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December 31, 2010

Re: Revised Interim Closure and Reclamation Plan Version 3.1

Diavik Diamond Mines Inc. (DDMI) is please to submit for your consideration Version 3.1 of Diavik's Interim Closure and Reclamation Plan (ICRP). This submission is being made pursuant to Water License W2007L2-0003 Part L Items 1, 2, 3, 4, 6 and the WLWB Directive of May 19, 2010.

As you are aware there were many comments on the ICRP. DDMI has made a substantial effort to both revise the document, advance closure research and prepare a closure cost estimates in support of this revision. Key areas of revision are noted below.

Editorial Improvements

Version 3.1 includes, in Section 5.2.1 an overview of the current plans for closure. This includes tables showing planned activities associated with each closure objective. We believe this overview will improve understanding of the current closure plan. If a reviewer wants more information, the remainder of Section 5 describes how the preferred plan has evolved as well as the uncertainties still to be resolved.

DDMI retained an external editor to provide a final check on the document which should have eliminated grammatical and typographical errors.

Community Engagement

DDMI proceeded further with community engagement including efforts to develop formal engagement protocols with each community. Our goal is to ensure engagement protocols are in place for all community engagement, including engagement on closure planning, so that processes are understood and effective for everyone. It is taking time to meet with leadership from each community. Progress continues, however protocols have not yet been finalized.

Closure Objectives

Closure objectives have been substantially revised. They have been simplified by taking common objectives from the different closure management areas and making them site-wide objectives. For the North Inlet, objectives were simplified to being objectives specific to rejoining the North Inlet with Lac de Gras and removing what were effectively contingency objectives for if reconnection was not possible. Additionally, the language of the objectives was modified to remove qualifiers such as "where appropriate" and "if feasible" recognizing that these qualifiers are implicit for all objectives and if in the future it is determined that an objective cannot be achieved then, with the Boards approval, it can be revised.

Revised objectives were distributed to all reviewers. Discussions were held with several groups to obtain feedback and written comments were received from others. In general there seemed to be support for most of the changes.

Closure Criteria

It appears to be recognized by reviewers that the closure criteria are "works in progress" that will take time to finalize. DDMI has revised the text and table to better explain the criteria proposed and have included in the research plan how and when some criteria can be addressed further. Reviewers noted willingness to be involved in future criteria development.

Final Design Concept

DDMI has clarified that the goal is to have final design concepts by 2015 and the research plans are aligned to achieve this. Final designs are not required until around 2020, two years prior to closure. We expect to coordinate a full update to the ICRP for 2015 to provide documentation of the final design concepts.

Waste Rock

The description of the closure plans for the waste rock area has been expanded to describe the linkages with A21 open-pit mining, test pile research and that currently there is no immediate requirement for a final decision on the closure plan for the waste rock pile. Important factors that impact on the closure plan for this area remain undetermined including wildlife movement, landform and thermal/geochemical.

Pit Water Quality

We were surprised by the level of reviewer concern over possible vertical mixing conditions in a final pit lake at this stage of closure planning. As a result we engaged a consultant to conduct some preliminary mathematical modeling of a final pit lake to better describe anticipated post-closure conditions. These results are included in Version 3.1 and should address many of the reviewer concerns.

Processed Kimberlite Containment

In the previous ICRP it appears that our description of the preferred closure plan led reviewers to thinking that these designs were further along than they are. For Version 3.1 we have tried to clarify that the preferred plan is still at the concept level. We have removed engineered drawings of the concept and replaced them with a more appropriate illustration. We hope the illustration will be better suited for ongoing discussions with reviewers.

On-site Burial

On-site burial of inert waste is a reasonable, practical and environmentally responsible practice during operations and at closure. On-site disposal is an integral part of DDMI's existing closure plan and is approved operationally. As directed by the WLWB, DDMI obtained an external opinion on the advantages and disadvantages of on-site versus off-site disposal. This opinion is included in the ICRP and supports on-site burial.

2001 ICRP Conditional Approval

As stated above the objectives for the North Inlet have been revised to focus on the preferred option of reconnection with Lac de Gras. In 2010 DDMI initiated an extensive field and laboratory characterization program of the North Inlet Water Treatment Plant sludge and

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North Inlet sediments. Final reporting and interpretation of results is not yet complete so could not be included in the ICRP. Independent of the sludge/sediment characterization study, DDMI commissioned a review of alternatives for sludge disposal. This report is included in the ICRP. With the information above, the 2001 ICRP conditions have been met and further planning and evaluation of North Inlet can proceed.

A21 Development

A mine plan for the A21 kimberlite pipe has not yet been determined. As such the ICRP Version 3.1 does not include a closure concept, objectives, costs or research plans specific to the A21 area. If and when a mine plan is determined, DDMI will prepare a companion closure plan specific to the selected A21 mining approach.

Research

The reclamation research plans have been fully revised. They have been organized into 6 areas; one for community engagement and traditional knowledge and one for each of the five closure management areas. Research completed to date is summarized and reference material provided. The emphasis in the research plans are tasks to be completed over the next three years. An introduction section has also been added to better explain how research results link to DDMI closure planning and DDMI closure planning decision making.

Part L item 3(f) specifies that the research plans include “a description of how metal uptake in revegetated plant communities will be monitored”. At this point in the closure planning, it is premature to emphasize research related to monitoring methods particularly when it has yet to be determined which areas will be targeted for re-vegetation or if metal up-take in plants is likely to pose an unacceptable risk to people or wildlife. Research related to monitoring methods is more appropriately defined after closure concepts have been finalized and closure criteria are better defined through risk-based criteria. We expect that if a need for research into monitoring methods is identified, this can still be completed following a better definition of re-vegetation closure plans.

Re-vegetation

Identifying target area of the mine for re-vegetation has been included as a specific research question. As described above, it is premature to be emphasizing research related to monitoring metal uptake in plants. DDMI has included metals in plants as a potential contaminant pathway to be considered in deriving site-wide risk-based closure criteria. DDMI suggest that it would be more appropriate to first understand if metals in plants is likely to pose an unacceptable risk to people or wildlife and to understand where re-vegetation efforts are to be targeted, before emphasizing research on metal uptake monitoring methods.

Closure Cost Estimate

Included in the ICRP is a complete closure cost estimate using the most recent version of RECLAIM provided to DDMI by INAC. DDMI met with INAC in November and December 2010 to discuss INAC’s 2007 closure cost estimate and to explain how DDMI has revised the INAC 2007 estimate to align with the preferred closure concepts described in ICRP. The closure cost estimate reflects the current and maximum life of mine closure liability. The estimate does not include costs or liability for the A21 mine area. This will be added in the future pending a decision on A21 mining.

Finally, DDMI would like to acknowledge the efforts of all reviewers in their detailed review and comment on the ICRP. We would also like to thank WLWB Staff for their responsiveness to clarifications and questions that we had while revising the document. The document has substantially improved as a result of these efforts.

Please let me know if you have any questions regarding this submission.

Regards,

Gord Macdonald

cc Mark Cliffe-Philips (WLWB)
Ryan Fequet (WLWB)
Patty Ewaschuk (WLWB)

Attachment: Interim Closure and Reclamation Plan – Version 3.1

Interim Closure and Reclamation Plan – Version 3.1

Diavik Diamond Mines Inc.

December 2010

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ATTACHMENTS

TABLES

1. Executive Summary

This Interim Closure and Reclamation Plan (ICRP) update (Version 3.1) has been prepared as per the requirements of Diavik Diamond Mines Inc.'s Class "A" Water License WL2007L2-0003 and directives from the Wek'èezhíi Land and Water Board. The Interim Closure and Reclamation Plan currently approved under the Water License is Version 1.0 – October 2001.

Closure planning began with the original mine design work in 1996 to 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. These closure plans remain consistent with the October 2001 ICRP with the exception that the A21 mine area has been excluded pending a determination of a mining approach for this kimberlite pipe.

On land, the waste rock 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. The closure option for the waste rock and processed kimberlite areas have changed since the October 2001 ICRP. A21 mine waste will not be available to place as cover material on the waste rock pile under the current mine plan. The processed kimberlite containment area will drain to a central surface pond before flowing south from the facility through a series of small ponds and streams. In addition the south waste rock pile is currently not required, so not included in this ICRP.

Buildings, equipment, power lines, pipeline, fuel tanks and other infrastructure. 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. Inert material with no resale/reuse/recycle value will be disposed of on-site consistent with the October 2001 ICRP.

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. These plans are also consistent with the October 2001 ICRP.

Like the 2001 ICRP, this is an interim plan. Closure planning is an ongoing activity and this document is effectively a progress report towards the Final Closure Plan, required in 2020. Because many of the specific details of closure and reclamation activities have not yet been developed, this update to the interim plan still includes uncertainties. Research plans to address the uncertainties are included.

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 about 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 must also be made throughout the planning process. Some of these decisions are significant, are made early in the planning process and can affect the final closure plan. For example the decision on a location for the waste rock 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* (WLWB 2009) 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 the Environmental Monitoring Advisory Board (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 waste rock 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:

- describe the current closure plan and future direction of the 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 before 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.

Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2007a) provide three main areas of focus regarding closure and reclamation goals:

- *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 goals, specific to the Diavik mine site, have been developed through a process involving DDMI, reviewers and WLWB staff and are listed in Table 2-1. Selected options for site closure should be consistent with the stated closure goals. The goals have been designed to be reasonably attainable and specific enough to develop closure objectives.

Table 2-1 Closure Goals – Diavik Mine Site

Goals
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. Final site conditions that do not require a continuous presence of Mine Staff.

2.3 Closure and Reclamation Planning Team

Closure planning at Diavik is conducted by a multi-discipline, interdepartmental team that has been formally organized as a committee. The committee was established April 9, 2003, three months after production began. The committee's original focus was communicating closure plans and rationale to the operations departments, with the understanding that closure would remain a focus and that operations needed to be fully aware of the current plans. The committee also sought input on ways to improve these plans for both closure success and for operations. Participation on the committee was originally limited to operations and environment departments, and the focus was waste rock 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, Closure and Earthworks Engineering* – PKC and general earthworks including construction design, operations planning, engineering investigations, and closure costs estimating.
- *Senior Mine Engineer* – waste rock and ore planning and management.
- *Planner, Water Management* – water management infrastructure.
- *Specialist, Mineral Waste Management* – geochemistry, processed kimberlite investigations, waste rock segregation, test piles research and hydrology.
- *Superintendent, Communities and External Relations* – community engagement, Traditional Knowledge, socio-economics, business and community opportunities.
- *Specialist, Communications* – communications plans.
- *Superintendent, Environment* – monitoring, Traditional Knowledge, wildlife access, hazardous materials, landfill, vegetation research, permits, licenses and communication with Inspector.
- *Principal Advisor, Strategic Planning* – mine planning, closure costs and finance.
- *Manager Underground Mining* – 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 was initiated through general discussions about the Project in June 1995, when 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. The Project concepts that formed the basis of these initial discussions with communities are shown in Figure 5-7. 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 an exploration camp at the Diavik sites to present and discuss a 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 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 in 2009 related to this update of the ICRP included the following:

- 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 Dené First Nation, Lutsel K'e Dené First Nation, North Slave Métis 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 the 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 to 21, 2009 – DDMI invited representatives from the Tlicho, Yellowknives Dené First Nation, Lutsel K'e Dené First Nation, North Slave Métis 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 Métis Alliance required rescheduling. A copy of the closure presentation given at the community meetings is attached as Appendix IX-6.

Diavik would like to further advance community engagement as it relates to closure. Diavik is working to establish Engagement Protocols with each of the five Aboriginal organizations. The protocols, once developed, are intended to clearly outline engagement needs for both Diavik and communities, thereby providing process clarity for everyone involved. The template provides various topics of interest (including closure), identifies the purpose for engaging, and outlines the lead contact from both DDMI and the Aboriginal organization for each topic (Appendix IX-7). It is the intent that the lead contacts will work together to develop a suitable approach for engagement on each selected topic that would be specific to each Aboriginal organization. It is expected that these Engagement Protocols would be reviewed as required; for example, with a change in community leadership.

Diavik has now met with the leadership of each of the five Aboriginal organizations to discuss this overall approach and have provided copies of the template to each of the Parties. Once the lead contacts have been identified, a draft Engagement Protocol will be submitted for sign off by leadership from each of the Aboriginal organizations.

The Engagement Protocol addresses two key topics relating to community engagement for closure: Annual Updates and Closure Planning. Diavik will continue annual community visits to inform community members about what the mine site will look like at closure, considerations evaluated for closure and progress being made towards closure. Presentations for community visits usually include presentation slides (3 to 5) for each topic of interest to the community, of which closure would be one topic, with an opportunity afterwards for questions from attendees.

Annual updates completed to date for 2010 include: Wekweeti (October 25, 2010), Gameti (October 26, 2010), Whati (October 27, 2010), Behchoko (November 9, 2010), Kugluktuk (November 29, 2010) and N'Dilo/Dettah (December 13, 2010).

To discuss Closure Planning, each Aboriginal organization will be asked to identify 5 to 8 people to provide input on closure options for their organization through a facilitated workshop in their community. Each workshop would result in a summary document outlining that organization's recommendations and/or considerations for closure-related topics. Diavik hopes this process will start in 2011 and continue through to the development of the final closure plan. Ideally, the people identified for this type of activity will remain dedicated to the process and be available to participate in each workshop. Diavik will work with each Aboriginal organization to determine if this process is appropriate for their organization.

2.5 Closure Plan Requirements

2.5.1 Guidelines and Regulations

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

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

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	

The overall approach to closure and reclamation planning for the Diavik Diamond Mine 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.

2.5.2 Permits and Authorizations

The Diavik Diamond Mine received ministerial approval under the *Canadian Environmental Assessment Act* on November 1999 based on a Comprehensive Study Report (Canada 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.

2.5.2.1 Comprehensive Study Report Conclusions

Initial plans for closure were considered in the Environmental Assessment for the Project as documented in DDMI (1998d) and Canada (1999). These initial plans for closure are summarized in Section 5. Canada (1999) provided conclusions, relevant to closure, that DDMI understood to be for consideration in the regulatory phase (Land Leases, Water License, Fisheries Authorization). These conclusions included:

- p. 111 – "The RAs [Regulatory Authorities] conclude that there will be no significant adverse environmental effects provided that the mine is properly decommissioned. Diavik must prepare a comprehensive Abandonment and Restoration (A&R) Plan, and have it reviewed and approved by regulatory authorities."
- p. 111 – "The approved A&R Plan will not allow burial of buildings, machinery and equipment on the mine site. It will include an estimate of implementation costs at various stages in the life of the mine."

- p. 111,151 - “Should this project be allowed to proceed, Diavik must provide to the regulatory authorities adequate financial security for assuring that the A&R Plan will be fully implemented, independent of the corporation’s financial status when the mine is closed.”
- p. 111 – “The A&R Plan must be submitted within two years from the time of regulatory approvals should the Project be allowed to proceed. The A&R plan will address the time frame associated with the commencement of long-term closure procedures, advancement of rehabilitation procedures and identification of indigenous plant species to be used for re-vegetation.”
- p. 111 – “The follow-up program to be specified in the environmental agreement or land lease will also require Diavik to refine reclamation techniques in consultation with other developers that are best suited to the local climate and geology.”
- p. 141 – “Permafrost will aggrade into the saturated pond sediments of the PKC after mine abandonment, under the current proposal. Permafrost aggradation and the consequential build-up of pore water pressure ahead of the freezing front will enhance horizontal and vertical movement of metal-contaminated pore fluids, especially if there is no residual pond following abandonment. Permafrost may then rupture and contaminated PKC pore waters could be outside the confines of the PKC. The RAs concluded that the potential environmental effects from pore water release of contaminants to the environment can be mitigated through proper engineering design that would be detailed at the regulatory stage. Diavik must also develop appropriate closure and contingency plans for inclusion in its Abandonment and Reclamation Plan.”
- p. 145 – “These surface water collection systems will accumulate sediments and leachate from the country rock piles, plant site and road ditches, and Diavik must develop an Abandonment and Restoration Plan that fully addresses restoration of the collection system.”
- p. 151 – “The RAs concur with Diavik’s commitment to isolate the North Inlet from Lac de Gras with an impermeable barrier and to treat the North Inlet water before discharge to Lac de Gras. The RAs conclude that there will be no significant adverse environmental effects provided that the mine is properly decommissioned.”
- p. 151 – “Since no closure plan has been proposed for the North Inlet, Diavik must prepare a comprehensive Abandonment and Restoration (A&R) Plan, have it reviewed and approved by the regulatory authorities.”
- p. 167 – “At post closure, metal concentrations in fish flesh in some of the East Island lakes are predicted to exceed consumption guidelines. The RAs agree that Diavik should monitor metal concentrations post-closure and agree with KIA’s recommendation that a plan be developed to warn people fishing these lakes (e.g., posting signs), if the predictions are correct.”
- p. 169 – “The responsible authorities (RAs) concur with Environment Canada’s recommendations and direct Diavik to further consider the effects of climate warming on the long-term integrity of frozen structures at the regulatory stage should the Project be allowed to proceed. Geotechnical monitoring must continue for the life of the Project to ensure the integrity of the frozen dam structures for the abandonment and restoration.”

