JERICHO DIAMOND PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT
AQUATIC BIOTA

RL&L
Environmental Services Ltd.

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AQUATIC BIOTA

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The following R.L. & L. Environmental Services Ltd. personnel participated in this EIA:

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EXECUTIVE SUMMARY

Introduction

The Jericho Project constitutes an application by Tahera Corporation (Tahera) to construct and operate a diamond mine in Nunavut Territory adjacent to the northwest side of Contwoyto Lake. The proposed project entails mining and processing a single kimberlite pipe situated beside a small, unnamed waterbody locally known as Carat Lake.

The Jericho Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement. As part of this review, Tahera is required to prepare an application that includes sufficient data and analyses for a complete assessment of anticipated impacts of the project by the regulatory authorities. An integral part of this application is an Environmental Impact Statement. This report addresses the potential effects of the project on aquatic organisms.

The report identifies and evaluates environmental effects to fish and other aquatic organisms that could result from the proposed project. Specifically, the objectives are:

- to describe the project components, existing aquatic environment and biological community;
- to identify potential environmental effects of the proposed project on aquatic biota;
- to outline mitigative measures designed to minimize the potential environmental effects;
- to assess the significance of residual or adverse environmental effects that will remain following mitigation; and,
- to describe an environmental monitoring program that will be implemented to ensure the integrity of the aquatic biological community.

The approach to this Environmental Impact Assessment (EIA) follows the Nunavut Water Board document entitled *Guidelines for the Proposed Jericho Project, September 8, 1999 - Draft* (NWB 1999), which provides direction regarding the contents and format of the environmental assessment. The EIA considers all components of the proposed development at the Jericho Site; cumulative effects associated with the project are not addressed.

Summary of Aquatic Environment

Waterbodies in the Jericho Site exhibit characteristics similar to other subarctic lakes. Most have simple shorelines composed of cobbles and boulders. Most streams in the area are small, ill-defined channels containing coarse substrates. Stream hydrology is affected by low precipitation and the presence of permafrost. Water flows in many streams decrease rapidly after snow melt and water levels become very low or dry during summer.

Nutrient concentrations in lakes and streams are low, with most measurements being near or below detection limits. In general, all waterbodies are cold, oxygen rich and clear. Based on these characteristics, they can be categorized as oligotrophic. The oligotrophic status of these waterbodies severely limits their productive capacity. As such, their biological communities typically exhibit low species diversities and densities of organisms.

Aquatic macrophytes are severely limited in lakes, which is due to the lack of suitable substrates situated in shallow-water, sheltered areas, and low nutrient concentrations. Phytoplankton, periphyton, zooplankton, and benthic invertebrate communities exhibit low densities and are dominated by relatively few taxa.

Lakes in the Jericho Site support simple fish communities consisting of stable, slow-growing fish populations that are characteristic of cold, oligotrophic systems. Species recorded in the study area include Arctic char, Arctic grayling, burbot, lake trout, ninespine stickleback, round whitefish and slimy sculpin. Arctic char, lake trout and round whitefish tend to be numerically dominant in these communities; densities of all other species are low. No rare or endangered fish species were recorded in the Jericho Site.

The fish populations undertake limited movements between lakes in the Jericho Site due primarily to the lack of good movement corridors and the presence of fish barriers at several locations. In particular, fish in the upper Carat Lake basin are separated from fish in the Jericho River by a large barrier near the outlet to Jericho Lake.

Waterbodies in the Jericho Site provide all the habitats that are necessary to support resident fish populations. In general, feeding and overwintering habitats are abundant in most lakes. Potential spawning habitat for most species is also widely distributed. In contrast, sheltered rearing habitat for younger fish is limited. Streams in the Jericho Site freeze to the channel bottom in winter, but they provide rearing habitat for fish during the open water period. Most streams are used on an opportunistic basis by the lake resident fish populations and use is generally restricted to the lowermost section.

Environmental Impact Assessment

<u>Approach</u>

The primary purpose of this document is to evaluate the environmental effects of the proposed development on the aquatic biota. Fish have been selected as the valued environmental component (VEC) of the aquatic biological community since they are sensitive to changes to the aquatic environment and they are highly valued by society. Fish are also a good indicator of biodiversity.

The first step of the EIA process is to identify all potential environmental effects that may result from project activities, and then review each potential effect in relation to proposed environmental management and mitigative measures. Based on this review, each potential environmental effect is classified as having no effect or having a residual or adverse (negative) effect on fish. The second step of the EIA will be to evaluate the significance of residual effects.

Assessment of Potential Effects

Project activities have been grouped into three pathways of potential effects on fish: direct mortality, loss or degradation of habitat, and reduced water quality. Each pathway represents one primary effect, but it is acknowledged that a project activity could have multiple effects.

Project activities that potentially could cause direct mortality of fish include the water withdrawal intake, use of explosives at the mine pit, and angling by project personnel. Based on mitigative measures to be implemented by Tahera, only use of explosives will result in adverse environmental effects.

Loss of fish habitat may be associated with permanent and winter roads, the stream diversion, development of the processed kimberlite containment area, and the water withdrawal causeway. Residual effects after mitigation will be associated with most activities; all except the permanent and winter roads.

Project activities that potentially could cause reduced water quality include runoff from the mine pit, dumps and stockpiles, discharge from the PKCA, and emissions from mining activities. Based on mitigative measures to be implemented by Tahera, discharge from the PKCA and runoff from the mine site are the only activities that will result in adverse environmental effects.

Evaluation of Residual Effects

The residual effects remaining after mitigation of the six project activities were evaluated to ascertain whether they were significant. For the purposes of the evaluation, a significant adverse effect is one that affects a fish community, in sufficient magnitude, duration, or frequency, as to cause a change in the community structure that would not allow that community to return to its former structure.

Based on this definition, five of the project activities were rated as not significant, which included the use of explosives, the diversion of Stream C1, the water withdrawal causeway, the release of treated mine runoff, and discharge from the Processed Kimberlite Containment Area. Ratings of not significant were given because the adverse effects were not sufficient to cause a permanent change in the fish community residing in the receiving waterbody.

One project activity was deemed to cause significant adverse effects to the fish community: the Processed Kimberlite Containment Area. Significant adverse effects will result because the fish community residing in the Long Lake System will be extirpated. It should be acknowledged that the affected fish community consists of small, resident populations of slimy sculpin and burbot that are ubiquitous to the Jericho Site. Loss of this particular fish community will have no serious consequences to the ecological integrity of the aquatic system outside of the Long Lake System.

Accidents and Malfunctions

Accidents and malfunctions that may cause adverse effects include a spill of hazardous material during vehicle transport, a fuel farm spill, structural failure of the waste rock dumps or ore stockpiles, and structural failure of the Processed Kimberlite Containment Area (PKCA).

A review of potential effects, mitigative measures and an evaluation of residual effects for each of these project activities identified only one, structural failure of the PKCA resulting in an uncontrolled spill of effluent, as causing a significant adverse effect. Immediate consequences would include direct mortality of fish due to acute toxicity of contaminants in the effluent. Long-term consequences would involve degradation of habitat due to sedimentation and possibly reduced water quality. Due to low productivity characteristic of waterbodies affected, fish populations would require several generations to return to original densities. In addition, barriers to fish passage would hamper re-establishment of the fish communities in some lakes. The geographic extent of the spill would be restricted to waterbodies within the Jericho Site. A spill to the west would affect Lake C3, while an uncontrolled spill to the east would affect Key Lake, Lynne Lake, and possibly a small of Contwoyto Lake.

Aquatic Effects Monitoring

Regulatory agencies require a program to verify compliance with regulatory standards and to evaluate effectiveness of the mitigative measures as a condition of project approval. The aquatic effects monitoring program (AEM) for the proposed project is designed to monitor effects on aquatic biota. The main objective of the monitoring program is to monitor sources of effluent to detect un-anticipated effects on aquatic biota so that appropriate mitigative actions can be taken.

Components of the aquatic biological community that are suitable receptors for monitoring purposes, include periphyton, benthic invertebrates, and fish. The first two organisms were chosen as receptors because they are stationary and are likely to reflect changes in the environment more rapidly than other organisms such as fish. Lake trout and round whitefish were also chosen as receptors because they have the potential to bioaccumulate some contaminants and they have a higher social value than invertebrates. As well, the rate of sedimentation will be used for monitoring because it provides a link between elevated suspended sediments and changes in the aquatic biological community.

Compensation

The Jericho Diamond Project will fall under the jurisdiction of the Federal Fisheries Act. This act is regulated by the Department of Fisheries and Oceans which has also adopted a “No Net Loss” policy in regards to the productive capacity of fish habitats. Based on the proposed development in the Jericho Site and the mitigative measures that will be implemented, it is not known whether compensation will be required. As such, it is deemed premature to develop a detailed compensation plan to achieve no net loss of fish habitat. Some options, however, are available for discussion. These include creation of fish habitat and increasing available habitat by removal of barriers to upstream fish passage. When appropriate, Tahera will review these options with the Department of Fisheries and Oceans.

Note:

This report has been modified to remove Section 2 referring to the Jericho Project. Please refer to the Project Description, Appendix A.1, for current project information.

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1.0 INTRODUCTION

1.1 BACKGROUND

The Jericho Diamond Project constitutes an application by Tahera Corporation (Tahera) to construct and operate a diamond mine in Nunavut Territory north of the northwest side of Contwoyto Lake (65° 59' 50" Latitude, 111° 28' 30" Longitude). The Jericho Site is located 420 km northeast of Yellowknife and 170 km north of the Ekati NWT Diamonds Project, NWT (Figure 1.1). The proposed project is a ‘stand-alone’ operation, which entails mining and processing diamonds from a single kimberlite pipe situated beside a small, unnamed waterbody locally known as Carat Lake.

The Jericho Diamond Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement (INAC and TFN 1993). As part of this review, Tahera is required to prepare an application that includes sufficient data and analyses for a complete assessment of anticipated impacts of the project by the regulatory authorities. This application will be submitted for evaluation to the Nunavut Impact Review Board (NIRB). An integral part of this application is an Environmental Impact Statement that will allow the regulatory authorities to evaluate the potential environmental effects of the project. This report (Environmental Impact Assessment Report: Aquatic Biota) addresses the potential effects of the project on aquatic organisms.

1.2 OBJECTIVES

This report identifies and evaluates environmental effects to fish and other aquatic organisms that could result from the proposed project. Specifically, the objectives include:

- to describe the project components, existing aquatic environment and biological community;
- to identify potential environmental effects of the proposed project on aquatic biota;
- to outline mitigative measures designed to minimize the potential environmental effects;
- to assess the significance of residual or adverse environmental effects that will remain following mitigation; and,
- to describe an environmental monitoring program that will be implemented to ensure the integrity of the aquatic biological community.

1.3 APPROACH

The approach to this Environmental Impact Assessment (EIA) follows the Nunavut Water Board document entitled *Guidelines for the Proposed Jericho Diamond Project, September 8, 1999 - Draft* (NWB 1999), which provides direction regarding the contents and format of the environmental assessment.

To determine potential environmental effects, the EIA will first describe the project components along with the aquatic environment and biological community. Where appropriate, summaries of specific components will be provided, with references to more detailed studies. The EIA will then link specific project components to potential environmental effects on the aquatic biota. The report will also describe environmental management planning and mitigation that will be designed to minimize or reduce potential environmental effects and examine the expected effectiveness of these measures.

Adverse environmental effects that remain following mitigation (residual effects) will then be evaluated in terms of their significance to aquatic biota. Significance of effects will be ascertained based on assessment procedures and criteria established by the Canadian Environmental Assessment Agency (CEAA) as outlined in the *Responsible Authority's Guide* (CEAA 1997) and *Determination of Significant Adverse Environmental Effects Guide* (CEAA 1994).

This document will provide a description of the Aquatic Effects Monitoring (AEM) Program that will be used to verify the effectiveness of mitigative measures to ensure that project activities do not have adverse effects on aquatic organisms.

Finally, the report will briefly outline potential compensation options available to address residual effects that were deemed to be significant. This section lists ideas to be considered if the development proceeds; it does not provide detailed compensation plans or designs.

1.4 SCOPE

This EIA considers all components of the proposed development at the Jericho Site, including the mine, ore processing and disposal, waste rock storage and infrastructure. Cumulative effects associated with the proposed project will not be addressed. The present document is being submitted for evaluation prior to development of a formal Terms of Reference.

1.4.1 Project Scope

The Jericho Site will be situated on the southeast shore of Carat Lake and will consist of an open pit/underground mine and diamond processing plant operation at one kimberlite pipe (Figure 1.2). The mine area (pit, processing plant, waste rock and ore stockpiles) will be located adjacent to Carat Lake. The Processed Kimberlite Containment Area (PKCA) will be situated southwest of the mine area and will include a small unnamed waterbody locally known as Long Lake, which discharges via Stream C3 into Lake C3. Most of the support infrastructure for the mine (e.g., roads, housing, fuel storage, air strip) will be located farther to the north. A permanent road will extend east of the mine area to the shore of Contwoyto Lake and will be constructed in Year 2 of operations; during Year 1 a winter road along Stream D1 and across Lynne Lake will be used for access. A ramp at the Contwoyto Lake location will be used for emergency boat access and will facilitate entry by vehicle traffic onto a winter road that traverses Contwoyto Lake to Echo Bay Mines Ltd. winter road.

1.4.2 Temporal Scope

There are four time phases, or temporal boundaries, associated with the proposed development:

- construction;
- operation;
- closure; and,
- post-closure.

After project approval, which is anticipated to be in May 2001, it is anticipated that the infrastructure will be completed within one and a half years. Construction is to begin in February 2002 and commercial operation will commence in January 2003 to 2003. The mine will have an expected operating life of eight years, ending in approximately 2010. Closure is expected to be completed by approximately 2011. Post-closure activities will end in approximately 2016.

1.4.3 Spatial Scope

The geographic boundaries of the project were delineated into two areas to allow assessments of potential effects on aquatic biota. Potential effects in the immediate vicinity of the mine were examined within the local study area, whereas the broader, more far-reaching effects were assessed within the regional study area.

Local Study Area

Local refers to the immediate area of disturbance (the project footprint and waterbodies adjacent to the project). The local study area includes Carat Lake, Lake C3, Long Lake and all other waterbodies within the immediate influence of mining activities (Figure 1.3). Carat Lake and Lake C3 are the primary waterbodies of interest, because they are the receiving waterbodies of any potential effluents generated by the development. Long Lake is also of primary interest because it will be removed from production by development of the PKCA. Other waterbodies adjacent to the mine area may also be affected by road construction, borrow extraction and angling by mine personnel. These other waterbodies include lakes immediately downstream of Carat Lake (e.g., Jericho Lake) and the “O” and “D” Series of lakes situated to the northeast and southeast, respectively. The local study area also includes a small bay on Contwoyto Lake in the vicinity of the road entry point.

Regional Study Area

The Jericho Site is located within a small catchment basin (227 km^2) that drains to the northeast via the Jericho River. The Jericho River eventually joins the Burnside River, which flows to the Arctic Ocean. To allow examination of the effects of the proposed project on a regional basis, the catchment basins of Carat Lake and Contwoyto Lake (950 km^2) were used as the regional study area.

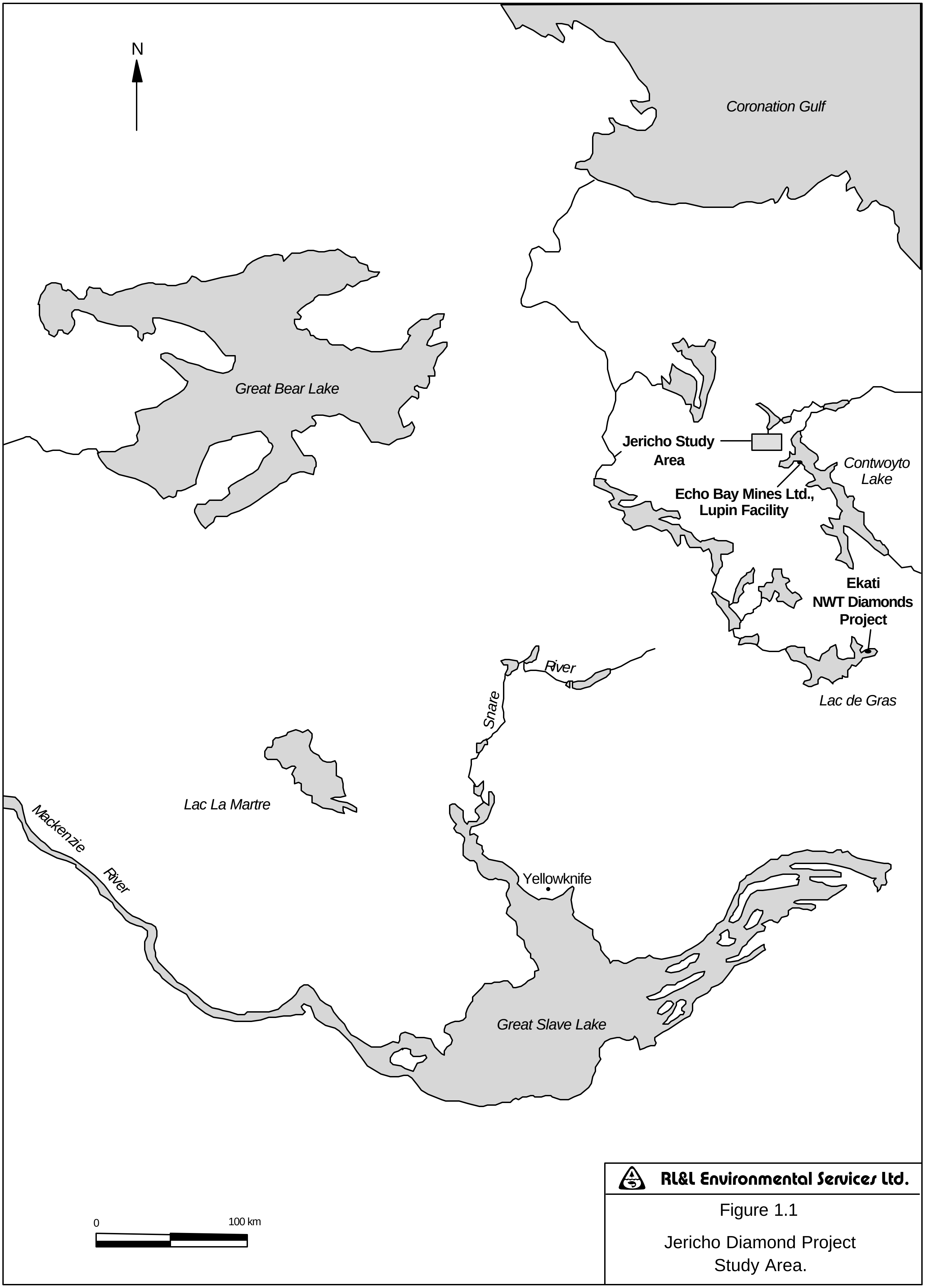

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Figure 1.1

Jericho Diamond Project
Study Area.

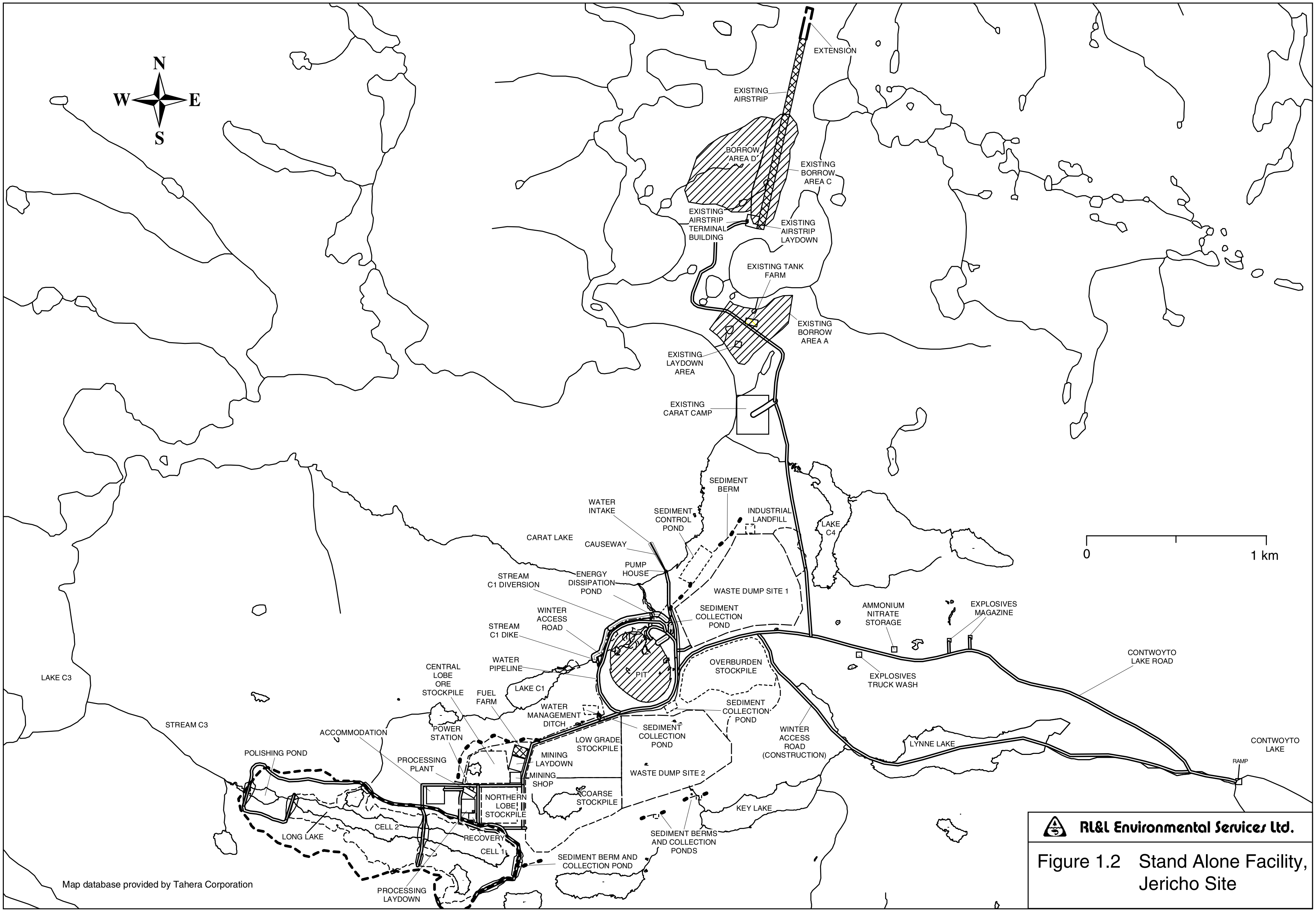

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Figure 1.2 Stand Alone Facility, Jericho Site

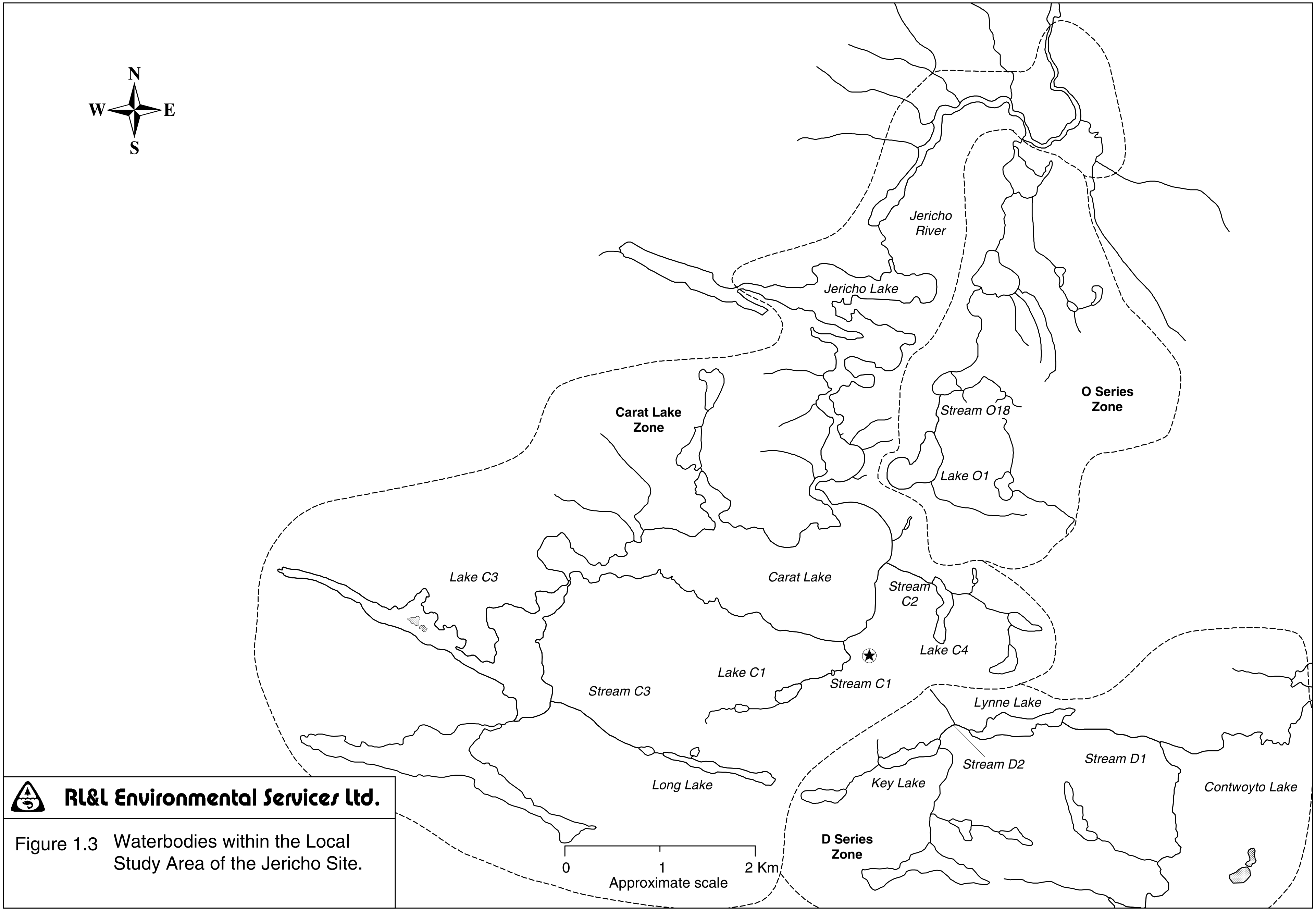

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Figure 1.3 Waterbodies within the Local Study Area of the Jericho Site.

3.0 AQUATIC BIOPHYSICAL ENVIRONMENT

3.1 INTRODUCTION

3.1.1 Background

Baseline aquatic inventories at the Jericho Site were initiated in 1995 and continued, at differing levels of intensity, during 1996, 1998, 1999, and 2000. The purpose of this program was to collect data in sufficient detail and quality to enable a proper evaluation of potential impacts of the proposed development on the aquatic biota in the Jericho Site. The study program included three general components: 1) synoptic surveys to describe the aquatic biological community and environment; 2) detailed surveys to collect quantitative data from waterbodies potentially removed from production; and, 3) collection of quantitative data to be used as part of Aquatic Effects Monitoring. The specific objectives of each program component were as follows:

Synoptic Surveys

- describe the physical characteristics (morphology and water quality) of waterbodies;
- describe the seasonal abundance, distribution, and biological characteristics of invertebrate communities (benthic invertebrates, zooplankton, phytoplankton, and periphyton); and,
- describe the seasonal abundance, distribution, movements, and biological characteristics of fish species, as well as describe the habitat used by these fish.

Detailed Surveys

- develop density estimates for fish;
- quantify the amount of fish habitat; and,
- quantify the trophic status of waterbodies.

Aquatic Effects Monitoring

- sedimentation rates;
- species composition, density, and productivity of periphyton;
- species composition and density of benthic invertebrates; and,
- concentrations of metals in tissues of fish.

