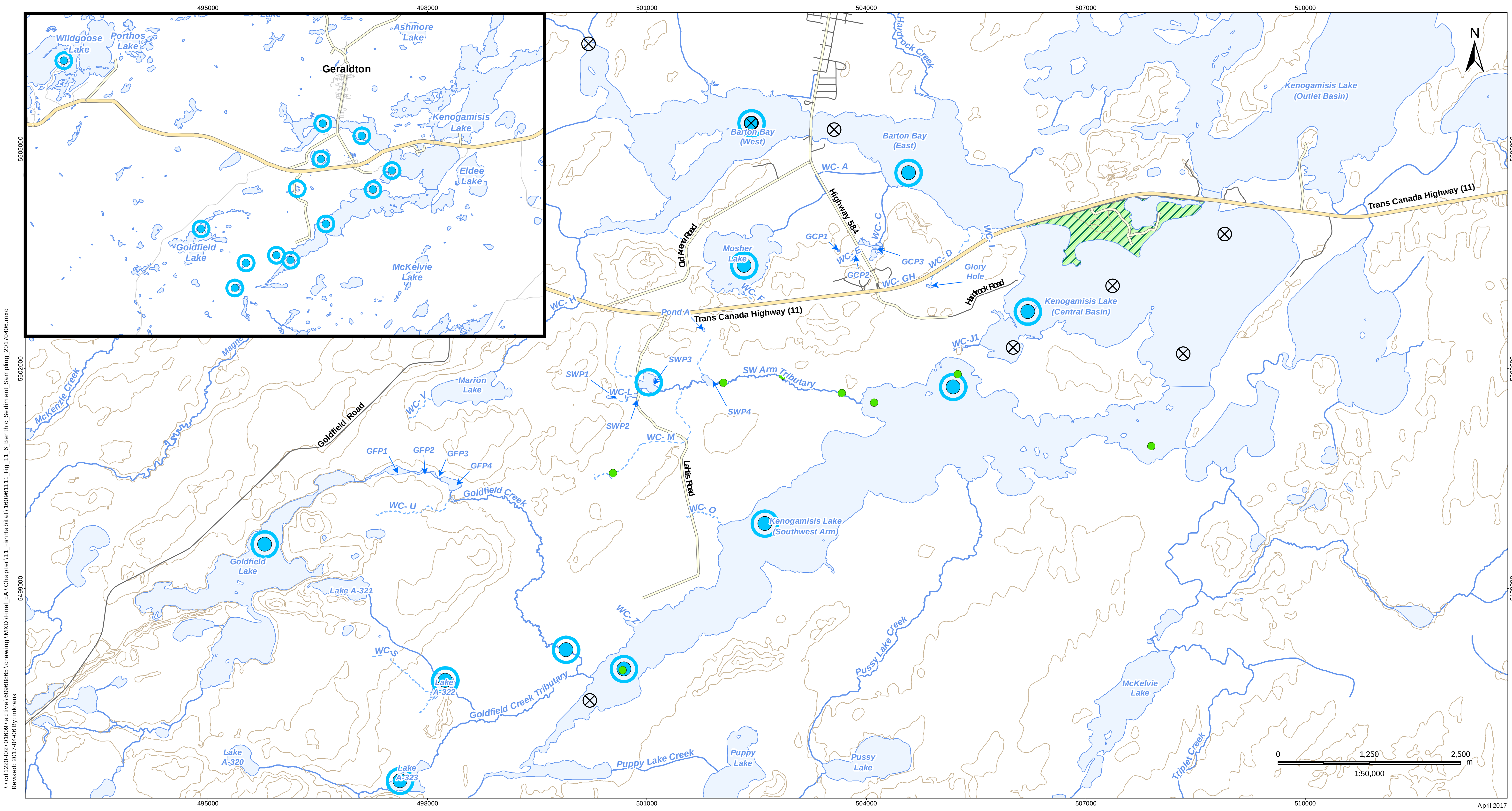
Skinless, boneless fillets were collected from large-bodied fish and analyzed, following standard methods for tissue analysis. The minimum target sample size for large-bodied fish was 10 fish; up to 25 samples were collected if fish were present in abundance. Small-bodied fish were composited together based on body size to achieve a minimum sample mass for analysis. Small-bodied fish were submitted for analysis as whole-body samples, except for representative specimens that had their heads removed to obtain ageing structures (i.e., otoliths). The target sample size for small-bodied fish was between 5 and 10 composite samples. The following parameters were analyzed in fish tissue:

- mercury
- total metals (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, P, K, Se, Ag, Na, Sr, Tl, Sn, Ti, U, V, Zn)

To gain a better understanding of potential toxicological effects on aquatic biota, a bioavailability study was completed. In addition to total metals, methylmercury and arsenic species were analyzed. The bioavailability study is presented in Metal Bioavailability TDR (Appendix F7).

Sediment Sampling

During fall 2013 and 2014, Stantec collected sediment from 11 stations, including samples from a reference area, Wildgoose Lake. Another 35 sediment sampling locations were sampled in fall 2016, including reference areas in Gamsby Lake and several smaller lakes. Benthic invertebrate and sediment sampling locations are shown in Figure 11-6.



Stantec

Legend

Existing Features
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Provincial Park
- Waterbody

Sampling Stations
- Benthic (Cordillera 2010)
- Benthic and Sediment (Parks, 2013)
- Benthic (Stantec 2013 and 2014)
- Sediment (Stantec 2013 and 2014)

Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
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Client/Project
Premier Gold Mines Hardrock Inc
Hardrock Project

Figure No.
11-6

Title
Benthic and Sediment Sampling Locations

Sediment and benthic invertebrate samples were collected from the same location in each waterbody, to allow correlation of physical and biological characteristics. The following parameters were analyzed in sediment:

- particle size
- total organic carbon (TOC)
- mercury
- total metals (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, P, K, Se, Ag, Na, Sr, Tl, Sn, Ti, U, V, Zn)

Historical sediment data for Kenogamisis Lake were obtained from Parks (2012a) and also used to describe existing conditions.

Benthic Invertebrate Sampling

Stantec collected benthic samples to supplement baseline benthic data previously collected by Cordillera Consulting Inc. in 2010 (eight locations) and Parks Environmental Inc. in 2012 (eight locations). The Stantec benthic programs were conducted in fall 2013 (eight locations), fall 2014 (an additional three locations in Kenogamisis lake and a reference location in Wildgoose Lake as a part of a bioavailability study; Metal Bioavailability TDR (Appendix F7), and fall 2016 (35 locations). Many of the samples collected in 2016 were collected at previously sampled locations, to provide an additional year of data. New stations were added in 2016 to address concerns raised by LLFN about conditions downstream of Kenogamisis Lake identified through consultation. Benthic and sediment sampling locations, shown in Figure 11-6, include those sampled by Stantec in 2013, 2014, and 2016, Parks Environmental Inc. in 2011 (unpublished data), and Cordillera Consulting Inc. in 2010 (Salter 2010).

Stantec's methods for collection and analysis of benthic invertebrates followed the MMER EEM Technical Guidance Document (EC 2012). Benthic invertebrate samples were collected using a Petite Ponar™ grab sampler (area = 0.0232 m^2) at depositional stations and a Surber sampler at erosional stations (e.g., Goldfield Creek). Five replicates were collected at each benthic station. Each replicate sample from a depositional station consisted of three composite grabs, for a total sampling area of 0.0696 m^2 per replicate sample. Three grabs were composited in each replicate to account for the small sampling area of the Petite Ponar and anticipated low densities of macroinvertebrates in depositional habitats. Surber samples had a total sampling area of 0.0929 m^2 per replicate sample (no composites). Supporting environmental measurements (DO, temperature, pH, conductivity) were obtained at each benthic sampling station and were measured near the water/sediment interface. Details on sample sorting methods and data analysis are presented in Baseline Report – Fish and Fish Habitat (Appendix E7).

Some sampling and analysis methods varied slightly among surveys. Samples collected by Cordillera were identified to the family level, whereas samples collected by Parks and Stantec were identified to the lowest practical level. Samples collected by Parks consisted of three replicates of one grab each, whereas samples collected by Cordillera and Stantec consisted of five replicates of three grabs each. These differences are documented and addressed in Baseline Report – Fish and Fish Habitat (Appendix E7).

Sub-lethal Toxicity Tests

Sub-lethal algae toxicity tests of lake water were conducted following standard MMER test procedures for mine effluent and the green alga *Pseudokirchneriella subcapitata* (Reference Method EPS 1/RM/25; EC 2007). The tests were conducted to assess the influence of baseline conditions on algal growth, given the elevated concentrations of arsenic measured in waters of Barton Bay and the Central Basin of Kenogamisis Lake and the known sensitivity of algae to arsenic (CCME 2001). In 2016, samples were collected from eight stations (1A and 1 in Southwest Arm; 4 in east Barton Bay, 6 and 12 in the Central Basin, 11 and 17 in the Outlet Arm basin, and 50 in Gamsby Lake reference area). Samples were collected from surface water in May, July, August, September, and October 2016 and shipped to AquaTox Testing and Consulting Inc. (Puslinch, ON) for testing using the standard 72-hour exposure.

11.2.2 Overview

This section summarizes baseline fish and fish habitat conditions in waterbodies within the RAA. Additional details are provided in Baseline Report – Fish and Fish Habitat (Appendix E7), which presents baseline fisheries information from 2013, 2014 and 2015. Additional baseline fisheries data were collected in 2016 in support of future permitting and pre-construction data set requirements. The data presented in Appendix E7 are comprehensive in characterizing fish and fish habitat for the purpose of the Final EIS/EA. Some of the information gathered in 2016 is also presented in this overview fish and fish habitat. For example, the list of fish species summarized by watercourse in this Final EIS/EA includes the results of the 2016 fish catch data. Clarifications were also made in 2016 on the extent of habitat that is usable by fish in intermittent and ephemeral drainage features. The watercourses shown in this Final EIS/EA summary more accurately represent the extent of fish habitat.

The Project is in the Kenogamisis River watershed, adjacent to Kenogamisis Lake (Figure 11-1 and Figure 11-2). There are also numerous smaller waterbodies and watercourses within the LAA, many of which are ephemeral or human-made (e.g., golf course ponds, historical MacLeod and Hardrock tailings subsurface seepage collection system and highway ditches). Of these, several were previously unnamed but have been assigned names to be referenced for this Project. These smaller water features generally offer limited habitat diversity. Many do not support fish directly, or support few species of fish (see Section 11.2.2.2 Fish Communities). The locations of all waterbodies and watercourses referenced in this chapter are provided in Figure 11-3.

11.2.2.1 Fish Habitat

Physical Habitat Characteristics

Lakes and Ponds

Kenogamisis Lake is the biggest lake within the LAA, with a 4,250 ha surface area and 197 km of mostly undeveloped shoreline. Riparian vegetation communities consist mostly of black spruce forest. There are four main basins: Southwest Arm, Barton Bay, Central Basin, and Outlet Arm. With a mean depth of 1.9 m and a maximum depth of 9.4 m, Kenogamisis Lake provides good habitat for coolwater species. Shallow bays and stream inlets commonly support emergent and submerged aquatic vegetation, which provide good cover and rearing and feeding habitat for a variety of fish species. These areas also provide potential spawning habitat for Yellow Perch and Northern Pike. Important Walleye spawning areas have been documented where the Kenogamisis River (sometimes referred to locally as the Wintering River) and Magnet Creek flow into Kenogamisis Lake (Parks 2013b). These areas also likely provide important spawning and feeding areas for benthivores (e.g., Lake Whitefish, White Sucker, and Shorthead Redhorse). Kenogamisis Lake supports a recreational fishery. There are two public boat launches on the lake and people often angle at the narrows where bridges cross the lake at three locations. There is an annual Walleye derby known as the Geraldton Walleye Classic organized by Kenogamisis Fish and Game Conservation. Aboriginal communities have indicated that Kenogamisis Lake has traditional value and that the lake is accessed for fishing by community members (Appendix J). Kenogamisis Lake Resort is located on the Central Basin and offers boat rentals and fishing to their clients.

Goldfield Lake is the second biggest lake in the LAA, with a surface area of 193 ha and a mean depth of 2.4 m. With a maximum depth of 12.7 m, this lake provides good habitat to a variety of coolwater fish species. Like Kenogamisis Lake, Goldfield Lake has numerous shallow areas that support emergent and submerged aquatic vegetation and has a deeper basin that provides thermal refuge. The shoreline is undeveloped. Goldfield Lake supports a recreational and Aboriginal fishery for Walleye, Northern Pike, and Lake Whitefish.

Mosher Lake is located immediately north of the PDA. This lake has a surface area of 64 ha, a mean depth of 2.2 m, and a maximum depth of 5.0 m. Submerged macrophytes are common and provide good habitat for Yellow Perch, Northern Pike, and a variety of small-bodied fish. Bait fish collection and angling occur in Mosher Lake (MNRF e-mail message to Stantec, June 30, 2015).

Table 11-4 summarizes morphological characteristics of lakes and ponds in the LAA. Habitat diversity generally increases with lake size, with larger lakes such as Kenogamisis Lake and Goldfield Lake providing a diversity of aquatic vegetation, cover, structure (i.e., humps, shoals, and flats), and substrate types. Greater detail on bathymetry and habitat in lakes is provided in Baseline Report – Fish and Fish Habitat (Appendix E7).

Table 11-4: Morphological Characteristics of Lakes and Ponds in the LAA

Waterbody Name	Surface Area (ha)	Shoreline Perimeter [A] (km)	Maximum Depth (m)	Mean Depth (m)	Volume (m^3)
Gamsby Lake [B]	601	41	7.6	1.7	10,217,000
Golf Course Pond 1 (GCP1)	0.09	0.13	1	0.5	450
Golf Course Pond 2 (GCP2)	0.22	0.22	3	1.5	3,300
Golf Course Pond 3 (GCP3)	3.35	1.92	1.5	1.0	33,500
Goldfield Lake	193	15.81	12.7	2.4	4,620,000
Goldfield Pond 1 (GFP1)	3.52	1.4	2.1	1.0	35,200
Goldfield Pond 2 (GFP2)	0.49	0.37	1.5	0.8	3,920
Goldfield Pond 3 (GFP3)	0.38	0.28	1.4	0.4	1,520
Goldfield Pond 4 (GFP4)	3.05	0.78	1.4	0.7	21,350
Kenogamisis Lake	4,250	197	9.4	1.9	78,300,000
Lake A-320	18.1	1.4	2	1.1	199,000
Lake A-322	6.73	1.22	4.8	1.5	101,000
Lake A-321	16.05	2.13	3.48	1.45	232,918
Lake A-323	13.2	1.9	9.4	2.9	375,000
Marron Lake	30.8	3.04	24.7	5.7	1,755,600
Mosher Lake	64	4.59	5	2.2	1,440,000
Pond A	0.17	0.15	NR	NR	NR
Southwest Arm Tributary Pond 1 (SWP1)	0.39	0.26	2.2	1.5	5,850
Southwest Arm Tributary Pond 2 (SWP2)	0.84	0.51	1	0.35	2,940
Southwest Arm Tributary Pond 3 (SWP3)	4.7	1.19	8.1	3.0	142,228
Southwest Arm Tributary Pond 4 (SWP4)	1.61	0.53	1.1	0.75	12,075
Wildgoose Lake [B]	1,738	73	15.9	3.6	62,568,000

NOTES:
A shoreline perimeter includes islands
B reference lake, not within the LAA

Watercourses

The Kenogamisis River is within the RAA and is the largest tributary to Kenogamisis Lake. Upstream of Kenogamisis Lake, the river drains an area of approximately 760 km^2. The upstream watershed is almost entirely natural, except for some forestry activities and forest access roads. There are no communities or developed areas in the Kenogamisis River watershed, upstream of Kenogamisis Lake. There is a rapids and deep run with coarse substrate where the river flows into Kenogamisis Lake at the head of the Southwest Arm. This area is a documented spawning location for Walleye from Kenogamisis Lake and likely provides important spawning and feeding habitat for other species such as Lake Whitefish, White Sucker, and Shorthead Redhorse. Downstream of Kenogamisis Lake, the Kenogami River flows into the Kenogami Diversion Reservoir. Goldfield Creek, Goldfield Creek Tributary, and the Southwest Arm Tributary are within the PDA and have been delineated into reaches of similar habitat (Figure 11-4). General descriptions of fish habitat in these streams are provided below. Stream habitat attributes and photographs of watercourses assessed within the LAA are provided in the Baseline Report – Fish and Fish Habitat (Appendix E7).

Goldfield Creek

Goldfield Creek is the outlet of Goldfield Lake and discharges into the Southwest Arm of Kenogamisis Lake. The flow regime is permanent and the thermal regime is coolwater.

Within the lowest reach (Reach 1), Goldfield Creek has a mean water depth of 0.6 m and a mean wetted width of 5.0 m. A large cattail wetland is present at the mouth of Goldfield Creek, where flow converges with Goldfield Creek Tributary. Bank full width in this area ranges from 10 to 18 m. There is abundant instream cover provided by aquatic vegetation, deep pools, and large organic debris. Hydrophilic shrubs overhang the banks and riparian habitat consists of spruce forest. Most of the substrate is comprised of detritus and sand, with few areas of gravel, cobble, and boulder. Riffle habitat is present at one location approximately 80 m upstream of an ATV trail (an extension of Lahtis Road), which could provide spawning habitat for White Sucker. Although there may be potential for Walleye to spawn at this location, the habitat is not ideal due to limited water depth and stream discharge.

The middle reach (Reach 2) has a bank full width of 4.0 m. Stream banks are steeper than in Reach 1 and the channel is often more confined. Substrate varies and consists of organic muck, small gravel, and silt, with small amounts of sand and clay. Overhanging vegetation and large woody debris provide abundant in-stream cover. Gradient is low and stream morphology is dominated by slow run habitat, except for one riffle in the upper portion of Reach 2.

The upper reach (Reach 3), immediately below Goldfield Lake, is punctuated by frequent beaver dams, both active and inactive, which form a series of on-line ponds (GFP1 through GFP4). Abundant cover is provided by undercut banks, deep pools, organic debris, and overhanging shrubs and grasses. The stream in this area has a large floodplain with a wetted width ranging from approximately 2 m in confined areas to 15 m in ponded areas. Where the channel is confined, and not influenced by beaver activity, bank full width ranges from 4.0 m to 4.5 m. Deep pools are common in the highly sinuous channel, with some run habitat where the channel is more confined. Riffle habitat is also present.

Goldfield Creek Tributary

An unnamed tributary flows into Goldfield Creek from the west, near the mouth of Goldfield Creek. This second order tributary drains Lake A-320 and Lake A-323. The lower end (Reach 1) has a wide channel that meanders through a large cattail marsh. The wetted width ranges from 4 m to 30 m. Cover is provided by dense emergent and submergent aquatic vegetation.

In the upper reach (Reach 2), the channel is more confined, with a mean channel width of 1.7 m and mean depth of 0.4 m. This reach is slow flowing and meandering. Some beaver activity was apparent, but fish passage under spring conditions was not inhibited. This reach is dominated by pool morphology and detritus is the predominant substrate. Beaver dam debris, overhanging grasses and shrubs, submergent vegetation, and pools provide fish habitat throughout this reach. Alder and dogwood dominate the riparian habitat and often hang over the stream channel. There are no barriers to fish passage that would prevent fish from moving through this watercourse between Lake A-323 and Kenogamisis Lake.

Goldfield Creek Tributary - North Branch

The north branch of Goldfield Creek Tributary drains Lakes A-321 and A-322. Habitat in Reach 1 of this watercourse (downstream of Lake A-322) is similar to Reach 2 of Goldfield Creek Tributary. This low gradient reach is bordered by a broad, hummocky floodplain. Riparian vegetation is predominantly hydrophilic grasses and shrubs. There are no barriers to fish passage that would prevent fish from moving through this watercourse between Lake A-322 and Kenogamisis Lake.

Reach 2, between Lake A-321 and Lake A-322, is much narrower and more confined, with a dense riparian canopy. Riparian vegetation is comprised mostly of mature eastern white cedar. There is abundant large woody debris in the watercourse. Stream gradient is moderate and substrates are comprised of sand and detritus. Fish passage throughout this reach is likely inhibited by occasional step pools caused by woody debris in the channel. Low summer flows are also likely to inhibit upstream fish passage in this reach.

Southwest Arm Tributary

The Southwest Arm Tributary flows into the northern extent of the Southwest Arm of Kenogamisis Lake. This watercourse originates near two wetland ponds (SWP1 and SWP2) on the west side of Lahtis Road, approximately 1.2 km south of Highway 11. Watercourse K (WC-K) and Watercourse L (WC-L) form the headwaters of this stream.

Reach 1 of the Southwest Arm Tributary is wide and shallow, with a wide riparian cattail marsh and abundant submerged aquatic vegetation. The slow flow and abundant aquatic vegetation provides potential spawning habitat for Northern Pike and Yellow Perch.

Immediately east of Lahtis Road, the Southwest Arm Tributary flows out of SWP3 and down through SWP4. This reach (Reach 2) has a bank full width ranging from 2.5 m to 4.0 m, a mean depth of 1.0 m, and maximum pool depth of 1.5 m. The banks are overgrown with hydrophilic shrubs, providing instream cover and allochthonous inputs to the stream. Most of Reach 2 has a meandering, slow flowing morphology, providing ideal conditions for submergent and floating aquatic vegetation. There is one narrower, faster flowing section within Reach 2 with boulder and cobble substrate, which may provide potential spawning habitat for White Sucker. Aquatic vegetation and other structures such as deep pools and boulders provide fish habitat.