Where follow-up programs with environmental aspects are not within the jurisdiction of a specific permit, license or authorization, Canada (1999) determined that it would be included in an environmental agreement. On March 8, 2000 an Environmental Agreement was established. Article XV – Security and Enforcement – of the Environmental Agreement specifies the terms and conditions regarding financial securities held by the INAC Minister for the performance by DDMI of its reclamation and abandonment obligations under the Water License, Land Lease and any other obligations for which the INAC Minister is responsible. All other environmental aspects of closure are specifically included in the terms and conditions of the regulatory instruments listed in Table 2-3 and described below.

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 Explosives 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
Water Licence W2007L2-0003	Wek'èezhìi Land and Water Board
Fisheries Authorization	Fisheries and Oceans Canada
Navigable Waters Permit	Transportation Canada
Explosives Permit	Natural Resources Canada
Land Lease	Indian and Northern Affairs Canada

2.5.2.2 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 (Appendix VII);
- DDMI shall implement the Restoration Research Plan (hereafter referred to as the Reclamation Research Plan) as approved under License N7L2-1645 (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 (Appendix VIII).

2.5.2.3 Fisheries and Oceans Canada 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 before habitat compensation works within each dike area is expected to begin;
- DDMI shall demonstrate that water quality will be acceptable to DFO before any dike are breached;
- if water quality within the dike 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 before implementing compensation efforts within the dike;
- upon demonstration of acceptable water quality, DDMI shall begin the Compensation Plan for each of the dike 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 any 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.

2.5.2.4 Land Lease Requirements

The Diavik Diamond Mine operates under a set of five Land Leases covering the mine footprint area on the East Island. Conditions specified within the Land Lease relevant to closure include:

- Submission of a plan of restoration within 2 years of commencement of the lease with the objective of restoring the land as near as possible to its original state, including the removal of all buildings and structures, or such alternative objectives as may be approved by the Minister.
- The plan of restoration should be based on new information and technology as well as regulatory requirements so that the Project will be abandoned incrementally, in a manner consistent with sustainable development.
- Undertake ongoing restoration during the term of the lease in accordance with the approved plan of restoration.
- Requirements for security deposits.
- Dispose of all combustible garbage and debris by burning in an incinerator and all non-combustible garbage and debris by removal to an authorized dump site. Shall not deposit any waste materials in any body of water or the bed or banks thereof which will in the opinion of the Minister impair the quality of the waters or the natural environment.

2.5.2.5 Navigable Waters Permit Requirements

In accordance with the Navigable Waters Permit (DFO Canadian Coast Guard 2000), DDMI must meet the following requirements before 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.

2.5.2.6 Explosives Permit Requirements

In accordance with Explosives Permit requirements, DDMI must remove all explosives and ammonia nitrate off site before 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 (°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 1998c). 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 -6.2°C to -12.0°C between 1999 and 2009 (Table 3-2).

Table 3-1 Mean, Minimum and Maximum Seasonal Recorded Temperatures at the Meteorological Stations Between 1999 and 2009, Open Water and Ice-covered Seasons

	Lowest	Average	Highest
Open Water Season			
Mean Seasonal Temperature	-4.5	4.4	7.2
Minimum Seasonal Temperature	-23.6	-20.0	-12.7
Maximum Seasonal Temperature	21.6	24.9	27.3
Ice-covered Season			
Mean Seasonal Temperature	-19.9	-16.2	-12.7
Minimum Seasonal Temperature	-44.3	-41.7	-36.6
Maximum Seasonal Temperature	18.3	22.4	27.3

Note: unit for temperature = °C.

Table 3-2 Annual Average, Minimum and Maximum Temperatures Recorded at the Meteorological Stations, 1999 to 2009

	Lowest	Average	Highest
Mean Annual Temperature	-12.0	-9.0	-6.2
Minimum Annual Temperature	-44.3	-41.7	-36.6
Maximum Annual Temperature	21.6	25.4	27.3

Note: unit for temperature = °C.

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 -4.5°C to 7.2°C (Table 3-1) Average temperatures under ice-covered conditions vary from -19.9°C to -12.7°C (Table 3-1).

3.1.1.2 Precipitation

Based on data collected before 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 anthropogenic 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 ($\mu g/m^3$) or a small fraction of Environment Canada's 120 $\mu g/m^3$ objective (Environment Canada 1997) 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 to 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 Diamond 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 (RSA) 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 (DDMI 1998a; Golder 1997a). 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 (LSA) and 3% (13,406 ha) of the RSA, 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 LSA, and Golder 7 ha within the RSA (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 to 30 m), but most often occurs approximately 3 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 crevices 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 (less than 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 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 RSA 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 to 2.0 m deep in till deposits, 2.0 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 (less than 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 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 less than 500 milligrams per litre [mg/L])) Na-Mg-Ca – HCO_3-(Cl) (sodium-magnesium-calcium-bicarbonate-[chloride]) 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 groundwater 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,b). 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 RSA 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 LSA 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. Organic materials, glaciolacustrine materials, frost boil materials and soliflucted materials are the most suitable for reclamation. Maps of these areas are included in Appendix X-7 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 LSA (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 before 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 m 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). The sampling sites are presented in Figure 3-12.

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%. Total Organic Carbon (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	Sand	Silt	Clay	Clay/Silt	TOC
		(m)	(wt%)	(wt%)	(wt%)	(wt%)	(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	-	-	32.2	3.1
	WQ14-3	17	71.3	-	-	27.5	3.4

Note: 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

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

3.3.2.2 Baseline Sediment Chemistry, 1997 to 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). These data are as presented in the most recent Aquatic Effects Monitoring Program (AEMP) Design Report (DDMI 2007a).

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

Analyte	Units	Statistic	Far-field	Mid-field	Near-field
Aluminum	mg/kg	Median	13,400	13,900	14,600
		75 Percentile	16,600	16,850	16,425
		25 Percentile	12,250	11,800	12,400
		N	11	18	42
Arsenic	mg/kg	Median	19.5	32.5	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

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

Analyte	Units	Statistic	Far-field	Mid-field	Near-field
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	1,095	900
		75 Percentile	947.5	1,187.5	1,375
		25 Percentile	615	763	597.5
		N	11	18	12
Total Kjeldahl Nitrogen (TKN)	mg/kg	Median	-	1,363	758.9
		75 Percentile	-	1,615	931
		25 Percentile	-	1,175	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

Notes: mg/kg = milligrams per kilogram;
% = percent; N = sample size; - = not collected.
Source: DDMI 2001a.

Based on data from 1997 and 2000, arsenic concentrations were higher in the near-field (median = 49.8 milligrams per kilogram [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). Total Kjeldahl Nitrogen (TKN) increased from the near-field (758.9 mg/kg) to the mid-field (1,363 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 began 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 AEMP reports (Golder 2008; 2009a).

Sediment characteristics are described by 10 analytes plus TOC and percent silt. The results for the near-field, mid-field, and far-field areas from 2001 to 2006 (DDMI 2005) are provided in Tables 3-6 to 3-8. 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., Christl et al. 2001; Sholkovitz and Copland 1981). 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	20,000	15,500	16,300	13300	15,400	15,200
	75 Percentile	20,350	15,650	16,350	13450	15,450	15,750
	25 Percentile	20,000	15,400	15,900	13250	15,200	14,450
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	32.05
	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

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

Analyte	Statistic	2001 Open Water	2002 Open Water	2003 Open Water	2004 Open Water	2005 Open Water	2006 Open Water
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
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	1,100	1,075	1,050	980	1,120	1,080
	75 Percentile	1,100	1,075	1,060	980	1,170	1,095
	25 Percentile	1,100	1,075	1,050	980	1,030	1,065
Total Kjeldahl Nitrogen (mg/kg)	Median	2,500	2,200	1,700	2,500	2,100	2,400
	75 Percentile	2,600	2,300	1,400	2,550	2,150	2,450
	25 Percentile	2,450	2,150	1,700	2,400	2,000	2,300
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

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.
Calculations were made based on three sub-samples that were submitted for analysis.
Source: DDMI 2005 and unpublished data.

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

Analyte	Statistic	2001 Open Water	2002 Open Water	2003 Open Water	2004 Open Water	2005 Open Water	2006 Open Water
Total Aluminum (mg/kg)	Median	21,600	18,200	16,800	19,500	18,200	19,300
	75 Percentile	21,750	18,300	16,900	19,600	18,700	19,400
	25 Percentile	19,500	17,750	16,700	18,850	18,150	18,700
Total Arsenic (mg/kg)	Median	60.10	21.80	21.60	23.20	152	22.30
	75 Percentile	60.75	22.20	21.65	32.50	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
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	1,100	1,100	1,140	1,030	1,390	1,170
	75 Percentile	1,150	1,138	1,150	1,085	1,645	1,175
	25 Percentile	1,110	1,100	1,135	990	1,335	1,100
Total Kjeldahl Nitrogen (mg/kg)	Median	2,600	1,800	2,100	2,300	1,900	2,200
	75 Percentile	2,800	1,900	2,050	2,400	2,000	2,300
	25 Percentile	2,550	1,650	2,250	2,250	1,800	2,150

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

Analyte	Statistic	2001	2002	2003	2004	2005	2006
		Open Water	Open Water	Open Water	Open Water	Open Water	Open Water
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

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.
Calculations were made based on three sub-samples that were submitted for analysis.
Source: DDMI 2005 and unpublished data.

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	21,000	14,700	13,700	19,300	19,500	18,300
	75 Percentile	22,500	14,850	14,250	19,700	19,550	19,600
	25 Percentile	19,500	14,550	13,600	19,200	17,800	16,100
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
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

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

Analyte	Statistic	2001 Open Water	2002 Open Water	2003 Open Water	2004 Open Water	2005 Open Water	2006 Open Water
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	1,400	1,300	1,340	2,060	2,070	2,030
	75 Percentile	1,450	1,313	1,350	2,120	2,145	2,050
	25 Percentile	1,400	1,290	1,340	2,005	2,040	1,955
Total Kjeldahl Nitrogen (mg/kg)	Median	4,700	4,400	5,200	6,500	4,800	5,100
	75 Percentile	4,750	4,650	4,900	6,600	4,900	5,150
	25 Percentile	4,550	3,700	5,550	6,150	4,650	49,503
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

Notes: mg/kg = milligrams per kilogram; % = percent; N = sample size.
Calculations were made based on three sub-samples that were submitted for analysis.
Source: DDMI 2005 and unpublished data.

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 50 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).

The analytical capabilities of laboratories to measure low-level metal and nutrient concentrations have improved significantly since the baseline data were collected. Additionally, the sampling protocols have also become more regimented. As a consequence the quality of the data collected today is better than it was during baseline. The AEMP relies on environmental data collected in far-field reference areas instead of the baseline data to compare with conditions in the near-field (DDMI 2007a).

Water samples were collected at mid-depth or as depth-integrated samples (0 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, TKN, total phosphorus); and
- total metals – multi-element Inductivity Coupled Argon Plasma Atomic Emission Spectrometric Analysis/Mass Spectometry (ICP-MS) Scan.

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

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,e,f)
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). These data are as presented in the most recent AEMP Design Report (DDMI 2007a). 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 before 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 to 1996. 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 1998a).

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 to 0.40 mg/L) were also in the upper range of the concentrations found in the sites of Lac de Gras (0.06 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 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 BHP Billiton Sites

Water from several lakes close to Lac de Gras was studied in 1975 and 1976 by Moore (1978a,b). 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 about 30 km north of the Mine (Figure 3-15).

Contwoyto Lake is about 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 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 to 10 m (Moore 1978b). Water samples were collected from the 10 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 to 12 µS/cm), and Matthews Lake and Unnamed Lake (both 18 to 20 µS/cm) were similar to levels measured in Lac de Gras (7.9 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 to 17 µS/cm (BHP Diamonds Inc. 1995).

Hardness varied from 4.3 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 (less than 1 mg/L) and highest in Lac de Gras (5.2 to 6.6 mg/L in 1995). Turbidity values were similar among all the lakes and equal or below 2.2 Nephelometric Turbidity Units (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 (less than 0.003 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 3-10) (BHP Diamonds Inc. 1995). The concentrations of total phosphorous for the various lakes at the Ekati Mine site (0.0049 to 0.0127 mg/L) were on the upper range or greater than concentrations in Lac de Gras (less than 0.003 to 0.007 mg/L in 1995, less than 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 3-10 Median Concentrations of Water Quality Parameters in Lac de Gras (1995 to 1996), Nearby Lakes (1975 to 1976) and BHPB Sites (1994)

Analyte Name	Units	Lac de Gras		BHPB Sites	Courageous Lake	Matthews Lake	Contwoyto Lake[(b)]	Unnamed Lake[(c)]
		1995[(a)]	1996[(a)]					
General Parameters								
Electrical Conductivity, Lab	µS/cm	7.9 to 12.3	11.7 to 12.1	8 to 17	10 to 12	18 to 20	5.8	18 to 20
Hardness	mg/L	-	4.3 to 5.6	-	4.2	13.6	<5.0	9.6
pH of Water, Lab	pH	6.55 to 6.63	6.06 to 6.16	6.3 to 6.7	-	-	-	-
Total Alkalinity	mg/L	5.2 to 6.6	4.8 to 5.9	-	3.7	6.2	<1	3.7
Turbidity	NTU	-	0.1 to 0.7	-	2	2.2	1.5	1.7
Nutrients								
Ammonia as nitrogen, total	mg/L	<0.01	<0.01 to 0.05	0.006 to 0.02	-	-	-	-
Nitrite-N	mg/L	<0.2	<0.003 to 0.004	0.0017 to 0.0023	-	-	-	-
Nitrate-N	mg/L	<0.003	0.014 to 0.064	0.0053 to 0.1740	-	-	-	-
Nitrite+Nitrate Nitrogen	mg/L	-	<0.003 to 0.028	-	<0.01	0.01	-	<0.01
Total Phosphorus	mg/L	<0.003 to 0.007	<0.003	0.0049 to 0.0127	-	-	<0.005 to 0.010	-

Table 3-10 Median Concentrations of Water Quality Parameters in Lac de Gras (1995 to 1996), Nearby Lakes (1975 to 1976) and BHPB Sites (1994) (continued)

Analyte Name	Units	Lac de Gras		BHPB Sites	Courageous Lake	Matthews Lake	Contwoyto Lake[(b)]	Unnamed Lake[(c)]
		1995[(a)]	1996[(a)]					
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

(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) (DDMI 1998a; 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.

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.

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

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,b; 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 3-11. The lakes were smaller than Lac de Gras and were usually shallower (Table 3-11).

Table 3-11 Arctic Lakes Surface Area in Maximum Depth

	Surface Area (km^2)	Maximum Depth (m)
Lac de Gras	572	56
Yellowknife 1991	0.53 to 5.02	2.5 to 25
NWT-Nunavut 1996	0.009 to 0.366	0.5 to19.0
Yukon 1982	1.6 to 90	2.5 to 93[(a)]
Yukon and NWT 1990	0.011 to 12.62	1.2 to 49

[(a)] Mean depths.

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

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,b; 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).

Total Kjeldahl nitrogen 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 less than 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 iron in Lac de Gras (less than 0.01 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 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 (Blowes and Logsdon 1997; DDMI 1998a).

The groundwater at the proposed Project site is a slightly alkaline (pH near 8), moderate TDS (generally less than 500 mg/L), Na-Mg-Ca – HCO_3-(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 groundwater 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.

A general trend of increasing concentration of most major species with depth is evident. 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 is provided in Figure 3-17. 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 before 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 to 5% of the kimberlite, contains fine-grained sulphides that can contribute to ARD/MLch during subaerial weathering;
- the volcanogenic portion of the kimberlite (greater than 95% of the kimberlite material) contains low sulphide concentrations with an excess of carbonate; and
- the carbonates in the volcanogenic portion act to neutralize acidity derived from oxidation of the sulphides in the siltstone/mudstone portion.

The average Acid-Base Accounting measurements conducted during the baseline study (Blowes and Logsdon 1997) are summarized in Table 3-12. 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 samples 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 3-12 Average Acid-Base Accounting Measurements From the Baseline Study

Lithology	Average Sulphur Concentration	Average Neutralization Potential (NP)	Average Maximum Potential Acidity (MPA)	Average Net Neutralization Potential (NP-MPA)
	(wt% S)	(kg $CaCO_3$/tonne)	(kg $CaCO_3$/tonne)	(kg $CaCO_3$/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

Notes: wt% S = percent by weight sulphur; kg $CaCO_3$/tonne = kilograms calcium carbonate per tonne.
Source: Blowes and Logsdon 1997.

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 3-13). 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 3-13 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 to 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

Notes: wt% = percent by weight; S = sulphur; < = less than.

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 the 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 (Ecological Stratification Working Group [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 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 understorey 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 several 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. 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 to 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,h). The intensive study area involved 100 km of Lac de Gras shoreline, which included 32 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. The shoreline habitat key map (Figure 3-19) summarizes information from 15 more detailed habitat maps; the detailed habitat maps can be found in Golder (1997g,h).

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 three study areas are 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 four 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 RSA 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 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 regional study, were traced from satellite data and through density-association surveys of collared cows while they were in the study area.