The program components, tasks, and the number of waterbodies inventoried differed between years (Tables 3.1 and 3.2). The majority of work during 1995 and 1996 involved synoptic surveys of a large number of waterbodies within the Jericho Site. Investigations in the final years of the program (1999 and 2000) also involved synoptic surveys, but the primary focus was the collection of detailed information from waterbodies potentially impacted by the development and the initiation of the AEM program. A complete list of documents produced during the 1995 to 2000 aquatic studies programs are presented in Appendix A.

Table 3.1 Aquatic studies program components and tasks undertaken in the Jericho Site, 1995 to 2000.

Program Component	Task	Year				
		1995	1996	1998	1999	2000
Synoptic Studies	Waterbody characteristics	✓	✓		✓	✓
	General water quality	✓	✓		✓	✓
	Invertebrate communities	✓	✓		✓	✓
	Fish communities	✓	✓	✓	✓	✓
Detailed Studies	Fish densities		✓		✓	✓
	Quality and quantity of fish habitat		✓		✓	✓
	Productive capacity				✓	✓
Monitoring Studies	Fish tissue background metal levels	✓	✓		✓	
	Aquatic Effects Monitoring Program				✓	

Table 3.2 Number of waterbodies investigated during the aquatic studies program in the Jericho Site, 1995 to 2000.

Year	Lakes	Streams
1995	7	16
1996	14	56
1998	0	16
1999	5	5
2000	6	4

Numerous lakes and streams were investigated in the Jericho Diamond Project Area during the aquatic studies program (Figure 3.1). These waterbodies were differentiated into three zones based on drainage basin: Carat Lake Zone, O Series Zone, and D Series Zone.

The Carat Lake Zone is situated adjacent to and downstream of the proposed mine site. Lake C3, Carat Lake, Jericho Lake, and the Jericho River are the major fish-bearing waterbodies in this zone (Figure 3.1). Lake C3 drains into Carat Lake, which flows into Jericho Lake which in turn drains into the Jericho River, and eventually Kathawachaga Lake. A major fish passage barrier exists at the outlet of Jericho Lake; the barrier consists of a series of cascades that drop approximately 15 m over a 120 m section. It essentially isolates downstream fish communities from the upper Carat Lake drainage. Stream C1, which is adjacent to the kimberlite pipe to be mined, drains a small fish-bearing waterbody (Lake C1) into the southeast corner of Carat Lake. Stream C3 situated to the southwest of Carat Lake, drains water from Long Lake (identified as Lake D10 in aquatic baseline reports) into Lake C3.

The O Series Zone is situated within an esker complex and encompasses five small lakes and well-defined streams that drain north into Jericho River. Lake O1 is the waterbody in this zone that is nearest to the development.

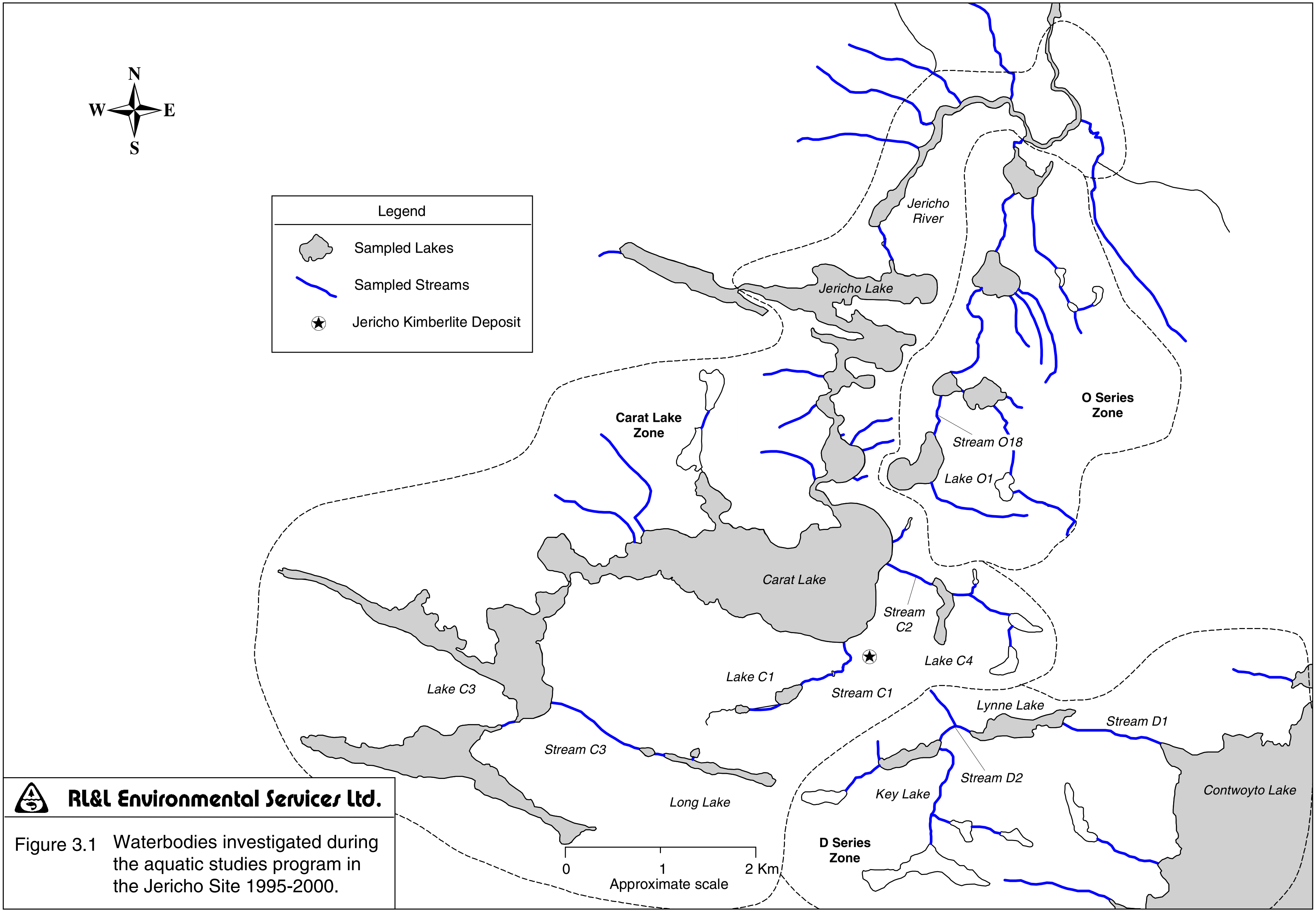

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Figure 3.1 Waterbodies investigated during the aquatic studies program in the Jericho Site 1995-2000.

The D Series Zone includes a series of small lakes and ill-defined streams that drain into Contwoyto Lake. These include, Key Lake, Lynne Lake, and Contwoyto Lake connected by Streams D1 and D2. A shallow pond known as Ash Lake, which was not sampled during the aquatic inventory program, is situated at the extreme upstream end of the D series drainage.

For the purposes of this review, data from a selected number of waterbodies will be used to illustrate the aquatic environment and aquatic biological communities in the Jericho Site. These waterbodies include Carat Lake, Long Lake, Lakes C1 and C3, and Streams C1, C2, and C3 in the Carat Lake Zone; Lake O1 and Stream O18 in the O Series Zone; and Key Lake, Contwoyto Lake, and Stream D1 in the D Series Zone. These lakes and streams were chosen because they represent a range of biophysical characteristics and some of these waterbodies will be potentially impacted by the development.

3.1.2 Terrestrial Environment

A detailed description of the terrestrial environment is provided in the *Jericho Diamond Project Proposal* (Tahera 1999); as well, additional details are provided in the vegetation (Burt 1999) and wildlife (Hubert 2000) reports. The following section provides a concise summary of this information in relation to its effects on the aquatic environment in the Jericho Site.

Climate

The Jericho Site is located approximately 60 km south of the Arctic Circle. This area is characterized by short, cool summers and long, cold winters. Daylight is mostly continuous at the beginning of summer and virtually absent at the beginning of winter. The mean air temperature difference between summer and winter is 40^{o} C. Annual precipitation is limited, with an average of approximately 300 mm (50% rainfall and 50% snowfall per year).

Surficial Geology

Surficial geology of the Jericho Site is characterized by low relief tundra terrain with numerous lakes and ephemeral streams that are interspersed among boulder fields, eskers, and bedrock outcrops. This area was inundated by glaciers several times, with the last deglaciation occurring 9 300 years ago. Associated with this glaciation is a discontinuous, but locally thick blanket of till. Glaciolacustrine sediments locally blanket the till, particularly below the elevation of 480 m around Carat Lake. There are also numerous glaciofluvial land forms present, such as eskers, outwash deltas, kame deltas, and supraglacial deltas. Glaciofluvial sediments range from clean sand and gravel to thick boulder and block accumulations. Organic soils have also developed in some poorly drained areas.

Permafrost

The Jericho Site lies within the region of continuous permafrost. Permafrost is present everywhere except beneath large lakes and rivers that do not freeze to the bottom. The permafrost layer can extend to depths of approximately 540 m. In the surficial soils, the active layer ranges in thickness from less than one metre in organic soil to slightly more than three metres in well-drained granular materials, such as those found in eskers.

Groundwater and Hydrology

Carat Lake is part of the Burnside River drainage, which flows into the Arctic Ocean near Bathurst Inlet. Carat Lake has a relatively small catchment basin (227 km^2) and accounts for approximately 65% of the total area draining into the Jericho River. The flow regime of streams in the vicinity of the Jericho Site reflect the cold climate of the region. Low flow periods (i.e., less than 10% of the average annual runoff) occur during cold months (October to May). Peak stream flows occur in May-early June during snow melt, with flows diminishing throughout the remainder of the open water period.

Groundwater was not detected in the Jericho Site. This is not unexpected due to the presence of permafrost to depths of 540 m, which prevents groundwater flow.

3.2 WATERBODY CHARACTERISTICS

3.2.1 Morphology

Lakes

Lakes in the Jericho Site exhibit a wide range of morphological characteristics. The majority are small and have simple characteristics. Most have shorelines dominated by rock substrates and narrow bands of shallow-water zones adjacent to the shoreline. Despite their relatively small size, many of these lakes exceed 10 m in depth.

Carat Lake is the largest waterbody (271 ha) within the Jericho Site (Table 3.3). This lake has one major inlet and outlet source, but it also receives water from several small tributaries, including Stream C1. Carat Lake consists of three basins, the largest comprising the central portion of the lake. This lake is deep, with a maximum depth of 32 m. Lake C1 represents the other extreme in lake size within the Jericho Site (3.5 ha). It consists of a single basin and has a maximum water depth of 12 m. The shorelines of both lakes are dominated by cobbles and boulders. The only exception is the eastern shore of Carat Lake that has extensive areas of sand and gravel.

Lake C3 is the second largest waterbody (103 ha) surveyed in the Jericho Site (Table 3.3). This lake has one major inlet and two outlet sources. Lake C3 has a central basin associated with an elongated basin that extends to the west. The central basin comprises two smaller sub-basins, attaining maximum depths of 14 and 15 m. The elongated basin that extends to the west, consists of three basins. The mean depth within the elongated basin is 5.0 m, with a maximum depth of 14 m deep. The shoreline of Lake C3 is irregular, as indicated by the high shoreline development ratio (3.0), and the shoreline is dominated by cobble-boulders and bedrock.

Long Lake is located to the south of Carat Lake and to the east of Lake C3. This waterbody has no defined inlet stream, but drains to the west, via Stream C3, into Lake C3. This small waterbody (9 ha) is elongated along an east-west axis and has three basins. The two eastern basins do not exceed 6 m in depth and are separated by a shallow-water area <1.0 m deep. The western basin is slightly deeper exhibiting a maximum depth of 8 m. Long Lake is relatively shallow (mean depth of 1.9 m). As such, a large percentage of the lake would be subjected to freezing (89% of area and 71% of volume). This lake has areas of steep shorelines (north and south side), as well as low relief areas (east and west side). The shoreline of this lake is dominated mostly by bedrock and boulders.

Lake O1 is representative of lakes in the O Series Zone. It has a preponderance of sand and gravel substrates along its shore and is relatively shallow with a mean depth of 4.1 m. Key Lake and the small bay of Contwoyto Lake are both relatively deep (maximum depths of 12 and 20 m, respectively) and have steep, rugged shorelines dominated mostly by bedrock and boulders.

Table 3.3 Morphometric characteristics[a] of selected lakes in the Jericho Site.

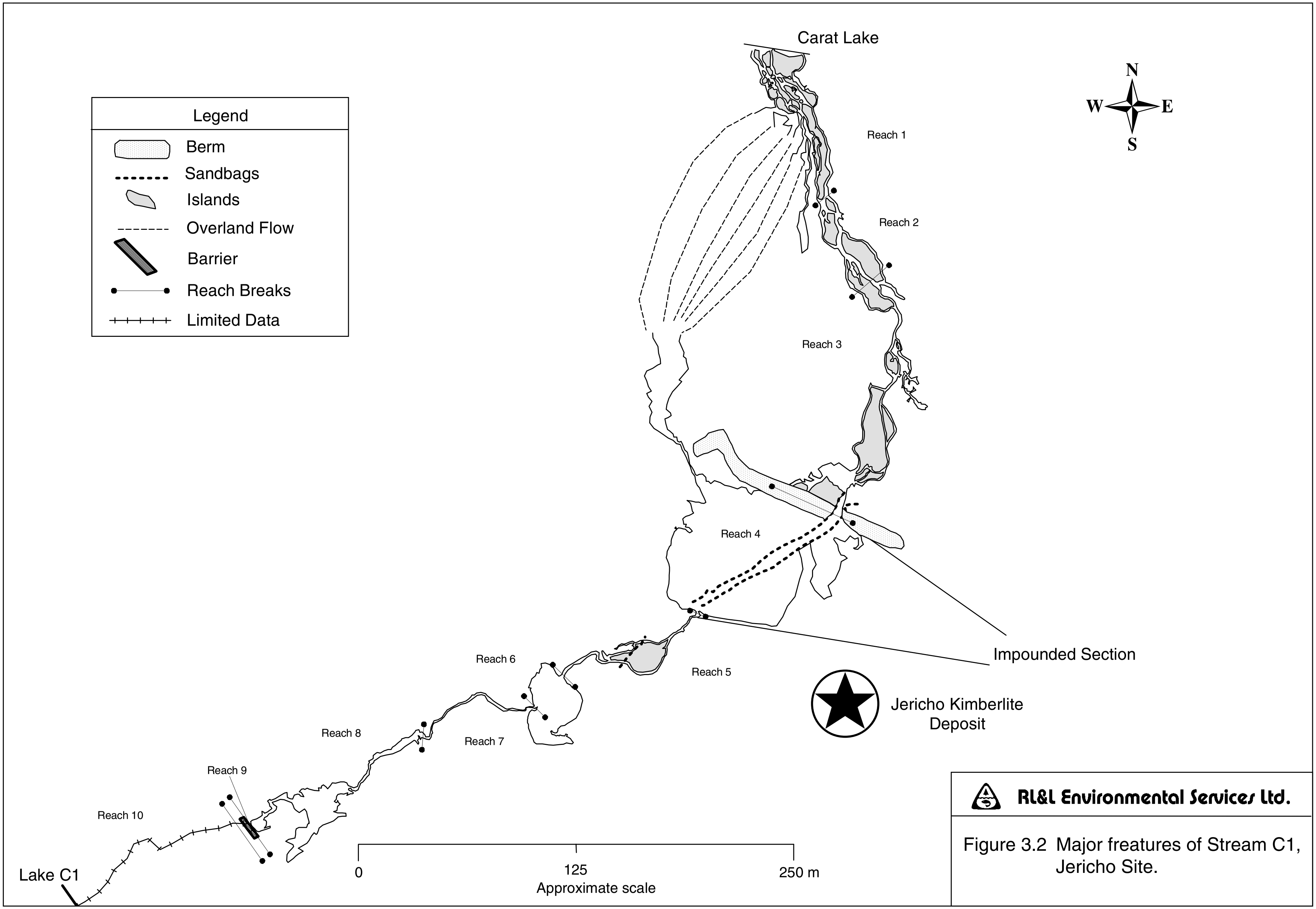
Lake	Surface Area (ha)	Lake Volume (m^3)	Mean Depth (m)	Maximum Depth (m)	Shoreline Length (m)	Shoreline Development Ratio
Carat Lake	270.5	27 203 110	10.1	32	12 270	2.1
Lake C1	3.5	126 980	3.6	12	779	1.2
Lake C3	102.5	4 743 239	5.1	15	10830	3.0
Long Lake	9.0	168 608	1.9	8	2571	2.4
Lake O1	18.1	734 500	4.1	14	1900	1.26
Key Lake	8.6	225 000	2.7	12	1700	1.67
Contwoyto Lake (bay)	67.5	-	-	20	5716	-

[a] Source: RL&L (1997, 2000a, 2000b).

Streams

The only large streams in the Jericho Site are the inlets and outlets of Lake C3, Carat and Jericho lakes, and the Jericho River. With the exception of the Jericho River and the connection between Carat Lake and Jericho Lake, these streams are shallow and have ill-defined boulder strewn channels. As such, they do not provide good movement corridors for fish, accept during periods of high flow. Most of the streams in the area are very small systems exhibiting base flow discharges of < 0.01 m^3/s. There are three categories of small streams in the study area: those dominated by ill-defined channels with water flow through multiple channels, those with better defined channels and water flow within distinct stream banks, and those with subsurface flow below boulder fields. Substrates present in the streams vary from silts to boulders.

Stream C1 received the most intensive study of the inventoried streams. It originates as the outlet from Lake C1 and flows a distance of 1031 m before draining into Carat Lake (Figure 3.2). Its major features include a natural barrier to fish passage (5.3 m in height) that is located 815 m upstream from Carat Lake and a large impounded area (351 m from confluence) that was formed by a containment berm constructed during exploration activities in the winter of 1995-96. The impounded area inundates a portion of the existing channel and diverts part of the stream discharge to the west. This diverted water flows over the tundra and rejoins Stream C1 near its confluence with Carat Lake. Unlike other small streams in the study area, Stream C1 exhibited surface water flow throughout the open water period during all years of this study. Discharge was approximately 0.060 m^3/s during the spring freshet and 0.002 m^3/s during base flows in summer.



RL&L Environmental Services Ltd.

Figure 3.2 Major freatures of Stream C1, Jericho Site.

Stream C1 can be differentiated into ten reaches based on changes in gradient and physical characteristics (Table 3.4). Reaches with higher gradients exhibit narrower channel widths, higher water velocities, and well-defined channels. Substrate types in most reaches are dominated by cobble and boulder substrates, although sand substrates were also present.

Stream C3 originates as the outlet from a deep pond (depth of 7 m) immediately adjacent to the west end of Long Lake and flows a distance of 912 m before draining into Lake C3. The stream exhibits subsurface flow in several locations and it freezes to the bottom during winter. Due its small size, a barrier to fish passage (dispersed flow) exists within 300 m of its confluence with Lake C3. Discharge in 1999 ranged from 0.003 m^3/s to 0.034 m^3/s during the open water period Tahera (1999).

Stream C3 can be differentiated into six reaches based on changes in gradient and physical characteristics (Table 3.4). Reaches with higher gradients exhibit narrower channel widths, higher water velocities, and better-defined channels, while reaches with lower gradients exhibit dispersed and subsurface channel types. Substrate types in most reaches are dominated by cobble and boulder substrates, although sand and gravel substrates were also present.

Table 3.4 Summary of stream characteristics[a] in reaches of Streams C1 and C3 in the Jericho Site.

Stream	Reach	Gradient (m/km)	Length (m)	Mean Wetted Width (m)	Mean Depth (m)	Mean Velocity (m/s)	Percent Channel Type[b]				Percent Bank Type[c]		Substrate Type[d] (%)				
							S	M	D	Sub	Def	Ill	Om/Si/Sa	Gr	Co	Bo	Be
C1	1	71	92	1.25	0.08	0.1		89	11		100		3	5	66	27	
	2	50	70	2.03	0.08	0.13		100			100			5	42	53	
	3	1	177	1.15	0.08	0.09		100			89	11	9	9	71	11	
	4	2	134	-	0.28	-	Ponded water					100	100				
	5	27	102	0.84	0.08	0.16	100				100		8	10	47	36	
	6	1	24	-	0.67	-	Ponded water					100	100				
	7	38	82	1.04	0.13	0.28	100				100		18	12	36	34	
	8	5	134	4.57	0.18	0.09		67	33		67	33	29	12	5	48	3
	9	33	16	-	-	-	-	-	-		-	-	-	-	-	-	-
	10	2	200	-	-	-	-	-	-		-	-	-	-	-	-	-
C3	1	81	110	0.78	0.09	0.11		100			29	71	38	26	20	16	
	2	63	215	0.56	0.14	0.18	87	13			88	12	26	26	14	34	
	3	54	113	4.26	0.12	0.22		20	80		20	80	80	20			
	4	10	198	0.74	0.11	0.22	66	34			50	50	50	8	13	29	
	5	7	276	-	-	-				100		100				100	
	6	14	139	11.4	0.12	0.26			100		20	80	74			26	

[a] Source: RL&L (2000a and 2000b).
[b] S = single; M = multiple; D = dispersed; Sub=subsurface.
[c] Def = defined; Ill = ill-defined.
[d] Om = organic material; Si = silt; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; Be = bedrock.
[e] Not sampled.

Other streams draining into Carat Lake are smaller than either of Stream C1 or C3. Stream C2 is an ephemeral system that originates in a shallow pond upslope from the east shore of Carat Lake. It is small stream (0.4 m wetted width and <0.20 m depth) and exhibits a very low discharge (<0.001 m^3/s; Table 3.5). As such, fish are restricted to the lowermost section of this stream. The lower section of Stream C2 has defined, multiple channels associated with predominantly fine and gravel substrates.

Table 3.5 Physical characteristics[a] of lower 100 m of selected streams in the Jericho Site.

Stream	Gradient (m/km)	Length (m)	Wetted Width (m)	Depth (m)	Discharge (m^3/s)	Percent Channel Type[b]			Percent Bank Type[c]		Substrate Type[d] (%)				
						S	M	Sub	Def	Ill	Om/Si/Sa	Gr	Co	Bo	Be
C2	46	543	0.4	0.09	<0.001	100			100		35	30	19	16	
O18	20	447	0.6	0.25	0.004	90	10		100		33	22	20	24	
D1	28	1079	10.0	-	-			100	100					100	

[a] Source: RL&L (1997 and 2000b).
[b] S = single; M = multiple; Sub = subsurface.
[c] Def = defined; Ill = ill-defined.
[d] Om = organic material; Si = silt; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; Be = bedrock.

Stream D1 drains into Contwoyto Lake from Lynne Lake. The channel of Stream D1 is dominated by large boulders, and as such, much of the water flow is subsurface. Due to these characteristics, the sections available to fish are restricted to the outlet and inlet areas adjacent to the lakes. In contrast, Stream O18 has a very well-defined channel and is used extensively by fish. This watercourse originates from Lake O1. Substrates in this stream consist of a mixture of sands, gravels and cobbles.

3.2.2 Water Quality

Temperature and Dissolved Oxygen

Thermal stratification (two non-mixing layers of water) occurred in deeper and/ or protected lakes in the Jericho Site (e.g., Carat Lake, Key Lake, and Lakes C1, C2, C3, and O1). Shallower lakes and the much larger Contwoyto Lake, exhibited isothermic conditions (continual mixing of water layers). Water temperatures generally remained cool during the open water period (<14^{o} C) and dissolved oxygen concentrations were at or near saturation at all times. These data are consistent with characteristics of other subarctic lakes in the general vicinity of the Jericho Site (RL&L 1993a, 1998).

Water temperatures of smaller streams in the study area tended to closely follow air temperatures. During 1999, daily water temperatures in Stream C1 warmed rapidly in spring to 12^{o} C and then fluctuated during the remainder of the open-water period. The close relationship between air and water temperature can cause small streams to attain high water temperatures. For example, during warm summer periods in 1996 and 2000, water temperatures in several systems exceeded 18°C.

Water Chemistry

Lakes and streams in the Jericho Site are typical of oligotrophic subarctic systems: low suspended sediment concentrations, low alkalinity, and low nutrient levels. Water quality parameters measured during the field program were consistent with these characteristics (Table 3.6). In general, concentrations of all sampled constituents were low. Nutrient constituents, such as total phosphorous, total kjeldahl nitrogen (TKN), and nitrite/nitrate-N concentrations were very low in most waterbodies. The results are consistent with findings made by other studies conducted in northern waterbodies (RL&L 1996c; Diavik 1998).

Table 3.6 Water quality parameters measured in selected waterbodies in the Jericho Site.

Constituent and Units of Measure		Present Study					Other Studies	
		Carat Lake[a]	Lake C1[b]	Lake C3[b]	Stream C1[b]	Stream C3[b]	Reno Lake North (RL&L 1996c)	Lac de Gras (Diavik 1998)
Turbidity	NTU	-	0.96	0.49	0.41	1.10	-	<1
Total Alkalinity	mg/L	4.9	11.0	4.0	13.0	6.0	5.0	6.1
pH in Water	µS/cm	6.35	7.00	6.60	7.00	6.50	6.50	6.10
Total Dissolved Solids	mg/L	10	14	6	15	9	8	8
Chloride (Cl)	mg/L	0.90	1.09	0.28	0.67	0.25	0.90	<0.5
Sodium (Na)	mg/L	-	0.70	0.50	0.70	0.50	1.10	0.50
Calcium (Ca)	mg/L	0.98	2.60	1.00	2.48	1.66	1.10	1.30
Magnesium (Mg)	mg/L	0.45	1.40	0.54	1.36	0.90	0.40	0.50
Total Phosphorus	mg/L	0.006	0.004	0.004	0.005	0.003	0.080	0.004
Total Kjeldahl Nitrogen	mg/L	-	0.48	0.24	0.25	0.18	0.34	<0.2
Nitrate/Nitrite	mg/L	0.01	0.02	<0.006	0.32	0.03	<0.05	<0.2

[a] Source: RL&L (1996a).
[b] Source: RL&L (2000a).

3.3 AQUATIC BIOTA

3.3.1 Introduction

The aquatic community in freshwater systems is composed of macrophytes, periphyton, phytoplankton, zooplankton, benthic invertebrates, and fish. Generally, aquatic communities in northern latitudes exhibit lower density and productivity then those in temperate systems.

Periphyton is the microflora (algae, bacteria, fungi, and their secretions) that grow on substrates in freshwater systems (Lock *et al.* 1984; Wetzel 1983). Phytoplankton and macrophytes are both aquatic plants. Phytoplankton are free floating, single-celled plants, with no or very limited locomotive abilities, whereas macrophytes are multicellular aquatic plants that may be rooted or nonrooted (Wetzel 1983). These groups are primary producers that form the basis of the aquatic food chain.

Zooplankton are microscopic animals that feed on periphyton, phytoplankton and/or smaller zooplankton. Benthic invertebrates comprise a diverse assemblage of taxa (e.g., gastropods, crustaceans, and aquatic insects) that inhabit the bottom substrates of waterbodies. Both groups are important sources of food for fish in subarctic systems.

Subarctic lakes of sufficient depth and size often have the potential to support fish populations if they are accessible. If the necessary life requisites are provided (i.e., spawning, rearing, feeding, and overwintering habitats), viable fish populations become established. In these cold, oligotrophic systems, slow growing and stable fish populations develop and are often composed of simple fish communities.

Most streams in the subarctic freeze to the bottom in winter. As such, they are used by lake resident fish only during the open water period. For some species, these streams provide critical habitats such as spawning areas or are important movement corridors between lakes; however, for most species, streams are used on an opportunistic basis for rearing and feeding.

3.3.2 Macrophytes

Aquatic macrophytes were not abundant in the Jericho Site; they were sparsely distributed in some lakes. Emergent macrophytes recorded in the area included sedges (*Carex* spp.) and aquatic grasses (*Glyceria* spp.). Submergent vegetation consisted of coontail (*Ceratophyllum demersum*). The only extensive zone of emergent plants was recorded in the southwest corner of Carat Lake, while submergent vegetation was present in the outflow channel. Submergent macrophytes were absent from all other study lakes. The low species diversity and scarcity of macrophytes are consistent with findings of other studies in the vicinity of the Jericho Site (RL&L 1996c, 1998).