First Order, Intermittent and Ephemeral Watercourses

Twenty-eight first order, ephemeral, or intermittent watercourses were identified in the LAA. Names have been assigned for referencing purposes and are shown in Figure 11-3. Fish were caught in 17 of the 20 watercourses sampled. Fish were not sampled in the remaining watercourses because either they did not provide direct habitat usable by fish (WC-E, WC-J, WC-N, WC-P, WC-Q, and WC-Y) or Project effects on fish and fish habitat were not anticipated (WC-K, and WC-S). In the case of WC-E, this ephemeral watercourse is located entirely on private property and has no connection to fisheries resources. Several of these watercourses are more accurately characterized as general drainage areas and have a poorly defined channel throughout most of their length, and flow is diffusely spread out across treed wetlands. Substrates in these poorly defined watercourses are largely comprised of organic forest soils. Examples of such watercourses include WC-G and WC-O.

Watercourses A, C, D, E, GH, I and J1 have been altered through human activity or exist only because of human activity. Watercourse E is located entirely on golf course property and does not outlet to other surface water features, but drains to an isolated golf course pond (GCP2). Watercourses D and GH are highway ditches on the north and south sides of Highway 11, respectively. Watercourse C exists due to the creation of a golf course and associated drainage and grading. It is located upon and adjacent to historical tailings and drains Golf Course Pond 3 (GCP3) on the east side of Michael Power Boulevard.

Barriers to Fish Passage

Other than the dam located at the outlet of Kenogamisis Lake, there are no anthropogenic barriers to fish passage within the LAA. A culvert at Lahtis Road and Watercourse L inhibits fish passage under some flow conditions, but is not considered a permanent barrier. Natural factors affecting fish passage in LAA waters are beaver dams and low water (i.e., lack of adequate flow). Low flow volume (i.e., stream discharge) has been identified as a likely factor limiting fish distribution and fish species diversity in most of the smaller (e.g., first and second order) watercourses within the LAA.

There is a section of higher gradient on Goldfield Creek between Goldfield Lake and Goldfield Pond 4 (GFP4), with a vertical drop in elevation of approximately 8 m over a horizontal distance of 1,500 m, with frequent beaver dams. Beaver dams inhibit fish passage but are not considered permanent barriers to fish passage. While there are a few beaver dams in Southwest Arm Tributary and Goldfield Creek Tributary, these are less than 0.3 m in height and are inundated during high flow events.

Fish can pass through the Southwest Arm Tributary from Kenogamisis Lake to Southwest Pond 3 (SWP3) under most flow conditions. Passage further upstream, through the culvert under Lahtis Road at the outlet of SWP2, is hindered under most flow conditions.

Fish can pass through the Goldfield Creek Tributary from Kenogamisis Lake upstream to Lake A-322 under most flow conditions. Fish passage between Lake A-322 and Lake A-321 is likely inhibited by high gradient and limited flow.

Water Quality

Extensive water quality information for Kenogamisis Lake and other lakes and watercourses in the RAA is provided in Baseline Report – Surface Water Quality (Appendix E4) and summarized in Section 10.2.2.8. Water quality is compared to the Provincial Water Quality Objectives (PWQO) for protection of aquatic life (MOE 1994), Canadian Council of Ministers of Environment (CCME 2016) Canadian Water Quality Guidelines for Protection of Freshwater Aquatic Life (CWQG-FAL), and, where available, Interim PWQOs (MOE 1994).

Water quality monitoring data collected from the Southwest Arm (stations 1A, 1, 23, and 24), Barton Bay (stations 2, 3, 4, and 5), Central Basin (stations 6, 7, and 12) and Outlet Basin (stations 8, 11, 17, and 48) from 2013 through 2016 is summarized here. There is a seasonal trend for general parameters and metals of concern, with minimum concentrations during winter and spring and maximum concentrations during late summer.

Water quality varies among the four basins of Kenogamisis Lake, as it is influenced by human activities in the surrounding subwatersheds. The Southwest Arm has relatively few inputs from human activities (with the exception of historical mining activities at the northeast end of the basin), and relatively few exceedances of CWGQ-FAL and PWQOs. Water quality in Barton Bay and the Central Basin has been affected by historical mining activities adjacent to the basins and in upstream areas, and by discharge of effluent from the Geraldton sewage treatment plant. These two basins have frequent exceedances of CWQG-FAL and PWQOs for arsenic, phosphorus, copper, and iron. The Outlet Basin is affected by the upstream sources of metals and phosphorus in Barton Bay and the Central Basin, but has lower concentrations and fewer CWQG-FAL and PWQO exceedances due to dilution with flows from the Southwest Arm.

General characteristics were similar among the four basins, with highest values reported for Barton Bay stations. Lake water was moderate in hardness (typically in the range of 40 to 140 mg/L as $CaCO_3$), circumneutral in pH (typically in the range of 6.0 to 8.0), moderate in conductivity (80 to 300 µS/cm), typically low in TSS (below the detection limit of 2 mg/L to 50 mg/L), low in sulphate (typically in the range of 0.5 to 30 mg/L), and moderate in TOC and DOC (typically in the range of 9 to 26 mg/L).

Nitrogen concentrations generally were low and similar among the four basins, with nitrate concentrations ranging from below the detection limit (0.02 mg/L) to approximately 0.35 mg/L, nitrite below the detection limit (0.02 mg/L), and ammonia ranging from below the detection limit (0.02 mg/L) to approximately 5 mg/L). Nitrate and ammonia concentrations were higher in Barton Bay and the Southwest Arm than in the Central Basin and Outlet Basin, but were below guidelines in all samples analyzed.

Phosphorus concentrations were higher in Barton Bay than in the other three basins, related to inputs of treated sewage effluent from Geraldton, with some exceedances of the Interim PWQO for total phosphorus (0.02 mg/L):

- In the Southwest Arm, total phosphorus ranged from below the detection limit (0.0005 mg/L) to 0.018 mg/L, with a mean value of 0.0099 mg/L.
- In Barton Bay, total phosphorus ranged from 0.0055 to 0.0969 mg/L, with a mean value of 0.026 mg/L, and with 16 of 49 samples exceeding the PWQO of 0.020 mg/L (mainly at station 5, near the sewage treatment plant discharge).
- In the Central Basin, total phosphorus ranged from 0.0032 mg/L to 0.0293 mg/L, with a mean value of 0.014 mg/L, and with 8 of 46 samples higher than the PWQO (0.02 mg/L).
- In the Outlet Basin, total phosphorus ranged from 0.0047 to 0.078 mg/L, with a mean value of 0.012 mg/L, and above the PWQO in 10 of the 65 samples collected.

Metals concentrations varied widely among the four basins, particularly for arsenic, copper, and iron, associated with ongoing groundwater and surface water inputs from the historical tailings areas adjacent to Barton Bay and the Central Basin, and due to historical mining activities in those sub-watersheds. The highest arsenic, copper, and iron concentrations were identified for Barton Bay. Most of the other metal parameters were below PWQOs and CWQG-FAL.

In the Southwest Arm, there were the following occasional guideline exceedances for arsenic:

- Total arsenic was higher than the Interim PWQO and CWQG-FAL (5 µg/L) in five samples (approximately 4 % of all samples), four of which were from Station 1, near the historic Hardrock Tailings. The other exceedance was from station 46 with a value of 5.43 ug/L. Total arsenic concentrations from all stations monitored within the Southwest Arm (Stations 1, 1A, 23, 24 and 46) ranged from 0.5 to 5.6 µg/L with an average of 1.75 µg/L for the whole basin.

In Barton Bay (73 samples collected), total and dissolved aluminum and total arsenic, copper, iron, lead (2 samples), and silver (1 sample) exceeded the following guidelines:

- Total arsenic was higher than the Interim PWQO and CWQG-FAL in 100% of the samples collected and was higher than the PWQO (100 µg/L) in 6 samples; with a range of 10.5 to 121 µg/L and average of 44.5 µg/L for the whole basin.
- Total copper was higher than the hardness-dependent CWQG-FAL (2.0 to 3.11 µg/L) in 44 samples (approximately 60%) and above the PWQO (5 µg/L) in 7 samples, with a range from below the detection limit (1 µg/L) to 7.81 µg/L.
- Total iron was above the CWQG-FAL and PWQO (300 µg/L) in 29 samples (approximately 40%), ranging from 161 to 1240 µg/L.
- Total aluminum was above the CWQG-FAL (100 µg/L) in 16 samples (approximately 22% of samples), with a maximum concentration of 527 µg/L.
- Dissolved aluminum above the PWQO (75 µg/L) in one sample (105 µg/L).

In the Central Basin (98 samples collected), arsenic, copper, iron, and mercury were above the following guidelines:

- Total arsenic was higher than the Interim PWQO and CWQG-FAL in 86 samples (88%), with a range of 2.43 to 48.4 µg/L and mean of 17 µg/L for the whole basin.
- Total copper was higher than the hardness-dependent CWQG-FAL (2.0 µg/L to3.06 µg/L) in 27 samples (28%), with a range from below the detection limit (1 µg/L) to 2.98 µg/L; all concentrations were below the PWQO (5 µg/L).
- Total iron was above the CWQG-FAL and PWQO (300 µg/L) in one sample, ranging from 61 to 341 µg/L.
- Total mercury above the CWQG-FAL (0.026 µg/L) in two samples (maximum of 0.543 µg/L), during the March 2016 sampling event.

In the Outlet Basin (90 samples collected), arsenic, iron, and aluminum were higher than the following guidelines:

- Arsenic was higher than the Interim PWQO and CWQG-FAL in 80 samples (89%), with a range of 1,8 to 105 µg/L and a mean of 12.2 µg/L for the whole basin.
- Total iron was above the CWQG-FAL and PWQO (300 µg/L) in three samples, ranging from 42 to 1,930 µg/L.
- Total aluminum was above the CWQG-FAL (100 µg/L) in two samples, with a maximum concentration of 142 µg/L.

Sediment Quality

Sediment characteristics are described in detail in the Baseline Report – Fish and Fish Habitat (Appendix E7) and discussed in relation to historical mining influences and potential toxicity effects on biota in the bioavailability study (Metal Bioavailability TDR; Appendix F7). Sediment metal levels are compared to the Provincial Sediment Quality Guidelines, which include a Lowest Effect Level (LEL) and Severe Effect Level (SEL) in their Guidelines for Identifying, Assessing, and Managing Contaminated Sediments in Ontario (MOE 2008), and to the CCME guidelines, which include an Interim Sediment Quality Guideline (ISQG) and a Probable Effects Level (PEL) (CCME 2016). The LEL and ISQG are generally similar (except for lower chromium and copper guidelines for the LEL than ISQG) and indicate a level of PoPC that can be tolerated by the majority of sediment-dwelling organisms. Sediments meeting the LEL are considered by MOE to be "clean to marginally polluted" (MOE 2008). The PEL and SEL indicate a level at which adverse effects are expected to occur (PEL) and at which detrimental effects to the majority of sediment-dwelling organisms are expected to occur (SEL). The PEL is lower than the SEL for copper, lead, mercury and zinc, but higher for arsenic, cadmium, and chromium. Sediments exceeding the SEL are considered by MOE to be "heavily contaminated" (MOE 2008).

Copper and arsenic commonly occur in sulphide-based minerals and the Geraldton area is rich in such minerals, so some naturally elevated levels of copper, arsenic, and other metals are expected. Arsenic concentrations exceeded the LEL at most stations, including in the Southwest Arm of Kenogamisis Lake. Arsenic exceeded the SEL in the majority of samples from Barton Bay and the Central Basin in Kenogamisis Lake, with maximum concentrations reported for east Barton Bay, and in some samples from Lake A-322, Southwest Pond 3 (SWP3), Goldfield Lake, and Mosher Lake. Cadmium, chromium, copper, lead, and nickel concentrations exceeded the LELs in several waterbodies in the LAA. Zinc exceeded its LEL in some replicate samples from the Central Basin and Barton Bay. Mean cadmium concentrations in sediment from Goldfield Lake, Lake A-322, and Lake A-323 were higher than in stations in Kenogamisis Lake.

Mean concentrations of arsenic, copper, iron, nickel, and zinc were higher in Barton Bay and the Central Basin of Kenogamisis Lake than in the Southwest Arm in the 2013 and 2014 sampling programs, and chromium and manganese concentrations were higher in Barton Bay than in the Southwest Arm. There was a similar trend in 2011 for arsenic, copper, iron and zinc (Parks 2012a). Within Barton Bay, many metals were higher in the eastern basin than in the western basin, which is consistent with spatial differences observed in 2011 (Hutchinson 2011). Arsenic concentrations were similar in the western basin of Barton Bay and the Central Basin, but considerably higher in the eastern basin of Barton Bay.

Mean mercury concentrations in sediment generally were below the LEL (0.2 mg/kg) at stations in Kenogamisis Lake, Mosher Lake, Goldfield Lake, Wildgoose Lake, and small lakes in the LAA. The exception was west Barton Bay (mean of 0.80 mg/kg), where the mean concentration was four-fold higher than the LEL but lower than the SEL (2 mg/kg) (Metal Bioavailability TDR, Appendix E7). Elevated mercury concentrations in west Barton Bay had been previously identified, with the highest concentrations (up to 1.34 mg/kg) identified at a station at the eastern end of the island in West Barton Bay, where mining and gold milling at the Elmos Mine on that island used a mercury amalgamation process in the 1930s (Parks 2012a, 2012b, Hargraft 1940). Hargraft (1940) also identified Little Longlac Mine, on the shore of west Barton Bay, and other mines in the Magnet Creek watershed upstream of west Barton Bay (Tombill, Magnet Consolidated, and Bankfield Consolidated mines) where the amalgamation process had been used to extract gold. This historical use of mercury to extract gold would have been the largest source of mercury to sediments in Kenogamisis Lake, given that sediments in east Barton Bay and Central Basin, adjacent to shoreline mine tailings areas and seepage had notably lower concentrations than in west Barton Bay. Atmospheric deposition, forestry, and forest fires are other potential sources of mercury in lake sediments (Parks 2012a).

11.2.2.2 Fish Communities

Field studies conducted within the LAA by Stantec between September 2013 and September 2016 resulted in capture of more than 6,000 fish, consisting of 25 species (refer to Table 11-6). No species identified in these or in previous studies were listed as federal or provincial species at risk, nor are aquatic species at risk expected to occur in the LAA.

Local residents and Aboriginal community members harvest fish from Kenogamisis Lake by angling, with Walleye being the most sought after species. Aboriginal communities (AFN, Biigtigong Nishnaabeg, CLFN, EFN, GFN, LLFN, MNO, PPFN) noted that fishing is in important practice for community members and fish were identified as an important part of the traditional diet.

Fish species identified as having traditional value or interest to Aboriginal communities are listed in Table 11-5 below. This information has been compiled from Project-specific TK studies and consultation input. Information on species caught or consumed by AFN is considered confidential and therefore detailed information from AFN was not listed in the table below, however, it has been assumed that the species listed will also be of traditional value or interest to other Aboriginal communities.

Table 11-5: Project Specific Information Received from Aboriginal Communities Related to Fish and Fish Habitat

Fish Species	Aboriginal Communities
Smallmouth Bass (a.k.a. bass)	MNO
Burbot (a.k.a. ling cod)	MNO
Northern Pike (a.k.a. jackfish)	CLFN, EFN, GFN, LLFN, MNO, PPFN
Yellow Perch (a.k.a. perch)	CLFN, GFN, MNO
Walleye (a.k.a. pickerel)	AFN, CLFN, EFN, LLFN, MNO, PPFN

Table 11-5: Project Specific Information Received from Aboriginal Communities Related to Fish and Fish Habitat

Fish Species	Aboriginal Communities
Salmon (may include Chinook, Coho and Pink Salmon)	MNO
Rainbow Smelt (a.k.a. smelts)	LLFN, MNO
Lake Sturgeon (a.k.a. Sturgeon)	AFN, EFN, LLFN, MNO,
Suckers (e.g. White Suckers)	AFN, EFN, MNO
Trout (may include Rainbow Trout, Brown Trout, Lake Trout, Brook Trout and Splake)	AFN, CLFN
Trout (e.g. Lake trout)	AFN, LLFN, MNO
Whitefish (may include Lake Whitefish and Round Whitefish)	AFN, CLFN, EFN, GFN, LLFN, MNO

Baseline studies suggest that sturgeon (Lake Sturgeon) and Lake Trout, bass, smelt, and salmon are not present in the LAA. The remaining species identified above are consistent with the findings of the baseline studies.

The MNO has indicated that Brook Trout are a valued species with traditional uses. A single adult Brook Trout was caught during baseline studies in the LAA, in the Southwest Arm Tributary in May 2016. This fish was believed to be transient and not indicative of a resident population in the Southwest Arm Tributary because it was present during the spring, when water temperatures and dissolved oxygen conditions were favourable for Brook Trout. The absence of juvenile and young of the year fish in previous and subsequent fish community sampling events also indicates that there is not a resident population of Brook Trout in the Southwest Arm Tributary. Chapter 18.0 (traditional land and resource use VC) provides greater detail about potential Project effects on traditional land and resource use.

Game and sustenance fish species, including Walleye, Northern Pike, Lake Whitefish, Yellow Perch, White Sucker, and Burbot were present in Kenogamisis and Goldfield Lakes. Of these, Walleye is believed to be the most sought after by local anglers. Northern Pike and Yellow Perch were present in most waterbodies in the LAA with a maximum depth greater than 3 m. Shallower, smaller lakes and ponds typically had lower species diversity and abundance than larger lakes.

Numerous small bodied fish species were captured throughout the LAA. Of these, Spottail Shiner, Trout-perch, and Blacknose Shiner were the most abundant. These species likely provide important forage for larger piscivorous fish. Brook Stickleback were widely distributed throughout the LAA and were often found in marginal habitats where few other fish species were present. Bait fish are reportedly collected commercially from Longacre Lake (MNRF e-mail message to Stantec, June 30, 2015) and may also be collected throughout the LAA for personal use.

Table 11-6 provides a summary of known fish distribution (presence) based on catch data from the following sources:

- MOECC Fish Tissue data base 1977 to 2012 (MOECC e-mail message to Stantec, March 25, 2014)
- MNRF Kenogamisis Lake Broadscale netting program, June 2013
- Parks Environmental – August 2013 Field Studies (Parks 2013a)
- Stantec – September and October, 2013 Field Studies (Appendix E7.2 - Baseline – Fish and Fish Habitat)
- Stantec – May and June, 2014 Field Studies (Appendix E7.2 - Baseline – Fish and Fish Habitat)
- Stantec – September and October, 2014 Field Studies (Appendix E7.2 - Baseline – Fish and Fish Habitat)
- Stantec – May, July and October, 2015 Field Studies (Appendix E7.1 - Supplemental Baseline – Fish and Fish Habitat)
- MNRF Fish ON-Line GIS tool (MNRF 2015b)

Total catch and catch per unit effort (CPUE) are presented with morphometric data (length, weight, external condition and age) in Baseline Report – Fish and Fish Habitat (Appendix E7).