Construction and operation of the Diavik mine was predicted to cause a Zone of Influence (ZOI) for caribou around the mine site. It was predicted that caribou would tend to avoid the mine site and area around it for 3 to 7 km (DDMI 1998a). Results of aerial survey and satellite collar monitoring data have suggested the ZOI may actually range from 11 to 33 km (see review in DDMI 2009d). The measure ZOI has been greater than the predicted ZOI. The larger ZOI means a reduction in suitability of caribou habitat within the ZOI area. The affected habitat areas increased from 3.45% to 12.3% of the LSA, and from 0.14% to 2.6% in the RSA (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. The size of the ZOI is expected to be proportional to the level of mine-site activity. As activity post closure decreases, it is expected that the ZOI will also decrease. This hypothesis will be tested over the next 10 years as surface mining activity reduces.

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 effects 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 the area north of Lac de Gras (Banci and Moore 1997; BHP 1995; Mueller 1995). 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 1998a). 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, the Waste Transfer Area (WTA) and landfill were inspected every two days from December 31 to January 1. 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 effect 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 1998a). 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 waterbodies 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 waterbodies might advance spring thaw.

Annual comparisons of the relative abundance of waterbirds among waterbody types indicate that diving ducks show the strongest pattern of use of mine-altered waterbodies, 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 waterbodies 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 Dené, about 2,500 years ago. The area has and is currently used by the Tlicho, Yellowknives Dené First Nation, Lutsel K'e Dené First Nation, Inuit, North Slave Métis 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 about 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 RSA. 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 RSA (Figure 3-26). These sites consist of 17 isolated finds, 71 artifact scatters, 96 quarries, 7 campsites, 1 meat cache, 1 burial, 1 site consisting of wooden poles and 1 stone marker identified as a burial by the Yellowknives Dené. Of these sites, 66 occur on the mainland, 1 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 LSA 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 Dené 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 artifacts 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 Diamond Mine is an unincorporated joint venture established by DDMI and 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, and 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.

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 tree line 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 immediately 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 November 9, 2007, Aber Diamond Corporation changed its name to Harry Winston Diamond Corporation reflecting the re-branding 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 Environmental Agreement 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, the EA 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 begin construction activities.

The Diavik Diamond Mine started 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 start of production is provided in Table 4-1.

Table 4-1 Project Milestones

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

4.3 Site Geology

The Lac de Gras RSA 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 outcrops 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 as dikes in small proportions (Figure 3-6).

The Diavik diamond deposits occur as kimberlite pipes intruding in the granitic 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, and organic deposits typically overlie glaciolacustrine deposits near the lake shore. Shallow (less than 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%.

Lake bottom sediments consist of a layer of organic-rich lake silts and clays underlain by bouldery glacial till. The organic silts and clays vary in thickness from 5 to 8 m and 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 was initially evaluated including both conventional and non-conventional methods. Non-conventional methods included jet boring, raise boring, blind drilling and dredging. Conventional methods included open-pit and underground mining methods. DDMI did not advance any non-conventional mining methods beyond the initial studies because, in general, they were experimental and found to have an unacceptably high level of technical and economic risk to be used as the basis for a comprehensive mine plan.

Three options based on conventional mining approaches were developed:

- *All underground* – Mining would advance from underground only. Declines or shafts would be developed to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar, about 100 m thick) would be left in the top of the kimberlite pipe to separate the underground workings from the water of Lac de Gras. Lac de Gras would be immediately above the active mine. Water retention dikes are not a part of this alternative.
- *Underground with open pit crown pillar* – Underground mining would advance the same way as Option 1. 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.
- *Open pit and underground* – Open-pit mining would be used to mine the kimberlite pipes to an elevation of 190 m (A418), 130 m for A154S, 265 m 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 Option 1 was that dike construction in Lac de Gras would not be required. Option 1 would eliminate any effects on fish habitat and water quality associated with the dikes and their construction. However, because the health and safety of workers is of primary importance to DDMI, it was determined that 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.

Underground mining displaces less waste rock than open-pit mining. Although both Options 2 and 3 would require storage areas on the East Island for waste rock, the storage area for Option 2 would be less than Option 3.

Communities have consistently described the importance of using resources wisely. Whereas 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 DDMI maximize resource recovery and not just take the best parts. Option 3 would be the alternative that comes closest to matching this community value.

From a diamond recovery perspective, Option 3 produces the most diamonds. Based on 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 was a larger open pit followed by underground mining in the later years. From an economic perspective, Option 3 was preferred because it resulted in the lowest overall operating cost per carat recovered and was therefore the most financially robust. Option 3 was clearly the preferred option based on healthy, safety, environment, community and business considerations.

The final decision from the EA was to proceed with Option 3, 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 periodically, 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, as per Option 3.

The current mine plan utilizes two open pits for initial access to the A154N, A154S and A418 kimberlite pipes, and then underground mining to access the lower portions of the kimberlite pipes. A21 mining is currently in the study phase and has not yet been included in the mine plan.

4.4.1 A154 and A418 Mine Plans

The diamondiferous 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. A general layout of open pits and underground mine workings is presented in Figure 4-1.

To allow open pit and underground mining, two water retaining dikes were constructed in Lac de Gras: A154 dike; A418 dike (Figure 2-2). The A154 dike was completed in 2002 and encircles the A154North and A154South pipes. The second dike, A418, encircles the A418 pipe and 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 at the Diavik site involves drilling and blasting and uses conventional truck and shovel methods. The open pit excavations are separated from the toe of the dikes by an 80-m- to 100-m-wide perimeter shelf. The pit bottom in A154 is 125 m elevation, about 290 m below lake level, and the planned pit bottom for A418 is 200 m elevation, about 215 m below lake level. Open-pit mining is virtually complete in A154 and will be complete in A418 by 2012. A418 open pit is currently at the 270 m elevation.

Underground mining plans are based on Underhand Cut and Fill (UCAF) methods for the A418 pipe and A154 south pipe, and a combination of UCAF and blast hole stoping in the A154 north pipe. Mined stopes will be backfilled 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, 15.5 Million tonnes (Mt) of kimberlite have been mined from A154N/S and A418. There remains some 20.7 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 the “load-haul-dump” trucks. The main portal exit is shown in Figure 2-2.

A water collection and pumping system collects water from precipitation and groundwater seepage, as well as groundwater collected from the drainage galleries that are used to dewater the rock mass ahead of mining. The collected water is pumped 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. The majority of this volume is groundwater collected from the drainage galleries. The 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 be mined economically using the dike and open-pit mining method applied to A154 and A418 pipes. Engineering and environmental studies are currently underway to determine a preferred mining approach for the A21 kimberlite ore. The A21 kimberlite remains part of the Project scope; however, it is not included in the mine plan at this time is not included in this ICRP.

4.4.3 Waste Rock and Till Storage

The waste rock 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).

Waste rock and till from the A154 and A418 open pits is placed on the north side of the island in a designated storage area (Figure 2-2). Waste rock 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 to 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

Notes: wt% = percent by weight; S = sulphur; > = greater than.

Type I rock is reserved for construction material including roads, laydowns and the PKC dams. All Type III rock goes to the waste rock and till area. Type III rock is dumped within specific drainage basins in the waste rock storage area (see Section 5.2.2). Currently, the volumes of Type II rock are very low and they are dumped with the Type III rock.

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

Table 4-3A A154 and A418 Open Pit Till and Country Rock Production[1]

Year	Till (Mt)	Type I (Mt)	Type II (Mt)	Type III (Mt)	Total Tonnage (Mt)
2002	6.78	1.17	0.13	1.09	9.17
2003	5.64	6.76	2.25	10.87	25.52
2004	1.27	9.65	4.16	14.92	29.95
2005	0.00	11.79	2.33	12.77	27.03
2006	0.00	11.95	3.07	8.29	23.32
2007	4.29	10.79	2.20	5.14	22.42
2008	1.67	15.77	0.64	3.58	21.65
2009	0.00	16.17	1.11	5.86	23.16
2010[a]	0.00	18.68	1.25	4.98	24.94
2011[b]	0.00	5.88	0.40	1.56	7.87
2012[b]	0.00	0.27	0.03	0.08	0.34
Totals	**19.7**	**108.9**	**17.6**	**69.1**	**215.4**

[a] 2010 tonnages are actual from January 1 to October 31, 2010.
[b] 2011 and 2012 tonnages are from the most recent mine plan forecast.
Notes: Mt = Million tones (1 tonne = 1,000 kilograms).

At the completion of open-pit mining in 2012 the waste rock and till areas will be at the maximum size. From 2012 to 2022 more than 20 Mt of waste rock is expected to be re-mined for underground backfill and PKC dam raises.

The expected maximum elevation for the waste rock pile is 500 m (about 85 m above the level of Lac de Gras).

Throughout the mine life Type I waste rock has been used as a construction material for roads, laydowns and collection pond dams. Some of this material could be available for use as a closure material when these features are decommissioned.

Estimates of material requirements for closure are detailed with the closure cost estimate in Appendix VII. The largest closure requirements are for Type I waste rock. The 2 m cover envisaged for the PKC (see Section 5.2.6.3 requires 13.5 Mt and the 3 m cover on the side slopes of the waste rock area (see Section 5.2.5.3) requires 2.9 Mt. For the original PKC closure concept (see Section 5.2.6.3), INAC estimated that 11.4 Mt of Type I rock and 3.1 Mt of till were required (INAC 2007b).

The amount of till that will be used for re-vegetation has not been determined.

The anticipated remaining site-wide inventory after removing materials for operations and material for PKC, fish habitat and waste rock area closure is listed in Table 4-3B. There is ample material for closure and no identified need to quarry additional material.

Table 4-3B Expected Material Inventory 2025

Area	Type I (Mt)	Type II (Mt)	Type III (Mt)	Till (Mt)
Waster Rock and Till Area	14.72	12.87	92.49	3.46
Till Pile West of PKC	0	0	0	0.19
Type I Storage Area	0.36	0	0	0
Roads, laydowns, airstrips, ROM	9.32	0	0	0
Collection pond dams	1.46	0	0	0
Total	**25.85**	**12.87**	**92.49**	**3.65**

Notes: Mt = million tonnes (1 tonne = 1,000 kilograms); PKC = processed kimberlite containment; ROM = run of mine.

A drainage collection system exists around the waste rock and till area. Pond 1 is located on the southeast side and collects any runoff or seepage from the Type I rock and till area. Pond 3 is located on the southwest corner of the waste rock area and collects any runoff and seepage from the Type III rock placed in this drainage basin. Pond 2 on the northwest corner collects seepage and runoff from mixed Type I and Type II storage areas (Figure 2-2).

The existing level of development and the expected maximum level of development of the waste rock and till storage 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. After this small fraction of diamonds is removed, the kimberlite that was processed during ore recovery is placed in the PKC area (Figure 2-2). Constructed in a natural valley in the centre of East Island, the PKC area is an engineered containment area surrounded by dams on all sides. The PKC was designed to hold 42.5 Mt of processed kimberlite (PK). At the completion of mining, the PKC area will be approximately 1 km long by 1.3 km wide and contain PK up to 40 m thick.

The PK materials include 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 discharged from spigot points around the perimeter of the facility to form long beaches around a central pond. Coarse PK is deposited by truck in the south-west area of the PKC. Containment of the entire PKC area is provided primarily by perimeter dams. In addition to the low permeability diaphrams (combination of till and synthetic liners) in the dams, the cold arctic temperatures will result in long-term freezing of the fine PK beaches and coarse PK, further limiting potential seepage.

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

- PK slurry from the Processing 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 to reclaim water, which is pumped via an insulated pipeline to the Processing Plant for re-use in ore processing. Water can also be transferred to the NI, if required. In addition, a pipeline from the North Inlet (NI) can supply mine water directly to the Processing Plant for ore processing.

Collection Ponds 4, 5 and 7 (Figure 2-2) and piping systems have been constructed downstream of the PKC dams to provide secondary containment to collect PKC seepage. Collected seepage is pumped back to the PKC. Seepage monitoring and interception wells have been installed in the East, West and South dams.

4.4.5 Water Management Facilities

Water management is the collection, storage, recycling, treatment and controlled release of water in a safe and compliant manner. The Water Management Plan (DDMI 2008) discusses the water collection system constructed around East Island. Through a system of sumps, all-weather seepage pump-back systems, piping, storage ponds and reservoirs, Diavik collects runoff water and groundwater seepage which can be used in the Processing 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 waste rock 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;
- water transferred from the PKC via Pond 3;
- 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);
- return seepage from Pond 4 and 5;
- pumped surface runoff from collection ponds on-site; and
- surface runoff within the PKC facility sub-catchment;

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;
- processing plant makeup water as required;
- fire suppression;
- dust suppression; and
- drill water for underground drilling if necessary.

The NI is located between the waste rock 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 before 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 flocculent preparation equipment, and four high-capacity clarifiers.

Treated minewater is discharged into Lac de Gras via 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. The NI water levels and inflow rates from mine areas are regularly monitored. Treatment rates are adjusted to maintain water levels within planned levels.

4.4.5.1 Collection Ponds

The Collection Pond characteristics are summarized in Table 4-4.

Table 4-4 Runoff Collection Pond Summary

Drainage Area	Pond No.	Drainage Basin Area (ha)	Total Volume (m^3)
Waste Rock and Till Area	1	86	64,280
	2	106	367,460
	3	60	1,304,240
PKC Seepage	4	15	47,610
	5	20	16,310
	7	40	230,000
Plant Site Area	10	21	15,060
	11	7	18,660
	12	20	52,590
North Site - Underground Area	13	15	123,110

Notes: ha = hectare; m^3 = cubic metre; PKC = processed kimberlite containment.

Water levels in the 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 Processing Plant, a permanent accommodation complex, a maintenance complex, six 18-Million Litre (ML) diesel fuel storage tanks, two power plants, and the Power House (Figure 2-2). Elevated arctic corridors carry services and provide enclosed walkways that connect all major buildings.

4.4.6.1 Processing Plant

Three modules make up the Processing 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. The Processing Plant is 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 Processing Plant. A loader places the ore into the run-of-mine building where it is crushed before entering the Processing Plant. In the Processing Plant the ore 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 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 X-rays 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 Processing 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 Processing Plant. A portion of reclaim water is filtered for use in clean services, such as pump gland water. The recovery process uses reclaim water for most services, but does use raw water for critical services including water for the X-ray sorter and grease table. Raw water is also used in case of shortages of reclaim water, but a pipeline from the NI to the Processing Plant installed in 2009 provides a reliable feed of mine water to the Processing Plant and reduces freshwater use for Processing Plant requirements. The NI pipeline enables DDMI to process kimberlite with only minimal requirements for fresh water from Lac de Gras.

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 assembled into four wings. Recent expansions have increased the capacity to 380 dormitory rooms. Each floor has a laundry facility. The accommodations core complex was built on-site under a separate Northern contract. It houses security offices, cafeteria, and recreational facilities including a gymnasium with running track, and a squash court. The location of the accommodation complex is shown in Figure 2-2.

The Emergency Response Vehicle garage is located in a separate building attached to 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 complex, which includes a cafeteria and more modest recreational facilities (Figure 2-2).

4.4.6.3 Maintenance Complex

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

4.4.6.4 Fuel Storage

Diesel fuel is the primary fuel for the site. Six 18-ML diesel fuel tanks are 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

Two power plant buildings, each 25 m high, 60 m long and 36 m wide are also located on site (Figure 2-2). They house 11 diesel engines capable of producing a total of 46.2 megawatts (MW) 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 British Thermal Units (BTUs) per hour. The boilers are held in reserve and can be used to keep the buildings from freezing if a failure occurs within the main Power Plant. The boiler plant also houses four backup generators each capable of producing 1.25 MW 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;
- Ware Transfer Area (WTA) and inert landfill; and
- miscellaneous administration, storage, repair shops and laydown areas.

The mine site buildings and their approximate sizes are listed in Table 4-5. The expected full building development, which is being used as the basis for decommissioning planning, is represented in Table 4-5.

Table 4-5 Mine Site Buildings and Approximate Sizes

Building Name	Perimeter (m)	Area (ha)	Height (m)
Processing Plant	573.2	0.85	36
Main Accommodation Complex	750.2	0.70	11
Maintenance Building	373.6	0.65	20.9
Paste Plant	262.4	0.29	35.6
Ammonia Nitrate Building	271.7	0.29	16
Power House #1	247.2	0.26	14
Power House #2	213.5	0.25	14
(NEW) Mine Dry	195.5	0.19	8.8
Boiler House	195.6	0.15	11.5
Lube Oil Storage	170.9	0.15	10
North Inlet Water Treatment Plant Acid Storage	151.6	0.14	13.5
MAC E Wing	267.8	0.13	ATCO Trailer (Single)
North Inlet Water Treatment Plant	140.0	0.11	14
North Inlet Water treatment Expansion	128.9	0.10	14
LDG Offices	260.4	0.10	ATCO Trailer (Single)
Sewage Treatment Plant	132.0	0.10	7.6
UG Mine Dry	137.7	0.10	ATCO Trailer (Double)
Emulsion Plant	132.4	0.09	7.5
Crusher Building	136.6	0.09	27.03
Surface Operations Welding Shop	116.5	0.07	7.5
Surface Operations Building	115.9	0.07	7.5
Dorm 2	111.3	0.06	10.9

Table 4-5 Mine Site Buildings and Approximate Sizes (continued)

Building Name	Perimeter (m)	Area (ha)	Height (m)
Dorm 1	110.8	0.06	10.9
North Construction Offices	157.5	0.05	ATCO Trailer (Single)
Pit Muster	94.7	0.05	ATCO Trailer (Single)
Mine Rescue Fire Hall	79.3	0.04	6.1
LDG Muster	72.4	0.03	ATCO Trailer (Single)
LDG Offices	74.8	0.03	ATCO Trailer (Single)
A21 Offices	61.7	0.02	ATCO Trailer (Single)
Tank 4	141.4	0.16	14.63
Tank 5	141.4	0.16	14.63
Tank 3	141.4	0.16	14.63
Tank 2	141.4	0.16	14.63
Tank 1	141.4	0.16	14.63

Notes: ha = hectare; m = metre.

