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Chair
Wek'èezhíi Land and Water Board
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4 December 2009

Re: Interim Closure and Reclamation Plan – Version 3

Please find enclosed the *Interim Closure and Reclamation Plan - Version 3.0* as required by Water License W2007L2-0003 Part L. This submission was prepared following the direction of the Wek'èezhíi Land and Water Board (7 August 2008 and 7 May 2009).

The purpose of this Interim Closure and Reclamation Plan (ICRP) is to provide an updated description of the current closure plan and the direction DDMI is heading in the near future. It is also being submitted for consideration by communities, the advisory board and government.

The organization, and in some cases the type of information that is included in this ICRP update, has been revised so that it conforms with a new *Annotated Outline for Interim and Final Closure and Reclamation Plans* provided by the Wek'èezhìi Land and Water Board (WLWB). This reporting template was developed by the Mackenzie Valley Land and Water Board (MVLWB) Standard Procedures and Consistency Working Group. Although it has not been approved by the MVLWB it has been reviewed by the WLWB and meets their expectations for this ICRP.

Version 1 (2001) and Version 2 (2006) of the Diavik ICRPs included general closure objectives but did not include specific closure criteria. DDMI in conjunction with WLWB, regulators, communities and the advisory board implemented a process in 2009 that initiated the development of closure goals, objectives and criteria specific to the Diavik mine site. This ICRP documents the current state of these goals, objectives and criteria.

DDMI critically reviewed the technical aspects of the closure designs in 2009 and modified the preferred options for both the processed kimberlite containment (PKC) area and the wasterock area. A change was also made to the preferred mining approach for A21 and associated implications for closure. General aspects of all closure options were discussed with communities and regulators in 2009. This ICRP documents both the historical closure alternatives that were considered during the mine design phase, as well as the more recent option reviews, to provide a more complete description of options and alternatives that have been considered in the selection of a preferred option.

The plan remains however as an *Interim* plan. As such this plan does not include final closure designs or specific post-closure monitoring programs. These will be developed in the future. It does provide a comprehensive view of the current closure concepts for each area of the mine site and the plans to advance these designs.

Please advise the undersigned if you have any questions regarding this submission.

Regards,

Gord Macdonald

cc Kathleen Racher (WLWB)
Patty Ewaschuck (WLWB)
Ryan Fequet (WLWB)

Attachments: Interim Closure and Reclamation Plan – Version 3.0

Interim Closure and Reclamation Plan – Version 3.0

Diavik Diamond Mine Inc.

December 2009

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ATTACHMENTS

TABLES

1. Executive Summary

This Interim Closure and Reclamation Plan update has been prepared as per the requirements of Diavik Diamond Mine Inc.'s Class "A" Water License WL2007L2-0003 and directives from the Wek'èezhíi Land and Water Board .

Closure planning commenced with the original mine design work in 1996-1998 and continues to be refined based on new information. Many of the important design decisions related to closure occurred during the original mine design. This update documents the most recent changes but also provides a summary description of how the closure plan for each area has evolved. A comprehensive set of closure objectives have been developed to guide the closure planning. Initial criteria have also been proposed to describe how each objective might be evaluated.

Closure planning is an ongoing activity and the purpose of this document is to provide for general review and comment, but also regulatory acceptance, a description of the current state of the plan and intentions for the future.

The A418 and A154 open pit, underground and dike areas will be flooded at closure and the areas rejoined with Lac de Gras by excavating small sections of the dikes. Fish habitat enhancements, constructed during the mine operations in the pit shelf area will provide additional habitat for the fish of Lac de Gras. The North Inlet will similarly be rejoined with Lac de Gras.

On land, the wasterock pile and the processed kimberlite containment area will remain as a significant landscape feature post-closure. The area will be physically and geochemically stable and safe for people and wildlife but visually will remain as a large rock covered hill. Travel routes will be established to provide safe access and movement for people and wildlife.

Buildings, equipment, power lines, pipeline, fuel tanks etc. will not be visible post closure. Where possible buildings, equipment and materials will be salvaged for resale/reuse preferably in the north and where not possible material will be made available for recycling. Some material will be not have any resale/reuse/recycle value and will be disposed of on-site or off-site as appropriate for the water material.

The plant site, roads, airstrip and laydown areas will be contoured, original drainage channels restored, surfaces scarified and targeted for revegation. Travel routes for people and wildlife will be established and linked with those constructed for other areas.

As this is an update to the interim plan many of the specific details of closure and reclamation activities have not yet been developed. There are still uncertainties in the plan. These are identified as are the research plans that have been identified to address the uncertainties.

2. Introduction

The Diavik Diamond Mine (the Mine) is an unincorporated joint venture established by Diavik Diamond Mines Inc. (DDMI) and Harry Winston Diamond Limited Partnership (HW) to develop a diamond mine at Lac de Gras, in the Northwest Territories (NWT) of Canada.

DDMI is a wholly owned subsidiary of Rio Tinto plc of London, England, while Harry Winston Diamond Limited Partnership is controlled by Harry Winston Diamond Corporation of Toronto, Ontario, Canada. Under the Joint Venture Agreement, DDMI has a 60 percent (%) participating interest in the project, and HW a 40% participating interest. DDMI has been appointed Manager and is the corporate entity responsible for conducting Project activities.

The Diavik Diamond Mine is located on East Island, a 17 square kilometre (km^2) island in Lac de Gras, NWT, approximately 300 kilometres (km) northeast of Yellowknife (64 degrees (^{o}) 31 minutes (’) North, 110^o 20’ West) (Figure 2-1). The area is remote, and major freight must be trucked over a seasonal winter road from Yellowknife. Worker access is by aircraft to the Mine's private airstrip.

The Diavik Diamond Mine involves mining of four diamond-bearing kimberlite pipes. The pipes, designated as A154North, A154South, A418 and A21, are located directly off shore of East Island (Figure 2-2). All mining, diamond recovery, support activities and infrastructure will be limited to East Island.

Overall, DDMI and HW have a mineral claim to an area that includes portions of Lac de Gras, the East and West Islands, and portions of the mainland to the southeast and northwest. Lac de Gras is about 100 km north of the treeline in the central barren ground tundra of the NWT, at the headwaters of the Coppermine River. This river, which flows north to the Arctic Ocean east of Kugluktuk, is 520 km long and has a drainage area of approximately 50,800 km^2.

The Community of Wekweti lies approximately 187 km to the west-southwest of the mine site. Lutsel K’e is 230 km to the south, Bathurst Inlet is about 275 km to the northeast, and the Lupin mine site is about 125 km to the north. The BHP Billiton Diamonds Incorporated (BHPB) Ekati Mine is located roughly 25 km to the north (Figure 2-1).

2.1 Purpose and Scope of the Closure and Reclamation Plan

Diavik is committed to sustainable development, fully embracing our share in that joint responsibility with all legitimate interested parties. Diavik contributes to sustainable development by seeking to maximize the resources we mine, by pursuing opportunities to enhance environmental, social and economic benefits, and by reducing adverse effects that may result from our undertakings.

Mine closure has been integral to mine design and operations. Diavik recognizes that the land and water in the mine area is being borrowed, for the purpose of diamond mining, for a relatively short period of time. Diavik will operate and close the mine site responsibly, leaving behind a positive community and environmental legacy. (Diavik Sustainable Development Policy – November 2008).

Planning for permanent closure is an active and iterative process. The intent of the process is to develop a final plan for permanent closure. The process began in the mine design phase and continues through to closure implementation. It enables the plan to evolve as new information becomes available. However, timely closure plan decisions also need to be made throughout the planning process. Some of these decisions are significant, are made early in the planning process and can impact on the final closure plan. For example the decision on a location for the wasterock piles or the processed kimberlite containment (PKC) is made during the mine design phase and has implications for the final closure plan. Other decisions, for example a final cover material, can be made later in the mine life and can change. Closure planning ensures that information is collected, reviews completed and decisions made as appropriate for a successful implementation.

Interim Closure and Reclamation Plans (ICRP) are documents prepared during the life of the mine that describe the current state of closure planning. The ICRP builds from an *Initial* Closure and Reclamation Plan and ultimately become the *Final* Closure and Reclamation Plan. The expectation is that each iteration of the ICRP will be a step toward the Final Plan.

The focus of this ICRP is to:

- Revise the organization and in some cases the type of information that is included in the documentation so that it conforms more closely with a new *Annotated Outline for Interim and Final Closure and Reclamation Plans* provided by the Wek'èezhìi Land and Water Board (WLWB).
    - This reporting template was developed by the Mackenzie Valley Land and Water Board (MVLWB) Standard Procedures and Consistency Working Group. Although it has not been approved by the MVLWB it has been reviewed by the WLWB and meets their expectations for this ICRP (WLWB 2009). This document adheres very closely to this reporting template. In some areas small changes have been made to improve readability. Appendix XI describes where this has occurred.
- Document working goals, objectives and criteria for closure.
    - The 2001 and 2006 ICRPs both had general closure objectives and did not include specific closure criteria. DDMI in conjunction with WLWB, regulators, communities and EMAB implemented a process to initiate the development of closure goals, objectives and criteria specific to the Diavik mine site. It is recognized that there is still work to be done, particularly with regard to closure criteria. This ICRP documents the current state of these goals, objectives and criteria.
- Update preferred closure options.
    - DDMI has critically reviewed the technical aspects of the closure designs and modified the preferred options for both the PKC area and the wasterock area. A change to the preferred mining approach for A21 and implications for closure are also included. General aspects of all closure options were discussed with communities and regulators. These discussions will continue in the future and are

becoming more and more specific. This ICRP documents both the historical closure alternatives that were considered during the mine design phase, as well as the more recent option reviews, to provide a more complete description of options and alternatives that have been considered in the selection of a preferred option.

- Address deficiencies identified in the 2006 ICRP.
  - The WLWB has identified specific deficiencies (WLWB 2008). This ICRP document attempts to addresses these deficiencies.

This document remains however as an *Interim* plan. It does not include detailed engineering designs for preferred closure options. It also does not include specifics of post-closure monitoring programs. DDMI's intent with this document is to:

- Provide a description of where we are at today and the direction we are heading in our closure planning process for consideration by communities, regulators, advisory board and government;
- Satisfy the requirements of the Water License and Land Lease requirements; and
- Obtain feedback regarding the priority areas for advancement of the closure plan prior to the next ICRP.

A note to readers; in this document the term "closure" is specifically intended to mean both "closure and reclamation". The single term closure has been used simply for convenience.

2.2 Closure and Reclamation Plan Goals

Diavik's overall goal for the operation and closure of the mine site, as stated in *Diavik's Sustainable Development Policy* is:

> To operate and close the Diavik Mine responsibly, leaving behind a positive community and environmental legacy.

Regulatory requirements also provide guidance goals or global objectives for closure through the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007). This document describes three broad categories of global closure objectives as follows:

Physical Stability – Any mine component that would remain after closure should be constructed or modified at closure to be physically stable such that it does not erode, subside or move from its intended location under natural extreme events or disruptive forces to which it might be subject after closure. Mine site reclamation will not be successful into the long-term unless all physical structures are designed such that they do not pose a hazard to humans, wildlife, or environment health and safety.

Chemical Stability – Any mine component, including wastes, that remains after mine closure should be chemically stable; chemical constituents released from the mine components should not endanger public, wildlife, or environmental health and safety, should not result in the inability to achieve the water quality objectives in the receiving environment, and should not adversely affect soil or air quality into the long term.

Future Use and Aesthetics – The site should be compatible with the surrounding lands once reclamation activities have been completed. The selection of reclamation objectives at a project site should consider:

- Naturally occurring bio-physical conditions, including any physical hazards of the area (pre- and post development);
- Characteristics of the surrounding landscape pre- and post- development;
- Level of ecological productivity and diversity prior to mine development and intended level of ecological productivity and diversity for post-mine closure;
- Local community values and culturally significant attributes of the land;
- Level and scale of environmental impact; and
- Land use of surrounding areas, including the proximity to protected areas, prior to mine development and expected end land use activities for each area on site for humans and wildlife.

Closure objectives specific to the Diavik mine site have been developed through a process involving DDMI, reviewers and WLWB Staff. The WLWB considered the objectives developed through this process at a Board meeting May 5, 2009. The WLWB recognized that the closure objectives must be flexible to accommodate potential changes identified during ongoing work on the ICRP or as a result of changes at the mine. However, the Board concluded that the objectives were adequate to use for the ICRP.

Closure objectives are divided into global objectives and mine area specific objectives. Mine area specific objectives are provided and discussed in Section 5.2 and Appendix V. The global closure objectives provided in the WLWB (2009) are listed in Table 2-1.

Table 2-1 Global Closure Objectives – Diavik Mine Site

Global Objectives
1. Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life.
2. Land and water that allows for traditional use.
3. Final landscape guided by traditional knowledge.
4. Final landscape guided by pre-development conditions.
5. Final landscape that is neutral to wildlife – being neither a significant attractant nor significant deterrent relative to pre-development conditions.
6. Maximize northern business opportunities during operations and closure.
7. Develop northern capacities during operations and closure for the benefit of the north, post-closure.
8. Post closure conditions that, where appropriate, do not require a continuous presence of Mine Staff until a walk-away condition is achieved.

2.3 Closure and Reclamation Planning Team

Closure planning at Diavik is conducted as a team by virtue of the multi-discipline, interdepartmental nature of the work. The team working on closure planning is formally organized as a committee. The committee was established April 9, 2003, three months after the commencement of production. At that time the focus of the committee was communication of the closure plans and rationale with the operations departments. It was to be well understood that closure would remain a focus and that operations needed to be fully aware of the current plans. The invitation was also opened for input on ways to improve these plans for both closure success and for operations. Participation on the committee was limited at that time to operations and environment departments and the focus was wasterock segregation and deposition plans for the PKC.

By October 2004 the committee had expanded to include company wide representation including community affairs, human resources and finance. Currently the committee composition and areas of focus are as follows:

Principal Advisor, Sustainable Development – planning, coordination, internal and external communication, documentation, review and water related environmental aspects.

Superintendent, Workforce Planning – human resources.

Senior Specialist, Earthworks – PKC and general earthworks including construction design, operations planning, engineering investigations.

Senior Mine Engineer – wasterock and ore planning and management.

Planner, Water Management – water management infrastructure.

Specialist, Water Resources – geochemistry, processed kimberlite investigations, wasterock segregation, test piles research, hydrology.

Principal Advisor, Communities, Business Development and Agreements – socio-economics, business and community opportunities.

Principal Advisor, Communications – communications plans.

Specialist, HSEQMS and Compliance – permits, licenses, communication with Inspector, hydrocarbon contamination.

Superintendent, Environment – monitoring, Traditional Knowledge, wildlife access, hazardous materials, landfill, vegetation research

Principal Advisor, Strategic Planning – mine planning, closure costs, finance

Manager Technical Services – underground mining, planning, design and technical review and coordination

Each of the participants on the committee has access to or directly manages additional DDMI staff, expert consultants, researchers and external advisors to assist as required in closure related activities. External teams include but are not limited to:

- University of Alberta (vegetation, fish habitat, thermal)
- University of Waterloo (geochemistry, oxygen transport, microbiology)
- University of British Columbia (hydrology, water transport)
- Golder Associates Ltd. (Golder) (closure planning, geotechnical, mine and engineering design/investigation, deposition, fish habitat, wildlife, environmental assessment, monitoring, closure cost estimates)
- AMEC Earth and Environmental (geotechnical, engineering design/investigations)
- Rio Tinto Health Safety and Environment (closure planning, communication)
- Diavik Geotechnical Review Board (geotechnical)

The committee is responsible to the Vice President of Operations.

2.4 Community Engagement

Community engagement in closure planning commenced through general discussions about the Project in June 1995. At that time only a limited amount of information was available about the size of the kimberlite pipes or the assortment of infrastructure and additional engineering structures required to support a future mine. Figure 5-7 shows the initial Project concepts that formed the basis of these initial discussions with communities. Diavik heard the following from the communities:

- Land and Water are significant to the people of the north;
- Potential employment and business opportunities created by Diavik are important to the people of the north;
- Concern for compensation from use;
- Diavik needs to consult regularly with communities potentially affected;
- People are concerned about placing mining material in Lac de Gras, particularly waste;
- People of the north associate mining with chemicals and contamination of water and animals; and
- Minimizing the footprint of the proposed mine site would also minimize the environmental effects.

In June 1997 a workshop was held at what was then an exploration camp at the Diavik sites to present and discuss a first Project Description that had been developed with input from communities.

Key design principles that were incorporated were:

- Consolidate the mine site and locate all components on the East Island;

- Locate the PKC within the central depression on the East Island and not in Lac de Gras between the two islands;
- Manage water discharged to Lac de Gras; and
- Consider aspects of closure in the design of the mine and associated facilities.

Community engagement then proceeded to the Environmental Assessment (EA) and Water Licensing phases. Engagement activities associated with the EA are documented in Canada (1999) and in DDMI (1999a) where closure planning continued to be discussed including the Initial Abandonment and Restoration Plan (DDMI 1999b).

As the mine developed, community engagement was more focused on employment, training and environmental monitoring. DDMI regularly engaged with communities through the Environmental Monitoring Advisory Board (EMAB) and the Diavik Technical Committee (DTC) of the MVLWB. The DTC was involved in the review and recommendation for approval of the Interim Abandonment and Restoration Plan (DDMI 2001b). While there was opportunity for community engagement through the DTC and EMAB, minimal additional closure input from communities was provided beyond what had been provided from 1995 to 1998.

Specific community engagement related to this update of the ICRP in 2009 included:

- January 13 and 15, 2009 – DDMI participated in the EMAB hosted communities workshop on closure. DDMI made presentations on the history of closure planning at Diavik (Appendix IX-1.1) and on future planning considerations (Appendix IX-1.2). DDMI staff engaged in workshop sessions to brainstorm closure ideas and concepts specific to the Diavik mine site and in general. The report prepared for EMAB on the workshop is included as Appendix IX-1.3 with EMAB permission.
- January 14, 2009 – DDMI invited representatives from the Tlicho, Yellowknives Dene First Nation, Lutsel K'e Dene First Nation, North Slave Metis Alliance and Kitikmeot Inuit Association to the mine site for a tour and associated discussion specific to mine closure. A copy of the guide for the site tour and the list of participants are included in Appendix IX-2.
- February 25 and 26, 2009 – WLWB hosted a workshop to develop closure objectives specific to the Diavik mine site. DDMI provided proposed objectives for the workshop and participated as a resource and participant in workshop. The outcome from this workshop is included as Appendix IX-3.
- May 12 and 13, 2009 – DDMI hosted a workshop to review specific closure options for the mine site and to initiate the development of closure criteria specific to each closure objective. A list of possible closure research ideas/opportunities were also identified by participants during the discussions. The outcome of this workshop is included as Appendix IX-4.
- August 17-21, 2009 – DDMI invited representatives from the Tlicho, Yellowknives Dene First Nation, Lutsel K'e Dene First Nation, North Slave Metis Alliance and Kitikmeot Inuit Association to the mine site to review and provide some initial considerations towards

possible caribou pathways through a post-closure mine site. A summary of the outcomes from this site workshop is included as Appendix IX-5.

- September to December 2009 – DDMI went to communities to initiate further engagement with community leadership and a broader range of community members. Community visits were held in Ndilo/Dettah (September 16, 2009), Gameti (September 21, 2009), Wekweti (September 28, 2009), Whati (September 17, 2009), and Behchoko (October 19, 2009) and Lutsel K'e (December 3, 2009). Scheduled visits with Kugluktuk and the North Slave Metis Alliance required rescheduling. A copy of the closure presentation given at the community meetings is attached as Appendix IX-6.

2.5 Closure Plan Requirements

2.5.1.1 Guidelines and Regulations

This ICRP follows applicable regulatory guidelines, the principles of which are described in:

- Indian and Northern Affairs Canada Mine Site *Reclamation Guidelines for the Northwest Territories* (INAC 2007); and
- Indian and Northern Affairs Canada *Mine Site Reclamation Policy for the Northwest Territories* (INAC 2002).

This ICRP is also subject to several Federal and Territorial Acts and Regulations which are listed in Table 2-2.

The overall approach to closure and reclamation planning for the Diavik Diamonds Project conforms to both corporate and established international guidelines for mine closure. Selected aspects of closure and reclamation planning completed for other mining operations in the NWT have been reviewed in the development of this plan.

Table 2-2 Relevant Federal and Territorial Acts and Regulations

Federal Acts and Regulations	Territorial Acts and Regulations
Arctic Waters Pollution Prevention Act and Regulations	*Commissioner's Lands Act* and Regulations
Canadian Environmental Assessment Act and Regulations	*Environmental Protection Act* and Regulations
Canadian Environmental Protection Act and Regulations	*Environmental Rights Act* and Regulations
Fisheries Act and Regulations	*Mine Health and Safety Act* and Regulations
Mackenzie Valley Resource Management Act and Regulations	*Science Act* and Regulations
Navigable Water Protection Act and Regulations	
Northwest Territories Waters Act and Regulations	
Territorial Lands Act and Regulations	
Transportation of Dangerous Goods Act and Regulations	

2.5.1.2 Permits and Authorizations

The Diavik Diamond Mine received ministerial approval under the *Canadian Environmental Assessment Act* on November 1999. On March 3, 2000, DDMI signed an Environmental Agreement with parties including the Federal Government, the Government of the Northwest Territories, and First Nations, and on March 31, 2000, the Federal Government issued DDMI 30-year land leases for the mine site (all expire March 29, 2030) under the *Territorial Lands Act* .

In August 2000, a Class "A" Water Licence (successfully renewed in 2007 and expires November 2015) was granted under the *Mackenzie Valley Resource Management Act*, various fisheries authorizations were granted under the *Fisheries Act*, and a Navigable Waters Permit (expires August 2030) was issued under the *Navigable Water Protection Act*. Energy, Mines, and Resources Canada issued an Explosive Permit (renewed annually with no expiry) in December 1999.

A summary of all potential permits required and existing authorizations held by jurisdiction for closure are listed in Table 2-3.

Table 2-3 List of Permits and Authorizations

List of Existing Permits, Authorizations and Agreements	Responsible Authority and Contact Information
Water Licence W2007L2-0003	Wek'èezhìi Land and Water Board
Fisheries Authorization	Fisheries and Oceans Canada
Navigable Waters Permit	Transportation Canada
Explosive Permit	Natural Resources Canada
Land Use	Wek'èezhìi Land and Water Board
Land Lease	Indian and Northern Affairs Canada

Water Licence Requirements

The water license for the Diavik Diamond Mine (Class “A” Water Licence W2007L2-0003) sets out several conditions with respect to DDMI’s right to alter, divert or otherwise use water for the purpose of mining. Specifically, Part L: Conditions Applying to Closure and Reclamation specifies that DDMI shall implement the Abandonment and Restoration Plan as approved under License N7L2-1645. Updates to this ICRP shall be in accordance with directives from the Board, the most recent edition of Indian and Northern Affairs Canada’s “*Mine site Reclamation Guidelines for the Northwest Territories*”, the most recent edition of the Canadian *Dam Safety Guidelines* and a list of specific items.

The plan is to include specific closure and reclamation objectives and an evaluation of alternatives for the closure of each mine component. A summary of the specific requirements listed within the water license are provided in Appendix XIII.

In addition to the Interim Closure and Reclamation Plan, Part L of the Water License specifies that:

- DDMI shall annually, and upon request of the Board submit to the Board, an updated estimate of the anticipated mine restoration liability at the end of the upcoming year (see Appendix VII);
- DDMI shall implement the Restoration Research Plan (hereafter referred to as the Reclamation Research Plan) as approved under License N7L2-1645 (see Appendix VIII); and
- DDMI shall submit to the Board a Reclamation Monitoring Program to evaluate the effectiveness of all progressive reclamation and to identify any modifications required to facilitate landscape restoration (see Appendix VIII).

DFO Authorization Requirements

The Diavik Diamond Mine is subject to the Authorization for Works or Undertakings Affecting Fish Habitat File No SC98001 ("Fisheries Authorization") issued by Fisheries and Oceans Canada (DFO 2000). The Fisheries Authorization outlines reporting requirements and approvals, compensation requirements for the harmful alteration, disruption or destruction (HADD) of fish habitat, and requirements for compensation plans. DDMI must also produce monitoring plans to determine the effectiveness of all fish habitat enhancement and development efforts.

The Fisheries Authorization also stipulates that DDMI must meet the following specific requirements prior to final closure and reclamation of the enclosure dikes and open pits:

- DDMI shall provide updated estimates of pit water quality for each dike area a minimum of three months prior to anticipated date of commencement of habitat compensation works within each dike area;
- DDMI shall demonstrate that water quality will be acceptable to DFO prior to any dike breaching;
- If water quality within the diked area is unacceptable, DDMI shall submit a revised Compensation Plan (within six months of the unacceptable water quality results) for habitat compensation within the A21 area of Lac de Gras prior to implementing compensation efforts within the dike;
- Upon demonstration of acceptable water quality, DDMI shall commence with the Compensation Plan for each of the diked areas provided that the locations and sizes of dike breaches are as specified within the Navigable Waters Permit (DFO Canadian Coast Guard 2000);
- DDMI shall ensure that habitat features within the dike areas upon completion of mining in each open pit (including depth, substrate type, size and configuration), are modelled after those features found in other productive areas of the lake, as well as incorporating traditional knowledge where applicable;

- DDMI shall submit a report on the habitat compensation efforts (a final calculation of actual habitat losses and habitat gains expressed as habitat units for each of the dikes) including and follow-up monitoring within one year of breaching of each dike; and
- DDMI shall maintain all habitat compensation as required, and monitor, verify and report on the effectiveness of the compensation efforts that will be outlined in Compensation and Monitoring Plans as approved by DFO.

Navigable Waters Permit Requirements

In accordance with the Navigable Waters Permit (DFO Canadian Coast Guard 2000), DDMI must meet the following requirements prior to final closure and reclamation of the enclosure dikes and open pits:

- all internal fish habitat reefs shall be placed a minimum 2 m depth from lower water; and
- dike breaches shall be 30 m width and minimum 2 m depth from low water.

Explosive Permit Requirements

In accordance with Explosives Permit requirements, DDMI must remove all explosives and ammonia nitrate off site prior to final closure and reclamation.

3. Project Environment

The following sections provide descriptions and references for the pre-disturbance environment of the mine site area. More detailed description of the baseline conditions can be found in The Integrated Environmental and Socio-Economic Baseline Report (DDMI 1998a). Where relevant to pre-disturbance conditions, data and information have been updated.

3.1 Atmospheric Environment

3.1.1 Climate Conditions

The Mine has been collecting meteorological data since 1994. In 2003, a second weather station was installed to aid in collecting evaporation data and supplement weather data. The meteorological stations measure the following:

- wind speed;
- wind-direction;
- precipitation;
- ambient air temperature;
- incoming solar radiation; and,
- relative humidity.

Manual precipitation stations were also used to measure rain, snow, and evaporation. Summary information for temperature is presented below based on data collected at the Mine from 1999 to 2005. In addition, available information from baseline studies and the EA has been provided below.

3.1.1.1 Temperature

The Canadian Arctic is characterized by long, cold winters and short, cool summers. Based on data collected from 1999 to 2005, January is typically the coldest month of the year in the region of Lac de Gras, with a mean daily air temperature of about -24 degrees Celsius (^{o}C) to -33°C (Figure 3 1). The minimum daily air temperature recorded during the period was -44°C in January 2005 (Figure 3-2). These cold temperatures result in slow development of soils, and the presence of permafrost, where soils and bedrock remain frozen year-round (DDMI 1998b). July is typically the warmest month, with mean daily air temperature of approximately 9°C to 16°C. The maximum hourly air temperature recorded was 33°C in July 2000 (Figure 3-3).

Annual average, minimum and maximum temperatures are presented in Table 3-1. The annual average temperature in the Lac de Gras area ranged from -7.4°C to -12.0°C between 1999 and 2005 (Table 3-2).

Lac de Gras has two seasons: ice-covered (generally, January to June and November, December) and open water (July to October). During the open water period, average daily temperatures ranged from 3.79°C to 7.16°C (Table 3-1) Average temperatures under ice-covered conditions vary from -14.60°C to -19.91°C (Table 3-1).

Table 3-1 Average, Minimum, and Maximum Recorded Temperatures at the Meteorological Stations between 1999 and 2005, Open Water and Ice-covered Seasons

	1999	2000	2001	2002	2003	2004	2005
Open Water Season							
Average Temperature	4.29	5.43	5.88	4.64	7.16	3.79	4.67
Minimum Temperature	-18.98	-22.25	-20.80	-21.86	-23.58	-22.44	-14.96
Maximum Temperature	23.34	27.33	25.80	25.74	25.89	25.Golder	25.02
Ice-covered Season							
Average Temperature	-14.60	-16.17	-15.73	-16.83	-16.64	-19.91	-15.55
Minimum Temperature	-41.27	-41.27	-41.20	-43.72	-42.97	-41.26	-44.00
Maximum Temperature	27.21	21.48	23.90	21.85	18.33	22.55	19.30

Note: unit for temperature = ^{o}C.

Table 3-2 Annual Average, Minimum, and Maximum Temperatures Recorded at the Meteorological Stations, 1999 to 2005

	1999	2000	2001	2002	2003	2004	2005
Average Temperature	-7.4	-9.0	-8.5	-9.7	-8.7	-12.0	-8.8
Minimum Temperature	-36.6	-41.3	-41.2	-43.7	-43.0	-41.3	-44.0
Maximum Temperature	27.2	27.3	25.8	25.7	25.9	25.3	25.0

Note: unit for temperature = ^{o}C.

3.1.1.2 Precipitation

Based on data collected prior to 1998, the specific annual precipitation at Lac de Gras is below 400 millimetres (mm), consisting of approximately 60% snowfall and 40% rainfall (Golder 1997a). Precipitation occurs as snow year-round, although maximum monthly snowfall is usually observed in October. Precipitation may occur as rainfall from May to October (inclusive), with mean monthly rainfall peaking in August (Golder 1997a). Rainfall in the Arctic region usually occurs as prolonged, low-intensity events.

3.1.1.3 Wind

From 1994 to 1996, the west wind occurred most frequently at the Mine site (18% of the time). The average wind speed recorded was 18 kilometres per hour (km/hr), although the average speed from the northwest wind was the highest (24 km/hr). The 100-year hourly wind speed was estimated to be 128 km/hr from the northwest direction (Golder 1997a).

3.1.2 Air Quality Conditions

Diavik's location is considered a remote site where ambient concentrations are primarily the result of emissions from distant anthropomorphic sources and natural sources. Remote sites located on the tundra normally have good air quality, especially for the primary air contaminants such as particulate, carbon monoxide, sulphur dioxide and nitrogen dioxide.

Based on a limited number of measurements of suspended particulate matter recorded between 1994 and 1997, the ambient concentrations were low, less than 10 micrograms per cubic metre (µg/m^3) or a small fraction of Environment Canada's 120 µg/m^3 objective for a 24 hour average. Existing air quality is considered good. Ambient concentrations of parameters such as particulates, carbon dioxide, sulphur dioxide, and nitrogen dioxide are normally low.

Annual monitoring of dust deposition is conducted as part of the Aquatic Effects Monitoring Program. Two methods are used to monitor dustfall: snow core surveys and dust collection gauges. In 2008, the overall amounts of deposited dust were greater than predicted by EA modelling (see DDMI 2009a for detailed results). Dustfall averaged 459 milligrams per square decimetre per year (mg/dm^2/yr) in the 25-100 m from the mine footprint zone. Activities are currently underway to remodel dust deposition and add sources that were underestimated in the EA; particularly earthworks construction sources.

3.2 Physical (or Terrestrial) Environment

3.2.1 Overview

The Diavik Mine is located at Lac de Gras, about 300 km northeast of Yellowknife in the NWT (64º 31' North, 110º 20' West) (Figure 2-1). The project site is approximately 100 km north of the treeline, at the headwaters of the Coppermine River. This river, which flows north to the Arctic Ocean east of Kugluktuk, is 520 km long and has a drainage area of roughly 50,800 km^2 (Figure 2-1).

The Lac de Gras area is characteristic of the northwestern Canadian Shield physiographic region, with rolling hills and relief limited to approximately 50 metres (m) in elevation. The terrain in this area has been formed as a result of multiple glaciation periods, the most recent being the Late Wisconsin. The landscape consists of relatively diffuse watersheds with numerous lakes interspersed among boulder fields, eskers and bedrock outcrops. Lac de Gras is within the continuous permafrost zone. Harsh physiographic conditions have resulted in little soil development and low growing vegetation cover.

3.2.1.1 Topography and Relative Relief

The regional study area is part of the Slave Geological Province, which is located in the north-western portion of the Canadian Shield and within the continuous permafrost zone. Major elements of the landscape were shaped in pre-Quaternary times (i.e., before 1.64 million years ago); however, many details of the terrain are products of Quaternary glaciation (Fulton 1989).

The growth and decay of the Laurentide ice sheet of the Wisconsin ice age (about 9,500 years ago), have had the most significant effect on the terrain of this region (Fulton 1989), with eskers, boulder fields, and large exposed bedrock outcrops being major landscape features. The glacial deposits have been and continue to be modified by geomorphological processes, especially those associated with the annual freeze-thaw of the active layer of permafrost. Hence, the present landscape results from the interaction between the bedrock geology of the area, historical glacial activity and current geomorphological processes.

The terrain on East Island is characterized by steep sided bedrock ridges, undulating to strongly rolling slopes consisting of glacial till, ridged eskers and level to depressional glaciolacustrine and organic deposits. The topographical relief is low to moderate, with elevations ranging from 415 metres above sea level (masl) at the shoreline of Lac de Gras to 445 masl inland. Most of the terrain features are controlled by shallow bedrock and boulders are present on all portions of the island.

3.2.1.2 Watershed and Lake Characteristics

The Lac de Gras watershed is located close to the southern boundary of the Low Arctic region, north of the tree line boundary, in the central barren-ground tundra of the NWT (Figure 3-4). It has a drainage area of 3,559 km^2 (Golder 1997a; DDMI 1998a). The landscape of the watershed consists of relatively diffuse water flows and numerous lakes interspersed among boulder fields, eskers, and bedrock outcrops (DDMI 1998b).

Lac de Gras is a large lake with a surface area of 572 km^2, which is about 14% of the total watershed area (Figure 3-4; Golder 1997a). The lake is approximately 60.5 km long and up to 16.5 km wide (DDMI 1998b). Lac de Gras has approximately 470 km of lake shoreline and 267 km of islands shoreline (DDMI 1998b). Lac du Sauvage (120 km^2 surface area) provides the main inflow to Lac de Gras, although small tributary streams also contribute directly. Over 200 small tributary streams, many of which are ephemeral (*i.e.*, flow intermittently, usually during snowmelt), discharge directly into Lac de Gras (see Section 3.2.7 for more details on local hydrology).

In terms of the presence and frequency of wetlands in the watershed, sedge wetland occupies 2% (46 hectare [ha]) of the local study area and 3% (13,406 ha) of the regional study area, as defined in the EA for the Mine (DDMI 1998c). The riparian tall shrub type is the least widely distributed cover class. It occurs in less than 1% of either study area, covering approximately 5 ha within the local study area, and Golder7 ha within the regional study area (DDMI 1998c).

Several rock types, which have different groundwater flow characteristics, are present at the Mine site. Permafrost (*i.e.*, soil or rock that is continuously below 0°C for two or more years) is present within the Mine site (DDMI 1998d). The thickness of permafrost decreases towards Lac de Gras and is absent beneath the lake itself. Permafrost underlies all of the small lakes on the East Island; the permafrost effectively prevents shallow groundwater from flowing from any small lakes into Lac de Gras.

The estimated levels of total dissolved solids (TDS) in the groundwater increase exponentially with depth (DDMI 1998d). The increase in TDS with depth is consistent with data from other mines in the Canadian Shield, including mines in the Yellowknife area. The general groundwater chemistry is typical of water that has a lengthy residence time in association with granitic rock (DDMI 1998d).

In terms of slope in the watershed, the proportion of each terrain type in total basin area was calculated for each basin as part of baseline studies (Golder 1997a). Sloping surfaces were identified as having slopes of more than 7° and were classified according to aspect. Uplands, and lowlands with slopes of less than 7°, were classified separately. Riparian zones were identified from the satellite-based land classification and mapping.

3.2.1.3 Littoral Zone Description

The shoreline of Lac de Gras is rugged and interspersed with numerous bays and inlets. In most areas, shorelines are delineated by a sharp drop-off into deeper waters. This drop-off occurs at varying distances from the water's edge (0 m to 30 m), but most often occurs approximately 3 m to 5 m from the waterline (DDMI 1998a).

In the sheltered bays of Lac de Gras, the shorelines are frequently a mixture of sand and silt. In general, beaches occur infrequently along the shorelines and are usually in association with eskers (DDMI 1998a).

In open water areas of Lac de Gras, the shorelines along the islands are mainly boulder with a variety of secondary substrates including cobble, sand, and silt. Boulder substrates extend away from the shoreline into the open water area, but are abruptly replaced with silt (DDMI 1998a).

Almost no rooted aquatic plants grow along the shoreline and little or no overhanging cover from shoreline vegetation exists as the tundra runs right to the edge of the lake. At the base of inlet streams, dense willows can be found but these are restricted to the wetted width of the stream (DDMI 1998a).

In the 1998 EA, it was predicted that the construction of the Mine would remove, alter, and create sections of shoreline. Construction of the dikes required for mining of the four kimberlite pipes was estimated to physically alter approximately 10.5 km of existing shoreline of Lac de Gras that adjoins the East Island and small offshore islands (DDMI 1998b). It was also predicted that approximately 4.6 km of shoreline of the North Inlet (NI) would be affected by water level fluctuations and altered nutrient regime due in part to Mine discharge to this diked-off area (DDMI 1998b). Dike and dam construction were predicted to create approximately 7.9 km of new rocky shoreline along dikes and dams by the year 2020. Construction of the NI, and A154 and A418 dikes have been completed according to the original plans considered in the EA.

3.2.2 Surficial Geology

Soil development on East Island is restricted to pocketed areas within bedrock and till blankets, and in depressions and rock cervices where organic matter has accumulated. Maximum soil depths are typically less than 0.5 m thick and up to 2.0 m where organic matter has accumulated (Figures 3-5a and 3-5b).

Glacial till is the dominant surficial material on East Island, and overlies most of the bedrock. Glaciofluvial deposits are in the form of eskers and kames, and are most common on the north end of the island. Glaciolacustrine deposits occur mainly in lowland areas, while organic deposits typically overlie glaciolacustrine deposits near the lake shore. Shallow (<1 m) organic deposits typically have large stones exposed at the surface.

All of the soils that have developed on East Island are Cryosols which have been influenced by varying degrees of cryoturbation. There are also numerous solifluction lobes on East Island. These lobes typically occur on slopes ranging from 10% to 25%, although they may occur on slopes as shallow as 2%.

Lakebed sediments are underlain by a layer of organic-rich lake bottom sediments overlying bouldery glacial till. The lake bottom sediments primarily consist of organic silts and clays and vary in thickness from 5 m to 8 m. The underlying till may reach a thickness of between 20 m and 30 m.

3.2.3 Bedrock Geology

The Lac de Gras regional study area is located in the central part of the Slave Geological Province of the Precambrian Shield. This province is 190 000 km^2 and lies in the middle of the NWT, bordered to the south by Great Slave Lake and to the north by the Coronation Gulf (Goodwin 1991) (Figures 3-6 and 3-7). One-third of the Slave Province is underlain by metasedimentary rocks of Archean age (dated at 3.96 billion years old) (EMPR 1995). The remainder is primarily underlain by intrusive igneous rock of granitic composition (2.3 to 2.6 billion years old) (Douglas 1970).

The surface expression of East Island is controlled by bedrock, with bedrock outcropping occurring over about 40% of the surface of the island. The bedrock geology of the island is dominated by granitic rock, with volcanic rocks such as diabase present in small proportions.

The Diavik diamond deposits occur in kimberlite pipes intruding in the granitoid country rock located under Lac de Gras adjacent to East Island. Material within the kimberlite pipes comprises three broad classes: hypabyssal kimberlite, volcanic and epiclastic kimberlite and xenoliths. Volumetrically the kimberlite pipes are dominated by volcaniclastic and epiclastic material, often with a significant xenolithic component. The hypabyssal phases are volumetrically less significant, occurring as feeders to the pipes at deeper levels and as contact intrusions along the pipe margins.

3.2.4 Geological Hazards and Seismicity

The site is situated in a region of low seismicity: Acceleration Related Seismic Zone (Z_a) = 0, Velocity Related Seismic Zone (Z_v) = 1, and Zonal Velocity Ratio (v) = 0.05.

3.2.5 Permafrost Conditions

The Diavik Diamond Mine site is located just north of the diffuse boundary between the widespread discontinuous and continuous permafrost, which generally coincides with the northern extent of trees (Heginbottom 1989; Johnston 1981).

Based on deep thermistor installation measurements, the permafrost has been confirmed to a depth of 150 m in the Lac de Gras area; however temperature projections from these thermistor installations also suggest that the permafrost may extend up to a depth of 240 m. The seasonal active layer in the vicinity of the mine site is about 1.5 m to 2.0 m deep in till deposits, 2.0 m to 3.0 m deep in well-drained granular deposits (eskers) and about 5 m in bedrock. In poorly drained areas including bogs, with thicker vegetation cover, the active layer is less than 1 m in depth.

The depth of the permafrost decreases towards Lac de Gras, and permafrost is absent beneath the lake itself. Other smaller lakes and very small islands in the region may also be underlain by unfrozen materials referred to as “taliks”.

3.2.6 Hydrogeology

In the Arctic, the relatively low amount of precipitation (<400 mm in Lac de Gras area) restricts the amount of water available to recharge aquifers. Permafrost in the Arctic terrain can act to reduce the movement of groundwater. Aquitards may be continuously present in ground that is frozen year-round (Prowse and Ommanney 1990).

Groundwater at the Diavik Diamond Mine site is contained within surface and lakebed sediments, and fractures contained within the country rock and kimberlite pipes. Currently, groundwater at the Diavik project site appears to have essentially no regional groundwater flow. This is likely the result of the combined effects of 1) the presence of Lac de Gras that acts as a boundary for water movement, 2) the low topographic relief, and 3) the presence of permafrost beneath the islands and the mainland.

The hydraulic conductivity of the lakebed sediments is estimated to be approximately 1×10^{-5} metres per second (m/s). The hydraulic conductivity of the competent country rock is estimated to be approximately 5×10^{-8} m/s. Weathered and fractured zones of the country rock are considerably more permeable, with hydraulic conductivities of approximately 1×10^{-5} m/s and 1×10^{-6} m/s, respectively. The kimberlite pipes are more permeable than the competent country rock, with an estimated hydraulic conductivity of 1×10^{-6} m/s.

The hydraulic conductivity of the permafrost zone is very low (essentially zero). The hydraulic conductivity of the surface sediments has not been characterized, but is expected to vary in accordance with local lithology. Groundwater flow occurs in warmer seasons through the thin (0.5 m to 1.5 m thick) active layer near surface, but these flows are considered relatively small.

Groundwater sampled from boreholes and active seeps on the faces of declines in the vicinity of the A154 and A418 pipes in 1996 and 1997 indicated a slightly alkaline (pH near 8), moderate TDS (generally <500 milligrams per litre [mg/L])) Na-Mg-Ca – HCO3-(Cl) water. This general chemistry is consistent with water that has had a long residence time in a granitic terrain. The stable isotope geochemistry indicates that the groundwater recharged under a cold climate. The stable isotope and tritium signatures of ground water are distinct from those of water in Lac de Gras. Metals in the groundwater are low to very low, and radionuclides are very close to detection limits in all samples. There is a general trend of increasing concentration of most major species with depth.