Table 11-6: Fish Species Present in LAA and Reference Water Bodies

Common name (Scientific name)	Glory Hole	Goldfield Creek	Goldfield Creek Trib.	Goldfield Lake	Golf Course Pond 2	Golf Course Pond 3	Hardrock Creek	Kenogamisis Lake	Lake A-320	Lake A-321	Lake A-322	Lake A-323	Marron Lake	Mosher Lake	Pond A	South Magnet Lake	Southwest Arm Trib.	Southwest Pond 1	Southwest Pond 2	Southwest Pond 3	Southwest Pond 4	Unnamed Lake 1	Unnamed Lake 2	Watercourse A	Watercourse B	Watercourse C	Watercourse D	Watercourse F	Watercourse G	Watercourse GH	Watercourse H	Watercourse I	Watercourse J1	Watercourse L	Watercourse M	Watercourse O	Watercourse R	Watercourse U	Watercourse V	Watercourse W	Watercourse X	Watercourse Y	Watercourse Z	Wildgoose Lake	Wildgoose Trib.
Lake Whitefish (*Coregonus clupeaformis*)				✓				✓																																				✓	
Cisco (*Coregonus artedi*)								✓																																					
Northern Pike (*Esox lucius*)		✓	✓	✓				✓			✓	✓				✓	✓			✓			✓								✓				✓									✓	
Central Mudminnow (*Umbra limi*)							✓															✓																				✓		✓	
White Sucker (*Catostomus commersonii*)		✓	✓	✓		✓		✓		✓	✓		✓	✓		✓	✓						✓			✓																	✓	✓	
Brook Tout (*Salvelinus fontinalis*)																	✓																												
Shorthead Redhorse (*Moxostoma macrolepidotum*)								✓																																					
Northern Redbelly Dace (*Chrosomus eos*)	✓					✓							✓					✓	✓							✓														✓				✓	
Finescale Dace (*Phoxinus neogaeus*)	✓				✓	✓			✓	✓			✓	✓				✓	✓			✓			✓	✓					✓			✓						✓					
Northern Redbelly Dace Finescale Dace Hybrid										✓								✓							✓									✓											
Blackchin Shiner (*Notropis heterodon*)							✓																																						
Blacknose Shiner (*Notropis heterolepis*)				✓	✓			✓			✓	✓	✓	✓																														✓	✓
Spottail Shiner (*Notropis hudsonius*)		✓	✓	✓	✓	✓		✓				✓	✓				✓														✓													✓	✓
Fathead Minnow (*Pimephales promelas*)	✓				✓	✓								✓				✓	✓			✓			✓	✓					✓			✓											
Northern Pearl Dace (*Margariscus nachtriebi*)	✓					✓							✓	✓					✓			✓			✓	✓								✓										✓	
Lake Chub (*Couesius plumbeus*)		✓																																											
Burbot (*Lota lota*)		✓	✓	✓				✓									✓														✓													✓	
Brook Stickleback (*Culaea inconstans*)	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓				✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	
Ninespine Stickleback (*Pungitius pungitius*)												✓																																✓	
Trout-Perch (*Percopsis omiscomaycus*)		✓						✓																																				✓	✓
Yellow Perch (*Perca flavescens*)		✓	✓	✓				✓			✓	✓	✓	✓		✓	✓			✓																								✓	
Walleye (*Sander vitreus*)		✓		✓				✓									✓																											✓	
Iowa Darter (*Etheostoma exile*)		✓		✓								✓		✓			✓					✓															✓							✓	
Johnny Darter (*Etheostoma nigrum*)		✓		✓				✓			✓	✓					✓																												
Logperch (*Percina caprodes*)		✓						✓																																				✓	
Longnose Dace (*Rhinichthys cataractae*)		✓																																											
Mottled Sculpin (*Cottus bairdii*)																																												✓	

11.2.2.3 Metals in Fish Tissue

Metal concentrations were measured in muscle tissue (game fish, including Walleye, Northern Pike, and Yellow Perch) or whole body samples (small-bodied forage fish, including Spottail Shiner, Trout-perch, and Northern Pearl Dace) from lakes and creeks in the LAA. Concentrations are reported as mg/kg wet weight. Data are reported in Appendix E7.2 and include results for the Stantec sampling programs and for MOE programs conducted between 1977 and 2011 (summarized in Parks 2012b). Arsenic and mercury have been identified as metals of potential concern, related to historical mining activities, and data for other metals are also provided in the Baseline Report – Fish and Fish Habitat, Appendix E7 and Parks (2012b). The information presented below focuses on arsenic and mercury in Walleye, representing sport fish, and Spottail Shiner, representing small-bodied fish, due to the amount of data available for these species and their ecological characteristics.

Arsenic concentrations in fish are of interest because of elevated levels in water and sediment of Barton Bay and the Central Basin, related to historical mining activities. Mean total arsenic concentrations in whole bodied forage fish (0.073 mg/kg to 1.24 mg/kg wet weight in Spottail Shiner) were higher than in game fish (0.018 mg/kg to 0.223 mg/kg in Walleye), with a mean concentration of 0.12 mg/kg wet weight for Walleye in Kenogamisis Lake. Arsenic accumulation rates are species-specific and were higher in areas affected by historical mining activities (Barton Bay and Central Basin) than in the Southwest Arm of Kenogamisis Lake and in Goldfield and Wildgoose Lakes (Baseline Report – Fish and Fish Habitat, Appendix E7, Metal Bioavailability TDR, Appendix F7). There is no provincial or federal consumption guideline for arsenic; however, Walleye from the LAA did not exceed consumption guidelines (1 to 5 mg/kg wet weight) published for other countries (MacDonald et al. 2000).

Mercury is a common metal of concern in fish from northern Canada, and can be associated with natural sources and human activities (e.g., minerology of the area, effluent discharges, atmospheric deposition, forest fires, and forestry). Total mercury concentrations in edible sport fish tissue from northern Canada often exceed the MOECC (2015) partial restriction guidelines for consumption (MOECC 2015). Lockhart et al. (2005) reported that total mercury levels in Walleye, Northern Pike, and Lake Trout from lakes in northern Canada usually exceeded the partial restriction guideline and less frequently exceeded the total consumption restriction guideline. Parks (2012b) reported similar findings for historical MOECC data from Kenogamisis Lake (Appendix E14).

Baseline monitoring of mercury and methylmercury in fish tissue and review of historical data were undertaken to address agency, Aboriginal communities, and stakeholder concerns about existing conditions, although it is noted that treated effluent from the Project is not expected to contain elevated mercury concentrations.

For women of child-bearing age and children under 15, the consumption advisory changes from 32 to 16 meals per month at a mercury concentration of 0.06 parts per million (ppm), from 16 to 12 meals per month at 0.12 ppm, from 12 to 8 meals per month at 0.16 ppm, from 8 to 4 meals per month at 0.25 ppm, while complete restriction (i.e., do not eat) is advised for levels above 0.5 ppm. For the general population, an advisory changes from 32 to 16 meals per month at mercury concentration of 0.15 parts per million (ppm), from 16 to 12 meals per month at 0.3 ppm, from 12 to 8 meals per month at 0.4 ppm, from 8 to 4 meals per month at 0.6 ppm, from 4 to 2 meals per month at 1.2 ppm, while complete restriction is advised for levels above 1.8 ppm (MOECC 2015).

Mercury concentrations in fish tissue are presented in Metal Bioavailability TDR, Appendix F7, for both organic (methylmercury) and inorganic forms. Methylmercury is the form associated with adverse effects on humans and wildlife. Aquatic microorganisms transform the inorganic mercury present in sediments into methylmercury, which then biomagnifies through the food web, with the highest concentrations typically found in large, long-lived predatory fish (Counter and Buchanan 2004, Gochfeld 2003). Bioaccumulation of methylmercury in fish depends on a variety of physico-chemical variables as well as age, size, and species life characteristics (Grieb et al. 1990, Jackson 1991, Wong et al. 1997, Ullrich et al. 2001, Power et al. 2002, Jewett et al. 2003). As a result, a change in methylmercury levels in tissue can be associated more strongly with activities that affect methylation rates (e.g., forest fires, inundation of soils to form reservoirs [Ullrich et al. 2001]) or structure of the fish community (predator-prey relations) than with changes in inorganic mercury levels (Power et al. 2002, Wong et al. 1997).

Mercury concentrations were higher in sediments from west Barton Bay compared to east Barton Bay and the Central Basin (Parks 2012b, Appendix E7.1). Mining has occurred in those areas and upstream in the Magnet Creek watershed since the 1930s and may be the source of mercury observed in sediments in west Barton Bay. For example, mercury was used in gold and silver extraction (in a flotation-amalgamation process) at Little Long Lac Mine, which deposited tailings adjacent to west Barton Bay, and at the Elmos Mine located on an island in west Barton Bay (Hargraft 1940). Mercury was also used at the Bankfield Gold Mine, located on Magnet Lake, which flows via Magnet Creek into west Barton Bay (Hargraft 1940). Elevated mercury concentrations have been observed in Magnet Lake and Magnet Creek sediments (Hornbrook et al. 1997, Parks 2012b). In contrast, mercury levels in lake water and in historical tailings runoff are low in the area of the Project (Baseline Report – Surface Water Quality, Appendix E4).

The following paragraphs summarize the observed baseline concentrations of mercury in fish tissue relative to applicable guidelines. For an assessment of potential effects of mercury and other PoPCs in fish tissue, refer to Chapter 19.0 (human and ecological health VC). Concentrations of total mercury in Walleye from Kenogamisis Lake were above the partial restriction guidelines for human consumption, a result consistent with those generally reported for sport fish in northern Ontario (Lockhart et al. 2005). Average total mercury concentrations were higher in Walleye from Kenogamisis Lake (0.59 mg/kg wet weight) than from reference areas in Wildgoose Lake and Goldfield Lake (0.38 and 0.25 mg/kg wet weight, respectively), as were age-adjusted mercury concentrations (Metal Bioavailability TDR, Appendix F7). Mercury and methylmercury concentrations in individual fish at their associated ages (i.e., age-adjusted mercury and age-adjusted methylmercury) were compared by site using Analysis of Covariance (ANCOVA). Data were assessed for normality and homogeneity of variances prior to ANCOVA. Data transformations (e.g., natural log, inverse) were used as necessary to normalize data. Data that failed assumptions of normality and/or homogeneity were analyzed using a non-parametric ANCOVA. The assumption of homogenous slopes for mercury versus age in different sites was tested using an ANCOVA with an interaction term between mercury and site; if the interaction term was not significant ($p > 0.05$), parallel slopes were assumed and the interaction term was removed from the ANCOVA. Tukey's post hoc tests were used if necessary to determine differences between sites following the ANCOVA. Age-adjusted mercury concentrations in Walleye were also higher in Goldfield Lake than in Wildgoose Lake. Although historical mining activity may be partially responsible for the higher mercury concentrations observed in Walleye from Kenogamisis Lake (i.e., due to elevated mercury levels in sediment of one area of west Barton Bay), differences among waterbodies can also be related to differences in natural conditions (e.g., bacterial or benthic productivity, pH, DOC levels, lake size, predator-prey relationships in the fish community).

Because Walleye can move large distances within a waterbody, the elevated mercury levels in Kenogamisis Lake fish cannot be ascribed to a particular source, such as the historical mining activities described above. Small-bodied fish tend to have a smaller home range than sport fish, and can provide information about local conditions. Mercury concentrations were higher in Spottail Shiners from Kenogamisis Lake (Southwest Arm, eastern Barton Bay adjacent to the historical MacLeod tailings, and Central Basin adjacent to the historical Hardrock tailings) compared to Goldfield Lake and Wildgoose Lake (Metal Bioavailability TDR, Appendix F7). There were no statistically significant differences among the three areas of Kenogamisis Lake, suggesting that lake-wide characteristics, rather than historical mining activities, are at least partially responsible for differences among the three lakes. There were no statistically significant differences in methylmercury content of Spottail Shiners among the three lakes.

The Project is not anticipated to increase mercury loadings to the environment and, therefore, mercury concentrations in fish are not expected to increase because of the Project. This will be confirmed through monitoring of effluent and, if triggered, fish tissue, in accordance with EEM requirements.

11.2.2.4 Benthic Invertebrates

Mean total density of benthic macroinvertebrates ranged from 741 organisms per m^2 in the Southwest Arm (Station BA-1) to 2,440 organisms per m^2 in Wildgoose Lake (Station BA-WGLK). Densities were not so low at any benthic sampling station to suggest toxicity, nor were they high enough to suggest eutrophic conditions.

The mean number, or richness, of taxonomic families ranged from 4 (Mosher Lake) to 26 (Goldfield Creek). Family richness was lowest in small lakes (3 to 9 families), Barton Bay (7 to 11), and the Central Basin (6 to10) and generally was higher in the Southwest Arm (7 to 17) and in creeks (13 to 26).

The EPT taxa are those belonging to the mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) orders. They are typically most abundant in riffle habitat of streams and are generally considered less tolerant of environmental stress compared to chironomids (Chironomidae), aquatic worms (Oligochaeta), and other aquatic organisms. The taxonomic richness of EPT organisms varied widely within the LAA, from 0 (Mosher Lake) to 16 (Goldfield Creek). Lake A-322, Lake A-323, and the Central Basin of Kenogamisis Lake contained very few EPT taxa, suggesting that environmental conditions are not appropriate for these organisms. The absence of EPT taxa in Mosher Lake, together with total abundance and taxonomic richness at the low end of the range observed for lakes and streams, suggests that benthic communities at this station are under environmental stress.

11.2.2.5 Bioavailability Study

A bioavailability study (Metal Bioavailability TDR, Appendix F7) was conducted to integrate existing information about water and sediment chemistry, benthic communities, and fish populations and to augment this information with studies to better understand the biological effects of elevated metals levels in Barton Bay and the Central Basin. Runoff and discharge from the historical MacLeod and Hardrock tailings enter these two basins of Kenogamisis Lake, resulting in elevated levels of arsenic, copper, and iron in water and sediment. Arsenic is the main metal of potential concern, as it is above the Interim PWQO and CWQG-FAL (5 µg/L) in 100% of samples from Barton Bay and 86% of samples from Central Basin, although concentrations are below the PWQO of 100 µg/L (Baseline Report – Surface Water Quality, Appendix E4). Arsenic also exceeds the provincial SEL in sediments in the two basins. Copper, iron, and aluminum concentrations in water were higher than federal or provincial guidelines in 33%, 33%, and 15% of samples, respectively, from the two basins, but not at levels identified as being of concern for toxicity. Nutrients from the Geraldton sewage treatment plant also enter east Barton Bay, resulting in elevated phosphorus levels.

The bioavailability study was designed to assess whether existing elevated metals in surface water and sediment are biologically available and causing adverse effects on resident aquatic organisms. An enhanced Sediment Quality Triad approach was combined with a review of data from 2013/2014 baseline studies of water quality, benthic communities, fish, and fish habitat. Focused laboratory toxicity tests, bioaccumulation studies in aquatic macroinvertebrates and fish (metal levels in tissues), arsenic speciation in fish tissue, and modelling of metal toxicity (Biotic Ligand Model and Metal Effects Addition Model) using site-specific data were included. There were four main assessment areas: two exposure areas (Barton Bay and the Central Basin of Kenogamisis Lake, adjacent to historical MacLeod and Hardrock tailings) and two reference areas (the Southwest Arm of Kenogamisis Lake and Wildgoose Lake).

Both field and laboratory based lines of evidence were used to evaluate potential for bioavailability and toxicity of metals in Barton Bay and the Central Basin. The elevated water and sediment chemistry results for these two areas identify the potential for arsenic toxicity and the arsenic levels in tissues of benthic macroinvertebrates and fish indicate bioavailability and uptake of this metal. However, there is no evidence of adverse effects on the phytoplankton or benthic invertebrate communities related to these elevated metal levels. No depression of phytoplankton growth (chlorophyll a) was observed for Barton Bay or the Central Basin compared to the Southwest Arm reference area (algae are considered among the most sensitive aquatic organisms to arsenic; CCME 2001). No adverse effects on benthic communities were noted for Barton Bay and the Central Basin compared to the Southwest Arm.

No sediment or water toxicity was identified in chronic toxicity tests using the macroinvertebrates *Chironomus dilutes* and *Hyalella azteca*, or the green alga *Pseudokirchneriella subcapitata*. These laboratory test organisms are either common in lakes of the LAA or closely related to species common in these lakes. The tests were conducted using both sediment and water collected from Barton Bay, Central Basin, and the Wildgoose Lake reference area. *Hyalellla* collected from these areas, as well as *Hyalella* survivors from toxicity tests accumulated arsenic to levels higher than predicted lethal body concentrations (LBC25) but this did not result in reduced survival in toxicity tests or in the wild where they are present in abundance. The integrated Metal Effects Addition Model (Norwood et al. 2013) indicated that the observed bioaccumulation in *Hyalella* should result in reduced survival in toxicity tests (as low as 8 to 22% in sediment exposures); however, the actual toxicity tests showed 100% survival, indicating that modelling using metal body burdens overestimated the potential for toxicity. Hence, although arsenic bioaccumulates in tissue of benthic invertebrates (*Hyalella* and *Chironomus*), it does not appear to reduce survival of these species in the laboratory.

Arsenic accumulated in Spottail Shiner to a greater extent in Barton Bay and the Central Basin than in the Southwest Arm and Wildgoose Lake, a spatial trend consistent with historical mining activity. Arsenic levels in Walleye from Kenogamisis Lake were also significantly higher ($p<0.05$) than in those from Wildgoose Lake. Arsenic speciation analyses performed on Walleye muscle tissue from Kenogamisis and Wildgoose lakes showed that bioavailable arsenic is present primarily in a toxicologically unavailable form (arsenobetaine). The measured concentrations of arsenic in Walleye tissue (from Wildgoose and Kenogamisis lakes) are below those that would will result in adverse effects on fish (McIntyre and Linton 2012) and below fish consumption guidelines used internationally (MacDonald et al. 2000), given that there are no tissue guidelines for arsenic in Canada.

Mercury and methylmercury levels in Walleye and Spottail Shiner tissue were also measured, as discussed in Section 11.2.2.3.

Although Walleye from Kenogamisis Lake bioaccumulated significantly more arsenic and mercury than did Walleye from Wildgoose Lake, levels observed did not have an adverse biological effect on this species, based on the assessed end points. There were variations in morphometric endpoints and age structure among Walleye captured from the study lakes sampled in the Stantec program, but the variations, for example in total length at age, were within the range for benchmark values developed by MNR (2002), except for two individuals collected from Kenogamisis Lake. Fish from Kenogamisis Lake were significantly smaller than those from Wildgoose Lake but not those from Goldfield Lake. Fish from Kenogamisis Lake were significantly older than those from Goldfield Lake, but not those from Wildgoose Lake. Since the independent analysis of age and length data indicated that Walleye from Kenogamisis Lake may be smaller at a given age, an ANCOVA was used to compare growth (fork length-at-age and total weight-at-age) between Kenogamisis Lake and Wildgoose Lake Walleye. Results showed that the growth endpoints fork length at age and total length at age were higher in Walleye from Wildgoose Lake than from Kenogamisis Lake and that the energetic endpoint fork length at weight was higher in Kenogamisis Lake (for females and both sexes combined, but not for males) than in Wildgoose Lake. Summary statistics are presented in Table 11-7.

Table 11-7: ANCOVA Results Comparing Growth of Walleye in Kenogamisis Lake (KL) and Wildgoose Lake (WGL) (fork length-at-age, total weight-at-age)

Sex	N (KL)	N (WGL)	Endpoint	Comparison	F statistic		p value	Result
Both	13	27	Growth	Ln(FL), Site+Age	Age	52.281	1.40E-08	WGL>KL
					Site	16.515	0.000242	
Male	8	13	Growth	FL, Site+Age	Age	22.356	0.000168	WGL>KL
					Site	19.462	0.00337	
Female	5	14	Growth	Ln(FL), Site+Age	Age	25.144	0.000127	WGL>KL
					Site	11.025	0.00433	

Table 11-7: ANCOVA Results Comparing Growth of Walleye in Kenogamisis Lake (KL) and Wildgoose Lake (WGL) (fork length-at-age, total weight-at-age)

Sex	N (KL)	N (WGL)	Endpoint	Comparison	F statistic		p value	Result
Both	13	27	Growth	Ln(TL), Site+Age	Age	37.058	1.57E-05	WGL>KL
					Site	8.714	0.00937	
Male	8	13	Growth	TL, Site+Age	Age	18.882	0.00039	WGL>KL
					Site	17.797	0.000516	
Female	5	14	Growth	Ln(TL), Site+Age	Age	37.058	1.57E-05	WGL>KL
					Site	8.714	0.00937	
Male	8	13	Age	Ln(Age), Site	Site	1.271	0.274	No difference
Female	5	14	Age	Ln(Age), Site	Site	0.035	0.853	No difference
Both	13	27	Energetics	Ln(WT), Site+Ln(FL)	Ln(FL)	732.56	<2.2E-16	KL>WGL
					Site	5.340	0.0265	
Male	8	13	Energetics	Ln(WT), Site+Ln(FL)	Ln(FL)	176.534	9.63E-11	No difference
					Site	2.040	1.70E-01	
Female	5	14	Energetics	Ln(WT), Site+Ln(FL)	Ln(FL)	114.71	1.05E-08	KL>WGL
					Site	13.44	0.00209	

NOTES:
N number of fish
FL Fork Length
TL Total Length
WT Weight

The bioavailability study concluded that, while the current elevated levels of arsenic and other metals in water and sediments of Barton Bay and the Central Basin may lead to bioaccumulation, they do not lead to recognizable adverse effects on phytoplankton, benthic invertebrates, or fish populations studied. This may be related to the conservatism incorporated into sediment and water quality guidelines and derivation of the LBC25 values, site-specific water or sediment factors that modify biological responses in Kenogamisis Lake, and adaptation of the existing communities to elevated metal concentrations. Many lake-specific factors affect fish growth rates, including food supply and predator-prey relationships, which may account for observed differences among populations in Kenogamisis, Goldfield, and Wildgoose Lakes, making it difficult to attribute among-lake differences for Walleye to the presence of elevated arsenic levels in Barton Bay and Central Basin of Kenogamisis Lake.

11.2.2.6 Sub-lethal Toxicity Tests

Standard laboratory sub-lethal toxicity tests conducted using lake water and the green alga *Pseudokirchneriella subcapitata* indicated a stimulatory, not inhibitory, response in all test samples (eight stations sampled in May, July, August, September, and October 2016), with the Inhibition Concentration (IC25) for growth at >90.91% lake water (basically full-strength lake water). No indication of sub-lethal toxicity was identified in any of the tests. Arsenic concentrations in lake water at the time of the tests ranged from 0.9 µg/L (Station 1A in the Southwest Arm in May) to 121 µg/L (Station 4 in Barton Bay in October). Concentrations increased between May and October, and were above the CWQG-FAL and Interim PWQO (5 µg/L) in the majority of samples from Barton Bay, Central Basin, and Outlet Arm. Even in Barton Bay, where arsenic concentrations were higher than the PWQO (100 µg/L) in September and October (113 and 121 µg/L, respectively), there was no indication of sub-lethal toxicity on growth of green alga.

11.3 PROJECT INTERACTIONS WITH FISH AND FISH HABITAT

Table 11-8 identifies Project physical activities that may interact with fish and fish habitat. These interactions are indicated by a check mark (✓) and are discussed in Section 11.4 in the context of effects mechanisms, mitigation measures, and residual effects. Justification for non-interactions (-) is provided following Table 11-8.