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 for mining waste rock 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 commissioned on the north side of the mine site and include a crusher area, product storage area, and a Paste Plant (Figure 2-2). These facilities prepare various sizes of crushed rock and underground backfill materials. Underground backfill can be a trucked cemented rock fill or a pumped paste backfill. Crushed materials are used for both backfill products and 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 perimeter containment for most of the facilities.

The airstrip is 1,600 m long and has a 45-m-wide granular (crushed rock) 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 several 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 have been built for operations. The roads are constructed above grade from crushed rock Type I and Type I run-of-mine waste rock. Road widths range from 12 m for service roads, to 40 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. Roadbed thickness increase locally over ice-rich soils, as required for performance.

Many of the roads serve as containment for 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 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 utility service pipelines in the Processing Plant area. These pipelines include above ground lines for treated sewage, fire protection, potable water, and raw water for process makeup.

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 multimedia filters, polishing filters (carbon), and chlorine dosing (Figure 2-2). Pressurized water pipelines deliver potable water from the Potable Water Treatment Plant to the major buildings on-site, while a water truck is used to deliver potable water 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 Processing Plant for reuse within the plant.

4.4.7.7 Solid Waste and Hazardous 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 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 to minimize wildlife intrusion. The WTA includes: 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 regularly covered with waste rock to prevent wildlife attraction.

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

Hazardous wastes are classified, labelled and temporarily stored within the WTA (Figure 2-2) before 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 an impermeable liner. 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 Potentially Contaminated Areas

DDMI has a Waste Management Plan and Hazardous Materials Management Plan that include strategies for managing hazardous and non-hazardous waste streams. The primary objectives of these plans are to collect, store, transport and dispose of wastes generated by the Project in a safe, efficient and environmentally responsible manner.

Where hazardous materials are stored or used there is potential for contamination through accidental spills or storage contact, which can create areas to be addressed at closure.

Spills

Spills at Diavik are primarily related to equipment mechanical failures. These spills are typically hydrocarbon products (91% of the spills at Diavik since 2009 have been hydrocarbon products and glycol). Spills are cleaned up when they occur, and soil/rock impacted from spills are managed through landfarming (soil) in the WTA and encapsulation in the Type III Waste Rock Dump (rock).

The volume of impacted soil and rock generated each year is highly variable and depends on the number of spills, volume of the spills and where the spills occur. Estimates from summer 2008 through summer 2010 indicate that approximately 400 m^3 (or 200 m^3 per year) of soil was disposed in the WTA for landfarming. DDMI is currently managing that volume of soil in the WTA (i.e., no material disposed in the current WTA has been removed). Soil from the former WTA (which was located in the PKC South Cell) landfarming operation was disposed in the Type III Waste Rock Dump in 2010. Since closure criteria have not yet been established, DDMI used Canadian Council of Ministers of the Environment (CCME) Agricultural standards (CCME 1999) for guidance and obtain Inspector approval before disposing of the material.

Coarse material that has been impacted from a spill but is too large to manage by landfarming (e.g., rock in the open pits) is disposed in the Type III Waste Rock Dump.

Volume/tonnage of waste rock that has been affected from spills each year is very difficult to estimate. Due to the nature of the material (large cobbles/boulders with very low surface area compared to till and other fine-grain materials), most of what is hauled to the Type III dump is not actually “affected”. Instead, the rocks have typically been partially sprayed or partially covered with the spilled product.

In all spill scenarios, DDMI attempts to recover much of the spilled product instead of allowing soil to absorb it, or for it to flow into permeable areas between rocks. Drip pans and absorbent pads are used at spill sites to recover spilled products.

DDMI maintains records of historic spill locations so applicable areas can be revisited for additional follow-up if necessary.

Hazardous Materials Storage and Other Areas With Potential for Impacts

Locations where hazardous materials are regularly handled and stored could potentially be impacted from small (unnoticed) spills and leaks or improper handling/storage of materials. These areas include:

- bulk fuel storage;
- waste transfer facilities;
- explosives storage and manufacturing areas;
- chemical storage areas (includes the airport apron/helipad, NIWTP chemical storage building and acid building, North Chemical Storage building and warehouse sprungs); and
- equipment parking/storage areas (ready-lines and maintenance shops/parking lots).

Areas where there could be elevated risk for potential effects are shown in Figure 4-3. Many of these areas will remain active through the operations phase of the Project and will need to be assessed when they are decommissioned or at closure. In some cases, assessment could include detailed environmental site assessment, while some areas may only require inspection following decommissioning. Results of the post-closure assessments will identify areas that require further remediation or risk management.

In addition to the above referenced locations, minor amounts of hazardous materials and petroleum products are stored and used at many locations around the mine site. Products such as kitchen and bathroom cleaners, laboratory reagents or ink cartridges are present at site in relatively low volumes, and although they pose only minor environmental risks, they will need to be properly packaged and disposed at closure.

Closure

The volume/tonnage of impacted material that will require remediation or management at closure will depend on several factors:

- spill performance;
- success of landfarming during operations; and

- the agreed upon closure criteria for hydrocarbons.

Based on recent performance, an estimated 200 cubic metres (m^3) of hydrocarbon-impacted soil is generated annually, however, it is expected that landfarming in the WTA can reduce concentrations to levels acceptable for disposal in the Type III Waste Rock Pile. When this version of the ICRP was prepared, DDMI was in the process of completing a Human Health and Ecological Risk Assessment related to hydrocarbon-impacted soil management and disposal. The objectives of the assessment are to determine appropriate long-term disposal options for hydrocarbon-impacted soils and to look for possible improvements to the current DDMI landfarming practices for soil at the WTA.

4.4.7.9 North Construction Area

Several office and storage buildings, laydown areas and repair shops are located on the north side 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 permanent closure 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 will 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

This section presents the interim plans for the permanent closure of the mine site. Mining operations are expected to continue until around 2023. Although it is important to be planning for closure, it is premature to have detailed engineering plans.

Section 5.2.1 provides an overview of the closure planning process, a general description of the current closure concepts for each closure area, the main closure activities that have been identified to date, key uncertainties and a summary of research plans. The summary is intended to provide a reader with a quick reference of the current plans.

Sections 5.2.2 through 5.2.8 offer more detailed descriptions of the anticipated closure activities for each of the five mine areas. They include a history of closure planning for each component from initial mine design to the current plan, and provide a rationale for initial decisions and any changes that have occurred over the mine life. Also included are specific closure objectives for the site and for each of the five mine site areas. For context, relevant information identified in the Northwest Territories Mine Closure Guidelines and recent Environment Canada industry standards have been summarized and appended. Uncertainties, risks, monitoring programs and linkages to research programs are also provided.

5.2.1 Overview of Current Closure Plans

Closure Management Areas

The mine site has been divided into five management areas for the purpose of closure planning:

- Waste Rock and Till Storage Area.
- Processed Kimberlite Containment (PKC) Area.
- Open Pits, Underground and Dike Area.

- North Inlet (NI) Area.
- Mine Infrastructure.

These general areas are shown in Figure 5-1.

Closure Goals and Objectives

DDMI's overall goal is to operate and close the mine responsibly, leaving behind a positive community and environmental legacy. Regulatory requirements for closure are described in the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007a) under three general categories: physical stability; chemical stability; and future use and aesthetics. DDMI's eight stated closure goals are listed in Table 5-1.

Table 5-1 DDMI Closure Goals

Closure Goals
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. Final site conditions that do not require a continuous presence of Mine Staff.

More specific closure objectives for the Diavik mine site have also been developed through a consultative process. Objectives are both site-wide, meaning they are applicable to all five closure management areas, and area-specific. The closure objectives, both site-wide and area-specific, are shown in Table 5-2. Together these objectives cover all applicable aspects of physical stability, chemical stability, aesthetics and future use. The objectives may change over time as circumstances change and new information becomes available.

Table 5-2 DDMI Closure Objectives

Site-Wide Closure Objectives
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.
SW2. Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.
SW3. Dust levels safe for people, vegetation, aquatic life and wildlife.
SW4. Dust levels do not affect palatability of vegetation to wildlife.

Table 5-2 DDMI Closure Objectives (continued)

Site-Wide Closure Objectives
SW5. Re-vegetation targeted to priority areas.
SW6. Ground surface designed to drain naturally follow pre-development drainage patterns.
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.
SW10. Safe passage and use for caribou and other wildlife.
SW11. Mine areas are physically stable and safe for use by people and wildlife.
Open Pit, Underground and Dike Area Closure Objectives
M1. Water quality in the flooded pit and dike area that is similar to Lac de Gras or, at a minimum, protective of aquatic life.
M2. Pit and dike closure that do not have adverse effects on water uses in Lac de Gras, the Coppermine River or groundwater use.
M3. Enhanced lake-wide fish habitat to offset fish habitat temporarily lost during operations.
M4. Safe small craft navigation through dike and pit area.
M5. Physically stable pit walls and shorelines to limit risk of a failure impacting people, aquatic life or wildlife.
M6. Pit fill rate that will not cause adverse effects on water levels in Lac de Gras and Coppermine River.
M7. Pit fill rate that will not cause adverse effects on fish or fish habitat in Lac de Gras and Coppermine River.
M8. Wildlife safe during filling of pits
Waste Rock and Till Area Closure Objectives
W1. Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife.
W2. Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area.
W3. Contaminated soils and waste disposal areas that cannot contaminate land and water.
Processed Kimberlite Containment Closure Objectives
P1. No adverse affects on people, wildlife or vegetation.
P2. Physically stable Processed Kimberlite Containment area to limit risk of failure that would affect safety of people or wildlife.
P3. Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments.

Table 5-2 DDMI Closure Objectives (continued)

Site-Wide Closure Objectives
North Inlet Area Closure Objectives
NI1. Reconnect the North Inlet with Lac de Gras.
NI2. Water quality and sediment quality in the North Inlet that is safe for aquatic life, wildlife, and people.
NI3. Suitable fish habitat in the North Inlet.
NI4. Water quality in the North Inlet that is as similar to Lac de Gras as possible.
NI5. Water and sediment quality in the North Inlet that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.
NI6. Physically stable banks of the North Inlet to limit risk of failure that would impact the safety of people or wildlife.
Mine Infrastructure Closure Objectives
I1. Opportunities for communities to re-use infrastructure, allowable under regulation and where liability is not a significant concern.
I2. On-site disposal areas that are safe for people, wildlife and vegetation.
I3. Prevent remaining infrastructure from contaminating land or water.

Closure Planning

The closure planning framework that DDMI will use to guide the closure designs is illustrated in Figure 5-1. The framework is an iterative process that requires identifying a design concept, evaluating the expected performance of the design against objectives and criteria, and then considering options to revise the design. The expected performance is assessed under existing climate and possible climate change conditions. The climate change scenario currently envisaged for this evaluation is included in Appendix X-8.

Information from the research plans are expected to help understand the expected performance of a specific design, refine closure objectives and criteria, and identify possible design options or alternatives. Research plans will likely be revised based on outcomes from design iterations.

The design iteration process is an internal process with important outcomes periodically reported externally though updates to this ICRP document. Timing of the updates will be based on WLWB requirements and timing of key results from the design process. If significant design revisions are identified, it will be helpful to communicate these to all parties. Overall the schedule is to have a final design concept for all closure areas by 2015.

Preferred Design Concepts

This section summarizes the preferred design concept for each closure area. A table is provided that shows how aspects of the closure design contribute to each of the closure objectives. As the designs evolve, additional aspects will be identified and added to this summary. Key closure uncertainties that have been identified to date are provided and are followed by a summary of the research plans to reduce these uncertainties.

Open Pits, Underground and Dike Area

Dikes were constructed into Lac de Gras and the area behind the dikes was dewatered to allow open-pit and underground mining. At closure the underground, pit and dike areas will be flooded. When the water quality has been confirmed, small breaches will be cut into the dikes to allow fish and aquatic life from Lac de Gras to return to the area. Work to confirm that the expected water quality will be suitable for closure is currently underway. Fish habitat construction within the dike areas is also underway.

Although this closure design is still in development, there are few significant uncertainties compared to the other closure areas. This closure design for the pits, underground and dike areas remains unchanged from the original mine design.

The closure objectives and the activities that have been identified that contribute to achieving each of the closure objectives for this area are listed in Table 5-3.

Table 5-3 Closure Activities Identified for the Pits, Underground and Dike Areas

Closure Objective	Identified Closure Activities
M1. Water quality in the flooded pit and dike area that is similar to Lac de Gras or at a minimum protective of aquatic life.	Construct fish habitat in area between pit crest and inside toe of dike. Remove equipment and pipelines from pit/dike area. Remove hazardous materials and mobile equipment from underground. Clean and inventory materials that will remain underground. Fill pit/dike area with Lac de Gras water. Locate fill pipeline to minimize erosion and introduction of suspended solids. Excavate breaches to allow exchange of water between dike/pit area and Lac de Gras. Breach dikes after water quality can be confirmed at acceptable levels.
M2. Pit and dike closure do not have adverse effects on water uses in Lac de Gras, the Coppermine River or groundwater use.	Construct fish habitat in area between pit crest and inside toe of dike. Remove equipment and pipelines from pit/dike area. Remove hazardous materials and mobile equipment from underground. Clean and inventory materials that will remain underground. Fill pit/dike area with Lac de Gras water. Locate fill pipeline to minimize erosion and introduction of suspended solids. Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m. Excavate breaches to allow exchange of water between dike/pit area and Lac de Gras. Breach dikes after water quality can be confirmed to be within acceptable levels.
M3. Enhanced lake-wide fish habitat to offset fish habitat temporarily lost during operations.	Construct fish habitat in area between pit crest and inside toe of dike. Excavate breaches in dikes to allow fish from Lac de Gras to use dike/pit area.

Table 5-3 Closure Activities Identified for the Pits, Underground and Dike Areas (continued)

Closure Objective	Identified Closure Activities
M4. Safe small craft navigation through dike and pit area.	Excavate breaches in dikes to allow small craft navigation. Stabilize shorelines, as required, to reduce risk of slope failure.
M5. Physically stable pit walls and shorelines to limit risk of a failure impacting people, aquatic life or wildlife.	Stabilize shorelines, as required, to reduce risk of slope failure. Confirm long-term stability of underwater pit slopes.
M6. Pit fill rate that will not cause adverse effects on water levels in Lac de Gras and Coppermine River.	Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m.
M7. Pit fill rate that will not cause adverse effects on fish or fish habitat in Lac de Gras and Coppermine River.	Limit fill rate, if necessary, to maintain Lac de Gras levels above 415 m.
M8. Wildlife safe during filling of pits.	Remove any observed wildlife from pit/dike area before filling. Monitor area for approaching wildlife during filling. Employ deterrents such as herding as required.

Waste Rock and Till Storage Area

Waste rock and till from the open-pit mining of the A154 and A418 kimberlite pipes are stored on the north side of the mine site. Waste rock has been segregated based on sulphur content to ensure than rock that is used for the construction of roads and other structures does not have the potential to generate acidic drainage. Waste rock that is permanently stored is also segregated by sulphur content. The waste rock pile has been constructed with the expectation that seepage from the area will be limited by permafrost conditions within the pile. Seepage that may occur is expected to be water that moves through the seasonal active thaw zone and exits the pile at the perimeter toe. The sulphur content of rock in the active thaw zone has been kept low by design in an effort to maintain active zone seepage of acceptable quality. Till from the till stockpile is expected to be fully utilized as a reclamation material and a till stockpile is not expected to exist post-closure.

Closure plans for the waste rock pile have changed since the ICRP was approved in 2001. In 2001 the plan included a till cover to reduce infiltration, covered by a layer of low sulphur waste rock. Both materials were to be hauled directly from a planned A21 open pit. The A21 open pit is no longer in the current mine plan, resulting in a change to the waste rock closure plans in this ICRP.

The thermal, hydrological and geochemical behaviour of the waste rock pile is complex and uncertain. The key uncertainties are the long-term quantity and quality of any post-closure seepage and any possible changes to the quality or quantity as a result of climate change.

No decision has been made regarding appropriate wildlife access to, or exclusion from, the waste rock pile, however wildlife access has been identified as a planning priority. There are no plans to target the waste rock area for re-vegetation.

The closure objectives and the activities that have been identified that contribute to achieving each of the closure objectives for the waste rock area are listed in Table 5-4.

Table 5-4 Closure Activities Identified for the Waste Rock Area

Closure Objective	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Flatten top of waste rock pile to reduce snow accumulation and infiltration. Place 3-m-thick Type 1 rock layer on outside slopes to reduce average sulphur content in thermal/hydrologic active zone. Maintain side slopes as steep as possible to facilitate permafrost development.
SW2. Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Flatten top of waste rock pile to reduce snow accumulation and infiltration. Place 3-m-thick Type 1 rock layer on outside slopes to reduce average sulphur content in thermal/hydrologic active zone. Maintain side slopes as steep as possible to facilitate permafrost development. Add erosion protection to final surfaces with erosion potential. Decommission water collection structures at Ponds 1, 2 and 3 after acceptable water quality is confirmed. Include wetlands and/or settling basins in final drainage designs for Pond 1, 2 and 3 areas.
W1. Physically stable slopes to limit risk of failure that would impact the safety of people or wildlife.	Re-slope waste rock piles, as required, to conform to engineering stability specifications. Install signage to identify area as previous mine site.
W2. Rock and till pile features (shape and appearance) that match aesthetics of the surrounding natural area.	Remove equipment, buildings and other materials. Cover landfill area with waste rock. Leave surfaces of materials native to the area. Round edges of waste rock and till piles, if required.