3.2.7 Surface Water Hydrology

3.2.7.1 Inflow, Evaporation, Precipitation and Outflow

The hydrology of Arctic regions is strongly affected by low precipitation and permafrost. Most of the precipitation accumulates during winter as snow, which melts and runs off rapidly in early June. With its large surface area, Lac de Gras provides a large inflow storage and results in fairly steady outflows. Based on the 1998 baseline report (DDMI 1998a), average derived basin inflow to Lac de Gras was about 19 cubic metres per second (m^3/s), and the mean monthly inflows to Lac de Gras ranged from about 3 m^3/s in March to about 57 m^3/s in July. The average lake outflow was estimated to be 20.7 m^3/s. Mean monthly lake outflow peaked in September (29.6 m^3/s) and reached its lowest value in May (14.8 m^3/s) (DDMI 1998a).

Mean annual precipitation onto Lac de Gras was about 373 mm (Golder 1997a). This compares with an estimated mean annual lake evaporation of 275 mm, which mostly occurs from mid-June to mid-October. The mean annual net precipitation (total precipitation minus lake evaporation) on the lake was about 98 mm and represented a direct inflow onto the lake surface at an average rate of about 2 m^3/s (DDMI 1998a).

3.2.7.2 Lake Volume and Flushing Rate

The lake has an estimated volume of 6.7 billion cubic metres (m^3) of water and an estimated lake outflow of 20.7 m^3/s (DDMI 1998a). The flushing rate of Lac de Gras is estimated to be 0.09 times per year (residence time is estimated to be 11.6 years) (DDMI 1998b).

3.2.7.3 Major Inflows and Other Tributary Streams to Lac de Gras

Lac du Sauvage (120 km^2 surface area) provides the main inflow to Lac de Gras through a narrow channel located to the northeast of the lake. Over 200 small tributary streams also discharge directly to Lac de Gras. The majority of these small tributary streams are ephemeral and only flow during snowmelt (Figure 3-8). Small streams fed by small basins without significant lake storage and with drainage areas of less than 1,500 km^2 are likely to have no flows for extended durations in winter (Golder 1997a). Mean monthly inflows to Lac de Gras range from about 3 m^3/s in March to about 57 m^3/s in July. Daily lake inflow exceeds 9 m^3/s about 50% of the time.

On the northwest side of Lac de Gras, water discharges into the Coppermine River and flows north to the Arctic Ocean east of Kugluktuk (DDMI 1998b). The Coppermine River is 520 km long and has a drainage area of 50,800 km^2 (DDMI 1998a).

3.2.7.4 Bathymetry

The average water depth in Lac de Gras is approximately 12 m, and the maximum depth is about 56 m (Golder 1997b). Detailed bathymetry for Lac de Gras is presented in Figures 3-9 and 3-10.

3.2.7.5 Lake Currents

Modelling was conducted in association with the Integrated Baseline and EA to determine the circulation characteristics of Lac de Gras for baseline conditions and over the life of the Mine (DDMI 1998a, 1998b). A two-dimensional flow model (RMA-2) was used to quantify the potential effects of the dikes on lake circulation in areas near the East Island and away from the Mine. Simulated lake circulation patterns for construction, operations, and after closure conditions were compared with existing baseline conditions to quantify potential changes. Aspects of the lake circulation modelling relevant to fish habitat included current and direction.

Three dike configurations, at three snapshots in time, were used to represent the effects of the dikes on lake circulation conditions during construction, operations, and after closure. For each configuration, two modelling approaches were used to simulate lake circulation conditions in Lac de Gras: steady-state and dynamic (Golder 1997b).

Steady-state simulations were conducted to describe the lake circulation conditions under average wind and inflow conditions. For each configuration, nine simulations were carried out:

- eight simulations for the average wind speeds in eight different directions (northwest, north, northeast, east, southeast, south, southwest, west) during the open water season; and,
- one simulation for the ice-covered season.

Dynamic simulations, in daily intervals, were conducted to characterize the varying lake circulation conditions under representative median (1988) and extreme (1982) wind seasons. The period of simulation was the open water season, June 15 to October 15. Two simulations were conducted for each configuration: the median wind season, and the extreme wind season. The dynamic simulation results were analyzed to derive statistics of varying daily lake current velocities and water levels at various locations on the lake. Daily wind, inflow, and outflow series for 1982 and 1988 derived for Lac de Gras were used as input for the dynamic simulations (Golder 1997b).

Results of the baseline modelling indicated that there is a distinct flow circulation pattern around the East Island in summer (DDMI 1998a; Figure 3-11). This circulation is mainly caused by the long wave generation distance west to east across Lac de Gras and the location of the East Island. The circulation can be clockwise or counter-clockwise depending on the wind direction. Current velocities were generally estimated to be higher near the shore in shallower water than those further removed from the shore in deeper water (DDMI 1998a).

Lake circulation in winter is estimated to be relatively small under ice because the ice cover prevents contact between the water and the wind.

No adverse effect on lake circulation patterns was anticipated in the EA either regionally in Lac de Gras or locally near the dikes, resulting from construction of the dikes (DDMI 1998b). The maximum current velocity predicted regionally for Lac de Gras was not sufficient to move silt particles during any phase of the Mine. The maximum current velocity in areas near the dikes during operations was predicted to be sufficient to remove silt particles from fish habitat, but not larger substrate particles. The slight increase in lake currents predicted adjacent to the dikes would potentially be beneficial to fish and fish habitat. For example, removal of silt particles from fish habitat by lake currents assists in maintaining clean (*i.e.,* high quality) spawning shoals (DDMI 1998b).

3.3 Chemical Environment

3.3.1 Soil Chemistry

Soils in the regional study area are of the Cryosolic order. Cryosolic soils are formed in both mineral and organic parent material under the influence of seasonal freeze-thaw cycles and are characterized by disrupted, mixed or broken horizons. Cryosolic soils form where permafrost occurs within 1 to 2 m of the ground surface.

All of the soils that have developed on the East Island are Cryosols, which have been influenced by varying degrees of cryoturbation. There are also numerous solifluction lobes on the East Island. These lobes typically occur on slopes ranging from 10 to 25%, although they may occur on slopes as shallow as 2%.

More detailed mapping of terrain and soils in the local study area was conducted in the summer of 1996 by Golder (1997c). A detailed inventory and classification of the soils and surficial deposits of the East Island were conducted by investigating 47 representative sites. At each site, terrain characteristics were recorded, soil types were classified and photos were taken. Surficial materials were also classified with respect to their potential use for reclamation. Site-specific information was used to aid in airphoto interpretation and subsequent mapping of terrain in the study area at a 1:10 000 scale.

Determining the suitability of the soil materials for reclamation was a key objective of the soils inventory. The information collected will help identify the potential of these soils for reclamation. At each of the 47 inspection sites, soils were characterized by the depth of each horizon, colour, texture, structure, consistence and percent rock content. A reclamation rating was given for texture, consistence and percent rock content. In addition, landscape characteristics such as topography, slope, surface stoniness, drainage and parent material were also recorded. The soil and landscape inventory is described in detail in “Reclamation Materials Inventory and Mapping” (Golder 1997c).

3.3.2 Sediment Quality

3.3.2.1 Baseline Sediment Quality

To provide a description of baseline sediment quality in the local study area (i.e., Lac de Gras), various data sources were used including the following:

- baseline programs initiated by DDMI (the lake sediment quality baseline program conducted in 1996 and 1997 and the dike baseline monitoring program conducted in 2000);
- a survey of exposed sediments in the A154 dike area (EBA 2004a);
- a drilling program completed in March 2004 along the proposed alignment of the A418 dike (EBA 2004b); and,
- a study of lake sediments in the Coppermine River basin completed in summer 2000 (Peramaki and Stone 2005).

These results are summarized below.

Sediment in Deep Areas of Lac de Gras

Sediment in the A154 Dike Area

The dewatering of the A154 pit exposed a large area of lakebed, which previously could only be explored by drilling and sampling from the ice (EBA 2004a). An opportunity existed to gain knowledge from excavations in the drained lakebed. An investigation was carried out between September 3 and 12, 2003. Results of the survey indicated that the matrix component of the glacial tills comprised relatively well-graded fine to coarse sands with 10 to 30% fines. These matrix soils supported varying gravel, cobble, and boulders; they typically showed no evidence of segregation at the bedrock contact. Particle size analyses showed that fines were comprised of very little clay size particulate and that much of the silt was quite coarse. All of the glacial tills observed contained principally subangular clasts.

The till and glaciofluvial units were capped by beach sands or low to non-plastic silts (*i.e.,* silts that slump or deform easily with water). Boulder content was variable in the till (estimated between 10 and 20% by volume) with no trend of higher or lower boulder contents in any particular till unit. Boulders that were 1 m and larger in diameter were relatively few in number, whereas cobbles and small diameter boulders (up to 300 mm diameter) were pervasive.

Sediment Near the A418 Dike Area

Lakebed Sediment

Lakebed sediment was investigated in the area of the A418 dike prior to its construction. The thickness of lakebed sediment varied between 0.2 m and 5.7 m and averaged 2.0 m (EBA 2004b). The sediment was comprised of poorly graded, grey or brown grey silt with a trace of sand to silty sand. Sandy silt was the most typical material. More specifically, particle size analyses indicated that the lakebed sediment was comprised of 76 to 88% silt, 5 to 15% sand, 5 to 7% clay, and 0 to 1% gravel (EBA 2004b). Most of the material recovered during drilling was wet, soft, sensitive, dilative (*i.e.,* expands when wet), and low plastic (*i.e.,* does not take much water to make the material slump or deform without an applied load).

The thicker deposits of lakebed sediment were generally found in the deeper sections of the lake or within depressions of the underlying glaciofluvial or granular till deposit. The organic content of the samples selected for testing ranged between 0.6 and 1.3% by weight. The upper surface of the lakebed sediment was generally comprised of very soft to soft material (EBA 2004b).

Glaciofluvial Sediment

In some areas, the lakebed sediment was underlain by glaciofluvial sediment. The thickness of the glaciofluvial deposit varied between 0.3 and 3.3 m and was comprised mainly of grey to brown grey medium to coarse-grained sand (EBA 2004b). At some locations, the sediment consisted of fine grained sand with a trace of silt and gravel, and coarser stream bed deposits of sub-rounded gravel, sand, and cobble mixes. Overall, the particle size analyses of the glaciofluvial material indicated 49 to 83% sand, 15 to 44% silt, 1 to 6% clay, and 0 to 5% gravel. Organic content was low at 0.3% by weight (EBA 2004b).

Granular Till

Granular till underlays the lakebed sediments and/or glaciofluvial sediments along the proposed A418 Dike alignment (EBA 2004b). The thickness of the granular till material ranged between 0 m and 11.8 m, and averaged 4.5 m. The till typically consisted of a grey to olive-grey sand and silt with varying proportions of subangular gravel, cobbles and boulders, and a trace of clay. At some locations, the till was slightly coarser, silty gravely sand; silty sand and gravel; and in a few locations a sandy silty gravel (EBA 2004b). Results of particle size analyses indicated 26 to 68% sand, 4 to 37% silt, 2 to 6% clay, and 0 to 9% gravel. Generally the sand content of the till increased slightly with depth and the gravel content decreased. No evidence was found during this investigation to distinguish a lower till from an upper till (EBA 2004b).

Bedrock

The bedrock of Lac de Gras near A418 consisted of granite and pegmatite, which had been metamorphosed into a biotite schist at some locations (EBA 2004b). The rock was medium strong to very strong and faintly to slightly weathered. Due to the sonic drilling technique used to obtain the bedrock samples, the extent of the natural bedrock fractures could not be determined. The top of the bedrock was undulating with an elevation of generally between 383 m and 395 m; however, the elevation was close to 408 m at locations near the southern peninsula of the East Island (EBA 2004b).

Surficial Substrate Characteristics

Baseline sediment quality information collected by DDMI was combined with sediment quality information from other programs in Lac de Gras (DDMI 2002). These composite data were then used to establish baseline conditions near the Mine (near-field), in the main body of Lac de Gras (mid-field) and at points farthest away from the Mine within Lac de Gras (far-field). Figure 3-12 presents the sampling sites.

Sediment samples collected from the sediment baseline program in 1996 and 1997 were generally dominated by sand, with sand content varying from 44.6 to 71.3% (Table 3-3). Near-field and mid-field stations were very similar in sand and silt content. Silt was the second most abundant grain size in near-field and mid-field samples, representing 33.4 to 43.3% of the samples (Table 3-3). Far-field stations did not have silt content, but rather clay-silt in a proportion, of 27.5 to Golder.2%. TOC represented 1.1 to 4.0% of the samples content (Table 3-3).

The dike baseline samples were dominated by sand or silt with low levels of clay and TOC (Table 3-4). The majority of the samples were dominated by silt followed by sand. Silt content ranged from 12 to 82%, with a median of 64.5%. Sand content varied from 7 to 86% with a median of 27% (Table 3-4). Samples were composed of 1 to 13% clay and 0.3 to 2.6% TOC (Table 3-4).

Table 3-3: Sediment Characteristics in Lac de Gras, Sampling Stations from the Lake Sediment Quality Baseline Program

Year	Station	Depth (m)	Sand (wt. %)	Silt (wt. %)	Clay (wt. %)	Clay/Silt (wt. %)	TOC (wt. %)
Near-field Area							
1996	N7-1	17.0	56.5	33.5	10.0	-	2.7
	N7-2	15.1	56.6	35.4	7.9	-	3.5
	N7-3	21.6	44.7	43.3	12.0	-	1.1
Mid-field Area							
1996	F14-1	19.2	44.6	33.4	21.9	-	1.8
	F14-2	20.0	46.6	39.4	13.9	-	3.0
	F14-3	22.5	44.6	39.5	15.9	-	2.6
Far-field Area							
1997	WQ14-1	17	71.3	-	-	27.5	4.0
	WQ14-2	17	65.3	-	-	Golder.2	3.1
	WQ14-3	17	71.3	-	-	27.5	3.4

Notes: TOC = total organic carbon; m = metre; wt. % = percent by weight; - = no data available.

Table 3-4: Sediment Characteristics in Lac de Gras, Sampling Stations from the Dike Baseline Program

Transect	Distance from Dike (m)	Sand (wt. %)	Silt (wt. %)	Clay (wt. %)	TOC (mg/kg)
1	25	61	36	3	1.2
	75	38	58	5	2.4
	150	71	27	3	0.5
	450	53	41	6	0.7
	900	7	81	12	2.1
2	25	-	-	-	-
	75	-	-	-	-
	150	26	65	9	2.0
	450	31	63	7	1.5
	900	-	-	-	-
3	25	16	70	13	0.5
	75	-	-	-	-
	150	-	-	-	-
	450	86	12	2	0.4
	900	20	70	11	1.0
4	25	28	61	10	0.9
	75	28	64	7	1.4
	150	9	79	10	2.6
	450	21	71	7	0.4
	900	7	82	11	1.9
5	25	85	14	1	0.3
	75	22	70	8	1.9
	150	18	74	8	2.6
	450	15	76	8	2.6
	900	51	44	5	1.2

Notes: TOC = total organic carbon; m = metre; wt. % = percent by weight; mg/kg = milligram per kilogram; - = no data available;

3.3.2.2 Baseline Sediment Chemistry, 1997-2000

Bottom sediment chemistry in Lac de Gras is typical of sediment chemistry in other lakes in the Slave Geological Province (Puznicki 1996 in DDMI 2001a). The metals concentrations were generally similar among near-, mid- and far-fields (Table 3-5).

Table 3-5 Baseline Statistical Summary for Sediment Chemistry, Far-Field, Mid-Field and Near-Field of Lac de Gras, 1997-2000

Analyte	Units	Statistic	Far-field	Mid-field	Near-field
Aluminum	mg/kg	Median	13400	13900	14600
		75 Percentile	16600	16850	16425
		25 Percentile	12250	11800	12400
		N	11	18	42
Arsenic	mg/kg	Median	19.5	Golder.5	49.8
		75 Percentile	26.55	71.58	140.5
		25 Percentile	14.7	16.6	17.15
		N	11	18	42
Cadmium	mg/kg	Median	0.3	0.17	0.1
		75 Percentile	0.47	0.23	0.18
		25 Percentile	0.17	0.09	0.1
		N	11	18	42
Chromium	mg/kg	Median	55.7	61.5	53.4
		75 Percentile	89.5	75.9	58.73
		25 Percentile	45.95	52.8	46.8
		N	11	18	42
Copper	mg/kg	Median	45.1	43.9	42.05
		75 Percentile	64.9	52.55	48.43
		25 Percentile	33.35	36.7	28.85
		N	11	18	42
Lead	mg/kg	Median	3.42	4.23	4.29
		75 Percentile	6.58	6.78	5.28
		25 Percentile	2.71	4.03	3.65
		N	11	18	42
Nickel	mg/kg	Median	56.4	26.7	33.15
		75 Percentile	73.8	59.95	42.38
		25 Percentile	52.55	19.9	22.13
		N	11	18	42
Zinc	mg/kg	Median	74.6	73.35	68
		75 Percentile	82	81.3	73.48
		25 Percentile	69.55	64.8	56.35
		N	11	18	42
Total Phosphorus	mg/kg	Median	833	1095	900
		75 Percentile	947.5	1187.5	1375
		25 Percentile	615	763	597.5
		N	11	18	12

Analyte	Units	Statistic	Far-field	Mid-field	Near-field
TKN Total Kjeldahl Nitrogen	mg/kg	Median	-	1363	758.9
		75 Percentile	-	1615	931
		25 Percentile	-	1175	358.9
		N	0	9	9
Total Organic Carbon	%	Median	1.68	1.76	1.31
		75 Percentile	3.27	2.01	2.33
		25 Percentile	1.6	1.38	0.85
		N	11	18	36

Source: DDMI 2001a.

Notes: mg/kg = milligrams per kilogram;

% = percent; N = sample size; - = not collected.

Based on data from 1997 and 2000, arsenic concentrations were higher in the near-field (median = 49.8 mg/kg) compared to the far-field (median = 19.5 mg/kg) (Table 3-5). Cadmium concentrations were lower in the near-field and mid-field (medians = 0.10 mg/kg and 0.17 mg/kg, respectively) than in the far-field (0.30 mg/kg). Nickel concentrations were higher in the far-field (median = 56.4 mg/kg) than in the near- and mid-field (medians of 33.15 mg/kg and 26.7 mg/kg, respectively). TKN increased from the near-field (758.9 mg/kg) to the mid-field (1363 mg/kg) (Table 3-5).

Lac de Gras Study, 2000

Peramaki and Stone (2005) suggested that lake sediment represents a good indicator of the state for the Coppermine basin and documents historic trends of metal deposition. However, the indicator has low sensitivity to change and coarse temporal resolution due to low sedimentation rates in northern environments (Peramaki and Stone 2005). Arsenic and copper in sediments were slightly higher at Lac de Gras, with mean concentrations of 264.9 mg/kg and 105.3 mg/kg, respectively (Peramaki and Stone 2005). Arsenic concentrations increased in the 5 centimetre (cm) zone (Figure 3-13). Lead and copper were elevated compared to historic background levels, suggesting long-range atmospheric deposition (Peramaki and Stone 2005).

3.3.2.3 Current Sediment Chemistry

Data on sediment chemistry and quality (defined as particle size distribution and TOC) for Lac de Gras are gathered annually as supporting environmental information for the analysis of the benthic invertebrate community. Post-baseline monitoring of sediment quality commenced in 2001 and has continued annually since then. Sediment chemistry results from 2001 to 2006 are detailed below, while 2007 to 2009 results are described in detail in the annual Aquatic Effects Monitoring Program (AEMP) reports (Golder 2008; 2009a).

Sediment characteristics are described by ten analytes plus TOC and percent silt. Tables 3-6 to 3-8 provide the results for the near-field, mid-field, and far-field areas, respectively, from 2001 to 2006 (DDMI 2005). The data in these tables show that trace metals concentrations tend to be higher in the far-field relative to either the mid- or near-field (which are similar to each other in trace-metals concentrations). On average (from 2001 to 2006), the far-field median trace-metal concentration exceeded that of the mid- and near-field (averaged together for comparison purposes) by a factor ranging from 1.5 to 3.1 for arsenic, cadmium, copper, nickel, and zinc. Phosphorus and TKN were also higher in the far-field (1.5 and 2.3 times higher, respectively) relative to the mid- and near-field.

The overall trend toward higher trace metal concentrations in the far-field sediments is likely due to a combination of factors. First, the organic matter content was, on average, 2.6 times higher in the far-field. It is well known that organic matter can adsorb/accumulate trace metals (*e.g.*, Sholkovitz and Copland, 1981; Christl et al., 2001). The higher sediment TOC content may account for the higher associated trace-metals concentrations. Second, the differences in trace-metal concentrations may be due to the finer particle size distribution of the far-field sediments (DDMI 2007a). Fine sediment particles have more surface area relative to coarse, sandy sediments. This facilitates greater direct trace-metal adsorption as well as the accumulation of surface coatings (*e.g.*, organic matter, iron and manganese oxides/oxyhydroxides), which can adsorb trace-metals (see review by Horowitz 1991). The higher organic matter content of the far-field sediments may also be the source of the associated elevated phosphorus and nitrogen concentrations.

Table 3-6 Sediment Chemistry in Lac de Gras (Near-Field), 2001 to 2006

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Aluminum (mg/kg)	Median	20000	15500	16300	13300	15400	15200
	75 Percentile	20350	15650	16350	13450	15450	15750
	25 Percentile	20000	15400	15900	1Golder50	15200	14450
Total Arsenic (mg/kg)	Median	21.60	25.00	24.40	47.50	101.00	31.40
	75 Percentile	22.55	28.95	69.70	63.95	129.50	Golder.05
	25 Percentile	21.15	24.80	24.05	36.55	73.95	30.35
Total Cadmium (mg/kg)	Median	0.10	0.30	0.20	0.20	0.20	0.30
	75 Percentile	0.15	0.35	0.25	0.25	0.20	0.30
	25 Percentile	0.10	0.30	0.15	0.20	0.20	0.25
Total Chromium (mg/kg)	Median	63.30	58.90	60.50	40.40	47.80	52.90
	75 Percentile	66.75	59.45	63.10	41.70	48.15	53.15
	25 Percentile	62.25	58.65	58.45	40.30	47.05	49.30
Total Copper (mg/kg)	Median	49.90	47.00	46.20	37.70	38.50	38.60
	75 Percentile	51.90	48.00	47.05	38.85	38.75	38.85
	25 Percentile	49.40	47.00	46.15	37.05	38.20	35.25
Total Lead (mg/kg)	Median	4.90	9.20	8.20	10.00	9.40	12.30
	75 Percentile	5.15	9.60	8.65	10.75	10.00	12.65
	25 Percentile	4.85	9.15	7.85	9.65	9.30	11.05
Total Nickel (mg/kg)	Median	37.50	56.20	42.60	47.00	49.70	54.30
	75 Percentile	39.85	58.95	45.70	47.80	50.60	54.60
	25 Percentile	37.00	55.00	39.70	46.50	46.75	51.90

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Zinc (mg/kg)	Median	77.40	86.00	84.00	80.00	75.00	74.00
	75 Percentile	79.90	88.00	83.50	80.00	75.50	75.50
	25 Percentile	77.05	86.00	84.50	79.50	74.00	72.00
Total Phosphorus (mg/kg)	Median	1100	1075	1050	980	1120	1080
	75 Percentile	1100	1075	1060	980	1170	1095
	25 Percentile	1100	1075	1050	980	1030	1065
Total Kjeldahl Nitrogen (mg/kg)	Median	2500	2200	1700	2500	2100	2400
	75 Percentile	2600	2300	1400	2550	2150	2450
	25 Percentile	2450	2150	1700	2400	2000	2300
Total Organic Carbon (% Weight)	Median	3.80	2.60	1.60	3.00	2.30	2.70
	75 Percentile	4.05	2.60	1.65	3.05	2.35	2.70
	25 Percentile	3.05	2.55	1.50	2.85	2.25	2.60
Silt (%)	Median	83	82	78	82	84	78.00
	75 Percentile	84	82	77	83	85.5	80.00
	25 Percentile	38	82	78	81	83	78.00

Source: DDMI 2005 and unpublished data.

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.

Calculations were made based on three sub-samples that were submitted for analysis.

Table 3-7 Sediment Chemistry in Lac de Gras (Mid-Field), 2001 to 2006

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Aluminum (mg/kg)	Median	21600	18200	16800	19500	18200	19300
	75 Percentile	21750	18300	16900	19600	18700	19400
	25 Percentile	19500	17750	16700	18850	18150	18700
Total Arsenic (mg/kg)	Median	60.10	21.80	21.60	23.20	152	22.30
	75 Percentile	60.75	22.20	21.65	Golder.50	206.5	25.55
	25 Percentile	41.50	21.30	21.35	23.15	90	21.95
Total Cadmium (mg/kg)	Median	0.10	0.10	0.10	0.10	0.2	0.10
	75 Percentile	0.15	0.15	0.15	0.15	0.2	0.20
	25 Percentile	0.10	0.10	0.10	0.10	0.2	0.10
Total Chromium (mg/kg)	Median	62.90	68.60	61.80	58.70	59.3	68.30
	75 Percentile	63.65	69.40	65.80	60.10	60.3	68.75
	25 Percentile	62.25	67.15	61.45	57.10	59	65.65
Total Copper (mg/kg)	Median	47.50	51.00	47.20	50.20	47.6	46.50
	75 Percentile	49.45	51.00	47.25	50.70	48.95	47.00
	25 Percentile	47.30	49.50	46.15	48.80	46.85	46.35

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Lead (mg/kg)	Median	5.40	5.90	5.80	6.00	5.9	6.10
	75 Percentile	5.45	7.45	6.00	6.05	6	6.10
	25 Percentile	5.40	5.90	5.75	5.70	5.75	5.95
Total Nickel (mg/kg)	Median	42.50	43.70	37.50	39.10	45.2	39.20
	75 Percentile	42.90	47.40	40.00	40.55	45.25	45.10
	25 Percentile	41.75	42.80	36.70	38.30	43.65	39.10
Total Zinc (mg/kg)	Median	79.00	88.00	78.00	79.00	76	71.00
	75 Percentile	80.55	101.50	77.50	80.50	76.5	74.50
	25 Percentile	78.05	84.00	79.00	78.50	75.5	70.50
Total Phosphorus (mg/kg)	Median	1100	1100	1140	1030	1390	1170
	75 Percentile	1150	1138	1150	1085	1645	1175
	25 Percentile	1110	1100	1135	990	1335	1100
Total Kjeldahl Nitrogen (mg/kg)	Median	2600	1800	2100	2300	1900	2200
	75 Percentile	2800	1900	2050	2400	2000	2300
	25 Percentile	2550	1650	2250	2250	1800	2150
Total Organic Carbon (% Weight)	Median	2.50	2.20	2.00	2.80	2.20	2.10
	75 Percentile	2.55	2.30	2.15	2.90	2.30	2.20
	25 Percentile	2.45	2.00	1.95	2.80	2.10	2.10
Silt (%)	Median	81	85	81	85	81	83.00
	75 Percentile	82	86	77	86	83	84.00
	25 Percentile	81	85	82	83	79.50	81.50

Source: DDMI 2005 and unpublished data.

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.

Calculations were made based on three sub-samples that were submitted for analysis.

Table 3-8 Sediment Chemistry in Lac de Gras (Far-Field), 2001 to 2006

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Aluminum (mg/kg)	Median	21000	14700	13700	19300	19500	18300
	75 Percentile	22500	14850	14250	19700	19550	19600
	25 Percentile	19500	14550	13600	19200	17800	16100
Total Arsenic (mg/kg)	Median	15.80	36.00	36.90	109.00	172	166.00
	75 Percentile	16.90	36.20	43.55	121.50	173.5	187.50
	25 Percentile	15.55	30.65	33.90	96.25	159	119.45
Total Cadmium (mg/kg)	Median	0.40	0.50	0.40	0.50	0.5	0.50
	75 Percentile	0.40	0.50	0.40	0.55	0.5	0.55
	25 Percentile	0.35	0.50	0.40	0.50	0.45	0.45

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
Total Chromium (mg/kg)	Median	54.80	55.10	50.60	59.30	55.9	60.70
	75 Percentile	56.95	55.65	55.90	59.45	55.95	64.05
	25 Percentile	52.80	54.60	49.55	58.90	51.45	53.05
Total Copper (mg/kg)	Median	90.60	91.00	71.50	110.00	108	103.00
	75 Percentile	91.25	92.50	78.40	111.50	110	108.00
	25 Percentile	87.55	90.00	71.35	108.50	99.45	90.60
Total Lead (mg/kg)	Median	4.30	7.40	8.40	8.80	7.1	6.70
	75 Percentile	4.40	7.95	8.65	9.10	7.4	7.45
	25 Percentile	4.10	7.00	8.20	8.65	6.65	6.45
Total Nickel (mg/kg)	Median	63.10	81.20	79.10	94.60	90.7	94.70
	75 Percentile	63.90	87.10	81.45	98.80	96.85	100.35
	25 Percentile	61.20	80.25	72.80	92.90	90.55	83.00
Total Zinc (mg/kg)	Median	102.00	125.00	102.00	129.00	117	114.00
	75 Percentile	102.50	134.00	101.00	135.50	126.5	124.00
	25 Percentile	98.35	124.00	107.00	128.50	112	102.00
Total Phosphorus (mg/kg)	Median	1400	1300	1340	2060	2070	2030
	75 Percentile	1450	1313	1350	2120	2145	2050
	25 Percentile	1400	1290	1340	2005	2040	1955
Total Kjeldahl Nitrogen (mg/kg)	Median	4700	4400	5200	6500	4800	5100
	75 Percentile	4750	4650	4900	6600	4900	5150
	25 Percentile	4550	3700	5550	6150	4650	49503
Total Organic Carbon (% Weight)	Median	6.40	7.00	6.70	7.60	5.2	5.90
	75 Percentile	6.60	7.00	6.70	7.70	6	6.15
	25 Percentile	6.10	6.50	6.70	7.30	5.05	5.65
Silt (%)	Median	69	65	63	64	76	78.00
	75 Percentile	71	65	62	66	79.5	78.00
	25 Percentile	69	61	68	62	75.5	75.00

Source: DDMI 2005 and unpublished data.

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.

Calculations were made based on three sub-samples that were submitted for analysis.

3.3.3 Surface Water Quality

3.3.3.1 Baseline Water Quality

Baseline field programs designed to measure water quality in Lac de Gras were conducted annually between 1994 and 2000. Approximately fifty station locations were tested, with most being located in the area immediately surrounding the East Island (Figure 3-14). Water samples were collected during the two primary aquatic seasons: ice-covered (typically April/May) and open water (typically August/September).

Water samples were collected at mid-depth or as depth-integrated samples (0 m to 10 m) and submitted to accredited laboratories for analyses, which included:

- general parameters (conductivity, pH, total alkalinity, total organic carbon [TOC], total suspended solids [TSS]);
- major ions (calcium, chloride, magnesium, potassium, sodium, sulphate);
- nutrients (ammonia, nitrate-nitrite, Total Kjeldahl Nitrogen, total phosphorus); and,
- total metals – multi-element ICP-MS Scan.

A history of water quality programs conducted from 1994 to 2000 is listed in Table 3-9. Figure 3-13 shows locations of baseline water quality stations within Lac de Gras.

Table 3-9 Chronology of Baseline Water Quality Monitoring

Year	Stations	Reference
1994	LDG1 to LDG9	Acres and Bryant (1995, 1996)
1995	LDG1 to LDG25	Acres and Bryant (1995, 1996)
1996	WQ01 to WQ14	Golder (1997d, 1997e, 1997f)
1997	WQ01 to WQ14	Golder (1998a)
1998	WQ01 to WQ14	DDMI unpublished data
1999	WQ01 to WQ14	DDMI unpublished data
2000	LDG40 to LDG48	DDMI unpublished data

DDMI = Diavik Diamond Mines Inc.

Characterization of Baseline Water Quality in Lac de Gras

A detailed summary of baseline water quality (i.e., up to year 2000) at various stations in Lac de Gras are presented in the AEMP Design Document (DDMI 2007a); results are also detailed in DDMI 1998a.

The water quality of Lac de Gras is typical of many Arctic lakes. Baseline water quality data in Lac de Gras were characterized by very low levels/concentrations of conductivity, hardness, TSS, and major ions. In 2000, the lake was mildly acidic, with a pH range of 6.3 to 6.8. Many of the metals were near or below detection limits with the exception of aluminum, which was thought to be naturally occurring at levels above the detection limits (DDMI 1998b). Lac de Gras was classified as an ultra-oligotrophic lake in the EA because of its low phosphorus concentrations, low primary productivity, and very high water clarity (DDMI 1998b).

Lac de Gras in a Regional Context

To provide a regional context for water quality in Lac de Gras, this section compares analyte concentrations in Lac de Gras water to those in various lakes near to Lac de Gras and in the Arctic region. The comparisons were completed at three different levels:

Water quality data were compared between Lac de Gras and Lac du Sauvage for winter, summer, and fall 1996. Lac de Gras data were obtained from the intensive study area as defined in the 1998 EA (DDMI 1998a). Data for Lac du Sauvage came from the baseline program for the Mine.

Water quality data for Lac de Gras in 1995 and 1996 were compared to data in lakes sampled by BHPB and four additional lakes, including Courageous Lake, Matthews Lake, Contwoyto Lake, and Unnamed Lake (collectively referred to as the nearby lakes). Water quality results for the BHPB sites came from the aquatic monitoring program for the Ekati Mine (BHP Diamonds Inc. 1995). No information was available on the methods or the detection limits used for the BHPB sites. The sites were sampled in 1994 and were compared to baseline Lac de Gras data from 1996 (DDMI 1998a). The nearby lakes were studied by Environment Canada prior to 1978. No information was available on the methods, detection limits, and time of sampling. Water quality data for the nearby lakes were compared to 1995 and 1996 baseline data (DDMI 1998a).

Water quality data from Lac de Gras in 2000 were compared to data from various lakes sampled in the Arctic region between 1982 and 2000. The water quality data for this comparison were extracted from government reports and various scientific journals. Data collected from scientific journals included information on methods and sampling periods. Limited information was available on detection limits. Although lakes were sampled between 1982 and 1991, detection levels seemed similar or lower than detection limits from baseline data in 1995-96. Data from scientific journals were compared to 1996 and 2000 baseline data.

Sampling years with similar detection limit values were compared when possible.

Lac de Gras and Lac du Sauvage

Water samples were collected from Lac de Gras and Lac du Sauvage as part of the baseline program for the Mine (Figure 3-13). Information on methods can be found in the original baseline (DDMI 1998).

In 1995 and 1996, general parameters measured at the various sample sites in Lac de Gras and Lac du Sauvage did not vary substantially either between sites or between the two years. Parameters were low, although some parameters such as conductivity and TSS were slightly higher during winter. Conductivity in Lac de Gras and Lac du Sauvage were similar and varied from 11.5 micro Siemens per centimetre (μS/cm) to 17.8 μS/cm. Median pH measurements at the various sites in Lac de Gras and Lac du Sauvage were similar in 1996, ranging from 6.03 to 6.16.

In 1996, major ions concentrations were similar between Lac de Gras and Lac du Sauvage. Concentrations of calcium, magnesium, sodium and potassium were generally higher in winter samples compared with samples from other seasons. Higher winter levels associated with these ions were likely a reflection of freeze out, also known as cryoconcentration (Welch and Legault 1986).

Nutrient concentrations measured in 1996 were also low in both lakes. Nitrite-nitrate concentrations were above detection limits only during winter. Lac du Sauvage (0.047 mg/L) had a higher median concentration than Lac de Gras (0.026 mg/L). Nitrite and nitrate were only analyzed separately for the winter samples. Sites in Lac de Gras with higher median nitrate concentrations included WQ3 (0.058 mg/L) and WQ13 (0.064 mg/L), which are located between the East and West Islands. Total Kjeldahl nitrogen concentrations in Lac du Sauvage (0.09 mg/L to 0.40 mg/L) were also in the upper range of the concentrations found in the sites of Lac de Gras (0.06 mg/L to 0.29 mg/L).

In 1996, total phosphorus and orthophosphate concentrations in Lac de Gras and Lac du Sauvage were below the detection limit of 0.003 mg/L. The low concentrations of total phosphorus in Lac de Gras are consistent with the lake's ultra-oligotrophic status. The range of total phosphorus in oligotrophic lakes, *i.e.,* lakes that have low nutrient inputs with low organic production, is typically 0.003 mg/L to 0.018 mg/L (Wetzel 2001).

In both Lac de Gras and Lac du Sauvage, metal concentrations were similar and low. Aluminum, arsenic, barium, chromium, copper, lithium, manganese, nickel, silicon, strontium, sulphur, and zinc were the predominant metals (*i.e.,* metals consistently found in concentrations greater than the detection limit) at sites in Lac de Gras in 1996. Metals predominant in the waters of Lac du Sauvage in 1996 included aluminum, barium, copper, lithium, manganese, nickel, silicon, strontium, sulphur, and zinc. With the exception of arsenic and chromium, all metals identified as predominant in Lac du Sauvage in 1996 were also listed as predominant in Lac de Gras in 1996. No strong trends relating to season were found in the 1996 data for metals in either Lac de Gras or Lac du Sauvage.

Nearby Lakes and BHPB Sites

Water from a number of lakes close to Lac de Gras was studied in 1975 and 1976 by Moore (1978a, 1978b). The studied lakes were Courageous Lake, Matthews Lake, Unnamed Lake, Contwoyto Lake, and nine other lakes around Contwoyto Lake.

Courageous Lake, Unnamed Lake and Matthews Lake are three lakes less than 100 km southwest of Lac de Gras (Figure 3-15). They are all smaller than Lac de Gras in size. Courageous Lake is 40 km long and up to 7 km wide (Moore 1978a), compared to Lac de Gras, which is approximately 60.5 km long and 16.5 km wide. Unnamed Lake is 3 km long with a maximum width of 0.8 km. Matthew Lake measures 8 km long by 2 km wide. No information on depth of the lakes was available (Moore 1978a). Water quality samples were collected in these lakes in July, August, and September of 1976 (Moore 1978a). Other lakes in the Lac de Gras area were sampled in association with the Ekati Mine as part of their aquatic monitoring program (BHP Diamonds Inc. 1995). Sites were located approximately 30 km north of the Mine (Figure 3-15).

Contwoyto Lake is approximately 100 km northeast of Lac de Gras (Figure 3-16). The lake has a surface area of approximately 950 km^2 (Moore 1978b), which is greater than Lac de Gras (572 km^2). Nine lakes surrounding Contwoyto Lake were also included in the study. Surface areas of these lakes varied from 0.05 km^2 to 10.4 km^2. Contwoyto Lake has a maximum depth of 30 m, while the maximum depth for the other nine lakes ranges from 2 m to 10 m (Moore 1978b). Water samples were collected from the ten lakes (referred to as the Contwoyto Lake system) in July 1975 (Moore 1978b).

Overall, levels of general parameters in Lac de Gras corresponded to levels measured in the nearby lakes and BHPB sites. Levels of conductivity measured in Courageous Lake (10 μS/cm to 12 μS/cm), and Matthews Lake and Unnamed Lake (both 18 μS/cm to 20 μS/cm) were similar to levels measured in Lac de Gras (7.9 μS/cm to 12.3 μS/cm). Conductivity in the Contwoyto Lake system (5.8 μS/cm) was lower than Lac de Gras. The average conductivity at the Ekati Mine sites ranged from 8 μS/cm to 17 μS/cm (BHP Diamonds Inc. 1995).

Hardness varied from 4.3 mg/L to 5.6 mg/L in Lac de Gras whereas Contwoyto Lake and Courageous Lake had hardness values below 5.0 mg/L. Matthew Lake and Unnamed Lake had the highest hardness values at 13.6 mg/L and 9.6 mg/L respectively.

Median pH values in Lac de Gras varied from 6.55 to 6.60 in 1995 and 6.06 to 6.16 in 1996. Similar values for pH were found in various lakes sampled at the Ekati Mine site, ranging from 6.3 to 6.7, which is characteristic of waters flowing over the Precambrian Shield of the Lac de Gras area (BHP Diamonds Inc. 1995).

Total alkalinity was the lowest in Contwoyto Lake (<1 mg/L) and highest in Lac de Gras (5.2 mg/L to 6.6 mg/L in 1995). Turbidity values were similar among all the lakes and equal or below 2.2 NTU.

Concentrations of nitrate/nitrite in the nearby lakes (except Contwoyto Lake) were less than or equal to 0.01 mg/L (Moore 1978a). These values were within the range found in Lac de Gras in 1996 (<0.003 mg/L to 0.028 mg/L). The average concentrations of nitrogen compounds for the various lakes at the Ekati Mine site were similar to the concentrations found in the intensive area of Lac de Gras (Table 2.5-6) (BHP Diamonds Inc. 1995). The concentrations of total phosphorous for the various lakes at the Ekati Mine site (0.0049 mg/L to 0.0127 mg/L) were on the upper range or greater than concentrations in Lac de Gras (<0.003 mg/L to 0.007 mg/L in 1995, <0.003 mg/L in 1996).

Dissolved metals concentrations were usually below or close to detection limits in Lac de Gras and the nearby lakes. A few exceptions included arsenic (0.009 mg/L) and zinc (0.1 mg/L) in Matthews Lake; and zinc in Lac de Gras 1996 (0.0044 mg/L), Courageous Lake (0.016 mg/L) and Unnamed Lake (0.022 mg/L).

Table 2.5-6 Median Concentrations of Water Quality Parameters in Lac de Gras (1995-1996), Nearby Lakes (1975-1976), and BHPB Sites (1994)

Analyte Name	Units	Lac de Gras 1995[a]	Lac de Gras 1996[a]	BHPB Sites	Courageous Lake	Matthews Lake	Contwoyto Lake[b]	Unnamed Lake[c]
General Parameters								
Electrical Conductivity, Lab	µS/cm	7.9 - 12.3	11.7 - 12.1	8-17	10-12	18 – 20	5.8	18-20
Hardness	mg/L	-	4.3 - 5.6	-	4.2	13.6	<5.0	9.6
pH of Water, Lab	pH	6.55-6.63	6.06-6.16	6.3-6.7	-	-	-	-
Total Alkalinity	mg/L	5.2 - 6.6	4.8 - 5.9	-	3.7	6.2	<1	3.7
Turbidity	NTU	-	0.1 - 0.7	-	2	2.2	1.5	1.7
Nutrients								
Ammonia as nitrogen, total	mg/L	<0.01	<0.01 -0.05	0.006-0.02	-	-	-	-
Nitrite-N	mg/L	<0.2	<0.003 - 0.004	0.0017-0.0023	-	-	-	-
Nitrate-N	mg/L	<0.003	0.014 - 0.064	0.0053-0.1740	-	-	-	-
Nitrite+Nitrate Nitrogen	mg/L	-	<0.003 - 0.028	-	<0.01	0.01	-	<0.01
Total Phosphorus	mg/L	<0.003-0.007	<0.003	0.0049-0.0127	-	-	<0.005-0.010	-
Dissolved Metals								
Arsenic	mg/L	-	0.0002	-	<0.0005	0.009	-	0.0006
Cadmium	mg/L	-	<0.0002	-	<0.001	<0.001	-	<0.001
Cobalt	mg/L	-	0.0003	-	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	-	0.001	-	<0.001	0.002	<0.002	0.004
Iron	mg/L	-	<0.005	-	<0.005	<0.005	<0.05	0.010
Lead	mg/L	-	<0.0002	-	<0.005	<0.005	<0.005	<0.005
Manganese	mg/L	-	0.0014	-	<0.01	<0.01	<0.01	<0.01
Nickel	mg/L	-	0.0009	-	<0.005	<0.005	<0.005	<0.005
Zinc	mg/L	-	0.0044	-	0.016	0.1	<0.001	0.022

Source: DDMI 1998a Integrated Environmental and Socio-Economic Baseline Report.

