MISHIBISHU GOLD CORPORATION
MISHI PIT PROJECT

ENVIRONMENTAL BASELINE STUDY MACASSA CREEK WATERSHED

Submitted to:

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October 1997
TC 76166

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

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October 7, 1997
TC 76166

Mr. Jim Millard
Mishi Joint Venture
P.O. Box 87
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Re: Environmental Baseline Study for the Upper Watershed of Macassa Creek

Dear Mr. Millard:

AGRA Earth & Environmental Limited is pleased to provide you with three copies of the Environmental Baseline Study for the Mishi Pit Project.

If you have any comments or questions concerning the information contained in the enclosed document, please contact our office at your convenience.

Yours very truly,
AGRA Earth & Environmental Limited

Debbie Dyck, P.Eng.
Environmental Engineer

Encl.

2.17769

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1.0 INTRODUCTION

Mishibishu Gold Corporation (MGC), in a joint venture with MacMillan Gold Corporation, is proposing to proceed with an advanced exploration project, which entails the development of a small open pit gold deposit known as the Mishi #2 Zone (Mishi Pit Project). The property is owned by MGC, and is located in the Mishibishu Lake area, approximately 50 km northwest of Wawa, Ontario, and 20 km north of the Lake Superior shoreline (Project coordinates 48°06'N 85°27'W), (Figure 1).

Site exploration to date has consisted of geophysical surveys and surface diamond drilling. A small area was stripped of overburden between 1987 and 1990 during previous exploration activities, from which a 5,500 tonne bulk sample was obtained for metallurgical testing, however, no processing data are available. The proposed advanced exploration by MGC would occur in this same cleared area.

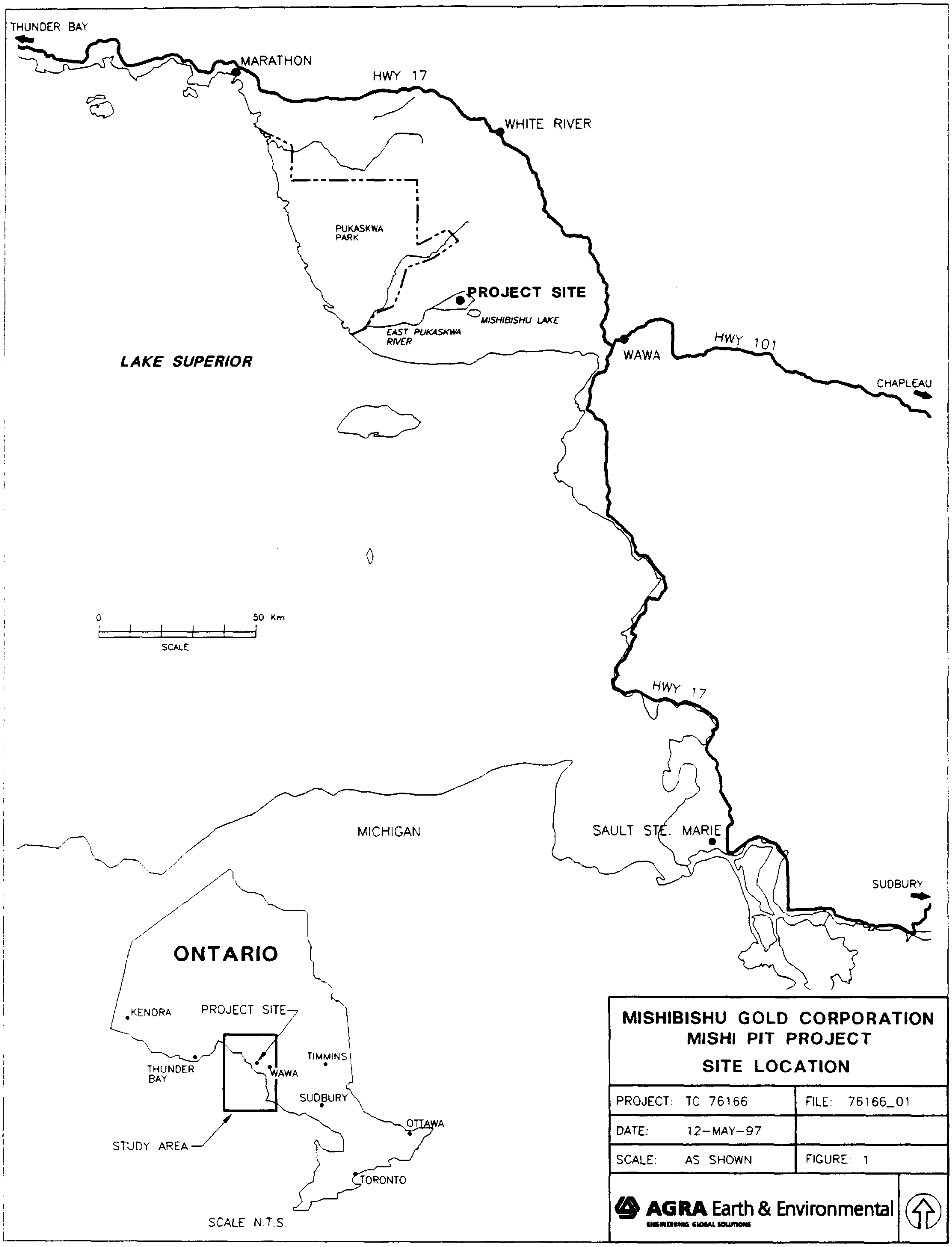
1.1 STUDY OBJECTIVES AND SCOPE

In order to proceed with Project development, beyond the exploratory surface diamond drilling phase, the Province of Ontario requires that pre-development environmental baseline conditions be defined for the site area. This includes consideration of both natural and human use features. Such requirements are embodied in the Ontario Mining Act, and less directly in the Ontario Water Resources Act and the Ontario Environmental Protection Act. The Federal Fisheries Act also includes regulations addressing the protection of fisheries and aquatic resources, and therefore defines a need for baseline data.

The Ontario Mining Act covers all phases of mineral exploration and development. One requirement of the Act is for the proponent to prepare a closure plan prior to undertaking advanced exploration or mine development (Part VII, Sections 141 and 142). Advanced exploration is defined as 'the excavation of an exploratory shaft, adit, or decline, the extraction of material in excess of the prescribed quantity (500 tonnes), the installation of a mill for test purposes, or any other prescribed work'.

The intent of the closure plan is to show how the proponent will restore the site to near natural conditions upon completion of all mining activities. As such, the Mining Act Regulations require the proponent to provide information on pre-development conditions. This information includes consideration of: site geology, physiography, climate, surface and groundwater hydrology, water quality, sediment and soil characteristics, plant communities, wildlife, fisheries and aquatic resources and land use.

The Ontario Water Resources Act, the Ontario Environmental Protection Act, and the Federal Fisheries Act are less specific in their requirements for baseline studies. All three Acts, and their associated regulations and guidelines, however, stipulate that relevant aspects of the natural and/or human use environments are to be protected against contamination and undue disturbance from industrial and other sources. In order to demonstrate compliance with these



MISHIBISHU GOLD CORPORATION
MISHI PIT PROJECT
SITE LOCATION

PROJECT: TC 76166	FILE: 76166_01
DATE: 12–MAY–97	
SCALE: AS SHOWN	FIGURE: 1

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requirements, it is necessary to have accurate descriptions of pre-development environmental conditions.

In addition, environmental baseline data are needed to assist in Project planning. With respect to the Mishi Pit Project, planning would include consideration of requirements for: mining operations, waste rock disposal, waste water management, water supply, infrastructure development, and other functions. The purpose and objectives of this study are therefore to describe and analyse environmental baseline conditions associated with the Mishi Pit Project.

Limited environmental data were collected by AGRA (formerly the Environmental Applications Group Limited) during previous exploration activities on the Project property in 1988/89. To provide additional and supplemental information on current (baseline) site conditions, AGRA personnel conducted field investigations between June 17 and 20, 1997. The 1997 investigations included water, sediment and benthic invertebrate sampling, and electrofishing and minnow trapping to assess fisheries resources. An inventory of the aquatic habitat was also recorded during the June 1997 field investigations. Both sets of data are provided in this report and are discussed in more detail in the respective sections.

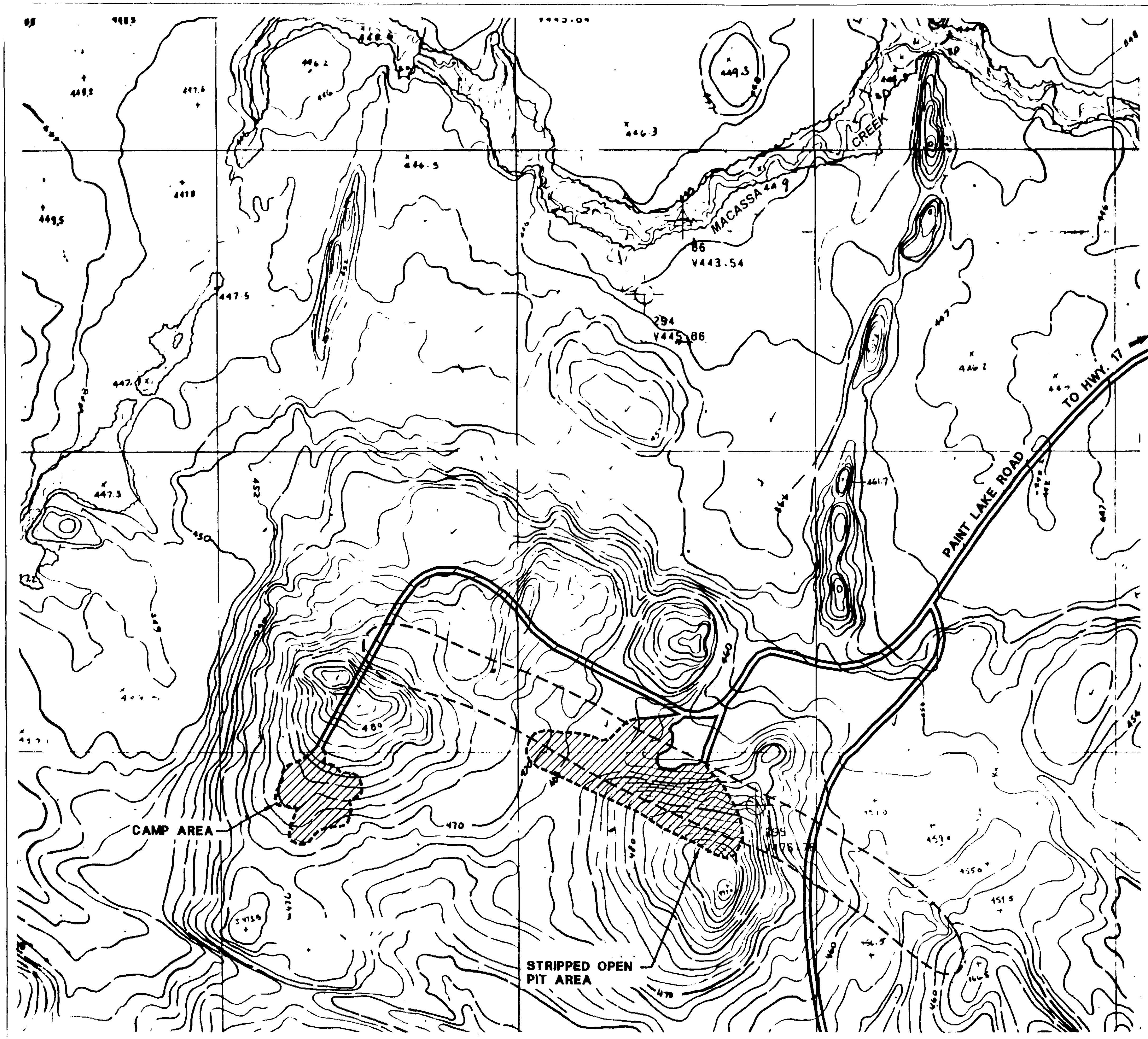
The baseline report is organized into two main sections, corresponding to physical and biological environments. The physical environment section addresses: climate, air quality and noise, bedrock geology, surficial geology and soils, surface water hydrology, surface water quality and sediment quality. Included in the biological section of the study are discussions of: vegetation communities, wildlife, fisheries and aquatic resources and benthic communities. The Project site is located in a remote, undeveloped area (with the exception of the Magnacon and Eagle River mine sites) and therefore, discussion of human use environments (including local communities, First Nation's interests, other land uses, area infrastructure, and heritage and archaeological resources) were not included within the scope of this document.

1.2 PROJECT DESCRIPTION

Access to the Project site is provided by an existing 52 km long, all weather gravel road (Paint Lake Road) which extends south from Highway 17. The Project site currently consists of a site access road, which traverses westward along the north side of an existing clearing (stripped to bedrock) remaining from previous exploration activities. The access road than heads south to a second clearing, which had been previously used as a camp and laydown area. Two buildings (portable trailers) remain in this area. The existing Project site is shown in Figure 2.

The ore body is situated along a 1 km strike zone, trending in a northwest-southeast direction and overlaps the base of two rock knobs (Figure 2). The Project property consists of bedrock controlled topography including rock knobs, steep sided valleys, and moderate relief, ranging from 381 to 472 m ASL. Exposed bedrock is common in the area along ridge crests and valleys. Overburden in the immediate area consists primarily of poorly sorted silty/sand ground moraines, ranging in thickness from less than 1 m (on bedrock knobs) to 3 m, or more, (in lowland areas).

EXISTING PROJECT SITE
FIGURE 2



LEGEND

- APPROXIMATE AREA OF ORE BODY
- AREA OF SITE CURRENTLY CLEARED
- EXISTING ACCESS ROADS

0 100 200 300 400 500 m

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Surface diamond drilling at the Project site was conducted by Granges Exploration Limited (Granges) in the mid 1980's, which defined an estimated 772,000 tonnes of gold ore, grading approximately 3.3 g/t of gold. During previous advanced exploration activities by Granges, between 1987 and 1990, an area of approximately 3 ha was stripped and cleared to bedrock in order to extract a 5,500 tonne bulk sample for testing (process data are not available). Preliminary metallurgical testing of drill core samples was also carried out by Granges.

The advanced exploration activities, proposed by MGC, entail extracting a bulk sample of approximately 100,000 tonnes of ore, using open pit mining methods. The ore would subsequently be transported to an existing, fully permitted, mill facility for custom processing. As part of the proposed advanced exploration phase, a mine water settling pond will be constructed on site.

Results from milling of the bulk sample will be used to determine the feasibility of advancing the Project to a production phase, which would involve mining the reserve on a seasonal basis (three to five months per year) and stockpiling the ore for off site milling. If recoverable grades are not sufficient, then the operation would be abandoned after the advanced exploration phase.

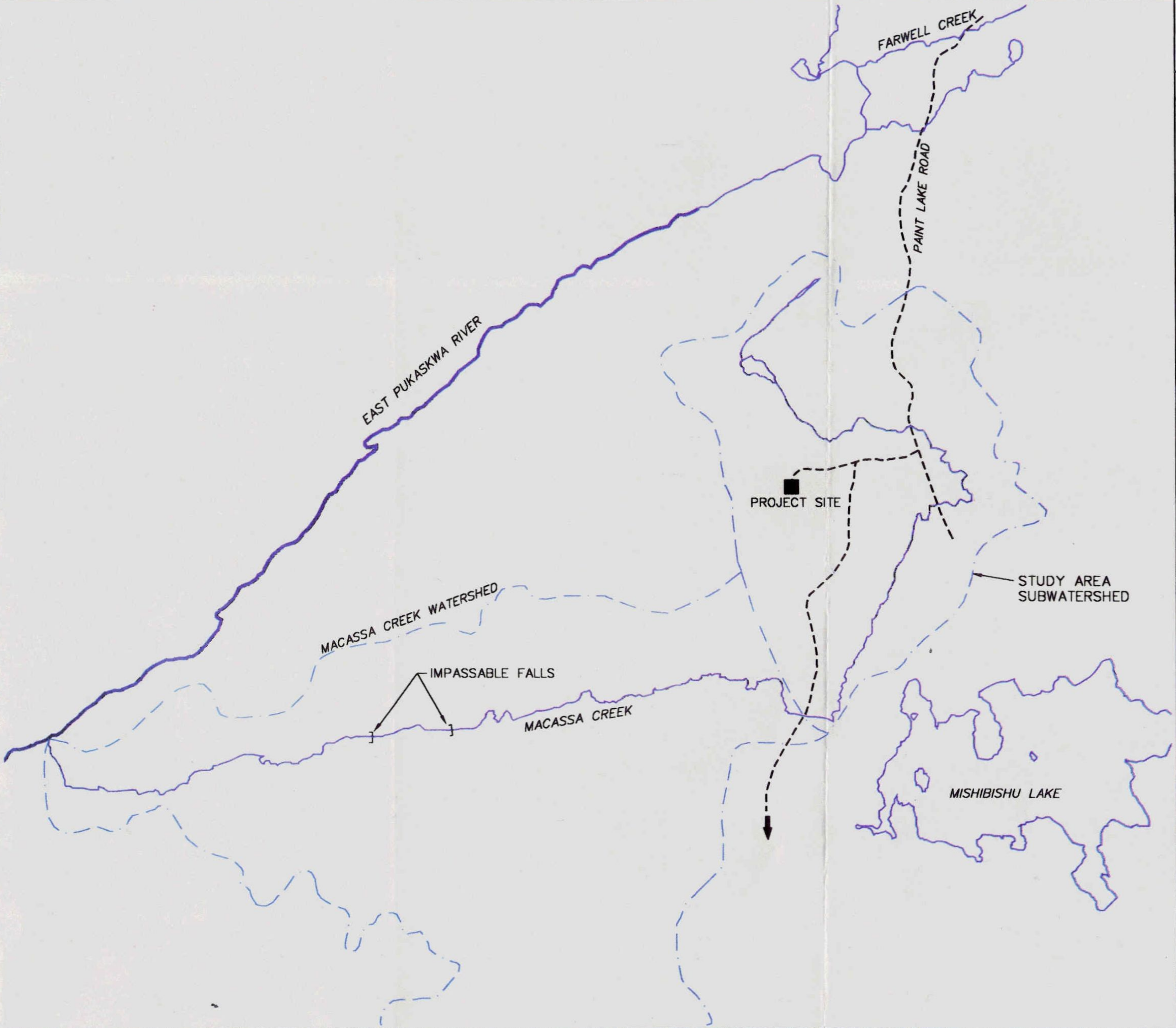
Based on the proposed infrastructure and operating parameters associated with the open pit operation, investigations of the surrounding environmental conditions were conducted in order to assess current site conditions and to determine any potential environmental impacts, related to Project development, which may require mitigation.