3.3.3 Periphyton

The periphyton community in lakes and streams in the Jericho Site was indicative of oligotrophic waterbodies. The total number of periphyton species identified in samples from the Jericho Site was low (<82 species) and total densities were below 1193 x 10^4 cells/cm^2. Although periphytic algal community consisted of five taxonomic divisions, four divisions accounted for more than 99% of the periphyton community, which included Bacillariophyta (diatoms), Chlorophyta (green algae), Chrysophyta (golden-brown algae), and Cyanophyta (cyanobacteria). Of these four groups, cyanobacteria dominated, followed by diatoms (Table 3.7).

In terms of frequency of occurrence in lakes and streams, diatoms were well represented by *Achnanthes minutissima* and *Tabellaria flocculosa*. *Schizothrix calcicola* was the most widely distributed cyanobacteria species. The most frequently encountered green algae species included *Oocystis lacustris* and *Oocystis elliptica*, while *Dinobryon sertularia* (lakes) and *Stichogloea doederleinii* (streams) were the dominant golden-brown algae.

Table 3.7 Density (cells/cm^2) of major periphyton taxa, total density and number of taxa in selected waterbodies during summer[a] in the Jericho Site.

Taxa	Carat Lake		Lake C1		Lake C3		Long Lake		Stream C1		Stream C3		Stream O18[b]	
	Density	Percent	Density	Percent	Density	Percent	Density	Percent	Density	Percent	Density	Percent	Density	Percent
Bacillariophyta	3470	27.0	607 910	18.0	14 824	10.5	128 864	6.5	232 560	11.8	25 658	26.5	200 524	32.1
Chlorophyta	440	3.5	72 190	2.1	7280	5.1	48 029	2.4	10 970	0.6	8033	8.3	40 008	6.4
Chrysophyta	-	-	40 910	1.2	5378	3.8	13 409	0.7	-	-	1673	1.7	15 191	2.4
Cyanophyta	8920	69.5	2 662 640	78.7	114 012	80.5	1 802 823	90.4	1 731 050	87.7	61 580	63.5	368 163	59.0
Total Density of the Major Taxa	**12 830**		**3 383 650**		**141 494**		**1 993 125**		**1 974 580**		**96 944**		**623 886**	
Total No. of All Taxa	**32**		**73**		**50**		**72**		**45**		**49**		**60**	

[a] Source: RL&L (2000a), unless otherwise indicated.
[b] Source: RL&L (1996a).

Periphytic algal communities in subarctic systems are often dominated by cyanobacteria, diatoms, and green algae (Roeder et al. 1975; Beak 1977; Moore 1978a, 1978b; RL&L 1999). Roeder et al. (1975) and Moore (1978a, 1978b) found that *Diatoma* sp., *Achnanthes minutissima*, and *Tabellaria flocculosa* (all diatom taxa) were the dominant periphytic algal species. Neither of these authors quantified cyanobacteria abundances, although, they did qualify that cyanobacteria dominated the periphytic communities in both lakes and streams. A study conducted in the Meliadine Lake area of Nunavut documented that *Diatoma elongatum* and *Achnanthes minutissima* were the dominant diatom species (RL&L 1999) and *Schizothrix calcicola* was the dominant cyanobacteria that overwhelmingly dominated the periphytic algal communities.

Chlorophyll *a* is an important photosynthesizing pigment of plants. Its concentration is a measure of the amount of living tissue and is often used as an indicator of productivity. Chlorophyll *a* values were low in waterbodies within the Jericho Site (<6.0 $\mu g/cm^2$). Other studies in subarctic environments also documented low values of chlorophyll *a* (RL&L 1996b, 1999), which are consistent with the findings of the present study. Recent work by Morin et al. (1999) suggested that the chlorophyll *a* concentrations recorded during this study were at the lower spectrum of primary production in freshwater systems.

3.3.4 Phytoplankton

The phytoplankton assemblage in lakes in the Jericho Site were indicative of oligotrophic waterbodies, exhibiting low species diversity and density. The total number of phytoplankton species identified in samples from the Jericho Site did not exceed 66 species and total densities were below 18 103 cells/mL (Table 3.8). Cyanobacteria exhibited the greatest abundance at Carat Lake and Lake C1, while golden-brown algae dominated at Lake C3, and green algae dominated at Long Lake. *Aphanocapsa elachista* was the dominant cyanobacteria species identified. Of the golden-brown algae, *Chrysosphaerella rodhei* was the dominant species in this group, and *Coelastrum microporum* and *Sphaerozosoma schroeteri* were the dominant green algae.

The species composition and densities of the phytoplankton communities in the Jericho Site were consistent with other studies conducted at northern latitudes (Beak 1977; Moore 1978a; RL&L 1996c; Diavik 1998). For example, a study conducted in the Izok Lake area of the Coppermine River drainage found that cyanobacteria was the most important taxonomic group in terms of density, and *Aphanothece clathrata* and *Aphanocapsa elachista* were the dominant species (RL&L 1996c). These studies also identified relatively few species in sampled lakes.

Chlorophyll *a* values collected during summer from selected lakes in the Jericho Site during summer ranged from 0.4 mg/m^3 to 2.3 mg/m^3 (RL&L 2000a). These values were indicative of low primary productivity characteristic of oligotrophic systems and were similar to those documented in other northern lakes (Shortreed and Stockner 1986; Ostrofsky and Rigler 1987; Diavik 1998; Morin et al. 1999).

Table 3.8 Phytoplankton density (cells/mL) and number of taxa in selected lakes during summer[a] in the Jericho Site.

Taxa	Carat Lake[b]		Lake C1		Lake C3		Long Lake	
	Density	Percent	Density	Percent	Density	Percent	Density	Percent
Bacillariophyta (Diatoms)	40	0.9	835	9.2	203	6.1	11	1.2
Cryptophyta (Cryptomonads)	104	2.4	943	10.3	173	5.2	101	10.8
Chrysophyta (Golden-brown algae)	306	7.0	1593	17.5	1712	51.6	254	27.3
Chlorophyta (Green algae)	244	5.6	160	1.8	330	9.9	396	42.5
Cyanophyta (Cyanobacteria)	3646	83.8	5545	60.8	896	27	168	18
Euglenophyta (Single-celled flagellates)	0	0.0	4	0.1	0	0.0	0	0.0
Pyrrophyta (Dinoflagellates)	11	0.3	40	0.4	4	0.1	2	0.2
Total Density (cells/mL)	**4351**		**9120**		**3318**		**932**	
Total Number of Taxa	**59**		**51**		**62**		**57**	

[a] Source: RL&L (2000a), unless otherwise indicated.
[b] Source: RL&L (1997).

3.3.5 Zooplankton

The zooplankton assemblage in lakes in the Jericho Site were indicative of oligotrophic waterbodies (Wetzel 1983). In the example lakes, the total number of zooplankton species recorded during summer did not exceed 15 and total densities were 72 272 organisms/m^3 or less (Table 3.9). Rotifers were the most abundant zooplankton group identified in Carat Lake and Lake C3, while cyclopoid copepods were the most abundant group in Lake C1 and Long Lake. Rotifers were comprised primarily of *Conochilus unicornis* and *Keratella longispina*. *Cyclopoid nauplii* was the most abundant copepod species, followed by *Leptodiaptomus sicilis* and *Dicyclops bicuspidatus*. *Holopedium gibberum* was the dominant cladoceran species.

Table 3.9 Zooplankton density and number of taxa in selected lakes during summer[a] in the Jericho Site.

Taxa	Carat Lake[b]		Lake C1		Lake C3		Long Lake	
	Density	Percent	Density	Percent	Density	Percent	Density	Percent
Copepoda								
Calanoida	685	9.0	1907	2.9	1958	5.9	5750	8.0
Cyclopoida	152	2.0	45 127	68.0	11 751	35.1	58 890	81.4
Cladocera	2513	32.9	170	0.3	189	0.6	34	0.1
Rotifera	4291	56.2	19 136	28.8	19 565	58.5	7598	10.5
Density (number/m^3)	**7641**		**66 340**		**33 463**		**72 272**	
Total Number of Taxa	**8**		**13**		**15**		**13**	

[a] Source: RL&L (2000a), unless otherwise indicated.
[b] Source: RL&L (1997).

The zooplankton communities in Jericho Site waterbodies were similar to those found in other subarctic lakes (Beak 1977; Moore 1978b; Diavik 1998). Moore (1978b) described the zooplankton community of Itchen Lake, NWT (headwaters of the Coppermine drainage) and found that rotifers (*Keratella cochlearis* and *Kellicottia longispina*) were the numerically dominant taxa. Diavik (1998) documented similar results at Lac de Gras and Lac du Sauvage, NWT.

3.3.6 Benthic Invertebrates

Lakes

Benthic invertebrate communities of selected lakes in the Jericho Site were dominated by few taxa and densities were low (Table 3.10). Chironomids were the dominant taxa, although, nematodes, oligochaetes, ostracods and pelecypods were also abundant. Species diversity and densities tended to be higher in the littoral zone (<5.0 m depth) than the profundal (≥5.0 m depth) zone. The general trend of higher values in the littoral zone reflects the greater productive potential of shallow-water habitats due to higher water temperatures and light penetration.

Streams

The benthic invertebrate communities in streams in the Jericho Site were dominated by nematodes, oligochaetes, chironomids, and ostracods (Table 3.11). Hydroids, ostracods, and plecopterans were not identified in samples collected from Stream C1, but were recorded in other streams. Stream O18 exhibited the highest species diversity and densities in the Jericho Site. Differences in stream habitat characteristics (i.e., water quality, temperature, depth, flow velocity, substrate composition) and natural variation may account for the large variations in species diversity and densities documented between waterbodies.

The benthic invertebrate communities in the Jericho Site were representative of other subarctic systems (Beak 1977; Reid Crowther and RL&L 1985; RL&L 1998; Diavik 1998). Densities and number of taxa reported by the present study and others indicated low productivity. Overall, the low species diversity and densities of benthic invertebrates were indicative of oligotrophic systems that have low productivity and a short growing season (Hynes 1970; Resh and Rosenberg 1984; Resh and Rosenberg 1993).

Table 3.10 Benthic invertebrate densities (no./m^2) in littoral and profundal zones[a] of selected lakes in the Jericho Site.

Taxonomic Group	Carat Lake[b]		Lake C1[c]		Lake C3[c]		Long Lake[c]	
	Littoral	Profundal	Littoral	Profundal	Littoral	Profundal	Littoral	Profundal
PLATYHELMINTHES								
TURBELLARIA								
MICROTURBELLARIA						43	435	217
NEMATODA	2725				43	87	435	304
MOLLUSCA								
PELECYPODA								
Sphaeriidae		29	260		2043	522	651	1217
ANNELIDA								
OLIGOCHAETA	1232				1782	130	477	43
ARTHROPODA								
ARACHNIDA								
Hydracarina	14			43	87		130	86
CRUSTACEA								
COPEPODA[d]								
HARPACTICOIDA	188	14					43	
OSTRACODA			43	217		43	435	217
MALACOSTRACA								
AMPHIPODA								
Gammaridae				43				
INSECTA								
COLLEMBOLA				43				
DIPTERA								
Chironomidae	855	216	1044	869	3826	739	5174	5609
TRICHOPTERA								
Limnephilidae	14						87	
Total No. Organisms/m^2	**5028**	**259**	**1347**	**1215**	**7781**	**1564**	**7867**	**7693**
Total No. Taxa	**9**	**5**	**8**	**9**	**15**	**9**	**18**	**14**

[a] Littoral < 5.0 m depth and profundal ≥5.0 m depth.
[b] Source: RL&L (1997).
[c] Source: RL&L (2000a).
[d] Does not include Calanoida and Cyclopoida copepods.

Table 3.11 Benthic invertebrate densities[a] in selected streams in the Jericho Site.

Taxonomic Group	Stream C1	Stream O18
COELENTERATA		
Hydridae		179
MICROTURBELLARIA		72
NEMATODA	1330	566
PELECYPODA		
Sphaeriidae		
ANNELIDA		
OLIGOCHAETA	573	1301
HYDRACHNIDIA	32	54
COPEPODA		
HARPACTICOIDA	36	43
OSTRACODA		1240
INSECTA		
DIPTERA		
Chironomidae	54	1050
Empididae	7	25
Simuliidae	68	22
Tipulidae		394
PLECOPTERA		
Nemouridae		366
TRICHOPTERA		
Limnephilidae		129
Total No. Organisms/m^2 (excluding Calanoida and Cyclopoida copepods)	**2104**	**5470**
Total No. Taxa	**7**	**25**

[a] Source: RL&L (1997).

3.3.7 Fish

3.3.7.1 Fish Population Characteristics

Distribution and Abundance

Lakes and streams in the Jericho Site supported resident fish populations and comprised simple fish communities. Fish species encountered in the Jericho Site included Arctic char, Arctic grayling, burbot, lake trout, ninespine stickleback, round whitefish, and slimy sculpin (Table 3.12). Carat Lake and Lake C3 contained most of these species; all except ninespine stickleback, as well as Arctic grayling in Lake C3. The absence of ninespine stickleback was likely due to the barrier located on the Jericho River, which prevented this species from accessing Carat Lake and all other sampled waterbodies in the upper Carat Lake watershed. Lake O1, which is a smaller waterbody, did contain ninespine stickleback, as well as the other six species encountered in Carat Lake. The Lake O1 drainage is downstream of this barrier.

Table 3.12 Species[a] recorded in selected lakes in the Jericho Site.

Species		Carat Lake	Lake C1	Lake C3	Lake O1	Long Lake	Key Lake	Contwoyto Lake (bay)
Common Name	Latin Name							
Arctic char	*Salvelinus alpinus*	✓		✓	✓		✓	✓
Arctic grayling	*Thymallus arcticus*	✓[b]			✓[b]			+[c]
Burbot	*Lota lota*	✓[b]		✓	✓[b]	✓		+[c]
Lake trout	*Salvelinus namaycush*	✓	✓	✓	✓		✓	✓
Ninespine stickleback	*Pungitius pungitius*				✓[b]			+[c]
Round whitefish	*Prosopium cylindraceum*	✓		✓	✓			+[c]
Slimy sculpin	*Cottus cognatus*	✓	✓	✓	✓[b]	✓	✓[b]	✓[b]

[a] Source: (RL&L 1996a, 1997, 2000a, 2000b).
[b] Includes data from tributaries flowing into lake.
[c] Reid Crowther and RL&L (1985).

Smaller, more isolated waterbodies such as Lake C1 and Long and Key Lakes contained much simpler fish communities. Only lake trout and slimy sculpin were recorded in Lake C1, whereas these species and Arctic char were encountered in Key Lake. Long Lake contained populations of burbot and slimy sculpin.

Based on gill net catches, lake trout was generally the dominant species in most lakes, followed by lower numbers of Arctic char and round whitefish (Table 3.13). Notable exceptions occurred in Lake O1 and Key Lake, where Arctic char was the most abundant species. In general, fish catch rates were low (<10 fish/100 $m^2 \cdot 12h$).

In general, Jericho Site streams supported fish, but the species composition and number of fish recorded varied between systems (Table 3.14). Streams in the Jericho Site were utilized by up to seven species: Arctic char, Arctic grayling, burbot, lake trout, ninespine stickleback, round whitefish, and slimy sculpin. It should be noted that streams in the Jericho Site freeze to the bottom in winter; therefore, the presence of fish in these systems indicates that they originate from lake populations.

Table 3.13 Average catch-per-unit-effort values (fish/100 $m^2 \cdot 12h$) for fish captured during gill net sampling in lakes during summer in the Jericho Site.

Species	Carat Lake[a]	Lake C1[b]	Lake C3[b]	Lake O1[a]	Long Lake[b]	Key Lake[a]	Contwoyto Lake (bay)[a]
Lake trout	5.9	5.6	2.8	1.4	-	4.4	4.5
Arctic char	1.3	-	0.1	9.1	-	7.1	0.3
Round whitefish	2.5	-	1.7	0.7[c]	-	-	-

[a] Source: RL&L (1997).
[b] Source: RL&L (2000a).
[c] Value recorded during fall.

Table 3.14 Number of fish recorded and species composition in selected streams in the Jericho Site.

Species	Stream C1[a]		Stream C2[a]		Stream C3[b]		Stream D1[b]		Stream O18[a]	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Arctic char	48	42.1	10	62.5	10	20.8			95	56.2
Arctic grayling	39[c]	34.2							12	7.1
Burbot	1[c]	0.9			1	2.1			9	5.3
Lake trout	9	7.9	2	12.5					1	0.6
Ninespine stickleback									5	3.0
Round whitefish	8	7.0							7	4.1
Slimy sculpin	9	7.9	4	25.0	37	77.1			40	23.7
Total	**114**	**100**	**16**	**100**	**48**	**100**	**0**	**100**	**169**	**100**

[a] Source: RL&L (1997).
[b] Source: RL&L (2000b).
[c] Source: RL&L (1996a).

Stream C1 contained the highest diversity (six species) of any sampled stream in the Carat Lake Zone. Of the streams that flow directly into Carat Lake, this was one of the few systems that contained Arctic grayling, but this species was recorded only during one year of inventory (1995). Density estimates of four species of fish that were present in the lower section of Stream C1 in 1999 ranged from 5 ± 2 fish/100 m for burbot to 54 fish/100 m for slimy sculpin. Arctic char was the dominant char species (30 ± 4 fish/100 m), followed by a lower number of lake trout 15 ± 12 fish/100 m.

Species diversity tended to be lower in other stream systems in the Jericho Site (e.g., Streams C2, C3, and D1). These waterbodies were generally smaller than Stream C1 and had less well-defined channels. A consistent finding was the restricted distribution of fish in sampled streams. Fish were generally recorded only in the lowermost 100 m, with the exception of Stream C3 where fish were recorded up to 229 m upstream. The reason for this restricted distribution is unclear, but it may be related to characteristics that restrict fish movements (i.e, shallow water and poorly defined channels). Systems in the O Series generally did not follow this pattern. Fish were usually encountered throughout the entire length of streams that connected lakes in this zone. The O Series streams also tended to have high species diversity and fish densities. For example, seven fish species were recorded in Stream O18 and density estimates of Arctic char were 40 ± 3.3 fish/100 m (young-of-the-year) and 9 ± 0.6 fish/100 m (juvenile).

Biological Characteristics

Populations of larger-sized fish in the Jericho Site (Arctic char, lake trout, and round whitefish) were slow growing, late maturing and contained a wide range of age-classes. Gill net catch data indicated that several lake populations (e.g., lake trout, Arctic char, and round whitefish) exhibited a bimodal length-frequency distribution, as illustrated by lake trout in Carat Lake (Figure 3.3).

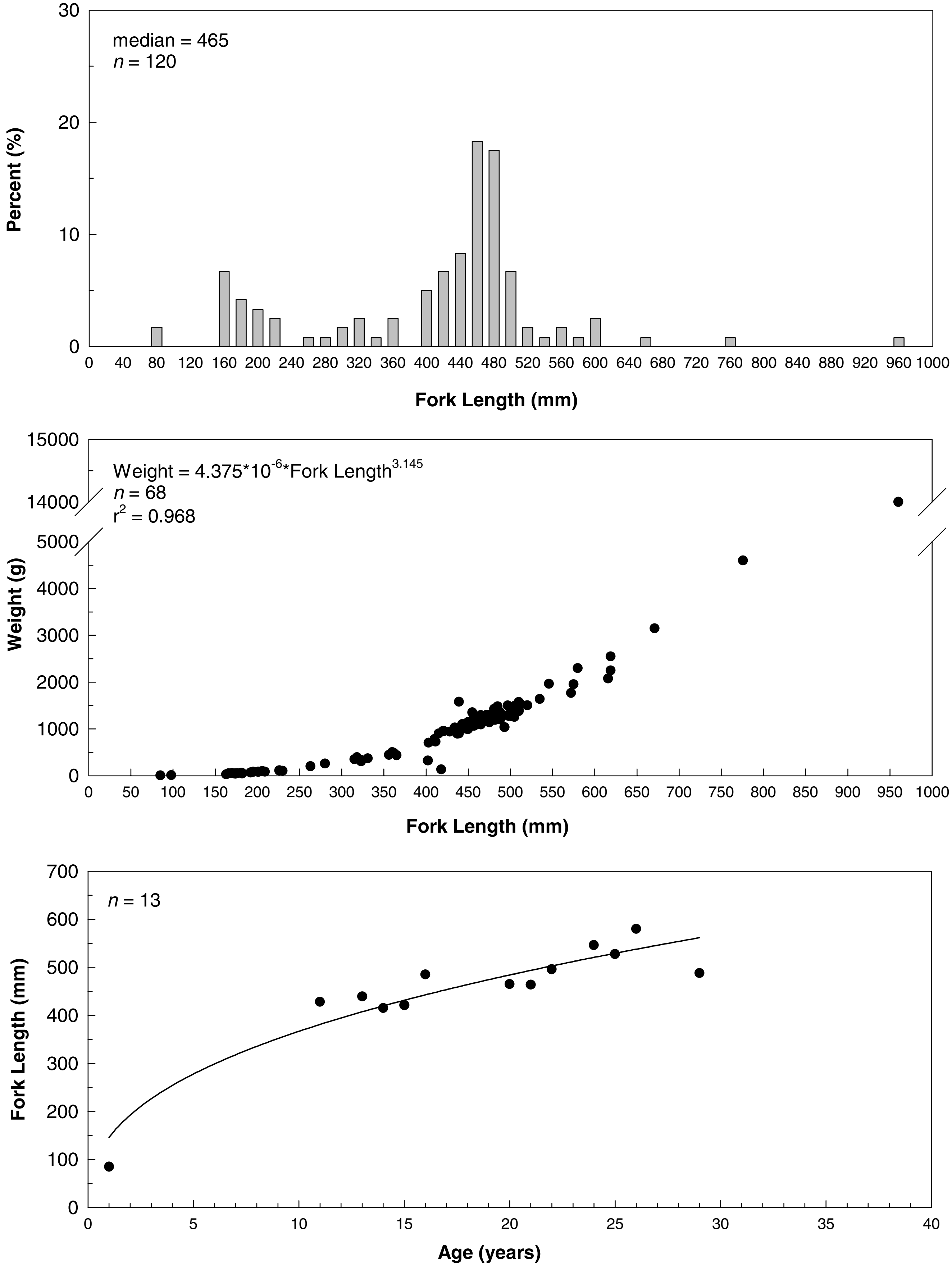


Figure 3.3 Length-frequency distribution, length-weight and length-at-age data for lake trout in Carat Lake, Jericho Site (RL&L 1997) (all seasons and methods combined).

The mean size of species such as lake trout and Arctic char tended to be correlated to the size of the sampled lake (Table 3.15). Arctic char in Lake C3 tended to be smaller than in the other study area waterbodies; however the lake trout in Lake C1 were considerably smaller than all other sampled lakes in the Jericho Site (differences of >86 mm average fork length).

The reproductive status of fish in the Jericho Site provided evidence that these populations were slow growing. Age-at-maturity data (i.e., age at which a fish spawns for the first time) for fish populations in Carat Lake indicated that Arctic char were 10 years old, lake trout were 15 years old, and round whitefish were seven years old before they were sexually mature (Table 3.16). Information for Arctic char and lake trout also suggested that a portion of the mature population may not spawn in a particular year (27% of mature Arctic char and 23% of mature lake trout).

The species composition and abundance of fish populations encountered in the Jericho Site were consistent with other studies (Reid Crowther and RL&L 1985; RL&L 1993b, 1996b, 1998). Results indicate that they are typical of subarctic fish populations residing in cold, oligotrophic waterbodies. These characteristics are indicative of unexploited fish populations in a state of equilibrium with their environment (Johnson 1972).

Table 3.15 Fork length[a] of fish sampled by gill nets in selected lakes in the Jericho Site.

Species	Lake	Fork Length (mm)		
		Sample Size	Mean	Range
Arctic char	Carat Lake	19	473.9	225 - 623
	Lake C3[b]	3	249.3	242 - 256
	Lake O1	64	445.6	173 - 613
	Key Lake	34	351.9	266 - 409
	Contwoyto Lake (bay)	4	438.8	204 - 525
Lake trout	Carat Lake	119	420.5	85 - 960
	Lake C1	11	213.6	176 - 429
	Lake C3[b]	31	434.1	176 - 835
	Lake O1	20	533.3	104 - 999
	Key Lake	16	299.9	187 - 482
	Contwoyto Lake (bay)	53	336.2	96 - 684

[a] Source: RL&L (1997), unless otherwise indicated.
[b] Source: RL&L (2000a).

Table 3.16 Age-at-maturity and percentage of nonspawners in fish populations in Carat Lake[a] in the Jericho Site.

Species	Age-at-Maturity	Percent Nonspawners
Arctic char	10	27
Lake trout	15	23
Round whitefish	7	0

[a] Source: RL&L (1997).

Feeding Habits

Fish in the Jericho Site were generalist feeders (i.e., feeding on the most abundant food item available). Zooplankton and chironomids were the most frequently consumed food items by all species. Lake trout and Arctic char also consumed fish. Round whitefish, which is a benthic feeder, tended to feed to a greater extent on benthic invertebrates than other fish species.

Fish Movement

The Jericho Site contains several lakes that are interconnected by larger streams with discharges >0.5 m^3/s during the open water period in high flow years (Tahera Corporation, unpubl. data); however, most streams in the Jericho Site are too shallow and ill-defined to facilitate fish passage.

Limited recapture data precluded a detailed assessment of fish movements in the Jericho Site; however, movements between Jericho Lake and Carat Lake have been documented for lake trout. As well, a lake trout tagged in Contwoyto Lake in 1996 was recaptured near its release location in 2000, indicating that some fish in large lake systems may remain relatively stationary.

Fisheries survey data also indicated that annual fish movements do not occur into the site from downstream areas of the Burnside River system. This is due to a barrier to fish passage that is located immediately downstream of Jericho Lake on the Jericho River. It should be noted that streams in the O Series Zone do provide a fish movement corridor between the lakes and the Jericho River.

Fish Health

Fish health in the Jericho Site did not appear to be adversely affected by parasites or other factors. High parasite burdens were not recorded in sampled fish and indices of fish condition approximated one (Table 3.17), which is an indication of isometric growth (Ricker 1975).

Table 3.17 Mean Fulton's condition factor[a] for fish in selected lakes in the Jericho Site.

Species	Carat Lake	Lake C1	Lake C3[b]	Lake O1	Key Lake	Contwoyto Lake (bay)
Lake trout	1.05	0.94	1.02	1.11	0.95	1.05
Arctic char	1.01	-	0.99	0.96	0.96	1.03[c]
Round whitefish	1.2	-	1.1	1.08	-	-

[a] Source: RL&L (1997), unless otherwise indicated.
[b] Source: RL&L (2000a).
[c] Source: RL&L (2000b).

Background metal concentrations in fish tissues can be used as an indicator of fish health. As part of the Aquatic Effects Monitoring (AEM) program, tissues were collected from lake trout and round whitefish in Carat Lake and a control lake located upstream of the development (RL&L 1997). For the purposes of fish health, the discussion will focus on results for Jericho Lake and will deal with only those metals that appeared to be elevated. Of the 26 metal elements tested, only concentrations of two were considered higher than expected: aluminum and mercury.

Aluminum

Detectable concentrations of aluminum (>1µg/g) in liver samples were recorded in 100% of the lake trout and 95% of round whitefish (RL&L 1997). The mean aluminum concentrations in liver tissues were 21 µg/g in lake trout and 9 µg/g in round whitefish. For muscle tissue, however, aluminum concentrations did not exceed the detection limit for either species.

The availability of aluminum to aquatic organisms has been correlated with the pH of the aquatic environment (Holtze and Hutchinson 1989); however, it is unclear at what pH threshold, or at what concentration, aluminum becomes toxic to fish. Aluminum can be acutely toxic at high exposure levels, but it does not bioaccumulate in aquatic organisms (Neville 1985).