Notes: mg/L = milligrams per litre; NTU = nephelometric turbidity unit; µS/cm = micro Siemens per centimetre; < = less than; - = Sample was not collected or analyzed during that period.

a = Ranges were based on the median concentrations calculated for the Lac de Gras intensive area sites as defined in the 1998 EA (1995 = LDG1 to LDG8, LDG10 to LDG19, LDG 21 to LDG25; 1996 = WQ2 to WQ9, WQ13) (See Figure D6-2). Median concentrations at each site were based on concentrations measured during the winter, summer and fall seasons of either 1995 or 1996.

b = Concentrations at Contwoyto Lake are arithmetic means that take into account concentrations of parameters in Contwoyto Lake as well as concentrations in nine smaller lakes immediately next to Contwoyto Lake.

c = Values represent means not medians.

Arctic Lakes

Lac de Gras data collected in 1996 and 2000 were compared to water quality data published in the scientific literature (Pienitz et al. 1997a, 1997b; Ruhland et al. 2003; Shortreed and Stockner 1986). Data from the scientific literature were collected between June and September 1982 (Shortreed and Stockner 1986), in July 1990 (Pienitz et al. 1997b), in July 1991 (Pienitz et al. 1997a), and in August 1996 (Ruhland et al. 2003).

Pienitz et al. (1997a) studied 24 lakes in the Yellowknife area. The lakes are located in the Slave Geologic province, to which Lac de Gras belongs. Ruhland et al. (2003) sampled 56 lakes in the same area. The two other datasets (*i.e.,* as presented in Pienitz et al. 1997b; Shortreed and Stockner 1986) came from studies completed in the Yukon and in the NWT close to Inuvik (referred as the Yukon 1982-83 and Yukon-NWT 1990). Although these lakes are located outside of the Slave Geologic province, water quality data from these lakes were compared to Lac de Gras.

The vegetation cover for the various lakes investigated in the scientific literature included boreal forest, forest-tundra, Arctic tundra and alpine tundra. When possible, data from lakes located in the arctic tundra vegetation zone were isolated to minimize the effect of vegetation cover on water quality.

Concentrations of nitrogen parameters (*e.g.,* nitrite, nitrate, total Kjeldahl nitrogen [TKN]) and silicone (reactive) were available from some studies (Pienitz et al. 1997a, 1997b; Shortreed and Stockner 1986). However, the concentrations were determined from filtered samples and consequently could not be compared to the Lac de Gras results.

Surface areas and depths of Lac de Gras and the lakes utilized in the comparison are presented in Table 3-10. The lakes were smaller than Lac de Gras and were usually shallower (Table 3-10).

Table 3-10 Arctic Lakes Surface Area in Maximum Depth

	Surface Area (km^2)	Maximum Depth (m)
Lac de Gras	572	56
Yellowknife 1991	0.53 - 5.02	2.5 - 25
NWT-Nunavut 1996	0.009 - 0.366	0.5 -19.0
Yukon 1982	1.6 - 90	2.5 – 93[a]
Yukon & NWT 1990	0.011 - 12.62	1.2 - 49

Note: km^2 = square kilometres; m = metres.
a = Mean depths.

The water quality of Lac de Gras was similar to other lakes in the Arctic region with very low levels/concentrations of conductivity and major ions. Median conductivity in Lac de Gras was 11.5 µS/cm and 13.45 µS/cm in 1996 and 2000, respectively. Similar levels were measured in lakes from the Yellowknife area and the NWT-Nunavut area, where median conductivity in lakes located in the Arctic tundra was 8 µS/cm and 10.8 µS/cm respectively (Pienitz et al. 1997a; Ruhland et al. 2003). Lakes sampled in 1990 in the Yukon-NWT area had higher median conductivity (128.5 µS/cm; Pienitz et al. 1997b). However, conductivity was strongly influenced by proximity to the oceans. Lakes sampled from the Arctic tundra in 1990 were very close to the ocean compared to Lac de Gras (Pienitz et al. 1997b).

Lac de Gras was mildly acidic, with medians of pH of 6.05 and 6.6. In general, Arctic lakes had a high variability in pH values, ranging from 5.9 to 9.3 (Pienitz et al. 1997a, 1997b; Shortreed and Stockner 1986; Ruhland et al. 2003). When the data from the Yellowknife, NWT-Nunavut, and the Yukon-NWT areas were limited to lakes in the same vegetation cover as Lac de Gras, pH values were still variable and median values were slightly higher.

Major ions concentrations were very low in Lac de Gras and in lakes sampled within the Yellowknife and NWT-Nunavut area. Lakes from these areas had low median concentrations of calcium, potassium, chloride, and sodium, with levels all below 1 mg/L (Pienitz et al. 1997a; Ruhland et al. 2003). Sulphate concentrations were similar in Lac de Gras and in the Yellowknife area, with median concentrations of 1 mg/L and 0.9 mg/L respectively. All major ion concentrations measured in the Yukon and NWT area were higher than the ones recorded in Lac de Gras, Yellowknife or NWT-Nunavut areas (Pienitz et al. 1997b). Chloride and sodium concentrations were strongly related to proximity to the ocean (Pienitz et al. 1997b). Increase of other major ions can be related to differences in geological and edaphic conditions (Pienitz et al. 1997b).

TKN concentrations were the lowest in Lac de Gras (0.08 mg/L both years) and slightly higher in lakes from the Yellowknife and NWT-Nunavut areas (0.123 mg/L in 1991 and 0.1455 mg/L in 1996). In comparison, the median TKN concentration in the Yukon and NWT area was 3.95 mg/L.

Concentrations of total phosphorus were low in all the lakes sampled. Median concentrations varied from <0.003 mg/L in Lac de Gras to 0.012 mg/L in the Yukon and NWT area. According to Pienitz et al. (1997b), the higher total phosphorus concentrations in lakes sampled from the Yukon-NWT area in 1990 could be related to particular geological and edaphic conditions (*i.e.,* soil development). All lakes sampled in the Yellowknife, NWT-Nunavut and Yukon 1982-83 areas were considerate oligotrophic.

Median concentrations for aluminum and barium were similar between Lac de Gras and lakes in the Yellowknife area. Median concentrations of total ion in Lac de Gras (<0.01 mg/L to 0.019 mg/L) were below the median concentration in the Yellowknife area (0.0272 mg/L) and an order of magnitude below the median concentration in the Yukon-NWT area (0.101 mg/L). Similarly, total lead and lithium concentrations were below detection limits in Lac de Gras, but were higher in lakes from the NWT-Nunavut area. The median concentration of total manganese was at or below 0.002 mg/L in Lac de Gras in 1996 and 2000 and in the Yellowknife –area. The median concentrations for total manganese in the NWT-Nunavut area and the Yukon-NWT area were 2.55 mg/L and 0.014 mg/L respectively. Finally, total strontium concentrations were greater in Lac de Gras (0.005 mg/L and approximately 0.006 mg/L in 1996 and 2000, respectively) than in the NWT-Nunavut area (0.001 mg/L).

3.3.3.2 Current Water Quality Conditions

The 2008 Water Chemistry Report (DDMI 2009b) represents the most recent analysis of effluent and water chemistry data collected during the 2008 AEMP program. Results of the analysis indicate a low-level effect on water quality within Lac de Gras resulting from the Diavik Diamond Mine. This conclusion is based on the following findings:

- Statistical differences between the near-field and reference sampling areas for the eight water chemistry variables with benchmarks (chloride, TDS, ammonia, total aluminum, total boron, total manganese, total molybdenum and total uranium);
- Statistical differences between the near-field and reference areas, and near-field means greater than two standard deviations above the reference area means for the four substances of interest without benchmarks (calcium, magnesium, potassium and strontium); and
- The toxicity tests from 2008 demonstrated that the effluent was not acutely toxic.

3.3.4 Groundwater Quality

3.3.4.1 Groundwater Flow

Groundwater flow occurs in warmer seasons through the thin (0.5 m to 2.5 m thick) active zone at the top of the permafrost, but these flows are considered relatively small and local.

There appears to be virtually no groundwater flow at depth near the proposed Project site. This is because of the extensive presence of Lac de Gras acting as a constant head boundary to the groundwater system and the absence of recharge through the permafrost on the islands and mainland. All the lakes on the East and West Islands are small and will therefore also be underlain by permafrost. These factors prevent the production of a driving head for groundwater flow near the proposed Project site.

3.3.4.2 Groundwater Chemistry

The composition and quality of the groundwater is described in the integrated baseline report (DDMI 1998a, Blowes and Logsdon 1997).

The groundwater at the proposed Project site is a slightly alkaline (pH near 8), moderate TDS (generally <500 mg/L), Na-Mg-Ca – HCO3-(Cl) water. This general chemistry is consistent with waters with long residence times in a granitic terrain. The stable isotope geochemistry indicates that the groundwater recharged under a cold climate. The stable isotope and tritium signatures of ground water are distinct from water in Lac de Gras. Metals in the groundwater are low to very low, and radionuclides are very close to detection limits in all samples. There is a general trend of increasing concentration of most major species with depth. Figure 3-17 shows a plot of TDS against depth for samples collected at the proposed Project site, the Lupin mine and data presented in Frape and Fritz (1987) for samples taken from numerous mines in the Canadian Shield including in the Yellowknife area. Profile 1 of Figure 3-17 is an interpretation made by Dr. David Blowes and Mark Logsdon, Diavik's geochemical consultants, of the Frape and Fritz (1987) data alone. The interpretation takes into account that some of the samples are considered to be diluted by shallower fresh groundwater which has flowed towards the mine during the years of operation prior to sampling. Considering the Diavik specific data and the data collected from the Lupin mine (which is geographically closer than many of the Frape and Fritz (1987) sample locations), profile 2 seems a much more likely profile for the proposed Project site. The distinctly different water chemistry of groundwater and Lac de Gras water (DDMI 1998a) is consistent with the interpretation that there is very little recharge or discharge of groundwater to or from Lac de Gras under baseline conditions.

3.3.5 Acid Rock Drainage/Metal Leaching Potential

3.3.5.1 Overview of Acid Rock Drainage/Metal Leaching Potential

Poor quality drainage may develop when sulphide minerals that may be contained in mining waste rock oxidize and weather when exposed to the atmosphere. If sulphide minerals are present in sufficient quantities, sulphide mineral oxidation can release acidity, sulphate and dissolved metals to water draining from waste materials. This type of drainage is commonly referred to as acid rock drainage (ARD) and metal leaching (MLch).

Prior to mine development, a comprehensive baseline geochemistry program conducted static and kinetic tests of Diavik ore and country rock to characterize the acid generating potential (Blowes and Logsdon, 1997). Mineralogical data and test results included:

- The biotite-muscovite granites (including pegmatite granites) contain only trace sulphides and are considered non acid-generating with very low potential to leach metals during weathering;
- The biotite schist contains locally disseminated sulphide minerals at low, but sufficient quantities to be considered potentially acid-generating;
- The granite and biotite schist contain little carbonate, providing little neutralization potential;
- The diabase dikes contain trace sulphides, but are considered insignificant because of their very limited spatial extent;
- The siltstone/mudstone portion of the kimberlite, comprising approximately 1-5% of the kimberlite, contains fine grained sulphides that can contribute to ARD/MLch during subaerial weathering;
- The volcanogenic portion of the kimberlite (>95% of the kimberlite material) contains low sulphide concentrations with an excess of carbonate;
- The carbonates in the volcanogenic portion act to neutralize acidity derived from oxidation of the sulphides in the siltstone/mudstone portion.

Table 3-11 summarizes the average Acid-Base Accounting measurements conducted during the baseline study (Blowes and Logsdon, 1997). The granite and diabase were determined to have non acid-generating potential. The biotite schist has more variable geochemical properties compared to the granite and diabase dikes. Most biotite schist sample ranged from non-acid generating to uncertain acid generating potential, with some samples in the potentially acid generating zone. Most kimberlite samples (volcanogenic and mudstone portions not segregated) were non-acid generating with few samples plotting in the uncertain to potentially acid generating zone.

Table 3-11 Average Acid-Base accounting measurements from the Baseline Study (Blowes and Logsdon, 1997)

Lithology	Average sulphur concentration	Average Neutralization potential (NP)	Average Maximum potential acidity (MPA)	Average Net neutralization potential (NP-MPA)
	(wt. % S)	(kg CaCO3/tonne)	(kg CaCO3/tonne)	(kg CaCO3/tonne)
Granite	0.02	8.1	0.6	7.6
Diabase	0.06	16.6	1.7	14.9
Biotite schist	0.16	9.2	4.3	4.8
Kimberlite	0.21	316	5.8	310
Kimberlitic mudstone	0.73	248	21.3	227
Processed kimberlite	0.6	196	14.8	181
Processed mudstone	1.8	128	50.7	77.3

3.3.5.2 DDMI Waste Rock Type Classifications

Waste rock classifications based on total sulphur content were developed to segregate potentially acid-generating waste rock, which contains biotite schist, from non acid-generating granites (Table 3-12). The classification criteria were based on results from the baseline geochemistry study and are described in greater detail in Blowes and Logsdon (1997) and DDMI (2009c).

Table 3-12 Waste Rock Type Classification Criteria

Waste Rock Classification	Criteria (total sulphur in wt%)	Description
Type I	< 0.04 wt%S	Predominantly granites Considered non acid-generating (“clean”) waste rock suitable for construction material
Type II	< 0.04 wt%S – 0.08 wt%S	Granites with little biotite schist Considered intermediate or mixed rock with low acid-generating potential
Type III	> 0.08 wt%S	Granites containing some amount of biotite schist Considered potentially acid-generating

Each type of waste rock is stored in designated containment areas. The containment areas were designed around separate drainage basins (See section 5.2.2). The drainage basin design reduces the likelihood of potentially poor quality seepage water from entering Lac de Gras. The Type I rock is used for construction material around site in addition to the minor amounts stockpiled when Type I supply exceeds construction requirements.

Processed kimberlite is stored in the designated PKC Facility. The PKC facility was designed around a central basin with lined, engineered dams to reduce the likelihood of potentially poor quality water entering Lac de Gras.

3.4 Biological Environment

3.4.1 Overall Ecosystem

The project area is located within the Southern Arctic Ecozone, as defined by Environment Canada and Agriculture Canada (ESWG 1995) (Figure 3-18). An ecozone is an area at the earth's surface representative of large and very generalized ecological units characterized by various abiotic (climate, geology, soil) and biotic (plants, animals) factors. There are 15 terrestrial ecozones in Canada.

Hudson Bay splits the Southern Arctic Ecozone into east and west portions, with over 80% of the land area in the western portion. It covers northern mainland Canada from the Richardson Mountains in the Yukon to Ungava Bay in northern Quebec. It has the most extensive vegetation cover and highest diversity of species of the three arctic ecozones identified by the Ecological Stratification Working Group (ESWG).

Each ecozone is subdivided into ecoregions, which are characterized by distinctive regional ecological factors, including physiography, climate, soil, vegetation, water and wildlife (ESWG 1995). There are 217 terrestrial ecoregions in Canada. Lac de Gras and the Diavik Mine site are within the Takijuq Lake Upland Ecoregion of the Southern Arctic Ecozone.

Within the ecoregions are ecodistricts, which are characterized by distinctive assemblages of relief, geology, landforms, soils, vegetation, water and fauna. There are 1,030 terrestrial ecodistricts in Canada (ESWG 1995). The Diavik Mine falls within Ecodistrict 168 of the Takijuq Lake Upland Ecoregion.

3.4.2 Vegetation and Wildlife Habitat

The Diavik Project is located in the tundra biome of the central Canadian Arctic, in an area described as the Low Arctic. This is the transition zone between taiga and upper arctic tundra. The short growing season, with cool soil and subsoil temperatures has limited soil development that in turn has limited the establishment of either productive or diverse plant communities. Plant community types vary between dwarf tree/shrub wetlands and wet sedge meadows, to drier, raised hummock grassland associations, and non-vascular (moss-lichen) plant communities associated with rock outcrops.

The Heath Tundra plant community is the dominant plant community and represents the climax vegetation stage in the tundra biome. It covers most of the dry upland area at Lac de Gras. Sedge associations (sedge meadows) less than 20 m in diameter are also very common in the Lac de Gras area. These develop on nearly level slopes or in shallow depressions in areas where water accumulates on silty or organic soil. These little sedge meadows occur throughout the heath tundra, among boulder associations, or in depressions in bedrock outcrops, anywhere water collects on organic soil.

All exposed (not flooded) boulders in the area are about 80% covered with lichens, while lichen coverage on exposed bedrock ranges from 5% on smooth rock that is highly exposed to the wind to 80% on protected faces. Crests of many of the islands and peninsulas are covered with an additional association termed lichen veneer. This occurs mostly on gravelly surfaces where the snow layer is very thin in winter, and where exposure creates an extremely harsh microclimate.

Shoreline vegetation varies depending on the soil or bedrock material in the area, water depth and slope of shore. Most of the shoreline of Lac de Gras is covered by boulders. Little emergent or submergent vegetation grows along these shores. Similarly, cobble to gravel shores do not support much vegetation since wave action and unstable substrates make it difficult for plants to survive. Silt and sand shores, which occur in sheltered areas with gradual slopes, support emergent vegetation such as sedges. Riparian shoreline shrub communities are found along the shores of islands or peninsulas extending out into Lac de Gras and sporadically along all shorelines of Lac de Gras. Shoreline shrub communities consist of dwarf birches and willows growing in slumped areas near the water's edge. Other less common vegetation communities associated with Lac de Gras shorelines are grass ridges, sedge meadows and heath tundra.

Specific vegetation communities on East Island include esker complexes, heath tundra, sedge associations, riparian associations, boulder associations and lichen veneer. Island riparian associations contain dwarf birches and willow, but do not contain alder and spruce, which are present on the mainland. As well, the understory is slightly less diverse than on the mainland, likely due to the slightly harsher climate.

In the immediate vicinity of the mine site, heath tundra is the most common association, followed by sedge associations, boulder associations, esker complexes, bedrock associations, riparian associations, and lichen veneer.

No rare plant species are reported in the literature for past collections in the Lac de Gras area, as summarized in McJannet et al. (1995). In addition, no rare plant species were found in any of the sites examined during the baseline study.

Vegetation and habitat availability for wildlife were anticipated to be reduced directly by disturbance from the mine footprint. In the Environmental Effects Report (EER), direct disturbance to vegetation from the mine footprint was predicted to be 11.6 km^2 (DDMI 1998c). Currently, the expected area of the mine footprint is 12.7 km^2, which is due to a change in shape and spatial extent of the mine site.

The 2008 Project footprint was estimated to be 9.66 km^2 (DDMI 2009d). This represents a total loss of 76.2% of the predicted mine disturbance. Direct habitat loss in 2008 was 0.26 km^2. Heath tundra represents the largest cumulative loss on East Island over the years, and represents the largest predicted vegetation habitat type loss due to mining activities (DDMI 2009b).

3.4.3 Aquatic Biota and Habitat

Based on nutrient levels in lake water, Lac de Gras is classified as ultra-oligotrophic. A small, isolated area between the East and West Island together with the unique, riverine habitat between Lac de Gras and Lac du Sauvage (referred to as the Narrows) are the main areas where aquatic plants can be found. Generally, Lac de Gras only supports marginal growth of aquatic plants (DDMI 1998a).

Most of the energy required by aquatic organisms in the lake comes from algal production. Phytoplankton growth is highly seasonal, depending on light availability, nutrient levels and grazing by zooplankton. In the spring, algae begin to multiply under the ice and typically undergo dramatic changes in standing stock through the short Arctic summer. Phytoplankton production is essentially zero during the winter, when the light level under the thick ice cover of Arctic lakes is too low to support algal growth.

The phytoplankton community in Lac de Gras is typical of other oligotrophic lakes at northern latitudes. The species of algae present are largely motile, nanoplanktonic (i.e., very small) forms. The community is dominated by relatively few taxa, compared to more southern waterbodies, and typically includes members of the families Chrysophyceae (golden-brown algae) and Chlorophyceae (green algae), and the cyanobacteria (blue-green algae) (DDMI 1998a; Golder 2009b).

Lac de Gras supports a zooplankton community that is also typical of northern lakes in that it is dominated by several key species. Members of the Phylum Rotifera (rotifers) are dominant in terms of abundance, but account for a small proportion of total zooplankton biomass; the crustacean Suborder Cladocera and Class Copepoda are present at lower abundances, but account for most of the zooplankton biomass. Benthic invertebrates are small animals such as insect larvae, worms, clams and crustaceans that live on the bottom of lakes. These organisms feed on a variety of materials, including algae growing on rocks, decaying algae and zooplankton that sink to the bottom, and other benthic invertebrates. Benthic invertebrate abundance can also vary considerably among seasons. The abundance of these organisms is controlled by a number of factors such as food availability, feeding by fish and life cycle processes. In arctic lakes, the dominant members of this group (chironomid midges) emerge from the lake as winged adults once their larval life stage is complete (DDMI 1998a).

The benthic community of Lac de Gras is characterized by low density and few species. This reflects low nutrient levels and water temperature, a short season of primary production and the lack of a well-developed littoral zone, which limit primary production in the lake. Invertebrate density varies considerably among different areas of the lake, suggesting a patchy distribution on the lake's bottom. The benthic community is dominated by chironomid midge larvae, which are represented largely by a few common genera (e.g., *Procladius*, *Micropsectra*, *Heterotrissocladius*) and small larvae in the Subfamily Orthocladiinae, which could not be identified to a lower level. Other common invertebrates include nematode worms, small clams in the Family Pisidiidae, oligochaete worms, ostracods and aquatic mites (DDMI 1998a; Golder 2009c).

The fish community in Lac de Gras consists of nine species which are present in variable abundance. These species include lake trout (*Salvelinus namaycush*), cisco (*Coregonus artedii*), round whitefish (*Prosopium cylindraceum*), Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), longnose sucker (*Catostomus catostomus*) and northern pike (*Esox lucius*). The community in general is stable and slow growing, and is characteristic of the cold, ultra-oligotrophic status of Lac de Gras. Despite the low productivity of the lake, the biomass of fish is high. This is due largely to the long life of the species present. It is important to note that the presence of a substantial fish community under nutrient poor conditions is representative of the incremental accumulation of low annual production over many years (DDMI 2007a).

Shorelines of Lac de Gras are covered by boulders which make the shorelines vary from unsuitable to moderately suitable for fish spawning, nursery/rearing, and foraging. The bottom of Lac de Gras is very uneven and shallow shoals (1 m – 10 m deep) are prevalent throughout open areas of the lake. Shoals in Lac de Gras provide fair to good quality spawning habitat for lake trout and cisco.

The shorelines of the inland lakes are also dominated by boulders. Fish species found in the inland lakes on the East Island include lake trout, round whitefish, cisco, lake whitefish, lake chub and longnose sucker. Of the 11 inland lakes surveyed on the East Island, one is of high importance, two are of moderate importance, and five are of low importance to inland lake fisheries (DDMI 2007a).

No sentinel fish species have been observed in any of the streams originating from the East Island. This is likely due to the ephemeral nature of the streams on the island. Even during spring melt, the flow in streams of the East Island is dispersed through sedge meadows with no distinct channel.

3.4.3.1 Fish Habitat Evaluations

Evaluation of Shoreline Habitat for Fisheries

In 1996, detailed habitat maps were drawn for the shorelines in Lac de Gras (intensive and extensive areas) to classify shoreline fisheries habitat (Golder 1997g, 1997h). The intensive study area involved 100 km of Lac de Gras shoreline, which included Golder km of East Island shoreline, 39 km of west island shoreline and approximately 30 km of shoreline along the mainland east of the project site. The extensive study area included 700 km of Lac de Gras shoreline outside the intensive area. Figure 3-19 is the shoreline habitat key map, which summarizes information from 15 more detailed habitat maps; the detailed habitat maps can be found in Golder 1997g, 1997h.

For the intensive and extensive areas of Lac de Gras, shorelines were classified into five habitat types:

1. Boulder ledge at shoreline; drop-off composed of boulders leading into sand and boulder patches.
2. Gravel ledge at shoreline, shifting to cobble, then boulders. Drop-off composed of boulders leading to mixed sand and boulders.
3. Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand.
4. Mixture of boulders and sand.

4a. Boulders dominant over sand.

4b. Sand dominant over boulder.

5. Mixture of boulder, cobble and gravel. Elevated gravel mounds alternate through the other substrates in a linear, winding fashion.

Shorelines in the intensive and extensive study areas of Lac de Gras are dominated by boulders (Type 1). The next most common shoreline habitat in the 3 study areas is bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand

(Type 3). Sandy areas with some interspersed boulders (Type 4b) are the third most common shoreline habitat types in all 3 study areas.

Fish use of shoreline habitat types depends on both the species of fish and the Fish's activity. Four primary activities include spawning, nursery activities, rearing and foraging. Boulder shorelines, the most abundant shoreline habitat in Lac de Gras, are moderately suitable for lake trout spawning, nursery/rearing and foraging. However, they are poor to moderately suitable for the various activities of round whitefish, cisco and Arctic grayling. Bedrock outcrops surrounded by boulder and cobble leading to a mixture of large boulders and sand, the second most abundant shoreline habitat, are poorly suited for any of the four primary activities undertaken by the 4 sentinel species. Sandy areas with some interspersed boulders, the third most abundant shoreline habitat, range from unsuitable to poor as areas for the spawning and nursery activities of lake trout, round whitefish and cisco. However, these areas are good rearing areas for round whitefish and cisco. Sandy areas are also poor to moderately suitable for foraging by the four sentinel species.

Evaluation of Shoal Habitat for Fisheries

Three of the four sentinel species, specifically lake trout, cisco and round whitefish, spawn in lakes. Shoals in lakes can be characterized as good, fair, poor or unsuitable spawning habitat for the three sentinel species depending on the degree to which characteristics of a given shoal match the spawning criteria. Maps summarizing shoal habitat for lake trout, cisco and round whitefish throughout the regional study area can be found in Golder (1997i).

The intensive study area of Lac de Gras has a slightly higher incidence of good and fair-quality shoals for lake trout (55%) and cisco (62%) compared with the extensive study area (48% and 58%, respectively). In contrast, potential spawning habitat for round whitefish occurs more frequently in the extensive rather than intensive study area of Lac de Gras (extensive study area = 39%; intensive study area = 23%).

Based on the number of good and fair-quality shoals, Lac de Gras has a higher occurrence of potential spawning habitat on shoals compared to Lac du Sauvage. Approximately 52% and 61% of the shoals in Lac de Gras displayed the characteristics required to support lake trout and cisco spawning activity, respectively, whereas 43% of the shoals in Lac du Sauvage would provide potential spawning habitat

3.4.4 Wildlife

The predominant natural land use in the Lac de Gras region is wildlife habitat. Mammals that reside in the area year-round are generally denning animals such as wolverines, grizzly bears, foxes, ground squirrels and ermine that are able seek shelter from the harsh winter conditions. Caribou feed and calve in the tundra during the spring through autumn, and then typically move to the forest during the winter. Predators such as wolves follow the caribou to the treeline.

Ground squirrels and lemmings are widely distributed on the islands and on the mainland. In contrast, Arctic hare abundance is significantly greater on the islands than on the mainland. Grizzly bear, wolverine and wolves regularly travel, hunt and forage on the East and West Islands and east mainland. Foxes den on the islands and are often sighted near the Diavik site.

Only two bird species (ptarmigan and raven) reside year round in the project area due to the scarcity of food during the long winter. However, many bird species migrate into the Lac de Gras area to take advantage of the productive, yet brief warm summer.

3.4.4.1 Caribou

In 1996, the population size of the Bathurst caribou herd was estimated at 349,000 ± 95,000 with periodic changes in seasonal migration routes and winter range (Case et al. 1996; Gunn et al. 1997). In June 2006, the Bathurst herd was estimated to be 128,000 ± 27,300 (ENR 2008). A recent survey in June 2009 has estimated that there are 31,900 ± 11,000 animals in the herd (ENR 2009). Caribou move through the study area during the northern migration to the calving grounds near Bathurst Inlet, and during the subsequent post-calving migration to the wintering grounds below the tree line (Figure 3-20). Individuals from the Ahiak herd may also migrate through or overwinter near the southern borders of the study area. The Bathurst and Ahiak herds are not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2007), and are listed as 'sensitive' in the NWT (ENR 2008).

Up to 100 000 caribou have been observed in the regional study area (RSA) during spring migration. Large waterbodies such as Lac de Gras have an influence on local caribou migration patterns. Spring migration movements across the ice on Lac de Gras tend to be towards nearest points of land including East Island and West Island. In the fall, when return movements from the north are often deflected by Lac de Gras, the caribou seek the easiest route to by-pass the lake. Occasionally this takes caribou onto East Island and West Island before they return to the north mainland and are deflected either east or west around Lac de Gras.

The Lac de Gras area lies within the broad spring migration, summer return and fall movement corridors of the Bathurst caribou herd (Figures 3-21, 3-22 and 3-23). The timing, duration and abundance of caribou movements in the Lac de Gras area vary between years in response to variables such as weather, insect harassment, winter ranges used in that year, calving and post-calving distributions and unpredictability of caribou movements. The variability of caribou movements and use of different parts of their range between years has been emphasized by Case et al. (1996) and Urquhart (1981). Therefore, spring migration and summer return and fall movements were examined from fall 1995 through the summer of 1997, to gain perspective on year to year variation. As well, caribou that were fitted with satellite radio-collars, as part of the West Kitikmeot Slave Study Society (WKSS) regional study, were traced from satellite data and through density-association surveys of collared cows while they were in the study area.

Recent analyses of aerial survey and satellite collar data have suggested the zone of influence (ZOI) for the probability of caribou occurrence near mineral developments may range from 11 km to 33 km (see review in DDMI 2009d). Analysis of caribou occurrence from monitoring data indicated that the ZOI was approximately 30 km around the Diavik mine, therefore increasing the spatial extent of changes to habitat suitability to include the entire local study area (LSA) in contrast to the affected 3 km to 7 km area predicted in the EER (DDMI 1998). As well, a larger ZOI increased the magnitude of the decrease in habitat suitability loss in the LSA from 3.45% to 12.3%, and in the RSA, from 0.14% to 2.6% (DDMI 2009d). As a result, there were no changes to the effects classification for the LSA, but the effects classification for the RSA increased from Level I to Level III.

Migratory movements of satellite-collared animals support the deflection predictions made in the EER, but the evidence was stronger for the post-calving migration (DDMI 2009d). During the northern migration, 57% of collared cows (N=148) travelled west of East Island. During the southern migration, 71% of collared caribou (N=154) travelled east of Lac de Gras. The number of collared animals travelling east or west of Lac de Gras appeared to be unrelated to the development phase of the mine. Therefore, there were no changes to the effects classification (DDMI 2009d).

A single incident of direct mine-related caribou mortality has occurred at the mine since 1996 (DDMI 2009d). The results suggest that current operations at the mine are not influencing the population persistence of caribou, and provide support for the prediction made in the EER.

To protect caribou migrating near the Diavik Diamond Mine, caribou advisory signs are posted on all haul roads. Caribou, and other wildlife, have the right of way. DDMI's environmental team also conducts routine caribou monitoring with the assistance of elders from local Aboriginal communities. Monitoring studies are also used to determine if herding procedures are successful, if winter road alignment diverts caribou away from East Island, and if there is preferential use of areas impacted by dust (DDMI 2009e).

3.4.4.2 Grizzly Bear

Barren-ground grizzly bears in the Slave Geological Province (SGP) have the largest annual home ranges and likely the lowest density of any grizzly bear population studied in North America (McLoughlin et al. 1999). Visual locations of radio-collared grizzly bears and sightings of uncollared bears were used to identify sites for the investigations of bear habitat use (McLoughlin et al. 1997) (Figure 3-24). It is believed that the large home ranges of grizzly bears in the SGP are correlated with the relatively lower productivity of habitat available to bears on the barren-grounds compared to coastal or alpine areas. Although the population of grizzly bears in the SGP appears to be currently stable or slightly increasing, any increase in mortality may place the population at risk (McLoughlin et al. 2003). The northwestern population is listed as a species of ‘Special Concern’ (COSEWIC 2007) and currently has no status under the *Species at Risk Act* (SARA) (2007, internet site). Their status in the NWT is considered ‘sensitive’ (ENR 2008).

Relative to pre-development conditions, monitoring results indicated that direct and indirect (sensory disturbance) seasonal habitat loss for both male and female grizzly bears in the LSA and RSA has been negligible. Thus, the level of impacts predicted prior to development is similar to the levels observed during monitoring (DDMI 2009e).

Monitoring results indicate that direct mine-related mortality to grizzly bears has been low (DDMI 2009d). Currently, direct mine-related bear deaths per year is 0.13, which is within the range of 0.12 to 0.24 predicted in the EER. The results suggest that current operations at the mine are not influencing the population persistence of grizzly bears, and provide support for the prediction made in the EER (DDMI 2009e).

3.4.4.3 Wolf

Wolves on migratory caribou ranges in the Northwest Territories generally prefer to den near the treeline where access to caribou during the summer is more reliable. The Lac de Gras area, which is about 50 to 100 km north of the treeline, appears to fall within the zone of regular and abundant denning by wolves. In 1996 and 1997, 38 wolf denning sites were located in the esker and intensive den search area (Figure 3-25). Many other wolf denning sites have been reported within area north of Lac de Gras (Mueller 1995, BHP 1995, Banci and Moore 1997.). Detailed information on regional distribution of wolf dens, denning activities and litter sizes of wolves is described in the baseline report (Penner and Associates 1997a).

All wolf dens identified were located in glaciofluvial materials. About half the dens were associated with esker systems (48%) and half were located in discontinuous glaciofluvial deposits (52%). Dens associated with eskers were more often located on terraces, side deposits or esker ends than on the main body of prominent, continuous eskers. Most denning sites were characterized as low mounds of exposed soils and a variable amount of vegetation cover dominated by grasses (32%), dwarf birch (13%) and crowberry (6%). Fox burrows were associated with about half the denning sites and most denning sites had ground squirrel burrows. Detailed information on den site characteristics is available in Penner and Associates (1997b).

3.4.4.4 Wolverine

Wolverines are year round residents in the Lac de Gras region (DDMI 1998). The western population is listed as a species of ‘Special Concern’ (COSEWIC 2007) and currently have no status under SARA (2007, internet site). Their status in the NWT is considered ‘sensitive’ (ENR 2008). Wolverines inhabiting the Arctic and sub-Arctic have large home range requirements and depend primarily on carrion, especially caribou, for food (Pasitschniak-Arts and Larivière 1995; Mulders 2000). Subsequently, populations generally exhibit low densities. Although little scientific information is available on wolverine habitat use and demography in the region, the animals are an important cultural and economic resource for people of the NWT.

Monitoring data from snow track surveys have indicated that wolverine track density fluctuated annually, but did not show a decreasing or increasing linear trend (DDMI 2009e). Similarly, the probability of detecting a wolverine track did not exhibit a significant temporal trend, but was statistically different between 2004 and 2006 (DDMI 2007b). The occurrence of wolverine tracks increased closer to the mine.

Results from a DNA hair sampling study indicated that the wolverine population in the Diavik and Ekati study areas was stable during 2005 and 2006, although the number of male wolverines appeared to decrease between years (DDMI 2007b; Boulanger and Mulders 2008). No wolverines were removed from the population due to mine-related incidents (i.e., mortality or relocations) at Diavik from 2002 through 2007 (DDMI 2009d). However, information from the Lac de Gras outfitting camp indicated that the annual number of wolverine harvested from the area ranged from two to five individuals between 2003 and 2006. Overall, the monitoring results suggest that current operations at the mine are not influencing the presence of wolverines in the study area, and provide support for the prediction made in the EER (DDMI 2009d).

Since 2000, two wolverines have been relocated and two mortalities have occurred at the DDMI mine site (DDMI 2009d). The results suggest that current operations at the mine are not influencing the population persistence of wolverines, and provide support for the prediction made in the EER.

Management of waste products through proper handling, storage, and disposal is a key component for mitigating effects to wildlife, particularly carnivores (DDMI 2009d). Diavik is committed to taking all the necessary steps so that the collection, storage, transportation, and disposal of all wastes generated by the Project are conducted in a safe, efficient and environmentally compliant manner.

Since 2002, inspections of the Waste Transfer Area (WTA) and landfill were conducted every two days from 1 January through 31 December. Inspections consisted of Environment personnel walking the area of the waste transfer and landfill, where safe to do so, and documenting the type and number of attractants found, as well as wildlife species and fresh sign (DDMI 2009d). Results from monitoring indicate that the waste management program is effective at determining annual changes in the frequency of attractants, wildlife, and wildlife sign at the waste transfer and landfill areas. The waste management program has been a successful mitigation practice for reducing the risk of direct mine-related mortality and injury to wildlife.

3.4.4.5 Raptors

Raptors were included in the wildlife monitoring program because they are considered valuable indicators of environmental change and occur in the RSA and LSA. Gyrfalcons and peregrine falcons are known to nest in the Lac de Gras region. The species status of gyrfalcons is currently not listed in the NWT or federally. Peregrine falcons (anatum-tunderius complex) are listed as a species of “Special Concern” (COSEWIC 2007) and have no status under SARA (2009, internet site). Their status in the NWT is considered “Sensitive” (ENR 2008).

Results from monitoring raptor nest occupancy and production indicate that changes to the presence and distribution of raptors related to the mine are consistent with local-scale effects predicted in the EER (i.e., no changes to magnitude and duration within the LSA) (DDMI 2009e). At the scale of the RSA, results from monitoring suggest that the magnitude of the impact predicted in the EER should be changed from low to moderate, and the expected ZOI increased from local to regional. The change in magnitude increases the effects level classification from Level I to Level III Regional effect (DDMI 2009e).

No direct mine-related mortality has been recorded for raptors from construction through current operations (DDMI 2009d). In 2004, a partially consumed carcass of a juvenile peregrine was discovered, but whether the death was related to mine activities or predation could not be determined. The results indicate that mortality related to the mine supports the prediction in the EER.

3.4.4.6 Waterfowl and Shorebirds

Many waterfowl (ducks, geese, swans, and loons) and shorebird (sandpipers and plovers) species use the Lac de Gras area for feeding, reproduction, and/or staging during migrations. A number of habitats surrounding East Island were identified as important for waterfowl and shorebirds including shallow bays, melt water ponds, mudflats, and shorelines (DDMI 1998). None of the waterfowl and shorebird species observed in the Lac de Gras area are currently listed in the NWT or federal status reports.

Monitoring has indicated that the cumulative loss of shallow and deep water habitats is currently 0.35 km^2 and 2.19 km^2, respectively. Thus, direct aquatic habitat loss is 2.54 km^2, which is 35.5% less than the 3.94 km^2 predicted. Subsequently, the effects classification levels predicted in the EER are similar to the levels observed during monitoring.

Based on monitoring annual changes in species richness, mine activities appear to have had a negligible influence on waterfowl and shorebird communities on the East Island (DDMI 2009e). There was little variation in species richness for waterbirds from 1996 through 2006 at the East and West bays. Eighteen species of shorebirds and 20 species of waterfowl have been detected. Since 2004, an additional five waterfowl species and one shorebird species were detected in the study area. Overall, the results suggest that mine activities have had a negligible affect on waterfowl and shorebird communities in the East and West bays, which is consistent with the impact prediction in the EER.

The construction and alteration of various water bodies was part of the design of the mine and necessary for operations and footprint runoff catchment. It was anticipated that waterbirds might use these wetlands due to the potential for them to be available earlier than the surrounding waters of Lac de Gras. This was expected because the presence of surface dust or warm water discharge at mine-altered water bodies might advance spring thaw.

Annual comparisons of the relative abundance of waterbirds among water body types indicate that diving ducks show the strongest pattern of use of mine-altered water bodies, where as shorebirds prefer shallow bays (DDMI 2009d). Patterns of all other waterbirds either varied annually or showed no preference. Possible explanations for these patterns are that mine altered water bodies have deeper water and shoreline features that are more suitable for nesting diving ducks, while the East and West bays have more extensive vegetation and shallow water areas suitable for feeding and nesting by shorebirds. Overall, the results indicate that waterbirds are using mine-altered wetlands, which supports the prediction in the EER.

Direct mine-related mortality occurred during 2002 and in 2006 when five and one red-throated loons, respectively, became entangled in a gill net and drowned during fish out activities (DDMI 2009d). In 2006, an unidentified species of duck died after it collided with a haul truck (DDMI 2009d). Collectively, these mortalities result in a mine-related mortality rate of 0.63 individuals per year, which is consistent to that predicted in the EER. Subsequently, the effects classification levels predicted in the EER are similar to the levels observed during monitoring.

3.5 Social (Human) Environment

Land usage in the region includes very limited hunting and fishing by northern communities, natural resource exploration and development (mostly diamond and gold recovery, with some base metal exploration) and recreation (several outfitting camps are now located in the area).

3.5.1 Recent and Traditional Land Use

Aboriginal people have used the Lac de Gras area for many centuries. First use of the area may have been by the Taltheili Tradition, ancestors of the modern Dene, about 2,500 years ago. The area has and is currently used by the Tlicho, Yellowknives Dene First Nation, Lutsel K'e Dene First Nation, Inuit, North Slave Metis and others to hunt caribou, fish and trap for furs.

The Slave Geological Province is an area of increased mineral exploration and development. In 1996, there were approximately 65 exploration activities in the Slave Province (EMPR 1995). Most of the past and present gold operations in the NWT are also located within this area (e.g., Lupin, Colomac, Giant, Con, Ptarmigan). Major exploration and development projects in the Central Arctic are shown in Figure 3-7.

The Tibbett Lake to Contwoyto Lake winter road, is the primary winter (ice) road that traverses the regional study area. Echo Bay Mines originally established this road in 1983 to provide transportation to the Lupin Mine at Contwoyto Lake. The road is typically open between January and March with an average of 70 "open" days during that period. The primary consideration that determines dates of road opening and closure is ice thickness. In addition to DDMI, BHPB, and DeBeers Mining Canada Inc. use the road to transport equipment and supplies. Other exploration companies, outfitters and resident hunters also use the road to access the Lac de Gras area.

Several outfitting operations conduct seasonal sport hunting, fishing and wildlife observation excursions within and around the Lac de Gras area. Sports hunting outfitters have camps located on north east shore of Lac de Gras, and nearby on Contwoyto, Point, Courageous, Clinton-Colden, Desteffany, Jolly and MacKay lakes. Licensed canoeing/rafting outfitters offer trips of varying length and duration on the Coppermine River system. Most trips start at points downstream from Lac de Gras, but some start at the west end of the lake and cover the entire river system.

3.5.2 Archaeological and Cultural Sites

During the baseline study, 195 archaeological sites were identified in the regional study area (Figure 3-26). These consist of 17 isolated finds, 71 artifact scatters, 96 quarries, seven campsites, one meat cache, one burial, one site consisting of wooden poles, and one stone marker identified as a burial by the Yellowknives Dene. Of these sites, 66 occur on the mainland, one occurs on a small island adjacent to the northern mainland, 21 occur on the west island and 107 occur on the East Island.

The site types present in the local study area include three isolated finds, 14 artifact scatters and 40 quarries. Of these 57 sites in conflict with the proposed Project footprint, 21 (about 37%) are associated with scientific heritage values. With the assistance of Aboriginal groups, these sites have been further examined and documented (summer 1998).

3.5.3 Protected and Heritage Sites

Eleven proposed protected areas or significant conservation-sites have been identified within the Slave Geological Province. These consist of one tribal park (proposed by the Yellowknives Dene First Nation), three International Biological Program sites, and 10 areas identified by World Wildlife Fund (WWF). The Diavik Mine site is near the proposed tribal park, a corridor extending south-westward from the MacKay Lake area to the Gordon Lake area. The Diavik Mine site is also within an area identified by the WWF as having high conservation interest. The proposed tribal park and the WWF site overlap. Important biological features include main and subwatershed divides, and forest-tundra transition areas (WWF 1996).