1.3 STUDY AREA DELINEATION

The area of study for baseline investigations focuses on the upper portion of the Macassa Creek watershed (Figure 3). The Macassa Creek watershed drains a total area of 68 km^2. The Project site and related infrastructure will be confined to the upper reaches of the creek drainage basin, which encompasses an area of approximately 23 km^2.

The Macassa Creek basin drains to the East Pukaskwa River, which has a watershed area of 276 km^2 at the confluence of the two watercourses. The East Pukaskwa River, in turn, flows into the Pukaskwa River, which drains south to Lake Superior. The confluence of the East Pukaskwa and the Pukaskwa Rivers is located within the Pukaskwa National Park Boundary, approximately 6 km north of the Lake Superior shoreline.

All potential developments associated with the Mishi Pit Project will be confined to the upper reaches of Macassa Creek, and therefore the focus of the environmental baseline study was limited to this portion of the watershed. All applicable environmental guidelines and regulations (i.e., with respect to water quality and aquatic resources) are expected to be achieved immediately downstream of the study area; investigations further downstream were therefore not considered to be necessary.



MACASSA CREEK WATERSHED AND BASELINE STUDY AREA

FIGURE 3

LEGEND

- PROJECT SITE
- ACCESS ROAD
- LAKES/CREEKS
- WATERSHED BOUNDARY

0 1000 2000 3000 4000 m

MISHIBISHU GOLD CORPORATION
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Focusing the study on watershed boundaries reflects recent environmental planning initiatives which are based on the ecosystem approach, with the watershed forming the primary ecosystem boundary (Ontario Ministry of Natural Resources [MNR], 1991; Ontario Ministry of the Environment [MOE], 1992; and Ontario Ministry of the Environment and Energy [MOEE], 1993. Ecosystems are defined as the summation of the biological and physical components of a given environment, and their interactions with one another. As such, the ecosystem approach describes not only the structural and chemical characteristics of the environment, but also the functional relationships between its various parts. The majority of these relationships are governed by the flow of surface and groundwater through the system, hence the choice of the watershed as the ecosystem boundary.

2.0 BACKGROUND

2.1 GENERAL SETTING

The Project site is located on the northeast shore of Lake Superior, 300 km east of Thunder Bay and 200 km northwest of Sault Ste. Marie, within the District of Thunder Bay. The Project site itself is located 20 km inland, in a remote area 3 km northwest of Mishibishu Lake. The closest community is Wawa, with an estimated population of 5,000. The Town of Wawa is located along Highway 17, approximately 50 km southeast of the Project site. Pukaskwa National Park is located 20 km west of the site.

The local landscape exhibits very rugged terrain typical of the Canadian Shield, with steep slopes, canyons, and rocky knolls and cliffs, which have developed as a result of glacial activity, bedrock faulting, and pre-glacial erosion. Most of the overburden in the region is characterized by unconsolidated deposits of sandy tills of varying thickness, deposited during the Quaternary glaciation period. In areas of high relief, overburden deposits are very thin, indicated by bedrock outcrops, while valleys and lake basins generally contain thicker overburden deposits. Numerous glaciofluvial outwash deposits exist in the region, as well as lacustrine deposits associated with the former shorelines of glacial Lake Superior.

The Project site lies within the Eastern Lake Superior subdivision of the Great Lakes - St. Lawrence Watershed (MNR, 1983), with area streams draining into Lake Superior. Watercourses are generally bedrock controlled, with water flowing along fractures or faults. Major changes in stream gradients are characterized by numerous rapids and waterfalls. Regional drainage in the Project area is generally provided by the Pukaskwa River and the Dog (University) River.

The Project area is located near the transition of the Boreal Forest and the Great Lakes - St. Lawrence Forest Regions (Rowe 1972), which contributes to a wide diversity of flora. The region consequently supports plant species which are common to northern, as well as more southern regions. Long-term vegetation community development is controlled by drainage and soil conditions. Short-term forest development is affected by logging and fire events. Forest communities in upland areas are generally dominated by jack pine, white birch, and poplar, while lowlands are dominated mainly by black spruce, white spruce, balsam fir, tamarack and eastern white cedar.

Local wildlife communities also exhibit a combination of Boreal and Great Lakes - St. Lawrence influences, with species diversity and abundance. The diversity and density of wildlife species typically increases with increasing structural complexity of forested habitats. Valley lands and riparian margins bordering lakes and rivers generally support the greatest number and diversity of wildlife species. Moose are the dominant ungulate species in the area, but white-tailed deer also occur. An isolated herd of woodland caribou are also present in the region, mainly within Pukaskwa National Park. Other wildlife species of note include black bear, wolves, lynx and beaver, as well as a variety of other furbearers and small mammals. Bird life is characterized by a moderately diverse avian community during the breeding and migratory periods, and by a sparse community during the winter, as most species are part of the continental migratory population.

Land uses in the region surrounding the Project site area include forestry, mining, commercial trapping, hunting fishing and recreational activities such as canoeing, snowmobiling, and cottaging. Pukaskwa National Park is located 20 km west of the site and supports a variety of recreational opportunities. Activities at the park include camping, picnicking, nature appreciation, hiking, fishing, and swimming.

Forestry operations are controlled through the issuing of "forest resource licences" and agreements with the licencees, whereby the province licences cutting rights to private companies. The major Crown timber licences in the area are held by Abitibi-Price Inc. and Dubreuil Brothers Ltd. (MNR, 1983). Forestry companies are responsible for the construction and maintenance of logging roads to provide access to cutting areas.

Compared with forestry, mining is a much more localized activity. Mining has been a principal industry of the region since the discovery of gold on Wawa Lake in 1897. This region contains the majority of the known and high potential economic mineralization in the Wawa area. The only active mining operation in the immediate vicinity of the Project site is the Eagle River Mine, located approximately 17 km south of the Project site, which currently supplies ore to the Magnacon mill (located 2 km east of the Project site).

2.2 SITE HISTORY

The Mishi Property has been the focus of extensive mineral exploration activities since 1982, when the property was first staked and recorded. Initial exploration work conducted on the Mishi Main Zone, which is the target for the proposed advanced exploration program, was part of a 50/50 joint venture between Granges Exploration Limited and MacMillan Gold Corporation, with Granges as the operator.

Extensive exploration activities were conducted on the Main Zone between 1987 and 1990 and included: soil geochemical surveying; diamond and percussion drilling; stripping, channel sampling, and detailed mapping; as well as the extraction, crushing, and stockpiling of a small (5,500 tonne) bulk sample. Limited metallurgical and environmental work was conducted on composite samples collected from the crushed ore stockpile during this period.

No work has been conducted on the Mishi Main Zone since 1990. The bulk sample stockpile was sold to River Gold Mines Ltd. in 1996, and was processed at the Magnacon mill. Records for processing of the bulk sample are not available

All of the property, including the Mishi Main Zone, reverted to MacMillan Gold Corporation in 1996. In 1997, the property was subsequently sold to Mishibishu Gold Corporation, which is now proposing to develop the Mishi Main Zone as an open pitable resource.

2.3 LAND TENURE AND MINERAL CLAIM STATUS

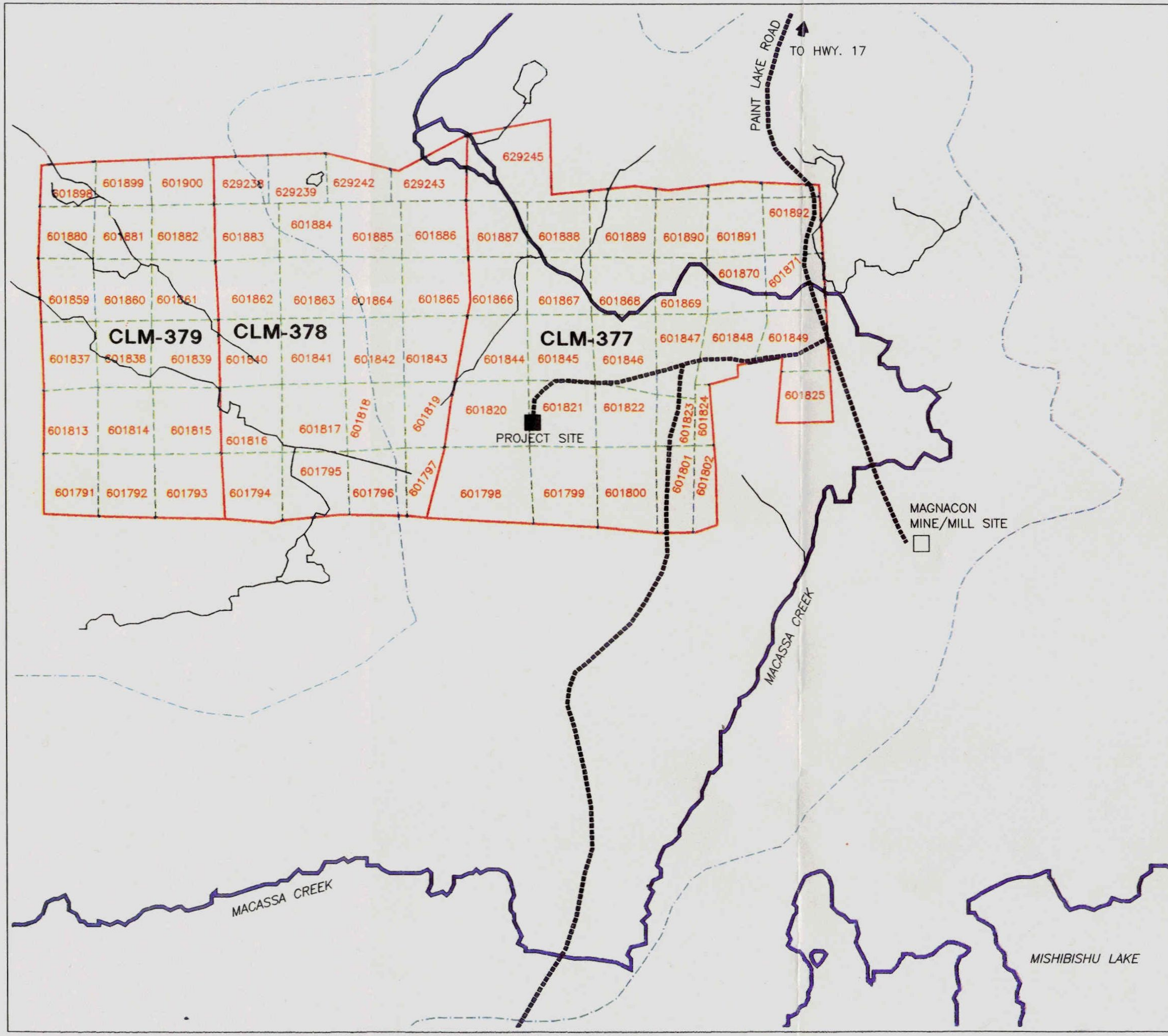
The Project site is situated on the Mishi Project Claim Group located in the Mishibishu Lake Area, Sault Ste. Marie Mining Division, Ontario (Figure 4). The claim group consists of leased surface and mining rights on the following claims:

CLM-377 (30 mining claims)
601798, 601799, 601800 through 601802 inclusive, 601820 through 601825 inclusive, 601844 through 601849 inclusive, 601866 through 601871 inclusive, 601887 through 601892 inclusive, 629245

CLM-378 (24 mining claims)
601794 through 601797, 601816 through 601819 inclusive, 601840 through 601843 inclusive, 601862 through 601865 inclusive, 601883 through 601886 inclusive, 629238, 629239, 629242, 629243

CLM-379 (18 mining claims)
601791 through 601793 inclusive, 601813 through 601815 inclusive, 601837 through 601839 inclusive, 601859 through 601861 inclusive, 601880 through 601882 inclusive, 601898 through 601900 inclusive

The proposed advanced exploration activities will be focused on mining claim group CLM-377.



CLAIM LOCATION MAP
FIGURE 4

LEGEND

- PROJECT SITE
- ACCESS ROAD
- LAKES/CREEKS
- WATERSHED BOUNDARY

0 500 1000 m

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3.0 PHYSICAL ENVIRONMENT

3.1 CLIMATE

Environment Canada's Atmospheric Environment Service (AES) maintains seven climate stations within a 200 km radius of the Project site. Table 1 lists the pertinent characteristics of these stations.

TABLE 1: AES Climate Stations

Station	Location	Elevation (m)	Period of Record	Length of Record (Years)
Caribou Island	47°20'N 85°50'W	187	1935 - 1988	53
Hornepayne	49°14'N 84°48'W	329	1917 - 1989	72
Manitouwadge	49°09'N 85°48'W	332	1956 - present	40
Marathon	48°43'N 86°24'W	189	1945 - 1984	39
Sault Ste. Marie A	46°29'N 84°30'W	187	1945 - present	51
Sault Ste. Marie 2	46°32'N 84°20'W	212	1957 - present	39
Slate Island	48°37'N 86°59'W	186	1966 - 1989	23
Project Site	48°06'N 85°27'W	457	none	-

Climate within the Great Lakes Basin is unique due to the moderating effects of the lakes. The Project site is located within the Superior Regional climate area, which borders the north shore of Lake Superior, from Sault Ste. Marie to Thunder Bay, and extends inland approximately 40 to 80 km. The climate in this area is described as modified continental, the modification being due to the proximity of Lake Superior.

The two closest climate stations to the Project site are Marathon and Sault Ste. Marie 2. Annual temperature ranges for the Project site are similar to those for Marathon, however, precipitation is more closely related to Sault Ste. Marie (Environment Canada, 1972). Even though the Marathon station is closest geographically (approximately 100 km), it does not accurately represent the amount of precipitation received at the Project site, due to the effects of Lake Superior. Marathon is located on the north shore of Lake Superior, and as such, precipitation is not generally affected by the prevailing westerly winds. Both Sault Ste. Marie and the Project site are located on the east (lee) side of the lake, which receives higher precipitation, as the prevailing westerly winds pick up moisture over the lake. Accordingly, temperature data for the Project site were obtained from the Marathon station, and precipitation data were obtained from the Sault Ste. Marie 2 station.

Temperature data available for the Marathon station are based on long-term records (years) and are presented in Table 2 (Environment Canada, 1993). The area exhibits a climatic profile typical of moderated northern continental settings. Winters are long and cold, with January mean temperatures of -13.9°C. Summers are moderately warm, with mean July temperatures of 13.6°C. Minimum January temperatures average -19.3°C, and maximum July temperatures average approximately 18°C. Extreme minimum and maximum temperatures recorded at Marathon, for the 1945 to 1984 period, are -45°C and +32.2°C, respectively (Table 2). The frost free period typically extends from late May to mid-September, but frost can occur any time between the dates of September 5 to June 27. The Project site has between 1,800 and 2,000 mean annual growing degree days (MNR, 1993), (each degree Celsius above 5°C is considered as one degree day).

As provided by records for the Sault Ste. Marie 2 station, the mean annual total precipitation in the area is 994.3 mm (Table 3). Of this amount, approximately 70% falls as rain and the remaining 30% falls as snow. The highest monthly precipitation, of approximately 98 mm, occurs during the late summer and early winter months (August to December). The least amount of precipitation occurs in February, with an average amount of 58 mm (Environment Canada, 1993).

TABLE 2
Temperature Data for the Marathon Station*

MARATHON

48°43'N 86°24'W/O. 189m. 1945 to/à 1984

	Jan janv	Feb févr	Mar mars	Apr avr	May mai	Jun juin	Jul juill	Aug août	Sep sept	Oct oct	Nov nov	Dec déc
Temperature												
Daily Maximum (°C)	-8.6	-6.5	-0.7	6.3	12.3	15.7	18.1	18.5	14.6	9.4	1.9	N
Daily Minimum (°C)	-19.3	-17.6	-11.2	-2.9	2.4	5.9	9.1	10.1	6.6	2.0	-5.0	N
Daily Mean (°C)	-13.9	-11.8	-5.8	1.8	7.4	N	13.6	14.3	10.7	5.9	-1.5	N
Extreme Maximum (°C)	7.2	8.3	12.8	24.5	28.9	30.0	32.2	30.0	25.6	25.0	17.2	13.5
Date	973/26	954/20	974/07	980/30	975/23	972/25+	950/28	955/14	961/02	983/01	956/03	982/02
Extreme Minimum (°C)	-45.0	-36.1	-33.3	-21.1	-10.0	-2.5	1.5	1.1	-6.1	-9.4	-27.8	-34.4
Date	982/17	966/18	967/07	950/08	981/10	983/08	983/05	957/27+	964/30	976/27+	964/30	953/30
Degree-Days												
Above 18 °C	N	N	N	N	N	N	2.2	N	N	N	0.0	N
Below 18 °C	N	N	N	N	N	N	137.9	N	N	N	587.9	N
Above 5 °C	N	N	N	N	N	N	267.3	N	N	N	5.2	N
Below 0 °C	N	N	N	N	N	N	0.0	N	N	N	90.2	N

*Source: Environment Canada, Atmospheric Environment Service, "Canadian Climate Normals 1961-1990: Ontario", 1993.