Table 11-8: Potential Project Effects on Fish and Fish Habitat, Prior to Mitigation

Project Components and Physical Activities	Potential Environmental Effects (prior to mitigation)		
	Lethal and sub-lethal effects on fish	Permanent alteration of fish habitat	Loss of fish habitat
CONSTRUCTION			
Site Preparation (removal of existing buildings and associated infrastructure, timber harvesting, vegetation clearing, earthworks, overburden and topsoil stockpiling, construction effluent treatment and discharge)	✓	✓	✓
Watercourse Crossings and Goldfield Creek Diversion	✓	✓	✓
Pre-Production Mining and Development of Mine Components (open pit, waste rock storage areas, ore stockpile, water management facilities, Phase 1 of TMF)	✓	✓	✓
Buildings and Supporting Infrastructure (process plant, temporary camp, STP, mine dry, administration building, truckshop, warehouse and offices, power plant)	-	-	-
Linear and Ancillary Facilities (site roads and parking areas, onsite pipelines, power lines/transformer station, fuel supply, storage and distribution)	✓	✓	✓

Table 11-8: Potential Project Effects on Fish and Fish Habitat, Prior to Mitigation

Project Components and Physical Activities	Potential Environmental Effects (prior to mitigation)		
	Lethal and sub-lethal effects on fish	Permanent alteration of fish habitat	Loss of fish habitat
Highway 11 Realignment and MTO Patrol Yard Relocation	✓	✓	✓
Aggregate Sources (excavation and dewatering related to aggregate source development and extraction)	✓	✓	-
Employment and Expenditure	-	-	-
OPERATION			
Open Pit Mining (drilling, blasting, loading and hauling of ore and waste rock)	✓	✓	-
Waste Rock Disposal	✓	✓	✓
Ore Processing (ore crushing and conveyance, ore milling)	-	-	-
Water Management (contact water collection system, process water supply, effluent management and treatment, open pit dewatering)	✓	✓	-
Tailings Management (including excavation and removal of historical tailings)	✓	✓	✓
Site Buildings, Linear Facilities and Associated Infrastructure (site roads, power plant, explosives facility, fuel supply, storage and distribution)	-	-	-
Employment and Expenditure	-	-	-
CLOSURE			
Active Closure (primary decommissioning and rehabilitation)	✓	✓	-
Post-Closure (pit filling and monitoring)	✓	✓	-
Employment and Expenditure	-	-	-

NOTES:
✓ Potential interactions that might cause an effect without mitigation.
– Interactions are not expected.

Employment and expenditure will not interact with fish or fish habitat during any Project phase.

Construction of buildings and associated infrastructure will occur away from watercourses and waterbodies and will not interact with fish and fish habitat. Ancillary facilities (fuel supply, storage and distribution) and aggregate sources) will be located away from fish and fish habitat and therefore will not result in a loss of fish habitat.

During operation, ore processing will not interact with fish and fish habitat as this is conducted in enclosed surroundings, eliminating exposure to fish and fish habitat. Buildings, linear facilities and associated Infrastructure will not interact with fish habitat because these facilities will be located away from fish and fish habitat. If unmitigated, open pit mining (drilling, blasting, loading, and hauling of ore rock) has the potential for sub-lethal effects, permanent alteration of fish habitat, and loss of fish habitat.

Activities during active closure (primary decommissioning and rehabilitation) and post-closure will not result in additional loss of fish habitat beyond that which occurs during construction or operation.

11.4 ASSESSMENT OF RESIDUAL ENVIRONMENTAL EFFECTS ON FISH AND FISH HABITAT

11.4.1 Analytical Methods

Methods used to predict Project effects on fish and fish habitat included quantification of habitat loss and permanent alteration and a qualitative evaluation of potential lethal and sub-lethal effects on fish. Predictions from the surface water assessment (changes in water quantity and water quality) were integrated with baseline fish habitat data and PDA information to quantify effects on fish and fish habitat.

Quantitative methods were as follows:

- The areal extent of habitat affected was calculated for disturbed or overprinted area (e.g., bank full width multiplied by length of stream overprinted).
- To estimate habitat affected by flow reduction, the anticipated change in watershed area was calculated, which provides an indication of flow reduction based on drainage area. The amount of downstream habitat affected by flow reduction is also provided. For loss of fish habitat, the area of overprinted fish habitat was estimated based on channel width and stream length, or, in the case of ponds, water surface area.
- Multiple fish collections were completed in water bodies potentially affected by the Project. These collections were completed in various seasons and over multiple years to determine species present and their relative abundance.
- Water chemistry modeling described in Chapter 10.0 (surface water VC), Section 10.4.6.3 was used to predict effects on fish and fish habitat due to changes in water quality (related to toxicity and nutrient enrichment). Predicted levels were compared to PWQOs, Interim PWQOs, CWQG-FAL, and scientific literature on the effects of water quality changes to species found in the LAA.

- Sediment metal levels were measured, including in areas outside the PDA with elevated metals from historical tailings deposition.
- A bioavailability study (Metal Bioavailability TDR, Appendix F7) was conducted to assess the effects of historical sediment and water PoPCs and the potential effects on aquatic biota (including fish health) that may occur as a result of the Project. Predicted conditions were compared to guidelines and to values from scientific literature that are considered harmful to aquatic life.
- Calculations for instantaneous pressure change and peak particle velocity (PPV) for blasting within the open pit and eastern extension.

11.4.1.1 Assumptions and the Conservative Approach

Several assumptions were employed in the assessment of Project effects on fish and fish habitat, resulting in conservative predictions of residual effects:

- The maximum potential Project footprint was assessed.
- When sampling small and ephemeral watercourses with no historical fish community data, the best available habitat was sampled to determine fish presence.
- Where fish have been documented at a sampling location, they are assumed to be present throughout the entire length or area of homogenous habitat.
- Where fish are present in upper stream reaches or headwater lakes and ponds, it is assumed that those species have the potential to inhabit all downstream areas.
- Areas identified as spawning habitats include areas with documented and potential spawning areas.
- The most sensitive habitats, fish species and fish life stages were used to characterize potential effects that may cause serious harm to fish.
- Predictions of change in fish habitat based on changes in hydrology and water quality used conservative assumptions outlined in Chapter 10.0 (surface water VC) (e.g., treated effluent discharge mixing zone size is based on a worst-case scenario of a high volume discharge during a dry year in the receiving environment, a condition that is not likely to occur).
- When developing offsetting measures, uncertainty is taken into account by offsetting for more habitat than is lost.

11.4.2 Assessment of Lethal and Sub-Lethal Effects on Fish

The following section describes the assessment of lethal and sub-lethal effects on fish that may result in a loss of fisheries productivity. Potential effects on aquatic biota that support fish are considered changes to fish habitat and described in Section 11.4.2.2.

11.4.2.1 Project Mechanisms for Lethal and Sub-Lethal Effects on Fish

Project mechanisms for lethal and sub-lethal effects on fish are categorized by Project phase.

Construction

During construction, potential mechanisms for lethal and sub-lethal effects on fish are listed below:

- Mobilization and transport of sediment into fish habitat (e.g., while working near water during excavation, grading, channel construction, vegetation clearing, culvert installation and culvert removal) that results in mortality of fish eggs caused by sedimentation, or disruption of biological processes caused by high TSS (e.g., gill inflammation and limited foraging ability).
- Change in timing, duration, and frequency of flow, which can lead to change in fish mortality by displacing or stranding fish or by preventing access to spawning areas.
- Dewatering work areas, which has the potential to strand, entrain, and impinge fish.
- Destruction of fish eggs by equipment during instream work.
- Stranding of fish within a work area during isolation activities.
- Entry of deleterious materials into fish habitat through point and non-point sources.
- Use of explosives in or near water, which produces shock waves that can damage fish swim bladders and rupture internal organs and vibrations that may kill or damage eggs or larvae.

Operation

During operation, potential mechanisms for lethal and sub-lethal effects on fish are as follows:

- Entrainment and impingement of fish on the freshwater intake structure in Kenogamisis Lake.
- Use of explosives in or near water, which produces shock waves that can damage fish swim bladders and rupture internal organs and vibrations that may kill or damage eggs or larvae.
- Entry of deleterious materials into fish habitat through minor spills or leaks from vehicles, equipment, storage containers/facilities. Major spills are covered in Chapter 22.0 (potential accidents and malfunctions).
- Entry of deleterious materials into fish habitat through point and non-point sources.
- Maintenance or replacement of in-water structures (e.g., culvert replacement, maintenance of water intake structures).

Closure

During active closure, some construction activities and heavy equipment use will be required. Activities include site grading, and removal of culverts and in-water Project infrastructure (e.g., water intake and treated effluent discharge pipelines) where necessary. Although these activities will be on a smaller scale than for the construction phase, the same potential mechanisms for fish mortality will exist (except for blasting, which is not anticipated to occur during closure).

After active closure, TMF surface runoff will flow passively via a closure spillway to the Goldfield Creek diversion. Once the water level in the open pit reaches approximately 331.0 m amsl elevation, water from the pit lake will drain passively via a closure spillway into the Southwest Arm of Kenogamisis Lake.

11.4.2.2 Mitigation for Lethal and Sub-Lethal Effects on Fish

The mitigation measures listed in Table 11-9 will be used to protect fish from lethal and sub-lethal effects and effects on fish habitat due to potential Project-related effects. For convenience and in the interest of avoiding repetition, the mitigation measures for other environmental effects (i.e., permanent alteration of fish habitat, discussed in Section 11.4.3, and loss of fish habitat, discussed in Section 11.4.4) are also listed in the Table 11-9. The standard mitigation measures presented are taken from the DFO website (http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html) and are applicable when conducting a project in or near water to avoid causing serious harm to fish. Table 11-9 also references Conceptual Environmental Management and Monitoring Plans (EMMPs) that have been developed for the protection of fish and fish habitat, including a Conceptual Erosion and Sediment Control Plan (ESCP), Spill Prevention and Response Plan (SPRP), and a Conceptual Waste Rock Management Plan (WRMP). Chapter 23.0 (follow-up monitoring and environmental management plans), provides a summary of follow-up monitoring and Conceptual EMMPs designed to mitigate potential environmental effects of the Project. The Conceptual EMMPs are presented in Appendix M.

Table 11-9: Mitigation Measures for Fish and Fish Habitat

Mitigation Category	Mitigation Number	Mitigation Measure	Potential Project Effect		
			Lethal and Sub-lethal effects	Permanent Alteration of Fish Habitat	Loss of Fish Habitat
Project Planning (Timing)	1	Limit duration of in-water work.	✓	-	-
	2	Conduct instream work during periods of low flow (e.g., summer, fall, or winter) to further reduce the risk to fish and their habitat or to allow work in water to be isolated from flows.	✓	-	-
	3	Within the construction timing window, schedule in-water work to avoid wet, windy, and rainy periods that may increase erosion and sedimentation.	✓	-	-
	4	Design and plan activities and works in waterbodies such that loss or disturbance to aquatic habitat is limited and sensitive habitats are avoided.	✓	✓	-
	5	Comply with spring timing window for in-water work. The timing window for Northwestern Ontario restricts in-water work from April 1 to June 20 for spring spawning species (e.g., Northern Pike and Walleye). This timing restriction would apply to work within and adjacent to water (i.e. within 30 m of water) for the entire PDA. Where a timing window exemption may be required, work with MNRF and DFO to seek an exemption and avoid adverse effects on fish.	✓	-	-
	6	Comply with coldwater timing window for in-water work. The timing window for Northwestern Ontario restricts in-water work between September 1 and May 31 for fall spawning species present in the LAA (e.g., Cisco and Lake Whitefish). This timing restriction would will apply to work within and adjacent to Kenogamisis Lake (i.e. within 30 m) and other work areas with the potential to affect Cisco and Lake Whitefish spawning activity. Work in Kenogamisis Lake would will follow both the spring and fall avoidance periods, unless approved beforehand by the MNRF and DFO, resulting in an in-water construction window of June 21 to August 30. Where a timing window exemption may be required, work with MNRF and DFO to seek an exemption and avoid adverse effects on fish.	✓	-	-
Project Planning (Containment and Spill Management)	7	Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.	✓	-	-
	8	Treat and handle building material used in water in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.	✓	-	-
	9	Follow the "Hardrock Project Conceptual Water Management and Monitoring Plan" (Conceptual WMMP; Appendix M1), which been developed to divert noncontact water around Project components and to collect and manage contact water.	✓	✓	✓
	10	Implement a SPRP immediately in the event of a sediment release or spill of a deleterious substance and an emergency spill kit will be kept onsite.	✓	✓	✓
Shoreline Revegetation and Stabilization	11	Keep clearing of riparian vegetation to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction. When practicable, prune or top the vegetation instead of grubbing/uprooting.	-	✓	-
	12	Limit the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the waterbody below the ordinary high water mark. If material is removed from the waterbody, set it aside and return it to the original location once construction activities are completed.	-	✓	-
	13	Design and construct approaches to waterbodies such that they are perpendicular to the watercourse to reduce loss or disturbance to riparian vegetation.	✓	✓	-
	14	Promptly stabilize shoreline or banks disturbed by activities associated with the Project to prevent erosion and/or sedimentation, preferably through revegetation with native species appropriate for the site.	✓	✓	-
	15	Restore bed and banks of the waterbody to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage would be restored.	-	✓	-
	16	Where replacement rock reinforcement or armouring is required to stabilize eroding or exposed areas, use appropriately-sized, clean rock, and install rock at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.	-	✓	-
	17	Remove all construction materials from site upon Project completion.	-	✓	-

Table 11-9: Mitigation Measures for Fish and Fish Habitat

Mitigation Category	Mitigation Number	Mitigation Measure	Potential Project Effect		
			Lethal and Sub-lethal effects	Permanent Alteration of Fish Habitat	Loss of Fish Habitat
Fish Protection	18	Undertake all in-water activities, or installation of associated in-water structures, such that interference with fish passage, reduction in channel width, or reduction in flows is limited.	✓	✓	-
	19	Retain a qualified environmental professional to confirm that applicable permits for relocating fish are obtained and to capture fish trapped within an isolated/enclosed area at the work site and relocate them to an appropriate location in the same waters. Fish may need to be relocated again, should flooding occur on the PDA.	✓	-	-
	20	Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.	✓	✓	-
	21	Avoid using explosives in or near water where possible. To mitigate potential blasting effects on fish, a blasting plan will be developed if and as required. DFO provides guidelines for the use of explosives on their website (http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html).	✓	✓	-
	22	Design the effluent treatment plant (ETP) to treat effluent to levels that will not be acutely toxic in the effluent, will not have chronic toxicity outside the mixing zone, and will meet applicable guidelines outside the mixing zone.	✓	✓	-
	23	Design water intake and treated effluent discharge location to prevent entrainment or impingement of fish and to prevent scour erosion. This includes temporary intakes for dewatering during construction. Water intake structures will be designed following the Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995). Designs will be based on site-specific parameters including anticipated fish use and resident fish species.	✓	-	-
	24	Detoxification of cyanide (used to process the ore and extract gold) in effluent prior to discharge to TMF (closed system during operation; cyanide destruction at closure).	✓	✓	-
Operation of Machinery	25	Limit access to waterbodies and banks to protect riparian vegetation and limit bank erosion.	✓	✓	-
	26	Maintain equipment to be used in water in a clean condition, free of fluid leaks and aquatic invasive species.	✓	✓	-
	27	Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that limits disturbance to the banks and bed of the waterbody.	✓	✓	-
	28	Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.	✓	✓	-
	29	Use temporary crossing structures or other practices to cross streams or waterbodies with steep and highly erodible banks and beds (e.g., dominated by organic materials and silts). For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g., swamp mats, pads) if minor rutting is likely to occur during fording.	✓	✓	-
	30	Wash, refuel, and service machinery and store fuel and other materials for the machinery in such a way as to prevent deleterious substances from entering the water.	✓	-	-
Culvert Design	31	Design and install culverts in a way that prevents the creation of barriers to fish movement, and maintains bank full channel functions and habitat functions including: • embedment • re-instatement of low flow channel and native substrates • proper sizing maintaining adequate channel slope.	-	✓	✓

Table 11-9: Mitigation Measures for Fish and Fish Habitat

Mitigation Category	Mitigation Number	Mitigation Measure	Potential Project Effect		
			Lethal and Sub-lethal effects	Permanent Alteration of Fish Habitat	Loss of Fish Habitat
Waste Rock Management	32	Follow the WRMP; a conceptual version is provided in Appendix M2.	✓	✓	-
Erosion and Sediment Control (ESC)	33	Implement an ESCP for the site to reduce risk of sedimentation of waterbodies during all phases of the Project. ESC measures will be maintained until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the waterbody or settling basin and runoff water is clear. The ESCP will be based on standard specifications such as Ontario Provincial Standard Specifications (OPSS), in particular, OPSS 805 (Construction Specification for temporary ESC measures), OPPS, PROV 182 (General Specification for Environmental Protection for construction in Waterbodies and on Waterbody Banks) and OPSS 206 (Grading).	✓	✓	-
	34	Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.	-	✓	-
Natural Channel Design	35	Habitat offsetting for the loss of fish habitat that cannot be avoided or mitigated will employ a natural channel design and incorporate habitat attributes as provided in the Draft Fisheries Offset Plan (Appendix F10).	-	✓	✓
Use of Explosives (Blasting)	36	Implement a Blasting Plan for the Project to reduce risk of lethal or sub-lethal effects on fish, changes in bank stability and composition and sedimentations within Kenogamisis Lake. Blasting Plan measures would be followed for the construction and operation phases of the Project.	✓	✓	

NOTES:
✓ Mitigation measures are applicable.
– Mitigation measures are not applicable.

11.4.2.3 Characterization of Residual Lethal and Sub-Lethal Effects on Fish

Construction

Construction-related activities with potential for fish mortality will be mitigated as described in Table 11-9. By following timing windows to avoid sensitive life stages, salvaging fish prior to construction in a watercourse, adhering to sediment and erosion control measures and blasting mitigation measures, and following measures identified in the EMMPs, most residual lethal or sub-lethal effects are avoided. However, since the discharge of final treated effluent will occur year-round and may exceed the interim PWQO for some parameters, a residual effect on fish and fish habitat has been identified. This residual effect would also occur through operation and is assessed in more detail in the following section.

Operation

Residual sub-lethal (chronic) effects are identified for the operation phase, within the effluent mixing zone of Southwest Arm, related to release of treated effluent. The Assimilative Capacity TDR (Appendix F6) and Chapter 10.0 (surface water VC), Section 10.4.4.3 describe the predicted treated effluent quality and behaviour of the treated effluent within the Southwest Arm of Kenogamisis Lake during operation. Effluent will mix within the lake water and metals concentrations will decrease with distance from the treated effluent discharge location. Size of the mixing zone will vary for different flow conditions and for individual parameters. Arsenic is the PoPC with the largest predicted mixing zone, and is the focus of this discussion. For the worst-case, conservative scenario (i.e., maximum effluent flow rate during extremely low flow conditions in the lake), arsenic concentrations are predicted to decrease from 100 µg/L (the modelled treated effluent concentration and the PWQO), to 20 µg/L within 30 m of the treated effluent discharge location, and to 5 µg/L (Interim PWQO and CWQG-FAL) within 2,000 m. This modelling was done using a two-dimensional hydrodynamic model (RMA4) that was run in continuous simulation mode and provides a conservative estimate of concentrations in the mixing zone. Additional near-field steady-state modelling (CORMIX) predicts higher dilution and mixing potential than with the RMA4 model. For example, CORMIX predicts a 1:20 dilution ratio for arsenic (to 5 µg/L, the CWQG-FAL and Interim PWQO) within distances of less than 60 m downstream of the discharge, whereas the RMA4 model predicts a dilution ratio of 1:20 at greater than 1,000 m. These results emphasize the conservatism of the predictions. In more typical conditions (average year flow and average effluent discharge rates), the mixing distance required to reach 5 µg/L will be shorter. The modeled mixing zone for arsenic is shown in Figure 11-7 and Figure 11-8 in relation to potential fish spawning habitat and lake bathymetry, respectively.

Table 11-10 shows how predicted worst-case scenario arsenic concentrations (using the RMA4 model) decrease with distance from the effluent discharge point. Figure 11-7 and Figure 11-8 show arsenic concentrations in relation to bathymetry and potential fish spawning areas. Modelled arsenic concentrations are less than 15 µ/L in areas identified as potential spawning habitat.