One hundred and thirty-four heritage resource sites have been identified on East Island and West Island combined. Of these, 61% are located where exposed quartz veins were battered to obtain material for tool manufacture. They occur almost exclusively on elevated areas in the central and southern portion of East Island. Thirty two percent of the sites are either scatters of stone tool manufacturing debris or isolated artefacts where a single episode of tool manufacture or use took place. Generally, these manufacturing sites are concentrated around the central valley and near interior lakes on East Island, or on elevated landforms around the central wetland on the west island. The remaining 7% comprise more unique sites, including eight campsites, two with hearth structures, and a stone trap marker. Of these only the two sites with hearths are considered significant enough to warrant avoidance and would be considered special.

4. Project Description

4.1 Location and Access

The Diavik Diamond Mine is located on East Island, a 17 km^2 island in Lac de Gras, NWT, approximately 300 km northeast of Yellowknife (64º31’ North, 110º 20’ West) (Figure 2-1). The area is remote, and major freight is trucked over a seasonal winter road from Yellowknife. Worker access is by aircraft.

The Diavik Diamond Mine involves mining of four diamond-bearing kimberlite pipes. The pipes, designated as A154North, A154South, A418, and A21, are located directly off shore of East Island (Figure 2-2). All mining, diamond recovery, support activities and infrastructure are located on the East Island.

In total the mine site at full development was expected to have a footprint of 12.76 km^2. The current footprint is 9.66 km^2.

4.2 Site History

The Diavik Diamonds Mine is an unincorporated joint venture established by Diavik Diamond Mines Inc. (DDMI) and Harry Winston Diamond Limited Partnership (HW) to develop a diamond mine at Lac de Gras, in the NWT of Canada.

DDMI is a wholly owned subsidiary of Rio Tinto plc of London, England, while Harry Winston Diamond Limited Partnership is controlled by Harry Winston Diamond Corporation of Toronto, Ontario, Canada. Under the Joint Venture Agreement, DDMI has a 60% participating interest in the project and HW a 40% participating interest. DDMI has been appointed Manager and is the corporate entity responsible for conducting Project activities.

The Diavik Diamond Mine is located on East Island, a 17 km^2 island in Lac de Gras, NWT, approximately 300 km northeast of Yellowknife (64º31’ North, 110º 20’ West) (Figure 2-1). The area is remote, and major freight must be trucked over a seasonal winter road from Yellowknife. Worker access is by aircraft to the mine's private airstrip.

The Diavik Diamond Mine involves mining of four diamond-bearing kimberlite pipes. The pipes, designated as A154North, A154South, A418, and A21, are located directly off shore of East Island (Figure 2-2). All mining, diamond recovery, support activities and infrastructure will be limited to East Island.

Overall, DDMI and HW have a mineral claim to an area that includes portions of Lac de Gras, the East and West islands, and portions of the mainland to the southeast and northwest. Lac de Gras is about 100 km north of the treeline in the central barren ground tundra of the NWT, at the headwaters of the Coppermine River. This river, which flows north to the Arctic Ocean east of Kugluktuk, is 520 km long and has a drainage area of approximately 50,800 km^2.

Aber Resources Ltd. began staking mineral claims in the Lac de Gras area of the Mackenzie Mining District, NWT, in November 1991. Through an option agreement dated June 1, 1992, Kennecott Canada Inc. ("Kennecott") acquired the right to earn a 60% Joint Venture interest in the Diavik claim blocks of Aber Resources Ltd. Kennecott exercised its rights under the option agreement following the discovery of the four diamond bearing kimberlite pipes just off the eastern shore of East Island. The Joint Venture was consummated on March 23, 1995 with Kennecott initially appointed as Manager. Kennecott assigned its rights and interests to DDMI on November 29, 1996. Aber Resources Ltd. assigned its rights and interests to Aber Diamond Mines Ltd. on January 30, 1998. On 9 November 2007, Aber Diamond Corporation changed its name to Harry Winston Diamond Corporation reflecting the rebranding of the company.

On the basis of a Feasibility Study completed in July 1999, DDMI and HW began actively proceeding with implementation of the project. The Diavik Diamonds Project EA documents were formally submitted to the Federal Government in September 1998, and in early November 1999 the Federal Minister of the Environment approved the Diavik Diamonds Project for permitting and licensing. On March 8 2000, an Environmental Agreement was signed and the Department of Indian Affairs and Northern Development (DIAND), now Indian and Northern Affairs Canada (INAC), issued permits to allow DDMI to commence with construction activities.

The Diavik Diamond Mine commenced production in January 2003 producing approximately 3.8 million carats in 2003. Full production began in 2004 with a production target of 7 to 8 million carats. It is expected that the mine will produce approximately 107 million carats of diamonds over a 16 to 22 year mine life.

A historical summary of project milestones leading to the commencement of production is provided in Table 4-1.

Table 4-1: Project Milestones

Date	Milestone
1991-1992	Aber stakes mineral claims
Mar 1992	Exploration begins
Jun 1992	Aber Resources forms joint venture with Kennecott Canada Exploration
1994-1995	Pipes A21, A154North, A154South and A418 discovered
Feb 1996	75-person exploration camp erected on-site
Jul 1996	5,900 metric tonne bulk sampling of A418 and A154S pipes completed
Nov 1996	Diavik Diamond Mines Inc. created, with head office in Yellowknife
Mar 1997	Bulk sample transported over the winter road to Yellowknife for processing. Approximately 21,000 carats of diamonds discovered
Jun 1997	Environmental baseline studies completed
Sep 1997	Pre-feasibility study completed
Mar 1998	Project description submitted to Federal Government triggering formal environmental assessment review under Canadian Environmental Assessment Act
Sep 1998	Environmental Assessment Report submitted and Comprehensive Public Involvement Plan initiated
Nov 1999	Federal Government approves project for permitting and licensing
Sep 2000	All necessary permits and licenses to bring mine into production received
Dec 2000	Investor approvals to build the mine received
Jan 2001	Mine construction begins
Oct 2001	Earthworks for the A154 dike completed
Jul 2002	A154 dike complete and dewatering commences
Dec 2002	Mine infrastructure construction virtually complete
Jan 2003	Start of diamond production

4.3 Site Geology

The Lac de Gras regional study area is located in the central part of the Slave Geological Province of the Precambrian Shield.

The surface expression of East Island is controlled by bedrock, with bedrock outcropping occurring over about 40 percent of the surface of the island. The bedrock geology of the island is dominated by granitic rock, with volcanic rocks such as diabase present in small proportions (Figure 3-6).

The Diavik diamond deposits occur in kimberlite pipes intruding in the granitoid country rock located under Lac de Gras adjacent to East Island. Kimberlite ore is found in four pipes located under Lac de Gras just offshore of East Island; A154N and A154S (collectively identified as “A154”), A418, and A21 (Figure 2-2). The kimberlite pipes are the roots of relatively young volcanoes dated at approximately 55 million years old. The host rocks are ancient Precambrian granites and metamorphosed sedimentary rocks that are approximately 2 billion years old. Material within the kimberlite pipes comprises three broad classes: hypabyssal kimberlite, volcanic and epiclastic kimberlite and xenoliths. Volumetrically the kimberlite pipes are dominated by volcaniclastic and epiclastic material, often with a significant xenolithic component. The hypabyssal phases are volumetrically less significant, occurring as feeders to the pipes at deeper levels and as contact intrusions along the pipe margins.

Glacial till is the dominant surficial material on East Island, and overlies most of the bedrock. Glaciofluvial deposits are in the form of eskers and kames, and are most common on the north end of the island. Glaciolacustrine deposits occur mainly in lowland areas, while organic deposits typically overlie glaciolacustrine deposits near the lake shore. Shallow (< 1 m) organic deposits typically have large stones exposed at the surface.

All of the soils that have developed on East Island are Cryosols which have been influenced by varying degrees of cryoturbation. There are also numerous solifluction lobes on East Island. These lobes typically occur on slopes ranging from 10% to 25%, although they may occur on slopes as shallow as 2%.

Lakebed sediments are underlain by a layer of organic-rich lake bottom sediments overlying bouldery glacial till. The lake bottom sediments primarily consist of organic silts and clays and vary in thickness from 5 m to 8 m. The underlying till may reach a thickness of between 20 m and 30 m.

4.4 Mine Plan

A mine plan describes the method and sequence for extracting the kimberlite resource from the ground. A broad range of mining methods were initially evaluated including both conventional and non-conventional methods. Non-conventional alternative methods included jet boring, raise boring, blind drilling and dredging. Conventional methods included open-pit and underground mining methods. Diavik did not advance non-conventional mining methods beyond the initial studies as in general they were found to be experimental resulting in an unacceptable level of technical and economic risk to be used as the basis for a comprehensive mine plan.

Three conventional mining approaches were developed:

1. *all underground* – Mining would be from underground only. Declines or shafts would be sunk to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar) would be left in the top of the kimberlite pipe (around 100 m thick) to separate the underground workings from the water of Lac de Gras, which would be immediately above. Water retention dikes are not a part of this alternative.

2. *underground with open-pit crown pillar* – Underground mining would be the same as in the all underground alternatives. Additionally, open-pit mining would be used to mine to a depth of 100 m. Three water retention dikes would be constructed, and water removed from the open-pit areas.

3. *open-pit and underground* – For this option, open-pit mining would be used to mine the kimberlite pipes to an elevation of 190 m (A418), 130 m for A154S, 265M for A154N and 220 m for A21. At these depths it would become economical to shift to

underground mining in A154S/N and A418. Three water retention dikes would be constructed and water removed from the open-pit areas.

One of the clear advantages with all the underground alternative is that construction of dikes in Lac de Gras would not be required. This would remove any issues with respect to effects on fish habitat and water quality associated with the dikes and their construction.

Communities have consistently described the importance of using resources wisely. While their comments usually referred to the use of land and water, concerns were also expressed about the use of mineral resources. Communities requested that if the natural environment of the East Island is to be disturbed to recover diamonds, that Diavik maximize resource recovery and not just take the best parts. Alternative 3 above would be the alternative that comes closest to matching this community value.

Underground mining would displace less country rock than open-pit mining. Both alternatives that include open-pits would require storage areas on the East Island for wasterock. The storage area for alternative 2 would be less than alternative 3.

The health and safety of workers is of primary importance to Diavik. It would be cost prohibitive and may not be technically possible to achieve a satisfactory level of safety for an all underground alternative without a dike.

From a diamond recovery perspective the open-pit and underground alternative 3 would produce the most diamonds. Based in estimated capital, operating costs and the value of diamonds produced, it was determined that the mine would not be economically viable without water retention dikes and removal of water from above the crown pillar.

With the removal of the water, the most attractive method of mining is a larger open-pit followed by underground mining in the later years. From an economic perspective Alternative 3 is preferred as it results in the lowest overall operating cost per carat recovered and is therefore the most financially robust.

The final decision from the EA was to proceed with a mine plan that involved water retention dikes with open-pit mining and underground mining. It was noted that mine planning is an ongoing process and that alternate mining technologies should be re-evaluated in the future including alternative or emerging technologies to recover currently uneconomic resources (Canada 1999). The Water License and Land Leases are based on dewatering a portion of Lac de Gras for the purpose of mining the A154 North and South, A418 and A21 kimberlite pipes.

The current mine plan utilizes two open pits for initial access to the A154N, A154S and A418 kimberlite pipes followed by underground mining methods. A21 mining is currently in the conceptual design phase with plans to mine using a wet mining technique where the kimberlite is mined through the overlying water column.

4.4.1 A154 and A418 Mine Plans

The mineralized kimberlite pipes in the current mine plan are located near the shoreline of East Island and are surrounded by granitic country rock. The proximity of the pipes to the surface allows for economic ore extraction by open pit mining. At greater depths the ore will be mined by underground mining methods, subject to economics. Refer to Figure 4-1 for general layout of open pits and underground mine workings.

To allow open pit and underground mining, two water retaining diversion dikes were constructed: A154 dike; A418 dike (Figure 2-2). DDMI completed the first dike, which encircles the A154North and A154South pipes, in 2002. Construction of the second dike which encircles the A418 pipe was completed in 2006. Details of the A154 and A418 dike designs can be found in Nishi Khon-SNC Lavalin (NKSL) (1999) and NKSL (2004), respectively.

Open pit mining involves drilling and blasting and will be carried out with conventional truck and shovel methods. The open pit excavations are separated from the toe of the enclosure dikes by an 80 m to 100 m wide perimeter shelf. Planned pit bottom in A154 is 140 m elevation and 200 m elevation for A418. Open-pit mining is virtually complete in A154 and will be complete in A418 by 2012. A418 open-pit is currently at the 310 m elevation.

Underground mining plans are based on using underhand cut and fill (UCAF) methods at A418 pipe and A154 south pipe and a combination of UCAF and blast hole stoping in the A154 north pipe. Mined stopes will be back filled to enhance physical stability during operations and beyond closure. Underground mining is currently planned to an elevation of about 0 m. Development work has currently advanced to 50 m elevation.

To date 13.5 Million tonnes (Mt) of kimberlite have been mined from A154N/S and A418. There remains some 19.1 Mt to be mined before completion of underground mining in 2022

Underground facilities include maintenance shops and storage areas for fuels and lubricants. Primary underground equipment includes tunnelling machines, "load-haul-dump" vehicles, and drills. Kimberlite is transported to surface by truck. The main portal exit is shown in Figure 2-2.

A water collection and pumping system collects water from precipitation and groundwater seepage and pumps the water to the NI (see Section 4.4.5). Groundwater inflow and runoff estimates for the A418 and A154 pits, as well as underground mining operations, are given in the Water Management Plan (DDMI 2008). Total flows are expected to peak at about 45,000 cubic metres per day (m^3/day) by 2013 and remain at that level for the remained of the mine life. These estimated flow rates will be reviewed and updated as required based on monitoring results, findings of field investigations and mathematical modelling.

Existing and full development conditions for the A154 and A418 mine areas are also described in Section 5.2.1.

4.4.2 A21 Mine Plan

DDMI determined in 2008 that the A21 kimberlite pipe could not mined economically using the planned dike and open-pit mining method. Alternative mining approaches were reviewed that do not require the removal of Lac de Gras water from the A21 mine area and so do not require the construction of a water retention dike. The approach would employ underwater mechanical mining of the kimberlite, also termed "wet mining". Wet mining is currently the preferred mining method for mining A21 kimberlite ore.

Wet mining could, for example, use a cutter head suspended from a barged crane floating above the A21 kimberlite pipe. Kimberlite would be cut and drawn to the surface through a slurry line. The kimberlite ore would be transported to the process plant and diamonds recovered. If wet mining is proven to be feasible it is expected to be used to mine up to 3.6 Mt of A21 kimberlite ore by 2022.

The water of Lac de Gras would not be removed from the A21 mining area however a sediment control structure would be constructed to isolate any turbid water generated from the wet mining, from dispersing into Lac de Gras. The sediment control structure is currently envisaged as a rock groin surrounding the mine area made from run-of-mine rock (Figure 2-2). This rock structure would support a plastic silt curtain (or equivalent) to keep suspended solids in the mine area from disbursing into Lac de Gras.

No wasterock would be generated from the A21 mine area using the wet mining approach. Processed A21 kimberlite would be sent to the PKC.

The expected development of the A21 mine area is also described in Section 5.2.1.

4.4.3 Wasterock and Till Storage

The wasterock mined to access the kimberlite ore is generally granitic in nature with small amounts of pegmatite, diabase and biotite schist lithologies. The granite, pegmatite and diabase rocks which account for approximately 80% to 90% of the total rock mass are generally non-reactive with very low sulphur levels and adequate alkalinity to neutralize any potential reaction (see Section 3.3.5)

Wasterock and till from the A154 and A418 open pits is placed on the north side of the island (Figure 2-2). Wasterock is segregated by sulphur content (Table 4-2).

Table 4-2 Waste Rock Classification

Waste rock classification	Criteria (total sulphur in wt%)	Description
Type I	< 0.04 wt%S	Predominantly granites Considered non acid-generating ("clean") waste rock suitable for construction material
Type II	0.04 wt%S – 0.08 wt%S	Granites with little biotite schist Considered intermediate or mixed rock with low acid-generating potential
Type III	>0.08 wt%S	Granites containing some amount of biotite schist Considered potentially acid-generating

Type I rock is reserved for construction including roads, laydowns and the PKC dams. All Type III rock goes to the wasterock and till area. Type III rock is dumped within specific drainage basins in the wasterock area (see also Section 5.2.2)

The estimated volumes of the country rock and till that will be produced by the A154 and A418 open pits are given in Table 4-3.

Table 4-3: A154 and A418 Open Pit Till and Country Rock Production[a]

Year	Till (Mm^3)	Type I (Mm^3)	Type II (Mm^3)	Type III (Mm^3)	Total Volume (Mm^3)
2002	2.56	0.44	0.05	0.41	3.46
2003	2.13	2.55	0.85	4.10	9.63
2004	0.48	3.64	1.57	5.63	11.3
2005	0	4.45	0.88	4.82	10.2
2006	0	4.51	1.16	3.13	8.8
2007	1.62	4.07	0.83	1.94	8.46
2008	0.63	5.95	0.24	1.35	8.17
2009	0	6.10	0.42	2.21	8.74
2010	0	7.05	0.47	1.88	9.41
2011	0	2.22	0.15	0.59	2.97
2012	0	0.10	0.01	0.03	0.13
Totals	7.42	41.09	6.63	26.09	81.26

[a]2009 to 2012 volumes are estimated
Mm^3 = million cubic metres

At the completion of open-pit mining in 2012 the wasterock and till areas will be at its maximum size. From 2012 to 2022 more than 20 Mt of wasterock is expected to be re-mined for underground backfill, PKC dam raises, A21 sediment control structure, etc. By 2022 there will be an estimated 112 Mt of wasterock and 1.8 Mt of till in this area. Of the 112 Mt of wasterock 15 Mt is expected to be Type I, 13 Mt as Type II and 84 Mt as Type III.

The expected maximum elevation for the wasterock pile is 500 m.

A drainage collection system exists around the wasterock and till area. Pond 1 is located on the south east side and collects any runoff or seepage from the Type I rock and till area. Pond 3 is located on the south west corner of the wasterock area and collects any runoff or seepage from the Type III rock placed in this drainage basin. Pond 2 on the north west corner collects seepage and runoff from mixed type I and type II (see Figure 2-2).

The existing level of development and the expected maximum level of development of this area are also described in Section (5.2.2).

4.4.4 Processed Kimberlite Containment

The diamonds represent approximately one part per million of the host kimberlite rock. Once this small fraction of diamonds is removed, the remaining kimberlite is placed in the PKC area

(Figure 2-2). Constructed in a natural valley in the centre of East Island, the PKC area is surrounded by dams on all sides.

Processed kimberlite (PK) is stored in an engineered containment area designed for 42.5 Mt. At the completion of mining, the PKC area will be approximately 1 km long by 1.3 km wide and contain up to a 40 metre thickness of processed kimberlite.

There are two PK materials: a coarse PK fraction (10 mm to 1 mm particle sizes) and a fine PK fraction (minus 1 mm particle sizes). The fine PK is pumped as a slurry to the PKC and discharges from spigot points around the perimeter of the facility forming long beaches around a central pond. Coarse PK is deposited by truck in the northeast corner of the PKC. Containment of the entire PKC area is provided primarily by perimeter dams. In addition to the impermeable elements in the dams, the cold arctic temperatures will result in long term freezing of the fine PK beaches and coarse PK, limiting seepage.

The PKC pond functions as an equalization reservoir for inflows from four sources:

- PK slurry from the Process Plant;
- Treated and disinfected sewage effluent;
- Surface runoff from PKC watershed; and
- Surface runoff transferred from the collection ponds.

The PKC facility includes a pond that is designed to accommodate a normal operating water volume of between 500,000 m^3 and 1.4 Million cubic metres (Mm^3), while leaving sufficient freeboard to contain a 1 in 500-year runoff event.

A floating barge is located within the PKC pond for reclaim of water, which is pumped via an insulated pipeline for reuse in the process plant. Water can also be transferred to the NI, if required.

Collection Ponds 4, 5 and 7 (Figure 2-2) have been constructed downstream of the two main dams as secondary containment to collect PKC seepage. Collected seepage is pumped back to the PKC.

4.4.5 Water Management Facilities

Water management is the collection, storage, recycling and treatment of water in a safe, efficient and compliant manner. The Water Management Plan (DDMI 2008) discusses the water collection system constructed around East Island. Through a system of sumps, piping, storage ponds and reservoirs, Diavik collects runoff water and groundwater seepage which can be used in the Process Plant or is treated in the North Inlet Water Treatment Plant (NIWTP) before being released to Lac de Gras.

The Water Management Plan (DDMI 2008) summarizes the current water sources. Water sources are divided into two areas as shown in Figure 4-2:

- NI Subsystem; and
- PKC Subsystem.

The water inflows reporting to the NI are:

- Runoff from the till storage area and the NI watershed;
- Runoff from the wasterock area;
- Runoff transferred from Pond 2, 3 and 13;
- Groundwater inflow to the A154 pit;
- Dike seepage collected at the toe of the A154 dike;
- Groundwater inflow to the A418 pit;
- Dike seepage collected at the toe of the A418 dike; and
- Groundwater inflows to underground development and mining of A418/A154.

Pit inflows, underground inflows and dike seepage are essentially continuous flows to the NI, while the other flows described above are intermittent.

The water sources reporting to the PKC pond include:

- Fine PK transport water (PK Slurry);
- Pumped surface runoff from collection ponds on-site; and
- Surface runoff within the footprint of the PKC facility;

Water outflows include treated water to Lac de Gras, surface runoff, seepage and evaporation.

Freshwater is drawn from Lac de Gras. Freshwater volume requirements will reduce as reclaim water and mine water are further utilized in kimberlite processing. The following are current uses of freshwater:

- Potable water;
- Process Plant makeup water as required;
- Fire suppression;
- Dust suppression; and
- Drill water for underground drilling if necessary.

The NI is located between the wasterock area and the airstrip (Figure 2-2). The NI is an inlet of Lac de Gras that has been dammed off to use as a sedimentation/equalization basin ahead of the NIWTP. The NI water storage reservoir currently has a live capacity of about 2.5 Mm^3.

The NIWTP was constructed at the northeast end of the NI to treat mine water to meet compliance requirements prior to discharge to the environment. The NIWTP is designed for removal of fine solids and dissolved phosphorus in cold water conditions with a proven treatment capacity of 90,000 m^3/day. The NIWTP has contingency design to reduce pH through the addition of acid if required. Major system components include coagulant and flocculant preparation equipment, four high capacity clarifiers.

Treated minewater is discharged into Lac de Gras via a two submerged outfalls located 200 m offshore at a depth of 20 m. Treatment flow rates, influent and treated effluent quality values of pH, turbidity, and conductivity are monitored continuously and alarmed if outside acceptable limits. Equipment faults and pH levels at points within the circuit are also monitored and alarmed. Effluent is physically tested by the operator regularly for turbidity, pH, conductivity, and alkalinity. North Inlet water levels and inflow rates from mine areas are regularly monitored. Treatment rates are adjusted to maintain water levels within plan levels.

4.4.5.1 Collection Ponds

Table 4-4 summarizes the collection ponds on-site.

Table 4-4: Runoff Collection Pond Summary

Drainage Area	Pond No.	Drainage Basin Area (ha)	Status
Wasterock and Till Area	1	86	Installed
	2	106	Installed
	3	60	Installed
PKC Seepage	4	15	Installed
	5	20	Installed
	7	40	Installed
Plant Site Area	10	21	Installed
	11	7	Installed
	12	20	Installed
North Site - Underground Area	13	15	Installed

Water levels in ponds are inspected daily during May and June. Ponds are pumped down as required during the spring freshet period. Water quality is monitored when water is present. The ponds are pumped substantially dry by October each year to provide additional storage capacity for the following spring freshet.

4.4.6 Plant Site, Accommodation Complex and Fuel Storage

The main plant site is located on East Island and includes a Process Plant, a permanent accommodation complex, a maintenance complex, six 18 ML diesel fuel storage tanks, two power plants, and a boiler house (Figure 2-2). Elevated arctic corridors carry services and provide enclosed walkways that connect all major buildings.

4.4.6.1 Process Plant

Three modules make up the Process Plant - a small run-of-mine building; the main dense media separation plant; and a smaller recovery building that removes the diamonds from the host kimberlite rock. The Process Plant has dimensions of 35 m high (11 stories), 40 m wide, and 152 m long.

The diamond-bearing kimberlite ore is trucked to a stockpile area located outside the Process Plant. A loader places the ore into the Run of Mine (ROM) building where it is crushed before entering the Process Plant. There it is mixed with water and further crushed to less than 25 mm in size. The ore is then conveyed to the dense media separation circuit where a fine grained, heavy and magnetic ferro-silicon (FeSi) sand is added to the crushed ore and water mixture. The FeSi magnifies the gravity effect and enhances diamond and other heavy mineral separation. A large magnet recovers the FeSi, which is recycled.

The less dense waste kimberlite fraction is directed to the PKC area for permanent storage. The heavy mineral concentrate (containing diamonds, garnet, diopside, olivine and spinel) is conveyed to the recovery circuit.

The diamonds are separated from the waste heavy minerals in the recovery building using X-rays. Diamonds glow under this kind of light and photo-electric sensors direct strategically placed air blasts to blow the diamonds off the conveyor belt into diamond collection receptacles. The diamonds are then shipped to Yellowknife to be cleaned and sized. Waste minerals are re-crushed or directed to the PKC.

The Process Plant is designed to maximize the use of water reclaimed from the PKC pond. Reclaim water is used for essentially all process services in the Process Plant. A portion of reclaim water is filtered to allow use in clean services including pump gland water. The recovery process uses reclaim water for most services, but does use raw water for critical services including X-ray sorter cooling water and grease table water. Raw water is also used in case of shortages of reclaim water.

4.4.6.2 Accommodation Complex

The permanent accommodations complex was built in several stages. The dormitory units were prefabricated off-site as a training program under a northern Aboriginal joint venture. A total of 156 modules were constructed and trucked to site, where they were placed into four wings. With recent expansions there are currently a total of 380 dormitory rooms. Each floor has a separate lounge area and laundry facility. The accommodations core complex was built on-site under a separate northern contract. It houses security offices, cafeteria, and recreational faculties including a gymnasium with running track, and a squash court. Figure 2-2 shows the location of the accommodation complex.

The Emergency Response Vehicle garage is located in a separate building off of the accommodation complex.

Numerous contractors and subcontractors are mobilized to site for ongoing construction and research activities. Additional accommodations of 767 beds are available in the South Camp (Figure 2-2)

4.4.6.3 Maintenance Complex

The Maintenance Complex is 25 m high, 127 m long and 60 m wide. Equipment service bays (10 in total), maintenance shops, warehousing and are located on the main floor, while operations support facilities, utility rooms, and additional warehouse space are on the second floor. The third floor houses the Diavik Mine Planning and Administration Offices. The height of the building allows the large haul trucks to raise their boxes for maintenance.

4.4.6.4 Fuel Storage

Diesel fuel is the primary fuel for the site. There are six 18 ML diesel fuel tanks located at the South Tank Farm which provide fuel for mobile equipment, diesel power generators, and heating.

Gasoline storage is also provided for smaller equipment, boats, snowmobiles and gas-powered tools. Jet fuel is stored near the airstrip for helicopters and fixed wing aircraft.

All fuel tanks are housed within secondary containment facilities that include berms, release prevention barriers and impervious liners.

4.4.6.5 Power Plants

There are two power plant buildings, each 25 m high, 60 m long and 36 m wide (Figure 2-2). They house 11 diesel engines capable of producing a total of 46.2 megawatts of power.

Waste heat is recovered and is used to heat the plant site buildings.

Power is carried throughout the plant site through the Arctic Corridors, and elsewhere on the site along 13.8 kilovolt (kV) lines supported by over 200 wooden poles or on surface cables.

4.4.6.6 Boiler Plant

The boiler plant (Figure 2-2) houses three boilers, each capable of producing 23,000 BTUs per hour. The boilers are held in reserve and, in the event of a failure within the main power plant, can be used to keep the buildings from freezing. The boiler plant also houses four backup generators each capable of producing 1.25 megawatts of power.

The boilers use a 60:40 glycol/water mix which is pumped through the system at a rate of 84 litres per second. The temperature of the glycol mix leaving the plant is 90°C and it returns at 70°C.

4.4.7 Infrastructure

The project is supported by a variety of infrastructure including:

- Plant yard;
- Arctic Corridors, which carry services and provide enclosed walkways between major buildings;
- Communication system;
- Ammonium Nitrate Storage, Explosive Mixing Plant and Caps Magazine Storage;
- Batch Plant;
- Paste Plant and Crusher;
- Airstrip with Helicopter Pad and Fuel Storage;
- Roads, which form a perimeter containment for most of the facilities;
- Water pipelines;
- Raw water intake and potable water treatment plant;
- Sewage treatment plant with treated sewage outfall;
- Hazardous wastes storage facility;

- WTA and inert landfill; and
- Miscellaneous administration, storage, repair shops and laydown areas.

4.4.7.1 Explosive Management

Explosives on-site are managed and stored at three separate facilities: the Ammonia Nitrate Storage; the Caps/Explosive Storage; and the Emulsion Plant. These facilities are located southwest of the PKC area, away from the south camp and plant site (Figure 2-2).

Explosives are used in the mining of wasterock and kimberlite ore. The required emulsion blends are manufactured in the Emulsion Plant and are delivered to the blast holes in bulk delivery trucks.

4.4.7.2 Paste Plant and Crusher

A paste plant and crusher were recently added on the north side of the mine site (Figure 2-2). The facility is used to prepare various sizes of crushed rock and underground backfill materials. The facility consists of a crusher area, product storage area and a paste plant. Underground backfill can be a trucked cemented rock fill or a pumped paste backfill. Crushed materials are used for both backfill products but also for ongoing surface construction and road maintenance.

4.4.7.3 Airstrip and Roads

The transportation facilities for the project include:

- Airstrip with Helicopter Pad and Fuel Storage; and
- Roads, which form a perimeter containment for most of the facilities.

The airstrip is 1,600 m long and has a 45 m wide granular surface. It is capable of accepting Boeing 737 jet and Hercules transport aircraft. A host of smaller aircraft also bring freight and workers to and from a number of northern communities. Adjacent to the airstrip are a terminal building, helicopter pad, fuel storage and navigational aids.

Approximately 25 km of construction haulage and service roads exist for operations. The roads are constructed above grade from quarried crushed rock and Type I wasterock. Road widths range from 12 m for service roads, to 40 m to 42 m for main haul roads. Access roads vary between 20 m and 22 m in width. Typical granular thickness ranges from 1.0 to 1.4 m, with roadbed thickness increased locally over ice-rich soils depending on performance.

Many of the roads serve as the perimeter surface water collection system. Where applicable, the roads are lined with till blankets on the contained and up-slope side, and have ditches to direct water to collection ponds.

4.4.7.4 Water Pipelines

The site has some 35 km of pipelines to convey water between various locations. Approximately 21 km (60%) of all the pipelines are related to collection of seepage and runoff water from the open pits and dikes, and transport to the NI area and to the NIWTP. Some 3.5 km of pipe (10%) are used for the transport of fine PK slurry, and the remainder (30%) of the pipelines are utilities service pipelines in the Process Plant area. These include above ground lines for treated sewage, fire protection, potable water, and raw makeup process water.

4.4.7.5 Potable Water Treatment Plant

Raw water is pumped from Lac de Gras to a potable water treatment plant consisting of deep bed multi media filters, polishing filters (carbon), and chlorine dosing (Figure 2-2). Pressurized water pipelines deliver potable water from the plant to the major buildings on-site, while a water truck is used to deliver potable to the Air Terminal Building, NIWTP and Explosives Handling Facilities and other support facilities on the mine site.

4.4.7.6 Sewage Treatment

The South Sewage Treatment Plant is an activated sludge system with tertiary filtration to remove phosphorus when required. The treated effluent is also disinfected with chlorine when treated water is directed to the Process Plant for reuse within the plant.

4.4.7.7 Hazardous Waste Management

Hazardous wastes are classified, labelled and temporarily stored within the WTA (Figure 2-2) prior to being transported off-site for recycle, treatment or disposal in a licensed waste disposal facility.

Hydrocarbon contaminated soils from spills or other releases are land-treated in a designated cell within the WTA. The cell is bermed and lined with a geomembrane. The hydrocarbon contaminated soil is placed within the cell and spread during the summer months to allow for remediation to acceptable levels by using natural micro-biological processes (bio-remediation).

4.4.7.8 Solid Waste Management

The main disposal methods for solid wastes generated on-site include incineration of all food wastes, categorical segregation of all non-food waste for storage and subsequent removal from site, and the on-site disposal of non-burnable inert wastes.

Incineration, segregation and storage of waste takes place at the DDMI WTA (Figure 2-2) which was established to ensure proper handling and storage of waste on-site. The WTA is approximately 130 m x 130 m, and is surrounded by a gated, 3 m high chain link fence erected to control wind transportation of any litter and minimize wildlife intrusion. The WTA includes the following: two incinerators for food waste; a burn pit for non-toxic/non-food contaminated burnable material; a contaminated soils containment area; a treated sewage containment area; and sea cans, sheds, and storage areas for drums, crates, bins and totes. The majority of wastes are inventoried and stored at the WTA while awaiting backhaul on the winter ice road. Hazardous wastes are not incinerated on-site.

On-site disposal of non-burnable wastes such as steel, plastics and glass currently occurs at the inert landfill located within the Type III waste rock pile. These materials are covered with waste rock on a regular basis to prevent wildlife attraction.

The inert landfill will remain operational within the wasterock area until final closure.

4.4.7.9 North Construction Area

Several office and storage buildings, laydown areas and repair shops are located on the north of the mine site (Figure 2-2) near to the A154 and A418 pits and underground. Some of these facilities are buildings reused from original construction camp facilities.

5. Requirements for Permanent Closure and Reclamation

5.1 Definition of Permanent Closure

Permanent closure is defined as the final closure of the mine site. At this time there would be no foreseeable intent by DDMI to use the site for active exploration or mining although permanent closure would not preclude renewed or future mining. Permanent closure also means that site activities are intended to be limited to post-closure monitoring and possibly contingency closure actions.

Throughout this document the terms “closure” and “closure and reclamation” are used synonymously.

5.2 Permanent Closure Requirements for Specific Components and Facilities

Section 2.5 provided the site wide requirements for permanent closure. This Section provides a more detailed consideration for each specific area of the mine site.

For the purpose of closure planning the Diavik mine site has been divided into closure management areas. These areas are shown in Figure 5-1 and defined as follows:

Wasterock and Till Storage Area

- Wasterock pile
- Till pile
- Collection ponds 1,2 and 3
- Perimeter roads

Processed Kimberlite Containment Area

- PKC structure and contents
- Collection ponds 4, 5 and 7

Open Pits, Underground and Dike Area

- A154 and A418 open pits
- A154 and A418 dikes
- Underground mine and all underground infrastructure
- Portal
- A21 mine area

North Inlet Area

- North Inlet
- East and west dams

Mine Infrastructure

- Collection ponds 10,11, 12 and 13
- Ammonium nitrate storage and Explosives Plant
- North Inlet Water Treatment Plant and Sewage Treatment Plant
- Process Plant
- Paste Plant
- Accommodation Buildings
- Power house
- WTA
- Airport and air strip
- All other surface buildings, pipelines, power, fuel storage, laydown, etc.
- Any infrastructure not included in the areas above

Figures have been prepared for each closure area to depict pre-disturbance, existing development and final development conditions. These are presented in each of the following sections to more specifically describe each area.

In addition to the overall closure goal and site-wide closure objectives described in Section 2.2, more specific closure objectives have been developed for each of the closure areas listed above. These objectives were developed through workshops and reviews coordinated by the WLWB (see Section 2.2). Closure objectives are intended to describe what the closure actions are aiming to achieve. Area specific objectives are referenced within each of the following sections and are listed in Appendix V. These objectives may be revised in the future with subsequent updates to this Interim Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

For each of the area specific closure objective there is also a proposed closure criterion (Appendix V). A closure criterion is a standard against which closure actions can be measured to determine if the closure objective has been met. Closure criteria were developed primarily by DDMI with input from a DDMI hosted workshop and initial reviewer comments. Notes from the workshop are included in Appendix IX-4. Some criteria are not ideal in that they are not as less specific or as not easily measured as desired. DDMI will look for opportunities and suggestions to improve on the specificity of these criteria in the future.

It is recognized that the closure criteria included in Appendix V will require further discussion with communities and regulators and that they may change over time based on new information, changes to objectives and particularly as the details of the preferred closure option are determined.

Alternative closure options have been considered both historically in the mine design and permitting phase and more recently. In the following sections a general description is provided of historical alternatives that have been considered. These are provided for context so the reader understands how the closure plan for an area has evolved. As noted in Section 2.1, this version of the ICRP includes some specific changes to the closure plans for the PKC, wasterock and A21 mine areas. These changes have come about largely from internal DDMI technical reviews, mine plan changes, and improved information from monitoring and research. The changes have also been informed by initial discussions with regulators and communities. DDMI hosted a workshop to discuss some general aspects of different closure options. The objective was to collect views on general advantages or disadvantages of specific closure options and to identify areas for further future consideration.

One area identified for further consideration was with regard to wildlife movement, specifically caribou, on and around a post-closure mine site. This is important as it appears to be a determinant of the final closure landscape. DDMI arranged for communities to discuss this aspect further at a site-based workshop. Outcomes are included in Appendix IX-5 and are discussed within the following area specific closure plans where relevant.

Closure options considered and the selected preferred option is described for each closure area. Detailed engineering has not been completed at this time for the preferred closure designs, nor would it be practical to require this to be completed 13 years prior to permanent closure. An important objective for DDMI of this ICRP is a review of the direction being taken in the selection of preferred closure options.

For each preferred closure option risks, uncertainties and contingencies are identified along with a very general schedule of closure activities. These activities include studies, monitoring, engineering designs as well as closure activities. These activities are described in terms of general scopes. Future versions of the ICRP would be expected to contain more detail.

A final landscape is presented, based on our current level of understanding, for each closure area. Anticipated residual environmental effects post-closure are also noted for each area. Context is provided for these residual effects in Section 9 where effects are assessed cumulatively over all closure areas.

5.2.1 Permanent Closure Requirements – Open Pit, Underground and Dike Area

5.2.1.1 Pre-disturbance, Existing and Final Mine Site Conditions

Figure 5-2a shows the A154/A418 and A21 mine areas pre-disturbance. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. There are no specific or unique environmental conditions of note in these areas.

The existing extent of mine development is shown in Figure 5-2b using an image from August 2009. The Figure shows the A154 and A418 dikes and the extent of the open pits. At A21 development is limited to the initial access road and causeway to the A21 mine area. At final development (2022) the A418 pit would be completed to an elevation of 200 m as shown in Figure 5-2c. A418/A154 mine plans are described in Section 4.4.1 and underground development, which does not show in a plan view, is included in Figure 4-1.

Fish habitat enhancements in the A418 and A154 areas would be complete by 2022 as shown in Figure 5-2c and detailed in Appendix X.

Figure 5-2c shows the current concept for development in the A21 mine area including the proposed sediment control structure and a mine infrastructure area.

5.2.1.2 Closure Objectives and Criteria

General guidance relevant to the open-pit and underground area closure objectives is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Minimize access to open-pits to protect human and wildlife safety
- Allow emergency access and escape routes from flooded pits
- Implement water management strategies to minimize and control migration and discharge of contaminated drainage, and if required, collect and treat contaminated water
- Meet water quality objectives for any discharge from pits
- Stabilize slopes to minimize erosion and slumping
- Meet end land use target for resulting surface expression
- Establish original or desired new surface drainage patterns
- Establish in-pit water habitat where feasible for flooded pits
- Minimize access to underground workings and surface openings to protect human and wildlife safety
- Maximize the stability of underground workings so that there is no surface expression of underground failure
- Prevent collapse, stress transfer and flooding of adjacent mines
- Ensure that underground workings do not become a source of contamination to the surface environment
- Minimize potential for contamination and, if required, collect and treat
- Resurface, re-slope and contour surface disturbance as required to blend with surrounding topography or desired end land-use targets
- Minimize erosion, thaw settlement, slope failure, collapse or the release of contaminants or sediment
- Build to blend in with current topography, be compatible with wildlife use, and/or meet future land use targets
- Build to minimize the overall project footprint

Additionally, *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009) provides recommendations for decommissioning of underground and open-pit mine workings:

- R506: If it is technically and economically feasible to do so, underground or in-pit infrastructure (e.g. crushers, rails, metal structures, water and air pipes) and equipment (e.g. fans and pumps) should be removed from the site. Any equipment to be left underground or in pit should be inspected and remediated as appropriate to ensure that there is no risk of leakage of any contaminants.
- R507: During the decommissioning of underground and open pit mines, any contamination associated with vehicles and equipment operations and maintenance should be identified and remediated, as appropriate.
- R508: Underground mine workings should be secured and signs should be posted warning the public of potential dangers associated with the facility.
- R509: The risk of subsidence in underground mines should be assessed. Appropriate measures should be taken to prevent subsidence in cases where the risk of subsidence is determined to be significant. The primary measure used to prevent subsidence is the backfilling of underground voids.
- R510: Open pits should be backfilled or flooded to the extent practicable to prevent unauthorized access and to protect public safety. In all cases, signs should be posted warning the public of potential dangers associated with the site.

Closure objectives have been developed specific to the DDMI underground, open-pit and dike areas (Appendix V Table V-1). They were developed through workshops and reviews coordinated by the WLWB (see Section 2.4). These area specific objectives may be revised with subsequent updates to this Interim Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

Appendix V Table V-1 also describes proposed closure criteria. Closure criteria are intended for use in evaluating success in achieving the objective. The intent is to have closure criteria that are specific and measurable. It is recognized that some of the criteria in Table V-1 are more general and less easily measured. As the closure plan evolves, particularly as the details of the preferred closure option are determined, DDMI expects that more specific closure criteria will be identified. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.1.3 Preferred and Alternative Closure Options

Closure planning commenced with the initial mine design work in 1996-1998. Many of the important design decisions related to closure occurred at this time. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the wasterock and till being managed, closure plans also advance. Closure planning typically involves reviewing benefits and risks for possible closure options. These reviews are both internal to DDMI and external with communities, government and regulators.

The following describes the general chronology of closure options considerations relate dto the mine plan ending with the preferred option.

Mine Plan 1996-1998

A mine plan describes the method and sequence for extracting the kimberlite resource from the ground. The mining method and sequence are important early considerations with regard to closure. In addition to general footprint and wasterock closure considerations the mining method also defines the mine workings that will remain at closure.

A board range of mining methods were initially evaluated including both conventional and non-conventional methods. Non conventional alternative methods included jet boring, raise boring, blind drilling and dredging. Conventional methods include open-pit and underground mining methods. Diavik did not advance non-conventional mining methods beyond the initial studies as in general they were found to be experimental resulting an unacceptable level of technical and economic risk to be used as the basis for a comprehensive mine plan.

Three conventional mining approaches were developed:

1. *all underground* – Mining would be from underground only. Declines or shafts would be sunk to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar) would be left in the top of the kimberlite pipe (around 100 m thick) to separate the underground workings from the water of Lac de Gras, which would be immediately above. Water retention dikes are not a part of this alternative.

2. *underground with open-pit crown pillar* – Underground mining would be the same as in the all underground alternative. Additionally, open-pit mining would be used to mine to a depth of 100 m. Three water retention dikes would be constructed, and water removed from the open-pit areas.