TABLE 3
Precipitation Data for the Sault Ste. Marie 2 Station*

SAULT STE MARIE 2

46°32'N 84°20'W/O, 212m, 1957 to/à 1990

	Jan janv	Feb févr	Mar mars	Apr avr	May mai	Jun juin	Jul juill	Aug août	Sep sept	Oct oct	Nov nov	Dec déc
Precipitation												
Rainfall (mm)	6.7	4.6	27.0	48.2	74.1	86.9	66.5	95.3	101.3	86.2	54.9	15.4
Snowfall (cm)	82.7	54.2	36.6	14.3	1.4	0.0T	0.0	0.0	0.1	8.8	40.6	88.7
Precipitation (mm)	89.4	58.0	63.6	62.8	75.5	86.9	66.5	95.3	101.5	95.3	95.5	104.0
Extreme Daily Rainfall (mm)	18.4	21.1	48.0	43.8	81.0	84.8	41.9	95.3	72.4	53.6	41.7	30.2
Date	980/16	966/09	976/26	980/08	970/30	961/22	958/04	968/21	985/02	959/24	963/22	971/10
Extreme Daily Snowfall (cm)	35.6	22.9	30.5	21.6	5.1	0.0	0.0	0.0	2.5	15.2	22.0	28.0
Date	972/25	968/02	976/12	981/23	966/02	990/30+	990/31+	990/31+	965/25	972/17	984/01	985/01
Extreme Daily Pcpn. (mm)	35.6	22.9	48.0	43.8	81.0	84.8	41.9	95.3	72.4	56.1	46.7	31.1
Date	972/25	968/02	976/26	980/08	970/30	961/22	958/04	968/21	985/02	959/24	963/22	982/05
Month-end Snow Cover (cm)	N	N	N	N	0	0	0	0	0	N	N	N
Days With												
Maximum Temperature >0°C	5	N	18	28	N	30	31	N	30	31	22	9
Measurable Rainfall	1	1	4	8	11	12	10	12	14	14	8	3
Measurable Snowfall	19	14	10	4	*	0	0	0	*	3	11	19
Measurable Precipitation	20	15	13	11	11	12	10	12	14	15	17	21

*Source: Environment Canada, Atmospheric Environment Service, "Canadian Climate Normals 1961-1990: Ontario", 1993.

3.2 AIR QUALITY AND NOISE

The Project site is remote from industrial air emission sources, with the exception of the Magnacon mill and Eagle River Mine sites, and is expected to show an air quality profile which is typical of regional background conditions. The closest regional background air quality station is located at Algoma, Ontario (47°02'N, 84°23'W). This station is located approximately 130 km southeast of the Project site, and is maintained by AES as part of the Canadian Air and Precipitation Monitoring Network (CAPMON).

The CAPMON program provides air quality data for: chloride, sulphate, sodium, ammonium, potassium, sulphur dioxide, nitrate and nitric acid concentrations. Particulate data are not included in the program. Table 4 summarizes available data for 1989 to 1993 for the Algoma station. Data are presented as annual mean values, together with their respective standard deviations. Maximum air quality concentrations for the period are also presented.

In viewing the data, it is evident that standard deviations normally equal, or exceed, mean values. This is indicative of highly variable data, and is to be expected for measurements of air quality, which are strongly affected by climatic conditions and the long range transport of air pollutants.

Sulphur dioxide and nitric acid are the only parameters listed in Table 4, for which the Province maintains ambient air quality standards. For sulphur dioxide, the annual and 24-hour ambient air quality criteria are 55 $\mu g/m^3$ and 275 $\mu g/m^3$, respectively. These limits are well in excess of regional background values, and are also in excess of the maximum values recorded for the five year period. Similarly for nitric acid, the Provincial 24-hour ambient air quality criterion of 35 $\mu g/m^3$ is well beyond any of the recorded regional measurements (Table 4).

Measurements of background noise levels were not taken for the simple reason that, in the absence of drilling activity, and under quiet conditions, expected noise values will be less than 30 dBA. There are no residences or other noise sensitive receivers adjacent to the Project site which could potentially be affected by noise level increases above background conditions.

TABLE 4
Mean Annual Regional Background Air Quality Data ($\mu g/m^3$)
(standard deviation given in brackets)

Parameter	Algoma - Ontario 47°02'00"N, 84°23'00"W					
	1989	1990	1991	1992	1993	Max *
Chloride (Cl)	0.013 (0.040)	0.014 (0.044)	0.026 (0.088)	0.013 (0.021)	0.023 (0.071)	1.197
Sulphate (SO_4)	3.031 (3.789)	2.492 (2.835)	2.581 (4.246)	2.451 (2.775)	1.983 (2.156)	42.916
Sodium (Na)	0.065 (0.086)	0.069 (0.190)	0.055 (0.074)	0.042 (0.046)	0.051 (0.079)	3.255
Ammonium (NH_4)	0.841 (1.115)	0.753 (0.885)	0.789 (1.242)	0.643 (0.806)	0.546 (0.702)	8.952
Potassium (K)	0.046 (0.043)	0.037 (0.029)	0.039 (0.042)	0.035 (0.038)	0.027 (0.025)	0.383
Sulphur Dioxide (SO_2)	2.897 (3.973)	2.733 (3.572)	2.801 (3.458)	3.137 (4.135)	2.141 (3.218)	40.189
Nitrate (NO_3)	0.401 (1.051)	0.536 (1.255)	0.434 (1.452)	0.322 (0.826)	0.261 (0.782)	16.225
Nitric Acid ($H\text{-}NO_3$)	0.942 (1.360)	0.908 (1.056)	0.889 (1.133)	0.910 (1.207)	0.703 (0.940)	9.794
Total Nitrate	1.339 (1.983)	1.440 (1.923)	1.316 (2.098)	1.233 (1.742)	0.958 (1.442)	21.463

Source: Environment Canada, Atmospheric Environment Service, Canadian Air and Precipitation Monitoring Network (CAPMON)
* Max: Maximum concentration for the monitoring period

3.3 BEDROCK GEOLOGY

3.3.1 Regional Geology

The Mishi Pit property is located within the Mishibishu Lake metavolcanic and metasedimentary belt, which is part of the Wawa Subprovince of the Superior Province of the Canadian Shield. The belt is 16 km wide, and forms a 55 km long arc, from Dog Harbour on the east shore of Lake Superior, and extends westward to the north of Pukaskwa River. The supracrustal rocks are intruded by several granitic to monzonitic stocks. Rocks dip moderately, to steeply, to the north, and strike between 90° and 120°. The common metamorphic grade in the belt is greenschist facies. Numerous broad deformation zones transect the belt in east-west directions, generally following metavolcanic-metasedimentary contacts. The Mishi Main

Zone is hosted in an east trending deformation zone known as the Mishibishu Lake Deformation Zone.

3.3.2 Deposit and Site Geology/Mineralogy

The rocks of the Mishi property consist of an overturned succession, with a set of mafic flows and tuffs occurring to the north. Rocks are dominantly fine to medium grained. In the vicinity of the proposed Mishi open pit, a massive conglomeroporphyritic gabbro intrudes the sequence. Minor felsic tuffs and interflow metasediments make up less than 10% of the sequence. A quartz-feldspar porphyry body is situated immediately south of the mafic horizon. To the south of this unit, an "intermediate lapilli tuff" resides. This massive unit is composed of up to 70% feldspars, and has 10 to 30% homogeneous chloritic clasts ranging from 0.3 to 10 cm in diameter. This tuff forms the foot wall to the mineralized zone for the proposed Mishi open pit. The tuff at this location is referred to as the "Chlorite Clast Conglomerate", and has been interpreted as a felsic lapilli tuff, or an intrusion with homogeneous clasts. South of this unit's southern contact are heterogeneous conglomerates, arkoses and wackes.

To the north, rocks are of magmatic origin - gabbro and quartz porphyry, or mafic and felsic flows and tuffs. The mafic rocks to the north are generally massive competent rocks. It is between, or at the contact between, massive mafics and the intermediate lapilli unit that marks the location of the shear hosting the proposed Mishi open pit mineralization.

The geology of the proposed Mishi open pit mineralization consists of a system of quartz lenses and veinlets, approximately parallel to stratigraphy, and is hosted by a mafic wacke unit in intermediate to mafic schists or fracture systems. Lenses and veinlets are white to smoky grey and comprise 20 to 40% relatively coarse grained (0.5 to 2 cm) subhedral carbonate. The sulphide content consists of 2 to 8% medium grained anhedral pyrite, ±2 tpo10% pyrrhotite. Lenses and veinlets tend to be on the order of 10 to 15 cm in width. Bulk quartz veins average 20%.

The altered mafic rocks of the proposed Mishi open pit (sericite-chlorite-ankerite-pyrite schists) are composed of 25 to 40% iron carbonate, 20 to 30% quartz, 20 to 30% sericite-chlorite, and 2 to 8% pyrite. Gold is dominantly contained in fine grained euhedral to subhedral pyrite, or is present as free gold in quartz. Grain size is dominantly 5 to 30 microns. Practically all quartz and iron carbonate show strain extinction, indicating relatively low strain after crystallization. The euhedral formation of carbonate at vein selvages and gold associated carbonate indicate mineralization at a relatively late stage in the history of the shear zone.

Because of pinch and swell of quartz lenses and the stringy nature of veinlets that host the gold mineralization, gold grades can be erratic and difficult to predict using standard drilling techniques. As a result, it is proposed that drill indicated gold reserves for the proposed Mishi open pit be verified using appropriate bulk sampling techniques.

3.3.3 Acid Production Potential

Acid producing potentials (APP) are evaluated by several prediction techniques, and typically entail static tests (i.e., Acid-Base-Accounting [ABA] tests) which examine the balance between potentially acid generating and potentially acid consuming materials. Maximum Potential Acidity (MPA) is determined from the total sulphur content of the sample, expressed on the basis of the calcium carbonate equivalent. The Neutralization Potential (NP) is determined from the amount of standard acid consumed by a known weight of sample, also expressed on the basis of the calcium carbonate equivalent.

The Common Net Neutralization Potential (CNNP) is determined by subtracting the MPA from the NP, and is a measure of the difference between the neutralizing and acid forming (generating) potentials. The value of CNNP can be either positive or negative. CNNP values less than -20 (expressed as kg $CaCO_3$ eq/tonne material) are likely to produce acid, while CNNP values greater than 20 are not likely to produce acid. For CNNP values between -20 and 20, it is difficult to determine acid producing potential. It is also generally accepted that if the NP (i.e., acid consuming ability) to MPA (i.e., acid generating potential) ratio is greater than 3:1, the material is not likely to produce acid.

Test work for the Mishi #2 Zone was conducted on seven composite ore samples and two composite waste rock samples in 1988, by Bacon, Donaldson & Associates Ltd. (BDA). A report was prepared by BDA in December 1988, which discusses the results of assay determinations and environmental evaluations of Mishi composite samples. Applicable portions of this report, including test results, are provided in Appendix A.

The composite ore and waste rock samples (consisting of between 6 and 23 subsamples of pulp and assay rejects), were tested to determine acid producing potentials. Results of this testwork are summarized in Table 5.

Ore

The analytical results indicate that the composite ore samples contained relatively low sulphur concentrations (0.28% to 1.27%). The ABA tests for the composite ore samples show CNNP values ranging from a low of 4.2 kg/tonne to greater than 128.6 kg/tonne, and NP/MPA ratios of from 1.1 to greater than 15.9. Although the sulphur contents are relatively low for all samples and the acid consuming potential was greater than the acid generating potential, the CNNP and NP/MPA ratios suggest that composite ore samples W1 and M1 may be potentially acid producing, ore composite E1 may also be potentially acid producing (CNNP was 27.45 kg/tonne but NP/MPA ratio was 2.1), and all other samples are considered unlikely to produce acid.

Assuming that the composite ore samples represent all of the material that would be processed (i.e., in equal proportions) the average sulphur content is 0.61%, the average MPA is 18.7 kg/tonne and the average NP is 91.55 kg/tonne. These values equate to an overall average CNNP value of 72.85 kg/tonne and an overall NP/MPA ratio of 4.9, which would suggest that the ore will have an overall non-acid producing potential. The relatively low sulphur contents of the samples would also support this prediction, regardless of the proportions.

Waste Rock

Results for the composite waste rock samples indicate that the samples contained low sulphur concentrations (0.20 and 0.30 %) and that the waste rock is strongly acid consuming (i.e., it is not acid producing).

During advanced exploration, a more thorough analysis of the deposit's major rock types will be tested for acid production potential to provide a greater level of comfort in the test results discussed above. Testing will become especially important when developing ore and waste rock stockpiles, as well as when using waste rock for construction material for roads and/or berms, in order to ensure that future acid mine drainage conditions do not occur. An important point to consider, however, is that ore will be trucked off site for processing elsewhere. The risks of development of acid generating conditions from stockpiled ore, on the Project site, is therefore minimal.

TABLE 5
Acid Producing Potential of Representative Ore and Waste Rock

Composite	Sulphur (wt %)	Maximum Potential Acidity (MPA) kg/tonne*	Neutralizing Potential (NP) kg/tonne*	Common Net Neutralizing Potential (CNNP = NP-MPA)	NP/MPA Ratio
Ore					
W1	0.82	25.1	41.15	16.1	1.6
W2	0.40	12.25	118.55	106.3	9.7
M1	1.27	38.9	43.1	4.2	1.1
M2	0.37	11.35	97.0	85.65	8.5
M3	0.34	10.4	151.9	141.5	14.6
E1	0.80	24.5	51.95	27.45	2.1
E2	0.28	8.6	>137.2**	>128.6	>15.9
Waste Rock					
EM1	0.20	6.1	191.6	185.5	31.4
EE2	0.30	9.2	148.0	138.8	16.1

* These values were converted from lb/ton (original data) to kg/tonne.
** This sample was still consuming acid (supplied by the automatic titrator) after 48 hours.

3.4 SURFICIAL GEOLOGY AND SOILS

3.4.1 Regional Setting

Present topography in the region is the result of orogenic (mountain building) episodes followed by periods of erosion and sedimentation, dating from the Precambrian era. As such, ancient mountains were eroded through millions of years of weathering and were scoured and gouged by continental glaciations. This type of formation is typical of many areas of Canadian Shield topography, which are characterized by numerous steep-sided valleys and gullies, rocky knolls and drift-filled valleys. Among steep slopes and bold massive hills, canyons and cliff faces are often found, most of which are associated with faulting. The regional topography is therefore strongly influenced by bedrock lithology (Tracey, 1971; Parks Canada, 1982; White, 1988; Foy, 1990).

Local relief varies from 15 m to 120 m (Parks Canada, 1982; Wilson, 1985). The highest elevation in the region is at Tip Top Mountain, which has a maximum elevation of 636 m ASL. Tip Top Mountain is one of the highest points in Ontario, and is located approximately 45 km northwest of the Project site, within the boundary of Pukaskwa National Park.

The region is characterized by exposed bedrock, which is often covered by a discontinuous, thin layer of glacial drift. Much of the area is also characterized by glaciofluvial outwash deposits consisting of sand and gravel. These features include pro-glacial river and other outwash deposits. Eskers are frequently encountered in the area, particularly north of the Project site (Barnett et al., 1991).

Other products of glaciation include lacustrine deposits along former shorelines of glacial Lake Superior. Receding water levels caused by the slow recession of meltwater, and uplift of the land following deglaciation, resulted in lacustrine deposits, old beaches, strand lines, dunes, and deltaic deposits (Canadian Parks Service, 1989).

Soils are generally thin and impoverished along the Lake Superior coast and on the higher knolls, but are better developed on more protected inland sites at lower elevations (White, 1988). Surface soils have generally formed from coarse-textured, acidic parent materials which are generally less than 100 cm thick and are underlain by the Precambrian Shield bedrock (Senes Consultants Ltd., 1986). Topography and drainage patterns are predominantly bedrock-controlled. As such, soils are susceptible to erosion due to the undulating and steep topography.

3.4.2 General Site Area

The general physiography of the Project area is bedrock controlled, being characterized by steep sided valleys, elevated plateaus and moderate relief, ranging from 381 to 472 m ASL. Exposed bedrock is common in the area along ridge crests and valleys. Overburden consists primarily of poorly sorted silty/sandy ground moraines and boulder tills, ranging in thickness from less than 1 m on bedrock knobs to 3 to 5 m in lowland areas. Several areas of well sorted sandy materials, derived from washed tills, can be found in wetland areas along Macassa Creek (EAG, 1989).

Poorly drained, low lying areas and diffuse drainage channels surround the site. A large north-south trending rock ridge, lies east of the Project site, and west of the main access road.

Based on the bedrock controlled geography, and the fact that no major structures will be constructed on the Project site (i.e., no tailings dams or a mill), a geotechnical drilling program, to obtain more detailed information on subsurface conditions, was not conducted for baseline purposes. During the initial on-site startup phase of the Project, it is expected that test pits and some overburden drilling will be conducted to investigate the underlying soils and to determine construction criteria for the required advanced exploration facilities.

3.5 SURFACE HYDROLOGY

The Project site is situated within the Macassa Creek watershed, which has a total drainage area of approximately 68 km^2 (Figure 3). From the unnamed headwater lake (north of the Project site), Macassa Creek flows southeast toward the main access road (Paint Lake Road), and then in a southwesterly direction to the East Pukaskwa River. At the point where Macassa Creek enters the East Pukaskwa River, the latter has a watershed area of approximately 276 km^2. The East Pukaskwa River, in turn, flows into the Pukaskwa River, which drains south to Lake Superior. The confluence of the East Pukaskwa and the Pukaskwa Rivers is located within the Pukaskwa National Park Boundary, approximately 6 km north of the Lake Superior shoreline.