Table 11-10: Extent of Mixing Zone for Arsenic – Effluent Concentration 100 µg/L, Worst-Case Discharge Scenario, using RMA4 Model

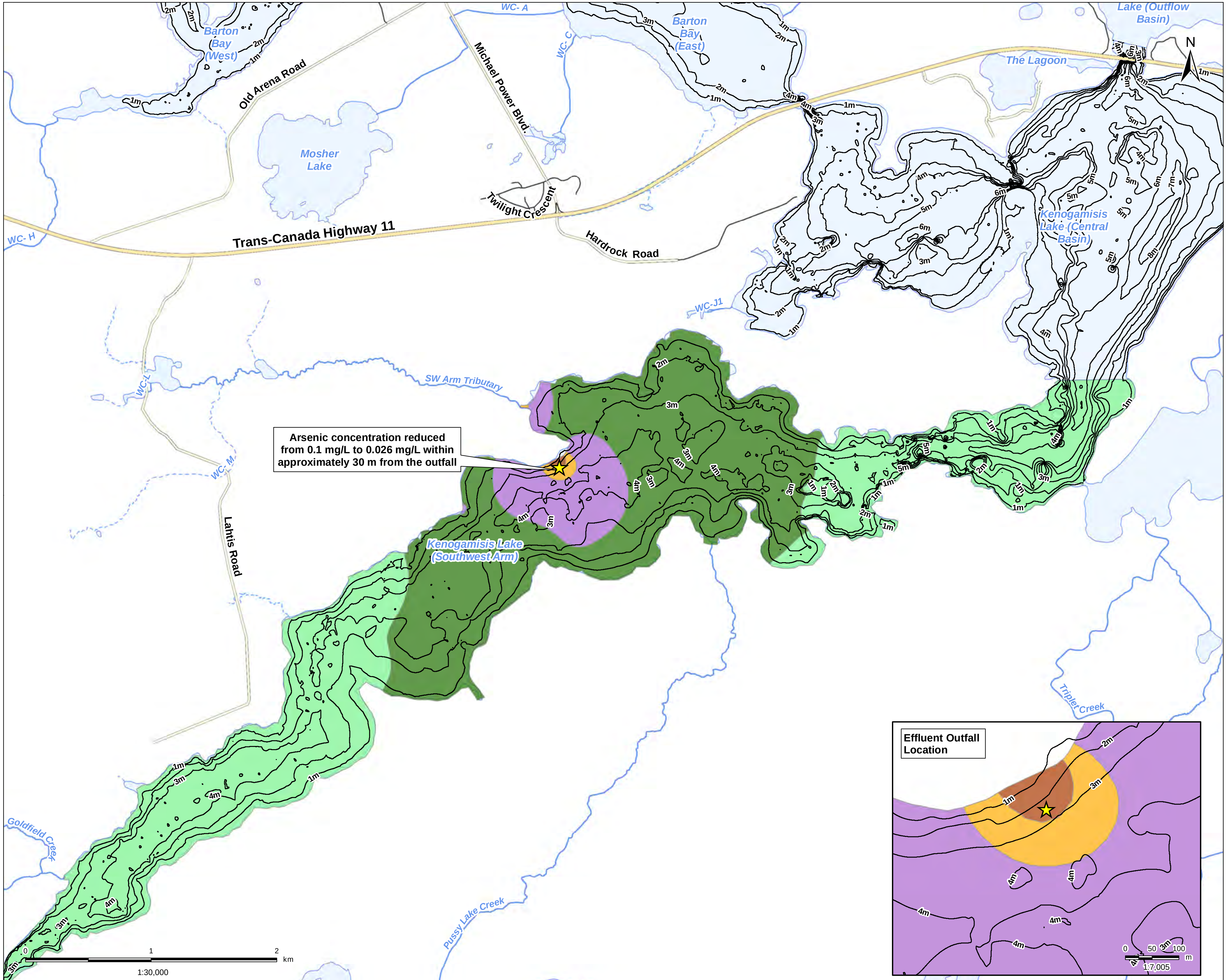
Arsenic Mixing Zone						
Arsenic Concentration in Receiver, µg/L	100	50	25	20	10	5
Distance from Treated Effluent Discharge Location, m	0	<30	<30	30	460	2,000

SOURCE:
Table 5-1 of Assimilative Capacity TDR (Appendix F6) of the Southwest Arm of Kenogamisis Lake

Similar mixing patterns, but with shorter distances to CWQG-FAL or PWQO levels, are predicted for other PoPCs, including copper, antimony, cobalt, uranium, and ammonia. Calculated dilution ratios are 1:5 at less than 30 m, 1:10 at 240 m, and 1:20 at 1,000 m from the treated effluent discharge location, which will result in small areas within the lake where water quality guidelines are not met (Assimilative Capacity TDR; Appendix F6).

Effluent will be treated to levels that are not acutely toxic to fish, and will be below MMER effluent criteria as described in Section 10. 4.3.2 of Chapter 10.0 (surface water VC) for modelled effluent criteria for the ETP. Within the mixing zone, concentrations will be higher than water quality guidelines and may result in chronic toxicity effects close to the treated effluent discharge location. However, it is important to recognize that the guidelines are conservative. For example, the CWQG-FAL for most of the metals incorporate an up to ten-fold safety factor for the most sensitive aquatic species tested (CCME 2016). Hence, a guideline exceedance in itself is not an accurate predictor of adverse effects. For arsenic (CCME 2001), the most sensitive test organism is a green alga (with effects on growth identified at 50 µg/L); fish are considered less sensitive (28 day LC50 of 550 µg/L for rainbow trout and a 72-hour lowest observed effect concentration of 970 µg/L for climbing perch), as are invertebrates (effect concentrations similar to fish).

Water quality predictions for the Southwest Arm (see Figure 11-7 and Table 11-12) show a 30 m wide area around the effluent discharge point where arsenic concentrations will decrease from 100 µg/L (full strength effluent) to 20 µg/L, where aquatic life will be exposed to this range of concentrations. These concentrations are lower than those identified as causing chronic toxicity for fish (CCME 2001). The residual effects are characterized as low in magnitude (i.e., higher than water quality guidelines designed for the protection of aquatic life, but below levels that will affect fish health).



Stantec

Legend

- ☆ Effluent Outfall Location
- Bathymetry Contours (1m intervals)
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody

Arsenic Mixing Zone (mg/L)

- 0.002 - 0.005
- 0.005 - 0.01
- 0.01 - 0.015
- 0.015 - 0.02
- 0.02 - 0.026

Notes

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

January 2017
160961111

Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project:

Figure No.
11-7

Title
Modeled Extent of Arsenic Mixing Zone

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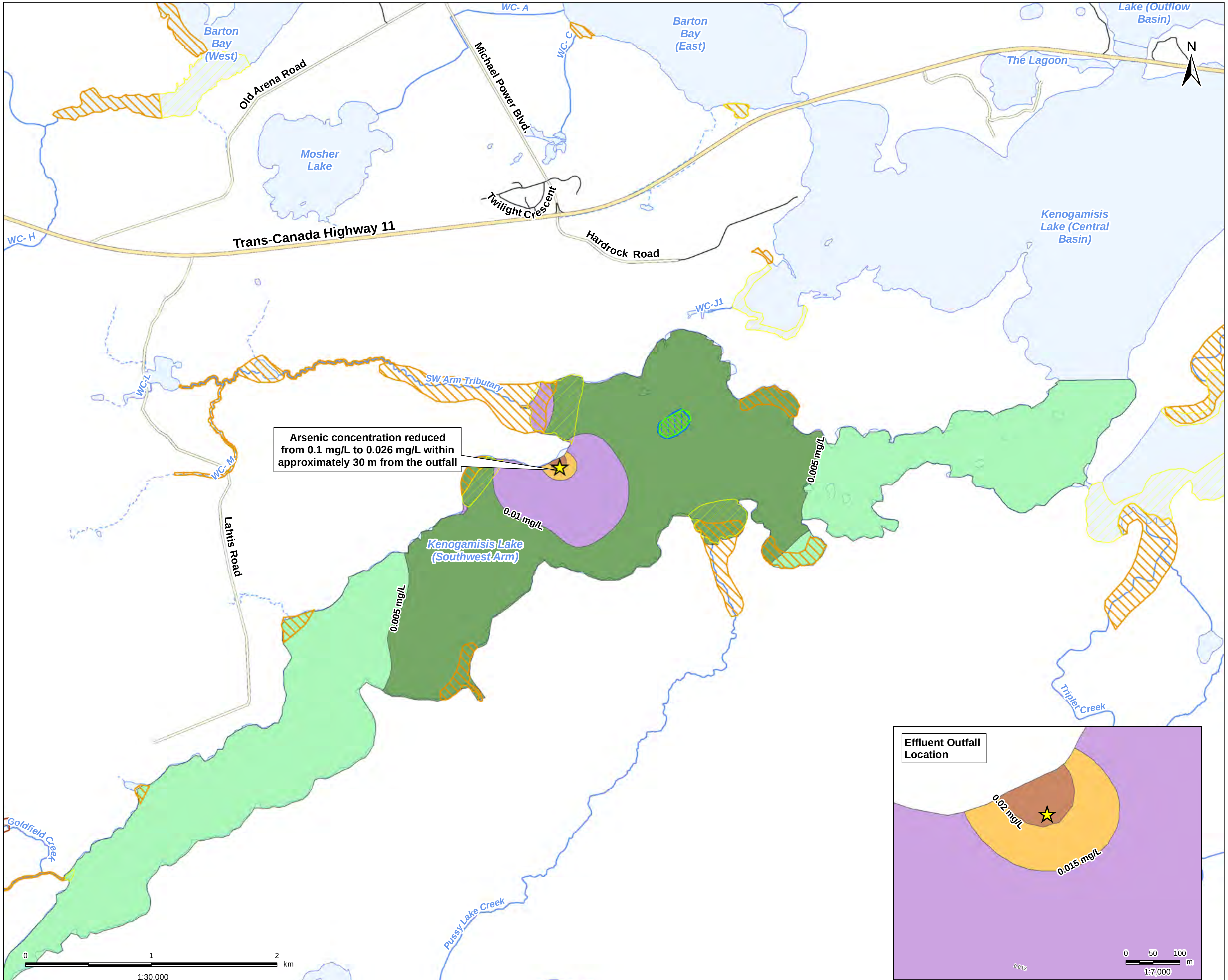
Revised: 2017-01-06 By: dharvey



N

Stantec

Legend

- Effluent Outfall Location
- Highway
- Major Road
- Local Road
- Watercourse-Permanent
- Watercourse-Intermittent
- Waterbody

Fish Spawning Area

- Cisco
- Lake Whitefish
- Northern Pike
- Waleye
- Waleye, White Sucker
- Waleye, White Sucker, Lake Whitefish
- White Sucker
- Yellow Perch

Arsenic Mixing Zone (mg/L)

- 0.002 - 0.005
- 0.005 - 0.01
- 0.01 - 0.015
- 0.015 - 0.02
- 0.02 - 0.026

Notes

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

March 2017
160961111

Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project:

Figure No.
11-8

Title
Modeled Extent of Arsenic Mixing Zone and Spawning Areas

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Revised: 2017-03-17 By: dharvey

A review of existing conditions provides perspective regarding elevated arsenic concentrations in Barton Bay and Central Basin due to historical tailings deposition (i.e., historical MacLeod, Little Long Lac and Hardrock tailings). Mean arsenic concentrations are higher than the CWQG-FAL and PWQO of 5 µg/L in east Barton Bay, the area of Kenogamisis Lake with the greatest effect on water quality from historical mining activities and ongoing runoff from tailings areas along the shore. In Barton Bay, baseline total arsenic concentrations ranged from 10.5 to 121 µg/L, with a mean of 44.5 µg/L as described in Table 10-23 of Chapter 10.0 (surface water VC). These concentrations are considerably higher than the CWQG-FAL and Interim PWQO (5 µg/L), but below the PWQO (100 µg/L) and toxicity endpoints identified for fish (CCME 2001). Also, as summarized in Section 11.2.2.5 and described further in the Metal Bioavailability TDR (Appendix F7), bioavailability study results indicated that arsenic in Walleye tissue from Kenogamisis Lake is stored mainly in a toxicologically inactive form (arsenobetaine), and that elevated tissue levels do not appear to result in adverse effects on this fish species.

Water quality predictions were also made using a mass balance model on a basin-wide basis to incorporate contact water seepage from the TMF, WRSAs, and open pit into groundwater then into Kenogamisis Lake and also the improvements related to the planned removal of a portion of the historical Hardrock and MacLeod tailings from areas adjacent to Barton Bay and Central Basin to the TMF. Removal of a portion of these historical tailings will result in an overall decrease in arsenic loadings, leading to reduced concentrations in Barton Bay, the Central Basin, and the Outlet Basin. A mass balance model was used to integrate loadings from these various Project sources into the subwatersheds of Kenogamisis Lake. During operation, the following predictions are made for arsenic concentrations on a basin-wide basis as described in Table 10.35 of Chapter 10.0 (surface water VC):

- In the Southwest Arm, from 1.75 µg/L as an overall baseline level to 2.25 µg/L during operation, related to discharge of treated effluent; below the CWQG-FAL and Interim PWQO.
- In Barton Bay (west basin), a 68% decrease, from 44.5 µg/L at baseline to 14.13 µg/L during operation, due to removal of portions of the historical MacLeod and Hardrock tailings and reduction in surface water and groundwater sources; remaining above the CWQG-FAL and Interim PWQO.
- In the Central Basin (eastern portion), a 63% decrease, from 17.8 µg/L at baseline to 6.57 µg/L during operation, due to removal of portions of the historical MacLeod and Hardrock tailings and reduction in surface water and groundwater sources; remaining above the CWQG-FAL and Interim PWQO.
- In the Outlet Basin, a 57% decrease, from 10.24 µg/L at baseline to 4.43 µg/L during operation, reflecting reductions related to removal of portions of the historical MacLeod and Hardrock tailings and an increase related to discharge of treated effluent into Southwest Arm; remaining above the CWQG-FAL and Interim PWQO.

Similar changes in arsenic loading (increase in Southwest Arm, decrease in Barton Bay, Central Basin, and Outlet Basin) were predicted using the STELLA Model (Appendix F13 - Mass Balance Modelling of Arsenic Concentrations of Kenogamisis Lake) and the mass balance model as described in Table 10-35 of Chapter 10.0 (surface water VC). The STELLA model accounts for changes in arsenic concentrations due to sediment-water interactions and varying arsenic loadings and geochemical conditions in the four basins. The predicted annual mean arsenic concentration between 2020 and 2050 is approximately 3.1 µg/L in the Southwest Arm, 25.7 µg/L in the western portion of Barton Bay, 6.6 µg/L in the east portion of the Central Basin, and 6.6 µg/L in the Outlet Basin.

The mass balance and STELLA models predict overall improvements for water quality in Barton Bay, the Central Basin, and the Outlet Basin as a result of the Project. An approximately 40% reduction in arsenic concentrations related to removal of portions of the historical MacLeod and Hardrock tailings is predicted for those basins. The models also predict an approximately 100% increase in arsenic concentrations in the Southwest Arm (but remaining below the CWQG-FAL and Interim PWQO in that basin).

No change in mercury or methylmercury levels in fish tissue, compared to baseline, is expected as a result of the Project. The geochemistry analyses indicate levels of mercury were at or below detection limits in the majority of analyses of ore, waste rock, and overburden, and in shake flask extracts and kinetic tests (Baseline Report – Geochemistry, Appendix E6). Also, the water quality predictions indicated mercury concentrations in sediment ponds and the open pit will be close to the detection limit (maximum of 0.007 µg/L) and that maximum concentrations in the TMF will occur during operation (when water will be managed within the TMF and ETP and are an over-estimate due to the use of elevated detection limits. Sulphate, known to promote methylation of mercury through the action of sulphate-reducing bacteria (Gilmour et al. 1992, Acha et al. 2012) is low for baseline conditions (75th percentile of 1.4 mg/L; (Assimilative Capacity TDR; Appendix F6). Predicted average sulphate concentration in Pond M1 during operation (Years 1-16) is 101 mg/L and predicted maximum monthly concentration during operation is 240 mg/L (2017 Geochemistry Report, Appendix E06). The 75th percentile of background sulphate concentration in Southwest Arm is 1.4 mg/L. Based on the results of dilution mixing modeling of Southwest Arm, conducted using an RMA4 model, it was concluded that 5 times dilution is observed within 30 m of the outfall, 10 times dilution is observed 240 m from the outfall, and 20 times dilution is observed 1,400 m from the outfall (Assimilative Capacity TDR; Appendix F6). Therefore, it is expected that average sulphate concentration during operation will reduce rapidly and reach an average 4.6 mg/L within 1,400 m of the treated effluent discharge. This localized increase is not expected to change conditions for methylation of mercury, which are typically associated with anoxic sediment (Gilmour et al 1992).

Bioaccumulation of methylmercury in fish depends on a variety of physio-chemical variables as well as age, size, and species life characteristics (Grieb et al. 1990, Jackson 1991, Wong et al. 1997, Ullrich et al. 2001, Power et al. 2002, Jewett et al. 2003). As a result, a change in methylmercury levels in tissue can be associated more strongly with activities that affect methylation rates (e.g., forest fires, inundation of soils to form reservoirs [Ullrich et al. 2001]) or structure of the fish community (predator-prey relations) than with changes in inorganic mercury levels (Power et al. 2002, Wong et al. 1997). Such changes are not expected to be associated with the Project.

Habitat alteration has the potential to change conditions for methylation of mercury along the new Goldfield Creek diversion, where existing soils will be inundated. However, mobilization of mercury from soils into water is not anticipated to result in increased methylmercury concentrations in fish tissue due to the generally low levels of mercury observed in the existing overburden and parent material. Furthermore, the areas that will be inundated already experience occasional flooding under baseline conditions, and this same variable water level condition will occur through most of new channel length. In areas where grade control structures will be installed (i.e., in the existing Southwest Arm Tributary as described in Section 4.4.19 of Chapter 5.0 (Project description) and in the Draft Fisheries Offset Plan (Appendix F10), water levels will be more stable, reducing the frequency of saturation and drying cycles. These design considerations will reduce the potential for increased methylation of mercury and uptake in fish tissue.

Blasting during operation will occur near but not in water. The use of explosives has the potential to produce instantaneous pressure changes that can cause damage to fish swim bladders and internal organs. Vibrations (PPV) from the use of explosives may also kill or damage fish eggs or larvae. Guideline thresholds have been identified by DFO for instantaneous pressure change (recommended 50 kPa) and PPV (13 millimeters/sec) (DFO 2010) and are used in this assessment. Calculations for instantaneous pressure changes and PPV were based on formulas from Wright and Hopky (1998).

Predicted blast parameters for the central portion of the open pit were made using a charge of 331 kg/delay. Based on the results of these calculations (Table 11-11) blasting in the central portion of the open pit will be below threshold levels. Therefore, no lethal or sub-lethal effects on fish are expected from blasting in the central portion of the open pit. When blasting within 275 m of fish (including fish eggs) bearing waters, blast charges may need to be adjusted to avoid lethal effects on fish.

Table 11-11: Value of Overpressure, PPV Values and Distance from Main Pit with a Charge Weight of 331kg/Delay

Blasting Parameters for the east side of the Open Pit	
Charge (kg/delay)	331
PPV (mm/sec)	13
Instantaneous pressure change (KPa)	17
Distance to comply with guidelines (m)	275

The eastern extension of the open pit is adjacent to the Central Basin of Kenogamisis Lake. Spawning surveys conducted in 2015 and 2016 found potential spawning habitat for Yellow Perch and Northern Pike in the embayment in the west end of the Central Basin of Kenogamisis Lake but no spawning activities were observed during these surveys. Other embayment areas near the eastern extension of the open pit, including those of the Southwest Arm and the shoreline of East Barton Bay, have the potential to provide spawning areas for forage fish. In addition to potential spawning habitat, the nearshore waters or littoral zone provide areas for feeding and rearing of juvenile fish for a number of species.

The use of a standard 331 kg charge/delay in the eastern extension may exceed PPV and instantaneous pressure thresholds for the protection of fish. To mitigate potential effects on fish, modified blasting methods will be used in this area to avoid instantaneous pressure changes (i.e., overpressure) that could cause the death of fish. Furthermore, blasting methods will be modified so that peak particle velocity does not exceed 13 mm/s in a spawning bed or where egg incubation or rearing of larval fish occurs.

Mitigation will be implemented to reduce the mobilization and deposition of dust from blasting and heavy equipment use (Chapter 7.0, atmospheric environment VC). However, some mobilization of dust containing PoPC is still anticipated and dust deposition will occur in fish habitat. The contributions of dustfall have been accounted for in the water quality mass balance and STELLA models, which predict overall improvements in water quality in Barton Bay, the Central Basin, and the Outlet Basin (Chapter 10, surface water VC).

Closure

During closure, most water quality changes will be reversed. The open pit will fill over approximately 16 years with precipitation, input from Kenogamisis Lake, and contact water, including TMF water. The pit lake is expected to become permanently stratified, with higher PoPC concentrations in the deeper water, and with surface discharge water predicted to generally meet CWQG-FAL and PWQOs as described in Section 10.4.3.3 of Chapter 10.0 (surface water VC). During closure, mass balance calculations of loadings indicate a return to baseline concentrations for most of the lake basins (Table 10-38). For example, total arsenic concentrations for active closure and post-closure are predicted at 1.29 and 2.21 µg/L in the Southwest Arm, 14.13 and 30.26 µg/L in East Barton Bay, 5.96 and 11.8 µg/L in the eastern Central Basin, and 3.83 and 7.09 µg/L in the Outlet Basin. As a result, residual adverse effects will be less during closure than during operation.

The pit lake will have an outlet channel that discharges to existing fish habitat. If warranted, a barrier will be installed to prevent fish from accessing the pit lake. A vertical drop of 0.5 m will be adequate to effectively prevent fish from swimming into the pit lake under most flow scenarios.

Cyanide used in the gold extraction process will not be released to surface waters. Water used to meet mill demand will be recirculated from the TMF reclaim pond, which is designed as a closed system during operation. During decommissioning and closure, residual cyanide will continue to degrade through natural processes (e.g., degradation from ultraviolet light).

Summary of Residual Lethal and Sub-Lethal Effects on Fish

A summary of the assessment process for lethal and sub-lethal effects on fish, including appropriate mitigation measures, is provided in Table 11-12. This table provides details about how the DFO pathways of effect will be broken for most activities.