Table 5-4 Closure Activities Identified for the Waste Rock Area (continued)

Closure Objective	Identified Closure Activities
W3. Contaminated soils and waste disposal areas that cannot contaminate land and water.	Remove or bury/encapsulate surface materials that exceed closure criteria. Cover landfill area with waste rock. Flatten top of waste rock pile to reduce snow accumulation and infiltration. Maintain side slopes as steep as possible to facilitate permafrost development. Decommission water collection structures at Ponds 3 after acceptable water quality is confirmed. Include wetlands and/or settling basins in final drainage designs for Pond 3 area.

Processed Kimberlite Containment Area

After the diamonds have been removed the PK waste is pumped (fine fraction) and trucked (coarse fraction) to a lined storage facility located in a central valley on the east island. Long beaches are formed from the perimeter of the facility and water is reclaimed from a central pond. The facility is operated towards a closure design where accumulated water will exit the facility through a spillway and then course through a series of streams and ponds before reaching Lac de Gras. The kimberlite beaches will be covered with a surface of mine rock to protect against wind and water erosion. A small pond will remain with clear water overlaying unconsolidated fine PK. Access to the inside of the facility by people and wildlife will be restricted because pond shorelines will likely be unstable due to ongoing freeze-thaw and consolidation processes. The PKC is not a target area for re-vegetation.

The closure concept described here, an engineered outlet for accumulated water that will have come in contact with PK, is a change from the concept approved in the most recent ICRP (DDMI 2001b). The 2001 closure concept was a domed rock and till structure over the surface of the PK to shed water and prevent meteoric water contact with PK. A combination of significant technical design issues and a current expectation of adequate pool water quality guided this revision of the PKC design concept.

The design concept is preliminary and there are significant uncertainties that need to be investigated over the next five years. The uncertainties relate to the expected outlet water quality and the stability of the closed facility surface, particularly the pond shorelines.

The closure objectives and the activities that have been identified to-date that contribute to achieving each of the closure objectives for the PKC facility are listed in Table 5-5.

Table 5-5 Closure Activities Identified for the Processed Kimberlite Containment

Closure Objective	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Remove free water, treat and discharge towards end of operations. Construct a post-closure drain during operations. Install post-closure outlet/spillway connected to the drain.
SW2. Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Remove free water, treat and discharge during operations. Construct a post-closure drain during operations. Install post-closure outlet/spillway connected to the drain. Decommission water collection structures at Ponds 4, 5, 7 and 12 after acceptable water quality is confirmed. Include wetlands and/or settling basins in final drainage designs for Ponds 4, 5, 7 and 12, as required. Cover facility with a 2-m-thick layer of Type 1 run-of-mine rock for wind/water erosion protection.
P1. No adverse affects on people, wildlife or vegetation.	Remove pipelines, building and equipment. Cover facility with a 2-m-thick layer of Type 1 run-of-mine rock for wind/water erosion protection. Construct wildlife movement routes when constructing final surfaces. Eliminate, isolate and/or reduce identified wildlife hazards. Remove free water, treat and discharge during operations.
P2. Physically stable processed kimberlite containment area to limit risk of failure that would affect safety of people or wildlife.	Remove free water, treat and discharge during operations. Construct a post-closure drain during operations. Install post-closure outlet/spillway connected to the drain. Cover facility with a 2-m-thick layer of Type 1 run-of-mine rock for wind/water erosion protection.
P3. Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environments.	Install post-closure outlet/spillway connected to the drain. Cover facility with a 2-m-thick layer of Type 1 run-of-mine rock for wind/water erosion protection. Decommission water collection structures at Ponds 4, 5, 7 and 12 after acceptable water quality is confirmed. Include wetlands and/or settling basins in final drainage designs for Ponds 4, 5, 7 and 12.

North Inlet Area

The NI function is water treatment equalization and settling basin. Operationally it is part of the NIWTP where mine water is treated before it is discharged to Lac de Gras. The NI was a bay in Lac de Gras and was isolated from Lac de Gras by constructing dams across the bay so the NI could be used during mining operations as part of the site water management system. At closure, the plan is to reconnect the NI with Lac de Gras.

Most recent monitoring results indicate that the sediments in the NI are not optimal for benthic invertebrates (bugs) that live on the sediment. However, it is uncertain at this time if sediment quality is likely to limit reconnecting the NI with Lac de Gras. Sediment quality is a key closure uncertainty to be addressed for the NI.

The closure objectives and the activities that have been identified that contribute to achieving each NI closure objective are listed in Table 5-6.

Table 5-6 Closure Activities Identified for the North Inlet

Closure Objective	Identified Closure Activities
NI1. Reconnect the North Inlet with Lac de Gras.	Excavate a breach(es) in North Inlet dam after acceptable water and sediment quality are confirmed.
NI2. Water quality and sediment quality in the North Inlet that is safe for aquatic life, wildlife and people.	Confirm during operations that sediment quality remains acceptable for closure. Treat and discharge the water in the North Inlet and replace with Lac de Gras water. Stabilize shorelines, as required, to reduce risk of erosion.
NI3. Suitable fish habitat in the North Inlet.	Confirm during operations that sediment quality remains acceptable for closure. Stabilize shorelines, as required, to reduce risk of erosion.
NI4. Water quality in the North Inlet that is as similar to Lac de Gras as possible.	Treat and discharge water in the North Inlet and replace with Lac de Gras water.
NI5. Water and sediment quality in the North Inlet that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Confirm during operations that sediment quality remains acceptable for closure. Treat and discharge water in the North Inlet and replace with Lac de Gras water. Stabilize shorelines, as required, to reduce risk of erosion. Excavate breach in North Inlet dam after acceptable water and sediment quality are confirmed.
NI6. Physically stable banks of the North Inlet to limit risk of failure that would impact the safety of people or wildlife.	Stabilize shorelines, as required, to reduce risk of failure.

Mine Infrastructure and Site-Wide Closure

Buildings and infrastructure will be removed and either salvaged or buried on-site. Roads, airstrip and laydown areas will be re-contoured to remove steep sides, scarified where human and wildlife access routes are not envisaged, and areas will be targeted for re-vegetation. Natural drainage paths will be restored and landforms modified to better match the natural surroundings. Note that the footprint of the mine site will remain discernable post closure.

This area will be one of the last to be closed because much of the basic infrastructure including roads, accommodation, truck shops and power will be required to support the closure activities. Key uncertainties related to mine infrastructure and site-wide closure include final land use plans (specifically wildlife movement); landforms and target areas for re-vegetation; and quantities of non-salvageable materials intended for on-site burial.

The closure objectives and the activities that have been identified that contribute to achieving each objective are listed in Tables 5-7 and 5-8. Tables are included for both the mine infrastructure specific objectives and the site-wide objectives.

Table 5-7 Closure Activities Identified for the Infrastructure Areas

Infrastructure Closure Objectives	Identified Closure Activities
I1. Opportunities for communities to re-use infrastructure allowable under regulation and where liability is not a significant concern.	Ensure final decommissioning plans facilitate reuse of infrastructure off-site. Assist communities to identify, plan for and obtain ownership of salvageable equipment, buildings, materials and supplies that could be re-used in or by communities.
I2. On-site disposal areas are safe for people, wildlife and vegetation.	Control the materials that are disposed during operations and closure. Cover on-site disposal areas with run-of-mine rock. Eliminate, isolate and/or reduce identified wildlife hazards.
I3. Prevent infrastructure from contaminating land or water.	Remove buildings and equipment. Add wind erosion protection for final surfaces that have erosion potential. Decommission water collection structures at Ponds 10, 11 and 12 after acceptable water quality is confirmed. Include wetlands and/or settling basins in final drainage designs for Pond 10, 11 and 12 areas.

Table 5-8 Closure Activities Identified Site-Wide

Site-Wide Closure Objectives	Identified Closure Activities
SW1. Surface runoff and seepage water quality that is safe for humans and wildlife.	Control materials used for all on-island construction; only confirmed non-acid generating material used. Add erosion protection to final surfaces with erosion potential. Safely dispose or remove from site materials that could be a source of contamination. Include wetlands and/or settling basins, as required, in final drainage designs.
SW2. Surface runoff and seepage water quality that will not cause adverse effects on aquatic life or water uses in Lac de Gras or the Coppermine River.	Control materials used for all on-island construction and closure to ensure only confirmed non-acid generating material used. Add erosion protection for final surfaces with erosion potential. Safely dispose or remove from site materials that could be a source of contamination.
SW3. Dust levels safe for people, vegetation, aquatic life, and wildlife.	Add protection from wind erosion to final surfaces with erosion potential.
SW4. Dust levels do not affect palatability of vegetation to wildlife.	Add protection from wind erosion protection to final surfaces with erosion potential.

Table 5-8 Closure Activities Identified Site-Wide (continued)

Site-Wide Closure Objectives	Identified Closure Activities
SW5. Re-vegetation efforts targeted to priority areas.	Re-vegetate using indigenous species, substrate amelioration and islands of pilot vegetation community. Target infrastructure areas for re-vegetation. Leave waste rock pile and PKC to re-vegetate naturally.
SW6. Ground surface designed to drain naturally follow pre-development drainage patterns.	Decommission water collection structures at Ponds 1,2,3,4,5,7,10,11 and 12 and remove any culverts. Re-establish natural drainage channels in areas where collection structures have been decommissioned.
SW7. Areas in and around the site that are undisturbed during operation of the mine should remain undisturbed during and after closure.	Flatten safety berms and edges of roads and laydowns inward. Limit re-sloping outward to areas of potential geotechnical instability and wildlife hazard/access. Decommission roads to enable post-closure access without additional disturbance.
SW8. No increased opportunities for predation of caribou compared to pre-development conditions.	Eliminate or reduce features in the PKC, waste rock piles and roads that can be considered predation hazards. Determine design for post-closure wildlife access routes in consultation with Traditional Knowledge, communities and biologists.
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	Remove building and equipment. Leave surfaces of materials native to the area. Return pit, dike and North Inlet areas to productive lake habitat. Round off engineered angles from surface structures, as required. Focus re-vegetation efforts on areas of highest benefit. Use indigenous plant species.
SW10. Safe passage and use for caribou and other wildlife.	Construct wildlife movement routes when constructing final surfaces. Use sections of existing roads for wildlife movement routes as much as possible. Eliminate, isolate and/or reduce identified wildlife hazards. Remove building and equipment.

Table 5-8 Closure Activities Identified Site-Wide (continued)

Site-Wide Closure Objectives	Identified Closure Activities
SW11. Mine areas are physically stable and safe for use by people and wildlife.	Use sections of existing roads for safe movement through the area post-closure. Install signage to identify area as previous mine site. Re-slope surface structures, as required, to conform to engineering stability specifications. Remove buildings and equipment. Construct wildlife movement routes when constructing final surfaces. Use sections of existing roads for wildlife movement routes. Eliminate, isolate and/or reduce identified wildlife hazards. Link roads for wildlife movement to pre-development wildlife access routes. Block wildlife and human access from surface opening to underground workings.

Research Plans

Six closure research plans are included in Appendix VIII, one plan for each of the five closure areas (waste rock and till, PKC, NI, infrastructure, and the pit, underground and dike area) and one specific to community engagement and Traditional Knowledge.

The plans describe the studies to be undertaken to support ongoing closure planning for the Diavik mine site. The studies are intended to provide information that can assist decision-making for closure options and aspects of closure designs, predict closure performance, and revise closure criteria. As new research information is obtained and closure designs evolve, uncertainties and risks will also change, resulting in different research requirements. The research plans are intended to be dynamic and are expected to change as new information becomes available.

DDMI's intent is to adapt the research plans to fit changing closure planning requirements. Annually, these plans will be provided to communities and regulators so that all parties will be aware of the current research plans. Preliminary results of research studies may be used before final documentation is available. DDMI will endeavour to provide annual summaries of research results. Each annual report will also include a copy of any final document produced in the previous 12 months. This annual report will be submitted by March 31 each year.

The six closure research plans in Appendix VIII are summarized as follows:

- Community Engagement and Traditional Knowledge – DDMI has identified some specific areas of focus for community and/or Traditional Knowledge input, which generally relate to aspects of final land use including wildlife movement, target areas for re-vegetation, details of fish habitat design and landforms. Other areas may be identified by communities for future consideration.

- Open Pit, Underground and Dike Area – Compared to other closure areas, the closure plan for the pit and dikes are reasonably well defined. Studies are planned to confirm fish habitat designs and predictions of final pit water quality. Research for underground closure is related to use of Type III material for backfill during operations.
- Processed Kimberlite Containment – The current closure plan for the PKC facility is at a conceptual level of engineering. Research studies will focus on characterizing the PKC using field studies and laboratory studies. A better understanding of the physical and geochemical characteristics of PK is required to design a stable surface, drainage outlet, and confirm acceptable water quality.
- Waste Rock and Till Storage– DDMI has an extensive ongoing research program for the geochemical, thermal, hydrological and microbiological behaviour of the waste rock piles. Information from this ongoing research will be used to evaluate waste rock pile seepage quality and quantity under different pile configurations and climate conditions.
- North Inlet – Research studies are focused on the current and future quality of NI sediments to evaluate the suitability of rejoining the NI with Lac de Gras.
- Infrastructure – The development of re-vegetation procedures is a key research plan for this closure area. Studies related to on-site landfill requirements are also planned.

Over the longer term, as closure designs are confirmed and better detail is available, research efforts will likely transition to supporting assessments of residual risks and uncertainties, contingency options and post-closure monitoring programs.

5.2.2 Closure Objectives and Criteria

The requirements for mine closure are driven by the closure goals and closure objectives, and defined by closure criteria. Closure goals are broader statements of intended outcomes (Table 5-1).

Closure criteria serve both to better define the objective, and to describe the conditions when the objective has been achieved. Objectives and criteria must also be consistent with, and inclusive of, specific terms and/or conditions specified in permits, licenses and authorizations (Section 2.5). The Water License (Part L) specifically references the “most recent edition” of *Mine Site Reclamation Guidelines for the Northwest Territories* as guidance for the content of a closure plan. The most recent edition, INAC (2007a) includes general guidance on closure objectives. DDMI reviewed this guidance when considering closure objectives.

Similarly, Environment Canada recently issued recommendations on “Environmental Codes of Practice for Metal Mines” including closure phases (Environment Canada 2009). These recommendations were also considered in establishing closure objectives.

Relevant aspects of both the INAC (2007a) guidance and the Environment Canada (2009) code of practice are referenced in Section 5.2.4 through 5.2.8 for each of the mine closure areas.

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 sufficiently flexible to accommodate potential changes identified during ongoing work on the ICRP or as a result of changes during mine operations. The WLWB has concluded that the objectives outlined below were adequate to use for this ICRP.

Following another round of review in 2010, the WLWB provided further direction regarding closure objectives and criteria (WLWB May 19, 2010). Revised objectives and criteria are detailed in Appendix V. Notable changes to the objectives include:

- Grouping together common objectives into "site-wide" objectives. These objectives could apply to one or more closure area.
- Removal of modifiers such as "reasonable", "where appropriate", "practical", "feasible" from the objectives with the understanding that by WLWB definition objectives must be achievable. If they prove to not be achievable as written they will be revised, subject to WLWB approval. For example Objective SW6 – *Ground surface designed to drain naturally following pre-development drainage patterns*. Clearly this objective is not achievable in areas such as the PKC, where the pre-development drainage basin no longer exists.
- Objectives for the NI area simplified from the May 5, 2010 version to focus on a single objective only, instead of objectives with contingency objectives.

For each objective in Appendix V there is also an initial closure criterion. The criterion is intended to describe the conditions when the objective has been achieved. It will take iterations of review, discussion and revision to obtain a final set of closure objectives and criteria that are appropriate for the Diavik mine site. The criteria in Appendix V should be considered "for further discussion".

In general, DDMI has tried to use available standards or guidelines as initial closure criteria; for example CCME Water Quality Guidelines (CCME 1999). These standards or guidelines are understood to be conservative (erring on the side of caution) and applicable broadly. DDMI intends to use these standards or guidelines as initial criteria unless it has been identified that there are specific site conditions (for example the presence of more sensitive species than used as a basis for the guideline) that might justify different criteria. In addition, if it is determined at some point that these initial criteria are not achievable or are not appropriate (for example if an exposure pathway is not applicable) then DDMI may conduct a site-specific risk assessment to derive a site-specific risk-based closure criterion. DDMI would seek opportunities to obtain both science and Traditional Knowledge input from regulators and communities to derive risk-based criteria. DDMI would apply to the WLWB to have any risk-based criterion accepted. Closure criteria that may require the development of risk-based criteria are noted in Appendix V.