To approximate average runoff yield from the ungauged watershed of Macassa Creek, historical streamflow data (Environment Canada, 1992) for the nearest hydrometric stations within 150 km of the Project site, and with relatively small, preferably non-regulated, watershed areas (less than 2,000 km^2), were examined. The local hydrometric stations located east and south of the Project site, that were considered for review, are listed (in order of increasing watershed area) in Table 6.

As shown in Table 6, flows are natural (non-regulated) at all but one station (Magpie River at Steep Hill Falls). Regulated stations limit the usefulness of station records for the analysis of water yield, low flows, and flood frequencies. This regulated station was therefore not considered further. The station along Magpie River near Michipicoten was also eliminated from further consideration, based on the large size of the drainage basin.

The drainage areas of the first four hydrometric stations are relatively small, and are therefore most suitable for comparison to the Macassa Creek watershed (area of 68 km^2). Mean annual runoff levels for Norberg Creek, Bennet Creek, Big Carp River and Root River were calculated as 798 mm, 658 mm, 500 mm and 578 mm, respectively (Environment Canada, 1992). Three of these stations, however, are located near Sault Ste. Marie, in moderately to significantly developed areas in comparison to the Macassa Creek watershed, which is undeveloped. The Bennet Creek station provides a limited period of record of only 8 years (and only 6 years of complete annual data). Based on these aspects, the most suitable hydrometric station for comparison to the Macassa Creek watershed is considered to be the station at Norberg Creek (Site A), above Batchawana River.

TABLE 6
Local Gauged Hydrometric Stations

Station Number	Station Name	Period of Record*		Total Years	Drainage Area (km^2)	Natural/ Regulated
		From	To			
02BF005	Norberg Ck. (Site A) above Batchawana R.	1980	1990	11	11.5	N
02BF003	Bennet Creek at Sault Ste. Marie	1971	1978	8	18.6	N
02BF004	Big Carp River near Sault Ste. Marie	1979	1990	12	51.5	N
02CA002	Root River at Sault Ste. Marie	1971	1990	20	108	N
02BF002	Goulais River near Searchmont	1967	1990	24	1160	N
02BF001	Batchawana River Near Batchawana	1967	1990	24	1190	N
02BD001	Magpie River at Steep Hill Falls	1920	1939	20	1640	R
02BD003	Magpie River near Michipicoten	1939	1990	52	1930	N

* Data were obtained from Environment Canada's 1992 publication: Historical Streamflow Summary - Ontario. to 1990.

Table 7 lists the expected mean monthly runoff distribution for the Project area, based on the Norberg Creek (Site A) flow data (1980-1995). As a conservative measure, and due to the significant variance of runoff levels between the four stations discussed above, a mean annual runoff of 634 mm (i.e., the average annual runoff of the four stations) was assumed for further hydrological calculations in the Macassa Creek basin. The mean monthly runoff levels were then calculated based on the runoff distribution provided by the station on Norberg Creek.

According to the data, April and May are typically periods of high flows, with October and November flows showing a secondary seasonal peak flow. Lowest flows typically occur in mid-winter (February) and mid to late summer (July and August). Based on flow data prorated from the average of the four area watersheds, the entire Macassa Creek watershed would discharge a mean runoff of approximately 1.37 m^3/s (118,100 m^3/day).

Based on the bedrock controlled topography, flows within Macassa Creek will be significantly influenced by precipitation events and runoff inputs rather than groundwater inputs. This was evident during the June 1997 field investigations, during which water levels dropped by approximately 25 to 30 cm over the three day period, which was likely preceded by a heavy precipitation event. Groundwater is therefore considered to be a comparatively unimportant component of the site hydrological system. As such, no specific groundwater studies were undertaken.

TABLE 7
Monthly Mean Runoff Distribution for Project Area
(based on Norberg Creek flow data, 1980-1995)

Month	Runoff (mm)	Percent of Annual
January	26.0	4.1
February	17.8	2.8
March	32.3	5.1
April	163.6	25.8
May	93.8	14.8
June	37.4	5.9
July	17.1	2.7
August	15.9	2.5
September	34.9	5.5
October	72.3	11.4
November	76.7	12.1
December	46.9	7.4
Total	634	100

3.6 SURFACE WATER QUALITY

3.6.1 General

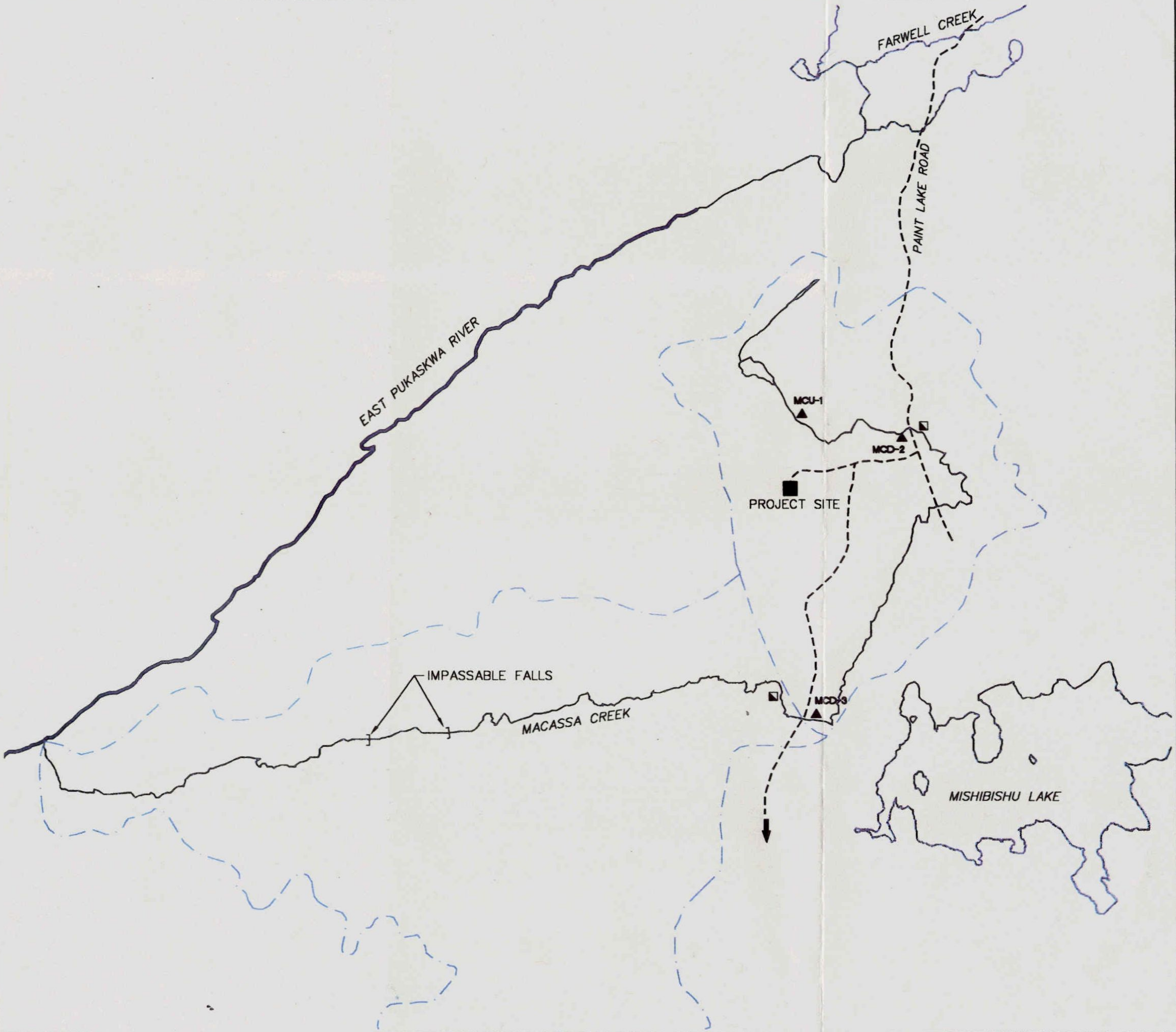
Surface water samples were collected in 1988 and 1989 from two sampling stations in Macassa Creek, during previous exploration activities by Granges Exploration Limited. Field investigations were also conducted by AGRA in June 1997 to supplement this database.

3.6.2 Methodology

Three sampling stations were selected based on: relative location (i.e., with respect to potential discharges from mining activities, such as from a mine water settling pond), locations previously sampled (i.e., in 1988/89), and ease of access. Accordingly, one station upstream of the potential discharge area of the mine water settling was selected, which would represent background conditions following site development. Two downstream stations were located at the access road stream crossings, one of which will likely be used to monitor downstream impacts following site development. These two downstream stations were also sampling during the 1988/89 field investigations. Locations of the three sampling stations are shown in Figure 5.

MACASSA CREEK SAMPLING STATIONS

FIGURE 5



LEGEND

- PROJECT SITE
- ACCESS ROAD
- LAKES/CREEKS
- WATERSHED BOUNDARY
- 1988 MONITORING STATIONS
- MCD-1 1997 MONITORING STATIONS

0 1000 2000 3000 4000 m

MISHIBISHU GOLD CORPORATION
MISHI PIT PROJECT

PROJECT:	TC 76166	FILE:	76166_05
DATE:	16-SEP-97	DRAWN:	JA/DAS
SCALE:	1:60000		

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

To assess the water quality of Macassa Creek, analytical results were compared to Provincial Water Quality Objectives (PWQO). Although Macassa Creek will likely not be used as a source of potable water, results were also compared to Ontario Drinking Water Objectives (ODWO).

Both of these objectives are the Ontario standards typically applied to background and receiving waters.

3.6.3 Results and Discussion

Analytical results for samples collected in November 1988; January, March and July 1989; and June 1997, are presented in Table 8. Certificates of Analysis are included in Appendix B. The relevant water quality samples for 1988 and 1989 were collected from the stations denoted on the laboratory certificates as Macassa Creek 'upstream' (equivalent to station MCD-2) and Macassa Creek 'downstream' (equivalent to MCD-3).

The sampling data show that Macassa Creek water quality is generally good and is within PWQO and ODWO limits, with the exception of a few parameters. The pH levels were below the lower PWQO limit of 6.5 at stations MCU-1 (5.89) and MCD-2 (6.05) in June 1997 and at station MCD-3 (6.45) in November 1988; copper slightly exceeded the PWQO of 0.005 mg/L at station MCD-2 in March 1989 (0.006 mg/L); and iron was above the PWQO of 0.3 mg/L at station MCD-2 in January and March 1989 (0.36 and 0.41 mg/L, respectively). Aluminum was analysed only for the June 1997 samples, all of which exceeded the interim PWQO limit of 0.075 mg/L. Turbidity and manganese slightly exceeded the ODWO on one occasion each, at station MCD-2, in January and March, respectively. Minor variations between results for 1988/89 and 1997 are likely a result of seasonal trends.

Overall, the surface waters of the area tend to exhibit a neutral, or near neutral pH, and exhibit low levels of alkalinity and hardness. These characteristics are typical of many bedrock controlled watercourses on the Canadian Shield. Water quality analyses conducted in 1989 (and confirmed by the June 1997 results) concluded that the levels of heavy metals were generally well below the Provincial Water Quality Objectives (PWQO) for the protection of aquatic life (MOEE, 1994), with the exception of aluminum, copper and iron. Copper and iron concentrations in Macassa Creek, and other watercourses in the area, have been observed to periodically exceed their respective PWQO limits. Such results are typical of most background creek waters in Canadian Shield environments.

TABLE 8: Macassa Creek Background Surface Water Quality

Parameters	Unit	PWQO ODWO*	MCU-1	MCD-2					MCD-3		
			June 1997	November 1988	January 1989	March 1989	July 1989	June 1997	November 1988	July 1989	June 1997
pH		6.5-8.5	**5.89**	6.9	6.58	6.6	7.36	**6.05**	**6.45**	7.67	6.69
Conductivity	(μs/cm)	-	20	25	63	80	170	24	43	114	40
Total Suspended Solids	(mg/L)	-	<2	<2	4.8	5.2	-	20	7	-	<2
Total Dissolved Solids	(mg/L)		57				-	58		-	58
Total Alkalinity ($CaCO_3$)	(mg/L)	30-500*	5	22	24	36	52	6	11	48	11
Ammonia as N	(mg/L)	-	0.027	<0.025	0.26	0.429	0.046	0.033	<0.025	0.061	0.070
Un-ionized Ammonia	(mg/L)	0.020	<0.001	<0.02	<0.001	<0.001	<0.001	<0.001	<0.02	<0.001	<0.001
Nitrate as N	(mg/L)	10.0*	<0.1	-	0.17	0.11	<0.1	<0.1	-	0.3	<0.1
Sulphate	(mg/L)	500*	1.7	-	3.6	3.0	2.2	1.4	-	5.9	2.1
Total Phosphorus	(mg/L)	0.02/0.03	0.01	-	0.01	0.01	<0.005	0.03	-	0.006	0.02
Total Hardness ($CaCO_3$)	(mg/L)	-	12	11	34	29	79	13	17	102	20
Turbidity	(NTU)	1.0*	0.8	0.3	1.1	0.84	0.42	3.0	0.6	0.41	1.0
Chloride	(mg/L)	250*	-	-	0.59	0.65	0.26	-	-	1.51	-
Metals											
Aluminum	(mg/L)	0.075 (I)	**0.24**	-	-	-	-	**0.17**	-	-	**0.17**
Arsenic	(mg/L)	0.1/0.025*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001
Cadmium	(mg/L)	0.0002/0.005*	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.0001	<0.002	<0.002	<0.0001
Chromium	(mg/L)	0.1	<0.01	-	<0.005	<0.005	<0.005	<0.01	-	<0.005	<0.01
Copper	(mg/L)	0.005/1.0*	0.003	<0.005	<0.005	**0.006**	<0.005	0.002	<0.005	<0.005	0.002
Iron	(mg/L)	0.3	0.20	0.21	**0.36**	**0.41**	0.061	0.20	0.19	0.13	0.02
Lead	(mg/L)	0.025/0.01*	<0.001	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.001
Manganese	(mg/L)	0.05*	0.01	0.014	0.025	0.14	-	0.01	0.01	-	0.02
Mercury	(mg/L)	0.0002/0.001*	<0.0001	<0.0002	<0.0002	-	<0.0002	<0.0001	<0.0002	<0.0002	<0.0001
Molybdenum	(mg/L)	0.010 (I)	<0.05	-	-	-	-	<0.05			<0.05
Nickel	(mg/L)	0.025	<0.005	<0.01	<0.005	-	<0.005	<0.005	<0.01	<0.005	<0.005
Zinc	(mg/L)	0.03/5.0*	0.007	<0.005	<0.005	0.01	<0.005	0.006	<0.005	<0.005	0.009

PWQO - Provincial Water Quality Objectives for the protection of aquatic life.
ODWO* - Ontario Drinking Water Objectives (includes health and non-health related concentrations).
Bolded boxes indicate an exceedance of the PWQO.

3.7 SEDIMENT QUALITY

3.7.1 General

Sediment samples were collected during one sampling event (on June 18, 1997) at the three water quality sampling stations along Macassa Creek (Figure 5). The sediment sampling program was conducted simultaneously with benthic invertebrate sampling (see Section 4.4). Sediment samples were collected in order to provide background sediment chemistry data, and to assist in the interpretation of benthic invertebrate sampling results (Section 4.4). There are no sediment sampling results available from the 1988/89 field investigations.

3.7.2 Sampling Methodology

Sediment samples were collected with a 3.8 cm (1.5 inch) Phleger Corer in deeper areas of the creek (i.e., pools), where the deposition of sediments would be expected. Three replicate core samples were collected (approximately 6-8 m apart) at each sampling station (Figure 5) and were retained in acrylic tubes until they could be composited. The top 10 cm of each sample was removed from the corer (at the laboratory) and sectioned into 0-5 cm and 5-10 cm interval subsamples, in accordance with MOEE sediment sampling protocols (Persaud, 1992). The subsamples were then pooled for laboratory analysis (i.e., two composite samples, representing each interval, per station).

Parameters included in the analysis were pH, arsenic, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, zinc, and organic content (loss on ignition - LOI). The organic content of sediments (as a percentage) is determined by the loss on ignition (LOI), the difference in weight being presumed to be the inorganic content. Typically, the higher the organic content, the lower the metals concentrations.

3.7.3 Sediment Quality Guidelines

Sediment analytical results were evaluated through comparison with Provincial Sediment Quality Guidelines (PSQG) (OMOE, 1992). These guidelines are presented with the sediment quality results which are discussed below, in Section 3.7.4. Sediment results were also compared to background concentrations for the Great Lakes pre-colonial sediment horizon (i.e., sediments which have not been influenced by European industrial, urban, or agricultural development) (OMOE, 1992b), as well as those used to regulate fill deposition into confined water bodies (MOE, 1992c).

Under the PSQG standards, two levels of effects are prescribed, which reflect potential chronic and long term effects of contaminants on benthic invertebrates. These are: i) **lowest effect level** (LEL) - level of sediment contamination that can be tolerated by the majority of sediment-dwelling benthic invertebrates, for which the sediment is considered to be clean to marginally polluted; and, ii) **severe effect level** (SEL) - level of sediment contamination at which pronounced disturbance of the sediment-dwelling community can be expected, for which the sediment is considered heavily polluted.

3.7.4 Results and Discussion

Sediment quality results for the three stations sampled along Macassa Creek in June 1997 are provided in Table 9. Certificates of analysis are provided in Appendix B.

Sediment results for each interval sample collected at the three sampling stations show that all parameter concentrations were well below the respective PSQG lowest effect concentrations, with the exception of copper. The copper concentration at station MCD-2 for the 5-10 cm interval (20 µg/g) was slightly above the lowest effect concentration of 16 µg/g, but well below the severe effect level of 110 µg/g. Copper concentrations for the remaining samples (at both intervals) were at or near the lowest effect concentration, ranging between 11 and 16 µg/g.