Residual environmental effects have been identified for sub-lethal effects on fish but lethal effects on fish are not predicted, given that mitigation methods will be effective in managing activities that can cause direct mortality to fish. No changes in mercury and methylmercury concentrations in fish tissue are predicted, given that mercury levels in effluent are predicted to be below detection limits and that changes in habitat that promote methylation of mercury are not expected. Sub-lethal effects may be associated with the release of treated effluent into a mixing zone within the Southwest Arm during construction and operation with concentrations of arsenic and other metals higher than water quality guidelines within the effluent mixing zone. Arsenic concentrations have been conservatively modelled for a worst-case scenario: they will be below the PWQO (100 µg/L) in treated effluent and decrease to 20 µg/L within 30 m of the treated effluent discharge location and to the CWQG-FAL and Interim PWQO (5 µg/L) within 2 km of the treated effluent discharge location. Predicted arsenic concentrations are lower than currently observed in Barton Bay, which is affected by historical mining activities. Removal of portions of the historical MacLeod and Hardrock tailings to the TMF will result in an approximately 60% decrease in arsenic concentrations in Barton Bay, Central Basin, and Outlet Basin during operation, compared to baseline, resulting in overall improvement of water quality in Kenogamisis Lake.

The residual effects are characterized as low in magnitude (higher than water quality guidelines but below levels that will affect fish health), limited to the mixing zone, continuous, medium term (during construction and operation), and reversible, following closure of the Project. For ecological and socio-economic context, fish habitat is important to the functioning of an ecosystem and the fish community; however, the area is typical because the fish species present are common in the RAA.

Table 11-12: Summary of Residual Effects of Lethal and Sub-Lethal Effects on Fish During all Project Phases

Activity	Description	Mitigation Number (see Table 11-9)	Residual Effect
CONSTRUCTION			
Site Preparation (removal of existing buildings infrastructure and tailings vegetation clearing, earthworks, overburden and topsoil stockpiling)	Mobilization and transport of sediment into fish habitat (e.g., while working near water during excavation, grading, vegetation clearing, and culvert removal)	1, 2, 3, 4, 5, 6, 7, 8, 10, 14, 25, 26, 27, 28, 29, 30, 32, 33	No residual effect anticipated (mitigated).
Watercourse Crossings and Realignments	Change in timing, duration and frequency of flow can lead to death of fish by displacing or stranding fish or by preventing access to spawning areas	1, 2, 3, 4, 5, 6, 13, 18, 19, 20, 29	No residual effect anticipated (mitigated).
	Mobilization and transport of sediment into fish habitat (e.g., while working near water during excavation, grading, vegetation clearing, and culvert installation	1, 2, 3, 4, 13, 14, 20, 25, 27, 28, 29, 33	No residual effect anticipated (mitigated).
	Dewatering work areas has the potential to strand, entrain, and impinge fish.	18, 19, 23	No residual effect anticipated (mitigated).
	Destruction of fish eggs by equipment during instream work	1, 2, 5, 6, 21, 28	No residual effect anticipated (mitigated).
	Stranding of fish within a work area	2, 18, 19, 20	No residual effect anticipated (mitigated).
	Entry of deleterious materials into fish habitat through spills from vehicles, placement of contaminated materials in water	7, 10, 26	No residual effect anticipated (mitigated).
	Use of explosives in or near water	5, 6, 36	No residual effect anticipated (mitigated).
Mine Components (open pit, waste rock storage areas, water management and treatment facilities, tailings management facility [TMF])	Entry of deleterious materials into fish habitat through spills from vehicles, placement of contaminated materials in water	9, 21, 25, 30 7, 10, 26,	No residual effect anticipated (mitigated).
	Collection and treatment of water during construction and subsequent discharge to Kenogamisis Lake	9, 22	Mitigation will reduce the magnitude of residual effects, resulting in a mixing zone around the treated effluent discharge location that contains metals and other constituents (e.g., phosphorus) at concentrations that exceed established guidelines for the protection of aquatic life.
	Collection and discharge of site run-off during construction	9, 22	No residual effect anticipated (mitigated).
	Use of explosives in or near water	21	No residual effect anticipated (mitigated).
Linear and Ancillary Facilities (site roads and parking areas, onsite pipelines, power lines/transformer substation, fuel supply, storage and distribution), Highway 11 realignment)	Vegetation clearing, culvert installation	1, 2, 3, 4, 14, 25, 27, 29, 33	No residual effect anticipated (mitigated).
OPERATION			
Open Pit Mining (drilling, blasting, loading and hauling of ore, waste rock. historic tailings and overburden)	Use of explosives in or near water	5, 6, 36	No residual effect anticipated (mitigated).
	Entry of deleterious materials into fish habitat through: Direct spills from vehicles, equipment, storage containers/facilities Placement of contaminated materials in waters	9, 21, 25, 30 7, 10, 26,	No residual effect anticipated (mitigated).
Water Management (contact water collection system, process water supply)	Entrainment and impingement of fish on the water intake structures	22, 23	No residual effect anticipated (mitigated).
	Maintenance of in-water structures (i.e., culvert replacement, maintenance of water intake structures)	1, 2, 4, 11, 12, 14, 18, 20, 23, 26, 27, 28, 29, 33	No residual effect anticipated (mitigated).

Table 11-12: Summary of Residual Effects of Lethal and Sub-Lethal Effects on Fish During all Project Phases

Activity	Description	Mitigation Number (see Table 11-9)	Residual Effect
Release of contact water and treated effluent to Kenogamisis Lake	ETP discharges that will meet MMER effluent criteria, resulting in treated effluent that is not acutely toxic to fish and that will meet PWQOs, Interim PWQOs, and CWQG-FALs outside of a mixing zone in the Southwest Arm. Seepage of contact water from the TMF and WRSAs into groundwater then into the lake. Water Management Plan that describes contact water collection system to avoid direct release to fish habitat. Relocation of portions of historical MacLeod and Hardrock tailings to the TMF	9, 22	Mitigation will reduce the magnitude of residual effects, resulting in a mixing zone around the treated effluent discharge location that contains metals and other constituents (e.g., phosphorus) at concentrations that exceed established guidelines for the protection of aquatic life. See Chapter 10.0 (surface water VC) for details of water quality predictions, which include surface water discharges and seepage via groundwater.
CLOSURE			
Primary Decommissioning	Mobilization and transport of sediment into fish habitat (e.g., while working near water during excavation, grading, vegetation clearing, and culvert removal)	1, 2, 3, 4, 8, 13, 25, 27, 28, 29, 33	No residual effect anticipated (mitigated).
	Entry of deleterious materials into fish habitat through spills from vehicles or placement of contaminated materials in water	7, 10, 26, 30	No residual effect anticipated (mitigated).
	Destruction of fish eggs by equipment during instream work	1, 2, 5, 6, 21, 28	No residual effect anticipated (mitigated).
	Stranding of fish within a work area	2, 18, 19, 20	No residual effect anticipated (mitigated).
Water Management	Continued input of nutrients and PoPC to Southwest Arm from the TMF, WRSA, and open pit.	9, 22	No residual effect anticipated (mitigated).
Rehabilitation (progressive rehabilitation, active closure)	Mobilization and transport of sediment into fish habitat (e.g., while working near water, grading, vegetation planting)	1, 2, 3, 4, 13, 14, 20, 25, 27, 28, 29, 33	No residual effect anticipated (mitigated).
	Entry of deleterious materials into fish habitat through spills from vehicles, placement of contaminated materials in water	7, 10, 26, 30	No residual effect anticipated (mitigated).
Post-Closure	Discharge of pit lake water to the Southwest Arm, with PoPCs meeting PWQOs Monitoring	n/a	No residual effect anticipated (mitigated).

11.4.3 Assessment of Permanent Alteration of Fish Habitat

Changes that could lead to permanent alteration of fish habitat were evaluated by overlaying the Project footprint on the baseline habitat conditions, incorporating information from the surface water assessment (Chapter 10.0) and the Conceptual WMMP (Appendix M1) to make quantitative predictions of changes from baseline.

11.4.3.1 Project Mechanisms for Permanent Alteration of Fish Habitat

Project mechanisms for the permanent alteration of fish habitat are categorized by Project phase, and have the potential to occur without the application of mitigation or offsetting.

Construction

The following construction activities have the potential for permanent alteration of fish habitat:

- Discharge of treated effluent, or groundwater discharge originating from the WRSAs and TMF into the Southwest Arm of Kenogamisis Lake could lead to permanent alteration of fish habitat by causing:
  - a change in water temperature
  - a change in DO
  - a change in nutrient concentrations leading to eutrophication
  - a change in water chemistry
  - a change in sediment chemistry such that ecological functions of sediments are impaired
  - effects on aquatic biota (phytoplankton, zooplankton, benthic invertebrates) that provide or support food sources for fish
  - effects on aquatic plants that provide in-water structure, cover and feeding habitat
  - deposition of suspended sediment from treated effluent, altering the ecological function and condition of lake sediments.
- Planting riparian vegetation can lead to the permanent alteration of fish habitat through:
  - disruption of bank material, which may lead to a change in sediment concentrations
  - altering canopy cover, which may change water temperature
  - altering riparian vegetation, which may result in a change in habitat structure, cover, and food and nutrient supply.

- Use of explosives in and adjacent to fish habitat can lead to the permanent alteration of fish habitat by altering shoreline and bank habitat, which may lead to a change in sediment concentrations and infilling of sediment interstitial spaces.
- Use of heavy equipment in and adjacent to fish habitat can lead to permanent alteration of fish habitat by altering bank stability and increasing erosion potential, leading to change in sediment levels.
- Use of heavy equipment in water can lead to permanent alteration of fish habitat by direct disruption/compression of substrates and in-stream cover and increasing erosion potential by disruption of natural substrates.
- Vegetation clearing can lead to the permanent alteration of fish habitat by causing:
  - a change in habitat structure and cover
  - a change in sediment concentrations
  - a change in food supply.
- Altering the volume, timing, duration or frequency of flow can lead to the permanent alteration of fish habitat by:
  - altering food supply (e.g., reduction in nutrients supporting lower trophic levels)
  - altering bank vegetation and shoreline/bank habitat and cover
  - scouring of channel beds and eroding banks, leading to a change in habitat structure and cover
  - mobilization and deposition of sediment through shoreline/bank erosion.
- Dredging may be required to bury the freshwater intake and treated effluent discharge pipes in the near shore area of Kenogamisis Lake, and can lead to permanent alteration of fish habitat by causing:
  - mobilization and deposition of sediments
  - a change in habitat structure and cover (e.g., aquatic vegetation and substrate characteristics).
- Placement of material or structures in water (e.g., culverts, water intake pipe and treated effluent discharge pipe) can lead to the permanent alteration of fish habitat by replacing existing habitat or altering flow regimes. New culvert crossings include, but may not be limited to:
  - Goldfield Creek Tributary North Branch: culvert crossing associated with the construction access road
  - Southwest Arm Tributary: culvert crossing associated with the haul road and TMF pipeline
  - WC-F: culvert crossing associated with the realigned Highway 11. Above ground crossing for the 44 kV distribution line realignment

  - WC-G: culvert crossing associated with the site access road. Above ground crossing for the 115 kV transmission line
  - WC-L, WC-K/SWP2: culvert crossing associated with the construction access road
  - WC-M: culvert crossing associated with the construction access road and TMF pipeline
  - WC-O: culvert crossing associated with the haul road.
- Removal of non-natural in-water structures such as existing culverts (e.g., at Goldfield Creek and at WC-L) can lead to mobilization of sediment or alter flow regimes, causing a change in habitat structure and cover.
- TMF reclaim pipeline crossings of the Goldfield Creek diversion could lead to a change in bank structure and cover or mobilization and deposition of sediment.

Operation

The following activities during operation may result in permanent alteration of fish habitat:

- Discharge of treated effluent, or groundwater discharge originating from the WRSAs and TMF into the Southwest Arm of Kenogamisis Lake could lead to permanent alteration of fish habitat by causing:
  - a change in water temperature
  - a change in DO
  - a change in nutrient concentrations leading to eutrophication
  - a change in water chemistry
  - a change in sediment chemistry such that ecological functions of sediments are impaired
  - effects on aquatic biota (phytoplankton, zooplankton, benthic invertebrates) that provide or support food sources for fish
  - effects on aquatic plants that provide in-water structure, cover and feeding habitat
  - deposition of suspended sediment from treated effluent, altering the ecological function and condition of lake sediments.
- Water extraction (e.g., pit dewatering) can lead to the permanent alteration of fish habitat through water table drawdown effects.
- Maintenance of roads, work areas, water crossings and water intake can lead to sedimentation of watercourses.
- Use of explosives in and adjacent to fish habitat can lead to the permanent alteration of fish habitat by altering shoreline and bank habitat, which may lead to a change in sediment concentrations and infilling of sediment interstitial spaces.

Closure

Closure may lead to permanent alteration to fish habitat, including:

- continued input of nutrients to Southwest Arm of Kenogamisis Lake from the TMF, WRSA and, once the pit lake has filled, natural drainage from the pit lake area
- erosion and sedimentation caused from the removal of culverts, water intake, and other infrastructure.

11.4.3.2 Mitigation and Offsetting for Permanent Alteration of Fish Habitat

Table 11-9 presents measures to mitigate potential environmental effects for permanent alteration of fish habitat. A Conceptual Fish Habitat Offset Plan was submitted as part of the Draft EIS/EA. Consultation has occurred with agencies and Aboriginal communities and this input is reflected in the updated Draft Fisheries Offset Plan (Appendix F10). The Draft Fish Habitat Offset Plan reflects updates to the channel design to accommodate the increased flow through the Southwest Arm Tributary, applicable avoidance and mitigation measures, and estimated habitat losses from the Project. The Draft Fish Habitat Offset Plan will be advanced through ongoing consultation during permitting. Plan development has taken a precautionary approach, to account for uncertainty in predicting the loss of fish habitat by aiming for a net gain in habitat. Implementation of the Fish Habitat Offset Plan will result in no residual effects due to the physical disruption fish habitat. Residual effects on fish habitat that may occur because of effluent discharge are discussed in Section 11.4.3.3.

11.4.3.3 Characterization of Residual Environmental Effect of Permanent Alteration of Fish Habitat

Construction

Most physical habitat alteration will occur during construction. Mitigation measures, implementation of EMMPs, and offsetting (Draft Fisheries Offset Plan, Appendix F10) will be applied to prevent a reduction in fisheries productivity such that there will be no residual effect because of permanent alteration of fish habitat during construction. Where habitat is affected by flow reduction, the amount of offsetting will be proportional to the area affected and the anticipated reduction in flow. The calculations of permanent alteration related to reduction in watershed area are made assuming losses of 15% or less will result in no permanent alteration, while losses of 85% or greater will result in permanent alteration of the entire area. Offsetting will occur within the Goldfield Creek diversion and will consist of a combination of new deep pond/lake habitat, new channel habitat and new shallow pond habitat. Intermittent and ephemeral habitats that will be lost or permanently altered are being replaced with permanent (year-round) habitat. In addition to providing habitat for fish, a functional and integrated riparian edge and productive littoral zones will be developed to benefit aquatic and other wildlife species that inhabit the creek valley. The margins of the diversion pond will be integrated into the existing forest cover along the west shoreline through careful implementation of an edge management design.

The shallow pond habitat will be created through the installation of grade control structures in the Southwest Arm Tributary, downstream of Southwest Pond 3 (SWP3) that will regulate flow and enable fish passage. The anticipated changes to fish habitat that will occur in the Southwest Arm Tributary due to increased flow and creation of inundated areas is not anticipated to result in serious harm to fish because the ecological function of the Southwest Arm Tributary can be maintained. These functions include fish passage to upstream habitats, potential spawning areas for spring spawning species, feeding habitat for fish from Kenogamisis Lake and rearing habitat for baitfish. Food supply for fish is not anticipated to decrease, because there will be additional flow volume and nutrient transport through this area, which contributes to primary production. The preferred flow management approach of using grade control structures has been selected to reduce potential for erosion of bank material and sediment transport.

Table 11-13 provides a summary of predicted effects on permanent alteration of fish habitat. For convenience and in the interests of avoiding repetition, a summary of predicted effects on loss of fish habitat (discussed in Section 11.4.4) is also provided in Table 11-13.

Table 11-13: Summary of Permanent Alteration and Loss of Fish Habitat to be Offset

Waterbody Name	Effect	Area Affected (ha)	% change in flow	Offset Requirement [A] (ha)
Goldfield Creek	**Habitat Loss**: Diversion (from the Goldfield Creek Diversion Dam at the upstream end to the pond T1 berm at the downstream end inclusive)	2.10	Not applicable	2.10
	Permanent Alteration: Flow reduction from pond T1 berm to confluence with Goldfield Creek Tributary	0.34	-99.3%	0.34
	Permanent Alteration: Flow reduction from confluence with Goldfield Creek Tributary to Kenogamisis Lake	0.38	-71.0%	0.27
Golf Course Pond 2	**Habitat Loss**: Due to overprinting	0.22	Not applicable	0.00 [B]
Golf Course Pond 3	**Habitat Loss**: Due to overprinting	3.35	Not applicable	3.35
WC-C	**Habitat Loss**: Due to overprinting	0.10	Not applicable	0.10
	Permanent Alteration: Flow reduction from pond A1 berm to Kenogamisis Lake	0.03	-84.7%	0.03

Table 11-13: Summary of Permanent Alteration and Loss of Fish Habitat to be Offset

Waterbody Name	Effect	Area Affected (ha)	% change in flow	Offset Requirement [A] (ha)
WC-D	**Habitat Loss**: Within the area of the open pit and the highway re-alignment	0.18	Not applicable	0.18
	Permanent Alteration: Flow reduction from the re-aligned Highway 11 to Kenogamisis Lake	0.03	-70.0%	0.02
WC-F	**Permanent Alteration**: Flow reduction due to reduced drainage area	0.02	-43.6%	0.01
WC-G	**Habitat Loss**: Due to overprinting	0.03	Not applicable	0.03
	Permanent Alteration: Flow reduction from WRSA C to the Southwest Arm Tributary	0.03	-61.0%	0.02
WC-I	**Permanent Alteration**: Flow reduction due to reduced drainage area	0.01	-80.0%	0.01
WC-M	**Permanent Alteration**: Flow reduction due to reduced drainage area	0.27	-17.0%	0.05
WC-O	**Habitat Loss**: Due to overprinting	0.04	Not applicable	0.04
	Permanent Alteration: Flow reduction due to reduced drainage area	0.02	-99.0%	0.02
WC-Z	**Permanent Alteration:** Flow reduction due to reduced drainage area	0.01	-90.7%	0.01
			TOTAL AREA	6.58

NOTES:

A Flow changes above 15% will be offset based on proportion of watershed affected (the Offset Requirement is the product of area affected and the flow reduction) and 100% of the area affected will be offset for areas with > 85 % flow reduction.

B Golf Course Pond 2, although populated by minnow species, is an entirely artificial pond constructed for irrigation purposes and is not connected to a fishery. As such, it is not protected under the Fisheries Act. Notwithstanding this, the proposed offset measures are sufficient to account for the lost area.

More than 50% of the areas requiring offsetting are human-made or degraded aquatic systems (i.e., Golf Course Pond 3, Watercourse C, Highway 11 ditching). Residual effects are categorized as either loss of habitat (e.g., infilling) or permanent alteration (e.g., change in flow). Where habitat loss occurs, 100% of the affected area will require offsetting. Where flow reduction occurs, a percentage of the affected habitat will require offsetting, relative to the flow reduction.

Extensive monitoring and modeling has occurred to predict changes in flow associated with the diversion of Goldfield Creek. For smaller intermittent and ephemeral watercourses, a simple method of estimating flow reduction was used, whereby anticipated change in flow is assumed to reflect the change in watershed area. For example, a watershed reduced in size by 25% is assumed to have a corresponding 25% reduction in flow. This approach was taken, given the inability to accurately measure ephemeral flow in low gradient, low volume wetland drainage features and given the low sensitivity of fisheries resources in these systems (i.e., WC-C, WC-D, WC-F, WC-G, WC-I, WC-M, WC-O, and WC-Z).

The *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* recognizes that increasing alteration to natural flow conditions on a cumulative basis will increase the probability of degradation to ecosystems that sustain fisheries (DFO 2013a). As a general guideline, the framework suggests that cumulative flow alterations of less than +/- 10% of actual (instantaneous) flow in a river relative to the natural flow regime, and variations thereof, have a low probability of detectable negative effects to the associated ecosystem. The framework also suggests that cumulative flow alterations that reduce instantaneous flows to less than 30% of mean annual discharge have a heightened risk of adverse effects to ecosystems that support fisheries.

In 2011, Alberta Environment released an independent report entitled *A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams* (Locke et. al. 2011). The report was written under the direction of the Alberta Instream Flow Needs Steering Committee, which included members from Alberta Environment, Alberta Sustainable Resource Development, and DFO. The method was based on a review of the findings from Canadian and international studies on instream flow needs. This method identifies a threshold of 15% instantaneous reduction from natural flow as the most conservative flow recommendation to protect the aquatic ecosystems.

In considering Project-related alterations to flow regimes of the low sensitivity watercourses resulting from catchment removal or loss, a threshold value of 15% reduction was chosen. Changes in flow of less than 15% are not anticipated to require offsetting and standard stream flow measurement techniques can not accurately measure flow within 15%.

The following section describes the specific areas and mechanisms that are predicted to result in the residual loss of habitat and permanent alteration of fish habitat prior to offsetting.