Specific water quality criteria is included in Appendix V, Table V-7. The actual criteria values presented in Table V-7 are initial planning numbers, as discussed above, however the approach used to derive the values is the approach DDMI intends to apply going forward. The approach is comparable to that used for determining operational effluent quality criteria. Water quality standards are specified that are protective of each type of water use. These standards are primarily derived from CCME Guidelines with some site-specific adaptation. These standards have been widely used as a basis for the Environmental Assessment (DDMI

September 1998; DDMI 1998a) and the Aquatic Effects Monitoring Program (DDMI December 2007; DDMI 2007a). During operations and post-closure there may be small areas adjacent to, or within the mine site where water quality is above one or more of the specified standards. For example, post-closure some surface runoff water quality may be above water quality standards as it drains from the mine site, but could be below water quality standards some distance into Lac de Gras. This is comparable to the "mixing zone" approach used in determining operational effluent quality guidelines. A full evaluation of mixing characteristics of each surface runoff drainage basin has not been conducted to date. Values in Table V-7 in the column titled "Waters Entering Lac de Gras" have an assumed mixing factor of 23 (value used for operations discharge criteria) to illustrate how closure criteria could be developed. In the future DDMI will consult with the WLWB, government and communities regarding appropriate methods for determining these such as criteria including best achievable closure standards, or the maximum extent of closure mixing zones. This information will then be used to revise the values in Table V-7.

In summary, the closure objectives and criteria are sufficiently defined to use as a basis for current closure planning but it is recognized that both the objectives and the criteria are works in progress that will evolve along with the closure plan.

5.2.3 Closure Management Areas

For the purpose of closure planning the Diavik mine site has been divided into five closure management areas. These areas are shown in Figure 5-1 and defined in Table 5-9.

Table 5-9 Description of Closure Management Areas

Closure Management Area	Associated Infrastructure/Feature
Waste Rock and Till Storage Area	Waste rock pile; Till pile, Collection Ponds 1, 2, and 3; and Perimeter roads.
Processed Kimberlite Containment Area	PKC structure and contents; and 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; and A21 mine area.
North Inlet Area	North Inlet; and East and west dikes.
Mine Infrastructure	Collection Ponds 10, 11, 12 and 13; Ammonium nitrate storage and Explosives Plant; North Inlet Water Treatment Plant and Sewage Treatment Plant; Processing Plant; Paste Plant; Accommodations buildings; Power House; Waste Transfer Area; Airport and air strip; All other surface buildings, pipelines, power, fuel storage, laydowns, etc.; and Any infrastructure not included in the other closure areas.

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

5.2.4.1 Pre-disturbance, Existing and Final Mine Site Conditions

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

The existing extent of mine development is shown in Figure 5-2b based on an image from August 2009. The A154 and A418 dikes and the extent of the open pits are also shown in Figure 5-26. 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 about 200 m below lake level as shown in Figure 5-2c. The A418 and 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.

5.2.4.2 Closure Objectives and Criteria

Closure objectives applicable to the DDMI underground, open-pit and dike areas include both the site-wide objectives (Appendix V, Table V-1) and the area-specific objectives (Appendix V, Table V-2). The guidance provided by INAC (2007a) relevant to the underground and open-pit closure objectives is listed in Table 1A – Appendix XIII, and Environment Canada (2009) recommendations for closure practices are listed in Table 1B – Appendix XIII. The DDMI closure objectives for the underground, open-pit and dike areas are consistent with both the INAC and Environment Canada references.

Possible closure criteria are described in Appendix V, Tables V-1 and V-2. Closure criteria are intended to be used to evaluate success in achieving the objective. Closure criteria must be specific and measurable. As discussed in Section 5.2.2, it is recognized that some of the criteria in this ICRP 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 planning began with the initial mine design work in 1996 to 1998 and many of the important design decisions related to closure occurred at that time. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the PK, waste rock and till being managed, the preferred closure options also develop. 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 chronology describes the closure option considerations related to the mine plan, and the resultant preferred option.

Mine Plan 1996 to 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 decision points for closure. In addition to general footprint and waste rock closure considerations, the mining method also defines the mine workings that will require closure.

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

Three options based on conventional mining approaches were developed:

- *All underground* – Mining would advance from underground only. Declines or shafts would be developed to gain access to underground workings. A layer of kimberlite (referred to as a crown pillar, about 100 m thick) would be left in the top of the kimberlite pipe to separate the underground workings from the water of Lac de Gras. Lac de Gras would be immediately above the active mine. Water retention dikes were not a part of this alternative.
- *Underground with open pit crown pillar* – Underground mining would advance the same way as Option 1. 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.
- *Open pit and underground* – 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 Option 1 was that dike construction in Lac de Gras would not be required. Option 1 would eliminate any effects on fish habitat and water quality associated with the dikes and their construction. However, because the health and safety of workers is of primary importance to DDMI, it was determined that 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.

Underground mining displaces less waste rock than open-pit mining. Although both Options 2 and 3 would require storage areas on the East Island for waste rock, the storage area required for Option 2 would be less than Option 3.

Communities have consistently described the importance of using resources wisely. Whereas 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 was to be disturbed to recover diamonds, that DDMI maximize resource recovery and not just take the easiest parts. Option 3 provided the best opportunity for this community value.

From a diamond recovery perspective, Option 3 produces the most diamonds. Based on 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 was a larger open pit followed by underground mining in the later years. From an economic perspective Option 3 was preferred because it resulted in the lowest overall operating cost per carat recovered and was therefore the most financially robust. Option 3 was clearly the preferred option based on health, safety, environment, community and business considerations.

No significant closure alternatives were evaluated for the open pit, underground and dike areas when selecting the mining method. 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 Environmental Assessment was to proceed with Option 3, 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 periodically, 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, A154 South, A418 and A21 kimberlite pipes, as per Option 3.

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).

Details of the original closure design for the open pits, underground and dike areas described in the references above include:

- Hazardous materials, mobile equipment, pumps and other equipment would be removed from the underground mine workings including lubricants, explosives and glycol. Mobile equipment, pumps and pipelines would be removed from the open pit areas. Thermosyphons, power and instrumentation would be removed from the dikes.
- Surface openings to the underground mine area including all access/egress openings such as vent raises and drill holes would be appropriately sealed to prevent access.
- The end use objective for the closed dike/pit areas would be to create, where appropriate, 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.
- After 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 with the dike/pit areas to facilitate use by aquatic life and navigation by people. Breaches would be kept small to limit water currents and provide 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.

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 (2007a) and those relevant to this area are included in Appendix XIII, Table 1C. These generic options are provided as context for the reader regarding different approaches to closure of open pit and underground mine areas.

2009 to 2010 Review

The closure approach for the A418 and A154 open pits, underground and dike areas was not the focus of the 2009 to 2010 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. External reviewers raised concerns about potential for vertical mixing in the flooded open pits and so an initial modelling evaluation was undertaken to determine the mixing potential.

A study was undertaken to determine how different approaches to filling the pit lakes may influence their mixing and turnover characteristics and to determine how water quality in the upper portions of the pit lakes may be affected by different rates of internal mixing and exchange with Lac de Gras. The study found that the depth of the pit lakes relative to the surface dimensions minimize the opportunity for rapid, full turnover events. Additionally, the internal stability of the pit lake appears to increase as its groundwater content increases. The study and its results are included in Appendix X-3.

Although 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 and approved by the Department of Fisheries and Oceans (DFO 2004).

A related closure option that was considered in the Options Workshop hosted by DDMI in May 2009 was an option to locate an inert landfill in one or more of the open pits 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 metres of mine rock and hundreds of metres 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 A21 kimberlite pipe is included in the scope of all licenses and permits for the Diavik mine, however this resource has not yet been added to the mine plan. Studies are underway to determine an appropriate mining approach for A21. No specific closure plans for A21 are included in this document. Final closure figures will still show a breached dike as envisaged during the Environmental Assessment for the Project. Closure plans will be prepared in conjunction with the development of a mining approach.

Preferred Design Concept

Designs have been developed for the 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 habitat features within the dikes areas are modelled after features found in other productive areas of Lac de Gras, including depth, substrate type, size and configuration.

The design for the areas between the crest of each pit and the respective dikes is shown in Figure 5-3. Before breaching the dike, run-of-mine rock and till will be placed to create a long narrow reef in the area between the inside toe of the dike and the pit crest. These reefs will be built approximately 2 to 3 m high from run-of-mine rock and will be in areas where the water depth is 5 m. Areas of granular and soft substrates between reefs will be constructed with a 0.5-m-thick layer of till to replicate conditions that existed in the NI. Disturbance of the shoreline may require modification in areas to establish conditions similar to pre-development conditions, which may require the placement of boulders in water depths up to about 5 m. Breaching the dikes (about 2 to 3 m depth from low water and 30 m wide) will create entrances for fish and some circulation of water. The breach sizes and number have been minimized to restrict water circulation to allow a higher productivity quiescent (motionless) habitat to develop. The minimum size, number and locations of the breaches were determined by Transport Canada based upon requirements for navigation and are a condition of their approval to construct the dikes (*Navigable Waters Protection Act* Approval of August 3, 2000).

The following breaches are planned:

- A154: Two breaches on the north side, three breaches on the east; and
- A418: One breach on the south side and two breaches on the east.

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

- installing turbidity barriers local to the breach construction area;
- excavating granular fill;
- breaking and excavating concrete wall installation guides; and
- breaking and excavating upper portions of the plastic concrete wall.

There are no plans to revisit the number, size or location of these breaches.

Overall, the area 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 begin when underground mining operations end. The decommissioning work for the open pits will consist of:

- removal of mining equipment;
- removal of instrumentation; and

- removal of pipes and pumps from the pit dewatering system.

The underground mine workings within the kimberlite ore will be progressively backfilled during operations; therefore, at closure limited areas will be open before flooding. Specific actions proposed for the closure of the A154/A418 underground workings include:

- ventilation raises will be capped with reinforced concrete fitted with ventilation pipes, 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;
- fixed equipment such as piping and wiring that cannot be salvaged will be cleaned and left in place;
- mobile equipment will be removed to surface;
- fuel, lubricants and hydraulic fluids will be removed from all underground locations and shipped off-site;
- explosives and accessories will be removed from the underground storage magazines to off-site locations;
- unused ammonium nitrate and areas with excessive hydrocarbon contamination will be removed or cleaned to the satisfaction of the Inspector;
- after all salvageable equipment has been removed metal mobilization will be suppressed by flooding underground workings to prevent oxygen access; and
- decommissioning of the underground mine will be reviewed by the Inspector before flooding.

After the A418/A154 open pit and underground workings 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 ensure 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 productive fish habitat with surface water quality similar to Lac de Gras. The lake area will be very deep with steep sides and relatively small surface area and will be protected from wind-driven mixing by the residual dikes. This lake configuration should result in stable permanently stagnant lower monimolimnion underlying an upper mixolimnion that circulates regularly. Mathematical modelling to date supports this anticipated condition (see Appendix X-3).

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. These dissolved and/or suspended constituents will include any residue or precipitates that may have formed on the exposed rock. Because the volume of in-flooding water will be very large compared to the amount of residual elements, the initial water quality is expected to be similar to Lac de Gras (Blowes and Logsdon 1998). Once the breaches have been excavated into the dikes, water will circulate with Lac de Gras.

Preliminary modelling has shown that this circulation will result in a surface layer where the water quality inside the dikes becomes the same as water quality in Lac de Gras. The water deep within the flooded pits is not expected to mix with the overlying water (see Appendix X-3). Over time the deep water in the pit will equilibrate with the natural groundwater chemistry. This meromictic condition will provide better aquatic habitat conditions than if the entire water column regularly mixed as this would introduce more groundwater constituents into the surface waters.

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. After the filling is complete, water quality monitoring will begin in order to determine chemical profiles within each pit area. The flooded open pits and under ground will remain behind the dikes for a minimum of 12 months to allow settling of any generated suspended solids. After water quality conditions in the open pit meet water license criteria, or are to the satisfaction of the Inspector, decommissioning of the dikes will begin to join the pool area with Lac de Gras.

Further work is planned to predict the expected water quality conditions after filling the pit and post-closure (see Appendix VIII-2).

The A154/A418 dike wall stability is expected to increase as the dike enclosure is flooded because any differential head across the structure will be removed. Long-term sediment load from the dike embankments is not expected to be a concern because the lake-side of the dikes will have been exposed to wave action since construction, and the mine-side of the dikes will have been washed by precipitation for approximately 10 to 20 years. Post-closure geotechnical stability of the dikes and mine areas will be confirmed by a geotechnical engineer. This stability analysis will be conducted for the Final Design Concept.

Thermosyphons, instrumentation and power lines will be removed form the surface of the A154/A418 dikes.

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

5.2.4.4 Reclamation Activities and Associated Engineering and Environmental Work

The general schedule of activities that is currently envisaged for advancing and implementing the preferred closure plan for the open pit, underground and dike area is shown in Figure 5-5. A brief description of each activity is provided here:

- *Mining Activities* – The mine areas are currently expected to be active until 2022 limiting the closure activities.
- *Engineering/Environmental Studies* – Several engineering and environmental studies are planned to prove the preferred closure concepts for the mine areas, address uncertainties and reduce risks (Appendix VIII). These studies primarily relate to expected water quality and fish habitat designs in the A418 and A154 areas.
- *Community and Regulatory Engagement* – Continued engagement is anticipated to refine the closure plans for the mine area. In particular, engagement is envisaged to strengthen Traditional Knowledge review of, and input into, final fish habitat configuration.

Final engagement is anticipated around 2029/2030 to confirm permanent closure has been achieved.

- *Final Design Concept* – A final design concept for closure of the open pit, underground and dike will be completed and submitted for review in 2015. The concept would incorporate all relevant findings and input from engineering and environmental studies, research, community and regulatory engagement.
- *Detailed Engineering* – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years before the final closure work begins.
- *Complete Fish Habitat Construction* – Any final fish habitat construction work not completed during operations will be completed before permanent closure.
- *Decommissioning of Surface Mine Infrastructure* –Mining equipment and associated infrastructure for A148/A154 open pits will be removed.
- *Decommissioning of Underground Mine Infrastructure* –A418/A154 underground mining equipment and associated infrastructure will be removed, and surface access locations will be sealed in preparation for flooding.
- *Flood Mine Areas – Clarify Water* –The A154/A418 open pit and underground mine areas will be flooded. Water quality of A154/A418 and A21 pool areas will be monitored. Two years has been allocated to provide time for settling of particulate material.
- *Decommissioning of Dikes/Sediment Control Structures* –Breaches in the dikes will be excavated to re-connect Lac de Gras with mine area.
- *Performance Monitoring* – As soon as filling in the pit/dike areas is complete, performance monitoring will begin in preparation for decommissioning the dikes/sediment control structure. Emphasis will be placed on water quality in the mine areas followed by monitoring of fish habitat use.
- *Engineering Inspections* – The A154/A418 mine areas will be inspected before flooding and in the years immediately following to review the closure performance.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatic Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will 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 will be prepared and submitted for review and information.

5.2.4.5 Residual Effects

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

- open pits will create areas within Lac de Gras with water depths greater than 200 m and water quality potentially 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 higher primary productivity zones within the original mine areas that is uncommon in Lac de Gras (but beneficial for fish); and
- 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). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.4.6 Uncertainties, Risks and Research Plans

Currently, two notable uncertainties have been identified in relation to the open pit, underground and dike areas. As specifics of the closure designs evolve, other uncertainties will be identified and addressed as part of the engineering process. The two uncertainties of note are:

- flood rate and relative proportions of groundwater and surface water required to optimize final surface pool water quality for A154/A418 mine area; and
- methods for decommissioning the underground workings, recognizing that there is limited time from when pumps are shut off to when the underground area is flooded.

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.

Closure Research Plans specific to this area include:

- Traditional Knowledge review/modification of fish habitat designs for A418/A154 pit shelf. (Appendix VIII-1);
- use by fish of exterior slopes of A154/A418 dikes (Appendix VIII-2);
- predicted closure water quality in a flooded A154/A418 pit/dike area (Appendix VIII-2); and
- consideration of underground backfill materials (Appendix VIII-2).

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 these program details are not required for an ICRP but will be required and included for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for the open pits, underground and dike area are summarized below and in Appendix VI-1.

General guidance relevant to post-closure monitoring of the open pit and underground area provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007a) are included in Appendix XIII, Table 1D as general reference material. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to the open-pit, underground, dike areas and environmental effects monitoring which will include combined effects from all post-closure areas. The scope of the performance monitoring will include:

- surface water quality in mine areas and depth profiles to monitor chemocline;
- Total Suspended Particulate (TSP) and dust deposition/quality measurements;
- geotechnical inspections including observations of subsidence, erosion and thermal condition; and
- wildlife use of the area.

In addition to area-specific monitoring, environmental effects post-closure will 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 will be based on the operations monitoring programs and will be revised along with the monitoring frequency, as appropriate, to focus on any post-closure effects.

Post-Closure maintenance requirements might include:

- repairs to any erosion of dikes or shoreline; and/or
- correction of identified wildlife hazards.

Results of all monitoring and maintenance will be documented in post-closure monitoring and maintenance reports. These reports will 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 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 that will remain. With the exception of A21, DDMI does not expect this final landscape to change considerably moving forward.

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 are evaluated. Possible contingency actions that have been developed based on our current understanding of uncertainties and risks (see Section 5.2.4.6) include:

- aerial application of lime, alum or a synthetic polymer to assist in clarifying mine area pool water to achieve acceptable water quality before dike breaching;
- controlled exchange of mine area surface water with Lac de Gras water to improve pool water quality before dike breaching;
- longer time frames for pool areas to clarify before breaching dikes; and/or
- possibility of not breaching dikes if breaches would put Lac de Gras at significant risk.