Overall, the sampling results indicate that the sediment is generally characteristic of a neutral to slightly acidic pH conditions, which correspond with water quality pH levels (Section 3.6.3). Organic contents were relatively low, particularly at station MCD-2, indicating minimal deposition or accumulation of sediments has occurred along the upper portion of Macassa Creek. It is likely that lighter organic material is being washed downstream during the spring freshet period, as suggested by the higher organic contents recorded for station MCD-3.

Concentrations for all parameters are generally in the same range between sampling stations, suggesting no significant differences in sediment quality between the upstream and downstream sampling stations. Selection of the MCU-1 sampling station (i.e., upstream of proposed mine water discharges) is therefore considered to be a representative control station for future monitoring programs.

TABLE 9: Sediment Quality - Macassa Creek (June 1997)

Parameter	Unit	Macassa Creek Sampling Stations						Sediment Quality Guidelines			
		MCU-1		MCD-2		MCD-3		MOE 1992b Lowest Effect Level	MOE 1992b Severe Effect Level	MOE 1992b Great Lakes Background	MOE 1992c Confined Fill
		0-5 cm	5-10 cm	0-5 cm	5-10 cm	0-5 cm	5-10 cm				
pH		5.68	6.19	6.55	7.82	5.99	6.05	-	-	-	3 - 10
LOI	(%)	12.6	1.6	0.9	0.5	10.3	13.2	-	-	-	-
Metals											
Arsenic	(μg/g)	0.4	0.5	0.5	0.5	1.4	1.6	6	33	4.2	11
Cadmium	(μg/g)	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.6	10	1.1	0.7
Chromium	(μg/g)	12	15	14	13	11	14	26	110	31	58
Copper	(μg/g)	11	14	16	**20**	14	14	16	110	25	41
Iron	(μg/g)	4440	5170	6320	5490	4240	7310	20,000	40,000	31,200	-
Lead	(μg/g)	6	6	7	<5	10	8	31	250	23	45
Manganese	(μg/g)	65	70	115	67	137	86	460	1,100	400	-
Mercury	(μg/g)	0.04	0.01	0.02	0.01	0.04	0.02	0.2	2	0.10	0.2
Nickel	(μg/g)	7	10	10	8	8	12	16	75	31	38
Zinc	(μg/g)	21	16	20	16	32	32	120	820	65	120

Bolded boxes indicate an exceedance of the MOE Lowest Effect Level guideline.

4.0 BIOLOGICAL ENVIRONMENT

4.1 TERRESTRIAL VEGETATION

4.1.1 Regional Forest Characteristics

The Project site is situated near the transition zone between the Boreal Forest and the Great Lakes - St. Lawrence Forest Regions, and as such, many species are either at or near their respective northern or southern range limits. All vegetation communities reflect the dynamics of a number of ecological processes such as climate, fire, insects and disease, as well as human effects. Over time, some vegetation communities, such as the Boreal Forest, have become dependent on progressive succession and disturbance events such as fire and insect infestations (Pruitt, 1978; Larsen, 1980). Regional diversity is increased by fires, which maintain early post-fire communities in a mosaic pattern. Forest types also vary quite noticeably with moisture conditions, topography, and soil characteristics. Since the Project site is located at the northern edge of the transition zone, the area contains more Boreal Forest species than Great Lakes - St. Lawrence Forest species, as indicated by a continuum, or gradual blending, of Boreal and Great Lakes-St. Lawrence Forest vegetation types.

Forest regions are subdivided into forest sections, with the Project site being located within the Superior Forest Section, close to the boundary with the Algoma Forest Section, as characterized by Rowe (1972). The Superior Forest Section is within the Boreal Forest Region, while the Algoma Forest Section is within the Great Lakes - St. Lawrence Forest Region. The Superior Forest Section extends from Michipicoten and west to Thunder Bay. Climate in this region is influenced by Lake Superior and as such, the vegetation is highly variable. Mixed forest communities of white spruce, balsam fir, white birch and trembling aspen dominate the valley lands. Upland sites, comprising rock outcrops and well drained soils, consist mainly of jack pine and white birch, with a minor association of black spruce. Poorly drained sites generally consist of pure stands of black spruce, with minor associations of tamarack and eastern white cedar. Great Lakes - St. Lawrence Lowlands Forest species in the area include eastern white pine, red pine, and in more sheltered valleys black ash is encountered. Sugar maple and yellow birch occupy favourable upland sites. This forest section has been greatly influenced by fire, which has favoured an increase in trembling aspen, white birch and pine.

Uplands of the Algoma Forest Section are dominated by sugar maple and eastern white pine, with a minor association of yellow birch and red pine. White spruce, eastern white cedar and balsam fir are prevalent on lower slopes. River valleys and riparian areas are characterized by white spruce - balsam fir communities, with associations of white birch and black spruce. Sand plains are generally dominated by pure stands of jack pine.

Open and treed bog or muskeg are generally found in areas of poor drainage. These habitats generally comprise black spruce, tamarack and eastern white cedar.

4.1.2 Vegetation Types in the General Site Area

Vegetation in the Project site area includes a predominance of white birch and white spruce on well drained uplands, and low lying areas underlain by ground moraine, with a limited occurrence of jack pine and aspen. Poorly drained muskeg areas are often treed with black spruce and white cedar, or they may be open with a dominant shrub cover. Other areas of poor drainage, as well as riparian margins (i.e., along Macassa Creek), consist largely of alder, grass and sedge (EAG, 1989).

No endangered or threatened floral species are expected to occur on the Project site, as the vegetation communities present are not considered to be rare or unique.

4.2 WILDLIFE

Wildlife species diversity and abundance are directly linked to vegetation communities. As a result, wildlife in the area include a combination of both northern and southern species, reflecting the vegetational transition zone (Section 4.1.1). The occurrence and abundance of wildlife also depends primarily on available habitat. Each species has its own specific habitat requirements for food, shelter, and reproductive facilities and also occupies its own ecological niche. Virtually all habitats are utilized to varying degrees by several species. For large mammals, such as moose, habitats can cover large areas, but for smaller, more sedentary mammals, such as voles, habitat requirements are generally restricted to smaller areas in the order of ten's of square metres.

Habitats which support the greatest diversity and abundance of wildlife species are generally those which are structurally more diverse. Within the Project area, habitats are relatively diverse, as represented by mixed upland and lowland forest communities consisting of black spruce, white spruce, balsam fir, poplar and white birch. The Project site is located approximately 20 km east of Pukaskwa National Park and about 60 km north west of Lake Superior Provincial Park. Wildlife known to utilize both park environments include moose, black bear, lynx, red fox, beaver, snowshoe hare and gray wolf (Parks Canada, 1982; Canadian Parks Service, 1989; Foy, 1990). Pukaskwa National Park also supports a herd of approximately 25 woodland caribou, with prime habitat located along the Lake Superior coastline. Woodland caribou are also found within Lake Superior Provincial Park as a result of a relocation project conducted in 1989 to re-establish a mainland population in their former range (OMNR, 1989). Both of these parks are at the southern edge of the woodland caribou range in Ontario, and the population present here is considered to be highly significant.

In addition, the Forest Habitat Suitability Matrix for Northeastern Ontario (D'Eon and Watt, 1994) and the Atlas of the Mammals of Ontario (Dobbyn, 1994) have recorded white-tailed deer, coyote, skunk, fisher, marten and numerous mice, shrews and voles utilizing the mixed forest habitats in the region. Raccoons are also found in the area, mainly in forest communities adjacent to streams and rivers. Other mammals utilizing riparian and aquatic habitats include river otter, muskrat, and mink.

Mixedwood communities are the preferred habitat for a variety of birds including the red-tailed hawk, boreal owl, blue jay, brown creeper, golden crowned kinglet, Swainson's thrush, vireos, warblers, sparrows, pine grosbeak and pine siskin (D'Eon and Watt, 1994). Other avifauna which utilize these communities at some time in their life cycle include ruffed grouse, yellow bellied sapsucker, woodpeckers, northern flicker, flycatchers, pewees, swallows, chickadees, nuthatches, wrens, and finches (Cadman et al., 1987).

Many birds are attracted to the region's lakes and rivers for nesting and feeding, such as the common loon, great blue heron, a variety of ducks and teals, mergansers, and the belted kingfisher (Cadman et al., 1987). Osprey and northern harriers are also attracted to these habitats.

Lowland forests, consisting primarily of coniferous species, provide nesting and feeding habitat for jays, crows, ravens, chickadees, pine siskin, finches, cedar waxwings, flycatchers, vireos, northern waterthrush, and woodpeckers. These forests also provide habitat for some warblers which feed on the spruce budworm, as well as the spruce grouse which often finds food and cover in the understorey or associated edge habitats. Some hawks and owls, such as the sharp-shinned hawk and the barred and great gray owls, are also attracted to these habitats (D'Eon and Watt, 1994).

No endangered or threatened faunal species are expected to occur on the Project site, as habitats are not considered to be rare or unique. The Project site is remote from areas utilized by woodland caribou.

4.3 FISHERIES AND AQUATIC RESOURCES

4.3.1 General

Macassa Creek will be the receiving water of potential discharges from the proposed mining activities to be conducted on the Mishi Pit property. Fisheries and aquatic habitat resource investigations were therefore conducted by AGRA in the upper portion of the Macassa Creek watershed in June 1997. Fisheries data are also available from previous investigations which were conducted by AGRA (formerly the Environmental Applications Group, EAG) for Granges Exploration Limited in November 1988.

Fisheries investigations were conducted in the general area of the three selected stations at which water and sediment sampling was conducted.

These investigations provide general descriptions of existing aquatic habitat conditions and of fish communities in the Macassa Creek upper watershed. Benthic invertebrate communities were also examined and are discussed in Section 4.4. Water and sediment quality were investigated during the aquatic habitat studies, and are reported in Sections 3.6 and 3.7, respectively.

4.3.2 Regional Description

The major trend of the regional drainage system is northeast to southwest, with each of the major rivers and large lakes exhibiting this orientation, which parallels the dominant direction of historical ice flow (Wilson, 1985). Drainage patterns are generally of the trellis type, with water being channelled along jointed and fractured bedrock. In many areas, faults have caused displacements which control the present drainage patterns. These drainage patterns are also often characterized by major changes in stream gradients (Gimbarzevsky et al., 1978).

Numerous lakes in the region have developed largely in response to glacial scouring, and frequently have poorly defined outlets due to inadequate time for development (Tracey, 1971). Many lakes are oligotrophic, which indicates a water chemistry low in the basic nutrients which are necessary for primary production. Regional waterbodies also exhibit a degree of natural acidity due to the granitic nature of local bedrock, and the abundance of surrounding coniferous vegetation cover (Schiefer and Lush, 1986; Environment Canada et al., 1988).

The quantity and diversity of fish species in regional lakes is typically limited. Few fish species occur in Pukaskwa National Park and Lake Superior Provincial Park lakes (Parks Canada, 1982; Environment Canada et al., 1988; Canadian Parks Service, 1989). Characteristic of the oligotrophic lakes of the Canadian Shield, the productivity of area lakes in the region tends to be low. The distribution of fish species in the area is also somewhat limited by physical barriers. The migration of fish from interior lakes, as well as from Lake Superior, along watercourses is restricted due to the numerous waterfalls and rapids located at major fault lines and other significant changes in stream gradients, many of which are impassable.

4.3.3 Methodology

4.3.3.1 Aquatic Habitat Inventories

A general inventory of the aquatic habitat, observed during the June 1997 field investigations, was recorded concurrently with fish sampling investigations, to characterize available fish habitat and to provide characteristic features of the creek sections in the area of each sampling station. Inventories at each station included a description of biophysical features related to riverine habitats, such as: floodplain and channel wetted widths, general creek morphology, overhead cover, aquatic vegetation and substrates.

4.3.3.2 Fish Sampling Procedures

Resident fish communities and population distributions in the upper reaches of the Macassa Creek watershed were determined by sampling with a series of gill nets, baited minnow traps and an electrofisher.

At each of the three sampling stations, gill nets (15 m in length) were set within deep, slow flowing pools (approximately 1.5 m in depth) with mesh sizes ranging from 1.5 to 3.5 inches. At station MCU-1, a 1.5 inch gill net panel and a 3.5 inch panel were set approximately 200 m and 100 m, respectively, upstream of the potential discharge area. Three minnow traps were also set at locations between the two gill nets. At station MCD-2, a 1.5 inch gill net panel and a 3.5 inch panel were set approximately 130 m and 50 m, respectively, upstream of the first road crossing. Two minnow traps were also set near the road crossing. At station MCD-3, a 1.5 inch gill net panel and a 2.5 inch panel were set approximately 300 m and 100 m, respectively, upstream of the second road crossing. Three minnow traps were also set near the road crossing.

Gill nets were checked periodically for the first few hours, but following limited capture success, the nets remained in place over night in order to obtain a sufficient catch to properly assess the fish community of Macassa Creek. Baited minnow traps were placed at each sampling station and also remained in place over night. Electrofishing was conducted at station MCD-2, with limited success. Electrofishing could not be safely completed at the other two sampling stations due to deeper water levels.

Captured fish were counted and identified by species and were then released in an area immediately adjacent to the collection location. Based on the size of the nets used, the number of fish collected, and the period of time over which sampling occurred, the Catch Per Unit Effort (CPUE) was also calculated. The greater the CPUE, the greater the fish captured per unit time.

The 1988 field investigations used similar methods to those employed during the 1997 field investigations. Results for both investigations are discussed below.

4.3.4 Results and Discussion

Between June 17 and 20, 1997, AGRA conducted fish community investigations in the upper reaches of the Macassa Creek watershed, in the general area of the three selected stations at which water and sediment sampling were conducted (Figure 5). Summaries of the aquatic habitat inventories and the results of the fish capture success are discussed below.

4.3.4.2 Aquatic Habitat

General

The Macassa Creek watershed has a total area of approximately 68 km^2, with a total stream length of approximately 21 km. Upper reaches of the creek, in the vicinity of the Project site, drain an area of approximately 23 km^2.

Within the study area, the morphology of the Macassa Creek headwater area consists of a wide floodplain, which has been impounded by beaver dams and exhibits a slow meandering flow pattern. Further downstream, the creek is confined to a narrow floodplain, with swift, rapid sections interspersed with deep pools, some pools being greater than 2 m in depth. Creek substrates are predominantly composed of organic material in the wide reaches, while sand, gravel, cobbles and boulders occur in the narrow reaches (EAG, 1989).

Riparian vegetation in wide floodplain areas generally consist of alder, dogwood, grasses, sedges and pond weed. Narrow creek reaches are characterized by dense black spruce forest, with pond weed and eels grass located on outer meander bends (EAG, 1989).

Within the study area, Macassa Creek can be characterized as an E-type channel (MNR, 1994), with a low gradient, highly stable banks, high sinuosity and an entrenched channel. Several beaver dams are located along the creek, creating larger ponded and marshy areas.

During the June 1997 sampling period, water levels appeared to be approximately 30 cm higher than baseflow levels, with flow velocities also higher than those expected for baseflow conditions.

The following sections describe in more detail the aquatic habitat at each sampling station. Table 10 provides a summary of the riverine habitat descriptions for each station.

Station MCU-1

Station MCU-1 was located approximately 750 m upstream of the proposed mine water settling pond discharge area. Beaver dams have altered the stream within this area, from a defined channel to a ponded habitat with braided and often ill-defined flows.

Approximately 25 m downstream of a large beaver dam, the stream morphology changes from a ponded habitat to a more defined stream channel. This area downstream of the beaver dam was chosen as the sampling station, since it provided similar habitat to the downstream stations, such that better comparisons could be made with the two downstream stations.

The stream channel width in this section of Macassa Creek averaged 3.5 m, with water depths of up to 1.2 m. Bottom substrates consisted of 90% organics and 10% silt and clay.

Aquatic vegetation was limited to that found in ponded areas and consisted of water lilies, arrowhead and submerged pondweed. Sweet gail, sedge and speckled alder dominated the stream banks. Forest margin consisted mainly of black spruce.

Station MCD-2

Station MCD-2 was located approximately 150 m upstream of the first mine access road stream crossing. This section of the creek was characterized by a well defined stream channel averaging 2.2 m in width. Water depths averaged 1.2 to 1.5 m and the water was slightly humic coloured. Substrates consisted of 25% organics, 10% clay, 20% silt and 45% sand.

Aquatic instream vegetation was not observed within the area of sampling station. Stream bank vegetation consisted of sweet gail, sedge and speckled alder. Black spruce characterized the forest margin.

TABLE 10
Summary of Riverine Habitat Descriptions - Macassa Creek (June 1997)

Station	Mean Depth (m)	Mean Wetted Width (m)	Substrates (%)	Instream Vegetation	Stream Bank Floodplain Vegetation (%)	Forest Margin Vegetation	Dissolved Oxygen (mg/L)	Temperature (°C)		Fish Species
								Water	Air	
MCU-1	1.2	3.5	Organic 90 Silt 10	water lilies arrowhead submerged pondweed	sedge 35 sweet gail 35 alder 30	black spruce	5.4	14	19	white sucker northern redbelly dace finescale dace
MCD-2	1.2	2.2	Sand 45 Organic 25 Silt 20 Clay 10	none observed	alder 55 sweet gail 30 sedge 15	black spruce	4.8	13	19	white sucker northern redbelly dace finescale dace creek chub Iowa darter
MCD-3	1.5	7.5	Organic 80 Silt 15 Sand 5	water lilies submerged pondweed	sweet gail 45 sedge 30 alder 25	black spruce	7.2	14.5	18	white sucker northern redbelly dace finescale dace creek chub

Station MCD-3

Station MCD-3 was located approximately 35 m upstream of the second mine access road stream crossing. The stream was significantly wider at this location, compared with Station MCD-2, with an average width of 7.5 m, and an average depth of 1.5 m. Bottom substrates consisted of 80% organics, 15% silt and 5% sand.