Mercury

Mercury concentrations were above the detection limit (>0.005 µg/g) in most tissue samples. The mean mercury levels in lake trout liver tissues were 2.803 µg/g in Carat Lake, which exceeds the allowed level for human consumption. The maximum mercury concentrations documented in lake trout was 4.760 µg/g and 1.720 µg/g in round whitefish (liver samples from Carat Lake).

Mercury in fish tissue is most commonly present in the form of methyl mercury. Because there are several types of mercury potentially present in the environment, total mercury is the form recommended for setting guidelines for human consumption (Reeder et al. 1979). The maximum allowable level of mercury in muscle tissue of fish sold in Canada for human consumption is 0.5 µg/g (wet weight), which is comparable to approximately 2.5 µg/g when expressed on a "dry weight" basis (assuming 80% moisture content).

To ascertain whether background concentrations of aluminum and mercury were higher than 'normal', data from Carat Lake were compared to data from Izok Lake situated east of the Jericho Site and Nisha Lake, which is located to the southwest (Table 3.18). Carat Lake fish contained mean aluminum concentrations in liver that were three times (lake trout) and two times (round whitefish) higher than mean concentrations in fish collected elsewhere. In contrast, mean concentrations of mercury in liver and muscle tissues from both species and tissues were generally similar among the three sample areas.

Table 3.18 Comparison of mean metal concentrations in fish tissues collected from three areas.

Species	Tissue	Mean Concentrations (µg/g of dry weight)					
		Aluminum			Mercury		
		Carat Lake[a]	Izok Lake[b]	Nisha Lake[c]	Carat Lake	Izok Lake	Nisha Lake
Lake trout	Liver	21	8	6	2.803	1.290	2.018
	Muscle	< D.L.[d]	< D.L.	< D.L.	1.074	0.660	0.695
Round whitefish	Liver	9	4	4	0.843	0.490	0.783
	Muscle	< D.L.	< D.L.	< D.L.	0.501	0.260	0.277

[a] Source: RL&L (1997).
[b] Source: RL&L (1993a).
[c] Source: RL&L (1996b).
[d] Detection limit.

3.3.7.2 Fish Habitat

Waterbodies in the Jericho Site provided habitats necessary for resident fish populations to complete their life requisites (i.e., spawning, rearing, feeding and overwintering). Subarctic lakes typically provide an abundance of feeding and overwintering habitats, but the low availability of spawning and rearing habitats could limit some populations.

Potential spawning habitats were identified in selected lakes throughout the Jericho Site (Figure 3.4). Spawning habitats required by lake dwelling species such as lake trout, Arctic char, and round whitefish are characterized by the presence of clean gravel to boulder-sized substrate in areas sufficiently deep to avoid freezing (Scott and Crossman 1973). Areas with these characteristics were widely distributed in all surveyed waterbodies, which suggested that spawning habitat was not limited.

Known spawning habitats (those documented by the presence of spawning fish or fry) were recorded in Carat Lake. Female lake trout in spawning condition were captured at sites on the north side and southeast corner of the lake. Arctic char fry (i.e., young-of-the-year fish with yolk sacs) were encountered along the southeastern shore of Carat Lake at the confluence of Stream C1.

Potential rearing habitats, which were characterized as shallow-water, sheltered areas, were not abundant or widely distributed in Jericho Site lakes. Also, high quality rearing habitats exhibiting low slopes and fine substrates that supported the growth of aquatic macrophytes (Randall et al. 1996) were severely limited. These are important features that provide shelter (i.e., protection from predators) and a source of food to younger age-classes of fish. Although rearing habitats were present in all lakes, they were not abundant and few areas were of high quality.

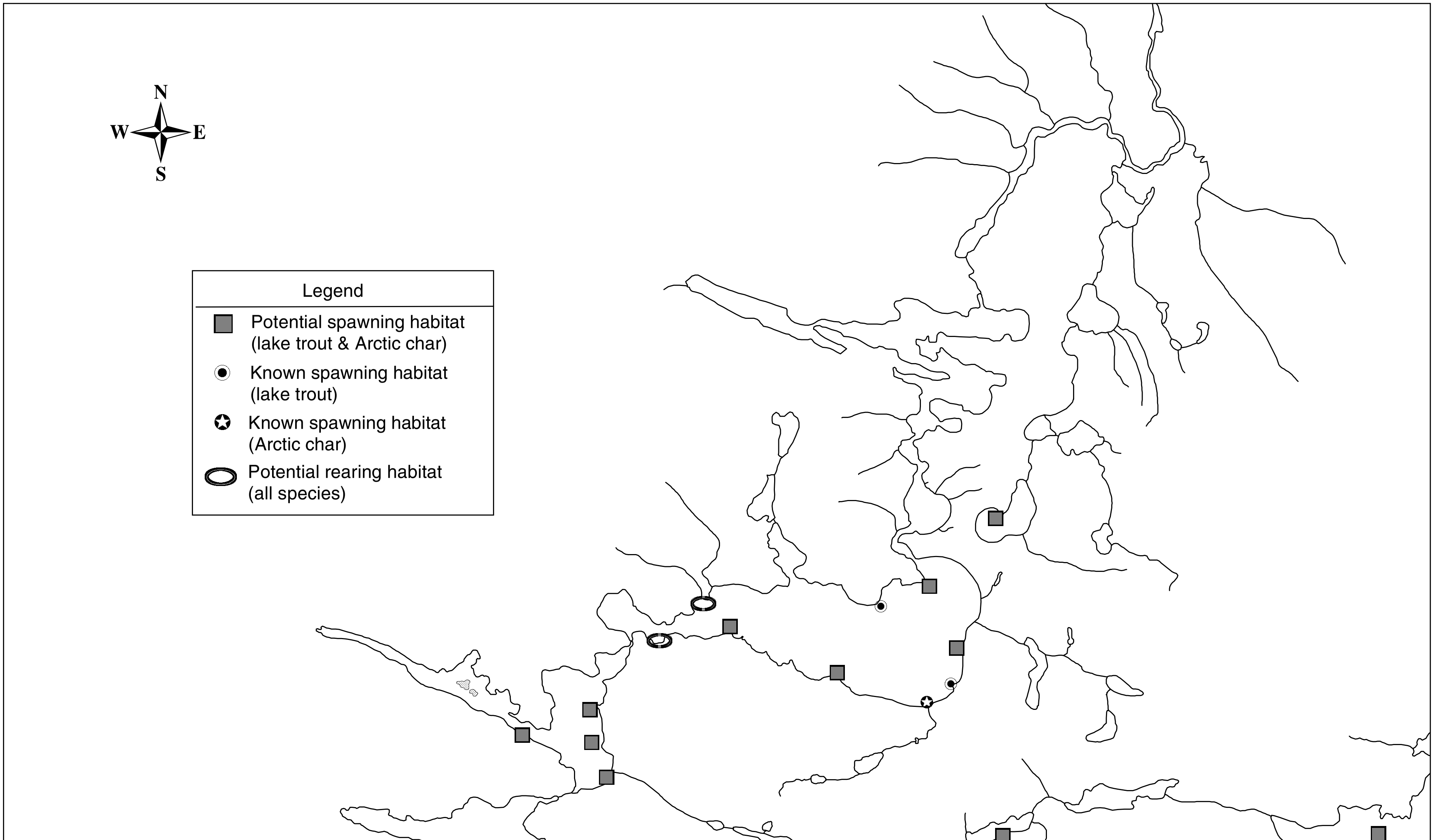


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Figure 3.4 Locations of spawning and rearing habitats, Jericho Site.

Streams in the Jericho Site provided fish habitat only during the open water period. Due to their small size, ill-defined channels and presence of barriers to fish movement, many of these streams were of limited value as fish habitat. In general, smaller-sized fish (young-of-the-year and juveniles) utilized only the lower sections of streams in the Jericho Site as rearing habitat on an opportunistic basis.

In the Carat Lake Zone, Stream C1 provided suitable rearing habitat for a diverse assemblage of species. The presence of good numbers of young-of-the-year and juvenile fish indicated that this system provided good quality rearing habitat; however, fish distribution in this system was still restricted to the lowermost 100 m of stream.

The habitat types available to fish in Reaches 1 and 2 of Stream C1 (92 m and 70 m in length, respectively) were dictated by the physical features of the stream. In general, RIFFLE and/or RUN type habitats dominated (Table 3.19). These reaches also exhibited high habitat complexity (frequency of occurrence of habitat units), which enhanced the value of the habitat to fish.

Table 3.19 Summary of habitat types (area and frequency) in Reaches 1 and 2 of Stream C1[a], Jericho Site.

Reach	Habitat Type	Area		Frequency	
		Square Metres	Percent	Number	Percent
1	FLAT	43	12.1	4	12.9
	POOL	2	0.6	1	3.2
	RIFFLE	173	48.9	14	45.2
	RUN	136	38.4	12	38.7
	Subtotal	**354**	**100.0**	**31**	**100.0**
2	FLAT	4	2.0	1	11.1
	POOL	0	0.0	0	0.0
	RIFFLE	154	76.2	6	66.7
	RUN	44	21.8	2	22.2
	Subtotal	**202**	**100.0**	**9**	**100.0**

[a] Source: RL&L (2000a).

3.4 SUMMARY

Waterbodies in the Jericho Site exhibit characteristics similar to other subarctic lakes. Most have shorelines predominantly composed of cobbles and boulders. Most streams are small with ill-defined channels containing coarse substrates. Sand, gravel and cobble substrates are most often found in streams with well-defined channels and moderate velocities. Stream hydrology in the Jericho Site is affected by low precipitation and the presence of permafrost. Because the ground is completely frozen at the beginning of snowmelt, water cannot infiltrate into the soil. As such, most of the precipitation that accumulates during winter as snow, rapidly runs off during spring. Water flows in many streams decrease rapidly after snow melt and water levels become very low or dry during summer.

Nutrient concentrations in Jericho Site waterbodies are low, with most measurements being near or below detection limits. In general, lakes are cold, oxygen rich and clear. Based on these data, lakes in the Jericho Site can be categorized as oligotrophic (Wetzel 1983). The oligotrophic status of these waterbodies severely limits their productive capacity. As such, biological communities in these waterbodies typically exhibit low species diversities and densities of organisms.

Aquatic macrophytes are severely limited in Jericho Site lakes. The absence of aquatic macrophytes is probably due to the lack of suitable substrate (i.e., silt) in shallow water, sheltered areas and the low nutrient concentrations.

The phytoplankton and periphyton communities in waterbodies of the Jericho Site exhibit low densities and are dominated by relatively few taxa. In summer, phytoplankton communities consist primarily of cyanobacteria, golden-brown algae, and green algae. Cyanobacteria also dominates the periphyton community, followed by diatoms. Chlorophyll *a* concentrations of periphyton and phytoplankton are very low. Zooplankton densities in the Jericho Site lakes are also low during summer. The most abundant zooplankton groups are rotifers and cyclopoid copepods. As is typical of oligotrophic subarctic lakes, benthic invertebrate communities in lakes and streams exhibit low densities and low species diversity. In lakes, chironomids and nematodes are numerically dominant and benthic invertebrates tend to be more abundant in the littoral zone compared to the profundal zone. Species diversity and densities in streams exhibited large variations between waterbodies. The most abundant groups encountered included: oligochaetes, ostracods, chironomids and nematodes.

Lakes in the Jericho Site support stable, slow-growing communities of fish that are characteristic of cold, oligotrophic systems (Hobbie 1973). Species in the study area include Arctic char, Arctic grayling, burbot, lake trout, ninespine stickleback, round whitefish, and slimy sculpin. Arctic char, lake trout, and round whitefish tend to be numerically dominant in these communities; however, densities are low for all species. No rare or endangered fish species were recorded in the Jericho Site.

Because streams in the Jericho Site freeze to the bottom in winter, they are used on an opportunistic basis by the lake resident fish populations. In particular, young-of-the-year and juvenile Arctic char, Arctic grayling and lake trout, as well as all age-groups of slimy sculpin, are encountered in these systems.

Jericho Site fish are typical of unexploited populations consisting of a large proportion of older and larger fish that have a long life span. These fish mature at an advanced age and they may not spawn every year. These fish are generalist feeders consuming food items that are most readily available.

The fish populations likely undertake limited movements between lakes in the Jericho Site. This is due primarily to the lack of good movement corridors between most of the lakes and the presence of fish barriers at some locations. In particular, fish in the upper Carat Lake basin are separated from fish in the Jericho River by a large barrier near the outlet to Jericho Lake. Similarly, the fish community in Carat Lake cannot access Lake C1 due to a barrier on Stream C1.

Waterbodies in the Jericho Site provide all the habitats that are necessary to maintain the fish communities. In general, feeding and overwintering habitats are abundant in most lakes (those having a maximum water depth >4 m). Potential spawning habitat is also abundant and widely distributed in sampled lakes. In contrast, sheltered rearing habitat for juveniles is limited. Most streams in the Jericho Site provide rearing habitat for fish; however, use of these systems is generally restricted to the lowermost section.

Note: Please refer to Attachment 4.1 for an updated aquatic impact assessment.

5.0 AQUATIC EFFECTS MONITORING

5.1 INTRODUCTION

The NWB draft guidelines (NWB 1999) require a program to verify compliance with regulatory standards and to evaluate the effectiveness of the mitigative measures as a condition of project approval. The aquatic effects monitoring program (AEM) for the proposed project, as described below, is designed to monitor effects on aquatic biota. It is assumed that water quality monitoring will also be required as part of the water license approval.

The main objective of the monitoring program is to monitor sources of effluent to detect un-anticipated effects on aquatic biota so that appropriate mitigative actions can be taken. Secondary objectives of the monitoring program are:

- to allow regulators to evaluate compliance with environmental regulations;
- to verify the predictions of environmental effects; and,
- to provide the data needed to revise mitigative measures.

5.2 DESIGN OF THE AEM PROGRAM

The ore bearing deposit at the Jericho Site is situated immediately adjacent to a Carat Lake. Following collection and treatment, effluent from mining activities (waste rock dump, ore stockpile, and pit) has the potential to drain downslope into Carat Lake. The diversion system on Stream C1 also has the potential to introduce deleterious substances (suspended sediment) into Carat Lake. The receiving environment in both cases is the southeastern portion of Carat Lake.

The deleterious substances and their associated effects can be categorized into three broad groups: nutrient loading, elevated suspended sediments and increased levels of contaminants. All three have the potential to adversely affect the aquatic biological community.

Components of the aquatic biological community that are potential receptors suitable for monitoring purposes, include periphyton, benthic invertebrates, and fish. The first two organisms were chosen as receptors because they are stationary and are likely to reflect changes in the environment more rapidly than other organisms such as fish. Lake trout and round whitefish were also chosen as receptors because they have the potential to bioaccumulate some metals and fish have a higher social value than invertebrates. Other organisms, such as phytoplankton and zooplankton, were deemed unsuitable as receptors for monitoring for two reasons. Firstly, both groups exhibit high levels of natural variability that will make it difficult to identify change. Secondly, neither receptor is stationary within the context of this project (southeast portion of Carat Lake), which makes it difficult to ascertain site-specific effects.

One abiotic component will be included in the AEM program. The rate of sedimentation will be used for monitoring because it provides a link between elevated suspended sediments and changes in the aquatic biological community. Table 5.1 lists the parameters that will be monitored to ascertain the effects of mining activities on the chosen biological receptor.

Table 5.1 Parameters used to monitor potential project induced changes in aquatic biological system in the Jericho Site.

Effect	Receptor	Parameter
Nutrient Loading	Periphyton	- biomass (chlorophyll *a*); species composition
	Benthic invertebrates	- total density; major taxon density; species diversity
Elevated suspended sediments	Periphyton	- biomass (chlorophyll *a*); species composition
	Benthic invertebrates	- total density; major taxon density; species diversity
	Sedimentation	- rate of sedimentation
Metal Contaminants	Lake trout, Round whitefish	- metal concentrations in muscle and liver tissues

Two approaches will be employed by the proposed AEM program. The first is a conventional approach used to detect environmental change (DFO 1993; DIAND 1997). For periphyton, benthic invertebrates, and sedimentation, the program will be designed to monitor near-field effects and far-field effects and to compare these data to two suitable reference sites. To ascertain near-field effects, monitoring will be undertaken in Carat Lake immediately downstream of the effluent source (i.e., outlet zone of Stream C1). Far-field effects will be monitored in Carat Lake adjacent to the outlet on the north shore of the lake. The two reference sites will be located on a control lake situated in the Carat Lake drainage, which is upstream of mining activity effects. The second approach to monitor change will be specific to fish. Because both receptor species are highly mobile, near-field and far-field effects cannot be properly ascertained; consequently, background metal concentrations in fish residing in the potentially affected waterbody (Carat Lake) will be compared to data collected from fish in an unaffected waterbody (a control lake).

The AEM program is designed to distinguish between natural variability in the environment and project induced changes. To this end, power analyses will be used where appropriate to identify the suitable level of sampling effort. Site-specific predevelopment monitoring data and information from other studies (e.g., RL&L 1996b, 1995) will be used to establish appropriate sample sizes. It should be noted that fish are being used as a receptor to monitor metal contaminants in tissues due to their social value. Power analyses have historically indicated that the sample size required to detect an acceptable change of a constituent in fish tissue often exceeds the harvest capacity of the population. Therefore, use of fish as a suitable receptor will be discussed with regulatory authorities.

6.0 COMPENSATION

The Department of Fisheries and Oceans has adopted a “No Net Loss” policy in regards to the productive capacity of fish habitats (DFO 1986). Fish habitat is defined by the Fisheries Act as “spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes”. To further the “No Net Loss” principle, DFO has also published a document on “Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction (HADD) of Fish Habitat” (DFO 1998b), with respect to the Fisheries Act, Section 35. This publication outlines the decision processes for authorization of HADD. Within the initial application process, DFO managers determine if the proposed project could result in HADD. If HADD could occur, the next step is to assess if the impacts could be fully mitigated. If the impacts could be fully mitigated then a Letter of Advice specifying mitigation would be issued; however, if the potential impacts cannot be fully mitigated, then a decision will be made as to whether compensation is possible.

DFO (1998b) has designed a hierarchy to compensate for HADD, which includes the following:

- create similar habitat at or near the development site within the same ecological unit;
- create similar habitat in a different ecological unit that supports the same stock or species;
- increase the productive capacity of existing habitat at or near the development site and within the same ecological unit;
- increase the productive capacity of a different ecological unit that supports the same stock or species;
- increase the productive capacity of existing habitat for a different stock or a different species of fish either on or off site; and
- artificial propagation.

The Jericho Diamond Project will fall under the jurisdiction of the Federal Fisheries Act, and Section 35 of the act will apply (DFO 1998a). Based on the proposed development in the Jericho Site and the mitigative measures that will be implemented, it is not known to what extent compensation will be required under a HADD authorization. As such, it is deemed premature to develop a detailed compensation plan to achieve no net loss of fish habitat. Some options, however, are available for discussion. These include creation of fish habitat in the diversion channel, enhancing rearing habitat in Carat Lake and other waterbodies, and increasing available habitat by removal of barriers to upstream fish passage in Stream O18. When appropriate, Tahera will review these options with the Department of Fisheries and Oceans.

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APPENDIX A - List of Documents

Jericho Diamond Project Aquatic Studies Program (1995). Report prepared for Canamera Geological Ltd. R.L. & L. Report No. 462BF: 122 p. + 10 app.

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ATTACHMENT 4.1
AQUATIC IMPACTS ASSESSMENT AMENDMENT

JERICHO PROJECT AQUATIC BIOTA EIA
– AMMENDMENT-

Prepared for

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P&E Environmental Consultants Ltd. personnel were responsible for the amendment as follows:

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1.0 INTRODUCTION

This document is an amendment to the original environmental impacts assessment presented in RL&L (2000). The purpose of the assessment is to evaluate the environmental effects of the proposed Jericho Diamond Project on aquatic biota. This document closely follows the environmental impact assessment procedure outlined by the Canadian Impact Assessment Agency (CEAA 1994, 1997), which provides a well-defined system to classify adverse environmental effects and a criteria rating system to ascertain their significance.

Environmental effects are complex and interrelated, and they can influence many different components of the aquatic biological community. To simplify and focus the assessment, fish have been selected as the Valued Environmental Component (VEC) of the aquatic biological community and will be the basis of all evaluations. Fish are deemed to be suitable candidates for this purpose because they are sensitive to changes to the aquatic environment and they are highly valued by society. They are also a good indicator of biodiversity, which should be an integral component of the assessment process (Environment Canada 1996).

The issues that will be discussed include direct and indirect effects on fish through changes in habitat and water quality. Indirect effects on invertebrates (primary producers, zooplankton, and benthic invertebrates) are also incorporated in the assessment where appropriate because changes to these aquatic biota can affect fish.

A pathways system approach will be employed to show the linkage between a project component and its effects on fish. Each pathway will identify the project component or activity, its direct or indirect effect, and the consequences of the effect. Each pathway also will include the location and phase of the project component or activity and the location of the receiving environment.

The first step of the EIA process is to identify all potential environmental effects that may result from project activities and then review each potential effect in relation to proposed environmental management and mitigation measures. Environmental management and mitigation are defined as any measure that is designed to eliminate, reduce, or control adverse effects of the project. Based on this review, each potential environmental effect is classified as having no effect or having a residual or adverse (negative) effect on fish. Any effect is deemed to be adverse if it causes a change in the existing fish community.

As specified in the environmental impact assessment procedure (CEAA 1994, 1997), the EIA will only evaluate the significance of residual effects (i.e., effects that remain after implementation of available environmental management and mitigation measures); it will not evaluate the significance of potential environmental effects.

2.0 ASSESSMENT OF POTENTIAL EFFECTS

2.1 INTRODUCTION

Project activities at the Jericho Site have the potential to affect fish in several ways. These may include direct mortality of fish, changes to habitat, and reduced water quality. It should be noted that fish habitat can be physically removed by the foot print of the development or its value to fish can be reduced through changes in water quality. Water quality may also influence fish by affecting the health of a population, or by changing the reproductive capacity of primary producers (phytoplankton and periphyton), or food sources (zooplankton and benthic invertebrates).

Project activities have been grouped into three pathways of potential effects on fish: direct mortality, loss of habitat by removal or degradation, and reduced water quality (Table 2.1). The specific activity is described and its location and project phase identified. Each pathway represents one primary effect, but it is acknowledged that a project activity could have multiple effects. Potential effects are discussed as they pertain to specific waterbodies. Project activities deemed to have no potential adverse effect are not discussed (e.g., extension of airstrip).

This section will examine each potential environmental effect in relation to the environmental management and mitigation plans that will be implemented. Project activities that have residual (adverse) environmental effects following mitigation then will be summarized.

2.2 POTENTIAL EFFECTS CAUSING FISH MORTALITY

2.2.1 Water Withdrawal Intake

Project Activity

A single water withdrawal system would be constructed in Carat Lake to supply potable water to the camp and raw water to the mine and processing plant (Project Description Map A; Figure 2.1). A nominal requirement of 30 m^3 per day will be drawn from the lake; this is a small fraction of the predicted annual runoff for the Carat Lake basin (0.6%). Total draw down for the period when there is no inflow (winter) would be 108,000 m^3 or 0.4% of the lake volume. Based on these data, water withdrawal will have no appreciable effect on the water level of Carat Lake.

Table 2.1 List of pathways, associated project activities and their potential environmental effect(s) on fish, Jericho Diamond Project.

Pathway	Project			Potential Environmental Effects	
	Activity	**Location**	**Phase**	**Effects**[a]	**Location**
Direct Mortality	Water Withdrawal Intake	Mine Area	Construction Operation Closure	1) Entrainment of fish by intake.	Carat Lake
	Use of Explosives	Mine Area	Construction Operation	1) Shock wave causing mortality of eggs and fish.	Carat Lake, Lake C1, and Stream C1
	Angling	Jericho Site	Exploration Construction Operation Closure	1) Harvest of fish and hooking injuries.	Jericho Site waterbodies
	Scientific Research	Jericho Site	Exploration Operation Closure	1) Lethal sampling of fish.	Jericho Site waterbodies
Loss of Habitat	Permanent and Winter Roads	Jericho Site	Construction Operation Closure	1) Blockage of fish passage. 2) Altered drainage into stream. 3) Increased suspended sediments and sedimentation (reduced water quality). 4) Foot print of ramp.	Streams C2, D1, and D2 Contwoyto Lake, Lynne Lake
	Stream Diversion	Mine Area	Construction Operation Closure Post-closure	1) Dewatering of natural stream. 2) Foot print of intake and outlet ports. 3) Increased suspended sediments and sedimentation (reduced water quality and direct mortality). 4) Stranding of fish (direct mortality).	Stream C1, Carat Lake
	Processed Kimberlite Containment Area (PKCA)	Mine Area	Construction Operation Closure Post-closure	1) Removal of natural lakes and ponds (direct mortality).	Long Lake, ponds, connecting channel
	Water Withdrawal Causeway	Mine Area	Construction Operation Closure Post-closure	1) Causeway foot print (direct mortality). 2) Increased suspended sediments and sedimentation (reduced water quality and direct mortality).	Carat Lake
Reduced Water Quality	Runoff from Mine Pit, Dumps and Stockpiles	Mine Area	Construction Operation Closure Post-closure	1) Increased contaminant and nutrient concentrations. 2) Increased suspended sediments and sedimentation (habitat loss and direct mortality).	Carat Lake, Stream C1, Lake C1, Key Lake
	Discharge from the PKCA	Mine Area	Construction Operation Closure Post-closure	1) Increased contaminant and nutrient concentrations. 2) Dewatering of stream channel (habitat loss). 3) Increased suspended sediments and sedimentation (habitat loss and direct mortality).	Lake C3, Stream C3
	Emissions from Mining Activities	Jericho Site	Construction Operation Closure	1) Increased suspended sediment concentrations and sedimentation (habitat loss and direct mortality).	Jericho Site waterbodies

[a] Items in brackets indicate potential effects that are in addition to those identified by the pathway.

The water withdrawal system will consist of an intake and pipeline that will extend offshore approximately 150 m east of the outlet of Stream C1. The intake and pipeline will be protected from ice damage by a 90 m long causeway constructed from waste rock material generated during construction of the mine. The intake will be located in water 5.5 m in depth and will be approximately 1 m above the lake bottom.