3. *open-pit and underground* – For this option open-pit mining would be used to mine the kimberlite pipes to an elevation of 190 m (A418), 130 m for A154S, 265M for A154N and 220 m for A21. At these depths it would become economical to shift to underground mining in A154S/N and A418. Three water retention dikes would be constructed and water removed from the open-pit areas.

One of the clear advantages with the all underground alternative is that construction of dikes in Lac de Gras would not be required. This would remove any issues with respect to effects on fish habitat and water quality associated with the dikes and their construction.

Communities have consistently described the importance of using resources wisely. While their comments usually referred to the use of land and water concerns were also expressed about the use of mineral resources. Communities requested that if the natural environment of the East Island is to be disturbed to recover diamonds, that Diavik maximize resource recovery and not just take the best parts. Alternative 3 above would be the alternative that comes closest to matching this community value.

Underground mining would displace less wasterock than open-pit mining. Both alternatives that include open-pits would require storage areas on the East Island for wasterock. The storage area for alternative 2 would be less than alternative 3.

The health and safety of workers is of primary importance to Diavik. It would be cost prohibitive and may not be technically possible to achieve a satisfactory level of safety for an all underground alternative without a dike.

From a diamond recovery perspective the open-pit and underground alternative 3 would produce the most diamonds. Based in estimated capital, operating costs and the value of diamonds produced, it was determined that the mine would not be economically viable without water retention dikes and removal of water from above the crown pillar.

With the removal of the water, the most attractive method of mining is a larger open-pit followed by underground mining in the later years. From an economic perspective Alternative 3 is preferred as it results in the lowest overall operating cost per carat recovered and is therefore the most financially robust.

No significant closure alternatives were evaluated for the open-pit, underground and dike areas. The obvious closure concept was to flood the open-pit and underground mine workings and breach the water retention dikes to rejoin these areas with Lac de Gras.

The final decision from the EA was to proceed with a mine plan that involved water retention dikes with open-pit mining and underground mining. It was noted that mine planning is an ongoing process and that alternate mining technologies should be re-evaluated in the future including alternative or emerging technologies to recover currently uneconomic resources (Canada 1999). The Water License and Land Leases are based on dewatering a portion of Lac de Gras for the purpose of mining the A154 North and South, A418 and A21 kimberlite pipes.

Open Pit, Underground and Dike Area Closure Options

Guidance on generic options for closure of open pits, and underground mine workings are provided in INAC (2007) and those relevant to this area include:

Open Pit Workings

- for multiple pits, sequentially backfill with wasterock and/or tailings as operations proceed
- backfill open pits with appropriate materials (e.g. waste rock, tailings)
- flood the pit (natural or accelerated)
- allow gradual slope failure of pits involving rock masses, or slope pit walls
- block open-pit access routes with boulder fences, berms and/or inulshuks (guidance from local communities and Elders should be sought)
- post warning signs (with visible symbols placed close enough so they are visible from one to another) and fences or berms around the perimeter for actively managed sites (not acceptable for remote sites into the long-term)

- long-term fencing to prevent access may only be appropriate if the mine site is located close to a community where regular access for maintenance is possible and where there is a higher risk of access by the general population
- clover slopes with rip rap thick enough to provide insulation or stabilization to minimize erosion or permafrost degradation
- Stabilize exposed soil along the pit crest or underlying poor quality bedrock that threatens to undermine the soil slope above the final pit water level
- Backbrush area to improve visibility
- Plug drill holes
- Maintain an access/egress ramp down to water level for flooded pits
- Contour to discourage or encourage surface water drainage into pits where appropriate
- Cover exposed pit walls to control reactions where necessary
- Collect waters in pit that do not meet the discharge criteria and treat passively (active treatment is not acceptable for the long term) or passively treat waters in the pit
- Breach diversion ditches and establish new water drainage channel
- Establish aquatic life in flooded pits

Underground Workings

- Seal all drill holes and other surface openings, especially those connecting the underground workings to the surface
- Backfill underground with benign tailings and wasterock
- Secure underground shafts and raise openings using concrete to ensure permanent closure; wooden barricades are only suitable for temporary closure
- Construct a reinforced concrete wall or a plug of weakly cemented waste if the barricade is for access control only
- Flood and plug workings to control acid generation and associated reactions if appropriate (engineering designs must consider hydrostatic heads and rock mass conditions – reinforced slabs should be avoided)
- Construct pillars to retain long-term structural stability after mining activities cease and to sustain their own weight and, if applicable, the weight of unconsolidated deposits, water bodies and all other surface loads
- Permanent support boundary pillar if practical and necessary
- Avoid the use of fencing for barricades in remote northern mine sites where regular inspection is not feasible
- Use ditches or berms as barricades except in areas of continuous permafrost; where continuous permafrost exists, inukshuks, fencing or some other method may need to be considered

- Remove all hazardous materials from the underground shops, equipment and magazines (fuels, oils, glycol, batteries, explosives, etc.)
- Contour to establish natural drainage patterns and blend in with the surrounding topography or re-contour the surface to prevent natural surface and groundwater flows from becoming contaminated by mine water where appropriate

Original Closure Design – 2001

The original closure design for the open-pits, underground and dikes areas are documented in the Initial Abandonment and Restoration Plan (DDMI 1999b), the 2001 Interim Abandonment and Restoration Plan (DDMI 2001b), and the 2006 Interim Closure and Reclamation Plan – Version 2 (DDMI 2006).

The original closure design for the open-pits, underground and dike areas described in the references above can be summarized as follows:

- Hazardous materials, mobile equipment, pumps, etc would be removed form the underground mine workings including lubricants, explosives, glycol etc. Mobile equipment, pumps and pipelines will be removed from the open pit areas. Thermosiphons, power and instrumentation would be removed from the dikes
- Surface openings to the underground mine area including all access/egress openings vent raises, drill holes etc. would be appropriately sealed to prevent access
- The end use objective for the closed dike/pit areas is to create wherever possible nursery and rearing fish habitat. Habitat features such as shallow shoals and reefs would be constructed during mining operations in the area between the pit crest and the inside toe of the dike.
- Each of the three open pit mines would be flooded at closure by siphoning water from Lac de Gras into the pit and dike area until water levels inside the pit/dike area equalled the levels in Lac de Gras. Siphon rates would be established to manage water quality in the flooded dike/pit area and ensure no significant drawdown effects on Lac de Gras.
- Once adequate water quality was verified in the dike/pit area each dike would be breached with series of small excavations to reconnect Lac de Gras and the dike/pit areas to facilitate use by aquatic life and navigation by people. Breaches would be kept small to limit water currents as preferred fish habitat.
- This closure design was to apply to the A154, A418 and A21 mine areas with the exception that there was no planned underground mining at A21.

2009 Review

The closure approach for the A418 and A154 open-pits, underground and dike areas has not been the focus of the 2009 closure review. In DDMI's view the closure concept for these areas are appropriately defined for an interim plan and are generally supported by communities and regulators. While specifics such as the siphon rate and predicted pit/dike area water quality remain undefined, scientific aspects of the fish habitat designs have been finalized.

A related closure option that was considered in the May 2009 DDMI Options Workshop was option to locate an inert landfill in an open-pit at closure (Appendix IX-4). DDMI proposed the option of an in-pit landfill as an additional or alternate landfill site. In concept inert waste materials would be hauled to the pit bottom at closure, covered with several meters of mine rock and hundreds of meters of water. Opposition was raised at and subsequent to the workshop. The opposition seems to be based on what were expressed as: a) DDMI commitments made in the Comprehensive Study Report, and b) conditions of the DDMI Land Leases. Environmental rationale, as to why an open-pit landfill location was inferior to a land based location, were not provided. DDMI has decided to not advance this option further at this time.

The mine plan for the site was reviewed in 2009, particularly with regard to the DDMI determination that the A21 kimberlite pipe could not mined economically using the planned dike and open-pit mining method. Alternative mining approaches were reviewed that do not require the removal of Lac de Gras water from the A21 mine area and would not involve mining wasterock to access the kimberlite pipe. The approach would employ underwater mechanical mining of the kimberlite, also termed “wet mining”.

Wet mining is currently the preferred mining method for A21 and as a result the preferred closure approach for this area has been revised as described below.

Open pit, Underground and Dike Area Closure – 2009 Preferred Option

Designs have been developed for creation of fish habitat within the A154 and A418 dike areas (see Design Reports included in Appendix X-1 and X-2). Specific requirements for these areas include:

- the development of shallow rearing habitat and shoreline habitat; and
- ensuring that the habitat features within the dikes areas are modelled after those features found in other productive areas of Lac de Gras, including depth, substrate type, size, and configuration.

Figure 5-3 shows the design for the areas between the crest of each pit and the respective dikes. Before breaching the enclosure dike walls, mined country rock and finer sediment materials will be placed creating a long narrow reef in the area between the inside toe of the dike and the pit crest. These reefs would be built in areas where the water depth is 5 m and would be approximately 2 m to 3 m high. Areas of granular and soft substrates between reefs would be based on the conditions that existed in the NI. Disturbance of the shoreline may require modification in areas to establish conditions similar to pre-development. This may require the placement of boulders in water depths up to about 5 m. Breaching of the dikes (about 2 m to 3 m depth from low water) would create entrances that deter movement of larger fish. Overall, this will present an opportunity for the creation of shallow water fish-rearing habitat for species such as whitefish. Earthworks associated with habitat creation within the dikes will take place progressively during mining; however, the actual habitat will not be realized until the dikes are breached and fish can access the area.

Closure of the A154 and A418 open-pits and underground will commence once underground mining operations have ceased in this area. The decommissioning work for the open pits will consist of:

- Removal of mining equipment;
- Removal of instrumentation; and
- Removal of pit dewatering system.

The underground mine workings will be progressively backfilled during operations; therefore, at closure limited areas will be open prior to flooding. The following specific actions are proposed for the closure of the A154/A418 underground workings:

- Ventilation raises will be capped with reinforced concrete fitted with ventilation pipes and then covered with granular material and re-graded;
- The main decline access on East Island will be closed by constructing a concrete plug and removing ground supports from the portal to prevent public and wildlife access.;
- Unused ammonium nitrate and areas with excessive hydrocarbon contamination will be removed or cleaned as necessary;
- Metal mobilization will be suppressed by flooding of underground workings to seal off oxygen after all salvageable equipment has been removed;
- Fixed equipment such as piping and wiring that cannot be salvaged will be cleaned and left in place;
- All mobile equipment will be removed to surface;
- Fuel, lubricants and hydraulic fluids will be removed from all underground locations and shipped off-site; and
- Explosives and accessories will be removed from the underground storage magazines to off-site locations.

For the A21 mine area all mining equipment, barges and associated pipelines will be removed. Any turbidity barriers used within the sediment control structure constructed in the lake will remain until final water quality can be confirmed.

Once the A418/A154 open-pit and underground workings a have been fully-decommissioned and fish habitat within the open-pits completed the area will flooded. Water will be introduced to the open-pit by controlled siphons with discharge pipe ends located in such a way as to minimize surface erosion and reduce the creation of suspended solids in the pool water. The flooding rate will also be controlled to insure that there are no adverse effects on Lac de Gras or Coppermine River water levels.

The end target for the lake area within the A418/A154 open-pit and dike area is to establish properties of meromictic lake. The deeper water in the area of the open-pits is expected to chemically equilibrate with the more saline groundwater and establish a chemocline. Combining the shape of this lake area, very deep with steep sides and relatively small surface area, with the protection from wind driven mixing provided by the residual dikes and a chemocline should result in stable permanently stagnant lower monimolimnion underlying an upper mixolimnion that circulates regularly. Mathematical modelling is planned to better predict this condition (see Appendix VIII-5).

It is anticipated that minor amounts of chemicals dissolved in pit seepage water, such as residual ammonium nitrate, dissolved phosphorus or trace metals, will be introduced into the pool water during flooding. This will include any residue or precipitates that may have formed on the expose rock masses. The very large volume of in-flooding water relative to the amount of residual elements is expected to result in water quality similar to Lac de Gras (Blowes and Logsdon 1998).

Flooding will continue until the open-pits and underground tunnels have fully flooded and the water level inside the dike area equals the water level of Lac de Gras. The area will be allowed to remain in this state for a minimum of 12 months to allow settling of any generated suspended solids. Water quality testing will be conducted to confirm that surface water in the pool area is adequate to commence decommissioning of the dikes to join the pool area with Lac de Gras.

At the A21 mine area, where there was no dewatering the water quality will be similarly verified at the completion of the A21 mining. It is anticipated that it may take longer for the water in the A21 mine area to clarify given the level of activity that will have occurred within this water area.

A154/A418 dike wall stability will increase as the dike enclosure is flooded. Long term sediment load from the dike embankments and A21 sediment control structure is not expected to be a concern since the lake sides of the dikes will have been exposed to wave action and the mine side of the dikes will have been washed by precipitation (A154/A418) or lake water (A21) for approximately 10 to 20 years.

Thermosysphons, instrumentation and power lines will be removed form the surface of the A154/A418 dikes. Dike crest edges will be trimmed to produce a sloping surface to towards the water.

The breaches will be localized, and will be managed to achieve the desired water circulation and navigation. The water retention dikes will be breached in a manner that enables the restoration of navigation on Lac de Gras that is acceptable to Navigable Waters Protection Division (DFO 2000).

The following breaches are planned but may be changed as the design progresses:

- A154 - 2 breaches on the north side, 3 breaches on the east;
- A418 - 1 breaches on the south side and 2 breaches on the east; and
- A21 - 3 breaches on the south and east sides and 1 breach in the causeway.

Breaching will consist of approximately 30 m wide slots with a minimum water depth of 2 m. The breaching will involve:

- Excavating granular fill;
- Breaking and excavating concrete wall installation guides; and
- Breaking and excavating upper portions of the plastic concrete wall.

The anticipated final landscape for the preferred closure option described above is depicted in Figure 5-4.

5.2.1.4 Reclamation Activities and Associated Engineering and Environmental Work

Figure 5-5 shows the general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the open-pit, underground and dike area. A brief description of each activity follows.

Mining Activities – The mine areas are currently expected to be active until 2022 limiting the closure activities.

Engineering/Environmental Studies – There are a number of engineering and environmental studies that need to be undertaken to prove up the preferred closure concept for these areas, address uncertainties and reduce risks. These primarily relate to expected water quality and fish habitat designs in the A418 and A154 areas and the properties of the settled A21 kimberlite.

Community and Regulatory Engagement – Continued engagement is anticipated to refine the closure plans for this area. In particular engagement is envisaged with regard to Traditional Knowledge review input of final fish habitat configuration. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Design – A final engineering closure design for this area will be completed and submitted for review in 2015. This design would incorporate findings from engineering and environmental studies, research, community and regulatory engagement etc.

Detailed Engineering – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years prior to the initiation of the final closure work.

Complete Fish Habitat Construction – Complete any final fish habitat construction work not completed during operations.

Decommissioning of Surface Mine Infrastructure – Removal of mining equipment and associated infrastructure for A148/A154 open pits and A21 mining area.

Decommissioning of Underground Mine Infrastructure – Removal of mining equipment, and associated infrastructure, sealing of surface access locations for A148/A154 underground in preparation for flooding.

Flood Mine Areas – Clarity Water – Flood the A154/A418 open-pit and underground mine areas. Monitor clarification of A154/A418 and A21 pool areas.

Decommissioning of Dikes/Sediment Control Structures – Excavation of breaches to re-connect Lac de Gras with mine area.

Performance monitoring – Performance monitoring will be conducted starting in 2024 in preparation for decommissioning the dikes/sediment control structure. Emphasis will be on water quality in the mine areas followed by monitoring of fish habitat use.

Engineering Inspections – Inspections would commence prior to flooding of the A154/A418 mine areas in the years immediately following to review the closure performance.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras and wildlife effects.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

5.2.1.5 Residual Effects

Post-closure environmental conditions in the open pit, underground and dike area are expected to improve measurably over environmental condition during operations. Residual environmental effects will however still exist post-closure. Potential residual effects of note include:

- Areas within Lac de Gras with water depths of greater than 200m and water quality different from the surface water in Lac de Gras;
- Water quality in the mine areas that will be initially different from Lac de Gras and may experience turbidity events during high wind/wave events greater than experienced elsewhere in Lac de Gras;
- Development of high primary productivity zones within the original mine areas that is uncommon in Lac de Gras but beneficial for fish;
- The mine areas will appear differently than pre-development particularly with regard to the remnants of the dikes/sediment control structures and changes to the shoreline.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). The residual effects identified above fall within the general range of effects considered in the EA. This initial assessment of the cumulative effects from all closure areas is summarized in Section 9. The residual effects noted above are not expected to be significant adverse effects.

5.2.1.6 Uncertainties, Risks and Research Plans

Two uncertainties have been identified in relation to the open-pit, underground and dike areas. Other specifics of the closure design will be addressed as part of the engineering design. Two uncertainties of note are:

- Flood rate and relative proportions of groundwater and surface water to optimize final surface pool water quality for A154/A418 mine area; and
- Natural settling properties of A21 kimberlite that will influence closure conditions in the A21 mine area;

One risk has been identified by DDMI:

- Water quality in one or more of the mine areas that would prevent re-joining the mine area pool with Lac de Gras.

Specific Closure Research includes:

- Prediction of Closure Water Quality in a Flooded A154/A418 Pit/Dike Area (see Appendix VIII-5)
- Traditional Knowledge Review/Modification of Fish Habitat Designs – A154/A418 Pit/Dike Area (see Appendix VIII-6)
- Fish Usage of Exterior Slopes of Dikes A154/A418 (see Appendix VIII-7)
- Physical, Chemical and Biological Characterization of Settled A21 Kimberlite (see Appendix VIII-8)

5.2.1.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. This detail is not appropriate in an Interim Closure and Reclamation Plan but will be required for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized below and in Appendix VI-1.

General guidance relevant to post-closure monitoring of the open-pit and underground area is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) is as follows:

Underground

- Inspect sealed areas
- Check for surface expression (subsidence) of underground failure
- Conduct geotechnical assessment of the overall safety and risk within the subsidence zone.
- Install and check thermistors where appropriate to monitor freeze-back in permafrost areas and to confirm that the ground thermal regime is not degraded
- Periodic backfilling of areas of subsidence may be required
- Inspect groundwater plumes and hydrogeology

Open-pit

- Identify areas that are not stable
- Check ground conditions to confirm permafrost conditions are being re-established as predicted
- Sample surface water and profiles of flooded ponds/pits
- Ensure that there is sufficient water supplied to maintain an appropriate water depth for flooded pits

- Sample quality of groundwater seeping from pit walls to assess potential for contamination of mine water due to melting permafrost and ARD/MLch from pit walls.
- Identify and test water management points (including seepage) that were not anticipated
- Inspect barriers such as berms, fences, signs and inukshuks
- Inspect fish habitat in flooded pits where applicable

DDMI anticipates that there would be two types of post-closure monitoring programs: performance monitoring specific to the open-pit, underground, dike areas and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring would include:

- Surface water quality in mine areas and depth profiles;
- TSP and dust deposition/quality measurement;
- Geotechnical inspections including observations of subsidence, erosion, thermal condition, etc. as described above; and
- Wildlife use of the area.

In addition to area specific monitoring, environmental effects post-closure would be monitored through a continuation of a Post-Closure Aquatic Effects Monitoring Program in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods would be drawn from the operations monitoring programs and revised along with the monitoring frequency as appropriate to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs to nay erosion of dikes or shoreline;
- correction of identified wildlife hazards.

Results of all monitoring and maintenance would be documented in post-closure monitoring and maintenance reports. These reports would include any recommendations for future corrective actions or changes to monitoring programs.

5.2.1.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the open-pit, underground and dike area is shown in Figure 5-4. This landscape shows the breach locations in the A21, A154 and A418 mine areas and the sections of the dikes and sediment control structures that would remain. DDMI does not expect this final landscape to change considerably moving forward.

5.2.1.9 Contingency Program

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks are evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.1.6),

- Aerial application of lime, alum or a synthetic polymer to assist in clarifying mine area pool water to achieve acceptable water quality prior to dike breaching;
- Controlled exchange of mine area surface water with Lac de Gras water to improve pool water quality prior to dike breaching;
- Allow more time for pool areas to clarify before breaching dikes;
- Consider not breaching dikes if breaches would put Lac de Gras at significant risk.

5.2.2 Permanent Closure Requirements – Waste Rock and Till Storage

5.2.2.1 Pre-disturbance, Existing and Final Mine Site Conditions

The area used for wasterock and till storage is shown pre-disturbance, in Figure 5-6a. The image is from June 2000 and shows some initial pioneering roads and the start of the quarry for the A154 dike construction. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. Some archaeological sites were identified in this area (Figure 3-26) and an esker. No other specific or unique environmental conditions are of note in this area.

The extent of the current wasterock and till is shown in Figure 5-6b using an image from August 2009. The Figure shows the till area, wasterock and the inert landfill. The maximum height of the wasterock is elevation 495 m. Quantities by rock type are included in Section 4.4.3.

Figure 5-6c shows the wasterock and till area at the maximum extent of development 2012. After this year some wasterock will be re-mined for use as underground backfill and other construction/closure activities.

5.2.2.2 Closure Objectives and Criteria

General guidance relevant to the wasterock and till area closure objectives are provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Minimize erosion, thaw settlement, slope failure, collapse or the release of contaminants or sediment
- Build to blend in with current topography, be compatible with wildlife use, and/or meet future land use targets
- Build to minimize the overall project footprint
- Develop and implement preventative and control strategies to effectively minimize the potential for ARD and MLch to occur
- Where ARD and MLch are occurring as a result of mine activities, mitigate and minimize impacts to the environment
- No reliance on long-term treatment as a management tool (e.g. effluent treatment facilities are not appropriate for final reclamation but may be used as a progressive reclamation tool)
- Minimal maintenance requirements in the long-term

Additionally, *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009) provides recommendations for decommissioning of wasterock piles:

- R 524: At the end of the mine operations phase, detailed inspections and assessments of wasterock piles and tailings management facilities, particularly dams and other containment structures, should be carried out. The objective of these inspections and assessments is to evaluate the actual performance against design projections related to anticipated post-closure conditions. Factors that should be considered include:
  - the extent of deformation;
  - the rate and quality of seepage;
  - the condition of foundations and sidewalls; and
  - design loads, which may be different after mine closure.
- R 525: At the end of the mine operations phase, comprehensive risk assessment should be conducted for mine closure to:
  - evaluate the long-term risk associated with possible failure modes for wasterock piles and tailings management facilities;
  - identify possible impacts on the environment and human health and safety in the event of a failure;
  - determine parameters critical to these failure modes and possible impacts; and
  - develop and implement long-term control strategies to manage the identified risks.
- R 527: At the end of mine operations phase, plans for management of wasterock and tailings to prevent, control and treat metal leaching and acidic drainage should be re-evaluated and revised as necessary, to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
  - the results of the re-evaluation of the performance of these facilities;
  - the performance of progressive reclamation to date; and
  - possible alternative technologies for closure.
- R 529: At all mines that exist in permafrost conditions, downstream slopes of tailings containment structures should be revegetated.

Closure objectives have been developed specific to the DDMI wasterock and till area (Appendix V Table V-2). They were developed through workshops and reviews coordinated by the WLWB (see Section 2.4). These area specific objectives may be revised with subsequent updates to this Interim Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

Appendix V Table V-2 also describes proposed closure criteria. Closure criteria are intended for use in evaluating success in achieving the objective. The intent is to have closure criteria that are specific and measurable. It is recognized that some of the criteria in Table V-2 are more general and less easily measured. As the closure plan evolves, particularly as the details of the preferred closure option are determined, DDMI expects that more specific closure criteria will be identified. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.2.3 Preferred and Alternative Closure Options

Closure planning commenced with the initial mine design work in 1996 to 1998. Many of the important design decisions related to closure occurred at this time. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the wasterock and till being managed, closure plans also advance. Closure planning typically involves reviewing benefits and risks for possible closure options. These reviews are both internal to DDMI and external with communities, government and regulators.

The following describes the general chronology of closure options considered ending with the preferred option.

Wasterock Pile Closure Options 1996 to 1998

Sizeable volumes of wasterock are removed in the process of mining the kimberlite ore. Three general locations were considered when evaluating alternative sites to store the mined wasterock:

1. A typical wasterock area could be placed on the East Island near the open pit being mined;

2. A open-pit that has already been mined could store wasterock from an active open-pit (backfilling); and

3. Wasterock could be placed in Lac de Gras as a widening of the dikes (top widths of greater than 500 m were considered).

The three siting options are shown in Figure 5-7. Advantages and disadvantages of each alterative are discussed below.

Geochemistry was a predominant factor in evaluating the site of the wasterock area. Geochemical testing of the wasterock identified that while the general sulphide content of the wasterock is very low (0.04% Wt), there is still potential for some metals to leach from the wasterock areas (Sala and Geochemica 1998). The preferred method to control the leaching of metals was to place material sub-aqueously, where reduced oxygen levels limit the leaching reactions. This was the reason for the Lac de Gras alternative. Wasterock mined after the dikes were constructed could be put into the lake allowing the material to be permanently stored in an oxygen-limited environment. Some on-land storage would likely have been required to accommodate all of the mined wasterock.

Placement of country rock on the East Island has disadvantages from a geochemical perspective. Leaching of metals could be controlled by long-term water management measures that might include capping the country rock to reduce metal leaching and/or the continued operation of a water treatment facility.

Backfilling of a mined pit has geochemical advantages if the backfilled pit can be filled with lake water immediately after the wasterock has been placed. This would provide long-term storage in an oxygen-reduced environment, therefore limiting leaching reactions. However, if the wasterock is backfilled and not immediately covered with water then metals would leach and pool within the open pit and form precipitates on the wasterock. When the backfill pit is eventually filled with water, precipitates would move into solution and potentially result in unacceptable water quality in the flooded area. This would also be the case if the wasterock was stored on the surface over the mine life and later re-mined and placed into a completed pit. Similar precipitates would be expected to form on this wasterock. Even if this option were chosen, not all the wasterock could be backfilled. The volume of wasterock to be placed is 30-40% larger than the volume where the rock was mined due to void spaces in the blasted rock. Additionally, the mined out pit would not be available for storage during mining of the first open-pit and the final open-pit could not be used for backfilling.

Moving mined wasterock to the place it is ultimately stored is an appreciable component of the mining cost. Only loading and hauling wasterock once and reducing haul distances can, therefore reduce mine costs. Of the three alternatives, storage on the East Island with no additional rock placed into Lac de Gras and no backfilling would have the greatest total haul distance. Backfilling and use of Lac de Gras would have comparable total haul distances.

Although the post-closure appearance of the wasterock pile was not raised as a predominant issue in the initial community and regulatory consultations, the visual appearance of the wasterock area was considered. The least visual impact would result from either the Lac de Gras or the backfilling alternatives. Both would result in the smallest amount of wasterock being left in a location that could be readily seen on the East Island. The wasterock area could be created higher with a smaller surface area or flatter with a larger surface area.

One alternative, backfilling was eliminated from further consideration on the basis of technical and economic feasibility. The full advantages of backfilling can only be realized if a completed open-pit is available. Since open-pit mining of A418 and A154 is to be followed by underground mining, neither would be available for backfilling. Re-mining and hauling over 100 million cubic meters of wasterock post-closure to a completed pit area at an expected to cost around $5.65 per cubic meter of rock (Brodie 2007) would be uneconomical.

From a community perspective, placement of country rock in Lac de Gras as an extension of the dikes, was viewed as placing waste where waste did not belong.

The geochemical benefits of underwater storage of country rock appears to be a generally accepted theory within the regulatory community. However, the benefits of geochemical control versus the potential effects on fish habitat were raised. It was unlikely that DFO’s “No Net Loss” policy for fish habitat could have been achieved with extensions of the dikes to allow storage of mined wasterock. Therefore this alternative was not proposed.

The final decision from the EA and the basis for the Water License and Land Leases is wasterock piles on the East Island, restricted to two areas (north for A154 and A418 – south for A21).

Wasterock Area Closure Options

Guidance on generic options for closure of wasterock and overburden areas that are provided in INAC (2007) and relevant to the wasterock and till area include:

- Doze down crest if required or construct toe berm to flatten overall slope
- Remove weak or unstable materials from slopes and foundations
- Off-load materials from crest of the slope
- Leave waste piles composed of durable rock “as is” at the end of mining if there is no concern for deep-seated failure or erosion, and if the end land use targets can be achieved
- Cover to control reactions and/or migration (re-slope to allow for cover placement if necessary)
- Place riprap insulation/stabilization layer
- Freeze waste into permafrost
- Place potentially acid generating rock underwater or underground if available
- Place potentially acid generating within the centre of the waste pile so it is encapsulated be permafrost if conditions permit and underwater or underground disposal are not viable options
- Construct collection system to collect contaminated runoff or leachate
- Construct diversion ditches to divert uncontaminated runoff
- Install horizontal drains or pump leachate from relief wells at the toe of the slope
- Passively treat contaminated waters where necessary, active treatment is not acceptable for the long term
- Use benign waste rock as backfill in underground mine workings, to seal portals, to fill open-pits, or for construction material such as ramps or covers
- Revegetate using indigenous species or use other biotechnical measures (use of living organisms or other biological systems for environmental management) to reduce surface erosion
- Reslope, contour and/or construct ramps to facilitate wildlife access
- Use inukshuks to deter wildlife where appropriate (guidance from local communities and Elders should be sought)
- Include records of construction drawings, as-built drawings, location of landfill sites, and potential ARD material and other contaminated materials which are contained within the rock pile in the reclamation research plan.
- Control acid water at the source, preventing contaminated water flows, and allow contaminated water to be collected and treated (this would be incorporated into water management system)
- Divert or intercept surface and groundwater from ARD source

- Install covers and seals to prevent or reduce infiltration
- Induce or maintain freezing conditions to limit the formation and discharge of leachate
- Place acid generating materials in topographic lows or depressions where they are most likely to be submerged under water under natural conditions
- Mitigate consequences of ARD by the use of passive and active treatment systems, as appropriate for in-situ conditions
- Passive treatment measures include:
  - Chemical (alkali trenches, attenuation along flow path)
  - Biological (sulphate reduction, wetlands, metal uptake in plants)
  - Physical (physical removal – filtration by plants, attenuation)
- Active treatment measures may include:
  - Chemical (Lime neutralization, adsorptive process)
  - Biological (Sulphate reduction)
  - Physical (Solid/liquid separation)

Original Closure Design – 2001

The original closure design for the wasterock and till area is documented in the Initial Abandonment and Restoration Plan (DDMI 1999b), the 2001 Interim Abandonment and Restoration Plan (DDMI 2001b), the 2006 Interim Closure and Reclamation Plan – Version 2 (DDMI 2006) and the Country Rock and Till Storage Update Design Report (NKSL 2001a).

The original closure design for the wasterock and till area described in the references above can be summarized as follows:

- Segregate wasterock in the pit into three types based on acid generating potential.
- Separate the storage area by drainage basin and place the highest acid generating potential rock in the most secure drainage basin. Separate rock types by storage areas (i.e. drainage basins).
- Type III rock has a higher percentage of biotite schist rock, which has the greatest potential for acid generation. Final closure design included a 1.5 m till cover layer protected with a 3 m Type I rock to prevent seepage and oxygen infiltration. The covers was to be placed as areas of the pile reach final elevation and suitable cover materials became available. Once the cover was in place and the till frozen, the cover would inhibit the penetration of water and oxygen into the Type III rock. The rock cover would also provide erosion protection.
- Type II rock has a very low potential to leach metals in an arctic environment. This rock was to be placed in separate watersheds from the other rock Types so that the final cover design could be confirmed from seepage observations. The treatment of Type II rock consisted of placing 4 m of Type I rock over the Type II to keep the active layer completely within the Type I rock.

- No cover was anticipated for Type I rock areas with no acid generating potential.
- The wasterock area was to be surrounded with a perimeter road with ditches and collection ponds so that all surface and seepage water could be collected and checked for water quality. Water meeting Lac de Gras discharge criteria, was to be discharged to Lac de Gras during operations. Water that did not meet these criteria will be pumped to the PKC Pond or NI.
- The wasterock and till storage area would include shallow gradient ramps at final closure to allow caribou migration.
- A south wasterock and till storage area was included in these original closure designs for the wasterock and till from the A21 pit area. This wasterock was expected to be all Type I.

2009 Review

DDMI undertook a critical review of the approach described above for closure of the wasterock and till area. The review was guided by information, review and experience gained to date with regard to:

- Operational seepage water quality and quantity
- Preliminary results from the Test Pile Research Program
- Thermal results and observation from the BHPB Ekati operation.
- 2006 ICRP review comments
- Life-of-Mine Plan
- Material Quantities

Challenges identified included:

- Availability of direct haul Type I and till materials for closure.
- Constructability – Long term stability of a 3 m rock cover over a 1.5 m till layer.
- Till layer performance – ability of the till layer to prevent water infiltration.
- Thermal – ability to maximize permafrost area of pile.

Experience gained to date:

- Type I and till will not be available for direct haul as cover.
- Type I and till quantities limited.
- Lack of poor quality seepage from the area to date.
- Importance of wind driven winter super cooling in permafrost development
- Current depth of active layer measured in test piles
- Possible benefits of limiting wildlife access to pile post-closure

During the review two closure design options became apparent:

1. Should the slopes in the wasterock area be steeper or flatter?

2. Is a till cap layer required on the top surface, side faces, or not at all?

Flatter side (batter) slopes would improve aesthetics, increase wildlife access and provide a better surface for placement of a till cap layer if this is required. Flatter side slopes would likely result in a larger footprint. Flatter slopes also means larger batter surface areas where rain and snow/melt can accumulate and infiltrate. Steeper side slopes are expected to be better suited to movement of cold air into the wasterock pile promoting permafrost development.

Benefits of a till layer relate primarily to reducing risk that the wasterock area would generate low quality seepage. A till layer may reduce the infiltration of rain/snow melt and may limit the re-supply of oxygen within the pile. A till layer placed on an unfrozen or partially frozen pile can reduce the rate of permafrost development by impeding the movement of cold air into the pile. However if the till layer is placed in the winter on a completely frozen pile then the till layer could reduce the extent of seasonal thaw.

The performance of a till layer with regard to controlling rain/snowmelt infiltration is uncertain. To be most effective this till layer needs to be low permeability material and kept within the permafrost zone. Initial information from the DDMI Test Pile Research, supported by ground temperature monitoring at Ekati suggests that the seasonal active zone in a wasterock pile could be greater than 5 m. Water movement through the wasterock pile occurs as matrix flow with preferential flow paths occurring during high intensity infiltration (rain or snowmelt). These flow mechanisms are likely to develop with or without a till layer because of till permeability. Till permeability is about an order of magnitude lower than dumped wasterock. Unfrozen till may be of sufficient permeability to reduce air movement but may not prevent water infiltration. Till permeability is expected to be of similar magnitude to the compacted waste rock surface caused by traffic and vehicle movement, such as the traffic surface currently at on the top of the wasterock area.

Cold air movement into the wasterock pile is being found to be an important control for reducing the risk of poor seepage water quality. Maximizing the extent of the permafrost zone in the wasterock pile appears to be the leading mitigation approach at Ekati (BHPB 2008). DDMI Test Pile Research results are still preliminary and require several more years of observation, but they appear to indicate a similar conclusion.

Seepage monitoring of the wasterock area has not identified any discrete seepage zones. Water quality in collection Ponds 1, 2 and 3 similarly do not indicate ARD or metal leaching from the wasterock piles. However, it should be noted that the water quality of these collection ponds is significantly influenced by PKC water, surface runoff and precipitation that has been either pumped to these ponds or collected in them.

Preliminary geochemical results from the DDMI Test Piles Research support the original geochemical investigations. The sulphur content of the wasterock is a good predictor of geochemical loading.

The option around side slopes and use of till were also included in the May 2009 Options Workshop. Identified advantages and disadvantages from the workshop are summarized in Appendix IX-4.

The outcome from the 2009 DDMI review with regard to the closure approach for the wasterock and till area can be summarized as follows:

- Changes to mine plan (removal of A21 open-pit) has eliminated the option of direct placement of till and Type I rock as a cover for the wasterock area.
- Emphasis should be placed on development of permafrost within the wasterock area through vertical exposure of run-of-mine sized rock.
- Consider till/rock cover as a contingency pending results from continued wasterock area monitoring over the next 10 years and DDMI Test Pile Research results.
- Dump planning for the remaining two years of open-pit mining to focus on strategies for placement of Type I and Type III rock to best supports final closure plans for the area.
- Need to develop a re-mining plan for use of wasterock for underground backfill that similarly supports final closure plans for the area.

Wasterock and Till Area – 2009 Preferred Option

This alternative closure approach of utilizing the 10 year period from 2011 (end of wasterock and till pile development) to 2022 (end of kimberlite production) to determine if there are any areas where additional closure actions may be required, is the DDMI preferred option for closure of the wasterock and till area.

The operational approach to managing the potential for poor quality seepage from the wasterock area through waste segregation remains as per the original design. Wasterock is segregated into three types in the A154 and A418 pits and hauled to the wasterock area where it is placed in designated areas. The areas are designated by drainage basin with the overall goal being to concentrate Type III rock (highest potential for generating poor quality seepage) in the basin developed from the initial construction quarry and the drainage basin for Pond 3 (see Figure 5-8).

Wasterock production from the open-pits will end in 2011 with the completion of the A418 open-pit. Underground mining produces relatively small amounts of wasterock. Placement of wasterock over the next two years represents the final opportunity to strategically place rock for final closure without having to double handle any material. The wasterock area plan for the next two years includes:

- Designated landfill area for ongoing use during operations and closure.
- Stockpile of Type III rock for use in underground backfill.
- Maximize the thickness of low sulphur rock on perimeter slopes.

The designated landfill area is shown in Figure 5-6. It is within the Type III rock area and located to facilitate a final cover of rock.

From 2009 to 2011 Type I wasterock will be placed on the outside of final Type III rock faces. The current plans have these primarily located at the western boundary of the wasterock area. The intent is to manage the batter zones of the wasterock area, particularly the batter zones that are on original ground, to reduce the risk of poor quality seepage. Batter zones are expected to be the most exposed to rain/snowmelt infiltration and seasonal active zone thaw. The closure management approach for these zones is to:

- Minimize the sulphur content of wasterock in the batter zones. Higher sulphur content rock is expected to produce greater geochemical loading to any seepage or runoff waters. Sulphur content of batters can be managed both through placement of low sulphur rock in the batters but also by maintaining a steep side slope to minimizing the volume of rock in a batter.
- Enhance freezing. Steeper run-of-mine sized rock side slopes are expected to better enable movement of cold air into the wasterock pile to promote the development of a permafrost core.

Underground mining from 2010 to 2022 requires backfilling of mined stopes for stability. The backfill materials will be produced in the paste plant. Current source material for the underground backfill is both Type I and Type III rock, but primarily Type I based on initial strength testing results. Investigations are planned to further investigate the possibility of using more Type III rock and possibly coarse kimberlite.

Wasterock used for underground backfill will be re-mined from the wasterock area. Re-mining the wasterock area provides an additional closure opportunity. The re-mining plan for the wasterock area includes:

- Stockpile of Type III material close to the paste plant for immediate use
- Secondary target Type III areas for re-mining
- Final landscaping of the wasterock area

The re-mining plan for the wasterock area can be revised as more information becomes available regarding:

- Use of Type III rock in underground backfill
- Final landscape shape of the wasterock area including wildlife access
- Geochemical performance

The final landscape for the wasterock and till area, based on current closure concepts, is shown in Figure 5-9. Figure 5-9a shows the wasterock area at 2022 based on the current re-mining plan. At 2022:

- All Type III faces would have a minimum 3 m thick zone of Type I rock on exposed faces.
- All slopes would be geotechnically stable.
- Type I material has been removed for the PKC cover.

In this preferred closure option, the till area is largely intact in year 2022. The intent is to keep this material stockpiled until a final use can be confirmed. Possible closure uses for this till material include substrate for revegatation work, final surfaces material, contingency capping material for any identified problem wasterock seepage areas.

Initial thoughts on wildlife access routes are shown in Figure 5-9b for ongoing review and suggestions.

Once seepage and runoff quality can be confirmed, natural drainage channels through Ponds 1, 2 and 3 will be restored by excavating the respective collection pond dams (Figure 5-9b).

5.2.2.4 Closure Activities and Associated Engineering and Environmental Work

Figure 5-10 shows the general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the wasterock and till area. A brief description of each activity follows.

Dump Development – The wasterock area is an active facility. It will continue to receive wasterock from open-pit mining through to 2011.

Re-Mining for Backfill – Waster rock will be re-mined for underground backfill starting in 2010 and continuing until 2022 (current plan).

Engineering/Environmental Studies – There are a number of engineering and environmental studies that need to be undertaken to prove up the preferred closure concept for the wasterock and till area, address uncertainties and reduce risks. Several of these studies are related generation of poor quality seepage water and will be studied as part of the DDMI Test Pile Research which will be completed by 2014.

Performance monitoring – Extended performance monitoring will be conducted starting in 2012. At this point the final footprint of the wasterock area will be known. Emphasis will be on seepage water quality, thermal monitoring, any wildlife interactions and stability.

Community and Regulatory Engagement – Continued engagement is anticipated to refine the closure plans for this area. In particular engagement is envisaged with regard to options and closure criteria for wildlife including the integration of Traditional Knowledge. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Design – A final engineering closure design for this area will be completed and submitted for review in 2015. This design would incorporate findings from engineering and environmental studies, research, community and regulatory engagement etc.

Detailed Engineering – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years prior to the initiation of the final closure work.

Wildlife Access and Contouring – The detailed engineering design will be used to guide the re-mining work on the wasterock area to achieve final surfaces, access routes through the area, etc.

Decommissioning of Collection Ponds – Once runoff and seepage water quality/quantity have been confirmed, decommission collection ponds including removal of any pumping/piping infrastructure.

Engineering Inspections – Inspections would be conducted toward the end of the re-mining work and in the years immediately following to review the closure performance.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras and wildlife effects.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

5.2.2.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred closure plan the wasterock and till area. Potential residual effects of note include:

- The wasterock pile is a significant landscape feature that did not exist pre-development and will remain visibly different;
- There will be a permanent loss of the vegetation and associated wildlife habitat and some archaeological information that was covered by the wasterock and till;
- Even with revegatation efforts there will be an increase in the area of "human disturbed" category of vegetation/land cover (VLC) type;
- Localized seepage/runoff water quality and quantity will be changed from pre-development;
- Some small inland water bodies and ephemeral streams will be permanently covered by the wasterock and till;
- The wasterock pile may become a new attractant to caribou as an area to use for insect avoidance.
- Winds may generate dust from the wasterock and till and from new rock surfaces. Dust would be deposited on adjacent vegetation or water bodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). The residual effects identified above fall within the general range of effects considered in the EA. This initial assessment of the cumulative effects from all closure areas is summarized in Section 9. The residual effects noted above are not expected to be significant adverse effects.

5.2.2.6 Uncertainties, Risks and Research Plans

There are numerous uncertainties related to the detailed closure design that will be addressed through final design process. Anticipated key uncertainties with the preferred closure approach include:

- Seepage water quality and quantity;
- Wasterock requirements for underground backfill;
- Requirements for wildlife movement;
- Rate of permafrost formation; and
- Impact of climate change;

The closure risk of note for the wasterock and till area is seepage water quality/quantity that is not adequate for release onto the tundra or that is not adequate for release into Lac de Gras.