Aquatic vegetation in ponded areas consisted of water lilies and submerged pondweed. Stream bank and forest margin vegetation was similar to that observed at the other two sampling stations.

4.3.4.3 Fish Communities

Fisheries inventories conducted in 1988 and 1997 indicate that Macassa Creek supports a warm water fish community comprising mainly forage fish species. Fish habitat for warm water fish species is abundant in the upper portion of Macassa Creek, ranging from slow meandering deep water sections to swift flowing shallow areas. The warm water habitat is consistent with the fact that flows in Macassa Creek are derived predominantly from surface runoff, rather than from cooler groundwater inputs, as a result of the bedrock controlled topography.

During the June 1997 investigations, a total of 115 unit efforts of gill netting at all three stations (combined) resulted in a total capture of 75 common white suckers (*Catostomus commersoni*). The gill netting efforts represent CPUEs of 0.551, 0.095 and 0.054 for stations MCU-1, MCD-2 and MCD-3, respectively (Table 11). Lengths of the white suckers captured generally ranged between 20 and 25 cm, with a maximum length of 35 cm.

In November 1988, gill netting was only conducted at station MCD-3. The 1988 results (Table 11) show that a greater effort (50 hours total) was conducted, but resulted in zero captures. It is likely that differences in the capture success between the different years are a function of seasonality.

The June 1997 investigations show that the forage fish community consists of northern redbelly dace (*Phoxinus eos*), finescale dace (*Chrosomus neogaeus*), creek chub (*Semotilus atromaculatus*) and Iowa darter (*Etheostoma exile*). A total of eight minnow traps were set for a total of 158.5 hours of fishing effort, resulting in the capture of 379 dace, 16 creek chub, 1 Iowa darter and 6 common white sucker (Table 12). Again, the 1988 results showed no fish captures, with the use of three minnow traps.

TABLE 11
Summary of Gill Net Collections - Macassa Creek

Station	Mesh (inches)	# of Units (gill nets)	Hours Fished	Total Unit Effort	Catch (per species)	Catch per Unit Effort**
June 19 to 21, 1997						
MCU-1	1.5 3.5	2	19	38	69 white sucker	0.884
MCD-2	1.5 3.5	2	21	42	4 white sucker	0.052
MCD-3	1.5 2.5	2	18.5	37	2 white sucker	0.026
November 8 to 12, 1988						
MCD-3	1.5 2.0	2	25	50	0 fish	0

* Total Unit Effort refers to the number of 15 m gill nets multiplied by the number of hours fished.
** Catch per Unit Effort is the total catch divided by the total unit effort.

Electrofishing in June 1997 was conducted at station MCD-2, which resulted in the capture of 3 creek chub and 2 dace (Table 13). The 1988 electrofishing efforts resulted in similar captures of 4 redbelly dace and 1 Iowa darter.

Environmental factors which could affect fish populations in the upper portion of Macassa Creek include two sections of impassible waterfalls, located approximately 5 km upstream of the East Pukaskwa River (Figure 5). Upstream migration of local fish is inhibited, as both falls have vertical drops of over 2 m. As a result, it may be difficult for this creek to support populations of locally available game fish.

TABLE 12
Summary of Minnow Trap Collections - Macassa Creek

Station	Number of Traps	Total Time (hours)	Catch
June 17 to 19, 1997			
MCU-1	3	58.5	323 dace 2 white sucker
MCD-2	2	40	29 dace 6 creek chub 1 Iowa carter
MCD-3	3	60	27 dace 8 creek chub 4 white sucker
November 8 to 12, 1988			
MCD-3	3	75	0

TABLE 13
Summary of Electrofishing Collections - Macassa Creek

Station	Date	Sampling Time (minutes)	Electrofishing (seconds)	Catch
MCD-2	June 19, 1997	30	850	3 creek chub 2 dace
MCD-2	November, 1988	180	unknown	4 redbelly dace 1 Iowa darter

Other factors which may limit fish populations could also include low summer/winter water levels and oxygen concentrations and/or high summer temperatures. These environmental factors are particularly important for this site, as no large point sources of groundwater are apparent (EAG, 1989). Therefore the majority of water entering Macassa Creek during the summer consists of warm surface runoff. In addition, the beaver impoundment in the headwaters also contributes to a surface water warming effect.

4.4 BENTHIC INVERTEBRATE INVESTIGATIONS

4.4.1 General

Benthos sample results were interpreted using diversity indices (Shannon-Wiener) and similarity indices (Morisita). The samples were also enumerated to determine the number of organisms per square metre (density). The following discussion provides a general background on benthic invertebrates, and on the two aforementioned methods of data interpretation

Benthic invertebrates (benthos) inhabit the bottom substrates of creeks, rivers, lakes and ponds, for at least a portion of their life cycle. They provide an important food source for fish and some waterfowl, and have been recognized as important indicators of water quality (Krueger et al., 1988; Metcalfe, 1989; and Griffiths, 1993). Of particular interest in this regard are the larger forms, or macro invertebrates. These forms are typically visible to the naked eye (i.e., greater than 0.5 mm diameter; Griffiths, 1993). They include several insect groups, most notably stoneflies, mayflies, caddisflies, midges, other dragonflies and beetles; as well as other invertebrate groups such as crustaceans, snails, clams, segmented worms and leaches.

Griffiths (1993) considered macro-benthic organisms to be good indicators of water (and sediment) quality for the following reasons:

- they are abundant;
- they are easily collected with relatively inexpensive equipment;
- they are readily identified;
- they usually remain in localized areas because of their restricted mobility and habitat preference;
- they are continuously subjected to the full rigour of the local environment throughout their aquatic life-cycle, which may very from weeks to years;
- they show a wide range of tolerances to various degrees and types of pollution; and,
- they integrate the effects of all pollutants and environmental conditions over time and thus provide a holistic measure of ecological impact.

Despite these advantages, there are limitations to the use and interpretation of benthos populations, as indicators of water and sediment quality. Most importantly, benthos commonly exhibit patchy distributions, and show strong variations in seasonal abundance. Benthos populations in flowing water (i.e., creeks and rivers) are also influenced by drift from upstream waters.

Patchy distributions of organisms can result from varying dependence on specific bottom substrates and current conditions at the time of sampling. Wide population fluctuations are also frequently observed within even apparently homogeneous habitats. These limitations can be addressed by selecting and documenting appropriate sampling locations and conditions, collecting replicate samples, and by collecting samples at a time when seasonal variations are less likely to be a limiting factor. Typically, the best time to collect benthos samples is in the fall, following the period of major emergence by winged species, and prior to the winter season.

As a result of Project scheduling and the proposed Project startup date, benthic sampling in Macassa Creek could not be conducted in the fall, but was conducted instead during the late spring (June 1997). The results of the June sampling program will still provide a basis from which to assess water quality conditions, however, any future sampling would also be conducted in June for comparison purposes.

A general breakdown of species group sensitivities to water (and sediment) quality can be defined as follows:

- intolerant to pollution stresses, being indicative of excellent water and sediment quality (mayflies, stoneflies and caddisflies);
- more tolerant of pollution stresses, but still requires fair to good water and sediment quality (chironomids, damselflies and dragonflies, snails, shrimp and tube worms); and,
- pollution tolerant species (midges, craneflies, horseflies and redworms).

Data analysis of benthos populations frequently includes the use of various indices to provide an overall measure of community state, or health. Such indices tend to focus on the richness (number of species) and evenness (diversity), and on the presence of pollution intolerant forms. Common indices used for this purpose include variants of the Shannon-Wiener diversity index, and the Morisita similarity index, and various biotic indices such as the Trent, Chutters and Chandler indices (Krueger et al., 1988).

These authors recommend use of the Shannon-Wiener index for most situations where it is desirable to compare values from large communities. The diversity index (H') is utilized to determine species diversity within a community, which can then be compared to the diversity of other sampled communities.

Other authors have expressed preferences for other indices, but recognize the value of the Shannon-Wiener Index because of its historical, wide spread application (Washington, 1984). The formula for the Shannon-Wiener Index is as follows:

$$H' = -\sum_{i=1}^{n} p_i \log p_i$$

where: H' = diversity index;
n = total number of taxa; and,
p_i = proportion of the total number of individuals in the i-th taxa.

Sampling stations represented by high diversity indices generally consist of a community distinguished by a large number of species having either a uniform or irregular distribution.

Increased diversity generally results form a combination of diverse habitats and good water quality conditions. As conditions become less favourable, less tolerant species will diminish.

Use of the Morisita similarity index is also recommended by Krueger et al. (1988) where changes or similarities in community compositions are being examined. The Morisita similarity index has the advantage of being independent of diversity and sample size. Similarities between neighbouring communities can be determined by measuring the differences between the abundances of each species present (Brower, 1989). Similarity indices range from 0 (no similarity) to approximately 1.0 (identical).

The formula for the Morisita similarity index is expressed as:

$$C_\lambda = \frac{2 \sum_{i=1}^{n} x_i y_i}{(\lambda_x + \lambda_y)(N_x N_y)}$$

where: C_λ = Morisita similarity index;
$x_i y_i$ = the product of the number of individuals of the i-th taxa in samples x and y;
N_x and N_y are the total number of individuals of all taxa in samples x and y; and,
λ_x and λ_y are measures of the dispersion of species and taxa within samples x and y,

where:

$$\lambda_x = \frac{\sum_{i=1}^{n} (x_i)(x_i - 1)}{N_x (N_x - 1)}$$

4.4.2 Sampling Methodology

Sampling of native substrate, for the collection of benthic invertebrate organisms, was conducted using a Petite Ponar Dredge, with a sample area of 288 cm^2. At each station, three separate substrate samples (replicates) were collected and sieved in the field using a 400 μm mesh screen, and preserved in 4% formalin. Replicate samples were collected approximately 6 to 8 m downstream from one another to ensure that a representative sample of the substrate was collected. Each replicate was the further product of three pooled Ponar grab samples, which were collected approximately 1 to 2 m apart from one another.

Field efforts were conducted such that the habitats sampled were comparable between the three stations (i.e., were similar in character), and included consideration of: substrate type, water depth, currents, position relative to obstructions, and adjacent habitats. All samples were located within depositional zones of pools and/or back eddies.

Laboratory analysis consisted of standard practices of cleaning, sorting and sub-sampling techniques, followed by organism identification. Replicates (i.e., composites of three pooled grab samples) were enumerated to determine the number of organisms per square metre. Identification of most organisms was to the genus level, with identification to species, family or subfamily (as appropriate) for certain groups of organisms.

4.4.3 Results and Discussion

Benthic invertebrate (benthos) sampling in the upper watershed area of Macassa Creek was conducted on June 17 and 18, 1997, by AGRA field staff. Benthos samples were collected from the three stations at which the water and sediment samples were collected (Figure 5).

Results of the benthic invertebrate sampling program are provided in Table 14. Results for each station are discussed separately below. A comparison of results between the stations is provided in Section 4.4.3.4. There are no benthos sampling results for the November 1988 studies.

4.4.3.1 Upstream of Proposed Discharge (Station MCU-1)

A total of 15 different taxa were identified in the three replicate samples collected at the upstream station (MCU-1). The mean (average) number of taxa for the three replicates was 7. A maximum of 12 taxa was identified in one of the three replicates, indicating that there is a moderate variance in taxa within the area sampled. The mean density of organisms for the combined replicates at station MCU-1 was 880 organisms/m^2.

Diversity indices were calculated for each individual replicate utilizing the Shannon-Wiener diversity index (bottom of Table 14). Diversity indices were variable, ranging from 0.3010 to 0.9819, and suggesting a patchy and fluctuating environment. The mean diversity index, for the three replicates collected at station MCU-1, was 0.6644.

The order Diptera (true flies, mosquitoes, gnats, midges) had the greatest representation in the three replicate samples, and was represented primarily by the families Chironomidae (midges) and Tanypodinae. Chironomids are indicative of fair to generally good water and sediment quality conditions, however, many chironomid species are fairly tolerant of metal stressed conditions (Winner et al, 1980).

A limited number of taxa and individuals in the class of Oligochaetae (segmented worms) were identified in two of the replicates, and were represented by the families Naididae and Tubificidae. Oligochaetaes are fairly tolerant to stressed conditions.

Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies) are three orders of invertebrates that are particularly susceptible to water quality stresses. None of these taxa orders were represented in any replicates sampled at MCU-1. Given that the water and sediment quality are within acceptable limits, the absence of these organisms is presumed to be due to the lack of suitable habitat, and possibly to the time of sampling, rather than due to poor water or sediment quality (see Sections 3.6 and 3.7).

TABLE 14: Benthic Invertebrate Communities in the Macassa Creek Upper Watershed

Sample:	MCU-1			MCD-2			MCD-3		
Replicate:	1	2	3	1	2	3	1	2	3
Date:	97.06.18	97.06.18	97.06.18	97.06.17	97.06.17	97.06.17	97.06.18	97.06.18	97.06.18
% Subsampled:	25	12.5	12.5	12.5	12.5	25	12.5	25	25
ANNELIDA:HIRUDINEA									
ERPOBDELLIDAE:(juvenile)				8	8				
GLOSSIPHONIIDAE:									
Helobdella stagnalis				8		4			4
ANNELIDA:OLIGOCHAETA (segmented worms)									
NAIDIDAE:									
Slavina appendiculata			8						
TUBIFICIDAE: (sludge worms)									
Immature Without Hairs	12			96	40	4			
Immature With Hairs	4								
ACARINA: (water mites)									
Axonopsis						4			
Hydrozetes	4				8				
CRUSTACEA: (shrimps)									
OSTRACODA: (shrimp)									
Candona				8	8				
COLEOPTERA: (beetles)									
ELMIDAE:									
Dubiraphia						12	16		
HALIPLIDAE:									
Haliplus	4								
DIPTERA: (true flies)									
CERATOPOGONIDAE: (biting midges)						8			
CHIRONOMIDAE: (midges)									
CHIRONOMINAE:									
Chironomus				8			8		
Cladopelma	8	8	40	24			8		
Cladotanytarsus							40	28	32
Cryptochironomus				8					4
Dicrotendipes				8			8	8	
Glyptotendipes	4						8		
Lauterbournella					8				
Micropsectra					8				
Microtendipes			8	64	32	36	8		
Pagastiella							24	4	4
Paratanytarsus	4				8				
Polypedilum	4			88	64	32	40	8	16
Rheotanytarsus						4			
Tanytarsus						20	24		
ORTHOCLADIINAE:									
Corynoneura						12			
Cricotopus	8			80	136	32	8	4	
Heterotrissocladius						48			
TANYPODINAE:									
Ablabesmyia						4		4	12
Procladius	24	8	40	24	32		40	4	8
PSYCHODIDAE:									
Pericoma			8						
EPHEMEROPTERA: (mayflies)									
CAENIDAE:									
Caenis youngi							16		
EPHEMERELLIDAE:									
Eurylophella						8			
Serratella (? -early instar)					8				
HEPTAGENIIDAE:									
Arthroplea bipuncata						4			
MEGALOPTERA:									
SIALIDAE:									
Sialis							8		8
ODONATA:									
CORDULIIDAE:									
Cordulia shurtleffi	4		8						
TRICHOPTERA: (caddisflies)									
POLYCENTROPODIDAE									
Phylocentropodidae:									8
MOLLUSCA:BIVALVIA:									
SPHAERIIDAE:									
Pisidium	12		8	32	24	32	8		16
MOLLUSCA:GASTROPODA: (snails)									
VALVATIDAE:									
Valvata sincera				40	8			4	
PLATYHELMINTHES:				8					
TOTAL TAXA	12	2	7	15	14	16	15	8	10
TOTAL NUMBERS (3 grabs)	92	16	120	504	392	264	264	64	112
DENSITY (#/m2)	1,065	185	1,389	5,833	4,537	3,056	3,056	741	1,296
DIVERSITY INDEX	0.9819	0.3010	0.7101	0.9994	0.9170	1.0502	1.0776	0.7591	0.9015
TOTAL TAXA (within station)		15			30			20	
TOTAL NUMBERS (mean)		76			387			147	
DENSITY (#/m2) (mean)		880			4,475			1,698	
DIVERSITY INDEX (mean)		0.6644			0.9889			0.9127	

4.4.3.2 Downstream of Proposed Discharge (Station MCD-2)

Benthic invertebrate sampling at station MCD-2 resulted in the identification of a total of 30 different taxa (Table 14). The number of taxa in each replicate sample was 14, 15 and 16, with a mean number of taxa of 15. This is twice the average number of taxa identified at the upstream station MCU-1. The fact that there were a total of 30 different taxa at this station, but only an average number of 15 taxa in each replicate, indicates a wide variance of the types of taxa within the sampling area.

The mean density of organisms for the combined replicates at station MCU-1 was calculated to be 4,475 organisms/m^2. These results suggest a well established and diverse benthic community.

Diversity indices, calculated for each replicate, ranged from 0.9170 to 1.0502 (bottom of Table 14). Unlike the results for station MCU-1, these indices indicate a relatively even distribution of the number of individuals within each species.

The order Diptera (true flies, mosquitoes, gnats, midges) again exhibited the greatest representation of individuals in each replicate, which included the families/subfamilies Ceratopogonidae and Chironomidae (including Chironominae, Orthocladiinae and Tanypodinae). Chironomids were most strongly represented, and as mentioned above, are indicative of fair to generally good water and sediment quality conditions. A greater number of individuals in the class of Oligochaetae were also represented at this station in each replicate.

Although absent at station MCU-1, a limited number of taxa in the order Ephemeroptera (mayflies) were represented in two of the three replicates collected at station MCD-2.

The abundance and diversity of benthos at station MCD-2 is likely a result of a greater variety of microhabitats and substrate conditions, compared with station MCU-1.