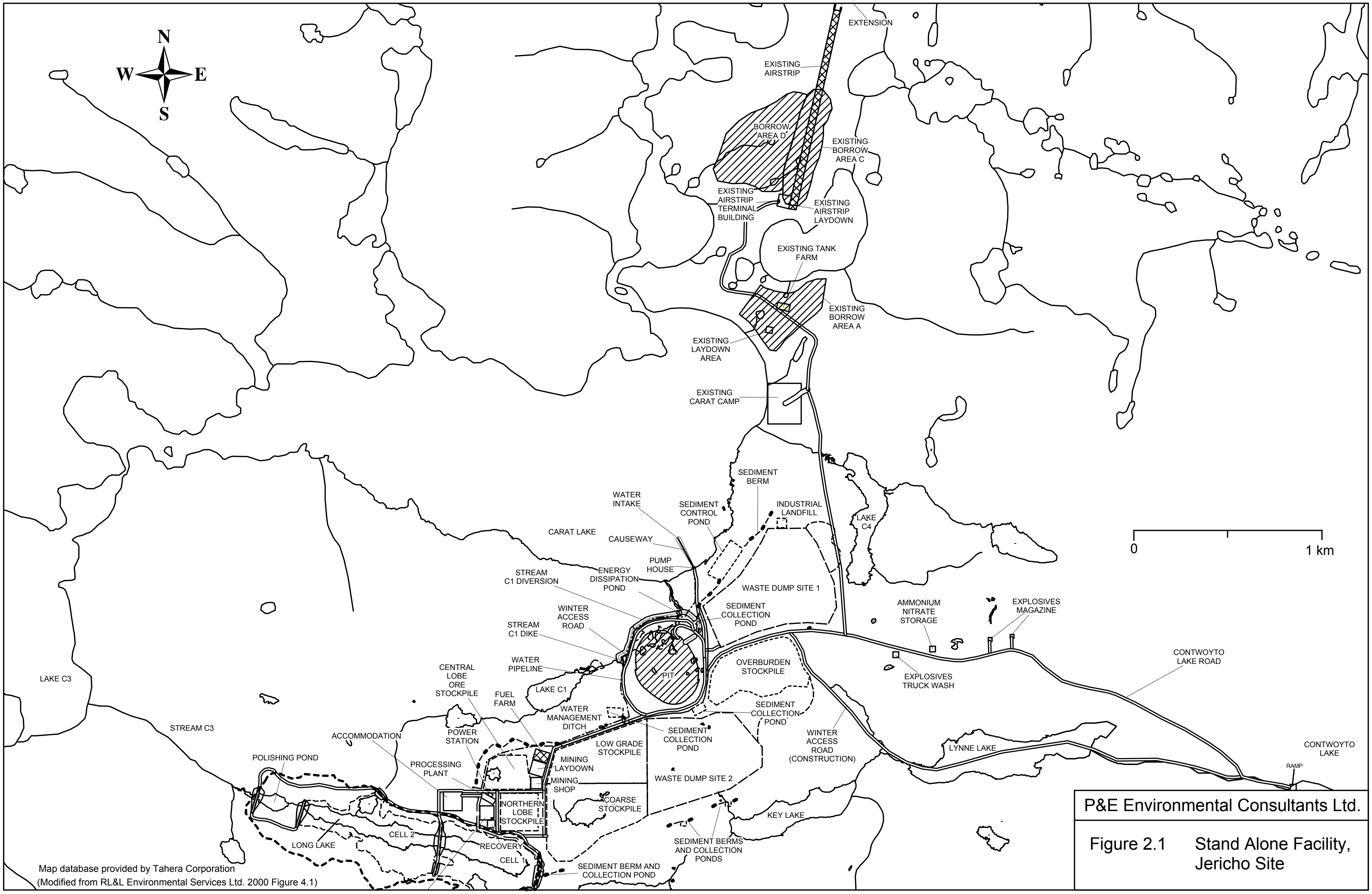

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Figure 2.1 Stand Alone Facility, Jericho Site

Potential Effects

Entrainment into the intake structure could cause direct mortality of fish. Larger-sized adult fish use the main lake in the vicinity of the intake for feeding, while the lake margins are used for rearing by young-of-the-year and juvenile fish. High concentrations of fish were not recorded in the vicinity of the proposed location of the intake and this area was not classified as high quality habitat. As such, there is the potential for fish mortality, but it is likely that few fish will be entrained.

Environmental Management and Mitigation

The Department of Fisheries and Oceans (DFO) has specific guidelines for the screening of water intake structures for the protection of fish (DFO 1995a). The guidelines present design criteria that are intended to protect small fish, such as young-of-the-year and juveniles, which are most susceptible to entrainment. The criteria are based on fish length, swimming ability, and water uptake volume per unit time, and are used to specify requirements for screen mesh size, water velocity, and surface area of the intake opening. Adhering to these criteria ensures that fish of a minimum size are not drawn into water intake structures. Tahera is committed to meeting these screening guidelines (Project Description, Appendix A.1). In addition, the water intake structure will be placed in an area not typically used by small fish. This measure will reduce the possibility of smaller fish encountering the intake structure.

Assessment of Potential Effects

The DFO guidelines (DFO 1995a) for screening of water intakes will be met and the intake structure will not be placed in an area that could potentially contain large concentrations of small fish. As such, no adverse environmental effects associated with the water intake structures are anticipated.

2.2.2 Use of Explosives

Project Activity

Explosives would be the primary method of excavating waste rock and kimberlite ore during construction and operation of the open pit. Use of explosives would cause shock waves that radiate outwards from the point of detonation. The project design requires detonation of explosives approximately once per day (Tahera, pers. comm.). Individual charges will be inserted into 23 or 32 holes drilled in the rock to be excavated; the number of holes is dependant on rock type. The drill holes will be evenly spaced in a series of five rows, with the explosives and holes evenly distributed among the rows. The weight of explosives used in each hole will be either 167 kg (32 holes) or 227 kg (23 holes) depending on the rock to be blasted. Based on this design, the total weight of explosives per detonation each day would be either 5344 kg or 5221 kg.

Potential Effects

Free-swimming fish are present in Stream C1, Lake C1, and along the southeast shoreline of Carat Lake, which are in the vicinity of the pit (Figure 2.2). Incubating fish eggs will be present in Lake C1 during part of the year (resident populations of lake trout and slimy sculpin) and incubating eggs (lake trout, Arctic char, round whitefish, and slimy sculpin) may also be located along the southeast shore of Carat Lake. The assumption for the presence of incubating eggs is based on indirect evidence (i.e., presence of suitable spawning habitat, the presence of fish in spawning condition and young-of-the-year Arctic char) rather than a physical collection of fish eggs. Although spawning by larger fish species was not documented in Stream C1, it is likely that slimy sculpin use this system for spawning and egg incubation. Based on the timing of spawning (McCart and Den Beste 1979), incubating eggs of lake trout, Arctic char, and round whitefish could be present on shoals along the lake margins between September and March; eggs of slimy sculpin could be present during June and July (Scott and Crossman 1973).

Since the pit is adjacent to fish bearing waters, there is the potential for shock waves produced by explosives to affect fish. Shock waves cause "a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure" (Wright and Hopky 1998). The drop below ambient hydrostatic pressure causes most of the negative effects on fish, which can range from damage to the swim bladder or other organs to the disruption of development and mortality of fish eggs (Wright and Hopky 1998). Small fish are more susceptible to the effects of shock waves than large fish (Wright 1982) and changes in fish behaviour have also been recorded (Wright and Hopky 1998).

Environmental Management and Mitigation Measures

There are a number of mitigation measures available to reduce the magnitude of the shock waves produced by the explosion (Munday et al. 1986). The most appropriate mitigation would be to reduce the total weight of explosives, or separate the total explosion into a series of smaller explosions (and weights) by increasing the detonation delay period between charges (Munday et al. 1986). *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998) recommend a minimum detonation delay period of 25 milliseconds (ms). To reduce the potential effects of explosives in the mine pit, Tahera will implement the following measures (Tahera, pers. comm.):

- There will be a detonation delay of 500 ms between each of the five rows of explosives.
- There will be a detonation delay of 25 ms between each charge within each row.

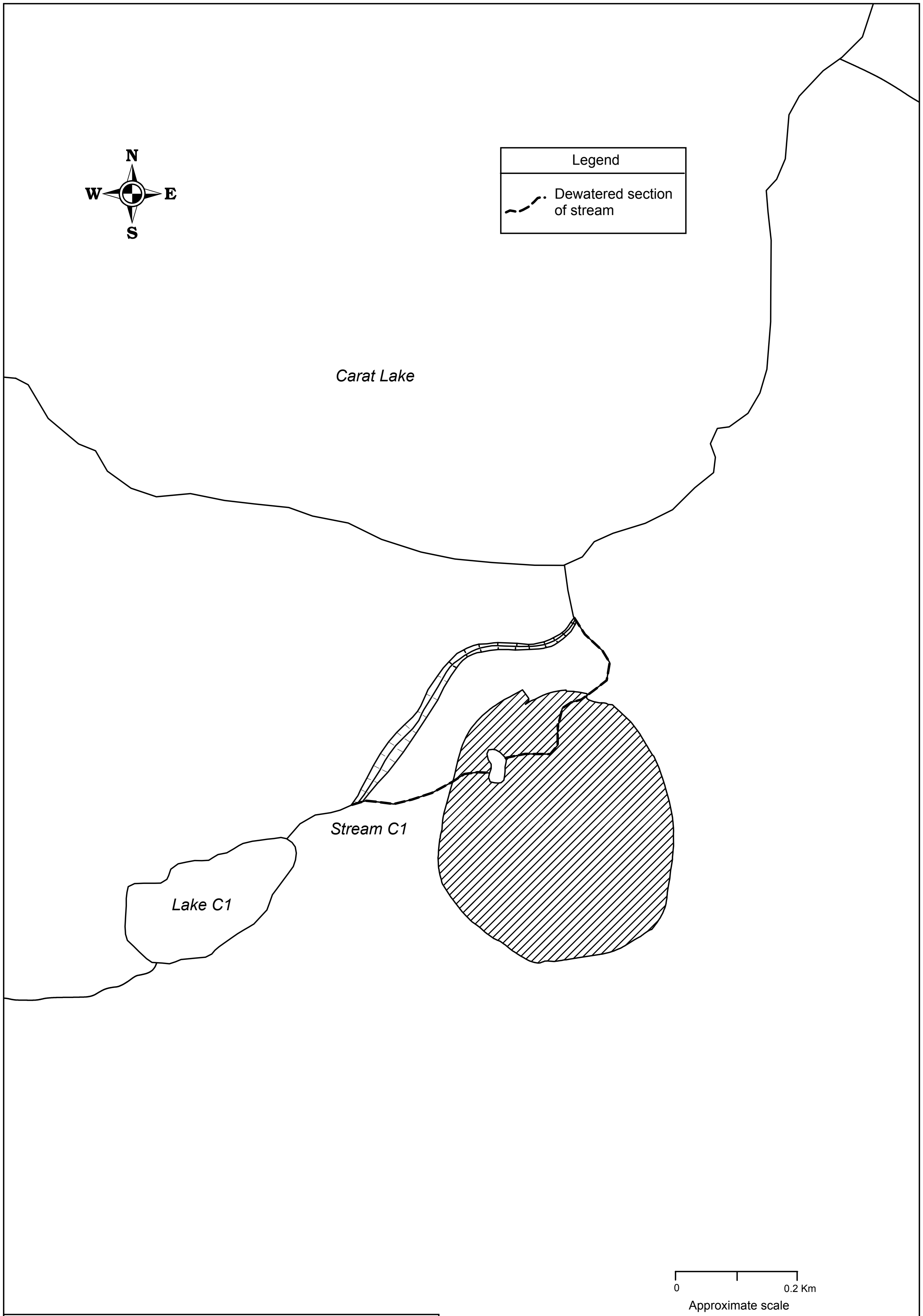

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Figure 2.2 Waterbodies potentially affected by use of explosives, Jericho Site.

Map database provided by Tahera Corporation
(Modified from RL&L Environmental Services Ltd. 2000 Figure 4.2)

Based on these mitigation measures, which correspond to the guidelines outlined in Wright and Hopky (1998), the maximum weight of explosive that may potentially affect fish is limited to an individual charge that will not exceed 227 kg.

Assessment of Potential Effects

Guidelines have been developed by Wright and Hopky (1998) for the protection of fish from exposure to shock waves induced by the use of explosives. Two factors may cause harm to fish and fish eggs: an instantaneous pressure change or "over pressure" and "peak particle velocity", which is a measure of ground vibration. The threshold for an instantaneous pressure change is 100 kPa measured in the swim bladder of a free-swimming fish. For spawning beds where eggs are incubating, peak particle velocities below 13 mm/s are recommended to ensure the protection and viability of eggs. Both thresholds are based on a 50% mortality rate (Dennis Wright Coordinator, Environmental Science Division Federal Department of Fisheries and Oceans, pers. comm.).

Based on guidelines presented in Wright and Hopky (1998), the intensity of the shock wave produced would vary depending on the weight of the charge, the distance from the point of the explosion, the characteristics of the substances through which the shock wave is traveling and the time delay between explosions.

To assess the effect that explosives may have on fish, the magnitude of the shock waves that are expected to enter the waterbody can be determined based on formulas provided in Wright and Hopky (1998). The following assumptions were made to calculate estimates of instantaneous pressure change and peak particle velocity:

- Excavation of rock in the pits would be accomplished using an explosive weight of 227 kg.
- The minimum distances between the pit and the waterbody would be approximately 200 m (Carat Lake), 230 m (Lake C1) and 100 m (Stream C1) (effects on fish in Stream C1 are limited to the 100 m because fish distribution is restricted to lower section of stream).
- The location of detonation would be the outer edge of the pit that was closest to each waterbody.
- The geologic material between the pit and the lakes consists of bedrock.

Peak Particle Velocity (PPV)

Peak particle velocities for an explosion detonated during the proposed development would decline at the rate dictated by the following equation:

$$PPV = 1000\ (D/W^{0.5})^{-1.6}$$

Where,

PPV = peak particle velocity (mm/s)
D = distance between explosion and receptor (m)
W = maximum explosive weight detonated (kg)

Instantaneous Pressure Change (IPC)

Three equations are used to calculate the instantaneous pressure change of the shock wave as it enters water. The first is the peak particle velocity equation; the second describes the pressure of the shock wave in the substrate; and, the third typifies the wave once it enters the water. The change in density from rock to water typically acts to reduce the force of the shock wave. The instantaneous pressure change is determined as follows:

Instantaneous pressure in the substrate:

$$Pr = (PPV*Dr*Cr)/2$$

Where,

Pr = pressure in substrate (kPa)
PPV = peak particle velocity (cm/s)
Dr = density of rock substrate = 2.64 g/cm^3
Cr = compressional wave velocity in rock = 457 200 cm/s

Pressure transfer from the substrate to the water:

$$Pw = (2(Zw/Zr)Pr)/(1+(Zw/Zr))$$

assuming, $Zw/Zr = (DwCw)/(DrCr)$

Where,

Pw = pressure in water (kPa)
Dw = density of water = 1 g/cm^3
Cw = compressional wave velocity in water = 146 300 cm/s

The predicted effects for Carat Lake, Lake C1 and Stream C1 are presented in Table 2.2. Based on the maximum weight of explosives that can be expected, only the *Peak Particle Velocity* guidelines for use of explosives will be exceeded in the lower section of Stream C1 and in Carat Lake.

Table 2.2 Predicted estimates of *Peak Particle Velocity* and *Instantaneous Pressure Change* in waterbodies adjacent to the proposed mine pit of the Jericho Diamond Project.

Waterbody	Distance between Detonation and Point of Impact (m)	Peak Particle Velocity (mm/s)	Instantaneous Pressure Change (kPa)
Carat Lake	200	16	20.6
Lake C1	230	12.8	16.5
Stream C1	100	48.4	62.6

[a] Wright and Hopky (1998) thresholds for *Peak Particle Velocity* and *Instantaneous Pressure Change* are 13 mm/s and 100 kPa, respectively.

If there is the potential to exceed either one of these thresholds, an application is to be submitted for authorization under Sections 32 and/or 35(2) of the Federal Fisheries Act for the use of explosives. An authorization may be issued by DFO for the use of explosives if the following conditions are met:

- The use of explosives is the only technically feasible means to attain the desired objective.
- Mitigation measures to reduce the effects on fish and fish habitat to insignificance will be employed.
- Or, it can be reasonably expected that there are no economically important and/or significant biological resources at risk.

Based on this information, use of explosives in the mine pit could result in some level of adverse environmental effects, but only on a very localized scale.

2.2.3 Harvest by Angling

Project Activity

Angling is a common recreational activity in northern mining camps. Lake trout and Arctic char are anticipated to be the target species for the majority of anglers. Angling targeted at other sportfish is unlikely because they occur infrequently in the project area (Arctic grayling) or are not normally considered a target species (round whitefish).

Potential Effects

Angling of fish in waterbodies within the Jericho Site under the existing sportfishing regulations would likely result in the harvest of sportfish. Even if anglers practice catch-and-release for lake trout and Arctic char during their fishing excursions, a percentage of the fish captured and then released may die from hooking injuries (Falk et al. 1974; Loftus et al. 1988).

In subarctic lakes, even low levels of harvest can cause a shift in fish community structure and may lead to an eventual collapse of the target fish population. McDonald and Hershey (1989) examined the potential change in fish community structure due to exploitation in Toolik Lake in Alaska. Prior to extensive angling pressure, lake trout contributed 55% to the total catch, whereas round whitefish and Arctic grayling contributed 28% and 17%, respectively. After several years of angling activity, the community structure had shifted to 50% lake trout, 42% round whitefish and 8% Arctic grayling. Intensive angling in the Jericho Site area could also result in a shift in fish community structure.

All of the waterbodies within the Jericho Site represent oligotrophic systems that have low primary productivity. As such, fish in these waterbodies are slow-growing and exhibit a low reproductive potential. Many of these waterbodies are small (<20 ha) and contain few fish. Given these characteristics, most fish populations in the Jericho Site (all except Contwoyto Lake) are unlikely to sustain even low levels of harvest over an extended period of time.

Environmental Management and Mitigation

Tahera proposes to implement a 'no fishing lake' policy for sensitive waterbodies in the Jericho Site for the life of the proposed mine as a condition of employment (Tahera, pers. comm.).

Assessment of Potential Effects

A 'no fishing lake' policy in the vicinity of the mine will eliminate fish mortality associated with harvest and hooking injuries in those lakes designated as no fishing. The policy will not include Contwoyto Lake because the potential harvest of fish in this waterbody is considered negligible due to limited angler access to the resource. Angling would occur from the shore because boats would not be provided for recreational purposes (Tahera 1999). This will severely restrict the number of anglers using Contwoyto Lake, which will result in very low harvest rates. Based on implementation of these mitigation measures, there will be no adverse environmental effects associated with harvest by angling within the Jericho Site. Tahera will endeavor to coordinate the company's initiatives with DFO and the territorial government.

2.2.4 Scientific Research

Project Activity

Lethal sampling of fish occurred during the baseline inventories of the exploration phase. Several fish species were sampled from a number of lakes during the baseline inventories. Additional lethal sampling will be required during the monitoring program of the operation and closure phases of the project to properly monitor the health of the fish community. Lake trout and round whitefish from a select number of waterbodies would be targeted during the monitoring program.

Potential Effects

A limited number of fish (n<25) of each species were sacrificed from a particular waterbody during the baseline inventories and fewer fish would be sampled during the monitoring program. The majority of fish were (will be) collected from larger waterbodies such as Carat Lake.

Environmental Management and Mitigation

Tahera proposes to limit the amount of lethal sampling during biological monitoring to that specified by the regulatory authorities. Nonlethal sampling techniques (e.g., tissue plugs and use of scales for ageing) will be investigated.

Assessment of Potential Effects

The limited number of fish required for monitoring purposes and use of nonlethal sampling methods will minimize the adverse effects of this project activity. As such, the effect of scientific research is considered negligible.

2.3 POTENTIAL EFFECTS CAUSING LOSS OF FISH HABITAT

The Federal Fisheries Act (Section 34) defines fish habitat as “spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes”. These habitats refer to any aquatic environments that support fish populations (DFO 1998). Also, DFO (1998) guidelines for habitat conservation and protection apply to habitats that:

- Currently produce fish, or could potentially produce fish for harvest in subsistence, commercial or recreational fisheries.
- Although not directly supporting fish, provide nutrients and/or food supply to adjacent habitat or contribute to water quality for fish.

Many waterbodies in the Jericho Site currently support or have the potential to support fish populations. Based on these definitions, project activities that have the potential to alter, disrupt, or destruct fish habitat in these waterbodies are subject to review under the Federal Fisheries Act.

This section will assess project activities associated with the ‘foot print’ of the development that may cause physical loss of fish habitat. The current design of the proposed project will ensure that the foot print of the development will not infringe on most waterbodies that currently support or have the potential to support fish (Figure 2.1). The mine infrastructure will infringe on some ponds and ephemeral streams, but these waterbodies are too small and too shallow to support resident fish populations and/or are isolated from fish bearing waters. It is acknowledged that fish habitat can be adversely affected by changes in the productive capacity of upstream areas (i.e., nutrients and food resources, but these effects are considered negligible). As such, small ponds and ephemeral streams are not deemed potential fish habitat and will not be dealt with by this assessment.

2.3.1 Permanent and Winter Roads

Project Activities

The mine infrastructure would require a 6.9 km network of permanent roads within the mine area. Only one defined stream channel would be crossed (Stream C2). The existing road connecting the exploration camp to the portal has an existing culvert at the Stream C2 crossing. The proposed road alignment at this location is approximately the same as the existing alignment (Tahera 1999). A permanent road connecting the mine to the western shore of Contwoyto Lake would also be required. This road would traverse approximately 3.5 km over tundra before connecting to the lake, but would not cross any defined watercourses (Tahera, pers. comm.). The road will end as a ramp that will facilitate vehicle access to Contwoyto Lake during winter and emergency boat access during summer (Tahera, pers. comm.). The exact dimensions of this ramp are not presently known, but it would be approximately the width of the road (10 m) and would extend no more than 15 m into the lake. As such, the surface area of the ramp would be approximately 150 m^2.

Prior to construction of the permanent road, a winter road along a pre-existing route would be used to access Contwoyto Lake (during the construction phase). This road would traverse two watercourses (Streams D1 and D2) and Lynne Lake, but no permanent structures, such as culverts, would be required.

Upon closure of the mine, all permanent roads and associated structures (culverts) will be removed, and the sites rehabilitated (Project Description, Appendix A.1).

Potential Effects

All streams traversed by permanent and winter roads freeze to the channel bottom during winter; therefore, potential adverse effects would occur only during the open water period. The construction, operation, and closure of the permanent roads in the Jericho Site have the potential to alter drainage patterns by preventing down slope movements of surface water, resulting in reduced runoff to streams. Ditching along permanent roads may also accelerate erosion processes and funnel sediment laden water into the stream, which could reduce water quality. Both have the potential to adversely affect fish habitat. Culverts may also create barriers to fish passage by preventing access to habitat that is potentially available to fish.

The proposed crossing location on Stream C2 is not a fish bearing section. Inventories indicated that fish distribution was limited to the first 100 m upstream of the lake confluence and the crossing is situated well upstream of this point (approximately 400 m). Due to its small size and ill-defined channel, the stream section at the proposed crossing is not easily accessible to fish; therefore, its value as fish habitat is negligible.

The permanent road to Contwoyto Lake would require a ramp on the shore of Contwoyto Lake. Construction of the ramp would potentially reduce water quality by increasing suspended sediment concentrations and could cause sedimentation in the immediate vicinity of the ramp.

The primary concern of the ramp would be potential loss of fish habitat caused by the foot print. The potentially affected shoreline area is characterized by boulder and bedrock substrates and it has a very steep gradient. As such, it provides only a limited area of useable habitat. Concentrations of fish were not recorded in the vicinity of the ramp, either in the main lake or in the outlet area of Stream D1. Stream D1 consists of a boulder field along its entire length, a no fish habitat is available in this watercourse.

Winter road crossings over streams that are frozen to the channel bottom are considered temporary (DFO 1995b), and if constructed without disturbance to the stream bed or its banks, the effects on fish and fish habitat can be deemed as negligible. Because no permanent structures or alterations are required to operate and maintain the winter road, and all activities occur when the stream bed is frozen, there is no potential for adverse effects on fish habitat.

Environmental Management and Mitigation

Tahera will utilize standard mitigation measures during construction, operation, and closure of permanent and winter roads and will follow guidelines specified in *Fish Habitat Protection Guidelines - Road Construction and Stream Crossings* (DFO 1995b) (Tahera, pers. comm.). For example, silt fences will be employed during construction of the permanent roads to prevent suspended sediments from entering Stream C2 or Contwoyto Lake. If erosion potential exists, ditches will be armoured or routed to settling ponds that have been incorporated into the project design. Good engineering practices require appropriate placement of roads allowances and use of culverts to ensure that drainage into existing streams is not altered. Sediment catchment ponds along ditch alignments will be inspected frequently and sediment removed as required. Silt fencing downstream of sediment removal will be employed if clean out is required during periods when water is flowing in ditches (Tahera, pers. comm.).

Assessment of Potential Effects

The DFO (1995b) guidelines will be met regarding permanent and winter road construction, operation, and closure (Tahera 1999); therefore, potential effects on streams will be fully mitigated. Because the proposed crossing location of Stream C2 does not traverse a section that is used by fish and the ramp at Contwoyto Lake covers a small area of low quality fish habitat, permanent roads have a very low potential to cause adverse effects. The same is true for the winter road. Based on this information, there will be no adverse environmental effects associated with loss of fish habitat caused by permanent or winter roads.

2.3.2 Diversion of Stream C1

Project Activities

Stream C1 is part of a small drainage basin (1.13 km^2) situated at the southeast corner of Carat Lake. The foot print of the proposed mine pit will include a section of this stream (Figure 2.3). To maintain the drainage capacity of the basin and to prevent flooding of the pit, a diversion channel will be constructed along the western perimeter of the mine. The diversion system would consist of a dike across Stream C1 at the upstream end, a man-made channel to divert the flow around the mine pit and a dissipating pond at the downstream end where the flow re-enters the original stream bed. The diversion system will be designed to accept a predicted 1- in - 200 year return period flood discharge of 3.7 m^3/s and will be armoured with riprap to prevent erosion.

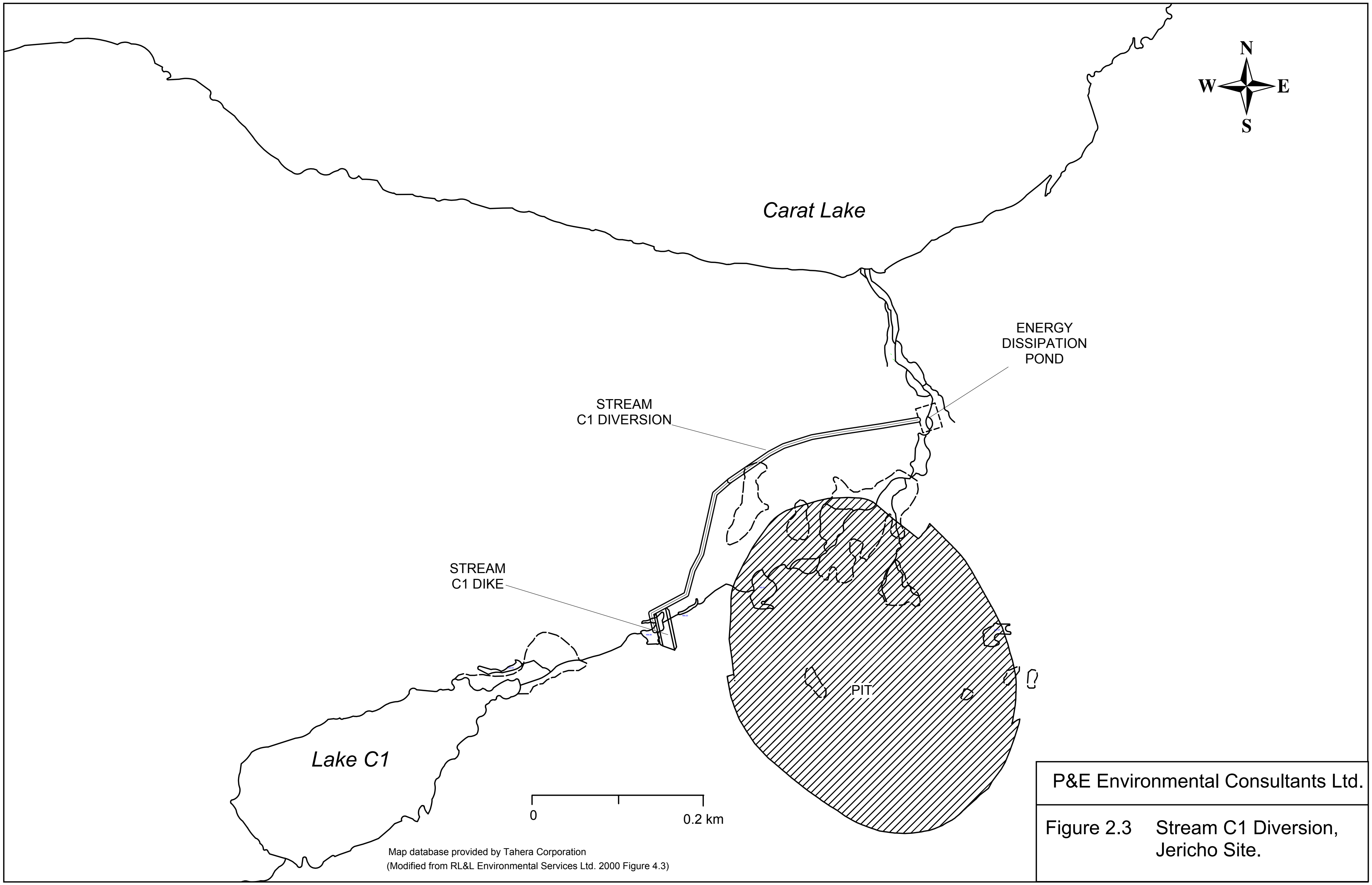

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Figure 2.3 Stream C1 Diversion, Jericho Site.