5.2.5 Permanent Closure Requirements – Waste Rock and Till Storage

5.2.5.1 Pre-disturbance, Existing and Final Mine Site Conditions

The area used for waste rock 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, along with additional references that provide more specific information. An esker and some archaeological sites were identified in this waste rock and till storage area (Figure 3-26). No other specific or unique environmental conditions were identified in this area.

The extent of the current waste rock and till is shown in Figure 5-6b using an image from August 2009. The till area, waste rock and the inert landfill are also shown. The maximum height of the waste rock is elevation 495 m, approximately 79 m above Lac de Gras water level. Quantities by rock type are included in Section 4.4.3.

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

5.2.5.2 Closure Objectives and Criteria

Closure objectives applicable to the waste rock and till area include both the site-wide objectives (Appendix V, Table V-1) and the area-specific objectives (Appendix V, Table V-3). The guidance provided by INAC (2007a) relevant to the waste rock area closure objectives is listed in Appendix XIII, Table 2A and Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 2B. The DDMI closure objectives for the waste rock and till area are consistent with both the INAC and Environment Canada references.

The proposed closure criteria are also described in Appendix V, Table V-3. Closure criteria are intended to be used to evaluate success in achieving the objective. The intent of a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2, it is recognized that some of the criteria in this ICRP 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 began with the initial mine design work in 1996 to 1998, when many of the important design decisions related to closure were made. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the waste rock 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 chronology describes the closure option considerations related to waste rock and till storage, and the resultant preferred option.

Waste Rock Pile Closure Options 1996 to 1998

Sizeable volumes of waste rock are removed when mining kimberlite ore. Three options were considered when evaluating sites to store the mined waste rock:

- a typical waste rock area placed on the East Island near the open pit being mined;
- backfilling a completed open pit with waste rock from an active open pit; and
- waste rock placed in Lac de Gras by widening the dikes (e.g., top widths greater than 500 m were considered).

Water quality (geochemistry), community opinion, technical feasibility, and fish habitat were considered when evaluating the three waste rock storage alternatives.

Geochemical testing of the waste rock identified that, although most waste rock had sulphide content that was very low (less than 0.04 wt%S), some waste rock had low, but sufficiently high sulphide content (less than 0.4 wt%S) that could cause acidic drainage and metals to leach from the rock (Sala and Geochemica 1998). In practice, the two types of rock would be blended in various proportions such that overall sulphur concentrations would typically be less than 0.2 wt%S. When waste rock that contains sulphide minerals is exposed to oxygen in the atmosphere, acidic drainage and metal leaching can occur.

Option 1 has a disadvantage from a geochemical perspective because the waste rock is stockpiled on land where it is exposed to atmospheric oxygen. Any metal leaching, acidic drainage or secondary precipitates formed by the metal leaching/acid drainage could accumulate on the rock surfaces and/or in any drainage that reports from a stockpile. Potentially poor-quality drainage from a stockpile 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.

A common and preferred method to control metal leaching from waste rock is to place material sub-aqueously (under water), where reduced oxygen levels limit the leaching reactions. This oxygen limitation was the basis for the Options 2 and 3.

In Option 2, open pits that were backfilled with waste rock would then be flooded with water from Lac de Gras. This option would provide long-term storage in an oxygen-reduced environment, therefore limiting leaching reactions. However, if the waste rock is backfilled and not immediately covered with water then metals could leach and accumulate within the open pit and form precipitates on the waste rock. When the backfilled pit eventually floods, precipitates would move into solution and potentially result in unacceptable water quality in the flooded area. This water quality issue would also be encountered if the waste rock was stored on the surface over the mine life and later re-mined and placed into a completed open pit because precipitates would also form on waste rock stored in a stockpile on land. Even if Option 2 were chosen, not all the waste rock could be backfilled, and some volume would require on-land storage. The volume of waste rock produced is 30 to 40% greater than the volume where the rock was mined due to void spaces in the blasted rock. Additionally, a completed open 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 because all the waste rock would have already been removed.

With Option 3, waste rock mined after the dikes were constructed could be put into the lake allowing the material to be permanently stored in an oxygen-limited environment. Similar to Option 2, some on-land storage likely would have been required to accommodate all of the mined waste rock.

Moving mined waste rock is an appreciable component of the mining cost. Loading and hauling waste rock only once and reducing haul distances can, therefore, reduce mining costs. Of the three alternatives, Option 1 would have the greatest total haul distance, whereas Options 2 and 3 would have comparable total haul distances.

Option 2 was eliminated from further consideration on the basis of technical and economic feasibility. The full advantages of backfilling open pits can only be realized after mining is complete. From a technical and safety perspective, an open pit could not be backfilled if mining was occurring underground. Because open-pit mining of A418 and A154 was to be followed by underground mining, neither open pit would be available for backfilling. Re-mining and hauling over 220 Mt (100 million m^3) of waste rock post-closure to a completed open pit area at an expected to cost around $5.65 per cubic metre of waste rock (Brodie 2007) would be uneconomical.

From a community perspective, Option 3 was unfavourable because placing waste rock in Lac de Gras as an extension of the dikes was viewed as placing waste where waste did not belong. Furthermore, although the geochemical benefits of underwater storage of waste rock appears to be a generally accepted theory within the regulatory community, the question was raised regarding benefits of geochemical control versus the potential effects on fish habitat. It was unlikely that DFO's "No Net Loss" policy for fish habitat could have been achieved with Option 3. Therefore, Option 3 was not pursued.

Although the post-closure appearance of the waste rock pile was not identified as a predominant issue in the initial community and regulatory consultations, the visual appearance of the waste rock area was considered. The least visual impact would result from either Option 2 or 3. Both options would result in the smallest amount of waste rock being left in a location that could be readily seen on the East Island. For all Options, the waste rock area could be created higher with a smaller footprint, or flatter with a larger footprint.

The final decision from the EA and the basis for the Water License and Land Leases is Option 1, waste rock piles on the East Island, restricted to two areas (north for A154 and A418, and south for A21).

Waste Rock Area Closure Options

Guidance on generic options for closure of waste rock and overburden areas that are provided in INAC (2007a) and relevant to the waste rock and till area are included in Appendix XIII-5, Table 2C. These generic options are provided as context for different approaches to closure of waste rock and till areas.

Original Closure Design – 2001

The original closure design for the waste rock 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 waste rock and till area can be summarized as follows:

- Segregate waste rock in the pit into three types based on sulphur content and acid generating potential. Waste rock at the Diavik mine is comprised of granites, which contain very low concentrations of sulphide minerals, and biotite schist which contains low, but present sulphide concentrations. Waste rock that contains a higher proportion of biotite schist has a higher potential to leach metals and generate acidic drainage. Type I rock has the lowest sulphide content (greater than 0.04 wt %S) and is considered non acid-generating, Type II rock has intermediate sulphide content (0.04 to 0.08 wt%S) and is considered to have uncertain acid-generating potential, and Type III rock has the highest sulphide content (greater than 0.08 wt%S) and is considered potentially acid generating.
- Separate the storage area by drainage basin and place the waste rock with the highest acid-generating potential (Type III) in the most secure drainage basin. Separate rock types by storage areas (i.e., drainage basins).
- The final closure design for the Type III waste rock consisted of a 1.5 m lower permeability till cover layer intended to reduce water infiltration and oxygen supply, protected by a 3 m layer of Type I rock to act as a thermal blanket. The covers were to be placed as areas of the pile reach final elevation and suitable cover materials became available. After the covers were in place and the till had frozen, the covers would inhibit the penetration of water and oxygen into the underlying Type III rock. The Type I cover would also provide erosion protection.
- Type II waste rock has a very low, but uncertain, potential to leach metals in an arctic environment. This waste rock type was planned to be placed in separate watersheds from the Type I and Type III waste rock so that the final cover design could be confirmed from seepage observations. The proposed closure treatment for Type II consisted of

covering the waste rock with 4 m of Type I to ensure the active layer was completely within the non-acid-generating (Type I) waste rock layer.

- No cover was anticipated for the Type I areas because it is considered non acid generating.
- The waste rock storage area was designed to have a surrounding perimeter road that created ditches and collection ponds, such 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 would be pumped to the PKC Pond or the NI.
- The waste rock and till storage area would include shallow gradient ramps at final closure to allow for caribou migration.
- A south waste rock and till storage area was included in these original closure designs for the waste rock and till mined from the A21 pit area. All waste rock from A21 was non acid generating Type I (Sala and Geochemica 1998).

2009 to 2010 Review

Waster rock segregations remains as the operational approach to managing the potential for poor quality seepage from the waste rock area. Waste rock is segregated into three types in the A154 and A418 pits and hauled to the waste rock area where it is placed in designated areas. Drainage basins were delineated by topography or in the case of the quarry area, excavation. The overall goal is to limit the number of basins that contain Type III rock (highest potential for generating poor quality seepage). The drainage basins in the waste rock area and the two basins where Type III rock has been placed are shown in Figure 5-8. Only limited amounts of Type II rock have been produced and they have been placed within the Type III basins.

The closure design for the waste rock pile was dependent upon the availability of till and Type I rock from an A21 open pit. The till and Type I would be direct-hauled from the mine to the waste rock pile to be used as cover materials. When the original design was proposed (NKSL 2001a) the specific benefits of till and rock covers to seepage water quality were unknown. The cost to place this material was limited to the incremental increase in haul distance (i.e., instead of hauling to the south waste rock and till area it would be hauled to the north waste rock and till area). On the basis of a relatively low incremental cost, DDMI made the decision to proceed with this closure design basis, concurrent with research studies to better understand the environmental benefits of a till and/or rock cover(s).

In December 2007 DDMI deferred the development of the A21 kimberlite pipe pending further engineering studies and economic evaluations so the economics of mining A21 could be improved significantly. A feasibility study and environmental review of alternative mining methods for the A21 kimberlite pipe, including methods that would not require removal and haulage of till and waste rock, are proceeding. At this time DDMI cannot plan to use till or Type I rock from an A21 mine to construct a low-cost till/rock cover(s) for the Type II/III areas of the waste rock pile.

This change in the mine plan reduced cover material availability, thus it was necessary to reconsider options for the closure of the waste rock pile.

Information on the thermal, chemical, hydrological and biological behaviour of waste rock in an arctic environment, while incomplete, continues to become available for use in closure planning. The information base today is considerably greater than it was when the original closure designs were developed in 2001, and this information base is expected to continue to grow through ongoing research activities and monitoring of existing waste rock piles.

DDMI initiated an extensive waste rock research project in 2004. The research is described in Appendix VIII-3 and includes a summary of results to date and references to publications prepared to date. A copy of the most recent progress report on the research is included in Appendix X-6. This research is planned to continue for another five years with a shift in emphasis from data collection to data interpretation and analysis. Of particular interest to DDMI is insight into the expected benefits of a possible closure configuration on the generation of poor-quality seepage water.

In addition to ongoing research at the Diavik mine site, the BHP Ekati operation, less than 30 km away with comparable waste rock, continues to monitor the performance of its waste rock piles (BHP *Interim Closure and Reclamation Plan* 2008; BHPB 2008). The Ekati operation started about five years before the Diavik mine operation so the development, monitoring and evaluation of the performance of their full-scale waste rock piles is further advanced. DDMI expects to be able to apply insight gained at Ekati to the closure of the waste rock piles at the Diavik site.

The change in the Diavik mine plan (deferred A21 development, discussed above) has had the greatest impact on the closure plans for the waste rock pile. Additional aspects that factor into closure considerations include:

- Sulphur content of waste rock has been confirmed to be the best predictor of geochemical loading from waste rock.
- Air flow through the pile, conventionally considered from the perspective of limiting oxygen availability for sulphur oxidation rates within a waste rock pile, has been identified as an important influence on the thermal evolution and conditions within the pile. Air flow appears to dominate super cooling within the piles during winter but may also be a significant factor influencing the depth of the seasonal thaw zone within the waste rock pile.
- Operational experience at Diavik indicates that the local till does not have a sufficiently low permeability to be a very effective water infiltration barrier.

The 2001 closure design included access ramps that would enable wildlife, particularly caribou, to travel over the pile and access the top of the pile as a possible refuge from insects. Discussions continue with communities and wildlife experts to confirm that this is the preferred approach and consider specifics of ramp location, width and surface material.

Open-pit mining of waste rock from the A154 and A418 areas will be largely complete by mid-2011. Segregation of waste rock by sulphur content has been practiced since the start of mining operations. The waste rock pile development continues to be guided by waste rock sulphur content with the objective of managing potential operational and closure seepage water quality.

DDMI has concluded that it is neither necessary nor advisable to make final decisions regarding the closure of the waste rock pile at this time. The development of the waste rock pile is largely complete and there are few operational opportunities to further optimize areas for closure.

The immediate operational opportunities are:

- Designate some of the remaining waste rock haulage to level out areas on the top surface of the pile to minimize snow accumulation (and hence water infiltration) into the pile.
- Develop an accessible source of Type III rock near the crusher/paste plant to take advantage of opportunities to use Type III rock in underground backfill. From a geochemical perspective, encapsulation of Type III rock in cement underground is a preferred long-term location compared with a surface location.
- Where possible use re-mining activities to construct aspects of final landforms for the waste rock area including any wildlife access ramps.
- Now that the extent of the Type III areas within the waste rock pile can be reasonably defined, begin placing any low sulphur content waste rock on the outside slopes of the Type III material instead of expanding the Type I dump areas. Expanding the Type I areas is of no benefit to closure whereas reducing the sulphur content in the batters around the Type III areas would be advantageous from a seepage water quality perspective.
- Leave an area within the centre of the Type III rock for use as a landfill during operations and closure.

Backfilling using Type III material has been considered from the perspective impacts on mine water quality. Encapsulating Type III rock in cement and disposing of it underground is preferable to storing it on the surface where it has the potential to contribute to poor quality seepage. During operations, seepage water from backfill areas form part of the mine water that is pumped from underground, treated and discharged to Lac de Gras. Using Type III rock as part of the backfill material is not expected to affect the metals levels in the mine water (see Appendix X-9).

These opportunities have been included in the waste rock haulage plans for the remainder of the A154 and A418 waste rock.

Beyond these operational opportunities, the next activities toward the final closure of the waste rock area require decisions on the shape (side slopes, wildlife access, re-vegetation) and configuration (any additional geochemical mitigation). Any of these activities would require significant earthworks and costs that would only be undertaken with a confirmed final design. With continued mine operations to 2023 there are at least 10 years to consider new information, make final closure decisions and initiate closure activities. Conversely, there is a risk that premature closure actions could result in unnecessary costs and/or undesirable final closure conditions.

Preferred Design Concept

The DDMI preferred approach for closure of the waste rock and till area is the alternative closure approach that utilizes the 10-year period from 2011 (end of waste rock and till pile development) to 2022 (end of kimberlite production) to determine if there are any areas where additional closure actions may be required.

The operational approach to managing the potential for poor-quality seepage from the waste rock area using waste segregation by sulphur content continues as per the original design. Waste rock in the A154 and A418 pits is segregated into three types based on sulphur content and hauled to the designated area in the waste rock area. Waste rock production from the open pits will end in 2011 when the A418 open-pit mine is completed. Underground mining produces relatively small amounts of waste rock. Placement of waste rock over the next year represents the final opportunity to strategically place rock for final closure without having to double-handle material. As described above, the operations waste rock haulage plan includes the following:

- Filling areas on top surface of waste rock area to minimize snow accumulation.
- Stockpile Type III rock for use in underground backfill. A 3.6 Mt stockpile is planned based on minimum requirements for cemented backfill for secondary stopes.
- Maximize the thickness of low-sulphur rock on Type III perimeter slopes.
- Continued use of designated landfill area during operations and closure.

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.

The preferred closure design for planning purposes is shown in Figure 5-9, which shows the waste rock area at 2022 based on the current re-mining plan:

- All waste rock slope faces will have a minimum of 3 m Type I rock on the outside.
- All slopes will be geotechnically stable but maximized to limit waste rock area footprint and enhance freezing.
- The waste rock area top surface will remain as a flattened surface and will not be a priority for re-vegetation efforts. This arrangement is expected to reduce snow accumulation and subsequent infiltration.
- Type I material will be removed to construct the PKC cover.
- Two caribou access ramps will be in place, one in the northwest and one in the southeast.

In this preferred closure design, 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 re-vegetation work, fish habitat, final surfaces material, and contingency capping material for any identified problem waste rock seepage areas. DDMI expects that the till will be fully used and the pile will not exist at closure. A grading and drainage plan for the area will be prepared once final material use has been confirmed.

DDMI will continue, during the remaining operations, to place Type I material on Type III slopes, whenever practical. In the unlikely event that it is determined this Type I material could be better used elsewhere for closure, it could be re-mined from these slopes. Given the volumes of Type I rock available elsewhere (see final materials inventory Section 4.4.3) re-mining these slopes seems unlikely.

Several decisions that are required for a final closure design are still outstanding. Many of these decisions are interrelated and include:

- final landscape (e.g., softening of angles and slope of sides);
- wildlife Access – location of access routes (if any) width, and surface material;
- re-vegetation – confirming that waste rock piles should not be a focus area for re-vegetation; and
- geochemical mitigation – determining any requirements for additional mitigation, (e.g., low permeability barriers, passive/active seepage collection and treatment).