4.4.3.3 Downstream of Proposed Discharge (Station MCD-3)

A total of 20 different taxa were identified in the replicates collection from station MCD-3, with a mean of 11 taxa for all three replicates combined (Table 14). Based on these results, this station is representative of average conditions between station MCU-1 and MCD-2.

Diversity indices calculated for each replicate ranged from 0.7591 to 1.0776. The mean diversity index is 0.9127, which is comparable to 0.9889 for station MCD-2, and indicates a relatively even distribution of individuals within each species.

Similar to results for stations MCU-1 and MCD-2, the order Diptera again exhibited the greatest representation of individuals in each replicate collected at station MCD-3. Chironomids were most strongly represented, and as mentioned above, are indicative of fair to generally good water and sediment quality conditions. Unlike the other two stations, however, stress tolerant Oligochaetae were not represented in any of the replicate samples collected at station MCD-3.

The order Ephemeroptera (may flies) were represented in only one of the three replicates sampled at station MCD-3. In addition, station MCD-3 was the only station at which the order Trichoptera (caddisflies) were represented. Although Oligochaetae were not represented in the samples collected at station MCD-3, the presence of Ephemeroptera and Trichoptera and a moderate abundance of chironomids suggest that a relatively stable environment exists in the area of station MCD-3, with good water and sediment quality, as outlined in Sections 3.6 and 3.7.

4.4.3.4 Comparisons Between Sampling Stations

Morisita similarity indices were calculated for the three stations sampled along Macassa Creek (Table 15). Similarity values between each station were relatively low, with the greatest similarity (0.402) occurring between stations MCD-2 and MCD-3. The comparatively low similarity values shown for the Morisita Index is indicative of patchy habitat, and hence benthos distributions. Direct comparisons between the three stations, following mine development, will therefore have to be interpreted within this context.

TABLE 15
Morisita Index Values - Benthic Invertebrate Collections (June 1997)

Sample Station	MCU-1	MCD-2	MCD-3
MCU-1	-		
MCD-2	0.318	-	
MCD-3	0.362	0.402	-

Respectfully submitted,
AGRA Earth & Environmental Limited

Prepared by:

Debbie Dyck, P.Eng.
Environmental Engineer

Reviewed by:

David Simms, Ph.D.
Head, Environmental Impact Assessment
and Resource Development

5.0 REFERENCES

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6.0 QUALIFICATIONS

I, Debbie Dyck, declare that:

1) I reside at 1177 Bloor Street East, Apartment 401, Mississauga, Ontario, L4Y 2N9.

2) I graduated from the University of Waterloo, with a B.A.Sc. in Chemical Engineering, in 1990. I also obtained a certificate in Environmental Management from Ryerson Polytechnic University in 1992.

3) I have worked in the mining industry for the past 7 years in various capacities as an environmental engineer for a number of mining companies.

4) I have worked as a consulting engineer, with AGRA Earth & Environmental Limited, since 1990.

5) I have no interest or shares in the Magino Mine Property, Mishibishu Gold Corporation, or any of their affiliates, nor do I expect to receive any.

Debbie Dyck

October 7, 1997

APPENDIX A

Acid-Base Accounting Test Results
(relevant results from Bacon, Donaldson & Associates Ltd., December 1988)

BACON,
DONALDSON
& ASSOCIATES LTD.

2036 COLUMBIA STREET
VANCOUVER, B.C. CANADA V5Y 3E1
TELEPHONE (604) 879-8461
TELEX 04-53437

ASSAY DETERMINATIONS AND ENVIRONMENTAL EVALUATIONS OF MISHI COMPOSITE SAMPLES

Prepared for:

MINESTART MANAGEMENT INC.,
1763 Scott Road
North Vancouver, B.C.
V7J 3J4

Attention: Bryan Slim

File Number: M89-031
December 12, 1988

W. G. Bacon
Dr. W. G. Bacon, P.Eng.

1.0 SUMMARY

Seven ore composites and two environmental composites were made as instructed by Mr. Bryan Slim, P.Eng.

The samples were processed to provide information with respect to whether there was a "nugget-effect" and to provide very preliminary metallurgical information.

The assay heads and calculated head assays were:

Composite Number	Assay Head oz/ton, Au	Calc. Head oz/ton, Au
W1	0.157	0.151
W2	0.020	0.020
M1	0.255	0.211
M2	0.026	0.025
M3	0.038	0.040
E1	0.086	0.071
E2	0.031	0.032

Low percentages of gold reported to the gravity concentrates. The reproductability of assays and the low percentages of gold reporting to gravity concentrates indicate there is no "nugget-effect".

There is approximately 20% of the gold that does not respond to cyanidation at 50 to 70% -200 mesh grinds. However only samples W1 and M1 would be considered economic and for these 15% was non-cyanidable at a 50% -200 mesh nominal grind.

The ore and environmental composites are net acid consumers, i.e., they are capable of consuming more acid than they can produce from the contained sulphur.

4.0 ACID PRODUCING/CONSUMING ABILITY

The following acid producing and acid consuming abilities were determined for the ore composites:

Composite	Sulphur wt %	Starting pH	Acid Prod. Ability lb/ton	Acid Cons. Ability lb/ton
W1	0.82	8.2	50.2	82.3
W2	0.40	8.0	24.5	237.1
M1	1.27	8.3	77.8	86.2
M2	0.37	8.5	22.7	194.0
M3	0.34	9.9	20.8	303.8
E1	0.80	7.6	49.0	103.9
E2	0.28	8.0	17.2	>274.4*

* This sample was still consuming the acid supplied by the automatic titrator after 48 hours.

The following acid consuming abilities were determined for the environmental composites:

Composite	Sulphur WT %	Starting pH	Acid Prod. Ability lb/ton	Acid Cons. Ability lb/ton
EM1	0.20	9.2	12.2	383.2
EE2	0.30	9.9	18.4	296.0

The ore samples are net consumers of acid and the environmental samples have a relatively high capability to neutralize any acid produced.

The four non-composited waste samples were assayed for sulphur. The results were too low to justify performing acid consuming ability tests. The sulphur assays were:

Sample	Sulphur
16236	<.01
16237	<.01
16239	<.01
16240	<.01
16241	0.27

APPENDIX B

Certificates of Analysis

THE ENVIRONMENTAL
APPLICATIONS GROUP LIMITED

20 Eglinton Ave. W., Ste. 1006
Toronto, Ontario
M4R 1K8

TEL: (416) 322-5701
FAX: (416) 322-5706

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Granges Exploration Ltd., 168 Second Ave., Timmins, Ontario. P4N 1G1

PROJECT NO. 807

SAMPLES OF 4 water samples

DATE SAMPLED NOV. 10, 1988
Date Received Nov.15, 1988

Physical and General	Units	Farwell Creek	Macassa Creek Upstream	Macassa Creek Downstream	Pukaskwa River
pH		6.80	6.90	6.45	6.90
Conductivity	mg/L	58	25	43	51
Suspended Solids(105°C)	mg/L	5	<2	7	<2
Ammonia-N	mg/L	0.036	<0.025	<0.025	<0.025
Un-ionized Ammonia	mg/L	<0.02	<0.02	<0.02	<0.02
Turbidity	NTU	0.4	0.3	0.6	0.4
Total Hardness	mg $CaCO_3$/L	19	11	17	21
Total Alkalinity	mg $CaCo_3$/L	21	22	11	19
Minor Cations					
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	<0.002	<0.002	<0.002	<0.002
Copper	mg/L	<0.005	<0.005	<0.005	<0.005
Iron	mg/L	0.32	0.21	0.19	0.11
Lead	mg/L	<0.01	<0.01	<0.01	<0.01
Manganese	mg/L	0.02	0.014	0.011	0.004
Mercury	ug/L	<0.2	<0.2	<0.2	<0.2
Nickel	mg/L	<0.01	<0.01	<0.01	0.01
Zinc	mg/L	<0.005	<0.005	<0.005	<0.005

SIGNATURE ____________________ DATE Dec 23/88

807-C2

THE ENVIRONMENTAL
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CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Granges Exploration Ltd.,
168 Second Ave.,
Timmins, Ontario. P4N 1G1

PROJECT NO. 807

SAMPLES OF 3 water samples

DATE SAMPLED JAN. 25, 1989
Date Received Jan. 27,1989

Physical and General	Units	Potable	Macassa Creek	Farwell Creek
pH		7.72	6.58	7.00
Conductivity	uS/cm	360	63	60
Suspended Solids(105°C)	mg/L	<2	4.8	<2
Ammonia-N	mg/L	0.044	0.260	0.145
Unionized Ammonia	mg/L	<0.001	<0.001	<0.001
Turbidity	NTU	1.1	1.1	0.47
Total Hardness	mg $CaCO_3$/L	179	34	34
Total Alkalinity	mg $CaCo_3$/L	180	24	25
Sulphate	mg/L	6.4	3.6	4.2
Chloride	mg/L	2.03	0.59	0.40
Nitrate	mg/L	<0.10	0.17	0.22
Phosphorus	mg/L	0.005	0.01	0.009
Minor Cations				
Arsenic	mg/L	0.007	<0.001	<0.001
Cadmium	mg/L	<0.002	<0.002	<0.002
Chromium	mg/L	<0.005	<0.005	<0.005
Copper	mg/L	0.12	<0.005	<0.005
Iron	mg/L	0.31	0.36	0.22
Lead	mg/L	<0.01	<0.01	<0.01
Manganese	mg/L	1.65	0.025	0.008
Mercury	ug/L	<0.2	<0.2	<0.2
Nickel	mg/L	<0.005	<0.005	<0.005
Zinc	mg/L	0.075	<0.005	<0.005

SIGNATURE [signature] DATE Feb 17, 1989

807-c3

THE ENVIRONMENTAL
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CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Granges Exploration Ltd.,
168 Second Ave.,
Timmins, Ontario. P4N 1G1

PROJECT NO. 807

SAMPLES OF 4 water samples

Date Received Mar. 22,1989

Physical and General	Units	East Pakaskawa	Farwell Creek	Macassa Creek	Potable
pH		7.54	7.19	6.60	7.70
Conductivity	uS/cm	970	110	80	353
Suspended Solids(105^{o}C)	mg/L	<2	<2	5.2	<2
Ammonia-N	mg/L	0.134	0.120	0.429	0.032
Unionized Ammonia	mg/L	<0.001	<0.001	<0.001	<0.001
Turbidity	NTU	0.58	0.40	0.84	0.46
Total Hardness	mg $CaCO_3$/L	40	46	29	146
Total Alkalinity	mg $CaCo_3$/L	45	53	36	194
Sulphate	mg/L	4.5	4.2	3.0	6.6
Chloride	mg/L	0.38	0.39	0.65	3.29
Nitrate	mg/L	0.20	0.10	0.11	<0.1
Phosphorus	mg/L	0.005	0.005	0.010	0.005
Minor Cations					
Arsenic	mg/L	<0.001	<0.001	<0.001	0.004
Cadmium	mg/L	<0.002	<0.002	<0.002	<0.002
Chromium	mg/L	<0.005	<0.005	<0.005	<0.005
Copper	mg/L	0.006	0.006	0.006	0.20
Iron	mg/L	0.15	0.24	0.41	0.01
Lead	mg/L	<0.01	<0.01	0.01	0.01
Manganese	mg/L	0.008	0.107	0.14	0.92
Nickel	mg/L	<0.005	<0.005	<0.005	<0.005
Zinc	mg/L	<0.005	<0.005	0.01	0.04

SIGNATURE Ron Atkinson DATE June 5/89

807-C4

THE ENVIRONMENTAL
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TEL: (416) 322-5701
FAX: (416) 322-5706

CERTIFICATE OF ANALYSIS

SAMPLE(S) FROM Granges Explorations PROJECT NO. 807

SAMPLE(S) 3 water samples DATE SAMPLED: JUL. 17, 1989
Date Received: Jul. 25, 1989

Physical and General	Units	Macassa Creek at Mine Access Road	Macassa Creek at Central Crude Crossing	East Pukaskua River
pH		7.36	7.67	7.56
Conductivity	uS/cm	170	114	98
Ammonia-N	mg/L	0.046	0.061	0.036
Un-inoized Ammonia	mg/L	<0.001	<0.001	<0.001
Turbidity	NTU	0.42	0.41	0.45
Total Hardness	$mgCaCO_3/L$	79	102	86
Total Alkalinity	$mgCaCO_3/L$	52	48	44
Sulphate	mg/L	2.2	5.9	4.4
Chloride	mg/L	0.26	1.51	0.31
Nitrate	mg/L	<0.1	0.3	<0.1
Phosphorus	mg/L	<0.005	0.006	<0.005
Minor Cations				
Arsenic	mg/L	<0.001	<0.001	<0.001
Cadmium	mg/L	<0.002	<0.002	<0.002
Chromium	mg/L	<0.005	<0.005	<0.005
Copper	mg/L	<0.005	<0.005	<0.005
Iron	mg/L	0.061	0.13	0.061
Lead	mg/L	<0.01	<0.01	<0.01
Mercury	ug/L	<0.2	<0.2	<0.2
Nickel	mg/L	<0.005	<0.005	<0.005
Zinc	mg/L	<0.005	<0.005	<0.005

SIGNATURE [signature] DATE August 30, 1989

807-C1

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

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Client : Agra Earth & Environmental
2233 Argentia Rd., Suite 400
Mississauga, Ontario L5N 2X7

Date: July 7, 1997

Page: 1 of 1

Project Name : Mishi Pit

Sample Type: Water

Project No. : TC 76166

Lab Ref.: F97-1042

Contact : Debby Dyck

Final

CERTIFICATE OF ANALYSIS

Lab # Sample ID Date Collected			**S9705356 MCD-3 (17/06/97)**	**S9705357 MCU-1 (18/06/97)**	**S9705358 MCD-2 (17/06/97)**	**Lab Blank**	**Q.C. Standard Actual**	**Q.C. Standard Expected**
Parameters	**Unit**	**MDL***						
pH			6.69	5.89	6.05	5.87	6.00	6.00
Conductivity	(us/cm)	1	40	20	24	<1	106	100
Total Suspended Solids	(mg/L)	2	<2	<2	20	<2	92	100
Total Dissolved Solids	(mg/L)	5	58	57	58	<5	498	500
Total Alkalinity (CaCO3)	(mg/L)	1	11	5	6	<1	101	100
Ammonia as N	(mg/L)	0.025	0.070	0.027	0.033	<0.025	0.40	0.40
Nitrate as N	(mg/L)	0.1	<0.1	<0.1	<0.1	<0.1	2.8	2.8
Sulphate	(mg/L)	0.1	2.1	1.7	1.4	<0.1	15.6	16.0
Total Phosphorus	(mg/L)	0.01	0.02	0.01	0.03	<0.005	0.48	0.50
Colour	(TCU)	5	120	140	140	<5	30	32.5
Turbidity	(NTU)	0.05	1.0	0.8	3.0	<0.05	9.66	10.0
Total Hardness (CaCO3)	(mg/L)		20	12	13	-	-	-

Comments: * Method Detection Limit

Cynthia Ridge, C. Chem.
Q.A/Q.C. Officer

Suman Punani, C. Chem.
Laboratory Manager

CHEMICAL PROFESSION OF ONTARIO
CHARTERED
Suman Punani

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

AGRA Earth & Environmental Limited
160 Traders Blvd.
Unit 4
Mississauga, Ontario
Canada L4Z 3K7
Tel (905) 890-0785
Fax (905) 890-1141

Client : Agra Earth & Environmental
2233 Argentia Rd., Suite 400
Mississauga, Ontario L5N 2X7

Date: July 7,1997

Project Name : Mishi Pit

Sample Type: Water

Project No. : TC 76166

Lab Ref.: F97-1042

Contact : Debby Dyck

Final

CERTIFICATE OF ANALYSIS

ICP Metals

Lab # / Sample ID / Date Collected			S9705359 MCD-2 (17/6/97)	S9705360 MCD-3 (17/6/97)	S9705361 MCU-1 (18/6/97)	Lab Blank	Q.C. Standards Actual	Q.C. Standards Expected
Parameters	**Unit**	**MDL***						
Aluminum	(mg/L)	0.05	0.17	0.17	0.24	<0.05	0.50	0.50
Arsenic	(mg/L)	0.001	<0.001	<0.001	<0.001	<0.001	0.0015	0.0016
Barium	(mg/L)	0.005	0.007	0.008	0.009	<0.005	0.20	0.20
Bismuth	(mg/L)	0.001	<0.001	<0.001	<0.001	<0.001	1.02	2.00
Beryllium	(mg/L)	0.001	<0.001	<0.001	<0.001	<0.001	0.050	0.050
Cadmium	(mg/L)	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.055	0.050
Calcium	(mg/L)	0.05	4.0	7.0	4.0	<0.05	19.4	20.0
Cobalt	(mg/L)	0.005	<0.005	<0.005	<0.005	<0.005	0.21	0.20
Chromium	(mg/L)	0.01	<0.01	<0.01	<0.01	<0.01	0.22	0.20
Copper	(mg/L)	0.001	0.002	0.002	0.003	<0.001	0.22	0.20
Iron	(mg/L)	0.01	0.20	0.20	0.20	<0.01	0.21	0.20
Lead	(mg/L)	0.001	<0.001	<0.001	<0.001	<0.001	0.21	0.20
Magnesium	(mg/L)	0.05	0.60	0.80	0.50	<0.05	5.0	5.0
Manganese	(mg/L)	0.05	0.01	0.02	0.01	<0.05	1.00	1.00
Mercury	(mg/L)	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	0.002
Molybdenum	(mg/L)	0.05	<0.05	<0.05	<0.05	<0.05	0.20	0.20
Nickel	(mg/L)	0.005	<0.005	<0.005	<0.005	<0.005	0.21	0.20
Phosphorus	(mg/L)	0.05	<0.05	<0.05	<0.05	<0.05	2.40	2.50
Potassium	(mg/L)	0.05	0.06	0.07	<0.05	<0.05	9.90	10.0
Silver	(mg/L)	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.054	0.050
Sodium	(mg/L)	0.05	0.30	0.40	0.30	<0.05	10.0	10.0
Vanadium	(mg/L)	0.05	<0.05	<0.05	<0.05	<0.05	0.18	0.20
Zinc	(mg/L)	0.001	0.006	0.009	0.007	<0.001	0.20	0.20

Comments: * Method Detection Limit

Analyst: M. Mak, C. Chem.