Construction of the diversion system will require instream activities at the upper and lower ends of the artificial channel during winter. Once operational, the system will divert all flow from Stream C1 into the artificial channel at a point that is approximately 815 m upstream from Carat Lake. The water will be transported around the pit and diverted back into Stream C1 at a point that is approximately 275 m upstream of Carat Lake. The total length of the stream that will be removed from production will be approximately 541 m; it will be replaced by 425 m of diversion channel.

Upon closure of the mine, the diversion system will be modified (Project Description, Appendix A.1). With approval from DFO, a weir will be placed in the diversion dike to allow excess flood water not required to maintain flow in the diversion system and the lower section of Stream C1 to flow via the natural channel to the mine pit. This water will gradually fill the mine pit; when full, the pit water would then flow through the lower natural channel to Carat Lake. It is estimated that the mine pit would require in excess of 180 years to fill to capacity (Project Description, Appendix A.1). Runoff water from areas upstream of the pit will also drain into the pit once mine closure is complete.

Potential Effects

Stream C1 originates as the outlet of Lake C1 and flows a distance of 1031 m before draining into Carat Lake. During the open water period, this stream exhibits discharges that range from 0.06 m^3/s during spring snow melt to 0.002 m^3/s during base water flows of summer. Stream C1 has an average channel width of 1.6 m and an average maximum depth of 0.15 m and like all small systems in the Jericho Site it freezes to the channel bottom during winter.

Stream C1 is a complex system composed of 10 reaches. Its major features include a natural barrier to fish passage (5.3 m in height) that is located 815 m upstream from Carat Lake and a large impounded area (351 m from confluence) that was formed by a man-made berm constructed during the winter of 1995-96. The impoundment inundated a portion of the existing channel and diverted part of the stream discharge to the west, where it flows over the tundra and rejoins Stream C1 near its confluence with Carat Lake.

Based on these characteristics, potential fish habitat is available to fish up to the natural barrier (815 m of stream); however, inventories completed in 1995, 1996, 1998, 1999, and 2000 provided strong evidence that fish distribution was restricted to the lower section of stream. Despite extensive sampling in the entire stream, no fish were ever recorded more than 100 m upstream from the confluence with Carat Lake.

Species recorded in the lower section of Stream C1 included Arctic char, Arctic grayling, burbot, lake trout, round whitefish, and slimy sculpin. The fish community was consistently dominated by young-of-the-year and small juvenile fish that used the system opportunistically for rearing. Adult fish were not recorded in Stream C1 (except slimy sculpin) and no fish eggs were ever found; therefore, the system was not used for spawning or feeding and it did not provide a movement corridor. The density of fish recorded in Stream C1 in 1999 ranged from 5 ± 2 fish/100 m for burbot to 54 fish/100 m for slimy sculpin. Arctic char was the dominant char species (30 ± 4 fish/100 m), followed by a lower number of lake trout 15 ± 12 fish/100 m.

Fish also use the outlet zone of Stream C1 and Carat Lake for rearing and feeding and the area may be used for spawning and egg incubation. The assumption of the existence of incubating eggs is made based on indirect evidence (i.e., presence of suitable spawning habitat, fish in spawning condition, and young-of-the-year fish that still had yolk sacs) rather than a physical record of fish eggs. Thus, incubating eggs of lake trout, Arctic char, and round whitefish could be present between September and March (McCart and Den Beste 1979). Although no spawning by larger fish species was documented in Stream C1 (e.g., Arctic grayling), slimy sculpin likely use this system for spawning and egg incubation; eggs of slimy sculpin would be present during June and July (Scott and Crossman 1973).

Project activities affecting Stream C1 have the potential to alter, disrupt, or destroy fish habitat in Stream C1 and its outlet zone with Carat Lake. The effects may include 1) physical removal of fish habitat in the stream due to dewatering (541 m of stream) during operation and 2) a reduction of water quality and habitat quality in Stream C1 and Carat Lake due to increased suspended sediment concentrations during and immediately following construction activities (construction, operation and closure phases). One additional effect may include fish stranding in the diversion channel. This could result if base water flows were not sufficient to maintain free standing water in the diversion system following spring freshet and fish actually entered the diversion channel.

Environmental Management and Mitigation

Tahera will implement erosion control techniques during instream construction and maintenance activities where required (Tahera, pers. comm.). The introduction of sediment can be minimized by utilizing several practices outlined in Furniss et al. (1991) and DFO (1995b):

- Minimize the area of bank that is cleared during construction.
- Work areas should be isolated from the stream by use of cofferdams or berms.

- Employ isolation methods (i.e., work in dry channel), where practical, during construction of diversion channel.
- Minimize siltation by opening the diversion channel at the downstream end first.
- Diversion channel gradient at its terminal end should approximate those of the existing stream.
- If fill is required, use clean granular material for fill within the channel.
- Ensure that pollutants from the machinery used during construction do not enter the stream.
- Where spawning fish are known to be present, timing constraints may be applied to in-stream work.
- Implement temporary and permanent erosion control measures, where warranted, on the banks and approach slopes to watercourses.

Assessment of Potential Effects

Stream C1 provides rearing habitat for young-of-the-year and small juveniles of several fish species; however, extensive fisheries inventories documented that the distribution of fish was restricted to the lower 100 m section immediately upstream of Carat Lake. Based on this information, removal of potential fish habitat in the upper portion of Stream C1 will not adversely affect fish. Because flows will be maintained by the diversion system, loss of nutrients or invertebrate production from upstream areas will be minimal.

The environmental management and mitigation plans are designed to reduce the introduction of sediments into Stream C1; however, increased concentrations of suspended sediments will occur during the open water period immediately following construction and during maintenance activities. As such, there is the potential for adverse environmental effects caused by elevated suspended sediment concentrations in the lower section of Stream C1 and in Carat Lake. Potential adverse effects include physical harm to fish or fish eggs, reduced water quality, and degradation of benthic invertebrate production.

Fish stranding is not likely to occur in the diversion channel. As stated earlier, fish distribution is restricted to the lower 100 m of stream, which is below the entry point into the diversion (275 m); therefore, the potential for fish stranding is extremely low.

Based on this information, the diversion of Stream C1 and the resulting loss of a portion of the channel will not result in loss of fish habitat. However, construction and maintenance activities may affect the downstream section of Stream C1, which could cause adverse environmental effects.

2.3.3 Processed Kimberlite Containment Area

Project Activities

The Processed Kimberlite Containment Area (PKCA) would be required to store the fine fraction (<1 mm) generated by the processing operation, discharge from the waste water treatment system, runoff from the plant site, and possibly runoff from the mine site. The PKCA would consist of two storage cells and a polishing pond. Construction of the PKCA would require the use of several waterbodies in the collectively termed the 'Long Lake System'. These include Long Lake, an unnamed pond at its west end, an ill-defined channel connecting the two, and an unnamed pond perched above Long Lake along its northern shore (Figure 2.4).

Upon closure of the mine, the dry portions of the PKCA would be rehabilitated, leaving a much smaller lake basin at its western end. Due to its small size and shallow depth, this waterbody will not support a viable fish population.

Potential Effects

There are several potential effects associated with the PKCA. The primary effect would be permanent loss of fish habitat that presently occurs in the Long Lake System. During construction and operation of the PKCA, direct mortality of fish would occur due to stranding or increased toxicity of the water within the storage cells.

Long Lake is a small (9 ha), elongated waterbody with a maximum depth of 8 m that has a moderate shoreline development ratio of 2.4 and a short shoreline length of 2571 m. Intensive fish sampling during 1999 and 2000 identified only limited numbers of two fish species in this waterbody: burbot and slimy sculpin. In 1999, 23 slimy sculpin were recorded, while in 2000, 7 slimy sculpin and 48 burbot were encountered. The majority of the sample consisted of young-of-the-year and juvenile fish. During extensive sampling in 1999 and 2000, adult fish were rarely encountered.

The unnamed pond to the west is connected to Long Lake via a shallow, ill-defined channel that is approximately 75 m in length. In 2000, this channel consisted of a boulder with subsurface water flow. The unnamed pond to the west is less than 1 ha in size, but it has a maximum depth of 7 m.

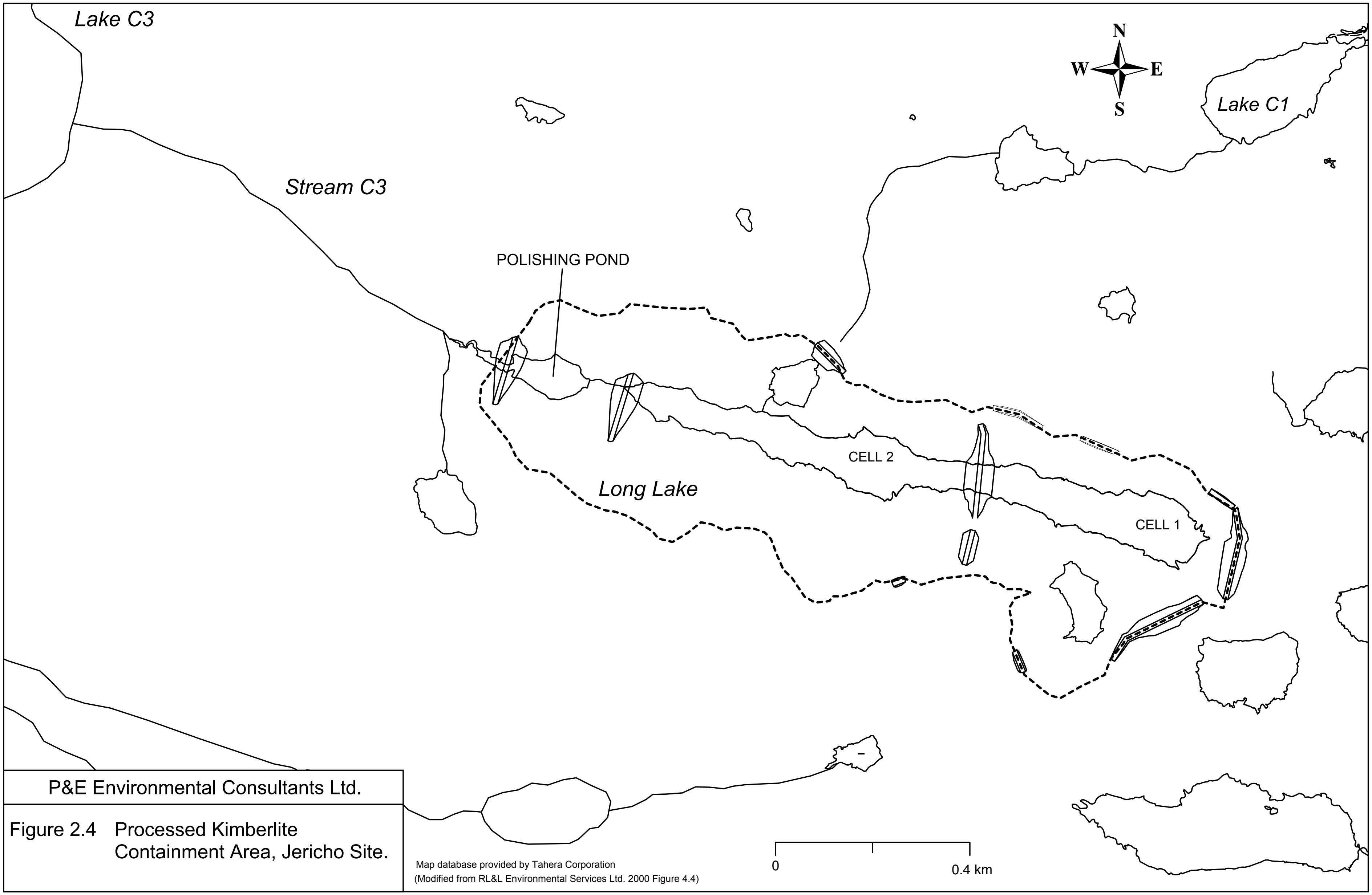

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Figure 2.4 Processed Kimberlite Containment Area, Jericho Site.

This unnamed pond also contained a small number of burbot and slimy sculpin (16 and 7, respectively). The connecting channel was not sampled for fish, but it is likely that both species used this area as habitat on an opportunistic basis.

Surveys of a second unnamed pond along the north shore of Long Lake recorded 2 slimy sculpin. This small waterbody is less than 1 ha in size, but has a maximum depth of 7 m. This perched basin is connected to Long Lake by an ephemeral stream that is impassable to fish. During August 2000, this waterbody had drawn down to approximately two-thirds its spring and early summer surface area and no water flowed out of the connecting channel between the pond and Long Lake.

This information indicates that the Long Lake System supports small populations of slimy sculpin and burbot. Stream C3, which connects this basin to Lake C3, is impassible to fish over much of its length (>600 m); therefore, the Long Lake System fish community is resident.

In addition to habitat loss and direct mortality of fish due to the PKCA, the altered discharge regime of Stream C3 during construction and operation of the facility could have detrimental effects on fish. These potential effects will be discussed in Section 2.4.2.

Environmental Management and Mitigation

No mitigation measures are available to prevent loss of fish habitat in the Long Lake System. Direct mortality of fish can be reduced by implementing a fish salvage program. Draw down is planned for winter to minimize sediment generation (Tahera, pers. comm.). This would concentrate fish into the two deep basins of Long Lake where they could be removed using a variety of methods during the open water period.

Assessment of Potential Effects

The Long Lake System supports small, resident populations of slimy sculpin and burbot. The lake and deep ponds provide all the necessary habitats to support viable populations. The shallow ill-defined channel likely provides rearing and feeding habitat for young-of-the-year and juveniles of these species. Based on this information, removal of waterbodies in the Long Lake System from production will adversely affect existing fish habitat. Direct mortality of fish can be partially mitigated by implementing a fish salvage program.

2.3.4 Water Withdrawal Causeway

Project Activity

A single water withdrawal system would be constructed in Carat Lake approximately 150 m east of the outlet of Stream C1 to supply potable water to the camp and raw water to the mine and processing plant. The water withdrawal system, which consists of an intake and pipeline, will be protected from ice damage by a causeway constructed from waste rock material generated during construction of the mine. The design of the causeway requires that it extend offshore to a water depth of 5.5 m. Information available from the aquatic biota fish sampling program indicates that this depth will likely occur no more than 90 m offshore. For the purposes of this assessment, it is assumed that the length of the causeway will be 90 m (Project Description, Appendix A.1). Assuming a maximum length and width (90 m and 15.5 m, respectively), the foot print of the causeway would not exceed 1400 m^2. This foot print represents part of the Crown Land Lease 'E' (Water Lot Lease) for the project (Tahera, pers. comm.).

Rehabilitation during the closure phase will entail sealing the water intake pipe and grading the causeway down to ice level during winter. In spring, the dislodged material would sink to the lake bottom. Alternatively, sections of the causeway above ice level could be graded onto shore or other upland areas during winter (Tahera, pers. comm.).

Potential Effects

Carat Lake in the vicinity of the causeway is used by several fish species including lake trout, Arctic char, burbot, round whitefish, and slimy sculpin. The lake margin is used for rearing and feeding purposes and spawning does occur in the vicinity of the causeway.

Potential effects associated with the causeway include loss of fish habitat, reduced water quality and destruction of fish eggs. Loss of fish habitat would occur because the causeway would physically cover fish habitat. Loss of habitat could also result indirectly from the causeway by alteration of water movement patterns in the southeast corner of Carat Lake. In lake environments, char species such as lake trout and Arctic char often seek areas exhibiting water movements to maximize the viability of incubating eggs that are deposited on rock substrates (lake trout) or in redds (Arctic char). An obstruction such as the causeway could impede water movement to the extent that fish may no longer use these sites for spawning. Because the causeway will extend only a short distance into Carat Lake (90 m) it is not expected to substantially alter water circulation.

Construction of the causeway also has the potential to destroy fish eggs that are deposited in the substrate. Because construction will occur during the period when fish eggs of the majority of species are not present (open water period), this potential effect is negligible.

Reduced water quality would be associated with construction of the causeway. Use of waste rock materials from the mine could introduce fine materials into the water resulting in increased suspended sediments and sedimentation. Rehabilitation of the causeway will result in additional loss of fish habitat by increasing the size of the foot print, destruction of fish habitat provided by the causeway and introduction of sediments from the top dressing of the roadway.

Environmental Management and Mitigation

Tahera will implement sediment control measures during construction of the causeway to minimize sediment inputs (Project Description, Appendix A.1). Tahera can also remove the top dressing from the causeway before grading to minimize sediment inputs during rehabilitation, or is willing to leave the causeway intact if acceptable to the regulatory authorities (Tahera, pers. comm.). Other mitigation measures being considered are shortening the causeway to minimize the footprint and/or burying the water intake pipeline in the lake bottom to protect it from ice damage instead of using the causeway (Tahera, pers. comm.). If the latter measure was implemented, the pipeline would have to be buried the same length as the proposed causeway, it would cause a temporary loss of habitat, and sediment production potentially would be a more serious issue.

Assessment of Potential Effects

Construction and rehabilitation of the causeway will cause physical loss of fish habitat. Water circulation patterns also will be altered in the immediate vicinity of the causeway, but given the short length of the causeway, these effects have a low probability of extending to spawning sites used by Arctic char and lake trout. It is assumed that the sediment control measures implemented during construction and rehabilitation will prevent large amounts of sediment from entering the aquatic environment. As such, physical loss of habitat is deemed to be the only potential adverse effect on fish caused by the water withdrawal causeway.

2.4 POTENTIAL EFFECTS CAUSING REDUCED WATER QUALITY

Several project activities could affect fish indirectly by reducing water quality. These include surface runoff from the mine site, discharge from the PKCA, and air emissions such as dust. These activities have the potential to introduce contaminants into the aquatic environment in the form of metals, nutrients, and suspended sediments. These contaminants may reduce water quality to the level where it would adversely affect aquatic biota. Potential effects to fish include increased contaminant loads, lowered reproductive capacity, and loss of habitat. A change in water quality can affect fish indirectly by altering the productive capacity of the aquatic ecosystem. Nutrient loading may increase the production of invertebrates, thereby providing more food for fish. Conversely, elevated suspended sediment loads could reduce primary production of phytoplankton by reducing light penetration. The consequences of a change in water quality on fish and other aquatic biota are briefly discussed below.

In nutrient poor waterbodies, biological productivity is generally limited by the nutrient (nitrogen or phosphorus) in shortest supply (Wetzel 1983). In waterbodies found in the Jericho Site, phosphorus is the nutrient in the shortest supply (Section 3.2.2 in aquatic biota EIA [RL&L 2000]). Adding more phosphorus could stimulate biomass production of algae, which in turn, may affect the food-chain by increasing the biomass of zooplankton, benthic invertebrates, and ultimately fish. This potential shift in trophic status and community structure could alter the natural state of the affected waterbodies. In the Jericho Site, phosphorus in rock occurs predominantly in an insoluble form, and therefore, addition of dust or sediment from project activities is unlikely to affect phosphorus availability in affected waterbodies (SRK Consulting, pers. comm. in Project Description, Appendix A.1).

Elevated metal concentrations can have both lethal and sublethal affects on fish (Alabaster and Lloyd 1982). The effects of increased suspended sediment concentrations on fish and fish habitat may involve the following (Anderson et al. 1996):

- Reduced fish survival by direct mortality or by reducing growth, overall health and resistance to disease.
- Modifying the abundance and type of pelagic food organisms available to fish.
- Interfering with the natural movements of fish.

Sedimentation would affect the egg and larval stages of fish for species that require clean rock substrates for incubation. Smothering of eggs and altering substrate porosity would reduce survival. Sedimentation could also affect fish habitat by reducing the productivity of benthic communities.

2.4.1 Runoff from the Mine Site

Project Activity

Several project components in the mine site are sources of runoff including the waste rock dumps, overburden stockpile, ore stockpiles, coarse processed kimberlite stockpile and the mine pit (Figure 2.5). Surface runoff from permanent roads associated with the mine may also contain elevated levels of suspended sediments. This potential effect is considered minor because ditches or the tundra would contain the sediment (Project Description, Appendix A.1); therefore, it will not be assessed.

Potential Effects

Given the topography of the mine site and the proposed layout of the mine area, mine runoff could potentially affect water quality in three fish-bearing lakes (Carat Lake, Lake C1, and Key Lake) through the introduction of nutrients and contaminants and/or sediments. Based on leachate tests of the waste rock and ore undertaken by Tahera (SRK Consulting, Appendix D.1.4 and D.1.6), the only constituents of the mine runoff that may exceed water quality guidelines are copper and ammonia. No quantitative data are available for suspended sediments levels associated with mine runoff. Experience at the Ekati Mine indicates that suspended sediment levels in mine runoff typically do not exceed water quality guidelines (Tahera, pers. comm.), but for the purposes of this assessment it is assumed that they could be problematic. The following provides a general description of potential effects of copper and ammonia; sediment effects are summarized in the preceding paragraphs.

Copper

Canadian Council of Ministers of the Environment water quality guidelines for the protection of aquatic life specify that concentrations should not exceed 0.002 mg/L (CCME 1999). Given that background levels in Carat Lake are low (≤0.0016 mg/L) and the predicted maximum concentration in the mine runoff (0.016 mg/L) is above the CCME (1999) threshold, there is the potential for reduced water quality, which in turn, may adversely affect fish and other aquatic biota.

Copper is an essential element and is required for normal functioning of biological organisms (Lewis 1995). In fish, copper forms part of several enzymes and glycoprotein, it promotes iron absorption and transport, and it is necessary for hemoglobin synthesis (Sorensen 1991). At excessive concentrations copper becomes toxic. The toxicity can include damage to tissues and organs, altered physiology and behaviour, and ultimately reduced growth, survival, and reproduction (Sorensen 1991).

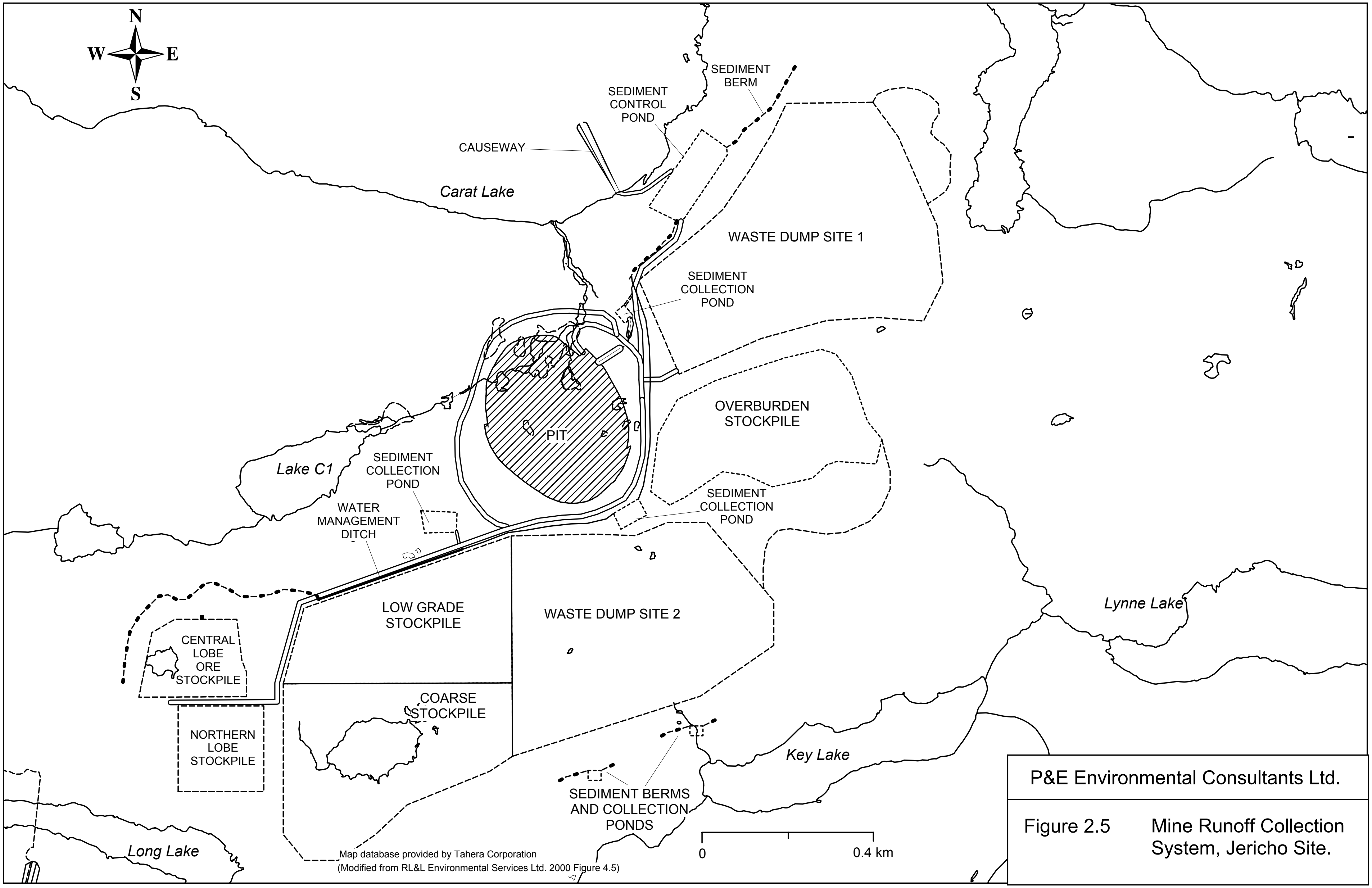

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Figure 2.5 Mine Runoff Collection System, Jericho Site.

Copper is not considered to be a cumulative systematic poison, as most of it is excreted from the body (Falk et al. 1973). Chronic exposure will cause copper to concentrate in the liver, muscle, and brain tissues (Demayo and Taylor 1981). Windom et al. (1973) observed lower trophic levels of fish to have higher concentrations of copper relative to higher trophic levels of fish.

Toxicity of copper to aquatic organisms is complex and highly variable (Lewis 1995). In general, low alkalinity, low hardness, and the absence of organic substances tend to increase toxicity, but absolute effects are controlled by the form of copper causing the toxicity and the presence of other elements in the environment. Copper toxicity varies depending on the taxonomic group and the mode of entry. Copper is a well known biocide (e.g., copper sulphate) used in aquatic systems to inhibit excessive algal and macrophyte growth, therefore, it can be a toxicant to plants (Lewis 1995). In benthic macroinvertebrates, effects will vary depending on taxonomic order (Clements et al. 1988) and whether the organisms are herbivores, detrivores, or predators (Leland et al. 1989). In fish, it would appear that salmonids are more sensitive to elevated copper levels than other taxonomic groups and smaller fish are affected more severely than larger fish (Sorensen 1991).

Because water quality of Carat Lake can be characterized as having low alkalinity and hardness (Tahera 1999) and the fish community is dominated by salmonids such as lake trout, Arctic char, and round whitefish, there is the potential for adverse effects caused by copper. It should be noted that acute toxicity values (LC^{50} - concentration causing 50% mortality) identified for fish and other aquatic organisms are typically greater than 0.030 mg/L (Sorensen 1991; Lewis 1995), which is higher than the maximum concentration that would be present in the mine runoff (0.016 mg/L).

Ammonia

CCME (1999) water quality guidelines for the protection of aquatic life specify that concentrations of ammonia should not exceed 1.37 mg/L (for pH 8.0 at 10^{0}C). Because the background levels in Carat Lake are low (≤0.017 mg/L; Tahera 1999) and the predicted maximum concentration in the runoff (30 mg/L) is above the CCME (1999) threshold, there is the potential for reduced water quality and adverse affects on aquatic biota.