Closure Research

Specific research activities that are anticipated to provide specific input into the final closure design include:

- DDMI Test Pile Research – geochemistry, hydrology, microbiology, thermal, oxygen movement behaviour of wasterock (see Appendix VIII-3).
- Wildlife Movement – Traditional knowledge and science specifications for routing wildlife over and around the wasterock and till area (see Appendix VIII-2)
- Wasterock for Underground Backfill – engineering investigations to determine source materials for underground backfill (see Appendix VIII-4)

5.2.2.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. It is DDMI's understanding that this detail is not required for an Interim Closure and Reclamation Plan but will be required for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized below and in Appendix VI-2.

General guidance relevant to post-closure monitoring of the wasterock and till area is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Periodically inspect areas where stabilization measures may be required
- Periodic inspections by a geotechnical engineer to visually assess stability and performance of waste pile and cover(s)
- Periodically inspect ditches and diversion berms
- Examine ground conditions to confirm predicted permafrost conditions are being established as predicted
- Check thermistor data to determine thermal conditions within waste piles to confirm predicted permafrost aggradation/encapsulation where applicable
- Test water quality and measure volume from controlled discharge points of workings to confirm that drainage is performing as predicted and not adversely affecting the environment

- Identify water discharge areas (including volume and quality) that were not anticipated
- Inspect physical stability of the mine site to confirm that no erosion, slumping or subsidence that may expose potentially ARD/MLch material to air and water are occurring
- Inspect any preventative and control measures (e.g. covers) to confirm that they minimize water and/or air exposure
- Confirm that predicted water quality and quantity of chemical reactions is occurring
- Develop monitoring locations and frequency on a site by site basis, incorporating locations where possible contaminated drainage may be generated, and where drainage may be released to the water management system or to the environment (also include downstream/down gradient locations)

DDMI anticipates that there would be two types of post-closure monitoring programs: performance monitoring specific to the wasterock and till area and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring would include:

- Seepage quality and quantity using a system similar to the Surveillance Network Program;
- Geotechnical inspections including observations of settlement, erosion, surface drainage, thermal condition, etc.;
- TSP and deposition/quality measurements of any dust generated from the closed wasterock and till area; and
- Wildlife use of the area.

In addition to area specific monitoring, environmental effects post-closure would be monitored through a continuation of a Post-Closure Aquatic Effects Monitoring Program in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods would be drawn from the operations monitoring programs and revised along with the monitoring frequency as appropriate to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs related to stabilization;
- repairs to drainage routes; and
- corrections to any identified wildlife hazards.

Results of all monitoring and maintenance would be documented in post-closure monitoring and maintenance reports. These reports would include any recommendations for future corrective actions or changes to monitoring programs.

5.2.2.8 Post Closure Landscape

The current view of the preferred post-closure landscape for the wasterock and till area is shown in Figure 5-9a. This landscape includes:

- Minimum 3 m thick layer of Type I rock on any exposed Type III rock faces;
- Re-establishment of drainage channels at Ponds 1,2 and 3 and removal of any pumping/piping infrastructure (Figure 5-9b), and;
- Specific access routes for people and wildlife (Figure 5-9b).

5.2.2.9 Contingency Program

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.2.6),

- Collect and treat seepage water until quality/quantity is adequate for release onto the tundra into Lac de Gras
- Add a till/rock cap to target areas if inadequate seepage is identified. Till would be available until 2022 from the till area. Type I rock would be re-mined from wasterock area, collection pond dams, laydowns or roads.
- Enhanced passive treatment of targeted seepages.
- Revised wildlife access routes including possible local re-sloping.

5.2.3 Permanent Closure Requirements – Processed Kimberlite Containment Area

5.2.3.1 Pre-disturbance, Existing and Final Mine Site Conditions

The valley on the East Island where the processed kimberlite facility (PKC) was located is shown in a pre-disturbance condition in Figure 5-11a. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. Lake e10 is noted in the Figure. It was identified as being a representative inland lake for fish habitat. Features of this lake were modelled for possible inland lake fish habitat enhancement efforts. Some archaeological sites were identified in the PKC area (Figure 3-26).

Currently the PKC dams have been developed typically to the 460 m elevation as shown in Figure 5-11b using an image from August 2009. The Figure shows the new south barge access road, the area for fine processed kimberlite deposition, coarse kimberlite placement and collection ponds 4,5 and 7.

At maximum development the PKC dams would be raised to an elevation of .475 m. Figure 5-11c shows a representation of the PKC at final development in 2022.

5.2.3.2 Closure Objectives and Criteria

General guidance relevant to PKC closure objectives is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Stabilize slopes surrounding the tailings impoundment or containment system for flooded and/or dewatered conditions
- Minimize catastrophic and/or chronic release of the tailings based on associated risk
- Minimize wind migration of tailings dust

- Minimize the threat that the impoundment becomes a source of contamination (e.g. tailings migration outside of contained area, contamination of water outside of contained area)
- Blend with local topography and vegetation were appropriate
- Discourage human and wildlife access from physically and chemically unstable tailings sites

Additionally, *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009) provides recommendations for decommissioning of tailings management facilities:

- R 524: At the end of the mine operations phase, detailed inspections and assessments of wasterock piles and tailings management facilities, particularly dams and other containment structures, should be carried out. The objective of these inspections and assessments is to evaluate the actual performance against design projections related to anticipated post-closure conditions. Factors that should be considered include:
  - the extent of deformation;
  - the rate and quality of seepage;
  - the condition of foundations and sidewalls; and
  - design loads, which may be different after mine closure.
- R 525: At the end of the mine operations phase, comprehensive risk assessment should be conducted for mine closure to:
  - evaluate the long-term risk associated with possible failure modes for wasterock piles and tailings management facilities;
  - identify possible impacts on the environment and human health and safety in the event of a failure;
  - determine parameters critical to these failure modes and possible impacts; and
  - develop and implement long-term control strategies to manage the identified risks.
- R 527: At the end of mine operations phase, plans for management of wasterock and tailings to prevent, control and treat metal leaching and acidic drainage should be re-evaluated and revised as necessary, to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
  - the results of the re-evaluation of the performance of these facilities;
  - the performance of progressive reclamation to date; and
  - possible alternative technologies for closure.
- R 529: At all mines that exist in permafrost conditions, downstream slopes of tailings containment structures should be revegetated.

Closure objectives have been developed specific to the DDMI PKC area (Appendix V Table V-3). They were developed through workshops and reviews coordinated by the WLWB (see Section 2.4). These area specific objectives may be revised with subsequent updates to this Interim Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

Appendix V Table V-3 also describes proposed closure criteria. Closure criteria are intended for use in evaluating success in achieving the objective. The intent is to have closure criteria that are specific and measurable. It is recognized that some of the criteria in Table V-3 are more general and less easily measured. As the closure plan evolves, particularly as the details of the preferred closure option are determined, DDMI expects that more specific closure criteria will be identified. The process of ongoing refinement of the criteria will include further discussions with communities and regulators

5.2.3.3 Preferred and Alternative Closure Options

Closure planning commenced with the initial mine design work in 1996-1998. Many of the important design decisions related to closure occurred at this time. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the processed kimberlite being managed, closure plans also advance. Closure planning typically involves reviewing benefits and risks for possible closure options. These reviews are both internal to DDMI and external with communities, government and regulators.

The following describes the general chronology of closure options considerations ending with the preferred option.

PKC Closure Options 1996-1998

There were two important decisions made as a part of the original mine design related to the PKC and closure; the location of the PKC and the site water management approach.

Three PKC siting options were considered in the original mine design and document as part of the EA (DDMI 1998a):

1. T-lake, a natural topographic feature on the mainland, east of the East Island,

2. The central valley on the East Island, a

3. Lac de Gras, between the East and West Islands

The three siting options are shown in Figure 5-7.

The T-Lake location was considered initially to have the best natural features for design of an on-land PKC facility. The steep hills surrounding the lake, combined with the deep lake, could accommodate the required storage volumes while limiting the number and extent of engineered structures. The facility could be accessed with the development of a causeway extending from the East Island to the mainland.

On the East Island the only appreciable topography occurs in the central valley. While providing less natural storage volume than T-lake, the central valley was closer to the open-pits, would not require a causeway, and is within a smaller drainage basin than T-lake, thereby providing some water management advantages.

The third option was the area of Lac de Gras between the East and West Islands. This area could be dammed off as a series of cells with processed kimberlite displacing Lac de Gras water. Ultimately, this area would be filled with processed kimberlite and capped with water. This option would manage any potential geochemical concerns by storing the processed kimberlite sub-aqueously (underwater). Also, this option would provide the best assurance of long-term stability (i.e. lowest elevation relative to Lac de Gras), and low potential for generation of poor quality leachate.

Options were discussed with communities during initial meetings in June 1997. Diavik's understanding from comments and discussions during these meetings was that water is considered to have a very high value, and that it was not appropriate to use areas of Lac de Gras for disposal of significant volumes of processed kimberlite. This was a clear indication to Diavik that the Lac de Gras option, while advantageous from a geochemical and closure perspective, would not be considered acceptable by communities. Diavik also understood that there was a general preference to minimize the extent of the development and to keep the footprint of the mine as small as possible. This guided Diavik's decision for placing the PKC on the East Island over using T-lake.

Closure was an important consideration in determining the location of the PKC facility. The Lac de Gras location would be the most secure closure alternative in the long-term. The advantages of this location included both geochemical control, through sub-aqueous placement of materials, and physical stability, since the material would be placed below lake levels. The T-lake alternative is towards the mouth of a sizeable drainage basin and would require a water diversion around T-lake for closure.

Options for the PKC location were discussed with DFO and reviewed by fisheries biologists. Concern was expressed over the Lac de Gras option because the area between the East and West Islands is shallow, sheltered habitat that is uncommon in Lac de Gras. Permanently removing this habitat for use by fish in Lac de Gras was deemed undesirable. From a fisheries perspective, locating the PKC in either T-lake or the central valley of the East Island was preferred over Lac de Gras.

The final decision from the EA and the basis for the Water License and Land Leases is a PKC located in the central valley on the East Island.

The planned operation of the PKC with regard to water was also an important consideration in reviewing water management options in the original mine design 1996-1998 (DDMI 1998a).

Water management alternatives were reviewed first based on the anticipated characteristics (quality and quantity) of the possible source waters. Plans focused on matching water use requirements with wastewater sources to identify opportunities to recycle and reuse water. Any remaining surplus water was considered for discharge to Lac de Gras, after treatment requirements and alternatives were examined. There were three primary water sources identified that required management:

- Runoff from the wasterock areas and plant site infrastructure. This water was expected to contain elevated concentrations of metals leached from the wasterock areas and would require treatment prior to discharge. Volumes were expected to be around 2,000 m^3/day.

- Processed kimberlite water ponded in the PKC. This water was expected to contain some metals leached from the kimberlite during kimberlite processing and from the containment area. Estimated excess water was expected to be around 2,500 m^3/day, after accounting for recycling and storage within the processed kimberlite.
- Mine water. This water is primarily groundwater that seeps into the open-pits and underground development. At full development water volumes were expected to reach 30,000 m^3/day.

The alternative water management plans, based on the general water qualities and quantities described above were as follows:

- treat and release the runoff and processed kimberlite water while using the minewater as make-up for the process plant; or
- treat and release minewater while using processed kimberlite and runoff water as make-up.

The second alternative, treating and releasing mine water while using processed kimberlite and runoff water as make-up water had some distinct advantages. Minewater was expected to have a good water quality requiring only filtration to remove suspended solids. It was also expected to have the largest volume. Therefore, minewater was considered to be the better water to discharge.

Processed kimberlite water and runoff water have the potential to contain elevated metals while having relatively low volumes. The total estimated volume of this water provided a close match with expected make-up water demand; therefore, processed kimberlite and runoff water were considered to be the best waters for recycling. However, excess water was expected to develop in the PKC that would require treatment and discharge. Some of this water would ultimately be contained with the processed kimberlite.

The final decision from the EA and the basis for water management on site to date has been to treat and discharge mine water and reuse processed kimberlite water and runoff water for the process plant.

PKC Closure Options

Guidance on generic options for closure of tailings areas that are provided in INAC (2007) and relevant to the PKC area includes:

- Stabilize embankments by removing weak or unstable materials from slopes and foundations and/or construct toe berms to flatten overall slope
- Breach water retention dams and drain impoundments, avoid post closure impoundment of water when possible
- Use a natural body of water that has sufficient storage capacity to hold the tailings and also a natural unimpeded flow via the drainage outlet if a permanent water cover is used

(this may not be viable if the supernatant water quality does not meet discharge water quality standards)

- Increase freeboard and/or upgrade spillway to prevent overtopping and possible erosion by extreme events
- Relocate and/or deposit tailings into underground mine workings or into flooded pits, depending on water quality considerations
- Flood to control acid generation and related reactions
- Cover to control acid generation and related reaction and surface erosion
- Promote neutralization reactions by use of alkaline materials for acid tailings
- Divert non-contact runoff away from the tailings facility to avoid contamination
- Promote freezing of tailings mass into permafrost if suitable conditions exits.
- Collect waters that do not meet the discharge criteria and treat passively, active treatment is not acceptable for the long term
- Remove structures, decant towers, pipes and drains where they already exist
- Plug decant towers, pipes, and drains with high slump (relatively liquid concrete which will flow to fill all voids) or preferably, expansive concrete, as a last resort
- Assess the soil around pipes for stability under the hydraulic gradients through the embankment, as this may be a potential zone of piping failure
- Avoid using diversion structures and ditching, especially in permafrost soils (diversion structures are not the preferred option into the long-term)
- Where diversion dams and channels are necessary, maintain them indefinitely to meet long term stability and hydraulic design requirements; design diversions and spillways for extreme events suitable for long term stability
- Provide frost protection cap over the phreatic surface for water-retaining dams
- Ditch, berm, fence or use alternative methods to deter access to motorized vehicles if compatible with end-use plans
- Establish indigenous vegetation, soil, riprap or water cover to control erosion

Original Closure Design – 2001

The original closure design for the PKC is documented in the Initial Abandonment and Restoration Plan (DDMI 1999b), the 2001 Interim Abandonment and Restoration Plan (DDMI 2001b), the 2006 Interim Closure and Reclamation Plan – Version 2 (DDMI 2006) and the Processed Kimberlite Containment Facility Engineering Updated Design Report (NKSL 2001b).

Figure 5-12 depicts the original closure concept described in the documents listed above. The key feature to note is the surface of the PKC Facility is elevated in the centre of the facility and graded down towards the perimeter to promote drainage of meteoric waters to a single controlled discharge point.

2009 Review

DDMI undertook a critical review of the approach described above for PKC closure. Operational considerations were also included in this review. The review was guided by information, review and experience gained to date with regard to:

- PKC pool water chemistry
- Operational PKC seepage
- PKC water balance
- 2006 ICRP review comments
- Processed kimberlite deposition and material balance
- Consideration of the physical properties of fine processed kimberlite

Challenges identified included:

- Constructability – particularly the rock dome over the slimes area.
- Ability to keep rain and snow melt separated from expelled pore water using a till barrier given the degree of anticipated differential settlement.
- Ability to maintain graded, positive drainage across the facility's surface based on the expected formation of thermokarst topography above the central pond/slimes area of the Facility.

Experience gained to date:

- Better than predicted water quality (Table 5-1)
- Negative water balance as compared with predicted positive water balance. Prediction was a surplus of around 2,500 m^3/day compared with current requirement of around 3,500 m^3/day fresh water make-up.
- Need to maintain a larger pond than originally planned to ensure water availability for reclaim to the process plant
- Regular operation of seepage collection ponds to return seepage water to the PKC.

Table 5-1 Comparison of Predicted and Actual Processed Kimberlite Containment Water Quality

	Units	Predicted [1]	Median	25th Percentile	75th Percentile
			Dissolved Metals		
Ag	mg/L	<0.0001	0.0002	0.0002	0.0002
Al	mg/L	<.001	0.01	0.01	0.01
As	mg/L	0.0019	0.0025	0.0019	0.0037
Ba	mg/L	0.049	0.261	0.210	0.359
Be	mg/L	<0.0002	0.0005	0.0005	0.0005
Bi	mg/L		0.00005	0.00005	0.00005
B	mg/L	0.07	0.032	0.025	0.034
Ca	mg/L	160	14.0	9.6	16.6
Cd	mg/L	0.0024	0.0005	0.0004	0.0006
Cl	mg/L		51.0	37.5	71.0

	Units	Predicted[1]	Median	25th Percentile	75th Percentile
Co	mg/L	0.0052	0.0002	0.0002	0.0004
Cr	mg/L	0.005	0.0009	0.0004	0.0025
Cu	mg/L	<0.0002	0.0009	0.0007	0.001
Fe	mg/L	0.02	0.005	0.005	0.005
Hg	mg/L		0.0001	0.0001	0.0001
K	mg/L	104	71.65	55.45	100.85
Mg	mg/L	283	24.50	15.55	36.35
Mn	mg/L	0.025	0.005	0.002	0.013
Mo	mg/L	0.623	0.348	0.264	0.388
Na	mg/L	108	66.1	52.925	76
Ni	mg/L	0.141	0.0137	0.0084	0.0160
Pb	mg/L	0.0006	0.0001	0.0001	0.0001
Sb	mg/L		0.0056	0.0044	0.0077
Se	mg/L	<0.0002	0.0012	0.0007	0.0019
Sn	mg/L	<0.001	0.0002	0.0002	0.0002
SO_4	mg/L	1400	183	132	243
Sr	mg/L	3.74	0.512	0.415	0.640
TDP	mg/L	0.027	0.010	0.005	0.015
Th	mg/L		0.00005	0.00005	0.00006
Ti	mg/L	0.005	0.0003	0.0003	0.0004
U	mg/L		0.0031	0.0007	0.0071
V	mg/L	0.019	0.0010	0.0009	0.0010
Zn	mg/L	0.0048	0.008	0.003	0.012
			Miscellaneous Parameters		
pH	pH units	7.95	8.66	8.26	9.26
Alkalinity	mg/L	67.9	90	71	108
EC	µS/cm	2700	868	728	1050
TDS	mg/L	2529	518	425	626
temp	°C		2.0	1.1	4.0
CO3	mg/L		5.0	5.0	9.5
HCO3	mg/L		96	79	107
TOC	mg/L		4	3.3	5
DOC	mg/L		4	3	4
DO	mg/L		6.5	4.2	9.3
NO_2 (as N)	mg/L	1.64	0.69	0.50	0.87
NO_3 (as N)	mg/L	83.4	5.98	4.60	9.18
NH_3 (as N)	mg/L	0.2	1.31	0.70	1.85
NO_2+NO_3	mg/L		7.10	6.10	9.69
TKN	mg/L	2.7	1.91	1.39	2.70
TSS	mg/L		11.0	7.0	25.0
Turbidity	NTU		13.4	8.4	24.3

Note 1 - Sources: Table 6-1 Blowes, D.W. and M. Logsdon. September 1998. Site water Quality Estimates for the Proposed Diavik Project.

What resulted from the critical review was an alternative closure design option that has a higher likelihood of meeting performance criteria over the long term. The focus of the second option was to enhance the consolidation of the slimes underlying the PKC pond water and decrease the amount of pore water expressed from further post-closure consolidation. It was determined that the best way to improve consolidation was to minimize the amount of free water (pond plus and unfrozen porewater) in the PKC. The sooner this could be done the greater the improvements in consolidation.

The limit on the minimum amount of free water is currently the requirement to have reclaim water available all year for the process plant. A minimum of about 4,500 m^3/d of reclaim water from the PKC is currently required for normal operation of the process plant. To ensure that this minimum can be accessed at the reclaim barge over the winter a pool size of greater than 1 Mm^3 of water is planned. Process plant production has been limited on occasions in the last few years due to a lack of pool water. The water balance around the PKC was originally predicted to yield an excess of water whereas the actual operations have required significant make-up water from Lac de Gras. In 2008 DDMI applied for, and received, a temporary (2 year) increase in fresh water use amounts to enable the development of a larger pool in the PKC. With a significant PKC pond volume, there was limited opportunity to enhance consolidation until process plant operations were finished – around 2022.

When combined, the negative water balance around the PKC and the better than predicted pool water quality (Table 5-1) identified the need to revisit the site water management plan. As described above, the existing site water management plan reuses PKC water and runoff water and, treats and discharges mine water. The premise for this was the predicted quality (worse) and quantity (surplus) of PKC pool water as compared to the actual quality (better) and actual quantity (deficit) of PKC water.

What has changed is that the quantity of available PKC pond water is significantly less than predicted and, the quality of the PKC water is better - in fact the PKC water (dissolved fraction) currently meets effluent quality criteria for discharge to Lac de Gras.

At the same time, groundwater that seeps into the open pit and underground mine workings (mine water), that is treated and discharged to Lac de Gras continues with volumes expected to reach 40,000 m^3/day. Chemistry of this water (ammonia and phosphorus) remains as an environmental management aspect.

As a result of the current conditions and to facilitate an alternative closure design the following changes to the site water management plan are currently underway:

1. Implement infrastructure to supply 100% of the process plant's water needs with mine water from the NI water and no raw water make-up from Lac de Gras and,

2. The PKC Facility will be operated as dry as possible to:

    a. minimize potential for entrapment of ice-lenses and

    b. Increase the degree of consolidation achieved during operations

These changes became the basis for revisiting the closure approach to the PKC. With these changes in water management, the free water in PKC pond could be minimized through out the year, thereby enhancing consolidation of the slimes.

The extent of post-closure consolidation was a key driver of the original PKC closure approach.

The following benefits are expected to arise from the changes listed above:

1. Diavik operations will use less fresh water.

2. The ultimate height of the PKC dams may be less due to reduced volumes of pore water and ice being trapped in the Facility.

3. Enhanced penetration of permafrost conditions due to less water and the attendant latent heat within the Facility.

4. A configuration that does not include ditches is consistent with NWT Guidelines (INAC 2007).

In addition to closure planning considerations, changing the water management approach would also provide operational benefits, including:

- Reduced loadings of phosphorus and ammonia to Lac de Gras
- Reduced seepage from the PKC and therefore reduced operation of PKC seepage collection ponds

DDMI made the decision in June 2009 to construct a pipeline from the NI to the process plant to provide 100% of the Process Plant water supply.

PKC Closure – 2009 Preferred Option

Changing the site water management, in particular removing the need for reclaim water from the PKC allows consideration of a different approach for closure. This revised approach while still at a conceptual engineering level, is the DDMI preferred option.

At closure, the PKC Facility surface will be provided with a low point near the southeast corner. As in the previous plans, surface runoff and expelled pore water will be directed south through an engineered outlet in the South PKC Dam and then through a series of channels and ponds eventually reaching Lac de Gras. The Facility's sloped surface will be formed during final years of operations by discharging fine processed kimberlite exclusively from the North, East and West PKC dams.

Initial discussion on final surface material have been largely guided by wildlife (caribou) requirements and engineering requirements to control wind/water erosion. From a caribou movement perspective options discussed included:

- physical barriers to prevent any access to PKC
- smooth final surface that would allow full and safe access
- trails to allow movement through the area

DDMI's preferred option at this time is to create a scarified (rough) final surface using waste rock with possible linear trails across the surface of the PKC following pre-development caribou routes. The trails would be smoothed for ease of caribou movement and would be wide enough for vehicles. Ramps would be constructed at the edges of the PKC to link the trails that cross the PKC with similar ground level trails.

Options considered for surface materials included (see Appendix IX-4 for photos of each material):

- PK beach material
- Coarse PK
- Wasterock Rock

Wasterock was selected as the preferred surface material. It is geochemically benign and has appropriate engineering properties for erosion control. Coarse kimberlite could similarly be used but comments from communities were taken to indicate a preference to limit any contact between caribou and kimberlite.

The scarified surface would not be specifically targeted for re-vegetation so as not to become an attractant to wildlife. This surface is expected to re-vegetate slowly over time.

Figure 5-13a is the concept drawing of the final PKC landscape. This landscape view represents our current thinking. It is intended for ongoing discussion and review.

The closure design for surface drainage has also changed. In the original closure concept the approach was to try to keep new water (from snow and rain), separated from porewater through the use of a 1 m thick till covered by 3 m of rock. The rain and snow melt was to follow engineered routes and be shed from the facility versus infiltrate into the processed kimberlite. Porewater that was expelled through ongoing consolidation would become permanently frozen in a central rock spacer that was under the 1 m till/3 m rock cover.

The alternative approach is a design that allows continual removal of freewater (porewater and rain/snow melt) from the facility. Removing this freewater will accelerate rates of consolidation and permafrost aggradation. The porewater/rain/snowmelt mixture would be routed south of the PKC through a series of channels and ponds, as originally planned, until it reached Lac de Gras.

This alternative drainage approach requires a different design. The south barge access road (Figure 5-11b) will be raised throughout operations. The preferred option proposes to use this road as a rock drain post-closure. The road fill would act as a conduit to pass water out of the PKC Facility by connecting the consolidating central slimes area with a proposed southern outlet from the PKC. Preferential deposition will provide a regional southern slope to the PKC surface and direct rain and snowmelt waters to the road area.

The south barge access road, which is made from run-of-mine rock, is ideally suited to function as a drain:

1. Void spaces within the run-of-mine rock combined with the large cross sectional area of the road will allow the drain to effectively transmit water.

2. Run-of-mine rock has a low potential for being blocked or caked by beach material.

Post-closure rain and snowmelt would mix with any expelled porewater and report to the lower area in the south of the PKC. From there waters would enter the drain, flow through a decommissioned section of liner and adjacent rock fill section of the PKC south dam and then along the tundra, channels and ponds to Lac de Gras. Over time as the consolidation rate of the slimes decreases and permafrost agrades into the processed kimberlite the amount of porewater being expelled will also be reduced and the quality and quantity of water exiting the facility will approach surface runoff values.

The drain will be progressively built during operations; the barge access road will be incrementally raised in 4 meter lifts as required to maintain the running surface above the PKC main pool water level.

The drain outlet would be built by decommissioning a section of PKC dam where the barge road intersects the PKC dam. The liner in this section would be cut down (bottom elevation of liner decommissioning to be determined). The rock fill of the dam would be excavated and sloped to form a stable channel through the dam section.

The drain may pass flows year round. In winter and spring seasons the transmissivity of the rock drain will decrease due to ice aggradation within the coarse rock fill of the drain which acts to reduce the cross sectional area available for water to flow through. Year round flows resulting from the porewater generated from consolidation process will provide heat flux that will act to maintain year round flow paths through the rock fill, albeit through a more limited flow area. As described above porewater flow volumes are expected to decrease over time with reduced consolidation rates and increased permafrost.

Within the PKC column, consolidation and freezing will eventually define a lower saturated frozen fine processed kimberlite zone and a thinner upper active layer. This could be expected to be typically 2 to 5 meters thick depending on material type, porosity and degree of saturation. In this zone the porewater water levels would fluctuate within a year resulting in seasonal flows through the south outlet.

It is recognized that high flow events, such as freshet (and potentially extreme precipitation events depending on the time of year) could occur when the transmissivity of the drain is at a minimum (due to peak seasonal frost aggradation within the active zone). To provide for these high volume flow event, the level of the surface of the drain rock material will be set a sufficient depth below the upper level of the South PKC Dam liner to safely convey the 1:500 year event (as per existing design). This will provide a conventional spillway, similar to the original PKC closure design.

Some porewater seepage is also expected along the east and west dams as these are the lowest original ground levels along the foundations of all the PKC dams. Based on current seepage monitoring it is expected that the seepage quantity and quality will be adequate for release over the tundra and into Lac de Gras. This would be made possible at closure by decommissioning the secondary collection Ponds 4 and 5.

Figure 5-14 shows the closure approach described above as concept drawings.

The closure scope for this area also includes:

- Removal of all pipelines and power lines
- Removal of reclaim barge
- Decommissioning of collection Pond 7

5.2.3.4 Closure Activities and Associated Engineering and Environmental Work

Figure 5-15 shows the general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the PKC area. A brief description of each activity follows.

PK Deposition – The PKC is an active facility and will be active until the last day of diamond production (currently 2022). Closure activities and associated works must remain mindful of this fact.

Revised Water Management – Commencing in 2010 the PKC will be an optional water supply for the process plant not a required supply. As such the intent over 2010 and 2011 is to modify the operation of the PKC to evaluate the extent to which the volume of pond water and possibly porewater, can be reduced.

Engineering/Environmental Studies – There are a number of engineering and environmental studies that need to be undertaken to prove up the preferred closure concept for the PKC, address uncertainties and reduce risks. Several of these studies are related to the physical properties of the PK and can, we believe be undertaken over the next 3-5 years through measurement of materials behaviour in the PKC. Follow-up verification studies are anticipated (2018). See also Section 5.2.6

Community and Regulatory Engagement – Continued engagement is anticipated to continually refine the closure plans for this area. In particular engagement is envisaged with regard to options and closure criteria for wildlife including the integration of Traditional Knowledge. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Design – A final engineering closure design for this area will be completed and submitted for review in 2015. This design would incorporate findings from engineering and environmental studies, research, community and regulatory engagement etc.

Detailed Engineering – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years prior to the initiation of the final closure work.

Placement of Final Surface and Wildlife Access – Rock placement to prepare final PKC surface, construction of access routes across PKC surface, re-sloping of access ramps, etc.

Outlet Preparation – Deconstruction of a section of PKC liner and preparation of an engineered water outlet.

Decommissioning of Collection Ponds – Once outlet and seepage water quality/quantity have been confirmed, decommission collection ponds.

Infrastructure Decommissioning – Removal of reclaim barge, water and slurry pipelines, power and any associated surface infrastructure.

Performance Monitoring – A specific performance monitoring program would be conducted starting in 2021 and anticipated last 6 years. This would include monitoring of seepage and outlet water quality, dust deposition, ground temperature, settlement, wildlife interaction etc.

Engineering Inspections – Inspections would be conducted during the closure work and in the years immediately following to review the closure performance.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras and wildlife effects.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

5.2.3.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred closure plan for the PKC. Potential residual effects of note include:

- The PKC structure is a significant landscape feature that did not exist pre-development and will remain visibly different;
- There will be a permanent loss of the vegetation and associated wildlife habitat and some archaeological information that was covered by the PKC facility;
- Even with revegatation efforts there will be an increase in the area of “human disturbed” category of VLC type;
- Seepage/runoff water quality and quantity will be changed from pre-development. Water quality in some inland lakes and streams could be significantly different;
- Some small inland water bodies and ephemeral streams will be permanently covered by the PKC facility;
- The PKC facility may become a new attractant to caribou as an area to use for insect avoidance.

- Winds may generate dust from the PKC facility from new rock surfaces. This dust may be deposited on adjacent vegetation or water bodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). The residual effects identified above fall within the general range of effects considered in the EA. This initial assessment of the cumulative effects from all closure areas is summarized in Section 9. The residual effects noted above are not expected to be significant adverse effects.

5.2.3.6 Uncertainties, Risks and Research Plans

There are a number of uncertainties with the preferred closure approach. Many of these uncertainties will be addressed as part of the engineering design. There are some key uncertainties that are expected to remain following the completion of the engineering design. These include but are not limited to:

- Consolidation rate and surface stability;
- Effectiveness of rock drain in shedding free water from the facility;
- Outlet water quality/quantity;
- Seepage water quality/quantity;
- Requirements for wildlife movement;
- Impact of climate change;

Three initial closure risks have been identified by DDMI:

- Outlet water quality/quantity that is not adequate for release onto the tundra or that is not adequate for release into Lac de Gras
- Seepage water quality/quantity that is not adequate for release onto the tundra or that is not adequate for release into Lac de Gras
- Significant continued consolidation post-closure resulting in cracking and slumping of surface creating unsafe conditions for people and wildlife

Closure Research

- Processed Kimberlite Properties Investigations – consolidation, porewater chemistry, thermal, etc. (see Appendix VIII-1)
- Wildlife Movement – Traditional knowledge and science specifications for routing wildlife over and around PKC (see Appendix VIII-2)

5.2.3.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. This detail is not appropriate in an Interim Closure and Reclamation Plan but will be required for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized below and in Appendix VI-3.

General guidance relevant to post-closure monitoring of the PKC area is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- conduct periodic dam safety and stability reviews of structures that remain after closure
- Inspect seepage collection system for water quality flows
- Check for degradation or aggradation of permafrost for tailings containment structures where permafrost was used in the design
- Assess dust dispersion and vegetation uptake with wind dispersion of tailings

DDMI anticipates that there would be two types of post-closure monitoring programs: performance monitoring specific to the PKC area and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring would include:

- Seepage and runoff quality and quantity using a system like the Surveillance Network Program;
- TSP and deposition/quality measurements of any dust generated from the closed PKC;
- Geotechnical inspections including observations of settlement, erosion, surface drainage, thermal condition, etc. as described above.; and
- Wildlife use of the area.

In addition to area specific monitoring, environmental effects post-closure would be monitored through a continuation of a Post-Closure Aquatic Effects Monitoring Program in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods would be drawn from the operations monitoring programs and revised along with the monitoring frequency as appropriate to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs to spillway or wildlife access routes;
- repairs to drainage routes; and
- corrections to any identified wildlife hazards.

Results of all monitoring and maintenance would be documented in post-closure monitoring and maintenance reports. These reports would include any recommendations for future corrective actions or changes to monitoring programs.

5.2.3.8 Post Closure Landscape

The current view of the preferred post-closure landscape for the PKC is shown in Figure 5-13a. This landscape includes:

- Rock cover for wind and erosion protections;
- Appropriate drainage;
- Re-establishment of drainage channels at Ponds 4, 5 and 7 (Figure 5-13b);
- Specific access routes for people and wildlife (Figure 5-13b); and
- Removal of all pipes, buildings, power lines, reclaim barge etc.

DDMI expects that this final landscape will change as a result of future Traditional Knowledge considerations. In particular with regard to the wildlife movement routes, final contours and surface textures.

5.2.3.9 Contingency Plan

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.3.6),

- Collect and treat outlet water until quality/quantity is adequate for release onto the tundra into Lac de Gras
- Collect and treat seepage water until quality/quantity is adequate for release onto the tundra into Lac de Gras
- Pre-load slimes area with coarse PK or rock to enhance consolidation. Regular surface maintenance to repair cracks/slumps.
- Pump ponds dry at closure and/or surface drainage modified and/or subsurface drainage enhanced to eliminate ponding.

5.2.4 Permanent Closure Requirements – North Inlet

5.2.4.1 Pre-disturbance, Existing and Final Mine Site Conditions

The NI of Lac de Gras is shown in a pre-disturbance condition in Figure 5-16a. The image is from June 2000. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. There are no specific or unique environmental conditions of note in this area.

Currently the NI area is fully developed with east and west dams to provide contingency water storage capacity as shown in Figure 5-16b using an image from August 2009. Figure 5-16c shows final development of the NI in 2022 which is the same as the existing conditions (Figure 5-16b).

5.2.4.2 Closure Objectives and Criteria

General guidance relevant to the NI area closure objectives are provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Dismantle and remove/dispose of as much of the system as possible and restore natural or establish new drainage patterns
- Stabilize and protect from erosion and failure for the long term
- Maintain controlled release from water dams, ditches and all points of water discharge to the environment
- Achieve approved water quality limits, and in the case of existing mines, implement long term treatment only if necessary and ensure that minimal maintenance is required.

Additionally, *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009) provides recommendations for decommissioning of water management and treatment systems:

- R531: At the end of the mine operations phase, water management plans should be evaluated and revised as necessary to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
  - The results of an evaluation of the performance of the existing water management plan;
  - Expected changes in water flow and water balance on site; and
  - Expected changes in wastewater volume and composition

Based on this evaluation, the following should be identified:

  - Water management structures, such as dams and diversion ditches, that will no longer be needed, methods to be used for decommissioning these structures, and the timing of decommissioning;
  - Water management structures that will continue to be needed and any long-term maintenance or replacement requirements associated with these structures;
  - Water management structures that will need to be modified, methods to be used to modify these structures, the timing of modification, and any long-term maintenance requirements associated with these structures; and
  - Long-term monitoring requirements to ensure that the water management system continues to function as designed.
- R532: At sites where it is determined that long-term treatment of wastewater will be necessary during post closure, a long-term wastewater treatment plan should be developed and implemented. This plan should include the following elements:
  - Identification of roles and responsibilities of persons to be involved in operation and maintenance of the treatment system;
  - Identification of the types of treatment system to be used;
  - Identification of any by-products from the treatment system, such as treatment sludge and management plans for the disposal of those by-products;
  - Identification of routine maintenance activities to be conducted on the treatment system and the frequency;
  - Identification of monitoring to assess ongoing performance of the treatment system and the frequency;
  - Identification of reporting requirements for internal management and regulatory agencies; and
  - Description of contingency plans to address any problems associated with the treatment system.

Closure objectives have been developed specific to the NI area (Appendix V Table V-4). They were developed through workshops and reviews coordinated by the WLWB (see Section 5.2). For the NI the objectives recognize the possibility that different closure options may be implemented and objectives are also provided for these alternative closure options. These area specific objectives may be revised with subsequent updates to this Interim

Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

Appendix V Table V-4 also describes proposed closure criteria. Closure criteria are intended for use in evaluating success in achieving the objective. The intent is to have closure criteria that are specific and measurable. It is recognized that some of the criteria in Table V-4 are more general and less easily measured. As the closure plan evolves, particularly as the details of the preferred closure option are determined, DDMI expects that more specific closure criteria will be identified. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.4.3 Preferred and Alternative Closure Options

Closure of the NI has been included in plans since the initial mine design work in 1996-1998. The following describes the general chronology of and options considerations ending with the preferred option.

North Inlet Plan 1996-1998

The NI was identified as an integral component of the water treatment system. It is to function as both an initial settling pond and as an equalization basin ahead of the NIWTP. With regard to closure it was identified that because the NI would receive dredged sediment, wastewater and backwash sludge throughout operations, that it may not be appropriate to open the NI up to Lac de Gras at closure.

This was the basis for the Water License and Land Leases.

North Inlet Closure Options

Guidance on generic options for closure of water management facilities that are provided in INAC (2007) and relevant to the NI include:

- Water management facilities including ditching and settling ponds that are not required for long-term use should be treated and discharged, sediment should be removed and disposed of properly, and the embankments, dams and culverts should be breached if not required
- Use passive treatment systems as the preferred method for dealing with contaminated waters if it can be demonstrated to be effective
- Locate permanent spillways in competent rock
- Drain, dismantle and remove tanks and pipelines from the site or fill and cover them with appropriate materials if they are approved to remain
- Cover embankments, ditches, culverts, and other drainage channel slopes with erosion resistant material (e.g. soil, riprap, vegetation)

Original Closure Designs – 2001 & 2006

The original closure design for the NI is documented in the Initial Abandonment and Restoration Plan (DDMI 1999b), the 2001 Interim Abandonment and Restoration Plan (DDMI 2001b), and the 2006 Interim Closure and Reclamation Plan – Version 2 (DDMI 2006).

The original design for the NI included three dams, one on the east and west to create water containment and an intermediate dike to contain dredged sediments and any settled solids from the mine water in the west. At closure the plan was that the intermediate dam would remain in place to permanently contain the settled materials. Seepage through the intermediate dam would maintain water levels in the west compartment at the same levels as Lac de Gras. Accumulated material in the east compartment would be evaluated to determine if the east area could be returned to productive Lac de Gras aquatic habitat. If it could then the east dam would be breached to allow fish passage and water circulation. If sediment quality was not adequate for aquatic life, then a section of the east dam would be excavated and replaced with ROM rock. This rock would act as a permeable barrier allowing water movement while containing sediments within the NI and not allowing fish to migrate into the NI.

By 2006 the operational plans had changed. An intermediate dam was no longer planned and lakebed sediments from A154 and A418 dike construction had been placed in the On-Land Dredged Sediment Containment Structure. DDMI had also undertaken an initial ecological investigation to characterize backwash from the NIWTP that is discharged to the NI and a review of alternative disposal option. The ecological characterization did not identify any material properties that would be expected to prohibit the establishment of productive aquatic habitat. Ammonia was identified as the main constituent of toxicological concern in the sludge, sludge porewater and sludge leachate (de Rosemond and Liber, 2005). The main disposal alternative considered was to discharge the slurry onto the wasterock pile to fill the voids in the wasterock. DDMI concluded that this alternative would increase the risk of poor quality seepage from the wasterock area. The wasterock voids are important initially to facilitate convective cooling and permafrost development in the pile and then to permanently store any water that does infiltrate.

The closure plan for the NI in the 2006 ICRP (DDMI 2006) was revised accordingly. The 2006 ICRP expected that discharge water quality criteria could be met in the NI, and that the east dam of the NI would be breached to allow fish passage and water circulation. If the quality of sediment collected within the NI over the mine life was not appropriate for aquatic life, a section of the east dam would be excavated and replaced with ROM rock. This rock would act as a permeable barrier allowing movement of water; however, fish migration into, and sediment transport out of the NI would be precluded.

2009 Review

Three closure options for the NI were discussed at the DDMI hosted Options Workshop in May 2009:

- Hydraulic connection to Lac de Gras – this would allow movement of water to maintain water levels but would not allow movement of fish
- Open Connection to Lac de Gras – this would a full exchange of water and fish with Lac de Gras
- No connection with Lac de Gras – this would prevent water release into Lac de Gras

Advantages and disadvantages of these three options were discussed at the workshop and are included in Appendix IX-4. The general conclusion from the workshop was consistent with the defined objective for the NI, i.e.:

"53. Reconnect the NI with Lac de Gras if possible, depending on sediment quality."

Additional information is being collected to assist with understanding the potential issue of ammonia as the main constituent of toxicological concern in the sludge, sludge porewater and sludge leachate as identified in de Rosemond and Liber (2005). Sediment microbiological work specific to ammonia and the NI was initiated with the University of Alberta in 2008. Results from this ongoing work will be used to assist in understanding the longer term ecological risk of ammonia in the NI sediments as they relate to closure.

North Inlet – 2009 Preferred Option

The preferred closure plan for the NI is to breach the east dam and allow fish passage and water circulation. This will require adequate sediment and water quality within the NI. If the quality of sediment collected within the NI over the mine life is not appropriate for aquatic life, as a contingency the east dam would be excavated and replaced with ROM rock (see Section 5.2.4.8). This rock would act as a permeable barrier allowing movement of water; however, fish migration into, and sediment transport out of the NI would be precluded. If the water within the NI was of sufficiently poor quality that it could not be safely joined to mix with Lac de Gras water, a contingency whereby the east dam would remain has been included (see Section 5.2.4.8).

The final landscape for the NI, based on the preferred closure plan is shown in Figure 5-17.

5.2.4.4 Closure Activities and Associated Engineering and Environmental Work

Figure 5-18 shows the general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the NI area. A brief description of each activity follows.

Mine Water Treatment – The NIWTP would continue to treated mine water until the completion of underground mining and decommissioning in 2023 under the current mine plan.

Environmental Studies – Environmental studies that need to be undertaken to prove up the preferred closure concept for the NI. These studies focus on the NIWTP backwash materials discharged to the NI and their ecological characteristics related to aquatic life usage of the area post-closure. Characterization work initiated in 2005 will be repeated over time to incorporate any operational changes in the NIWTP or source waters to the NIWTP.

Community and Regulatory Engagement – Continued engagement is anticipated to provide updates on the environmental studies and the final closure plan. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Design – A final engineering closure design for this area will be completed and submitted for review in 2015. This design would incorporate findings from environmental studies, research, community and regulatory engagement etc.

Detailed Engineering – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years prior to the initiation of the final closure work.

Decommissioning of East Dam – Once NI water and sediment quality have been confirmed, decommission the east dam by excavating a breach.

Performance monitoring – Performance monitoring will be conducted starting in 2023 to confirm the acceptability of the NI water and sediment quality prior to breaching the east dam and then to document use of the area by aquatic life following the breach.