Cynthia Ridge, C. Chem.
Q.A./Q.C. Officer

Suman Punani, C. Chem.
Laboratory Manager

CHARTERED
Suman Punani
CHEMIST

AGRA
Earth & Environmental

Client	:	Agra Earth & Environmental 2233 Argentia Rd., Suite 400 Mississauga, Ontario L5N 2X7	Date: July 11, 1997 Page: 1 of 1
Project Name :		Mishi Pit	Sample Type: Sediment
Project No.	:	TC 76166	Lab Ref.: F97-1041
Contact	:	Debby Dyck	Final

CERTIFICATE OF ANALYSIS

Lab # Sample ID Date Collected			S9705350 MCU-1 0-5 cm (18/6/97)	S9705351 MCU-1 5-10 cm (18/6/97)	S9705352 MCD-2 0-5 cm (18/6/97)	S9705353 MCD-2 5-10 cm (18/6/97)	S9705354 MCD-3 0-5 cm (18/6/97)	S9705355 MCD-3 5-10 cm (18/6/97)	Lab Blank	Q.C. Standard Actual	Q.C. Standard Expected
Parameters	**Unit**	**MDL***									
pH			5.68	6.19	6.55	7.82	5.99	6.05	5.87	6.00	6.00
Loss On Ignition	(%)	0.1	12.6	1.6	0.9	0.5	10.3	13.2 (10.9)	<0.1	-	-
Metals											
Arsenic	(ug/g)	0.1	0.4	0.5	0.5	0.5	1.4	1.6 (1.6)	<0.1	0.0016	0.0016
Cadmium	(ug/g)	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5 (0.5)	<0.5	0.21	0.20
Calcium	(ug/g)	5	4420	3040	2180	9340	2990	2560 (2820)	<5	20.8	20.0
Copper	(ug/g)	1	11	14	16	20	14	14 (14)	<1	0.99	1.00
Chromium	(ug/g)	1	12	15	14	13	11	14 (12)	<1	0.98	1.00
Iron	(ug/g)	1	4440	5170	6320	5490	4240	7310 (4330)	<1	1.99	2.00
Lead	(ug/g)	5	6	6	7	<5	10	8 (7)	<5	2.00	2.00
Manganese	(ug/g)	5	65	70	115	67	137	86 (80)	<5	0.99	1.00
Magnesium	(ug/g)	5	1730	2010	2880	5620	1420	2890 (1800)	<5	4.7	5.0
Mercury	(ug/g)	0.01	0.04	0.01	0.02	0.01	0.04	0.02 (0.03)	<0.01	0.002	0.002
Nickel	(ug/g)	5	7	10	10	8	8	12 (8)	<5	1.00	1.00
Zinc	(ug/g)	1	21	16	20	16	32	32 (30)	<1	0.95	1.00

Comments: * Method Detection Limit

for Cynthia Ridge, C. Chem.
Q.A/Q.C. Officer

Suman Punani, C. Chem.
Laboratory Manager

12.0 CERTIFICATE OF QUALIFICATION

J. G. SPITERI
CONSULTING MINING GEOLOGIST

C E R T I F I C A T E

As author of the report "Scoping Study on the Mishi Project-Mishibishu Lake Area Ontario, Canada" for Mishibishu Gold Corporation, I hereby make the following statements

1. My name is Joseph G. Spiteri and I am a Consulting Geologist, principal of Spiteri Geological & Mining & Mining Consultants Inc. My office address is RR #2 Acton, Ontario, Canada L7J 2L8

2. I have received the following degree in Earth Sciences: B.Sc. 1976, University of Toronto

3. I am a member of the Canadian Institute of Mining and Metallurgy as well as a Fellow of the Geological Association of Canada.

4. I have been practicing as a professional geologist and mine operator for over twenty years.

5. This report is based on technical information supplied by Mishibishu Gold Corporation and their consultants. I visited the property on July 3, 1997.

6. I have neither received nor do I expect to receive any interest, direct or indirect, in the properties of Mishibishu Gold Corporation or any affiliate; I do not beneficially own, directly or indirectly, any securities of Mishibishu Gold Corporation or any affiliate.

Dated at Acton, Ontario, Canada
October 14, 1997

Joseph G. Spiteri, B.Sc.

SPHERE AGRA

Ontario

Ministry of Northern Development and Mines

Declaration of Assessment Work Performed on Mining Land

Mining Act, Subsection 65(2) and 66(3), R.S.O. 1990

Transaction Number (office use) W9750.00895

Assessment Files Research Imaging

Personal information collected ... of subsections 65(2) and 66(3) of the Mining Act. Under section 8 of the Mining Act, the information is a ... correspond with the mining land holder. Questions about this collecti... Development and Mines, 6th Floor, 933 Ramsey Lake Road, Sudt...

42C03SW0025 2.17769 MISHIBISHU LAKE 900

Instructions: - For work pe... orm 0240.
- Please type or print in ink.

1. Recorded holder(s) (Attach a list if necessary)

Name: MACMILLAN GOLD CORP~~ORATION~~	Client Number: 162922
Address: 365 BAY ST., 11th Floor	Telephone Number: 416-363-1124
TORONTO, ON M5H 2V1	Fax Number: 416-360-0728
Name	Client Number
Address	Telephone Number
	Fax Number

RECEIVED OCT 23 1997 3:00 GEOSCIENCE ASSESSMENT OFFICE

2. Type of work performed: Check (✓) and report on only ONE of the following groups for this declaration.

[✓] Geotechnical: prospecting, surveys, assays and work under section 18 (regs)
[ ] Physical: drilling, stripping, trenching and associated assays
[ ] Rehabilitation

Work Type		Office Use	
~~SECTION 18(97)~~ ENVIRONMENTAL STUDY		Commodity	
		Total $ Value of Work Claimed	46,889 JEM
Dates Work Performed: From 01 02 97 (Day Month Year) To 07 10 97 (Day Month Year)		NTS Reference	
Global Positioning System Data (if available)	Township/Area: MISHIBISHU LAKE AREA	Mining Division	SSM
	M or G-Plan Number: G-3772	Resident Geologist District	SSM

Please remember to: - obtain a work permit from the Ministry of Natural Resources as required;
- provide proper notice to surface rights holders before starting work;
- complete and attach a Statement of Costs, form 0212;
- provide a map showing contiguous mining lands that are linked for assigning work;
- include two copies of your technical report.

2.17769

3. Person or companies who prepared the technical report (Attach a list if necessary)

Name: AGRA EARTH AND ENVIRONMENTAL LIMITED	Telephone Number: 905-568-2929
Address: 2233 ARGENTIA ROAD, SUITE 400 MISSISSAUGA, ON L5N 2X7	Fax Number: 905-568-1686
Name	Telephone Number
Address	Fax Number
Name	Telephone Number
Address	Fax Number

4. Certification by Recorded Holder or Agent

I, JAMES MILLARD (Print Name), do hereby certify that I have personal knowledge of the facts set forth in this Declaration of Assessment Work having caused the work to be performed or witnessed the same during or after its completion and, to the best of my knowledge, the annexed report is true.

Signature of Recorded Holder or Agent: JEMillard		Date: Oct. 22/97
Agent's Address: 16 BROADWAY, WAWA ON P0S 1K0	Telephone Number: 705-856-8195	Fax Number: 705-856-8196

Deemed Jan. 21/97.

W4750.00895

5. Work to be recorded and distributed. Work can only be assigned to claims that are contiguous (adjoining) to the mining land where work was performed, at the time work was performed. A map showing the contiguous link must accompany this form.

Mining Claim Number. Or if work was done on other eligible mining land, show in this column the location number indicated on the claim map.		Number of Claim Units. For other mining land, list hectares.	Value of work performed on this claim or other mining land.	Value of work applied to this claim.	Value of work assigned to other mining claims.	Bank. Value of work to be distributed at a future date.
eg	TB 7827	16 ha	$26, 825	N/A	$24,000	$2,825
eg	1234567	12	0	$24,000	0	0
eg	1234568	2	$ 8, 892	$ 4,000	0	$4,892
1 (500 8147)	CLM - 377	480 ha	$15,623	N/A		$15,623
2 (500 8148)	CLM- 378	384 ha	$15,623	N/A		$15,623
3 (500 8149)	CLM - 379	288 ha	$15,623	N/A		$15,623
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
		Column Totals	$ 46,869.00 JEM			46,869. JEM

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OCT 23 1997
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I, JAMES E. MILLARD (Print Full Name), do hereby certify that the above work credits are eligible under subsection 7 (1) of the Assessment Work Regulation 6/96 for assignment to contiguous claims or for application to the claim where the work was done.

Signature of Recorded Holder or Agent Authorized in Writing	Date
E Millard	OCT. 22/97

2.17769

6. Instructions for cutting back credits that are not approved.

Some of the credits claimed in this declaration may be cut back. Please check (✓) in the boxes below to show how you wish to prioritize the deletion of credits:

- [x] 1. Credits are to be cut back from the Bank first, followed by option 2 or 3 or 4 as indicated.
- [ ] 2. Credits are to be cut back starting with the claims listed last, working backwards; or
- [x] 3. Credits are to be cut back equally over all claims listed in this declaration; or
- [ ] 4. Credits are to be cut back as prioritized on the attached appendix or as follows (describe):

Note: If you have not indicated how your credits are to be deleted, credits will be cut back from the Bank first, followed by option number 2 if necessary.

For Office Use Only

Received Stamp	Deemed Approved Date	Date Notification Sent
	Date Approved	Total Value of Credit Approved
	Approved for Recording by Mining Recorder (Signature)	

0241 (02/96)

H4411

Ontario | Ministry of Northern Development and Mines

Statement of Costs for Assessment Credit

Transaction Number (office use): W9750.00595

Personal information collected on this form is obtained under the authority of subsection 6(1) of the Assessment Work Regulation 6/96. Under section 8 of the Mining Act, the information is a public record. This information will be used to review the assessment work and correspond with the mining land holder. Questions about this collection should be directed to the Chief Mining Recorder, Ministry of Northern Development and Mines, 6th Floor, 933 Ramsey Lake Road, Sudbury, Ontario, P3E 6B5.

Work Type	Units of Work Depending on the type of work, list the number of hours/days worked, metres of drilling, kilometres of grid line, number of samples, etc.	Cost Per Unit of work	Total Cost
GEOTECHNICAL SURVEY	CONSULTANT'S FEES/		~~$46,870~~
- ENVIRONMENTAL STUDY	EXPENSES		$38,870.
Associated Costs (e.g. supplies, mobilization and demobilization).			
CHEMICAL/BIOLOGICAL ANALYSES			$8,000
Transportation Costs			
Food and Lodging Costs			
		Total Value of Assessment Work	$46,870.00

RECEIVED
OCT 23 1997 3:00
GEOSCIENCE ASSESSMENT OFFICE

2.17769

Calculations of Filing Discounts:

1. Work filed within two years of performance is claimed at 100% of the above Total Value of Assessment Work.
2. If work is filed after two years and up to five years after performance, it can only be claimed at 50% of the Total Value of Assessment Work. If this situation applies to your claims, use the calculation below:

TOTAL VALUE OF ASSESSMENT WORK × 0.50 = Total $ value of worked claimed.

Note:
- Work older than 5 years is not eligible for credit.
- A recorded holder may be required to verify expenditures claimed in this statement of costs within 45 days of a request for verification and/or correction/clarification. If verification and/or correction/clarification is not made, the Minister may reject all or part of the assessment work submitted.

Certification verifying costs:

I, JAMES E. MILLARD (please print full name), do hereby certify, that the amounts shown are as accurate as may reasonably be determined and the costs were incurred while conducting assessment work on the lands indicated on the accompanying Declaration of Work form as AGENT (recorded holder, agent, or state company position with signing authority) I am authorized to make this certification.

Signature	Date
JEMillard	OCT. 22/97

Ministry of
Northern Development
and Mines

Ministère du
Développement du Nord
et des Mines

Ontario

Geoscience Assessment Office
933 Ramsey Lake Road
6th Floor
Sudbury, Ontario
P3E 6B5

Telephone: (888) 415-9846
Fax: (705) 670-5881

January 22, 1998

MACMILLAN GOLD CORP.
365 BAY STREET
11TH FLOOR
TORONTO, ONTARIO
M5H-2V1

Dear Sir or Madam:

Submission Number: 2.17769

		Status
Subject: Transaction Number(s):	W9750.00895	Deemed Approval

We have reviewed your Assessment Work submission with the above noted Transaction Number(s). The attached summary page(s) indicate the results of the review. WE RECOMMEND YOU READ THIS SUMMARY FOR THE DETAILS PERTAINING TO YOUR ASSESSMENT WORK.

If the status for a transaction is a 45 Day Notice, the summary will outline the reasons for the notice, and any steps you can take to remedy deficiencies. The 90-day deemed approval provision, subsection 6(7) of the Assessment Work Regulation, will no longer be in effect for assessment work which has received a 45 Day Notice.

Please note any revisions must be submitted in DUPLICATE to the Geoscience Assessment Office, by the response date on the summary.

If you have any questions regarding this correspondence, please contact Lucille Jerome by e-mail at jeromel2@epo.gov.on.ca or by telephone at (705) 670-5858.

Yours sincerely,

ORIGINAL SIGNED BY
Blair Kite
Supervisor, Geoscience Assessment Office
Mining Lands Section

Correspondence ID: 11797

Copy for: Assessment Library

Work Report Assessment Results

Submission Number: 2.17769

Date Correspondence Sent: January 22, 1998 **Assessor:** Lucille Jerome

Transaction Number	First Claim Number	Township(s) / Area(s)	Status	Approval Date
W9750.00895	377	MISHIBISHU LAKE	Deemed Approval	January 21, 1998

Section:
18 Other ENVIRO

Assessment work credit has been redistributed, as outlined on the attached Distribution of Assessment Work Credit sheet, to better reflect the location of the work.

Correspondence to:
Resident Geologist
Sault Ste. Marie, ON

Assessment Files Library
Sudbury, ON

Recorded Holder(s) and/or Agent(s):
James Millard
WAWA, ON, CAN

MACMILLAN GOLD CORP.
TORONTO, ONTARIO

Distribution of Assessment Work Credit

The following credit distribution reflects the value of assessment work performed on the mining land(s).

Date: January 22, 1998

Submission Number: 2.17769

Transaction Number: W9750.00895

Claim Number	Value Of Work Performed
CLM 377	40,000.00
CLM 378	6,869.00
Total: $	46,869.00

Correspondence ID: 11797


2.17769 ENVIRO
LEGARDE ADDITIONAL
LEGARDE TWP.
FOR STATUS OF LAND SEE TWP. PLAN
ST. GERMAIN TWP.
FOR STATUS SEE TWP. PLAN
GROSEILLIERS TWP.
FOR STATUS SEE TWP. PLAN
DAVID LAKES
POINT ISACOR
Mishibishu Lake
CLM 379
CLM 378
CLM 377
REFERENCES
LEGEND
HIGHWAY AND ROUTE No.
OTHER ROADS
TRAILS
SURVEYED LINES:
TOWNSHIPS, BASE LINES, ETC.
LOTS, MINING CLAIMS, PARCELS, ETC.
UNSURVEYED LINES:
LOT LINES
PARCEL BOUNDARY
MINING CLAIMS ETC.
RAILWAY AND RIGHT OF WAY
UTILITY LINES
NON-PERENNIAL STREAM
FLOODING OR FLOODING RIGHTS
SUBDIVISION OR COMPOSITE PLAN
RESERVATIONS
ORIGINAL SHORELINE
MARSH OR MUSKEG
MINES
TRAVERSE MONUMENT
LAND USE PERMIT
DISPOSITION OF CROWN LANDS
TYPE OF DOCUMENT
SYMBOL
PATENT, SURFACE & MINING RIGHTS
SURFACE RIGHTS ONLY
MINING RIGHTS ONLY
LEASE, SURFACE & MINING RIGHTS
SURFACE RIGHTS ONLY
MINING RIGHTS ONLY
LICENCE OF OCCUPATION
ORDER-IN-COUNCIL
RESERVATION
CANCELLED
SAND & GRAVEL
SCALE: 1 INCH = 40 CHAINS
DATE OF ISSUE
JAN 27 1998
PROVINCIAL RECORDING OFFICE - SUDBURY
THE INFORMATION THAT APPEARS ON THIS MAP HAS BEEN COMPILED FROM VARIOUS SOURCES, AND ACCURACY IS NOT GUARANTEED. THOSE WISHING TO STAKE MINING CLAIMS SHOULD CONSULT WITH THE MINING RECORDER, MINISTRY OF NORTHERN DEVELOPMENT AND MINES, FOR ADDITIONAL INFORMATION ON THE STATUS OF THE LANDS SHOWN HEREON.
AREA
MISHIBISHU LAKE
WAWA
SAULT STE. MARIE
ALGOMA
Ministry of Natural Resources
Ministry of Northern Development and Mines
Ontario
FEBRUARY 1987
G-3772
AREAS WITHDRAWN FROM DISPOSITION
M.R.O. - MINING RIGHTS ONLY
S.R.O. - SURFACE RIGHTS ONLY
M.+S. - MINING AND SURFACE RIGHTS
TRIM TO THIS LINE ALL AROUND