Based on information presented by the Canadian Water and Wastewater Association, ammonia is produced from a variety of anthropogenic sources and also occurs from natural sources (CWWA 1997). In the Jericho Site the primary source of ammonia will be ammonium nitrate that is used during the mining operation. Excess ammonia contributes to eutrophication of waterbodies through increased availability of nitrogen that can result in increased primary production. In oligotrophic systems such as Carat Lake, low concentrations of phosphorous would ultimately limit primary production even with increased inputs of ammonia.

Ammonia at high concentrations is toxic to all aquatic life, although data do indicate that freshwater phytoplankton and macrophytes are more tolerant than invertebrates or fish (CWWA 1997). Concentrations acutely toxic to fish can cause loss of equilibrium, increased metabolism and eventual death. At lower concentrations, adverse effects include reduced growth rate, lowered reproductive success, and damage to tissues such as gills, liver, and kidneys.

Ammonia is a naturally occurring compound that has no potential to bioaccumulate. Most organisms have mechanisms to excrete ammonia or convert it to ammino acids and protein. Aquatic organisms have a limited ability to detoxify ammonia; therefore, the body load is generally dependent on ammonia concentration in the water. Acute effects can occur at values as low as 2 mg/L, while concentrations of 0.5 mg/L may result in chronic effects (CWWA 1997).

Environmental Management and Mitigation

Tahera is committed to ensuring that the runoff generated at the mine site would be contained and treated so that it would not be acutely toxic to aquatic biota (Tahera 1999). To accomplish this, a collection system consisting of containment berms and ditches will be employed to contain and direct the runoff from the mine site into collection ponds. The collection ponds will allow settlement of sediments and partial oxidation of the ammonia. This system would operate during all phases of the project. If ammonia and copper concentrations exceed water quality guidelines the runoff will be treated until concentrations reach acceptable levels. Treatment measures for the collected runoff being considered by Tahera include the preferred option spray irrigation, transfer to the PKCA, and use of a treatment plant (Tahera, pers. comm.).

Upon mine closure, all runoff will be redirected from Carat Lake to the mine pit. The estimated amount of time required to fill the pit would be approximately 180 years. For the purposes of the aquatic impact assessment, it is assumed concentrations of potential contaminants will return to background levels within this period.

Assessment of Potential Effects

Based on the assumption that concentrations of suspended sediment, ammonia, and copper in the treated runoff meet metal mine effluent regulation limits and be non-toxic, the potential adverse effects of mine runoff will be negligible.

2.4.2 Discharge from Processed Kimberlite Containment Area

Project Activities

The Processed Kimberlite Containment Area (PKCA) would be required to store the fine fraction (<1 mm) generated by the processing operation, waste water, runoff from the plant area, and possibly runoff from the mine area. Construction of the PKCA would entail use of four dams and a series of small dikes. It is assumed that the first dam will be placed at the outlet zone of the Long Lake basin during winter, which would prevent disturbed sediment laden water from traveling downstream. This approach would also eliminate the primary water source for Stream C3 during filling of the PKCA.

During operation, discharge from the PKCA would be released from the polishing pond into Stream C3, which connects the Long Lake System to Lake C3. The amount of discharge from the PKCA would vary depending on several factors including snowpack depth, precipitation, and mining activities, but is not predicted to exceed 313,000 m^3 annually and a controlled release during the 3 to 4 month open water period of approximately 0.034 m^3/s would accommodate this requirement (Project Description, Appendix A.1).

Upon mine closure, the dry portions of the PKCA would be rehabilitated leaving a much smaller lake basin at its western end. This would result in a smaller catchment basin and lowered water inputs to Stream C3.

Potential Effects

Potential fish habitat is limited due to the small size of Stream C3. Fish use is restricted to the lower 300 m due to dispersed and subsurface water flow upstream of this point. Multiple channels and shallow riffle habitats dominate the lower 300 m stream section. In 1999, 3 juvenile Arctic char were recorded in Stream C3, while in 2000, 10 Arctic char, 1 burbot, and 37 slimy sculpin were encountered.

Fish use the Stream C3 outlet zone in Lake C3 for rearing and feeding. It is unlikely that the area is important for spawning due to the absence of suitable spawning habitat. Nor were spawning fish or young-of-the-year fish recorded within the immediate vicinity of the outlet zone. As such, the potential for mortality of fish and fish eggs is deemed to be negligible.

During construction and startup of the PKCA, water inputs from the Long Lake basin into Stream C3 will be eliminated. This will result in loss of fish habitat in the lower section of the stream.

During PKCA operation, release of PKCA discharge could potentially affect water quality in Stream C3 and Lake C3 through the introduction of nutrients and contaminants, and suspended sediments. Assuming no input of mine runoff into the PKCA, leach tests conducted by SRK Consulting (Appendix D.1.5) indicate that the only constituents of the PKCA discharge that may exceed water quality guidelines are ammonia (predicted value = 17.3 mg/L) and total suspended sediments (predicted value = 8 mg/L). It should be noted that, based on results at Ekati Mine, ammonia is not expected to be above concentrations of 2 mg/L in the PKCA supernatant (Tahera, pers. comm.). If mine runoff is directed to the PKCA, these values may be higher.

During post-closure, the smaller catchment basin will result in much lower water flows in Stream C3. This could result in dewatering and loss of fish habitat in the lower 300 m of stream.

Environmental Management and Mitigation

Logistical constraints during construction and startup of the PKCA preclude use of mitigation designed to maintain water flows in Stream C3. During operation, it is expected that containment within Cell 2 and the polishing pond of the PKCA will allow settlement of suspended sediments and oxidation of some ammonia before release into Stream C3. The discharge would then travel approximately 1080 m down slope through the Stream C3 channel before entering Lake C3. Due to the variability in stream flows with time, which results in both variable oxygenation of the water and variable water velocities, an unknown amount of ammonia oxidation and sediment settlement will occur during this transit. PKCA discharge released into Lake C3 will be tested routinely and will be controlled by a government license. Discharges from the operations are targeted to meet metal mine effluent regulation limits and be non-toxic. To ensure that contaminant levels meet these specifications, Tahera will treat the PKCA discharge. Measures being considered include use of the preferred option spray irrigation and a treatment facility (Tahera, pers. comm.).

Assessment of Potential Effects

Based on this information, fish habitat provided by Stream C3 will be permanently removed from production by the development because it will be dewatered during the post-construction and post-closure phases of the project. It should be noted that during the operations phase, discharge from the PKCA will maintain fish habitat Stream C3, but this is deemed a temporary mitigation measure. Contaminant concentrations are assumed to be at acceptable levels due to implementation of mitigation measures; therefore, issues associated with reduced water quality caused by discharge from the PKCA are considered negligible.

2.4.3 Emissions

Project Activity

Development of the open pit, use of haul roads, processing plant operation, infrastructure development and use of a sand/gravel air strip are all potential sources of air-borne contaminants (primarily dust). Other potential sources of air emissions include the diesel generator and the camp incinerator. The majority of emissions would mostly likely be dust generated from mining activities, such as blasting and the transportation of the waste rock and ore.

Potential Effects

A portion of the dust generated from the proposed development would eventually be deposited onto the surface of Carat Lake and other waterbodies within the Jericho Site. These deposits would disperse into the water column and ultimately settle on the bottom. The potential effect of dust on water quality would include increased levels of suspended sediment in the water column and sediment deposition on lake bottom habitat. This could result in decreased survival and biomass production of invertebrates. Extreme levels of sedimentation could result in mortality of fish eggs.

Environmental Management and Mitigation

Tahera will initiate an environmental management plan that will meet all government standards for dust control, such as watering road surfaces during warm weather months (Project Description, Appendix A.1).

Assessment of Potential Effects

Quantitative data are not currently available for the proposed project to assess the potential effects of dust and air emissions on water quality; however, information is available from the environmental impact assessment of the Diavik Diamonds Project (Diavik 1998). The Diavik Diamonds Project is also located in the subarctic approximately 170 km southeast of the Jericho Site, and is much larger in terms of its potential to generate air-borne contaminants.

The effects of dust deposition on water quality were evaluated for several fish bearing lakes in the vicinity of the proposed Diavik mine by calculating annual total suspended sediment (TSS) concentrations and sedimentation rates (Diavik 1998). The maximum annual potential increase was 5 mg/L for TSS and 0.05 mm/year for sedimentation; neither value exceeded the threshold for the protection of aquatic biota (5 mg/L and 1 mm/year for TSS and sedimentation, respectively). The Diavik EIA concluded that the effect of dust on water quality had a negligible effect on aquatic biota.

Based on data from the Diavik study, air-borne contaminants generated from the proposed Jericho development will not cause adverse environmental effects on aquatic biota.

2.5 SUMMARY

Potential environmental effects on fish that may result from project activities were reviewed in relation to proposed environmental management and mitigation measures. Based on this review, most potential environmental effects were classified as having no adverse effect on fish (Table 2.3); however, residual environmental effects remained as follows:

1) Destruction of fish and fish eggs in Stream C1 and Carat Lake due to use of explosives in the mine pit.

2) Reduced water quality (elevated suspended sediment concentrations) and direct mortality of fish eggs in Stream C1 and at its outlet zone on Carat Lake downstream of instream activities during construction and operation of the diversion system.

3) Loss of fish habitat and direct mortality of fish in Long Lake, an unnamed pond and a connecting channel due to construction of the PKCA.

4) Loss of fish habitat in Carat Lake due to construction and reclamation of the water withdrawal causeway.

5) Loss of fish habitat in Stream C3 caused by the altered discharge regime.

Table 2.3 Summary of residual effects that remain following assessment of potential environmental effects and planned environmental management and mitigation measures at the Jericho Site.

General Pathway	Project Activity	Potential Environmental Effect[a]	Residual Effects after Mitigation
Direct Mortality	Water Withdrawal Intake	1) Entrainment of fish.	No
	Use of Explosives	1) Shock wave causing mortality of eggs and fish	Yes
	Angling	1) Harvest of fish and hooking injuries.	No
	Scientific Research	1) Lethal sampling of fish.	No
Loss of Habitat	Permanent and Winter Roads	1) Blockage of fish passage. 2) Altered drainage into streams. 3) Increased suspended sediment concentrations and sedimentation (reduced water quality). 4) Foot print of ramp.	No No No No
	Stream Diversion	1) Dewatering of natural stream. 2) Foot print of intake and outlet ports. 3) Increased suspended sediment concentrations and sedimentation (reduced water quality and direct mortality). 4) Stranding of fish (direct mortality).	No No Yes No
	Processed Kimberlite Containment Area	1) Removal of natural lakes and ponds (direct mortality).	Yes
	Water Withdrawal Causeway	1) Causeway foot print. 2) Increased suspended sediments and sedimentation (reduced water quality).	Yes No
Reduced Water Quality	Runoff from Mine Pit, Dumps and Stockpiles	1) Increased contaminant and nutrient concentrations. 2) Increased suspended sediment concentrations and sedimentation (habitat loss and direct mortality).	No No
	Discharge from the PKCA	1) Increased contaminant and nutrient concentrations. 2) Dewatering of stream channel (habitat loss). 3) Increased suspended sediment concentrations and sedimentation.	No Yes No
	Emissions from Mining Activities	1) Increased suspended sediment concentrations and sedimentation (habitat loss and direct mortality).	No

[a] Items in brackets indicate effects that are in addition to primary effect identified by the general pathway.

3.0 EVALUATION OF RESIDUAL EFFECTS

3.1 INTRODUCTION

The main purpose of this document is to evaluate the environmental effects of the proposed development on the aquatic biota. This document closely follows the environmental impact assessment outlined by the Canadian Impact Assessment Agency (CEAA 1994, 1997), which provides a clear, well-defined system to classify residual environmental effects and a criteria rating system to ascertain their significance. As specified in the environmental impact assessment procedure (CEAA 1994, 1997), only the significance of residual effects will be evaluated in this section, not the significance of potential environmental effects.

The regulatory authorities must determine whether the proposed project is likely to cause significant adverse environmental effects, but determination of ‘significant adverse effects’ can be difficult. Localized effects may not be significant to the environment; however, widespread effects may be very important. Long-term effects may be significant compared to short-term effects, and effects that are reversible may be less significant than those that are irreversible.

Environmental effects are complex and interrelated, and they may influence many different components of the aquatic biological community. To simplify and focus the environmental impact assessment, fish have been selected as the Valued Environmental Component (VEC) of the aquatic biological community and will be the basis of all evaluations. Fish are deemed to be suitable candidates for this purpose because they are sensitive to changes to the aquatic environment and they are highly valued by society. They are also a good indicator of biodiversity, which should be an integral component of the EIA process (Environment Canada 1996).

For the purposes of this Environmental Impact Assessment, a significant adverse effect on fish is one that affects the fish community, in sufficient magnitude, duration, or frequency, as to cause a change in the community structure that would not allow that community to return to its former structure. This change is manifested through differences in abundance, health, and/or recruitment rates of one or more species populations that comprise that community.

A significant environmental effect on fish can be direct (mortality of fish) or indirect (loss of habitat, poor water quality and/or reduced productive capacity). Both types of effects could ultimately have the same consequences to fish.

Rating criteria developed under the Canadian Environmental Assessment Act (CEAA 1994) will be employed to evaluate the significance of the environmental effects. The rating criteria to be used are:

- Magnitude
- Geographic extent
- Duration
- Frequency
- Reversibility
- Ecological context
- Level of confidence
- Certainty

Magnitude

Magnitude describes the nature and extent of the environmental effect. The magnitude of an effect is quantified in terms of the amount of change in a parameter or variable from an appropriate threshold value, which may be represented by a guideline or baseline conditions. Three general categories of change to be employed are low (L), moderate (M), and high (H). The definitions used to rate the magnitude will be specific to a particular effect and will depend on the type of effect, the methods available to measure the effect and the accepted practices for a particular discipline.

Geographic Extent

Geographic extents are similar to the spatial boundaries of the assessment outlined in Section 1.4.3 of the aquatic biota EIA (RL&L 2000). It can be separated into three categories as follows:

Low (L) - Includes specific areas in waterbodies within the immediate influence of the project (foot print and immediately adjoining areas).

Moderate (M) - Includes entire waterbodies within the immediate influence of the project (foot print and immediately adjoining areas).

High (H) - Includes the Carat Lake and Contwoyto Lake drainage basins, excluding the local study area.

Duration, Timing and Frequency

Duration is defined as a measure of the length of time that the potential effect could last. It is closely related to the project phase or activity that could cause the effect. The four project phases, or temporal boundaries defined in Section 1.4.2 of the aquatic biota EIA (RL&L 2000), that are related to duration include construction, operation, closure, and post-closure.

The duration criterion is divided into three classifications:

Short-term (L) - Effects lasting for less than one year (associated with the construction period, or other short-term activities).

Mid-term (M) - Effects lasting from one to nine years (associated with the life of the mine).

Long-term (H) - Effects lasting longer than 10 years (persist beyond the closure of the mine).

Frequency

Frequency is associated with duration and defines the number of occurrences that can be expected during each phase of the project. The frequency criterion is divided into three classifications as follows:

Low (L) - Effects occur infrequently (< 1 per month during each project phase).

Moderate (M) - Effects occur frequently (from 2 to 15 per month during each project phase).

High (H) - Effects occur continuously.

Reversibility

Reversibility is the ability of the aquatic biological community (i.e., fish) to return to conditions that existed prior to the adverse environmental effect. The prediction of reversibility can be difficult because environmental effects may, or may not, be reversible. Despite this, it is important to ascertain reversibility because it has an important influence on the significance of an effect. Two rating criteria will be used: reversible (R) and not reversible (NR).

Ecological Context

Ecological context is a measure of the relative importance of the affected ecological component to the ecosystem, or the sensitivity of the ecosystem to disturbance. It indicates the degree to which an effect on the component would affect the ecosystem. The ecological context rating criteria are specific to each effect, but they can be grouped into three general categories: low (L), moderate (M), and high (H).

Level of Confidence

Using the rating criteria described in the preceding paragraphs, the significance of adverse environmental effects is evaluated based on a review of project specific data, relevant literature, and professional opinion. Based on recommendations by Barnes and Davey (1999), the assessment should also include a rating system that evaluates the level of confidence in the prediction of significance. Three rating criteria will be used to assess the level of confidence: low (L), moderate (M), and high (H).

Certainty

To arrive at a high level of confidence for a significance rating, it is usually desirable to apply rigorous scientific and/or statistical methods (quantitative approach). Where such methods are not feasible, professional judgment is usually employed (qualitative approach). Rating the certainty of the significance rating is an additional step that can be used to justify or substantiate the level of confidence in the evaluation. The three rating criteria that will be applied to each of the two certainty categories (quantitative and qualitative) are: low (L), moderate (M), and high (H).

The environmental impact assessment will evaluate individual adverse effects as being significant (S) or not significant (NS). It should, however, be acknowledged that the overall effect of the proposed development on fish may be the result of a combination of several effects; the combined effect of these factors may potentially be more significant than the individual components.

The assessment of potential effects in Section 2.0 identified six project activities that caused residual environmental effects after implementation of the environmental management and mitigation measures; these included:

1) Destruction of fish and fish eggs in Stream C1 and Carat Lake due to use of explosives in the mine pit.

2) Reduced water quality (elevated suspended sediment concentrations) and direct mortality of fish eggs in Stream C1 and at its outlet zone on Carat Lake downstream of instream activities during construction and operation of the diversion system.

3) Loss of fish habitat and direct mortality of fish in Long Lake, an unnamed pond and a connecting channel due to construction of the PKCA.

4) Loss of fish habitat in Carat Lake due to construction and reclamation of the water withdrawal causeway.

5) Loss of fish habitat in Stream C3 caused by the altered discharge regime.

3.2 USE OF EXPLOSIVES

3.2.1 Introduction

An assessment of the use of explosives in the mine pit identified the potential for adverse effects on fish following mitigation. Based on DFO guidelines (Wright and Hopky 1998), the impacted zone included the lower 100 m of Stream C1 (limit of fish distribution) and the shoreline area of Carat Lake. Detonation of the explosives in the mine pit would create a *Peak Particle Velocity* greater than the specified threshold (13 mm/s), which was designed to protect incubating fish eggs. The predicted shock wave was not sufficient to produce an *Instantaneous Pressure Change* greater than the specified criteria (100 kPa), which was designed to protect free-swimming fish. As such, the evaluation of significance will be restricted to the effects of *Peak Particle Velocity* on fish eggs.

Wright and Hopky (1998) provide an equation to calculate the predicted *Peak Particle Velocity* impact zone (radius in which PPV exceeds 13 mm/s) as follows:

$$\text{PPV Impact Zone} = (W^{0.5})(PPV/100)^{-0.625}$$

Where,

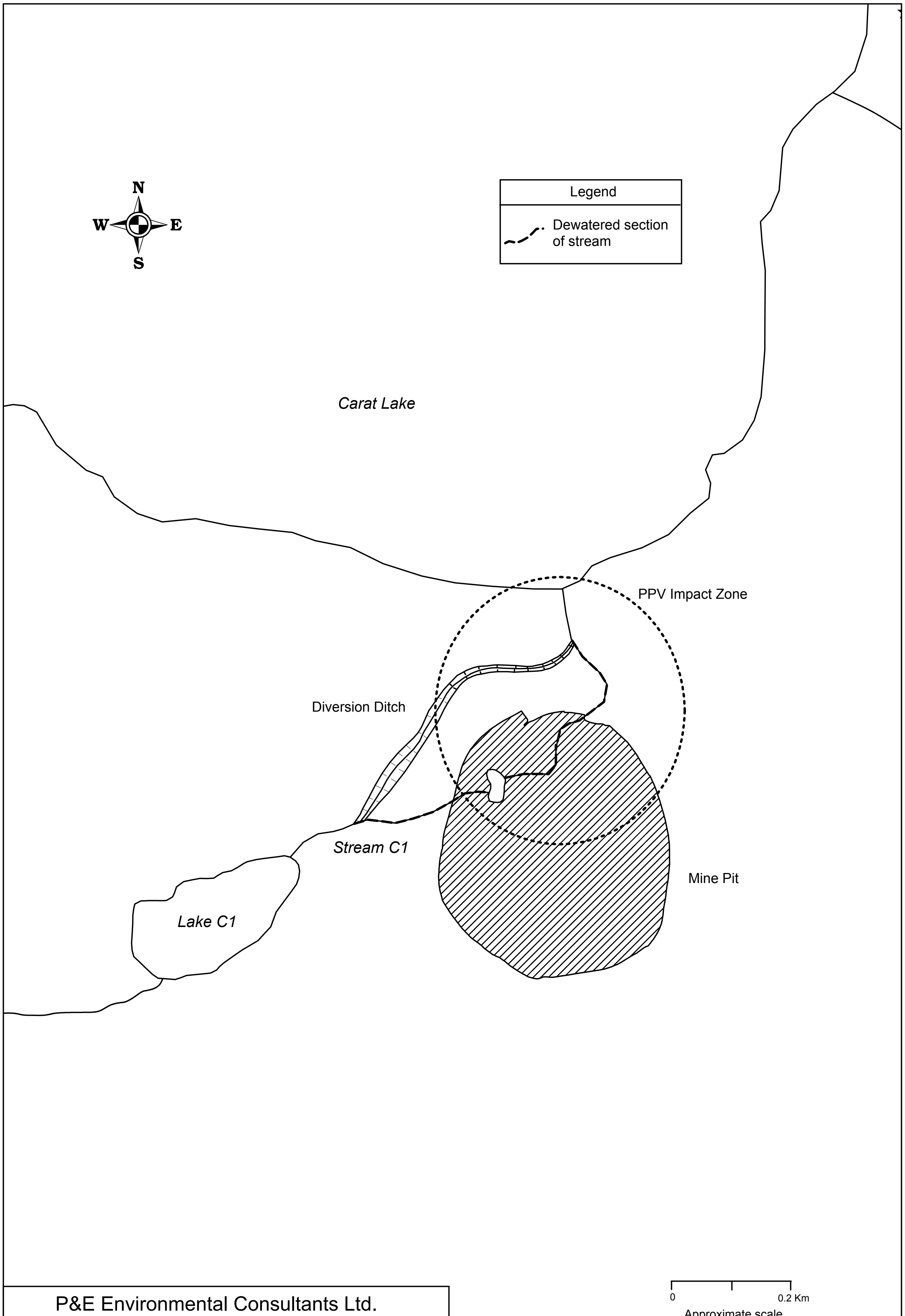
PPV = peak particle velocity (1.3 cm/s)

W = maximum explosive weight detonated (227 kg)

The predicted *Peak Particle Velocity* impact zone is estimated to be 225 m from point of the detonation (Figure 3.1). Based on this critical radius, the lower section of Stream C1 will be affected; however, only a small part of the Carat Lake shoreline is within the critical radius.

Based on their habitat requirements, slimy sculpin is the only species that uses Stream C1 for spawning and egg incubation (Scott and Crossman 1973). Arctic grayling is the only other species residing in Carat Lake that could potentially deposit eggs in Stream C1; however, extensive inventories never recorded spawning Arctic grayling or incubating eggs of this species in this system.

Several species, including Arctic char, lake trout, round whitefish and slimy sculpin, may spawn along the southeast shoreline of Carat Lake. The presence of Arctic char fry (young-of-the-year fish with yolk sacs) in the outlet zone of Stream C1 confirmed that Arctic char spawn in the area. It is unlikely, however, that this species would use the outlet zone of Stream C1. Arctic char (Johnson 1980), as well as lake trout (Ford *et al.* 1995) and round whitefish (Normandeau 1969), are fall spawners that deposit their eggs in clean rocky substrates, where the eggs incubate throughout the winter.



P&E Environmental Consultants Ltd.

Figure 3.1 Peak Particle Velocity impact zone associated with use of explosives in the mine pit, Jericho Site.

Map database provided by Tahera Corporation
(Modified from RL&L Environmental Services Ltd. 2000 Figure 4.6)

Successful incubation can only be achieved if the eggs are located at water depths that are sufficient to prevent freezing (approximately >2.5 m). The shoreline in the vicinity of Stream C1 exhibits a low slope and a shallow-water zone (<2.5m deep) that extends out approximately 50 m from shore; therefore, it is very unlikely that Arctic char or the other fall spawners use this shallow water, near-shore area. In contrast, these characteristics provide suitable spawning habitat for slimy sculpin, which suggests that the shoreline in the vicinity of Stream C1 is used for spawning by this species.

3.2.2 Evaluation Approach

The magnitude of impact is based on the exceedence of the *Peak Particle Velocity* threshold for the protection of fish eggs, which is 13 mm/s (Wright and Hopky 1998). Because this threshold is based on the premise of adverse effects (damage to fish eggs) versus no adverse effects (no damage), a conservative approach was used for the rating criterion; two levels were defined as follows:

Low - PPV is below the threshold level; and

High - PPV exceeds the threshold level.

The geographic extent criteria are as follows:

Low - Includes sub-local area within the immediate influence of the project activity (lower section of Stream C1 and outlet zone in Carat Lake).

Moderate - Includes the local area adjacent to influence of the project activity (Carat Lake), excluding the sub-local area.

High - Includes the regional area Carat Lake watershed, excluding the local study area.

Use of explosives will occur only during construction and operation of the development. As such, the evaluation of significance will be restricted to these two project phases. Also, it was assumed that the frequency of the effect would be continuous, since there would likely be one detonation per day during the entire project.

3.2.3 Evaluation of Significance

The magnitude of the use of explosives was rated as high during both the construction and operation phases (Table 3.1). A high magnitude rating was applied because the threshold was exceeded, and therefore, fish eggs will be damaged. Duration received ratings of low and moderate for the construction and operation phases, respectively. As expected, the frequency ratings were high.

Ratings of significance were low for geographic extent and ecological context. The effects of explosive use are restricted to the sublocal area (Stream C1 and its outlet zone) and slimy sculpin is the only species in the fish community that is affected. Slimy sculpin are widely distributed and there is an abundance of suitable habitat in Carat Lake. The effect on the population is also reversible.

Table 3.1 Residual environmental effects matrix used to rate the significance of use of explosives in the mine pit on fish, Jericho Site.

Residual Effect	Protect Phase	Evaluation Criteria for Assessing Significance[a]					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context
Damage to Fish Eggs	Construction	H	L	L	H	R	L
	Operation	H	L	M	H	R	L

[a] L - low; M - moderate; H - high; R - reversible; NR - not reversible.

3.2.4 Summary of Evaluation

The evaluation indicated that adverse effects associated with use of explosives in the mine pit will be high, but they will be restricted to a small area and will only affect slimy sculpin. Because this species is widely distributed in Carat Lake, the population would likely not be affected by this disturbance. As such, use of explosives received a not significant rating for both the construction and operation phases (Table 3.2). The level of confidence that the adverse effects would not be significant to the slimy sculpin population residing in Carat is high. This confidence is based on a qualitative assessment of the information. The quantitative certainty of this analysis is low due to the absence of quantitative data for the effects of peak particle velocities on slimy sculpin eggs. Based on the above information, the project received an overall rating of not significant.

Table 3.2 Summary of residual environmental effects evaluation of use of explosives in the mine pit on fish, Jericho Site.

Project Phase	Residual Environmental Effects Rating[a]	Confidence	Certainty	
			Qualitative	Quantitative
Construction	NS	H	H	L
Operation	NS	H	H	L
Project Overall	NS	H	H	L

[a] L - low; M - moderate; H - high; S - significant; NS - not significant.

3.3 STREAM C1 DIVERSION

3.3.1 Introduction

Several fish species from Carat Lake enter Stream C1 during the open water period. These include lake trout, Arctic char, Arctic grayling, round whitefish, burbot, and slimy sculpin. Based on several years of data lake trout, Arctic char, and slimy sculpin were the numerically dominant species in the stream. All other species were infrequently encountered or were scarce. The primary age-groups that enter the stream include young-of-the-year and juvenile fish. With the exception of slimy sculpin, adult fish do not use Stream C1 for feeding or spawning purposes. Fish distribution in Stream C1 is restricted to the first 100 m immediately upstream of Carat Lake. At no time were fish encountered above this section. As such, the fish community residing in Carat Lake utilizes the lower section of Stream C1 on an opportunistic basis for rearing purposes.