Goldfield Creek

Goldfield Creek habitat will be lost, from the Goldfield Creek diversion dam upstream of the TMF to the downstream containment berm at pond T1. This area (2.10 ha) is not known to provide critical spawning habitat for game or sustenance species. Although fish are not known to migrate between Kenogamisis Lake and Goldfield Lake, the new channel will maintain existing fish passage conditions between these two water bodies.

There will be a 99% reduction in stream flow between the downstream-most pond T1 berm and the confluence with Goldfield Creek Tributary. This area provides potential spawning habitat for Northern Pike and a feeding area for game and sustenance species from Kenogamisis Lake. Fish habitat in this section of Goldfield Creek may continue to function for several years, but may infill naturally over time due to vegetation encroachment and detritus deposition. This section of Goldfield Creek (0.34 ha) will be offset.

There will be a 71% reduction in stream flow between the confluence with Goldfield Creek Tributary and Kenogamisis Lake. Based on a wetted width of 20 m and a length of 192 m, approximately 0.38 ha of fish habitat will be affected by flow reduction in this area. Due to the low gradient and cross sectional channel profile (i.e., u-shaped channel), reductions in wetted area are not anticipated. Habitat is anticipated to be permanently altered in this area primarily by a change (reduction) in water velocity. This will be offset by creating approximately 0.27 ha of new habitat (0.38 ha affected x 71% flow reduction).

Offsetting will account for 2.10 ha of lost habitat and 0.61 ha of altered habitat in Goldfield Creek.

Watercourse C (WC-C)

Approximately 85% of the drainage area of WC-C will be infilled and graded in association with the Highway 11 realignment, removal of a portion of historical MacLeod tailings, and overburden storage. This will result in overprinting of 0.10 ha of fish habitat and a reduction of flow to WC-C downstream of the infilled area. The area affected by flow reduction is approximately 0.03 ha, and provides seasonal habitat for White Sucker, Brook Stickleback and a few species of cyprinids. Since flow reduction is estimated to be 85%, 100% of the habitat affected by flow reduction (0.03 ha) will be offset.

Watercourse D (WC-D)

Watercourse D is a highway ditch that will be realigned with the new Highway 11. WC-D provides poor quality habitat for low densities of Brook Stickleback. The new Highway 11 ditch will be designed to promote drainage and to comply with highway design traffic safety standards. Although fish may inhabit highway ditches occasionally, the new ditch will not be designed to promote fish use. Rather, the lost habitat (0.18 ha) or altered habitat (0.03 ha, due to 70% flow reduction) will be offset through creation of new habitat in the Goldfield Creek diversion.

Watercourse F (WC-F)

Approximately 44% of the drainage area of WC-F will be within the footprint of WRSA C, which will result in a reduction in flow to WC-F. Approximately 0.02 ha of wetted area will be affected by flow reduction and will be offset. Brook Stickleback were present in the lower end of WC-F, within the high water mark of Mosher Lake. Fish do not inhabit the area that will be overprinted by the WRSA.

Watercourse G (WC-G)

Approximately 0.03 ha of fish habitat in WC-G will be overprinted by WRSA C. Approximately 61% of the drainage area of WC-G will be within the footprint of WRSA C, which will result in a flow reduction to the lower reach of WC-G. The area affected by overprinting and flow reduction provides ephemeral habitat for low densities of Brook Stickleback.

Watercourse I (WC-I)

Approximately 80% of the drainage area of WC-I will be within the footprint of WRSA-A. The resulting reduction in flow to fish habitat downstream of the WRSA will cause a permanent alteration of fish habitat (approximately 0.01 ha) and provides habitat for low densities of Brook Stickleback. Watercourse I is an ephemeral drainage ditch adjacent to Highway 11 and the MTO Patrol Yard and fish do not inhabit the area that will be overprinted by WRSA-A.

Watercourse M (WC-M)

Approximately 17% of the drainage area of WC-M will be within the footprint of the TMF, WRSA D, and contingency WRSA D, which will result in a flow reduction to WC-M (approximately 0.2 ha). The watercourse provides habitat for Brook Stickleback and Northern Pike.

Watercourse O (WC-O)

Approximately 0.04 ha of fish habitat in WC-O will be overprinted by WRSA D. Approximately 99% of the drainage area of WC-G will be within the footprint of the TMF, WRSA D, and contingency WRSA D. This will result in a flow reduction to the lower reach of WC-O, affecting 0.01 ha of downstream fish habitat that currently provides habitat for low densities of Brook Stickleback.

Watercourse Z (WC-Z)

Approximately 91% of the drainage area of WC-Z will be within the footprint of the TMF. The resulting reduction in flow to fish habitat downstream of the WRSA will cause a permanent alteration of fish habitat (approximately 0.01 ha). Low densities of Brook Stickleback and a single juvenile White Sucker have been captured in WC-Z, near the confluence with Kenogamisis Lake.

Operation

Permanent alteration of fish habitat may occur through release of treated effluent into the Southwest Arm of Kenogamisis Lake through the co-discharge of treated STP and ETP effluent. Dewatering of the open pit will also result in less groundwater flow into the Southwest Arm Tributary, which has the potential to affect fish habitat.

Potential sub-lethal toxicity effects on fish, related to metals and cyanide, are assessed in Section 11.4.2 and that discussion is also relevant to other aquatic biota (phytoplankton, macrophytes, zooplankton, benthic macroinvertebrates) that comprise the aquatic food web and provide fish habitat and food supply. This is because the water quality guidelines are designed to protect the most sensitive aquatic species. The 5 µg/L CWQG-FAL and Interim PWQO was set to protect algae, which were the most sensitive species identified in toxicity tests used to establish the guideline: an EC50 of 50 µg/L for growth was reported in a 14-day test using the green alga *Scenedesmus obliquus*, and a ten-fold safety factor was used to develop the CWQG-FAL of 5 µg/L (CCME 2001). Toxicity endpoints for invertebrates are several times higher, similar to those for fish. Within the mixing zone for arsenic, concentrations will decrease from 100 µg/L in effluent to 20 µg/L within 30 m of the discharge point (Table 11-10). Within that distance, concentrations will be higher than 50 µg/L, suggesting that under the worst-case scenario modelled, there is potential for sub-lethal effects on phytoplankton, which is considered component of fish habitat.

There is low potential for adverse effects on phytoplankton that would lead to further effects on aquatic habitat that supports fish. Predicted arsenic concentrations for the Southwest Arm are lower than currently observed in Barton Bay, related to historical mining operations (maximum of 121 µg/L, mean of 44.5 µg/L) as described in Chapter 10.0 (surface water VC; Table 10-23). The metal bioavailability study (Metal Bioavailability TDR, Appendix F7) did not identify recognizable adverse effects on the phytoplankton, benthic invertebrates, and fish populations studied in Barton Bay or the Central Basin compared to unaffected basins of the lake. This includes primary productivity (chlorophyll *a* concentrations), structure of the benthic community, chronic toxicity tests with water and sediment, and bioaccumulation of metals in benthic invertebrate and fish tissue. Also, the 2016 toxicity tests using the green alga *Pseudokirchneriella subcapitata* and lake water from the Southwest Arm, Barton Bay, Central Basin, and Outlet Arm indicated no sub-lethal toxicity, even at the elevated arsenic concentrations measured in Barton Bay (up to 121 µg/L). Given that similar concentrations have not affected chlorophyll-a in Barton Bay or growth of algae in laboratory toxicity tests, it is expected that potential effects on primary producers will be of small magnitude and occur within a small portion of the mixing zone (i.e., less than 30 m radius in a conservative scenario), should they occur.

Potential eutrophication effects related to phosphorus discharges from sanitary wastewater are discussed below, as these may contribute to permanent alteration in fish habitat. Ammonia and nitrate releases (from blasting residues and sanitary wastewater) will be potential sources of nitrogen to the Southwest Arm. Contact water from WRSAs will be collected and treated prior to release and sanitary effluent will also be treated prior to release.

Effluent will be treated and will meet applicable ECA effluent discharge limits. Outside of the mixing zones corresponding to each parameter, nitrate, ammonia, and total phosphorus concentrations will meet the PWQOs, Interim PWQOs, or CWQG-FAL. Within the effluent mixing zone in the Southwest Arm, nutrient concentrations will be higher than these guidelines, which could stimulate growth of algae and lead to localized alteration of fish habitat, including a decrease in dissolved oxygen levels when algae decompose. Measurable changes to fish and fish habitat are not anticipated beyond the mixing zone.

Baseline total phosphorus concentrations (2014-2016 data) in the Southwest Arm of Kenogamisis Lake increase between Station 1A at the inflow to the basin (mean of 8.5 µg/L and 75th percentile of 10.8 µg/L; oligotrophic) and Station 1 near the treated effluent discharge location (mean of 10.6 µg/L and 75th percentile of 13.0 µg/L; borderline mesotrophic). Baseline phosphorus concentrations are below the Interim PWQO of 20 µg/L. A baseline total phosphorus concentration of 8.6 µg/L used to model project effects) in the Southwest Arm was developed using a mass balance calculation for data collected at Stations 1, 1A, 23, 24 and 46 as described in Table 10-30, Chapter 10.0 (surface water VC) and the Baseline Report – Surface Water Quality (Appendix E4).

Concentrations of phosphorus are predicted to increase during operation due to discharge of phosphorus associated with the treated sewage effluent (1,000 µg/L at 0.00086 m^3/s). Treated sewage effluent comprises less than 1% of the maximum combined effluent flow rate (0.141 m^3/s). ETP treated effluent is not expected to contain appreciable phosphorus (reported values reflect elevated detection limits used in groundwater analysis). Under worst-case flow conditions (i.e., maximum effluent flow rate during a low flow scenario), the RMA4 model predicts a 55 m long mixing zone to meet the Interim PWQO of 20 µg/L (Section 5.3.5 of the Assimilative Capacity TDR; Appendix F6). The mixing zone will be smaller for a normal climate year and for lower effluent flow rates, and is likely an overestimate, given the conservatism used to model the mixing zone (Section 11.4.2.3). On a mass balance basis for the Southwest Arm, total phosphorus is estimated increase 3%, from 9.9 µg/L at baseline to 10.2 µg/L during operation as described in Table 10-43 of Chapter 10.0 (surface water VC).

The 3% increase in mean total phosphorus concentrations could result in a slight shift in trophic status, from oligotrophic to borderline mesotrophic in the Southwest Arm during operation. The Interim PWQO is two-tiered, with the objective of 20 µg/L (average ice-free total phosphorus concentration) intended to prevent nuisance growth of algae in lakes and a second objective of 10 µg/L or less (average ice-free concentration) developed to provide a high level of protection against aesthetic deterioration for lakes naturally below this level (Ministry of Environment and Energy 1994). The conservatively predicted change in total phosphorus concentrations (to 10 µg/L throughout the Southwest Arm) would remain within the lower tier of the Interim PWQO.

Further guidance is provided in the Lakeshore Capacity Assessment Handbook (Ministry of the Environment, Ministry of Natural Resources, and Ministry of Municipal Affairs and Housing 2010). The Handbook describes the approach developed for predicting changes in trophic conditions and potential for eutrophication in Ontario lakes on the Precambrian Shield and is a planning tool for shoreline land development. The Handbook defines trophic status as oligotrophic (low in nutrients and productivity, less than 10 µg/L total phosphorus), mesotrophic (moderately nutrient enriched and moderately productive, 10 to 20 µg/L), and eutrophic (nutrient-enriched and high in productivity, greater than 20 µg/L). This document recommends using a maximum increase of up to 50% in total phosphorus concentration (compared to modelled baseline in the absence of human influence) for oligotrophic and mesotrophic lakes to avoid eutrophication.

Baseline total phosphorus concentrations (in the absence of human influence) were estimated using data from Station 1A, at the inlet of the Southwest Arm (annual mean of 8.5 µg/L, ice-free season mean of 9.3 µg/L). This is considered an appropriate approach given the low level of human development in the Kenogamisis Lake watershed upstream of the Southwest Arm, and the lack of permanent residences, cottages, resorts, or campsites on the Southwest Arm shoreline that could be a phosphorus source. Also, the lakeshore capacity model was calibrated for lakes deep enough to stratify thermally; in this model, shallow lakes (less than 5 m) often do not accurately predict the total phosphorus concentrations. This is likely the case for the shallow Southwest Arm. Higher mean baseline total phosphorus concentrations measured at stations within the lake basin (e.g., mean ice-free season values of 12 to 12.5 µg/L at Stations 1, 23, and 24) reflect other nutrient sources (e.g., runoff in the subwatershed, nutrient inputs via Southwest Arm Tributary related to historical mine activities) and in-lake nutrient cycling processes. Assuming the baseline ice-free season mean of 9.3 µg/L for Station 1A (lake inlet) reflects the absence of human activities, a 50% increase (the threshold recommended by the Lakeshore Capacity Assessment Handbook) would be 14.0 µg/L, which is higher than the 10.2 µg/L predicted by the water quality model described in Chapter 10.0, Table 10.43 (surface water VC).

Predicted total phosphorus concentrations during operation meet the Interim PWQO and the eutrophication threshold identified by the Lakeshore Capacity Assessment Handbook, and are at the interface between the oligotrophic and mesotrophic categories defined in the Handbook. Within a 55 m long effluent mixing zone, total phosphorus concentrations greater than 20 µg/L could lead to localized eutrophic responses (higher phytoplankton biomass).

Increased nitrogen levels will likely stimulate algal growth in the Southwest Arm to an extent controlled by both nitrogen and phosphorus. With the increase in both nutrients, there would likely be a shift in the limiting nutrient from nitrogen to phosphorus during operation.

Slight changes in nutrient levels are not anticipated to adversely influence fish communities because most fish species known to inhabit Kenogamisis Lake are typical of mesotrophic habitats. Walleye are generally most abundant in lakes or lake basins classified as mesotrophic (Regier et al. 1969, Kitchell et al. 1977, Leach et al. 1977, Schupp 1978, McMahon et al. 1984).

The mean total phosphorus concentration in Minnesota lakes containing Northern Pike in association with Walleye and Yellow Perch was 34 µg/L, compared to 20 µg/L for Lake Trout-Cisco (*Coregonus artedi*) lakes, 58 µg/L for Bass-Panfish lakes, and 126 µg/L for "rough fish" lakes. Lakes in which Northern Pike accounted for a significant fraction of the fish population typically had total phosphorus levels of 100 µg/L (Moyle 1956, Inskip 1982). Lake Whitefish and Cisco may be the most sensitive species to changes in nutrient concentrations; however, the anticipated changes in nutrient concentration are small (an increase of 3%), limited to a small area of the Southwest Arm and within known habitat suitability for the species present (meeting the Interim PWQO of 20 µg/L within 55 m of the treated effluent discharge).

Changes in biomass and dissolved oxygen concentrations are not predicted outside the mixing zone, since the nutrient levels in the water column will decrease rapidly with distance from the treated effluent discharge location.

The potential thermal effects of treated effluent on Kenogamisis Lake were estimated using a series of volumetric and energy balance equations (Appendix F12 - Assessment of Potential Thermal Effect of ETP Discharge on the Southwest Arm of Kenogamisis Lake). The results showed that the temperature differential between the treated effluent and the receiving environment throughout most of the year is minimal (i.e., within 2°C). Under conservative estimations of temperature and discharge volumes, a potential temperature differential of 9.1°C may occur at the treated effluent discharge location during the summer, with treated effluent being cooler than the receiving environment. Potential thermal effects are typically associated with increased temperature, whereas, in this case, treated effluent is anticipated to be cooler and within the applicable guideline of a 10°C differential (MOECC 1994). The treated effluent temperature will equilibrate with ambient temperature (to within 2°C) within approximately 37 m of the treated effluent discharge location. Fish may be attracted to or avoid this area in the summer due to temperature differential in a warmer than usual ambient lake temperature scenario (i.e., effluent is 7.8 °C lower than ambient lake temperatures during summer). However, given the small size of the thermal mixing zone, and given that habitat within the mixing zone is typical within the lake, it is unlikely that avoidance of the mixing zone would substantially change the diversity, distribution and abundance of aquatic animal life in Kenogamisis Lake. Furthermore, temperature changes within the thermal mixing zone are not anticipated to occur rapidly, due to the long attenuation times in pond M1. Therefore, fish will not be subject to sudden changes in temperature. Predicted changes are within applicable guidelines and are therefore not anticipated to cause an adverse effect on fish or fish habitat.

Over the life of the Project, a small decrease in sediment arsenic concentrations (from a simulated maximum baseline value of 26 mg/kg to a predicted concentration of 13 mg/kg) has been modelled for the Southwest Arm. This decrease will still result in concentrations above the ISQG and LEL, but will be below currently observed levels in Barton Bay and the Central Basin. The RMA4 model for water quality predictions in the mixing zone includes a 0.02 removal rate (2% per year) for arsenic and other metals from the water column to the sediment. It is assumed that metals settle to the sediment and accumulate over time, as a result of adsorption, sedimentation, and bioaccumulation as described in Section 10.4.1.2 of Chapter 10.0 (surface water VC). The 2013 and 2014 sediment data (Metal Bioavailability TDR, Appendix F7) indicate that baseline arsenic concentrations are low in the Southwest Arm (6.1 to 26.7 mg/kg) compared to west Barton Bay (100 to 159 mg/kg), east Barton Bay (232 to 1,250 mg/kg), and the Central Basin (67 to 380 mg/kg). Concentrations are higher than the CCME interim sediment quality guideline (ISQG; 5.9 mg/kg) and provincial lowest effect level (LEL; 6 mg/kg) in the Southwest Arm, reflecting naturally elevated arsenic concentrations in the Kenogamisis Lake watershed and some historical mining effects near Southwest Arm Tributary. Concentrations in Barton Bay and the Central Basin are higher than the CCME probable effects level (PEL; 17 mg/kg) and provincial severe effect level (SEL; 33 mg/kg), reflecting the influence of historical mining activities in those basins. Sediment-water interactions were modelled using STELLA, as described in Appendix F13 (Mass Balance Modelling of Arsenic in Water and Sediment of Kenogamisis Lake, Geraldon, Ontario). No adverse effects on aquatic biota are expected for the Southwest Arm, given that the higher sediment (and water) concentrations in Barton Bay and Central Basin do not currently appear to result in adverse effects on the aquatic endpoints studied (Metal Bioavailability TDR, Appendix F7). Fluctuations in sediment concentrations over time are also predicted for Barton Bay, the Central Basin, and Outlet Basin, related to removal of portions of the historical MacLeod and Hardrock tailings to the TMF.

Predicted changes to flow in the Southwest Arm Tributary were modeled to address concerns about reductions in groundwater discharge affecting fish habitat. The model predicted a 39 m^3/day (0.00045 m^3/s) reduction in groundwater discharge to the Southwest Arm Tributary, which considers effects related to drawdown related to the open pit dewatering as well as increases in recharge to WRSAs B, C, and D that are located in the vicinity of the Southwest Arm Tributary. This reduction in baseflow is very small and does not consider the increased surface flow within the Southwest Arm Tributary due to the Goldfield Creek diversion. In Chapter 10.0 (surface water VC), it is estimated that the mean annual flow in the Southwest Arm Tributary will increase from 0.128 m^3/s (baseline conditions) to 0.346 m^3/s during operation and to 0.414 m^3/s under post-closure conditions. In comparison, the baseflow reduction noted above is less than 0.1% of the total flow under operation and is not considered a measurable effect on flows within the tributary or changes to the fresh water flow into the Southwest Arm of Kenogamisis Lake. This minor reduction in groundwater contribution is not anticipated to have a discernable effect on water temperature or dissolved oxygen capacity in the Southwest Arm Tributary. Furthermore, the fish community known to reside in the Southwest Arm Tributary is not dependent on groundwater upwelling to carry out critical life processes (i.e., spawning, feeding, rearing).

Runoff and seepage collected from the portion of WRSA C footprint will reduce the effective contributing catchment area for Mosher Lake from 3.5 km^2 (baseline) to 3.4 km^2 (operation). The dewatering of the open pit and underground workings is predicted to reduce groundwater discharge to Mosher Lake from 0.014 m^3/s to 0.007 m^3/s as described in Chapter 9.0 (groundwater VC). As a result, the mean annual flow from Mosher Lake is predicted to be reduced from 0.025 m^3/s (baseline) to 0.016 m^3/s (operation). Based on lake bathymetry, the estimated surface water level changes in Mosher Lake would be approximately 0.15 m and the mean surface area of the lake could decrease by approximately 1%. However, water level changes in Mosher Lake are likely controlled by the outlet elevation, and less so by the mean annual inflow. Although water levels may be reduced during extended periods of hot, dry weather, when evaporation is a more significant factor, the anticipated changes are expected to be minor, limited to the operation period, within the natural variation of lake levels, and have no measurable effect on fish.

Permanent alteration of fish habitat could occur through changes in bank composition and stability, sedimentation, and changes in lake nutrients and PoPCs. The Kenogamisis Lake shoreline adjacent to eastern extension is stable, gently sloping and covered in a mixture of vegetation including trees, shrubs, and grasses. Changes in bank stability are not predicted to occur because of blasting. Although dust born nutrients and PoPC are likely to enter Kenogamisis Lake near the eastern extension, potential effects can be reduced through standard mitigation identified in Table 11-9 (mitigation item #21), Chapter 10.0 (surface water VC) and Chapter 7.0 (atmospheric environment VC). Since blasting will not occur in fish habitat, and blasting will be modified to limit peak particle velocities and instantaneous pressure change where fish habitat is present, this activity is not anticipated to result in the permanent alteration of fish habitat.