Engineering Inspections – Inspections would be conducted in advance of and following decommissioning of the east dam.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

5.2.4.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred option of full reconnection of the NI with Lac de Gras. Potential residual effects of note include:

- Water and sediment quality in the NI may be different from pre-disturbance conditions in Lac de Gras and could be long-terms low- level source nutrients and metals to Lac de Gras;
- Primary productivity maybe higher in the NI than would be typical in Lac de Gras and may be a preferred fish habitat.
- Winds may generate dust from the rock surfaces of the east and west dams.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). The residual effects identified above fall within the general range of effects considered in the EA. This initial assessment of the cumulative effects from all closure areas is summarized in Section 9. The residual effects noted above are not expected to be significant adverse effects.

5.2.4.6 Uncertainties, Risks and Research Plans

The primary uncertainty associated with the preferred closure plan for the NI is the ecological characteristics of the final sediments in the NI post-closure. The risks identified by DDMI are that the area will not be adequate for aquatic life and the possibly that the water in the NI could not be safely reconnected with Lac de Gras.

Closure research specific to this uncertainty is the Ecological Characterization of the NIWTP Backwash described in Appendix VIII-9.

5.2.4.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. It is DDMI's understanding that this detail is not required for an Interim Closure and Reclamation Plan but will be required for a Final Closure and Reclamation Plan as Appendix VI-4.

General guidance relevant to post-closure monitoring of water management areas is provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Periodically inspections are required in the post-closure period to assess the performance of the existing water management structures
- Check the performance of erosion protection on embankment structures such as rip rap or vegetation and the physical stability of water management systems including permafrost integrity where applicable
- Check water quality and flows to ensure system is working as predicted
- Conduct ongoing inspection and maintenance of passive or active water treatment facilities associated with non-compliant mine water or runoff discharges
- Sample surface and groundwater if site specific conditions dictate
- Check the smell and taste of water and fish (guidance from local communities and Elders should be sought)

DDMI anticipates that there would be two types of post-closure monitoring programs: performance monitoring specific to the NI area and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring would include:

- Water and sediment quality using a system similar to the Surveillance Network Program;
- Geotechnical inspections including observations of settlement, erosion, thermal condition, etc. as described above;
- TSP and deposition/quality measurement of any dust generated from the closed NI area; and
- wildlife use of the area.

In addition to area specific monitoring, environmental effects post-closure would be monitored through a continuation of a Post-Closure Aquatic Effects Monitoring Program in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods would be drawn from the operations monitoring programs and revised along with the monitoring frequency as appropriate to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs related to stabilization or erosion;
- corrections to any identified wildlife hazards.

Results of all monitoring and maintenance would be documented in post-closure monitoring and maintenance reports. These reports would include any recommendations for future corrective actions or changes to monitoring programs.

5.2.4.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the NI area is shown in Figure 5-17. This landscape includes a breach in the east dam to reconnect Lac de Gras and the NI.

5.2.4.9 Contingency Program

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.4.6),

- Continue to treat the water in the NI replacing water with Lac de Gras water to improve water quality prior to decommissioning the east dam
- Modify the decommissioning of the east dam to excavate a section and replaced with ROM rock. This rock would act as a permeable barrier allowing movement of water; however, fish migration into, and sediment transport out of the NI would be precluded.
- Do not decommission the east dam and continue to treat and discharge to Lac de Gras as necessary to manage water levels in the NI.

5.2.5 Permanent Closure Requirements – Mine Infrastructure

5.2.5.1 Pre-disturbance, Existing and Final Mine Site Conditions

All areas where there is currently mine infrastructure is shown in Figure 5-19a before the infrastructure was developed. The image is from June 2000 and shows some initial pioneering roads, the original North Camp, exploration decline, original airstrip and the start of the new airstrip. Pre-disturbance conditions are summarized in Section 3 with additional references provided for more specific information. Some archaeological sites were identified in these areas (Figure 3-26). No other specific or unique environmental conditions are of note in these areas.

The current extent of mine infrastructure development is shown in Figure 5-19b using an image from August 2009. With the exception of a few final buildings like the new mine dry facility, the mine infrastructure is fully developed. A more complete identification of the mine infrastructure can be found in Figure 2-2.

Figure 5-19c shows the same mine infrastructure at final development.

5.2.5.2 Closure Objectives and Criteria

General guidance relevant to closure of the mine infrastructure area closure objectives are provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) as follows:

- Ensure buildings and equipment do not become a source of contamination or a safety hazard to wildlife and humans
- Return area to its original state or to a condition compatible with the end-use targets
- Remediate any sources of contamination that may have been created during the development and operation of the mine site in order to protect humans, wildlife and environmental health
- Prevent significant releases of substances that could damage the receiving environment
- Remediate contaminated soil such that the area is compatible with future uses of the surrounding local area
- Re-establish the pre-mining ground cover, which may involve encouraging self-sustaining indigenous vegetation growth
- Provide wildlife habitat where appropriate and feasible
- Assist with providing physical stability of mine components

Additionally, *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009) provides recommendations for decommissioning of mine infrastructure:

- R514: On-site facilities and equipment that are no longer needed should be removed and disposed of in a safe manner, unless facilities or equipment are to be preserved for post-closure land use. Efforts should be made to sell equipment for reuse elsewhere or to send equipment for recycling, rather than disposing of it in landfill facilities.
- R515: The walls of on-site buildings should be razed to the ground, except in cases where they are to be preserved for post-closure land use. Foundations should be removed or covered with a sufficient thick layer of soil to support revegetation.
- R516: If buildings are to be preserved, either as a heritage resource or for some other post-closure land use, structures and foundations should be inspected to ensure that no contamination is present. If the structures or foundations are contaminated, they should be remediated as necessary to ensure public health and safety for post-closure land use.
- R517: Support infrastructure, such as fuel storage tanks, pipelines, conveyors and underground services should be removed, except in cases where it is to be preserved for post-closure land use.
- R518: The main access road to the site (or runway in the case of remote sites) and other on-site roads, as appropriate, should be preserved in a sufficient condition to allow post-closure access for monitoring, inspection and maintenance activities.
- R519: Roads, runways or railways that will not be preserved for post-closure should be reclaimed:
    - Bridges, culverts and pipes should be removed, natural stream flow should be restored, and stream banks should be stabilized by revegetating or by using rip-rap.
    - Surfaces, shoulders, escarpments, steep slopes, regular and irregular benches, etc. should be rehabilitated to prevent erosion; and

- Surfaces and shoulders should be scarified, blended into natural contours, and revegetated.

- R520: electrical infrastructure, including pylons, electric cables and transformers should be dismantled and removed, except in cases where this infrastructure is to be preserved for post-closure land use or will be needed for post-closure monitoring, inspection and maintenance. This includes infrastructure on site, as well as any off-site infrastructure owned by the mining company.
- R522: Waste from the decommissioning of ore processing facilities and site infrastructure, such as waste from the demolition of buildings and the removal of equipment, should be removed from the site and stored in an appropriate waste disposal site or disposed of on site in an appropriate manner in accordance with relevant regulatory requirements. If material is disposed of on site, the location and contents of the disposal site should be documented.
- R523: Sampling and analysis of soils and other materials should be conducted to ensure that none of the material is contaminated, e.g. with asbestos and mercury from buildings. If contaminated materials are identified, they should be handled and disposed of in an appropriate manner in accordance with all applicable regulatory requirements.

Closure objectives have been developed specific to the DDMI mine infrastructure areas (Appendix V Table V-5). They were developed through workshops and reviews coordinated by the WLWB (see Section 5.2). These area specific objectives may be revised with subsequent updates to this Interim Closure and Reclamation Plan but are considered adequate at this time to guide advancement of closure planning.

Appendix V Table V-5 also describes proposed closure criteria. Closure criteria are intended for use in evaluating success in achieving the objective. The intent is to have closure criteria that are specific and measurable. It is recognized that some of the criteria in Table V-5 are more general and less easily measured. As the closure plan evolves, particularly as the details of the preferred closure option are determined, DDMI expects that more specific closure criteria will be identified. The process of ongoing refinement of the criteria will include further discussions with communities and regulators.

5.2.5.3 Preferred and Alternative Closure Options

Closure planning commenced with the initial mine design work in 1996-1998. Many of the important design decisions related to closure occurred at this time. With regard to closure aspects of mine infrastructure the guiding principal in the design was to keep the mine footprint as small and compact as possible. Options considered in this 1996 to 1998 period included infrastructure on the mainland and the west island (Figure 5-7). These options were primarily considered in association with the location of the PKC. It was expected that a larger and more widely dispersed mine infrastructure would result in greater environmental effects during operation, notably wildlife, but it would also make final closure more difficult and increase the residual environmental effects on wildlife.

The final decision from the EA and the basis for the Water License and Land Leases is mine infrastructure restricted to the East Island with a limited footprint.

Mine Infrastructure Area Closure Options

Guidance on generic options for closure of mine infrastructure areas that are provided in INAC (2007) and relevant to the Diavik site include:

- Dismantling all buildings that are not necessary to achieve the future land use target
- Raze/level all walls to the ground and remove foundations
- Cover remaining foundations with materials conducive to vegetation growth
- Remove buildings and equipment during the winter to minimize damage to the land where appropriate
- remove and dispose concrete in an approved landfill if it contains contaminants such as hydrocarbons or PCB's that may pose a hazard over time
- where approved, break or perforate concrete floor slabs and walls to create a free draining condition in order that vegetation can be established
- backfill all excavations below final grade to achieve the final desired surface contours to restore the natural drainage or a new acceptable drainage
- cover excavated sites which have exposed permafrost with a rock cap to prevent thermokarst erosion
- Bury materials in the unsaturated zone or below the active layer
- Decontaminate equipment (free of any batteries, fuels, oils or other deleterious substances) and reuse or sell (local communities may have interest in some of the materials)
- If sale or salvage or equipment is not possible, dispose of decontaminated equipment in an approved landfill or as recommended by the regulatory authorities
- Cut, shred or crush and break demolition debris to minimize the void volume during disposal
- Maintain photographic records of major items placed into landfills, as well as a plan showing the location of various classes of demolition debris (e.g. concrete, structural steel, piping, metal sheeting and cladding)
- Leave non-salvageable materials and equipment from underground operations in the underground mine upon approval from the regulatory authorities
- Remove all hazardous materials and chemicals prior to demolition to national approved hazardous material treatment facilities, recycle, reuse, or dispose of in a appropriate manner upon approval from the regulatory authorities (check for PCBs in fluorescent light fixtures, lead-based paints, mercury switches or radioactive instrument controls)
- Backhaul materials for recycling or disposal to a southern location
- Excavate and remove contaminated soil and place into a designated and properly managed containment area on-site
- Treat contaminated soil in-situ (bioremediation, soil leaching, washing, etc.)
- Immobilize contaminated soil (cement solidification, lime/silicate stabilization, etc.)

- Excavate and relocate contaminated soil to approved facilities off-site.
- Some low level contaminated soil may be used progressively to cover landfills if the entire landfill is designed to be ultimately encapsulated in permafrost
- Dispose of wastes in quarries, borrow pits, underground mine workings, tailings impoundments, and waste rock piles
- Burn domestic waste in an incinerator during operations and at closure as part of camp maintenance
- Burn waste oils, solvents and other hydrocarbons on-site with an incinerator if approved (chlorinated substances should not be burned)
- Cover landfills and other waste disposal areas with erosion resistant material (e.g. soil, riprap, vegetation)
- Divert runoff with ditches or covers
- Ditch, berm, fence or use alternative methods to limit access to waste storage areas
- Contour/blend to match the natural topography or a new desired topography and re-vegetate with indigenous species to meet end use land targets
- Consider surface application of sewage for re-vegetation
- Begin revegetation efforts as soon as possible for mine site areas/components (progressively reclaim)
- Contour, scarify, and seed are using native seed mixes to establish vegetative cover
- Apply gravel barriers or other underlying cover systems where desired to control or limit the upward movement of acidic pore water or heavy metals that may inhibit plant growth or for moisture retention near the surface
- Apply stripped/stockpiled soil or growth medium to a depth sufficient to maintain root growth and nutrient enrichments
- Incorporate organic materials, mulches, fertilizers, or other amendments based upon local soil assessment
- Establish appropriate temporary or permanent wind breaks where necessary to establish vegetation
- Transplant vegetation that would otherwise be lost to mine disturbance where feasible
- Select indigenous vegetation for reclaimed sites that have a low potential for metal accumulation
- Re-vegetate with indigenous vegetation not used by wildlife or people if uptake of metals is a concern
- Place a gravel or coarse cover to discourage vegetation growth where desired

Original Closure Design – 2001

The original closure design for the mine infrastructure area is documented in the Initial Abandonment and Restoration Plan (DDMI 1999b), the 2001 Interim Abandonment and

Restoration Plan (DDMI 2001b), and the 2006 Interim Closure and Reclamation Plan – Version 2 (DDMI 2006). In summary the above references describe:

- Removal of all equipment, buildings, pipelines, power lines etc. for resale/reuse where practical
- Removal of all hazardous materials
- Salvageable materials recycled where practical
- Materials that are not reused or recycled safely disposed of on-site
- Materials that could not be safely disposed of on site would be hauled to approved off-site facilities
- Foundations and concrete slabs covered with rock
- Fuel tanks removed
- Contaminated soils bio-remediated and disposed of on-site or hauled off site for disposal
- Roads, laydowns, plant sites, airstrip scarified and targeted revegetation
- Revegetation options included use of a top soil strategy, ameliorative strategy or an adaptive strategy

2009 Review

DDMI undertook a general review of the approach to mine infrastructure closure in 2009. For this area in particular it is very early in the closure planning process as planning for most activities can be done closer to final closure. Regardless, aspects were identified where early planning would be helpful. These areas are:

- Topography options for roads, laydowns, plant sites, airstrip etc.
- Final surface texture options for roads, laydowns, plant sites, airstrip etc.
- Landfill locations options on-site and off-site
- Infrastructure use options
- Areas for revegetation

Each of these aspects of infrastructure closure was discussed at the DDMI hosted Options and Criteria Workshop in May 2009. The full listing of outcomes from this workshop are included in Appendix IX-4.

Site roads and laydowns, etc. are constructed from Type I mine rock. They typically have steep sides, safety berms and can be several meters thick and impact on human and wildlife movement. Where necessary for closure the edges of these areas can be re-sloped inwards, re-sloped outwards or some of the materials can be re-mined for closure use in other areas. It is DDMI's view that all three options have applicability in different situations. Re-sloping inward in areas where the thicknesses are greater than about 3 m and wildlife access is planned would reduce footprint size. In areas where the thickness is less than 3 m pushing the re-sloping outward would result in a minimal impact on footprint. Re-mining of material should be focused into areas such as drainage crossings where excavation will be required to return natural stream flow routes.

Surfaces of road and laydowns etc. would be scarified to enhance microhabitats for vegetation, reduce erosion and to be a better match with the surrounding landscape. However, scarified rock surfaces are difficult for people and wildlife to travel over. Smoother surfaces would be provided along a designed network for wildlife and human access through the closed mine site.

Disposal of unwanted materials and debris from the demolition of mine infrastructure was discussed with regard to on-site or off-site disposal. Some viewed off-site disposal as preferable as it would remove all materials from site and be most similar to the pre-development conditions. It is DDMI's view that on-site disposal of materials in most, but not all cases is the better environmental option.

Options on disposal locations on-site included the PKC, wasterock pile, pit bottom and underground workings. The PKC appears to be the most limiting as a post-closure landfill location as it would be challenging to cover suitably. Opposition to an in-pit landfill was expressed as discussed in Section 5.2.1.3. This opposition seemed to be based on what were expressed as: a) DDMI commitments made in the Comprehensive Study Report, and b) conditions of the DDMI Land Leases. Environmental rationale, as to why an open-pit landfill location was inferior to a land-based location, was not provided. DDMI has decided to not advance an in-pit option further at this time. Use of underground tunnels and an area of the wasterock pile are DDMI preferred options for land fills.

Post-closure reuse of mine site infrastructure both on-site and off-site in communities was discussed generally. There was a preference by all to maximize the reuse of as much of the infrastructure and materials as possible with a priority being reuse in the north. Plans for on-site or off-site reuse will need to be promoted in the years prior to closure.

Revegetation efforts could be distributed equally over the mine site area or focused. The roads, plantsite, laydowns and airstrip were identified as target areas for revegetation. Negative aspects of revegetation on wasterock and PKC areas included increased snow capture and wildlife attraction. DDMI expects there is still work to be done in association with Traditional Knowledge studies on preferred wildlife routes through the area.

Mine Infrastructure – 2009 Preferred Option

The majority of the mine infrastructure shown in Figure 5-19 was constructed to last the duration of the mine life and will be required until end of mine production. The closure design for this area is less advanced than for other closure areas as many of the specific plans and designs are more appropriately developed closer to the end of the mine life. For example plans to reuse infrastructure on or off-site will depend on interest and markets closer to that time.

In the 3-5 years leading up to the end of mine production detailed decommissioning plans will be developed. This is expected to include:

- Strategy to reduce on-site inventories of consumables leading up to the end of mine production
- Strategy to take advantage of back-haul opportunities in the final years of mine operations to remove any unused equipment or infrastructure that can be sold for re-use or salvaged.
- Market the resale, reuse and recycle opportunities for the equipment and materials that will become available and develop a decommissioning plan with the end consumer for each.
- Specific site decommissioning sequence to ensure availability of equipment and infrastructure to support closure activities and post-closure monitoring, inspection and maintenance.

All mine infrastructure will be removed. Mobile and fixed equipment will be removed. Buildings will removed and foundations covered with mine rock. Pipelines, power lines and poles will be removed. Fuel tanks will be removed. The approach to removing the mine infrastructure is to:

- Maximize the sale/reuse of equipment, buildings, materials, fuels, chemicals, etc. with preferred market in the north.
- If sale/reuse is not practical, next best option would be recycle. This will depend on demand for materials and cost to haul to recycle facilities.
- Materials and equipment with no sale or salvage value will be decontaminated (if required), broken down and disposed of in the designated wasterock landfill or underground tunnels as appropriate.
- Materials such as hazardous materials, fuels, lubricants, ammonium nitrate etc. including wastes generated decommissioning, that are not suitable for on-site disposal will be hauled off-site and returned to suppliers or disposed of at approved facilities.

Hydrocarbon contaminated materials collected during operations and during decommissioning will be assessed to determine the most appropriate option for in-situ remediation, volatilization, immobilization, landfilling or off-site removal.

Once all hazardous materials and contaminated soils have been removed from the WTA the area will be cleared of equipment and fencing removed. The area will be inspected for any residual contamination before a rock cover is placed.

A temporary camp, airstrip, power and fuel storage facility will be set up likely using some of the modular equipment remaining from the South Construction Camp. This will become the base for post-closure activities. A possible schedule is included in Section 5.2.5.4.

Collection ponds would remain functional to collect site runoff during the mine infrastructure decommissioning. The NIWTP would be one of the later facilities to be removed.

The final landscape for the mine infrastructure area, based on current closure concepts, is shown in Figure 5-20. The landscapes will be designed to be compatible wit the pre-mining environment and surrounding landscape (Figure 5-20a). Disturbed surface will be contoured and scarified except on planned routes for wildlife or human movement (Figure 5-20b). Surfaces will be stable and safe.

Within the mine infrastructure area there are several locations where stream drainage channels will be re-established including Ponds 10, 11 and 12 and the airstrip (Figure 5-20c). Figure 5-21 shows a typical section indicating the closure concept for stream drainage channels. This concept would apply for roads and collection pond dams.

The closure plan includes the re-establishment of boulder field and partially vegetated land, to the extent practical. Three strategies for the re-introduction of pioneer and more advances indigenous vegetation on disturbed surfaces are being considered. These are summarized as:

- **The topsoil strategy**, which requires placement of topsoil or an alternative "cultivable" material, followed by a conventional approach to establishing indigenous vegetation;
- **The ameliorative strategy**, which does not require topsoil to be placed, but rather promotes the establishment of stress resistant native species directly into an infertile substrate. Usually, the substrates require some chemical and/or physical improvement to create a soil-like condition; and
- **The adaptive strategy**, which also establishes native species directly into the substrate, but with less requirement for chemical and physical amendment of the material. This more cost-effective strategy uses varieties of native species, which have adapted to physical and chemical disturbances that may prevail at certain locations. It is particularly suited to the establishment of plants directly into mineralized substrates. Normal, non-adapted varieties would be severely compromised under such conditions.

5.2.5.4 Closure Activities and Associated Engineering and Environmental Work

Figure 5-22 shows the general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine infrastructure area. A brief description of each activity follows.

Accommodation/Power/Transportation Required – Infrastructure will be required at one level to support mining operations (currently ending 2022) and then at a lesser level for closure activities (currently ending 2029).

Engineering/Environmental Studies – There are a number of engineering and environmental studies that need to be undertaken to prove up a final decommissioning and closure plan. These studies are primarily related to revegetation, criteria for on-site landfill, and wildlife movement.

Community and Regulatory Engagement – Continued engagement is anticipated to refine the closure plans for this area. In particular engagement is envisaged with regard to options and closure criteria for wildlife and revegetation including the integration of Traditional Knowledge and criteria for on-site landfill. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Decommissioning Plan – A final plan for this area will be completed and submitted for review in 2015. This plan would incorporate findings from engineering and environmental studies, research, community and regulatory engagement etc.

Inventory of Assets – Detailed inventory of assets for sale/reuse, salvage, recycle would be completed three years prior to the initiation of the final closure work to initiate external marketing.

Commercial Arrangements – Sale/Transfer of Assets – Specific arrangements would be made for sale, reuse, salvage or recycle of equipment an materials in advance of decommissioning.

Decommissioning of Process and Paste Plants – Activities associated with decommissioning this facility.

Decommissioning of Explosives Plant and Storage – Activities associated with decommissioning these facilities.

Decommissioning of Accommodations and Other Buildings – Activities associated with decommissioning these facilities.

Decommissioning of Fuel Storage and Power – Activities associated with decommissioning these facilities.

Decommissioning of Waste Transfer – Activities associated with decommissioning this facility.

Decommissioning of Collection Ponds, and Pipelines – Activities associated with decommissioning these facilities.

Decommissioning of Final Camp, Airstrip and Landfill – Activities associated with decommissioning these facilities.

Decommissioning of Process Plant – Activities associated with decommissioning this facility

Performance Monitoring - Performance monitoring will be conducted starting in 2024. Emphasis will be on revegetation, hydrocarbon remediation, wildlife use of the areas and tracking success with equipment and materials reuse/recycle.

Engineering Inspections – Inspections would be conducted in associated on with the decommissioning of each facility or area to review conformance.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras and wildlife effects.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

5.2.5.5 Residual Effects

Residual environmental effects will exist even with the full implementation of the preferred closure plan the mine infrastructure areas. Potential residual effects of note include:

- The roads, plantsite, laydowns and airstrips will remain visibly different even after surfaces are recontoured, scarified and revegetated;
- There will be a permanent loss of the vegetation and associated wildlife habitat and some archaeological information that was covered by the mine infrastructure;
- Even with revegatation efforts there will be an increase in the area of "human disturbed" category of VLC type;
- Localized runoff water quality and quantity will be changed from pre-development;
- Some small inland water bodies and ephemeral streams will be permanently covered by the mine infrastructure;
- Winds may generate dust from the scarified rock surfaces that then deposits on adjacent vegetation or water bodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998). The residual effects identified above fall within the general range of effects considered in the EA. This initial assessment of the cumulative effects from all closure areas is summarized in Section 9. The residual effects noted above are not expected to be significant adverse effects.

5.2.5.6 Uncertainties, Risks and Research Plans

Uncertainty associated with the preferred closure plan for the mine infrastructure areas identified by DDMI and of note include:

- Amount of equipment and materials that will not be economically salvageable for reuse or recycle.
- Amount of non-salvageable material that can be safely disposed of on-site
- Results of the assessment of hydrocarbon contaminated material
- Best re-vegetation strategy
- Wildlife movement through the area

The risks identified by DDMI that are associated with these uncertainties are:

- That there will be insufficient on-site landfill capacity
- Significant amounts of hydrocarbon material will be hauled off-site
- Re-vegetation efforts will be wasted

Some of these uncertainties and risks such as the amount of non-salvageable material that will need to be disposed of on-site impacting on the landfill capacity requirements will be addressed in time with the marketing of assets for sale/reuse or recycle. Closure research specific to other uncertainties include:

- Field Experiments to Develop a Re-vegetation Procedure for the Diavik Diamond Mine (Appendix VIII-10)
- Development of Standard Operating Procedures – Closure Phase for On-site Non Mining Waste Disposal (Appendix VIII-11)
- Wildlife Movement Traditional Knowledge and Science Studies (Appendix VIII-2)

5.2.5.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. This detail is not appropriate in an Interim Closure and Reclamation Plan but will be required for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized below and in Appendix VI-5..

General guidance relevant to post-closure monitoring of the mine infrastructure areas provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007) include:

- Maintain all buildings and equipment left onsite
- Inspect disposal areas periodically to establish if buried materials are being pushed to surface as a result of frost heaving
- Maintain access infrastructure to support on-going reclamation and closure monitoring
- Monitor wildlife/fish use of area to ensure mitigation measures are successful
- Monitor other land users access and activity in the area
- Check stream crossing remediation and any degradation associated with decommissioned roads such as erosion and ponding of water.
- Carry out periodic inspections to investigate the quality of air, groundwater, discharge water, and water body sediment where contaminated soils have occurred
- Carry out periodic inspections to investigate thermal degradation, and physical stability where contaminants have occurred
- An assessment of residual contamination should be carried out to confirm the success of the remediation
- Inspect re-vegetation areas periodically following initial planting until vegetation is successfully established and self sustaining in accordance with the agreed criteria
- Conduct soil analysis for nutrients an pH until the vegetation is successfully established and self-sustaining
- Inspect vegetated areas that may be obscuring possible cracks and other problems on dams and embankments

- Inspect for root systems that are penetrating protective covers or decaying/rotting providing tunnels for water to pass through protective covers
- Identify excessive vegetation stress or poorly established areas and implement contingency measures if required.
- Sample water treatment sludge periodically to determine the chemical characteristics, sludge stability, and leachability under the proposed long-term storage conditions
- Test water quality and quantity to measure the success of the mitigation measures for waste disposal areas
- Identify and unpredicted sources of potential contamination
- Check the ground thermal regime (by means of thermistors) and cover performance to check if permafrost has aggraded into the landfill and if the seasonal active zone remains within the cover
- Check for cracking or slumping of the cover and for underlying waste material pushing its way up through the cover

DDMI anticipates that there would be two types of post-closure monitoring programs: performance monitoring specific to mine infrastructure areas and environmental effects monitoring which would include combined effects from all post-closure areas. The scope of the performance monitoring would include:

- Re-vegetation success;
- TSP and dust deposition/quality measurements of dust generated from mine infrastructure areas;
- Monitoring of levels of reuse, recycle versus landfill;
- Runoff water quality;
- Geotechnical inspections including observations of cracking, erosion, thermal condition, etc. as described above.; and
- Wildlife use of the area.

In addition to area specific monitoring, environmental effects post-closure would be monitored through a continuation of a Post-Closure Aquatic Effects Monitoring Program in Lac de Gras and a Post-Closure Wildlife Effects Monitoring Program. Monitoring methods would be drawn from the operations monitoring programs and revised along with the monitoring frequency as appropriate to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs to cracking or erosion;
- corrections to re-vegetation efforts;
- correction of identified wildlife hazards.

Results of all monitoring and maintenance would be documented in post-closure monitoring and maintenance reports. These reports would include any recommendations for future corrective actions or changes to monitoring programs.

5.2.5.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the mine infrastructure areas are shown in Figure 5-20. This landscape includes:

- Removal of all buildings, fuel storage, pipeline and power lines (Figure 5-20a)
- On-site landfill
- Remediation of stream crossings (Figure 5-20b)
- Contouring, scarifying and target re-vegetation
- Specific access routes for people and wildlife (Figure 5-20b)

DDMI expects that this final landscape will change as a result of future Traditional Knowledge considerations. In particular on the wildlife movement routes, final contours and surface textures.

5.2.5.9 Contingency Program

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.5.6):

- If on-site landfill requirements exceed the capacity of the designated area in the wasterock pile, conduct an environmental risk assessment of additional locations including pit-bottom landfill.

6. Progressive Reclamation

6.1 Definition of Progressive Reclamation

Progressive reclamation are closure activities that take place prior to permanent closure to advance the closure and/or decommissioning of areas or facilities that are no longer actively required for the current or future mining operation. These activities can be done during operations with the available resources to reduce future reclamation costs, minimize the duration of the environmental exposure and enhance environmental protection. Progressive reclamation may shorten the time for achieving reclamation objectives, and may provide valuable experience on the effectiveness of certain measures which might be implemented during permanent closure.

In it broadest definition all closure planning from initial mine design through to detailed closure design and including all closure studies or research could be considered as progressive reclamation activities. These are all activities done during operations to improve the implementation of permanent closure. Planning for closure and closure research are addressed elsewhere in this document, most specifically in Section 5. For the purpose of this section of this document only actual physical closure activities that would occur prior to the end of commercial mine production (currently planned as 2022) are considered as progressive reclamation activities.

6.2 Prospective Facilities/Areas and Reclamation Activities

The following sections identify, by closure management area, closure activities that are considered progressive reclamation activities. The specifics of these activities and how they contribute to achieving permanent closure objectives are described in Section 5.2.

6.2.1 Open Pits, Underground and Dike Areas

The open pits will not be flooded until final closure. Progressive reclamation activities for the open-pit area are limited to the construction of fish habitat. Designs for fish habitat in the A154 and A418 mine areas are included in Appendix X. Identified progressive reclamation activities include:

- Infilling of deep areas of original lake bottom between the pit crest and the inside toe of dike in both A154 and A21 areas;
- Construction of fish habitat features (reefs) in filled areas;
- Re-configure disturbed portions of original shoreline as necessary;
- Backfilling of underground workings will proceed as part of mining operations to limit extent of open kimberlite excavations at any one time; and
- Waste segregation by sulphur content is conducted during mining operations. This ensures construction of site facilities uses only Type I rock to eliminate the need for further closure activities for these areas and enables management of wasterock piles.

6.2.2 Wasterock and Till Areas

Identified progressive reclamation activities in this area include:

- Placement of segregated wasterock into designated locations;
- Keeping steep side slopes to enhance permafrost development;
- Direct placement of Type I rock on identified final Type III rock slopes;
- Re-mining wasterock for underground backfill;
- Re-mining Type III, if technical characteristics of material are suitable for backfill; and
- Re-mining wasterock following an area plan to achieve as much of final landscape design as practical.

6.2.3 Processed Kimberlite Containment Area

Identified progressive reclamation activities in this area include:

- changing the water management practices to minimize the amount of ponded water in the facility during operations enhancing consolidation and permafrost development;
- Construction of south barge road to be used for long term drainage management; and
- Deposition of fine PK in final years to create planned closure landscape.

6.2.4 North Inlet Area

The NI is as integral component of the site water management system and it will be required after completion of mining. As such no progressive reclamation activities have been identified for this area, at this time.

6.2.5 Mine Infrastructure Areas

Identified progressive reclamation activities in this area include:

- Back haul equipment or facilities as they are identified as no longer being required for operations; and
- Reduce inventories of consumables leading up to the end of mine production.

6.3 Progressive Reclamation Monitoring, Maintenance and Reporting Program

Two types of progressive reclamation monitoring are anticipated:

- Completion monitoring – this is tracking, recording and inspecting the work done so that it can be documented as part of permanent closure;
- Performance monitoring – where appropriate monitoring will be done to document how a closure activity is performing with regard to achieving a closure design, objective or criteria. In some cases this might overlap with closure research.

Specific progressive reclamation monitoring will include:

- Material moved or placed for construction of fish habitat in A154 and A418 dike areas;
- Waste produced by rock Type;

- Inventory of wasterock and till by rock type in the area and re-mined for underground fill;
- Wasterock and till area landscape relative to permanent closure design;
- Seepage quality, thermal condition, slope stability of wasterock and till area;
- PKC performance with regard to pond water volumes, pore water chemistry, physical and thermal properties of PK over time;
- PKC landscape relative to permanent closure design; and
- Inventory of back hauls.

Information collected during monitoring of progressive reclamation will be reported through updates to the Interim Closure and Reclamation Plan, Fisheries Authorization Reporting and/or the Annual Water License Report as appropriate.

No progressive reclamation maintenance activities have been identified at this time.

7. Temporary or Interim Closure Measures

In addition to planning for permanent closure, DDMI has prepared plans for an interim shutdown in accordance with the requirements of the Class "A" Water License and the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

7.1 Definition of Temporary/Interim Closure

Temporary or interim closure occurs when a mine ceases operations with the intent to resume mining activities in the future. Closure can last for a period of weeks or for several years, based on economical, environmental and social factors (INAC 2007).

7.2 Temporary Closure Goals, Objectives

The goal or objective of temporary or interim closure measures is to ensure the ongoing protection of people and the environment and regulatory compliance until the mining operations can resume. Measures necessary for this will depend upon the duration and extent of site activities/presence during the mine closure. INAC (2007) suggests the following be implemented or completed upon temporary mine closure:

- Access to the site, buildings, and all other structures must be secured and restricted to authorized personnel only
- All mine openings must be guarded or blocked and warning signs must be posted
- All physical, chemical and biological treatment and monitoring programs must continue according to licenses, permits and leases in order to maintain compliance
- All waste management systems must be secured
- An inventory of chemicals and reagents, petroleum products and other hazardous materials must be conducted and secured appropriately or removed if required
- Fluid levels in all fuel tanks must be recorded and monitored regularly for leaks or removed from the site
- All explosives must be relocated to the main powder magazine and secured, disposed of, or removed from the site
- All waste rock piles, ore stockpiles, tailings, mine water and other impoundments structures must be stable and maintained in an appropriate manner (including regular geotechnical inspections)
- Drainage ditches and spillways must be inspected and maintained regularly (e.g. seasonally depending on snow and ice accumulation and melting) during the closure period and included as part of geotechnical inspections
- Facilities and infrastructure must be inspected regularly
- The reclamation security deposit must be kept up to date

7.3 Temporary Closure Activities

7.3.1 Open Pits, Underground and Dike Areas

7.3.1.1 Open Pits

The open pits will not be flooded until permanent closure. The extent to which the procedures listed below are implemented would depend on the anticipated length of the closure and the seasonal limitations on overland transport if any materials or equipment had to be removed from the site in the case of an extended shutdown.

- Dewatering of the open pits would continue as conducted during operations since flooding and subsequent dewatering may adversely impact stability of the pit walls and underground workings.
- Surface water and seepage control systems would continue as conducted during operations. Refer to water management facilities in Section 7.3.4.
- Block open pit access routes with boulder fences and/or berms.
- Post warning signs and fences or berms around pit perimeters.
- Routine geotechnical stability monitoring and maintenance would continue at a reduced rate compared to that conducted during operations. The open pit areas would be inspected routinely to check for rockfalls, changes to groundwater inflows and overall integrity.
- All mobile equipment except for small service equipment required for open pit inspections would be removed and prepared for on-site storage.
- Fuel, lubricants and hydraulic fluids would be removed from the open pit area and stored in designated areas.

7.3.1.2 Underground Mine Workings

The underground mine workings will not be flooded until permanent closure. The underground mining plan involves the integral use of backfill. Therefore, only very limited excavations will be open at any one time within the kimberlite pipes and long term stability of the pipes is assured independent of the timing of a shutdown.

The extent to which the procedures listed below are implemented would depend on the anticipated length of the closure and the seasonal limitations on overland transport if any materials or equipment had to be removed from the site in the case of an extended shutdown.

- Dewatering of the open pits would continue as conducted during operations to maintain stability of the pit walls and underground workings. The underground workings are located below Pits A154 and A418 and therefore are influenced by open pit conditions.
- Dewatering of the underground facilities would continue as conducted during operations to maintain stability.
- Surface water and seepage control systems would continue as conducted during operations. Refer to water management facilities in Section 7.3.4

- Operation of the primary fans, dewatering pumps and drainage sumps would be maintained.
- Airflow through the mine ventilations systems would be maintained. The raises would remain open and primary intake/exhaust fans would continue to operate in conjunction with underground ventilation controls (doors and seals), to ensure air flow through areas requiring ventilation, including sump and dewatering pump stations; the air would be heated during winter months.
- Underground electric power distribution system would be maintained.
- Underground access to main decline would be blocked with boulder fences and/or berms, subject to leaving access for maintenance.
- Warning signs and fences or berms would be placed around perimeters of any access or surface opening for the underground workings.
- Routine geotechnical stability monitoring and maintenance would continue as conducted during operations. All underground facilities would be inspected routinely to check for rockfalls, changes to groundwater inflows and overall integrity.
- All mobile equipment except for small service equipment required for underground inspections would be removed to surface and prepared for on-site storage.
- Fuel, lubricants and hydraulic fluids would be removed from all underground locations and stored in designated on-surface areas.
- Explosives and accessories would be removed from the underground storage magazines to the surface magazines.

7.3.1.3 Enclosure Dikes

Dikes enclose both of the open pits. The dikes will not be breached until permanent closure to ensure that the open pits and the underground workings are not flooded. If there was an interim closure the following would be completed for the dikes:

- The dike seepage collection systems at the downstream toe of the dikes would remain active as in operations.
- Access to dike roads would be blocked with boulder fences and/or berms.
- Warning signs and fences or berms would be placed around the perimeters of the accesses to the dikes.
- Routine geotechnical stability monitoring and maintenance would continue as conducted during operations. Dikes would be inspected routinely to check for slope stability, changes to inflows and overall integrity.

7.3.2 Wasterock and Till Storage Areas

At the time of a temporary or interim closure the wasterock and till area could be in a state of active development or active re-mining for underground backfill. The action taken will depend on the anticipated duration of the closure but would include:

- Access to piles blocked with boulder fences and/or berms

- Warning signs would be placed around the perimeters toes.
- Routine geotechnical stability monitoring and maintenance would continue as conducted during operations. Piles would be inspected routinely to check for slope stability and seepage.

7.3.3 Processed Kimberlite Containment Area

During a shut down the following would be completed at the PKC facility:

- Fine PK pipe distribution system would be purged, flushed, and drained;
- Providing water quality is sufficient to be treated by the NIWTP, the barge would be operated periodically to pump excess water to the NI as needed to maintain design flood storage criteria within the PKC pond; and
- Geotechnical instrumentation would continue to be read.

7.3.4 Water Management Facilities

The water management plan would not change during an interim temporary shut down. However, the inflow from the PKC pond would decrease since the plant would not be processing kimberlite. The following procedures would be followed:

- Water from the ponds, and the NI would continue to be pumped to the NIWTP as conducted during operations;
- Collection sumps and ditches around the site would be maintained to manage runoff from the PKC facility, the wasterock and till area and the general site;
- The NIWTP would remain in operation to treat water pumped from the pits, underground workings and from the collection ponds;
- Operational daily monitoring of the water quality would be performed at the inlet of the treatment plant with regulatory sampling continuing on a six day frequency and at the outfall monthly. Operational monitoring would include flow rates, pH, turbidity, conductivity, ammonia, and temperature. Regulated sampling would continue as per the Water License.

If the short-term shutdown progresses into indefinite shutdown, then the runoff water from the site and the PKC pond would be redirected to the NI. The NIWTP would remain in operation to treat excess water from the NI prior to discharge to Lac de Gras.

7.3.5 Plant Site, Accommodation Complex and Fuel Storage

7.3.5.1 Process Plant

Any stockpiled kimberlite ore remaining on surface at the commencement of a temporary shutdown would be processed before plant operations cease. The plant would then be shut down in a planned and sequential manner in order to prevent damage to equipment, piping and instrumentation.

The following preparatory measures would be taken prior to plant shutdown:

- All rough diamonds would be removed from the diamond collection receptacles and shipped to Yellowknife;
- Remaining coarse PK fractions would be transported by truck to either the North or South Coarse PK Cells; and
- The fine PK slurry pipelines would be flushed of solids using reclaim water pumped from the PKC facility.

Short-term shutdown strategies for the Process Plant include:

- Minimal heating would be maintained to the Process Plant to prevent equipment freezing;
- The raw water supply to the Process Plant would be turned off;
- Power and process air supplies to the Process Plant would be maintained;
- An inventory of all chemical reagents would be undertaken and maintained;
- All tank levels would be recorded and monitored;
- All major equipment would be run periodically to ensure lubrication and integrity of the rotating parts; and
- FeSi would be periodically re-circulated to prevent setting up in the circulating medium tanks.

In addition to the above short-term shutdown strategies, the following measures would be taken in the case of long-term shutdown of the Process Plant:

- Equipment and gearboxes would be drained of lubricants and coolants, which would be stored in sealed drums in the maintenance complex, or removed from site;
- All tanks would be drained, and remaining FeSi would be transferred to the Wasterock and and Till area;
- All reclaim water and fine PK slurry pipelines would be flushed and drained;
- Sensitive electronic devices such as instrumentation control cards, personal laptop computers and control system computers would be removed from the site or warehoused within the Maintenance Complex;
- All chemical reagents would be inventoried and transferred to warehouse storage within the Maintenance Complex, or would be removed from site;
- Heavy rotating equipment would be lifted off bearings and safely supported;
- All heating and power would be turned off, and power lines to the Process Plant would be discharged and left open; and
- The entire Process Plant would be winterized and locked up with emergency access restricted to authorized personnel only.

7.3.5.2 Accommodation Complex

With the exception of accommodation facilities required for care-and-maintenance personnel, wings, common areas and offices within the Accommodation Complex would be closed off to reduce power, heating and ventilation requirements during temporary shutdown.

All care-and–maintenance personnel would be housed within one wing of the complex and would be serviced by a single cafeteria, common area and laundry room. Recreational facilities located within the gymnasium would also remain available to on-site personnel during the shutdown periods.

Any hazardous materials located within closed off areas of the accommodation complex would be collected, inventoried and stored in the maintenance complex warehouse. All closed off areas would be securely locked with access restricted to authorized care-and-maintenance personnel only.

7.3.5.3 Administration/Maintenance Complex

Non-essential areas and offices within the Administration/Maintenance Complex would be closed off during temporary shutdown so that heating and ventilation can be reduced to minimum levels. All necessary support facilities and services for care-and-maintenance personnel would remain in operation, including work shops, the Emergency Response Vehicle garage, and the warehouse.

Any hazardous materials located within closed off areas would be collected, inventoried and stored in the warehouse. All closed off areas would be securely locked with access restricted to authorized care-and-maintenance personnel only.

7.3.5.4 Fuel Storage

The fuel storage areas would remain functional during short-term and long-term shutdown periods in support of care-and-maintenance activities. All tank levels would be monitored throughout the shutdown period, and the tanks would be regularly inspected for potential fuel leaks.

7.3.5.5 Power Plant

The power plant and waste heat recovery would remain functional during temporary shutdown periods in order to supply power and heating requirements for care-and-maintenance personnel. All non-essential power lines would be discharged and left open during long-term shutdown when power and heating supplies to non-critical plant and infrastructure would be turned off. The power plant would be configured to operate at maximum efficiency under the reduced loading condition.

7.3.5.6 Boiler Plant

The boiler plant would remain functional during short-term and long-term shutdown periods in order to supply minimal heating requirements in the event of a failure within the main power plant. All non-essential glycol lines would be flushed and drained during long-term shutdown when heating supplies to non-critical plant and infrastructure would be turned off. Excess glycol would be placed in sealed drums, which would be stored in the Boiler Plant or sent to warehousing within the Maintenance Complex.

7.3.6 Infrastructure

During temporary shutdown, the site infrastructure would be placed into a care-and-maintenance mode to minimize operating costs and ensure environmental stability while maintaining conditions that would permit the safe mechanical resumption of operations at reasonable cost and schedule.