There is evidence that fish use the outlet zone in Carat Lake for rearing and the area is frequented by adult fish of all species for feeding. The presence of Arctic char fry (young-of-the-year fish that had just emerged) and female lake trout in spawning condition also confirms that the region in the vicinity of the outlet zone is used for spawning purposes by these two species.

The diversion system is designed to divert water at the upper end of Stream C1, transport it around the mine pit and deposit this water back into Stream C1. As a result, a 541 m section of Stream C1 will be dewatered. There are no residual effects associated with loss of fish habitat in the dewatered channel because this stream section is not used by fish.

Instream activities associated with winter construction of the diversion system (construction phase) and maintenance (operation and closure phases) may result in adverse effects because the planned mitigation measures will not completely eliminate the introduction of some suspended sediments into the stream. These suspended sediments will originate at two locations: at the diversion dike at the head works of the diversion channel and at the dissipation pond situated at the outlet of the diversion channel.

Ambient suspended sediment concentrations in Stream C1 and Carat Lake are very low (below detection limits); therefore, introduction of suspended sediments would alter existing conditions. Suspended sediment concentrations that may result from construction activities are very difficult to quantify. They likely would exceed 5 mg/L, which is the CCME (1999) guideline for the protection of aquatic life in clear water environments.

There are three potential residual effects associated with the introduction of suspended sediments; these are the direct mortality of fish eggs, the loss of fish habitat through sedimentation, and lowered production of invertebrates due to reduced water quality. These effects may occur in Stream C1 downstream of the diversion and in its outlet zone within Carat Lake.

3.3.2 Evaluation Approach

The significance of each residual effect identified above will be evaluated separately. Because it is difficult to quantify the suspended sediment concentrations that may occur, the magnitude of impact is based on ambient levels, which were below detection limits. The CCME (1999) guideline of 5 mg/L for the protection of aquatic life was used as the threshold. The three rating criterion for magnitude are as follows:

Low - Concentration does not exceed ambient level.

Moderate - Concentration exceeds ambient, but not threshold level.

High - Concentration exceeds the threshold level.

The geographic extent follows the criterion outlined in Section 3.1, but are specific to the effects as follows:

Low - Includes sub-local area within the immediate influence of the project activity (section of Stream C1 downstream of construction activities and outlet zone in Carat Lake).

Moderate - Includes the local area adjacent to the influence of the project activity (Carat Lake), excluding the sub-local area.

High - Includes the regional area Carat Lake watershed, excluding the local study area.

The significance of each residual effect is rated for each project phase. The period of greatest disturbance will potentially occur during the snow melt and runoff period immediately following construction (May to early June), but it is assumed that periodic maintenance of the diversion system is required during the operation and closure phases of the project.

3.3.3 Evaluation of Significance

The construction phase will have the greatest adverse effect on fish (Table 3.3). During this phase, the magnitude of effect was rated as high for mortality of fish eggs, loss of habitat, and reduced invertebrate production. The geographic rating will be low (restricted to the sub-local study area) because water flow in Stream C1 and wave action in Carat Lake will quickly disperse the suspended sediment load. Duration and frequency also received a rating of low and the effects are reversible because the stream will quickly return to pre-effect suspended sediment levels. Since fish communities in subarctic oligotrophic waterbodies are generally very sensitive to disturbances the ecological context was rated as high for all situations.

Table 3.3 Residual environmental effects matrix used to evaluate significance of construction and maintenance of the Stream C1 diversion, Jericho Site.

Residual Effect	Protect Phase	Evaluation Criteria for Assessing Significance					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context
Direct Mortality of Fish Eggs	Construction	H	L	L	M	R	H
	Operation	M	L	L	L	R	H
	Closure	M	L	L	L	R	H
Loss of Habitat	Construction	H	L	L	M	R	H
	Operation	M	L	L	L	R	L
	Closure	M	L	L	L	R	L
Reduced Invertebrate Production	Construction	H	L	L	M	R	H
	Operation	M	L	L	L	R	L
	Closure	M	L	L	L	R	L

[a] L - low; M - moderate; H - high; R - reversible; NR - not reversible.

Residual effects would still occur during operation and closure, but their magnitude was rated as moderate. A lower rating was given because the anticipated requirement for maintenance activities (e.g., repair of rip-rap protection) would be much less obtrusive than the original instream activities (e.g., flexibility in timing of work) required during the construction phase. All other criteria were the same as the construction phase.

3.3.4 Summary of Evaluation

The environmental effects evaluation indicated that adverse effects of the diversion system on fish will be largely restricted to the construction phase of the project and the effects will be at the sub-local level. A small area will be affected during a short time period and only a small component of the Carat Lake fish community will be affected. As such, the diversion system received a rating of not significant (Table 3.4). The likelihood that the predicted effects would occur during this phase is moderate. The qualitative and quantitative certainty of this analysis is low for two reasons. Information on the effects of suspended sediments on Arctic fish populations is limited and quantitative data of suspended sediment concentrations that will be generated during construction and maintenance are not available. Based on this information, the overall rating for the project is not significant, but there is also a low level of certainty.

Table 3.4 Summary of residual effects evaluation[a] of the Stream C1 diversion, Jericho Site.

Project Phase	Residual Environmental Effects Rating	Level of Confidence	Certainty	
			Qualitative	Quantitative
Construction	NS	M	L	L
Operation	NS	M	L	L
Closure	NS	M	L	L
Post-closure	NS	M	L	L
Project Overall	NS	M	L	L

[a] L - low; M - moderate; H - high; S - significant; NS - not significant.

3.4 PROCESSED KIMBERLITE CONTAINMENT AREA

3.4.1 Introduction

The PKCA foot print will include four fish-bearing waterbodies in the Long Lake System that include Long Lake, the unnamed pond to the west, the interconnecting channel, and the unnamed pond along the north shore of Long Lake. The fish community in the Long Lake System includes populations of slimy sculpin and burbot. Because these fish are restricted to the Long Lake System (i.e., no movements to or from Lake C3) they are considered resident.

Activities associated with construction and operation of the PKCA will permanently remove the Long Lake system waterbodies from production. The physical foot print will cause loss of habitat, and during construction, fish will suffer direct mortality due to stranding and/or reduced water quality. The result will be extirpation of these resident fish populations.

3.4.2 Evaluation Approach

Because each of the project effects identified above will have a similar effect (extirpation of the fish community), the magnitude of the effect is the same. A single magnitude rating of high will be used for the assessment.

Similarly, geographic extent will have a single rating of moderate that is defined as the local area adjacent to the influence of the project activity (Long Lake, the unnamed pond, and the connecting channel).

3.4.3 Evaluation of Significance

The adverse effect on fish will be initiated at the onset of construction and will extend into the post-closure phase of the project (Table 3.5). As such, ratings for duration and frequency are high, and the effect is not reversible. The ecological context was also rated as high.

Table 3.5 Residual environmental effects matrix used to evaluate significance of the Processed Kimberlite Containment Area foot print, Jericho Site.

Residual Effect	Protect Phase	Evaluation Criteria for Assessing Significance					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context
Loss of Fish Habitat	All	H	M	H	H	NR	H
Direct Mortality of Fish	All	H	M	H	H	NR	H

[a] L - low; M - moderate; H - high; R - reversible; NR - not reversible.

3.4.4 Summary of Evaluation

The environmental effects evaluation indicated that adverse effects of the PKCA will be high, but they will be restricted to the local level. A significant adverse effect on fish is one that affects a fish community, in sufficient magnitude, duration, or frequency, as to cause a change in the community structure that would not allow that community to return to its former structure. Because the waterbodies affected by the foot print of the PKCA presently supports a viable fish community, this project activity received a rating of significant (Table 3.6). The likelihood that the predicted significant adverse effect is high is based on a high qualitative certainty of the analysis.

Table 3.6 Summary of residual effects evaluation of the Processed Kimberlite Containment Area foot print, Jericho Site.

Project Phase	Residual Environmental Effects Rating[a]	Level of Confidence	Certainty	
			Qualitative	Quantitative
Construction	S	H	H	L
Operation	S	H	H	L
Closure	S	H	H	L
Post-closure	S	H	H	L
Project Overall	S	H	H	L

[a] L - low; M - moderate; H - high; S - significant; NS - not significant.

It should be acknowledged that the affected fish community consists of small, resident populations of slimy sculpin and burbot that are ubiquitous to the Jericho Site. Loss of this particular fish community will have no serious consequences to the ecological integrity of the aquatic system outside of the Long Lake System.

3.5 WATER WITHDRAWAL CAUSEWAY

3.5.1 Introduction

Several fish species reside in Carat Lake including lake trout, Arctic char, Arctic grayling, round whitefish, burbot, and slimy sculpin. Lake trout and round whitefish are the dominant species. All have been recorded in the southeast corner of Carat Lake in the vicinity of the proposed water withdrawal causeway. The shoreline in the vicinity of causeway exhibits a low sloped, shallow-water zone (≤2.5 m water depth) that extends approximately 50 m offshore. At the edge of this shelf, the water depth increases rapidly to approximately 7 m, beyond which the lake bottom exhibits a gradual slope to deeper water. There is evidence that fish use the shallow zone in the vicinity of the causeway for rearing purposes. The foot print of the causeway will include approximately 775 m^2 of this shoreline zone (i.e., to 50 m offshore; 50 m length x 15.5 m wide).

The presence of Arctic char fry (young-of-the-year fish that have just emerged), and lake trout and Arctic char in spawning condition also suggest that the lake in the vicinity of the causeway is used for spawning by at least two species. A confirmed lake trout spawning site is located at a shoal situated approximately 150 m to the east of the causeway and Arctic char may spawn near the mouth of Stream C1. Because much of the causeway will be located in an area that freezes to the bottom in winter, and the lake bottom substrates are not suitable for spawning purposes, it is very unlikely that the physical footprint of the causeway will cover spawning sites of these species. In contrast, this shoreline zone may provide suitable spawning habitat for slimy sculpin.

3.5.2 Evaluation Approach

Residual effects of the causeway that will be evaluated include habitat loss associated with the physical foot print of the causeway. For the purpose of this assessment, the habitat types of concern include spawning and rearing. Feeding habitat may also be affected, but it is assumed that changes to feeding habitat will not affect the viability of the fish community because this habitat type is abundant and widely distributed in Carat Lake.

The criteria used to quantify the magnitude of effect of habitat loss are:

Low -	≤ 1% loss of habitat available to the fish community.
Moderate -	>1 to 20% loss of habitat available to the fish community.
High -	>20% loss of critical habitat available to the fish community.

The geographic extents of these effects are as follows:

Low -	Includes sub-local area within the immediate influence of the project activity (southeast corner of Carat Lake).
Moderate -	Includes the local area adjacent to influence of the project activity (Carat Lake), excluding the sub-local area.
High -	Includes the regional area Carat Lake watershed, excluding the local study area.

The significance of each residual effect will be rated similarly for all project phases because the presence of the causeway is deemed to be permanent and its effects similar between project phases.

3.5.3 Evaluation of Significance

The magnitude of effect for loss of rearing habitat was rated as low (Table 3.7). Rearing habitat is limited in distribution and abundance in Carat Lake, but the approximate area affected (775 m^2) represents a small fraction of rearing habitat available along the Carat Lake shoreline. Loss of spawning habitat also received a magnitude rating of low. Only slimy sculpin spawning habitat could be affected by the causeway.

The geographic rating will be low (restricted to the sub-local study area); however, the rating for both duration and frequency is high. In all cases, the effects are not reversible. The ecological context is rated as high for both rearing and spawning habitat.

3.5.4 Summary of Evaluation

The environmental effects evaluation indicated that adverse effects of the causeway will be continuous, but the effects will at the sub-local level (Table 3.8). Using this approach, the causeway received a rating of not significant for its effects on spawning habitat and not significant for its effect on rearing habitat. The overall project effect is also deemed to be not significant because reducing the availability of slimy sculpin spawning sites in the southeast region of Carat Lake should not change the structure of the

Carat Lake fish community. The level of confidence in the prediction is high because both the qualitative and quantitative certainty of this analysis is high.

Table 3.7 Residual environmental effects matrix used to evaluate significance of the water withdrawal causeway, Jericho Site.

Residual Effect	Protect Phase	Evaluation Criteria for Assessing Significance					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context
Loss of Rearing Habitat	All	L	L	H	H	NR	H
Loss of Spawning Habitat	All	L	L	H	H	NR	H

[a] L - low; M - moderate; H - high; R - reversible; NR - not reversible.

Table 3.8 Summary of residual effects evaluation of the water withdrawal causeway, Jericho Site.

Project Phase	Residual Environmental Effects Rating[a]	Level of Confidence	Certainty	
			Qualitative	Quantitative
Construction	NS	H	H	H
Operation	NS	H	H	H
Closure	NS	H	H	H
Post-closure	NS	H	H	H
Project Overall	NS	H	H	H

[a] L - low; M - moderate; H - high; S - significant; NS - not significant.

3.6 DISCHARGE FROM PKCA

3.6.1 Introduction

Several fish species from Lake C3 enter the lower 300 m section of Stream C3 during the open water period. These include lake trout, Arctic char, burbot, and slimy sculpin. The age-groups that enter the stream include young-of-the-year and juvenile fish. With the exception of slimy sculpin, adult fish do not use Stream C3 for feeding or spawning purposes. Based on these data, the majority of fish utilize the lower section of Stream C3 on an opportunistic basis for rearing purposes.

There is evidence that fish use the outlet zone in Lake C3 for rearing and the area is frequented by adult fish for feeding purposes. The absence of young-of-the-year fish and females in spawning condition suggest that the region in the vicinity of the outlet zone is not used for spawning purposes by most fish species. Slimy sculpin is the only species that may use this area for spawning.

Based on the proposed operation of the PKCA fish habitat in Stream C3 could be adversely affected. Stream C3 will be dewatered during the construction and post-closure phases of the project. During mine operation, PKCA discharge would be released via Stream C3 to Lake C3, which will provide fish habitat over the short term (PKCA discharges are targeted to meet metal mine effluent regulation limits and be non-toxic [Tahera, pers. comm.]). Based on this information, it is assumed that fish habitat presently available in Stream C3 will be permanently lost from production.

3.6.2 Evaluation Approach

The significance of project effects will be restricted to loss of fish habitat in Stream C3 due to dewatering. The magnitude of impact during the construction and closure phases is based on the percentage of potential fish habitat within the waterbody physically removed from production as follows:

Low - $\leq$ 1% loss of habitat available to the fish community.

Moderate - >1 to 20% loss of habitat available to the fish community.

High - >20% loss of critical habitat available to the fish community.

The geographic extent has a single rating value:

Low - Includes sub-local area within the immediate influence of the project activity (300 m section of Stream C3 presently used by fish and 40 m radius of Stream C3 outlet zone in Lake C3).

3.6.3 Evaluation of Significance

The magnitude of effect was rated as high for loss of habitat (construction and post-closure) and low for the operations phase (Table 3.9). The geographic rating is low in all cases (restricted to the sub-local study area). The duration and frequency ratings were low during the construction and operation phases, but high during closure due to permanent dewatering. The PKCA will permanently alter the discharge regime of Stream C3; therefore, the effects on this watercourse are not reversible. The limited habitat quality and size of Stream C3 suggests that it is not important to the fish community; therefore, the ecological context received a rating of low.

3.6.4 Summary of Evaluation

The evaluation indicated that operation of the PKCA will cause permanent loss of fish habitat in Stream C3 (Table 3.10). Stream C3 provides only a limited amount of habitat for fish and it is available only on an opportunistic basis; therefore, it is not essential for the long-term viability of the fish community that resides in Lake C3. As such, loss of fish habitat in Stream C3 received a rating of not significant. The level of confidence in the rating is high, based on the degree of qualitative certainty that the relative importance of the affected areas to the fish is limited. As such, the overall rating for the project activity is not significant.

Table 3.9 Residual environmental effects matrix used to evaluate significance of discharge from the Processed Kimberlite Containment Area, Jericho Site.

Residual Effect	Protect Phase	Evaluation Criteria for Assessing Significance					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context
Habitat Loss in Stream C3	Construction	H	L	H	H	R	L
	Operation	L	L	L	L	R	L
	Closure	H	L	H	H	NR	L
	Post Closure	H	H	H	H	NR	L

[a] L - low; M - moderate; H - high; R - reversible; NR - not reversible.

Table 3.10 Summary of residual effects evaluation of discharge from the Processed Kimberlite Containment Area, Jericho Site.

Project Phase	Residual Environmental Effects Rating[a]	Level of Confidence	Certainty	
			Qualitative	Quantitative
Construction	NS	H	H	L
Operation	NS	H	H	L
Closure	NS	H	H	L
Post Closure	NS	H	H	L
Project Overall	NS	H	H	L

[a] L - low; M - moderate; H - high; S - significant; NS - not significant.

3.7 SUMMARY OF RESIDUAL EFFECTS EVALUATION

The residual effects that remained following mitigation of the five project activities were evaluated to ascertain whether these effects were significant (Table 3.11). For the purposes of the evaluation, a significant adverse effect is one that affects a fish community, in sufficient magnitude, duration, or frequency, as to cause a change in the community structure that would not allow that community to return to its former structure.

Based on this definition, four of the project activities were rated as not significant, which included the use of explosives, the diversion of Stream C1, the water withdrawal causeway, and discharge from the Processed Kimberlite Containment Area. Ratings of not significant were given because the adverse effects were not sufficient to cause a permanent change in the fish community residing in the receiving waterbody.

One of the project activities was deemed to cause significant adverse effects to the fish community: the Processed Kimberlite Containment Area. Significant adverse effects will result from the construction and operation of the Processed Kimberlite Containment Area because the fish community residing in the Long Lake System will be extirpated. It should be acknowledged that the affected fish community consists of small, resident populations of slimy sculpin and burbot that are ubiquitous to the Jericho Site. Loss of this particular fish community will have no serious consequences to the ecological integrity of the aquatic system outside of the Long Lake System.

Table 3.11 Summary of residual effects evaluation for project activities in the Jericho Site.

Project Activity	Effect Pathway	Receiving Waterbody	Significant
Use of Explosives	- Direct mortality of fish	- Stream C1 - Carat Lake	No
Stream C1 Diversion	- Loss of fish habitat - Reduced water quality - Direct mortality of fish	- Stream C1 - Carat Lake	No
Processed Kimberlite Containment Area	- Loss of fish habitat - Direct mortality of fish	- Long Lake System	Yes
Water Withdrawal Causeway	- Loss of fish habitat	- Carat Lake	No
Discharge from PKCA	- Loss of fish habitat	- Stream C3	No

4.0 ACCIDENTS AND MALFUNCTIONS

4.1 ROAD ACTIVITIES

There will be a network of roads in the Jericho Site (permanent and winter), which will be used to transport materials. The tonnage transported, frequency, and location of the traffic will vary depending on the project phase.

Highest activities and tonnage transported would occur during construction phase, which would require use of the existing winter road that extends 29 km from the Lupin Site. This route goes in a northerly direction across Contwoyto Lake, before turning east to traverse a 3.5 km section within the Jericho Site. The winter road in this section crosses three waterbodies (Lynne Lake and Streams D1 and D2) and the small bay where the winter road intercepts Contwoyto Lake. Stream D1 is the drainage channel between Lynne Lake and Contwoyto Lake. It has extremely limited value as fish habitat due to the absence of a well-defined channel, but it has been included in this assessment because a spill in this system could drain directly into Contwoyto Lake. In total, 361 truck loads would be required during the construction phase (Project Description, Appendix A.1).

During subsequent project phases (operation and closure), traffic volume would be much less and would be restricted to use of the permanent road in the Jericho Site. During this period, winter supplies would still be routed along the winter road from Contwoyto Lake before it connects to the permanent road in the Jericho Site. The permanent road does not traverse any permanent waterbody.

Based on this information, only vehicle activity during the construction phase has the potential to affect aquatic biota within the Jericho Site. As such, the assessment will be restricted to this component of the project.

Assessment of Potential Effects

A number of hazardous materials would be transported during winter. If an accidental spill occurred, Tahera's contractor would implement an established emergency response procedure to minimize the potential impact. All spills that are accessible would be properly collected and disposed. It is possible that some material would remain after clean up and could potentially affect fish depending on the location and timing of the spill.

Data for the period 1994 to 1998, presented in Diavik (1998), indicate a spill rate of 9.0×10^{-7} per loaded truck kilometer of travel on the existing route from Yellowknife. Using this information, the estimated number of return trips and the distance traveled within the Jericho Site (3.5 km), the number of potential spill incidents would be less than 0.01. Even if the total number of predicted trips were used (932), the number of incidents during the entire life of the project would not exceed 0.003.

This information suggests that the likelihood of a spill occurring during the life of the project is extremely low. It should also be noted that not all truck loads contain materials that are hazardous to the aquatic environment.

A number of potentially hazardous materials may be transported on the winter road, but the primary concerns, in terms of volume, are fuel (diesel and gasoline) and ammonia nitrate. At sufficient concentrations, hydrocarbons and ammonia are known to be toxic to aquatic biota (CCME 1999).

For the purposes of this assessment, it is assumed that a 'worst case spill' may occur in the Jericho Site; mitigation measures will not remove the entire spill and the spill will enter the aquatic system. Based on these assumptions, there could be residual environmental effects associated with a spill on the winter road that could occur within the Jericho Site or on Contwoyto Lake.

Evaluation of Significance

The effect of a spill on aquatic biota would depend on the volume remaining after cleanup and the volume of the waterbody affected. For this evaluation, the magnitude of the effect is based on the size of waterbody that could be affected by a spill. A larger waterbody would have a greater capacity to reduce the concentration of the contaminant. As such, a spill occurring in Lynne Lake (16 ha) or its tributary (Stream D2) would receive a high magnitude rating, while a spill on Contwoyto Lake or its tributary (Stream D1) would receive a rating of moderate. Spills are short duration events; however, the effects of a spill on aquatic life could be much longer. As such, the duration of a spill event has a single rating of moderate (several years). It is assumed that no more than one spill will occur during life of the project.

The magnitude of a spill was rated as high for small waterbodies in the Jericho Site that are traversed by the winter road and moderate for larger systems. The ecological context of a spill is high in a small waterbody such as Lynne Lake. This effect is not reversible during the life of the project. Stream access to the lake is severely restricted, which would inhibit recolonization by fish. In contrast, the impacted area in Contwoyto Lake could be recolonized by fish originating from populations not affected by the spill;

therefore, it is reversible. In Lynne Lake, the geographic extent of the spill would be moderate because the entire waterbody is affected, while in Contwoyto Lake it would be low because only a portion of the lake would be impacted.

Adverse effects associated with an accidental spill on the winter road in the Jericho Site may be high, but they would be restricted to the sub-local or local level. Based on this information, the rating for a 'worst case spill' is significant for Lynne Lake and not significant for Contwoyto Lake. The level of confidence in this rating is low, as is the certainty (qualitative and quantitative) in the evaluation. At the present time, there is insufficient information to accurately predict the magnitude of the effect on fish.

4.2 FUEL FARM SPILL

The fuel farm in the Jericho Site is situated adjacent to a fish bearing waterbody (Lake C1). As such, there is the potential for adverse effects on fish if a fuel spill were to occur. Tahera's environmental management plan will utilize a containment system around each fuel farm that has a design capacity of 110% of the fuel storage facility; therefore, no fuel originating from a fuel farm spill would reach the aquatic system. Based on the planned mitigation, no adverse effects on aquatic biota are expected.

4.3 STRUCTURAL FAILURE OF WASTE ROCK DUMP

The two waste rock dumps in the Jericho Site are situated adjacent to fish bearing waterbodies (Carat Lake and Lake C1). Structural failure of these dumps may allow rock and drainage from the dumps to enter each lake. If this happens, fish could potentially be affected due to introduction of contaminants. Based on the project design (dump slopes and height), the probability of waste rock entering either lake as a result of structural failure is zero (Tahera, pers. comm.). Tahera's water management plan will also utilize a containment system that incorporates a series of berms designed to prevent down slope movement of materials associated with a potential failure. An integral part of this plan will be a collection and treatment system. As such, materials originating from structural failure of the dump will not reach the aquatic system (Project Description, Appendix A.1); therefore, no adverse effects on aquatic biota would occur.

4.4 STRUCTURAL FAILURE OF PKCA

Introduction

The PKCA will be constructed in the Long Lake basin and will consist of two cells and one polishing pond. To achieve the required capacity for processed kimberlite storage, the existing elevation of Long Lake (mean = 515.5 m) will be increased to 524 m. To accomplish this, four dams and five perimeter dikes will be constructed. The maximum height of the dams will be 9 m, while the perimeter dikes will not exceed 2 m. The dam at the polishing pond will be built to an elevation of 518 m, which corresponds to a height of approximately 4 m. The polishing pond dam may also be raised to 524 m to provide one year's storage capacity (Tahera, pers. comm.). PKCA discharge will be to the west via Stream C3, which drains into Lake C3. Lake C3 drains directly into Carat Lake. The east and southeast dams will be used to separate the PKCA from a small watershed that drains into Contwoyto Lake. This watershed includes an unnamed waterbody immediately adjacent to the PKCA (Ash Lake), Key Lake, Stream D2, which connects Key Lake to Lynne Lake, and Stream D1, which drains into Contwoyto Lake. The north dam will be used to separate the PKCA from a small watershed that drains into Carat Lake via Lake C1.

Baseline inventories in the Jericho Site have identified several fish-bearing waterbodies downstream of the PKCA. In the Carat Lake drainage these include Stream C3, Lake C3, Lake C1, Carat Lake, and Jericho Lake. In the Contwoyto Lake drainage, they include Key Lake, Stream D2, Lynne Lake, and Contwoyto Lake.

Given the location of the PKCA, structural failure of the containment area resulting in an uncontrolled release of untreated PKCA fines has the potential to adversely affect the aquatic environment in any one of these drainages. The PKCA fines (sediment and water) would contain concentrations of suspended sediments and ammonia that are above background (Project Description, Appendix A.1). If this material reached the aquatic environment, the resulting potential effects would be loss of habitat, direct mortality of fish, and reduced water quality.

There are a limited number of emergency mitigation measures that can be implemented in the event of structural failure. They would involve construction of temporary coffer dams used to contain the spill.

Evaluation Approach

For the purposes of this evaluation, it is assumed that mitigation measures will not prevent entry of an uncontrolled spill into the aquatic system and the spill would likely occur in June when the potential volume of the spill would be at its highest.

The magnitude is considered to be high for each adverse effect (loss of habitat, direct mortality of fish, and reduced water quality) because the result would be mortality of a large component of the fish community in each affected waterbody. The downstream extent of the detrimental effects on fish of an uncontrolled spill would vary depending on the volume of the material released, as well as dilution effects and holding times in each basin. An assessment of water quality effects suggests that a spill to the east could influence most lakes and streams in the Contwoyto Lake drainage (all except Contwoyto Lake); a spill to the north would affect the Lake C1 system and possibly Carat Lake; the detrimental effects of a spill to the west would extend only to Lake C3 (Tahera, pers. comm.).

Evaluation of Significance

The adverse effects of an uncontrolled spill from the PKCA will be significant. Immediate consequences will include direct mortality of fish due to acute toxicity of contaminants. Long-term consequences would involve degradation of habitat due to sedimentation and reduced water quality. The ecological context of an uncontrolled spill is high in all cases and it is unlikely that the effect would be reversible during the life of the project. Due to low productivity characteristic of subarctic lakes, fish populations would require several generations to return to pre-impact densities. In addition, barriers to fish passage in the Contwoyto Lake drainage would hamper re-establishment of the fish communities. The geographic extent of the spill would be moderate because only waterbodies within the Jericho Site would be affected. The level of confidence in this rating is low, as is the certainty (qualitative and quantitative) in the evaluation. At the present time, there is insufficient information to accurately predict the duration of the effects.

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