The eastern extension of the open pit comes close to Kenogamisis Lake. Due to the low topography in this area and limited vertical resolution of the LIDAR data, detailed surveying is required to confirm the proximity of the eastern extension to Kenogamisis Lake. Detailed surveying and engineering will be carried out in this area to avoid effects on Kenogamisis Lake. If it is determined that offsetting is required, there is capacity within the Offset Plan (Appendix F10) to account for potential project encroachments into the high-water mark in this area.

Closure

Runoff from the TMF and WRSAs will occur through the closure phase. Nutrient concentrations generated from the Project will be lower during closure than during operation. Since no blasting or gold extraction will take place, the only nutrient sources in effluent will be those remaining in the TMF and WRSA, which will decrease over time. The STP and ETP will be decommissioned when no longer required. The mean total phosphorus concentration is predicted to be 10.4 µg/L for the Southwest Arm during closure, compared to 9.9 µg/L for baseline as described in Table 10-43 of Chapter 10.0 (surface water VC). Water management mitigation measures will include, where feasible, contouring, covers and revegetation to reduce infiltration through WRSA and promote surface runoff. These rehabilitation measures, combined with cessation of production in the open pit and process plant, will reduce treated effluent discharge and PoPC concentrations such that alteration of fish habitat is not anticipated beyond the immediate vicinity of the PDA. Residual effects on fish habitat are predicted to be less pronounced than those experienced during operation, and adverse effects on fish communities are not anticipated on a lake-wide basis.

Summary of Residual Effects of Permanent Alteration of Fish Habitat

A summary of the assessment process for the permanent alteration of fish habitat, including appropriate mitigation measures, is provided in Table 11-14.

Physical changes in habitat, associated with flow reductions, introduction of sediment during construction, and culvert removal or installation, will be mitigated and habitat changes will be offset (Draft Fisheries Offset Plan, Appendix F10), resulting in no residual effects.

Residual effects are associated with release of treated effluent into the Southwest Arm during operation, given that the increased phosphorus concentrations have the potential to cause some nutrient enrichment. The residual effect is characterized as adverse in direction, low in magnitude (meeting water quality guidelines outside a small mixing zone, not affecting sustainability and productivity of CRA fisheries), within the LAA in extent (in a portion of the mixing zone), continuous in frequency, of medium duration (during operation), and reversible (at closure). For ecological and socio-economic characterization, the fish habitat is important to the functioning of an ecosystem and the fish community; however, it is typical as the fish species and habitat are common in the RAA.

Table 11-14: Summary of Residual Effects of Permanent Alteration of Fish Habitat During all Project Phases

Activity	Description	Mitigation Number (see Table 11-9)	Residual Effect
CONSTRUCTION			
Site Preparation (removal of existing buildings, removal of contaminated materials, vegetation clearing and earthworks)	Use of heavy equipment on land can lead to permanent alteration of fish habitat by altering bank stability and increasing erosion potential leading to a change in sediment concentrations	14, 27, 28, 29, 33	No residual effect anticipated (mitigated).
	Use of heavy equipment in the water can lead to the permanent alteration of fish habitat by: • direct disruption/compression of substrates and in-stream cover • Increasing erosion potential by disruption of natural substrates.	27, 28, 29, 33	No residual effect anticipated (mitigated).
	Vegetation clearing can lead to the permanent alteration of fish habitat by causing a change in habitat structure and cover, sediment concentrations, and food supply.	11, 13, 14, 33	No residual effect anticipated (mitigated).
	Removal of non-natural in-water structures such as existing culverts (e.g., at Goldfield Creek and WC-L) can lead to permanent alteration of fish habitat by mobilizing sediment and cover	4, 14, 15, 16, 17, 18, 20, 25, 33	No residual effect anticipated (mitigated).
Watercourse Crossings and Realignments	Use of heavy equipment on land can lead to permanent alteration of fish habitat by altering bank stability and increasing erosion potential, leading to a change in sediment concentrations	4, 11, 12, 13, 14, 15, 25, 26, 27, 28, 29, 33	No residual effect anticipated (mitigated).
	Use of explosives in and adjacent to water can lead to the permanent alteration of fish habitat by causing: • mobilization and deposition of sediments • a change in habitat structure and cover (e.g., aquatic vegetation and substrate characteristics)	21, 35, 36	No residual effect anticipated (mitigated).
	Placement of material or structures in water (e.g., culverts) can lead to the permanent alteration of fish habitat by replacing existing habitat or altering flow regimes.	4, 13, 20, 34, 11, 12, 14, 15, 16, 17, 18, 25, 26, 27, 28, 29, 31, 33, 35	No residual effect anticipated (mitigated and offset).
	Altering the volume, timing, duration or frequency of flow can lead to permanent alteration of fish habitat by altering food supply, bank vegetation, and shoreline/bank habitat and cover, and by scouring channel beds, eroding banks, and mobilizing sediment through shoreline/bank erosion.	18, 20, 31, 35	No residual effect anticipated (mitigated and offset).
Mine Components (open pit, WRSAs, water management and treatment facilities, TMF)	Use of explosives on land can lead to permanent alteration of fish habitat by altering shoreline and bank habitat, which may lead to a change in sediment concentrations and infilling of sediment interstitial spaces.	21, 36	No residual effect anticipated (mitigated)
	Dredging, as may be required to bury water intake and treated effluent discharge pipelines in the near shore area of Kenogamisis Lake, can lead to the permanent alteration of fish habitat.	12, 13, 14, 15, 16, 21, 22, 35	No residual effect anticipated (mitigated and offset).
	Placement of material or structures in water (e.g., water intake pipe and treated effluent discharge pipe) can lead to permanent alteration of fish habitat by replacing existing habitat or altering flow regimes.	4, 20, 12, 14, 15, 16, 17, 26, 27, 35	No residual effect anticipated (mitigated and offset).
	Treated effluent discharge can lead to a permanent alteration of fish habitat in Kenogamisis Lake by causing: • a change in water temperature • a change in DO • a change in nutrient concentrations leading to increased trophic level and associated periphyton growth in the Southwest Arm (Project sources of nutrients will include treated sewage effluent, blasting residues and breakdown of cyanide used in the gold extraction into ammonia) • a change in PoPC concentrations (e.g. elevated levels of arsenic may inhibit macrophyte growth, which provides cover for fish; or may inhibit phytoplankton growth causing a potential change in primary production) • accumulation of PoPC in lake sediments such that ecological functions of sediments are impaired • effects on aquatic plants that provide in-water structure and cover for fish deposition of suspended solids from treated effluent altering the ecological function and condition of lake sediments.	9, 22, 24	Residual effect remains with mitigation. There will be changes to water quality in Southwest Arm of Kenogamisis Lake. Although lethal or sub-lethal effects on fish will not occur, these changes may alter fish habitat by affecting nutrient concentrations, algae abundance and dissolved oxygen, on a small scale, which are considered elements of fish habitat.

Table 11-14: Summary of Residual Effects of Permanent Alteration of Fish Habitat During all Project Phases

Activity	Description	Mitigation Number (see Table 11-9)	Residual Effect
Linear Facilities (site roads, on-site pipelines and piping, power lines/transformer station, Highway 11 realignment)	TMF reclaim pipeline crossings of the new section of Goldfield Creek (old Southwest Arm Tributary) could lead to a change in bank structure and cover or sediment mobilization and deposition.	4, 11, 12, 13, 14, 15, 16, 17, 20, 25, 27, 28, 29, 33, 34	No residual effect anticipated (mitigated).
	Altering the volume, timing, duration or frequency of flow can lead to permanent alteration of fish habitat by altering food supply, bank vegetation, or shoreline/bank habitat and cover, and by scouring channel beds, eroding banks, and mobilizing sediment through shoreline/bank erosion.	18, 35	No residual effect anticipated (mitigated and offset).
	Placement of material or structures in water (e.g., culverts) can lead to permanent alteration of fish habitat by replacing existing habitat or altering flow regimes	4, 11, 12, 13, 14, 15, 16, 17, 18, 20, 25, 28, 29, 33, 34	No residual effect anticipated (mitigated).
OPERATION			
Water Management (contact water collection system, process water supply	Treated effluent discharge (ETP and STP) can lead to a permanent alteration of fish habitat in Kenogamisis Lake by causing: • a change in water temperature • a change in DO • a change in nutrient concentrations leading to increased trophic level and associated periphyton growth in the Southwest Arm (Project sources of nutrients will include treated sewage effluent, blasting residues and breakdown of cyanide used in the gold extraction into ammonia) • a change in PoPC concentrations (e.g. elevated levels of arsenic may inhibit macrophyte growth, which provides cover for fish; or may inhibit phytoplankton growth causing a potential change in primary production) • accumulation of PoPC in lake sediments such that ecological functions of sediments are impaired • effects on aquatic plants that provide in-water structure and cover for fish • deposition of suspended solids from treated effluent altering the ecological function and condition of lake sediments.	9, 22, 24	Residual effect remains with mitigation. There will be changes to water quality in Southwest Arm of Kenogamisis Lake. Although lethal or sub-lethal effects on fish will not occur, these changes may alter fish habitat by affecting nutrient concentrations, algae abundance and dissolved oxygen, on a small scale, which are considered elements of fish habitat.
	Water extraction can lead to permanent alteration of fish habitat through water table drawdown effects associated with open pit dewatering	18	No residual effect anticipated (mitigated).
	Maintenance of site roads, work areas, water crossings and water intake could lead to sedimentation of watercourses	4, 33	No residual effect anticipated (mitigated).
CLOSURE			
Decommissioning	Erosion and sedimentation caused by removal of culverts, water intake, and other components.	4, 14, 15, 16, 17, 18, 20, 25, 33	No residual effect anticipated (mitigated).
Rehabilitation (progressive rehabilitation, active closure rehabilitation)	Erosion and sedimentation caused by removal of culverts, water intake, and other components.	4, 14, 15, 16, 17, 18, 20, 25, 33	No residual effect anticipated (mitigated).
	Continued input of nutrients to Southwest Arm from the TMF, WRSA, and open pit.	9, 33	No residual effect anticipated (mitigated).
Post-Closure	Continued input of nutrients to Southwest Arm from the TMF, WRSA and, once the pit lake has filled, overflow water from the pit lake.	9, 33	No residual effect anticipated (mitigated).

11.4.4 Assessment of Loss of Fish Habitat

Changes that could lead to loss of fish habitat were evaluated by overlaying the Project footprint over the baseline conditions, incorporating information from Chapter 10.0 (surface water VC) and the Conceptual WMMP (Appendix M1) to make quantitative predictions of changes from baseline.

11.4.4.1 Project Mechanisms for Loss of Fish Habitat

The following sections describe the specific areas and mechanisms that, unmitigated, would result in loss of fish habitat. Project mechanisms for loss of fish habitat are categorized by Project phase.

Construction

Placement of material or structures in water can lead to loss of fish habitat by direct overprinting. Table 11-13 provides a description of Project mechanisms for the loss of fish habitat for individual watercourses.

Operation

No Project activities that result in loss of fish habitat have been identified during operation. Any loss of fish habitat would have occurred during the construction phase.

Closure

No Project activities that result in loss of fish habitat have been identified during closure. Any loss of fish habitat would have occurred during the construction phase.

11.4.4.2 Mitigation and Offsetting for Loss of Fish Habitat

For the purpose of the Final EIS/EA, residual effects are determined after mitigation and offsetting is applied. Table 11-9 presents measures to mitigate the loss of fish habitat, which includes mitigation through avoidance and project design. Loss of fish habitat that cannot be avoided will be addressed through the implementation of the Fish Habitat Offset Plan such that there are no residual effects on loss of fish habitat. A cautionary approach to offsetting has been taken, to account for uncertainty in predicting the loss of fisheries productivity. The Draft Fisheries Offset Plan (Appendix F10) describes proposed offsetting and aims for a net gain in fisheries productivity. The Draft Fish Habitat Offset Plan has been developed taking into account consultation and will be finalized with DFO through ongoing consultation. A final Fish Habitat Offset Plan will be developed and submitted for approval to DFO to support regulatory approvals. Table 11-13 provides a summary of where offsetting will be required for the loss of fish habitat.

11.4.4.3 Characterization of Residual Effects for Loss of Fish Habitat

With implementation of the Draft Fisheries Offset Plan (Appendix F10), no residual effects on fish habitat will occur as a result of loss of fish habitat. The majority of habitat loss will occur during the construction phase and the offsetting strategy will also be implemented during this time period. Losses are documented in Table 11-13, and will be offset as described in the Draft Fisheries Offset Plan (Appendix F10). No further habitat losses are identified for the operation and closure phases beyond those that will occur during construction.

A summary of the assessment process for the loss of fish habitat, including appropriate mitigation measures, is provided Table 11-15.

Table 11-15: Assessment of Residual Effects of Loss of Fish Habitat During all Project Phases

Activity	Undertaking	Mitigation Number (see Table 11-9)	Residual Effect
CONSTRUCTION			
Site Preparation (removal of existing buildings and contaminated materials, vegetation clearing and earthworks)	Placement of fill and structures in water can lead to the loss of fish habitat direct by directly overprinting.	35	No residual effect anticipated (mitigated and offset).
Watercourse Crossings and Goldfield Creek Diversion	Placement of fill and structures in water can lead to the loss of fish habitat direct by directly overprinting.	31, 35	No residual effect anticipated (mitigated and offset).
Mine Components (open pit, WRSAs, water management facilities, TMF)	Placement of fill and structures in water can lead to the loss of fish habitat direct by directly overprinting.	10, 35	No residual effect anticipated (mitigated and offset).
Linear Facilities (site roads, on-site pipelines and piping, power lines and substations, Highway 11 realignment)	Placement of fill and structures in water can lead to the loss of fish habitat direct by directly overprinting.	10, 31	No residual effect anticipated (mitigated and offset).
OPERATION			
Water Management (contact water collection system, process water supply)	Contact water collection system, process water supply	9, 10	No residual effect anticipated (mitigated).
CLOSURE			
-	-	-	-

NOTES:
Offset: no residual effect following offsetting
- not applicable

No residual effects for loss of habitat are identified for any Project phase, given that habitat losses will be offset (Draft Fisheries Offset Plan, Appendix F10).

11.4.5 Summary of Residual Environmental Effects on Fish and Fish Habitat

A summary of residual environmental effects that are likely to occur as a result of the Project is provided in Table 11-16.

Residual adverse effects are considered further in terms of their significance in Section 11.5 and are carried forward to the cumulative effects assessment (Chapter 20.0). A conceptual framework and scope for EMMPs, including follow-up and monitoring programs is provided in Chapter 23.0 (follow-up monitoring and environmental management plans). Conceptual EMMPs are also provided in Appendix M.

Table 11-16: Summary of Residual Environmental Effects on Fish and Fish Habitat

Residual Effect	Activity			Residual Environmental Effects Characterization							
	Construction	Operation	Closure	Direction	Magnitude	Geographic Extent	Timing	Frequency	Duration	Reversibility	Ecological and Socio-economic Context
LETHAL AND SUB-LETHAL EFFECTS ON FISH											
Sub-lethal effects on fish due to PoPC inputs from treated effluent and non-point sources.	✓	✓	✓	**Adverse**	**Low**	**LAA**	**N/A**	**Continuous**	**Medium-Term**	**Reversible**	**Typical**
				Direction: Adverse, in that discharge of treated effluent and non-point source contributions will result in localized, Project-related increases in concentrations of PoPCs to levels that could result in sub-lethal effects on fish. **Magnitude:** Low. Concentrations of PoPCs in the mixing zone will not be acutely lethal to fish. The magnitude of sub-lethal effects is considered low because, due to the geographic range of fish, long-term exposure is not anticipated, especially given the overall predictions of improved water quality on a lake-wide basis. Furthermore, baseline data from Barton Bay, where concentrations of arsenic are currently higher than those predicted for all other basins as a result of the Project, do not indicate adverse effects on fish or other aquatic species tested. Concentrations will be above applicable guidelines at some locations, but the sustainability and productivity of CRA fisheries will not be affected. **Geographic Extent:** LAA. PoPC concentrations from treated effluent discharge are expected to decrease rapidly within the mixing zone such that fish have limited exposure to the highest concentrations. Likewise, non-point sources of PoPCs would be localized (as demonstrated by the predicted improvements on a lake-wide basis). However, since fish are mobile, the geographic extent includes all Kenogamisis Lake and its tributaries within the LAA. **Timing:** N/A. Timing does not influence the overall effect. Point and non-point sources contributions of PoPC will occur year-round. **Frequency:** Continuous. Point and non-point sources contributions of PoPCs will occur continuously throughout construction, operation, and closure.							

Table 11-16: Summary of Residual Environmental Effects on Fish and Fish Habitat

<table>
<tr><th rowspan="2">Residual Effect</th><th colspan="3">Activity</th><th colspan="8">Residual Environmental Effects Characterization</th></tr>
<tr><th>Construction</th><th>Operation</th><th>Closure</th><th>Direction</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Frequency</th><th>Duration</th><th>Reversibility</th><th>Ecological and Socio-economic Context</th></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="8">Duration: Long-term. Contributions of PoPCs will occur through construction, operation, and closure.
Reversibility: Irreversible. The potential effect is considered irreversible because there may be localized exceedances of guidelines established for the protection of aquatic life that continue after active closure.
Ecological and Socio-economic Context: Typical. The fish species in the assessment area are common in the RAA.</td></tr>
<tr><td colspan="12">PERMANENT ALTERATION OF FISH HABITAT</td></tr>
<tr><td rowspan="2">Permanent alteration of fish habitat due to nutrient inputs from treated effluent and non-point sources.</td><td rowspan="2">✓</td><td rowspan="2">✓</td><td rowspan="2">-</td><td>Adverse</td><td>Low</td><td>LAA</td><td>Applicable</td><td>Continuous</td><td>Medium-term</td><td>Reversible</td><td>Typical</td></tr>
<tr><td colspan="8">Direction: Adverse. Total phosphorus and nitrogen concentrations will increase to levels higher than baseline as a result of treated effluent discharge and airborne particulate emissions from blasting, which can lead to impaired fish habitat through eutrophication.
Magnitude: Low. The alteration to fish habitat is predicted to be less than applicable guidelines, legislated requirements and/or federal and provincial management objectives. Predicted concentrations are lower than the Interim PWQO and the predicted 3% increase in total phosphorus for the Southwest Arm is smaller than that required to cause a change in trophic status, as defined in the Lakeshore Capacity Assessment Handbook. Effects on sustainability and productivity of CRA fish populations within the LAA are not anticipated.
Geographic Extent: LAA. It is expected that the alteration of fish habitat that occurs as a result of Project related nutrient input will occur within the LAA. The most notable change is related to phosphorus in the treated effluent discharge, which will meet the Interim PWQO of 20 µg/L within a 55 m mixing zone. Changes beyond the mixing zone and in other basins of the lake are not expected to be measurable with respect to fish habitat.</td></tr>
</table>

Table 11-16: Summary of Residual Environmental Effects on Fish and Fish Habitat

<table>
<tr><th rowspan="2">Residual Effect</th><th colspan="3">Activity</th><th colspan="8">Residual Environmental Effects Characterization</th></tr>
<tr><th>Construction</th><th>Operation</th><th>Closure</th><th>Direction</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Frequency</th><th>Duration</th><th>Reversibility</th><th>Ecological and Socio-economic Context</th></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="8">Timing: Applicable. Nutrient sources will be present throughout the year. The biological effect (increased phytoplankton growth) will occur during the open water season (May through October). Potential effects of reduced oxygen due to biological oxygen demand, if observable, would be most pronounced in mid-winter and mid-summer, during lake stratification.
Frequency: Continuous. Treated effluent containing nutrients will be discharged continuously during operation. Blasting will occur during construction and operation, occurring approximately five times per week during operation.
Duration: Medium-term. Nutrients will be discharged in treated effluent during operation. Blasting can contribute nitrogen through airborne particulate, in runoff including entrained and dissolved blasting residuals and will occur during construction and operation.
Reversibility: Reversible. The alteration of fish habitat that occurs as a result nutrient releases is likely to be reversed at the end of operation, when sources of nutrients (i.e., treated effluent discharge and blasting) are discontinued.
Ecological and Socio-economic Context: Typical. Affected habitats are common in the RAA.</td></tr>
<tr><td colspan="12">LOSS OF FISH HABITAT – no residual effects identified because lost habitat will be offset.</td></tr>
</table>

NOTES:
See Table 11-2 for detailed definitions.
✓ Residual effect anticipated.
– No residual effect anticipated.

11.5 DETERMINATION OF SIGNIFICANCE

Significant residual environmental effects (serious harm to fish) are those that affect the productivity and sustainability of a CRA fishery. Through avoidance, mitigation and offsetting, the residual effects of the Project on fish and fish habitat during all phases are considered not significant. Changes to fish sustainability and productivity are not anticipated.

11.6 PREDICTION CONFIDENCE

Predictions of residual environmental effects for the permanent alteration and loss of fish habitat can be made with a high degree of confidence. There is a high confidence in the understanding of fish habitat in lakes and watercourses of the LAA and in the ability of mitigation measures to be effective. There is moderate confidence in the ability to estimate the loss of fish habitat productivity; however, the change in productivity would be expected to be small, and is addressed by providing greater amounts of offset habitat than that lost or altered.

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11.7.2 Personal Communications

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