Temporary shutdown strategies for the site infrastructure include:

- All support infrastructures necessary for care-and-maintenance activities would remain in operation during shutdown periods. This would include select Arctic Corridors, the communication system, the airstrip and roads, the raw water intake, the potable water treatment plant, the sewage treatment plant, the WTA and inert landfill.
- Minimal heating to critical facilities would be maintained to prevent equipment freezing.
- Water supplies would be turned off in specific areas that are not in use or are at the lower risk of fire.
- All non-critical facilities and equipment requiring power and/or heating would be shut down. Computing facilities including networks and databases will be backed-up. Equipment and gearboxes would be drained of lubricants and coolants, which would be stored in sealed drums in the maintenance complex, or removed from site. Heavy rotating equipment would be lifted off bearings and safely supported. All heating and power would be turned off, and power lines to the plants would be discharged and left open.
- Remaining equipment would be adjusted or modified to operate at lower capacity and consume less power. All major equipment would be run periodically to ensure lubrication and integrity of the rotating parts.
- Excess chemical reagents and hazardous materials stored within the site buildings would be collected, inventoried and warehoused within designated areas, or transferred off site.
- All non-essential tanks would be drained, and remaining materials would be transferred to the wasterock and till area for storage. All remaining tank levels would be recorded and monitored.
- Explosive materials would be inventoried and stored within the Ammonia Nitrate Storage or Caps/Explosives Storage, or transferred off site.
- The Ammonia Nitrate Storage, Caps/Explosive Storage and Emulsion Plants, and the Batch and Crusher plants would be locked up securely with emergency access restricted to authorized care-and-maintenance personnel only.
- Most surface mobile equipment would be relocated to a secured, common parking area and inspected for any potential oil or other fluid leaks. Emergency response vehicles would be kept in the garage located within the Maintenance Complex, available for use as required.

7.4 Monitoring, Maintenance and Reporting

In general, the required monitoring and reporting during interim closure will be the same as the required monitoring procedures carried out during operations as described in Water License, Fisheries Authorization, Land Use Permits and Environmental Agreement. Frequencies would be adjusted as appropriate and approved.

7.4.1 Open Pits, Underground and Dike Areas

7.4.1.1 Open Pits

Geotechnical and water quality monitoring of the open pits during interim closure will occur as in operations. The geotechnical instrumentation installed throughout the open pit includes:

- Piezometers;
- Thermistors;
- Inclinometers;
- Extensometers;
- Survey Pins; and
- Seismographs.

Visual inspections will also be conducted on a routine basis to check for signs of instability, rockfall and overall integrity.

Water quality samples of pit sump water located at the base of the open pits will be obtained at approved locations in accordance with the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients, oil and grease, and metals. In addition, the flows will be measured using flowmeters installed at the NIWTP.

7.4.1.2 Underground Mine Workings

Geotechnical and water quality monitoring of the underground mine workings during interim closure will occur as in operations. The geotechnical instrumentation for the underground workings will be integrated with the open-pit monitoring and may include:

- Piezometers;
- Thermistors;
- Extensometers; and
- Survey pins.

Water quality samples will be obtained from water pumped from the underground workings in accordance with the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. In addition, flows to the underground workings will be measured using flowmeters installed at designated locations.

7.4.1.3 Enclosure Dikes

Geotechnical and water quality monitoring of the enclosure dikes during interim closure will occur as in operations. The geotechnical instrumentation installed within the dikes and in proximity to the fish habitat areas include:

- Piezometers;
- Thermistors;
- Inclinometers;
- Extensometers; and
- Survey Pins.

Visual inspections will also be conducted to check for signs of instability, including bulging, slumping or the development of tension cracks.

Water quality samples will be obtained from the dike seepage collection system located between the dike toe and the open pit rim in accordance to the Water License SNP. The samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. In addition, the flows will be measured using flowmeters installed at the NIWTP.

7.4.2 Wasterock and Till Areas

Geotechnical monitoring of the wasterock and till area will be through regular inspections. Visual inspections will also be conducted to check for signs of instability.

Water quality and quantity monitoring of seepage and runoff from the wasterock and till area will occur as in operations as defined in the Water License. Water quality samples will be taken directly from the collection ponds. The water quality samples will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals.

The water collected in the collection ponds will be monitored (quantity and quality) and discharged to Lac de Gras if the quality meets Water License effluent criteria. If the discharge criteria are not satisfied, the water will be pumped to the PKC Facility.

7.4.3 Processed Kimberlite Containment Area

Geotechnical monitoring within the PKC area during interim closure will occur as in operations. The geotechnical instrumentation may include the following:

- Piezometers;
- Thermistors;
- Inclinometers; and
- Survey pins.

Visual inspections will also be conducted to check for signs of instability.

Water quality and quantity monitoring of the PKC pond will occur as in operations but at a reduced frequency since the plant will not be processing kimberlite. Inflow to the ponds will be reduced to surface flow and limited treated sewage water. Pond water volume will be monitored by changes in water elevation. Water quality samples taken from the pond will be tested for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. Actual dissolved metals concentrations will be monitored and trended in order to evaluate the need for additional water treatment.

Excess water collected within the PKC pond will be pumped to the NI for treatment at the NIWTP.

7.4.4 Water Management Facilities

Operational monitoring protocols and procedures will continue at the water management facilities during interim closure. Monitoring of the water quality will be performed at the inlet of the NIWTP and at the outfall as per the SNP requirements. Monitoring will include tests for physical parameters (i.e., pH, TDS, TSS and conductivity), major ions, nutrients and metals. Samples will also be obtained and tested per the Water License.

In addition to monitoring at the NIWTP, water quality samples will be taken from locations indicated in the SNP.

7.4.5 Plant Site, Accommodation Complex and Fuel Storage

The plant site, accommodation complex and fuel storage areas will be inspected and maintained on a regular basis during interim closure. In addition, monitoring of all tank levels, including fuel tanks, will be conducted as in operations.

7.4.6 Infrastructure

Infrastructure will be inspected and maintained on a regular basis during interim closure.

7.5 Contingency Program

A core staff with access to external consultants and advisors would be maintained during any temporary closure. This team would be available to resolve any unforeseen events or conditions identified through the monitoring program. Many of the contingency options and plans that could be implemented during a temporary closure would be the same as those employed during operations and are defined in DDMI (2009d).

7.6 Schedule

As temporary shutdown is commonly an uncertain condition, the schedule would be necessarily progressive as each week, month, season or year passes.

During periods of short-term shutdown (usually less than one year), mining activities other than maintenance, monitoring, intermittent testing, periodic operation of equipment and appropriate facilities, would generally cease together with all administrative duties required for compliance with permit and license agreements. A sufficient number of care and maintenance staff would be present on-site, and an appropriate level of security would be implemented at selected facilities. Activities related to ensuring public and wildlife safety would be a priority. Such activities would focus upon maintenance and monitoring of all facilities, equipment and stores to maintain physical and chemical stability. Access to temporarily inactive facilities would be restricted to authorized personnel. Fences and signposts to deny access would be erected as appropriate (e.g. underground portal).

Dewatering would continue at the open pit and underground workings to maintain stability. Underground areas would continue to be ventilated. Site-wide surface water, sediment and seepage control systems would be inspected regularly and would be maintained. Access to the PKC area would be restricted. Routine geotechnical stability monitoring and maintenance of the wasterock and till area, other material stockpiles, the PKC and other mine water impoundment structures would continue.

All facilities and infrastructure would be inspected regularly. Infrastructure, equipment, tools and utilities would remain in serviceable and safe condition. Non-emergency and non-essential vehicles would be parked in a secured common area, and when necessary, winterized. Non-essential buildings would be locked, and non-essential power lines would be discharged and locked open. All equipment would be maintained in a no-load condition. If necessary, selected equipment would be drained and stored. All tank levels, including fuel tanks, would be recorded and monitored, and inventories of chemical reagents, explosive materials and solvents would be undertaken.

8. Integrated Schedule of Activities to Permanent Closure

Figure 8-1 shows an integrated schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine site. The schedule as presented is highly uncertain. A refined schedule will only be possible once final designs and decommissioning plans have been completed. All schedules are subject to changes in mine plans. Market conditions could slow activities. Exploration or improved economics could extend the mine life beyond 2022.

The schedule in Figure 8-1 is a composite of the area specific schedules presented in Section 5.2. Common activities have been combined. A brief description of each activity follows.

Mining Activities A154/A418/A21 – The mine areas are currently expected to be active until 2022 limiting the closure activities.

Dump Development – The wasterock area is an active facility. It will continue to receive wasterock from open-pit mining through to 2011.

Re-Mining for Backfill – Wasterock will be re-mined for underground backfill starting in 2010 and continuing until 2022 (current plan).

PK Deposition – The PKC is an active facility and will be active until the last day of diamond production (currently 2022). Closure activities and associated works must remain mindful of this fact.

Mine Water Treatment – The NIWTP would continue to treated mine water until the completion of underground mining and decommissioning in 2023 under the current mine plan.

Accommodation/Power/Transportation Required – Infrastructure will be required at one level to support mining operations (currently ending 2022) and then at a lesser level for closure activities (currently ending 2029).

Revised Water Management – Commencing in 2010 the PKC will be an optional water supply for the process plant not a required supply. As such the intent over 2010 and 2011 is to modify the operation of the PKC to evaluate the extent to which the volume of pond water and possibly porewater, can be reduced.

Engineering/Environmental Studies – There are a number of engineering and environmental studies that need to be undertaken to prove up the preferred closure concept for each closure area, address uncertainties and reduce risks.

Community and Regulatory Engagement – Continued engagement is anticipated to refine the closure plans. In particular engagement is envisaged with regard to options and closure criteria for wildlife including the integration of Traditional Knowledge. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

Final Design/Decommissioning Plan – Final engineering closure designs and decommissioning plans will be completed and submitted for review in 2015. The designs will incorporate findings from engineering and environmental studies, research, community and regulatory engagement etc.

Detailed Engineering – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years prior to the initiation of the final closure work.

Wildlife Access and Contouring – Wasterock and Till – The detailed engineering design will be used to guide the re-mining work on the wasterock area to achieve final surfaces, access routes through the area, etc.

Inventory of Assets – Detailed inventory of assets for sale/reuse, salvage, recycle would be completed three years prior to the initiation of the final closure work to initiate external marketing.

Commercial Arrangements – Sale/Transfer of Assets – Specific arrangements would be made for sale, reuse, salvage or recycle of equipment and materials in advance of decommissioning.

Complete Fish Habitat Construction – Complete any final fish habitat construction work not completed during operations

Decommissioning of Collection Ponds 1,2,3 – Once runoff and seepage water quality/quantity have been confirmed, decommission collection ponds including removal of any pumping/piping infrastructure.

PKC Outlet Preparation – Deconstruction of a section of PKC liner and preparation of an engineered drainage outlet.

Placement of Final Surface and Wildlife Access - PKC – Placement of final PKC rock surface, construction of any access routes, re-sloping of access ramps, etc.

Decommissioning of Surface Mine Infrastructure – Removal of mining equipment and associated infrastructure for A418/A154 open pits and A21 mining area.

Decommissioning of Underground Mine Infrastructure – Removal of mining equipment, and associated infrastructure, sealing of surface access locations for A418/A154 underground in preparation for flooding.

Decommissioning of Process and Paste Plants – Activities associated with decommissioning this facility.

Decommissioning of Explosives Plant and Storage – Activities associated with decommissioning these facilities.

Flood Mine Areas – Clarify Water – Flood the A154/A418 open-pit and underground mine areas. Monitor clarification of A154/A418 and A21 pool areas.

Decommissioning of Accommodations and Other Buildings – Activities associated with decommissioning these facilities.

Decommissioning of Fuel Storage and Power – Activities associated with decommissioning these facilities.

Decommissioning of Collection Ponds 4,5, and,7 – Once outlet and seepage water quality/quantity have been confirmed, decommission collection ponds.

Decommissioning of Dikes/Sediment Control Structures – Excavation of breaches to re-connect Lac de Gras with mine area.

PKC Infrastructure Decommissioning – Removal of reclaim barge, water and slurry pipelines, power and any associated surface infrastructure.

Decommissioning of Waste Transfer – Activities associated with decommissioning this facility.

Decommissioning of Collection Ponds, and Pipelines 10,11,12 – Activities associated with decommissioning these facilities.

Decommissioning of North Inlet East Dam – Once North Inlet water and sediment quality have been confirmed, decommission the east dam by excavating a breach.

Decommissioning of Final Camp, Airstrip and Landfill – Activities associated with decommissioning these facilities.

Performance monitoring – Extended performance monitoring will be conducted starting in 2012. At this point the final footprint of the wasterock area will be known. Emphasis will be on seepage water quality, thermal monitoring, any wildlife interactions and stability.

Engineering Inspections – Inspections would be conducted during construction and decommissioning activities and in the years immediately following to review the closure performance.

Environmental Effects Monitoring – In addition to specific performance monitoring, environmental effects monitoring would be conducted on a 3 year cycle continuing on from operational monitoring but with an emphasis on closure effects. Key programs would be aquatic effects in Lac de Gras and wildlife effects.

Reporting – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring would be prepared and submitted for review and information.

9. Post-Closure Site Assessment

In this section the residual environmental impacts of the post-closure mine site are assessed. For this interim plan the assessment is the same as that conducted during the 1998 EA with modifications where EA predictions have been updated based on monitoring results. In the 1998 EA, environmental impacts were assessed for the construction, operation, closure and post-closure phases of development (DDMI 1998). Specifics of the closure plan have evolved since 1998 EA however post-closure effects identified in Section 5.2 generally fall within the scope and magnitude assumed in the 1998 EA.

Post-closure residual effects will become better defined as a result of performance and environmental effects monitoring of each mine area as closure is completed. This information, once available, will be used to prepare a final Post Closure Site Assessment. New information from monitoring will be used to define the post-closure changes in ecosystem components. These changes will then be assessed using the methods as employed in the 1998 EA and summarized below.

This section first summarizes the approach used in the 1998 EA to assess environmental effects. Then the results of the original assessment are summarized by key ecosystem component for the post-closure phase. Any differences based on current understanding of residual effects post-closure or changes to operational impacts as a result of environmental effects monitoring conducted to date are noted.

9.1 Assessment Approach

The 1998 EA focused on issues of importance to the people who would be affected by the mine development and of ecological importance. The EA was structured to provide focused, understandable and relevant information about the type, extent and magnitude of potential environmental effects. The general approach used to assess potential environmental effects in the EA was to:

- identify important issues relevant to the assessment of the mine;
- discuss the physical, biological, socio-economic and socio-cultural environments in which the mine would be introduced;
- explain the potential effects of the mine on those environments; and
- provide an assessment of the nature and, where possible, the magnitude and severity of these potential effects.

Potential environmental effects of the mine development were originally predicted for four phases construction, operation, closure and post-closure. It is the post-closure phase that is of relevance here.

To provide the information required by the Responsible Authorities to determine if the proposed Project would have significant adverse environmental effects, the environmental assessment describes potential effects according to their magnitude, duration and geographic extent.

In general, each discipline identified three study areas in which to analyze likely effects on the environment: local, regional and cumulative. The size of these areas varied among disciplines according to the context necessary to best understand and quantify potential effects. In general, the potential effects in the immediate vicinity of the mine were assessed within the local study area which most commonly was the East Island and adjacent water. On a regional basis, study areas were more varied. For example, the drainage basin of Lac de Gras (3559 km^2) was considered to be sufficiently large to examine the potential regional effects of the mine on fish and water. However, to adequately assess potential regional effects on wildlife, a much larger area (approximately 11,500 km^2) was used. Usually, the cumulative effects were assessed using the regional study area and beyond regional study areas, where applicable.

Table 9-1 provides a brief description of the local, regional and cumulative study areas for each discipline as well as the rationale for selection of the study areas. The local and regional study areas are also visually presented in Figures 9-1 and 9-2. Figure 9-1 illustrates the regional study areas for wildlife, vegetation and terrain, fish and water, heritage resources and air quality. Figure 9-2 illustrates the local study areas for those disciplines.

Geographic extent is the spatial area that is affected by an activity. For the purposes of the environmental effects assessment, potential effects that were restricted to the local study areas were judged as local in geographic extent. If an effect extended beyond the local study area, it was considered to be a regional effect. In some cases, effects have the potential to extend even farther and were considered “beyond regional.”

Magnitude describes the amount of change in a measurable parameter or variable relative to baseline conditions (e.g., 1996). The specific criteria used to determine the magnitude of an effect are related to the characteristic being investigated (e.g., fish populations, archaeological sites), the methods available to measure the effect, and the accepted practice in different scientific disciplines. Given this, definitions of magnitude are unique to each characteristic. Table 9-2 provides the criteria used to define magnitudes for each characteristic.

Table 9-1 Brief Descriptions of the Local, Regional and Cumulative Study Areas Used for Assessing Potential Effects in Each Discipline

Local Study Area	Regional/Cumulative Study Area	Rationale for Selection of Study Areas
Air Quality		
The East Island and adjacent waters of Lac de Gras.	An area 25 km east-west by 35 km north-south centred around East Island.	The local study area was selected as the area where ambient particulate concentrations and deposition rates would likely be the greatest. The regional study area encompasses the entire area within which ambient concentrations are likely above the thresholds commonly used to define the distance from the emissions sources to locations where modelling is no longer necessary.
Vegetation and Terrain		
The East Island.	The drainage basin of Lac de Gras.	The study areas were selected because they are representative of the areas that could be affected by the proposed Project. The local study area was selected for assessing direct effects from the Project, while the regional study area provides the context for understanding effects at the regional level.
Wildlife		
The East and West Islands; small islands in the east half of Lac de Gras; and the mainland along the south, east and north shores of Lac de Gras.	North to Yamba Lake; west to Destaffaney Lake; south to MacKay; and east to Glowworm and Afridi Lakes.	These study areas were selected to effectively represent and assess the diversity in patterns of use by wildlife. The local study area provides a framework for assessing effects on sedentary species with small seasonal ranges, and the regional study area provides a framework for assessing effects on species which have large seasonal ranges. Migratory species which use an area seasonally are also considered using these study areas.
Fish and Water		
The East Island and the surrounding water, within 1 km of the East Island shoreline.	The drainage basin of Lac de Gras.	The local study area was selected as a framework for presenting the effects on the aquatic environment that are likely to occur in the immediate vicinity of the proposed Project (e.g., fish habitat alterations on the East Island, alterations to water quality directly adjacent to the dikes). The regional study area was selected to present effects in a regional context which is most appropriate for assessing effects on fish populations in Lac de Gras and water quality in Lac de Gras as a whole.
Heritage Resources		
The East Island.	The East and West Islands and adjacent mainland to north and east.	The local study area corresponds to the area potentially affected by the footprint of the proposed Project. The regional study area corresponds to the initial baseline studies which encompasses the widest geographic area in which the Project facilities could have been situated.
Socio-Economics		
Communities of Gameti, Wekweti, Dettah, N'dilo, Rae-Edzo, Wha Ti, and Lutsel K'e. Yellowknife was included for economic analysis.	The Western NWT, emphasis on 20 study area communities.	The local study area encompasses the communities that would likely experience changes to traditional land use and occupancy, wage-based employment and community infrastructure, as a result of the proposed Project. The regional study area includes communities that may experience employment and business changes by virtue of their location and accessibility.

Table 9-2 Definitions for Magnitude and Duration

CLIMATE AND AIR QUALITY

Magnitude	Duration
Magnitude was determined by comparison to ambient air quality objectives	Duration was determined by the averaging period defined by the objectives used to determine magnitude

VEGETATION

Magnitude		Duration	
Negligible	less than 1% changes to measurement endpoint	Short-term	less than 1 year
Low	1% to 5% change	Mid-term	1 to 25 years
Moderate	6% to 30% change	Long-term	greater than 25 years
High	greater than 30% change		

WILDLIFE

Magnitude		Duration	
Low	less than 1% change from baseline conditions	Short-term	less than 3 years
Moderate	1% to 10% change	Mid-term	between 3 and 30 years
High	greater than 10% change	Long-term	greater than 30 years

HERITAGE RESOURCES

Magnitude		Duration	
Low	lost resource has limited scientific value with limited potential to contribute to public awareness and appreciation	Short-term	not applicable
Moderate	lost site has local and regional scientific interpretive values and has good potential to contribute to public awareness and appreciation	Mid-term	not applicable
High	lost site has regional scientific interpretive values with excellent potential to contribute to public awareness and appreciation	Long-term	heritage resources are permanently altered

FISH AND WATER - MAGNITUDE

Sub-Section	Magnitude	
Water Quality		
Suspended Sediment	Low	Severity classes 0 (representing no effect) to less than 9 (representing short-term behavioural, feeding and physiological effects)
	High	Severity classes 9 (representing short-term behavioural, feeding and physiological effects) to 14 (representing 80% to 100% mortality)
Porewater Release, Dike Leaching, Mine Water Discharge, East Island Runoff	Negligible	concentration is less than the drinking water and/or aquatic life guideline
	Low	concentration exceeds the drinking water and/or the aquatic life guideline by 10% or less
	Moderate	concentration exceeds the drinking water and/or the aquatic life guideline by 10% to 20%
	High	concentration exceeds the drinking water and/or the aquatic life guideline by more than 20%
Sedimentation and Dust and Air Emissions	High	sedimentation exceeds 1 mm for any spawning and nursery habitat
Groundwater Quality	Negligible	concentrations less than or equal to drinking water guidelines
	High	concentrations greater than drinking water guidelines
Water Supply		
Lac de Gras Water Balance	Negligible	less than or equal to 5% change
	Low	greater than 5% and less than or equal to 10% change
	Moderate	greater than 10% and less than or equal to 20% change
	High	greater than 20% change
Groundwater Quantity	Low	groundwater heads reduced but rock remains saturated
	High	rock is completely dewatered and becomes unsaturated
Fish		
Angling	Low	harvest rate below the sustainable yield
	High	harvest rate above the sustainable yield
Blasting	Negligible	peak particle velocity and instantaneous pressure change below threshold
	High	peak particle velocity and instantaneous pressure change above threshold
Dike Closure and Dewatering	Negligible	less than or equal to 1% change in fish populations
	Low	greater than 1% and less than or equal to 10% change in fish populations
	Moderate	greater than 10% and less than or equal to 20% change in fish populations

Sub-Section	Magnitude	
	High	greater than 20% change in fish populations
Habitat Change	Negligible	less than or equal to 1% loss of fish habitat
	Low	greater than 1% and less than or equal to 10% loss of fish habitat
	Moderate	greater than 10% and less than or equal to 20% loss of fish habitat
	High	greater than 20% loss of fish habitat
Fish Quality	Negligible	predicted metal concentration in fish tissue is equal to or less than the consumption threshold
	High	predicted metal concentration in fish exceeds threshold

FISH AND WATER - DURATION

Duration	
Short-term	less than 3 years
Mid-term	3 to 30 years
Long-term	greater than 30 years

The duration of potential environmental effects were broadly divided into three classifications, as shown below:

- **short-term effects** lasting for less than three years (i.e., effects generally associated with the period of intense construction activity prior to the start of operations, but may also occur during other phases);
- **mid-term effects** lasting from three to 30 years (i.e., effects generally related to mine operations and closure, and extending from the beginning of operations to the beginning of post-closure); and
- **long-term effects** lasting longer than 30 years (i.e., effects which persist beyond closure of the mine).

It is the long-term effects or those that last beyond closure that are of specific interest here.

In addition to the three main effect classifications of magnitude, duration and geographic extent, additional classifications were frequently considered.

Ecological context is a measure of the relative ecological importance of a component of the environment. It indicates the degree to which an affect on the component would substantially affect the functioning of the ecosystem within the local or regional study area. Ecological context was occasionally used to modify the magnitude classification assigned to an effect (i.e., the magnitude of an effect may be lowered or raised in accordance with the ecological context of the environmental component being assessed). In many cases, ecological context is explicit in the selection of the resource component being addressed (e.g., caribou were chosen as a wildlife species for the assessment because they are the primary herbivore in the ecosystem and important for hunting).

Reversibility is also a factor related to duration. Loss of heritage sites, for example, is not reversible because the site is not replaceable. Plant reclamation of disturbed sites is not reversible in the short-term, but natural processes would eventually result in vegetation recovery.

Because environmental effects assessments deal with predictions of future circumstances, or must predict how complex environmental systems could respond to disturbances, effects assessments vary in their level of certainty. In some cases, predictions can be made with a high degree of confidence. For example, archaeological sites within the mine footprint are highly likely to be affected. Conversely, predictions of how fish populations would respond to the effects of increased productivity can be made with less certainty. Each environmental effects report addresses issues of certainty when it is an important factor in judging the mine's potential effects.

With information on geographic extent, magnitude and duration an effect could then be given an effect level classification following Figure 9-3. Effects classifications with a level designation of "IV" are all long-term duration. It is Level IV effects that would be considered post-closure residual effects. Level IV effects are further defined by geographic extent:

- Level IV Local Effect
- Level IV Regional Effect
- Level IV Beyond Regional Effect

The Responsible Authorities took this classification system further in the *Comprehensive Study Report* to define a "significant adverse effect". A significant adverse effect is an effect that has a high probability of a permanent or long term effect of high magnitude, within the regional area that cannot be technically or economically mitigated. (Canada 1999).

9.2 Post Closure Effects Assessment

This section provides a summary of the effects assessment results from the 1998 EA with an emphasis on residual post-closure results. This is a summary of material presented in the Diavik Diamonds Project Environmental Effects Reports:

- Air and Climate (Cirrus 1998a),
- Vegetation and Terrain (Golder 1998a),
- Wildlife (Axys Environmental Consulting and Penner and Associates 1998),
- Fish and Water (Golder 1998b), and
- Heritage Resources (Fedirchuk McCullough & Associates 1998a).

These documents should be referenced for more specific information.

9.2.1 Air Quality

Effects on local and regional air quality are linked to mine emissions. The environmental assessment focused on maximum periods of emissions during operations and concluded that the predicted ambient air quality would not lead to identified adverse environmental effects. Post-closure mine emission sources will be removed resulting in improved local and regional air quality relative to operations. No long-term effects were identified.

Dust deposition is associated with potential effects to aquatic, vegetation and wildlife resources and was calculated based on information about the release of particulates into the air. The sources of the particulate material were all from mine related activities (rock hauling, blasting, dumping, crushing, etc) that would not exist post-closure. Some particulate would continue to be generated from wind erosion of rock surfaces but these would be substantially less than assessed for the operations phase. Dust deposition rates during operations have been measured by DDMI to be higher then predicted in the environmental assessment. Environmental impacts of dust on ecosystem components (aquatic, vegetation or wildlife) are discussed below where relevant.

The mine has been designed for very efficient use of energy and energy recovery which minimizes greenhouse gas emissions. Nevertheless, the mine operations emit greenhouse gases through fuel use on site and transportation of personnel and materials to the site. Emissions would primarily consist of carbon dioxide (CO_2), with much smaller amounts of methane (CH_4) and nitrous oxide (N_2O). The mine operation is a very minor emission contributor to Canada's total greenhouse gas emissions and would have no emissions post-closure.

9.2.2 Vegetation and Terrain

Conditions typical of arctic environments would result in slow recovery of any disturbed vegetation. Even with re-vegetation efforts effects of the mine development on vegetation are for the most part expected to remain as residual effects post-closure.

The main effect on vegetation resulting from mine development is the reduction in the aerial extent of all VLC types (see Figure 9-4). The VLC and water types within the local study area directly affected by the mine development are listed in Table 9-3. Locally, the magnitude of this effect would be high. Within the regional study area this direct loss of VLC from the mine development would be negligible, less than 1%. Additionally, because no uncommon plant species or plant communities were identified within the mine development footprint the ecological context of this vegetation loss would be low.

Table 9-3 Direct Losses To Vegetation/Land Cover Due To Development of The Diavik Diamonds Mine, Year 2018

Vegetation/Land Cover Type	Local Study Area - Baseline		Regional Study Area - Baseline		Total Disturbance (Diavik Project)		
	km2	%	km2	%	km2	%loss of VLC type in LSA	% loss of VLC type in RSA
Heath Tundra	8.70	38	1674.77	38	3.38	39	0
Heath Tundra 30-80 % Bedrock	1.65	7	83.51	2	0.75	45	1
Heath Tundra 30-80 % Boulders	3.84	17	530.82	12	1.70	44	0
Tussock/Hummock	2.70	12	382.12	9	1.48	55	0
Sedge Wetland	0.46	2	134.06	3	0.24	52	0
Riparian Tall Shrub	0.05	<1	3.27	<1	0.03	56	1
Birch Seep and Riparian Shoreline Shrub	0.34	1	55.88	1	0.10	28	0
Boulder Complex	0.22	1	17.05	<1	0.05	23	0
Bedrock Complex	0.10	<1	4.29	<1	0.07	72	2
Shallow Water	0.98	4	172.22	4	0.46	47	0
Deep Water	3.49	15	1304.04	30	3.12	90	0
Human Disturbance	0.06	<1	0.26	<1	0.06	100	22
Esker	0.25	1	39.95	1	0.14	55	0
Unclassified	0	0	1.08	<1	-	-	-
Total	22.84	100	4403.Gold er	100	11.57	51	<1

LSA=Local Study Area; RSA=Regional Study Area

Localized changes in plant community composition is expected to occur outside the mine footprint in response to dust deposition and changes in drainage conditions. The effects of dust would be concentrated within 10 m of project facilities, and mostly limited to within 50 m. Incremental losses (over losses due to the mine footprint) were calculated as being 1% and 9% for each zone of impact, respectively. Effects on vegetation due to changes in drainage were estimated to affect 10% of the local study area. The geographic extent of these changes would be restricted to the local study area, and effects would be up to a moderate magnitude. Effects on vegetation outside the mine footprint are expected to reverse in time but could last more than 25 years and therefore are classified as local residual effects post-closure.

No plant species, vegetation types or terrain type would be eliminated by the mine development. At the landscape level, the number of naturally occurring terrain units may drop, but man-made units would increase, such that a low magnitude local increase in terrain diversity would result. At the community level, the richness (number) of VLC units would decrease by 14%, which represents an effect of moderate magnitude. Introduction of disturbed types could result in an increase, although artificial, in the diversity of community types. The size and range of patches for most VLC types would decrease due to the mine footprint. These changes would have moderate to high magnitude local effects on community structure. At the species level, a reduction of some 44% of species diversity and richness units is expected at the local level. This represents a local loss of high magnitude. However, no rare or endangered species would be affected.

All changes to vegetation and/or terrain biodiversity are expected to have a local geographic extent and be long-term in duration and therefore are classified as local residual effects post-closure.

9.2.3 Wildlife

9.2.3.1 Grizzly Bear

At full development, existing habitat availability would be expected to be reduced (through reductions in habitat suitability and effectiveness) by >1% within the Local Study Area but by < 1% within the RSA, resulting in a high local effect but a low regional effect. Effects are considered to be regional in extent because the zone of influence of sensory disturbances extends marginally beyond parts of the Local Study Area.

At post-closure, the causes of reduced habitat effectiveness (sensory disturbance) would have been largely removed. Nevertheless, there could potentially be a holdover, regional level effect for some time after the cessation of mining activities due to the learned avoidance responses of individual bears. The impact extent would, therefore, continue to be classified as regional. The effects of reduced habitat suitability through direct habitat loss within the mine footprint would remain at post-closure. These effects directly affect much less than 1% of total grizzly bear habitat in the Regional Study Area, resulting in a low magnitude regional impact, but probably >1% of the total bear habitat in the Local Study Area, continuing to be equivalent to a moderate magnitude, Local impact. However, the percentage of habitat affected would be reduced as compared to full development.

9.2.3.2 Raptors

Cumulative effects at full development are anticipated to be moderate in magnitude, based on predicted impacts on areas currently providing high to very high raptor nest site potential. This represents a worst-case scenario, and the actual magnitude of reduced nesting potential would likely be lower than the 1.8% loss estimated in the EA (DDMI 1998). The magnitude of effects and overall impact rating would be reduced at post-closure because of the removal of sensory disturbances (i.e., ZOIs) and possible gains in habitat suitability from reclamation.

Based on this assessment, cumulative effects at full development would be mid-term in duration, resulting in Level III regional effects. In the worst-case scenario, assuming unsuccessful reclamation and some continuing sensory disturbance, post-closure cumulative effects would be classified as Level IV regional (i.e., moderate magnitude and long-term in duration). However, the removal of sensory disturbance and restoration of nesting habitat suitability in the physically affected area at post-closure would more reasonably be expected to reverse the direction of impacts to neutral, resulting in a post-closure assessment of no residual effects.

Reclaimed mine sites would likely provide more rugged terrain categories as compared to predevelopment conditions. Steep slopes and variable aspects could result from wasterock piles and, with the implementation of proven nest site enhancement techniques at these sites (e.g., ledge creation), raptor nest site potential could potentially be improved. Reclamation could, therefore, result in an increase in area of high to very high nest site potential at post-closure, relative to predevelopment or baseline conditions.

9.2.3.3 Waterfowl

At full development, existing staging and nesting habitat availability would be expected to be reduced (through reductions in habitat suitability and effectiveness) by greater than 1% within the Local Study Area but by less than 1% within the Regional Study Area, resulting in a high (Level IV) local effect but a low (Level I) regional effect on waterfowl. At post-closure, the causes of reduced habitat effectiveness (sensory disturbance) would have been largely removed, but physical impacts on habitat might remain even with successful reclamation, resulting in a long-term reduction in the ability of the East Island to support staging and nesting waterfowl. Thus, although the types and extent of impacts would be expected to be reduced at post-closure, the overall effects classification remains the same as at full development.

9.2.3.4 Caribou

Distribution

Long-term changes in the seasonal distribution of caribou are generally the result of long-term changes in habitat availability. Analysis of changes (direct and indirect) in caribou summer habitat availability from mine development and cumulative land use activities, has been estimated at high (12.3%) and moderate (2.6%) reductions in summer habitat availability at full development in the local and regional study areas, respectively, relative to 1996 baseline conditions. The area of direct habitat loss is within the original EA predictions but the measured zone of influence from monitoring studies is greater than predicted in the EA resulting in larger habitat changes. Habitat effects would not extend beyond the regional study area, they would have no influence on the calving and over-wintering distributions of the Bathurst herd. Within the broad migratory corridor and summer range of the herd which encompasses the mine development, the level of habitat reduction measured shows localized shifts in habitat use with no measurable effect on broad seasonal distribution. The duration of this effect on caribou is expected to be mid-term (3-30 years) and limited to the operations phase. With the removal of the operations stressors of noise, smell, etc. the indirect changes to habitat use are expected to be significantly reduced and only the direct habitat losses will remain.

Mortality

The likelihood of injuries to caribou was projected to be very low once the mine sites is closed and post-closure landscapes finalized. Hunting will continue to be the main source of human-caused mortality under the post-closure scenario.

Based on experiences at other mines, the likelihood of injury or direct mortality from industrial activity in the Regional Study Area is anticipated to be low under all conditions. It is assumed that hunting will remain the only significant source of human-caused mortality in the Regional Study Area and that hunting mortality will not increase as a result of mine development and operation.

Energetics

Post-closure, the predicted paths of least resistance for fall migration returned to the predevelopment route under the post-closure scenario. In the model it was assumed that movement through altered terrain in the development sites might involve traversing or going around difficult terrain. The magnitude of effects on fall migration were predicted to be slight, resulting in less than a 1% increase in the overall cost of migration through the Regional Study Area for individual caribou encountering the post-closure mine site.

9.2.3.5 Carnivores

Mine-related decreases in habitat availability, both for prey species and for denning sites, would cause a long-term reduction in the ability of the East Island to support wolves, wolverine and foxes. These decreases in habitat availability would remain post closure. During the operations phase of the mine, most carnivores would avoid the island. Red foxes would likely exhibit a high degree of tolerance to mining activities and might remain as residents on less disturbed portions of the island, assuming that an adequate prey base also remained. Wolves and wolverine likely would be less tolerant of mining activities, and might avoid the East Island to a greater degree than foxes. In either case, these localized shifts in habitat use off the island during operations would not represent a measurable shift in the distribution of these species within the regional study area. Post-closure the predicted and observed influence of the mine area as an attractant/deterrent to carnivores would be significantly reduced/eliminated.

The mine development would not be expected to have measurable effects on the population levels of wolves and foxes in the regional study area during operations. Habitat lost to the mine and its zone of influence would represent a loss of less than 1% of the available hunting habitat in the regional study area. Similarly, although at least one and possibly two fox den sites might be abandoned as a result of mining activities, comparable denning areas are widely distributed within the regional study area, and the loss of East Island sites would not measurably affect regional denning potential. Direct mortalities from vehicle kills and the relocation of animals would also be expected to be minimal, given the environmental management strategies adopted for the mine development. Consequently, Mine-specific effects on wolves and foxes at the population level are predicted to be low and limited to the operations phase.

Due to uncertainty regarding the current status of wolverine populations and the effectiveness of mitigation, mine-specific effects on wolverines at the population level have been classified as low to moderate. Even moderate level mine-specific effects would not be expected to affect wolverine population parameters at the beyond-regional scale (i.e., within the Slave Geological Province). These effects were also predicted to be limited to the operations phase.

The mine is not expected to contribute measurably to cumulative effects on carnivore populations during operations. However, if regular or frequent mine-related mortalities or removals of wolverines occur, further consideration of cumulative effects within the regional study area and implementation of remedial actions would be required to ensure that the viability of the regional wolverine population was not being jeopardized. Mine-related mortalities are not expected to occur post-closure.

9.2.4 Fish and Water

9.2.4.1 Water Quality

The effect of flooding and breaching of the open-pits at closure on water quality in Lac de Gras is classified as Level I Local effect for both drinking water and the protection of aquatic life as the magnitude was predicted to be negligible to low at a local geographic extent.

Flooding of the open pits at closure is not expected to have an adverse effect on groundwater quality. As mining proceeds, the quality of groundwater is expected to improve locally due to an overall decrease in TDS. Concentrations of TDS are expected to be higher near the bottom of the pits, but lower at the sides of the pits resulting in an overall decrease in TDS in groundwater.

Treated mine water discharge during operations introduce higher levels of nutrients, particularly phosphorus from the natural groundwater, to Lac de Gras. Up to 20% of the surface area of Lac de Gras is expected to increase in trophic status during operations. Effects of increased trophic status cannot be predicted with any certainty, but could include an increase in algal growth, increases in fish growth rates, improvements in fish health and increases in the abundance of some aquatic species and a decline in the abundance of others. Trophic levels are predicted to decline back to background levels post-closure with the elimination of the mine water discharge.

Containment of runoff during operations would effectively prevent any effects on water quality in Lac de Gras during operations. Post-closure, runoff from disturbed areas would be re-directed through East Island streams and lakes to Lac de Gras. Undiluted post-closure runoff water quality is expected to exceed thresholds for the protection of aquatic life for total phosphorus and nine metals (copper, aluminum, cadmium, chromium, lead, mercury, nickel, silver and zinc). Therefore, post-closure runoff could have a long-term, high magnitude affect on East Island lakes which receive drainage from reclaimed areas. Aluminum, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc concentrations in post-closure runoff could adversely affect sensitive aquatic organisms in East Island water bodies. Phosphorus levels in the post-closure runoff could substantially increase the trophic status of affected East Island lakes.

Once the runoff reaches Lac de Gras water quality in Lac de Gras is expected to be below thresholds for aquatic life for all parameters except total phosphorus, aluminum, cadmium and chromium at the smallest assessment boundary (0.01 km^2). The magnitude of effect would be high for total phosphorus, cadmium and chromium and low for aluminum. The magnitude of the effect from cadmium would remain high at the 1 km^2 assessment boundary, but would be negligible at the 5 km^2 assessment boundary. The geographic extent would be local.

Post-closure runoff water quality is predicted to be below drinking water thresholds for all parameters and so is not expected to impact on drinking water quality on the East Island or in Lac de Gras.

The potential for these effects would be evaluated further based on actual run-off monitoring information collected during operations and in advance of final closure.

9.2.4.2 Water Supply

The potential effects of changes to Lac de Gras water levels and outflows on the Coppermine River as a result of flooding the pit and dike areas are expected to be negligible and would not extend beyond closure. No measurable effect (i.e., <1% change) is predicted for flow in the Coppermine River downstream from the outlet of Point Lake.

9.2.4.3 Fish Mortality

The only effect of the mine development directly on fish mortality that was identified in the EA as lasting beyond closure was effects due to angling. Subsequent to the EA, a no fishing policy was adopted at the mine site eliminating this potential effect.

9.2.4.4 Fish Habitat

The analysis of potential effects of mine infrastructure development on fish-bearing lakes on the East Island predicted that there would be an effect of high magnitude and mid-term duration as a result of the permanent loss of four fish-bearing lakes on the East Island. Habitat enhancement efforts are expected to compensate these losses by providing an overall net gain in fish habitat post-closure. At post-closure, there would be a loss of burbot and longnose sucker habitat, as these species were not targeted for habitat restoration in the current mitigation plan. There is also a small reduction in rearing habitat for lake trout. However, the overall amount of habitat created for the remainder of the target management species results in a net creation of inland lake habitat.

Post closure there is expected to be a small reduction in stream migration corridor habitat on the East Island, a habitat type that only existed under very high flow conditions.

Fish habitat losses in Lac de Gras as a result of mine development and dewatering of Lac de Gras represent a maximum of 1% loss of the available habitat from baseline conditions. Post-closure, habitat enhancements would compensate for these habitat losses, resulting in a net gain in habitat. The effect on fish habitat in Lac de Gras regionally at post-closure would either be no adverse effect, indicating no net reduction or a net gain of habitat, or a negligible effect. All habitat losses at post-closure (i.e., those with negligible effects remaining) would be of habitat that is not considered limiting in Lac de Gras (i.e., no post-closure effects on rearing habitat).

9.2.4.5 Fish Quality

The EA analysis determined that the metal concentrations in the flesh of fish in Lac de Gras are not expected to exceed the guidelines for safe human consumption for any fish species examined during operation or post-closure. The analysis further indicated that tainting of fish flesh, as a result of the mine development would not be likely. However, post-closure runoff to two lakes on the East Island could result in elevated metals concentrations in fish flesh in those two lakes. The potential of this effect would be evaluated further based on actual runoff monitoring information collected during operations.

9.2.5 Heritage Resources

Heritage resource sites are non-renewable and as such any effects identified for the mine development would be permanent and remain post closure as residual effects. Effects on heritage resources include loss of artifacts and features, artifact distributions, loss of site location and site context. These effects would occur at the site, local and regional level of archaeological data. At the 57 sites that fall within the footprint of the mine, the effect of the mine development is a loss of these aspects of heritage resource either through disturbance or burial. Although these adverse effects would be offset by mitigative studies, the sites' physical location and context would still be lost.

Potential effects on heritage resources can also be positive in that the results of site inventories add to the regional database and contribute to our understanding of past lifestyles and landscape use. This is the case for 138 of the identified sites.

The magnitude of effects on individual sites was classified based primarily on the potential scientific interpretive value and the potential contribution to public awareness and appreciation of heritage resources. Specifically, the magnitude of effect on heritage resources was classified as low if the heritage resources potentially lost are associated with limited scientific interpretive value and with limited potential to contribute to public awareness and appreciation. Effects on heritage resources were classified as moderate if the loss is associated with local and regional scientific interpretive values and with good potential to contribute to public awareness and appreciation. The magnitude of an effect on heritage resources was classified as high if the loss of the heritage resources is associated with regional scientific interpretive values with excellent potential to contribute to public awareness and appreciation.

The magnitude of effect at the local level, for the 57 sites within the mine footprint, would be high. However, with the completion of mitigative studies, loss of data would be offset by information gain. Although at the local level, effects would occur at a high number of precontact quarries, when viewed from the context of regional level of data, the magnitude of effect would not be high. Given the nature of heritage resources, the confidence placed in the likelihood of the predicted effects occurring is high.

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