DDMI will not begin preparing the final landscape until final decisions have been made on all these aspects. Beginning this closure construction work prematurely could result in an increased risk of needing to redo the work if decisions change.

Initial concepts for wildlife access routes are provided in Figure 5-9b for ongoing review and suggestions.

When 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. The locations where the natural drainage will be restored are shown as blue lines in Figure 5-9.

5.2.5.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the waste rock and till area is provided in Figure 5-10. A brief description of each activity is provided below:

- *Dump Development* – The waste rock area is an active facility that will continue to receive waste rock from open-pit mining through to 2011.
- *Re-Mining for Backfill* – Waste rock will be re-mined for underground backfill starting in 2010 and continuing until 2022 (current plan).
- *Engineering/Environmental Studies* – Several engineering and environmental studies are planned to prove the preferred closure concept for the waste rock and till area, address uncertainties and reduce risks. Many of these studies are related to the generation of poor-quality seepage water and will be studied as part of the DDMI Test Pile Research which will be completed by 2015 (Appendix VIII).
- *Performance monitoring* – Extended performance monitoring will begin in 2012 when the final footprint of the waste rock area will be established. Emphasis will be placed on seepage water quality, thermal monitoring, stability and any wildlife interactions. Much of this monitoring is part of the waste rock area reclamation research plan (Appendix VIII-3).

- *Community and Regulatory Engagement* – Continued engagement is anticipated to refine the closure plans for the waste rock and till storage area. Engagement, which includes the integration of Traditional Knowledge, is envisaged for options and closure criteria for wildlife. Final engagement is anticipated around 2029/2030 to confirm permanent closure.
- *Final Design Concept* – A final engineering closure design concept for the waste rock and till storage area will be completed and submitted for review in 2015. The design will incorporate findings from engineering and environmental studies, research, community and regulatory engagement.
- *Detailed Engineering* – Detailed engineering to prepare final drawings and construction specifications for closure activities will be completed two years before the final closure work begins.
- *Wildlife Access and Contouring* – The detailed engineering design will be used to guide the re-mining work on the waste rock area to achieve final surfaces and access routes through the area.
- *Decommissioning of Collection Ponds* – When runoff and seepage water quality/quantity have been confirmed, collection ponds will be decommissioned, including the removal of any pumping/piping infrastructure.
- *Engineering Inspections* – Inspections will 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 will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatic Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will 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 will 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 for the waste rock and till area. Potential residual effects of note include:

- a significant landscape feature (waste rock pile) that did not exist pre-development and will remain visibly different from the surrounding landscape;
- a permanent loss of the underlying vegetation and associated wildlife habitat, and some archaeological information that was covered by waste rock and till;
- an increase in the area of “human disturbed” category of Vegetation/Land Cover (VLC) type;
- localized seepage/runoff water quality and quantity that will be different from pre-development;

- some small inland waterbodies and ephemeral streams that will be permanently covered by the waste rock and till;
- a waste rock pile that may become a new attractant to caribou (e.g., for insect avoidance); and
- dust may be generated from the waste rock and till and from new rock surfaces, which would be deposited on adjacent vegetation or waterbodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.5.6 Uncertainties, Risks and Research Plans

The detailed closure design has numerous uncertainties that will need to be addressed. Anticipated key uncertainties with the preferred closure approach include:

- seepage water quality and quantity;
- benefits of additional geochemical mitigation measures;
- requirements for wildlife movement;
- sediment quality in collection ponds;
- long term dust generation;
- depth of seasonal active thaw zone; and
- post-closure performance of the facility under current and possible future climate change.

The notable closure risk for the waste rock and till area is seepage water quality/quantity that is not adequate for release into Lac de Gras.

Closure Research

Specific research activities that are anticipated to provide specific input into the waste rock and till area closure design are described in Appendix VIII-3 and include:

- waste rock pile behaviour – geochemistry, hydrology, microbiology, thermal and oxygen movement; and
- effects of cover designs on seepage water quality and quantity.

In addition to the waste rock test pile, three 40-m-deep holes were drilled into the North Country Rock pile to measure and monitor the physicochemical processes occurring in the waste rock dump itself. Instrumentation was installed in each borehole for redundancy and reproducibility, and included thermistors, air permeability probes, gas sampling lines, pore water sampling devices, and an access port for thermal conductivity measurements and microcosms for microbiological characterization. Monitoring of the waste rock pile will continue after the test pile research has ended.

The closure research work is applicable to both the preferred closure concept and contingency with regard to the waste rock pile itself. If long-term active or passive treatment is required as a contingency, additional research specific to these contingencies may be required. The need for research related to these contingencies should be known by 2015 once the modelling and evaluations of the preferred closure plan are complete.

Wildlife movement requirements for the waste rock and till area are addressed in Appendix VIII-1 and include Traditional Knowledge and science specifications for routing wildlife over and around the waste rock and till area.

5.2.5.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. These program details are not required for an ICRP but it will be required and included in a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized in this Section and in Appendix VI-2.

General guidance relevant to post-closure monitoring of the waste rock and till area provided by the *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007a) are included in Appendix XIII, Table 2D as general reference material. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to the waste rock and till area, and environmental effects monitoring which will include combined effects from all post-closure areas. The scope of the performance monitoring will include the following:

- seepage quality and quantity using a system similar to the Surveillance Network Program (SNP);
- geotechnical inspections including observations and measurement of settlement, erosion, surface drainage and thermal condition;
- TSP and deposition/quality measurements of any dust generated from the closed waste rock and till area; and
- wildlife use of the area.

In addition to area-specific monitoring, post-closure environmental effects will 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 will be drawn from the operations monitoring programs. The program and monitoring frequency will be revised appropriately to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include:

- repairs related to stabilization;
- corrections to areas with poor-quality seepage;
- repairs to drainage routes; and/or
- corrections to any identified wildlife hazards.

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

5.2.5.8 Post Closure Landscape

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

- a minimum 3-m-thick layer of Type I rock on any exposed Type III rock faces;
- the re-establishment of drainage channels at Collection 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).

5.2.5.9 Contingency Program

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks are evaluated. The following possible contingency actions have been developed based on our current understanding of uncertainties and risks (see Section 5.2.4.6):

- Add additional Type I material to target batter areas if inadequate seepage quality is identified (see Introduction to Appendix VIII for risk-based approach to determine adequacy of seepage quality). Type I rock would be re-mined from the waste rock area, collection pond dams, laydowns and/or roads.
- Add a till cover to target batter areas if inadequate seepage quality is identified. Till would be available until 2022 from the till area. A contingency reserve of till could also remain after 2022.
- Collect and treat seepage water until quality/quantity is adequate for release into Lac de Gras.
- Enhanced passive treatment of targeted seepages.
- Revised wildlife access routes including possible local re-sloping.

5.2.6 Permanent Closure Requirements – Processed Kimberlite Containment Area

5.2.6.1 Pre-disturbance, Existing and Final Mine Site Conditions

The valley on the East Island where the 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, noted in Figure 5-11a, 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 new south barge access road, the area for fine PK deposition, coarse kimberlite placement and Collection Ponds 4, 5 and 7 are also shown in Figure 5-11b.

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

5.2.6.2 Closure Objectives and Criteria

Closure objectives applicable to the PKC area include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-4). The guidance provided by INAC (2007a) relevant to the PKC closure objectives is listed in Appendix XIII, Table 3A and Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 3B. These references are included to assist the review of the DDMI PKC objectives.

Appendix V, Tables V-1 and V-4 also describes possible closure criteria. Closure criteria are intended to be used to evaluate success in achieving the objective. The intent a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2, it is recognized that some of the criteria in this ICRP 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.

5.2.6.3 Preferred and Alternative Closure Options

Closure planning began with the initial mine design work in 1996 to 1998, when many of the important design decisions related to closure were made. As the mine develops and more is learned about the physical, chemical and biological characteristics of the site, engineered structures and the PK 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 chronology describes the closure considerations related to the PKC, and the resultant preferred option.

Processed Kimberlite Containment Closure Options 1996 to 1998

Two important decisions were made as a part of the original mine design that affect the PKC and closure: the location of the PKC, and the site water management approach.

Three PKC site options (Figure 5-7) were considered in the original mine design and the EA (DDMI 1998a):

- T-lake, a natural topographic feature on the mainland, east of the East Island;
- the central valley on the East Island; and
- a dammed/diked area within Lac de Gras between the East and West Islands.

Option 1 was initially identified as having the best natural features for design of an on-land PKC facility. The steep hills surrounding the lake combined with the deep lake bottom could both accommodate the required storage volumes, and limit the number and extent of engineered structures. The development of a causeway extending from the East Island to the mainland would be required to access the facility. However, T-lake is located toward the mouth of a sizeable drainage basin, which would require water diversion around T-lake for closure.

Option 2 was identified because the only appreciable topography on the East Island was the central valley. Option 2 would provide less natural storage volume than Option 1 but, Option 2 was closer to the open pits, would not require a causeway, and was located in a smaller drainage basin than T-lake (Option 1), thereby providing some water management advantages.

Option 3 was identified as a PKC storage option by damming off as a series of cells and depositing PK into the cells and thus displacing Lac de Gras water. Ultimately, the area would be filled with PK and capped with water. Option 3 would manage any potential geochemical concerns by storing the PK sub-aqueously. This option would also provide the best assurance of long-term (post-closure) physical and geochemical stability. The material would be physically stable because it would be placed below lake levels, and would be geochemically stable because sub-aqueos disposal limits leaching and has a low potential for generation of poor-quality leachate.

All three Options were discussed with communities during initial meetings in June 1997. From the comments and discussions, it was the understanding of DDMI 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 PK. These discussions gave Diavik a clear indication that Option 3, while advantageous from a geochemical and closure perspective, would not be considered acceptable by communities. DDMI 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 the decision to locate the PKC on the East Island (Option 2) rather than using T-lake (Option 1).

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 (Option 1) or the central valley of the East Island (Option 2) was preferred over Lac de Gras (Option 3).

The final decision from the EA and the basis for the Water License and Land Leases is a Option 2.

Water management within the PKC was an important consideration in the original mine design 1996 to 1998 (DDMI 1998a). Water management alternatives were reviewed based on the anticipated quality and quantity of the possible source waters. A priority was to match water use requirements with wastewater sources to identify opportunities to recycle and reuse water. Any surplus water quality was evaluated for water treatment requirements and alternatives, and considered for discharge to Lac de Gras. Three primary water sources were identified that required management:

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

- PK 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 PKC.
- Mine water. This water was identified as primarily groundwater that seeps into the open pits and underground developments. At full development water volumes were expected to reach 30,000 m^3/day.

The two identified options for water management were based on the general water qualities and quantities and included:

- treat and release the runoff and PK water, and use mine water as makeup for ore processing; or
- treat and release mine water, and use PK and runoff water as makeup for ore processing.

PK contact water and runoff water were identified as having relatively low volumes but the potential to contain elevated metals concentrations. The total estimated water volume of PK water and runoff was very similar to the expected makeup water demand for ore processing. As such, PK and runoff water was considered to be the best waters to use for recycling within the Processing Plant. However, excess water was expected to develop in the PKC. Some of this water would ultimately be contained within the PK, and the remainder would possibly require treatment before discharge.

Option 2 had some distinct advantages over Option 1. Mine water was expected to have the largest volume and to be of good quality, requiring only filtration to remove suspended solids. Mine water was considered to be the higher quality water to discharge.

The final decision from the EA and the basis for required water management was that Option 2 was most favourable.

Processed Kimberlite Containment Closure Options

Guidance on generic options for closure of tailings areas provided in INAC (2007a) and relevant to the PKC area are included in Appendix XIII, Table 3C. These generic options are provided as context for different approaches to closure of the PKC.

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).

The original closure concept is shown in Figure 5-12. Note from the figure that the final surface of the PKC facility is domed in the centre and graded downwards towards the perimeter to promote drainage of meteoric waters to a single controlled discharge point.

2009 to 2010 Review

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

- PKC pool water chemistry;
- operational PKC seepage;
- PKC water balance;
- 2006 and 2009 ICRP review comments;
- PK deposition and material balance; and
- the physical properties of fine PK.

Identified challenges associated with the domed approach 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; and
- ability to maintain a graded, positive drainage channel on the surface of the facility because of the expected formation of thermokarst topography above the central pond/slimes area of the PKC facility.

The original closure design for the PKC was based on an impermeable till cover over the PKC such that rain and snowmelt would be shed from the facility without infiltrating to the underlying PK material. However, the available till has been shown to have a large sand component and is not an impermeably/low permeability material. A significant cost and effort would be required to design and construct an alternate impermeable cover. Furthermore, it is unlikely that either a till or impermeable cover could maintain its integrity over the long term and achieve the expected performance objective of preventing snow melt and rain fall from contacting PK. Because of the till characteristics, constructability constraints, and reliability of an impermeable layer, this design concept has been determined to be unachievable.

Furthermore, the 2009 to 2010 review questioned the requirement to prevent snow melt and rain fall from coming in contact with PK. The current chemistry of the PKC pond (SNP 1645-16, 2007-2009, N=31) is listed in Table 5-10. The probable range of water quality is represented as the range between the low (25^{th} percentile) and the high (75^{th} percentile). Excluding value lower than or higher than this range eliminates focus on possible outliers. This PKC pond water has been recycled through the Processing Plant where the water is slurried with PK, and has been stored within the PKC where the water is in direct contact with PK. Using operational effluent quality criteria as a benchmark, the water currently within the PKC pond, with partial removal of suspended particulate material, is generally of suitable quality to discharge to Lac de Gras. Parameters of note that currently approach or exceed the operation discharge criteria are zinc and pH. However, most of the operational effluent quality criteria are based on what is achievable using metals treatment technology, and not based on any threshold of environmental effect. The value for zinc is an example where the criteria of 0.01 mg/L average and 0.02 mg/L maximum are actually less than the receiving environment threshold of 0.03 mg/L (CCME 1999).

Table 5-10 Processed Kimberlite Containment Water Quality (SNP 1645-16, 2007-2009, N=31)

	Units	Effluent Quality Criteria[a]	Total		Dissolved	
			25th Percentile	75th Percentile	25th Percentile	75th Percentile
Silver (Ag)	mg/L		<0.0004	<0.0004	<0.0002	<0.0002
Aluminum (Al)	mg/L	1.5/3.0	0.16	1.04	0.01	0.01
Arsenic (As)	mg/L	0.05/0.1	0.0023	0.0041	0.0019	0.0037
Barium (Ba)	mg/L		0.228	0.374	0.210	0.359
Beryllium (Be)	mg/L		<0.001	<0.001	<0.0005	<0.0005
Bismuth (Bi)	mg/L		<0.0001	<0.0001	<0.00005	<0.00005
Boron (B)	mg/L		0.03	0.04	0.025	0.034
Calcium (Ca)	mg/L				9.6	16.6
Cadmium (Cd)	mg/L	0.0015/0.003	0.0004	0.0007	0.0004	0.0006
Chlorine (Cl)	mg/L				37.5	71.0
Cobalt (Co)	mg/L		0.0009	0.0030	0.0002	0.0004
Chromium (Cr)	mg/L	0.02/0.04	0.0037	0.0192	0.0004	0.0025
Copper (Cu)	mg/L	0.02/0.04	0.002	0.003	0.0007	0.001
Iron (Fe)	mg/L		0.40	1.93	0.005	0.005
Mercury (Hg)	mg/L		0.0001	0.0002	0.0001	0.0001
Potassium (K)	mg/L				55.45	100.85
Magnesium (Mg)	mg/L				15.55	36.35
Manganese (Mn)	mg/L		0.023	0.048	0.002	0.013
Molybdenum (Mo)	mg/L		0.309	0.384	0.264	0.388
Sodium (Na)	mg/L				52.925	76
Nickel (Ni)	mg/L	0.05/0.1	0.026	0.0539	0.0084	0.0160
Lead (Pb)	mg/L	0.01/0.02	0.0003	0.0008	0.0001	0.0001
Sulphate (SO_4)	mg/L				132	243
Strontium (Sr)	mg/L		0.459	0.700	0.415	0.640
Deoxythymidine diphosphate (TDP)	mg/L				0.005	0.015
Thorium (Th)	mg/L		0.0001	0.0002	0.00005	0.00006
Titanium (Ti)	mg/L		<0.0004	<0.0004	0.0003	0.0004
Uranium (U)	mg/L		0.0015	0.0105	0.0007	0.0071

Table 5-10 Processed Kimberlite Containment Water Quality (SNP 1645-16, 2007-2009, N=31) (continued)

	Units	Effluent Quality Criteria[(a)]	Total		Dissolved	
			25th Percentile	75th Percentile	25th Percentile	75th Percentile
Vanadium (V)	mg/L		0.0014	0.0047	0.0009	0.0010
Zinc (Zn)	mg/L	0.01/0.02	0.004	0.013	0.003	0.012
pH	pH units	5.0 to 8.4			8.26	9.26
Alkalinity	mg/L				71	108
Electrical Conductivity (EC)	µS/cm		728	1,050		
Total Dissolved Solids	mg/L				425	626
temperature	°C				1.1	4.0
Carbon Trioxide (CO_3)	mg/L		5.0	9.5		
Bicarbonate (HCO_3)	mg/L		79	107		
Total Organic Carbon (TOC)	mg/L		3.3	5		
Dissolved Organic Carbon (DOC)	mg/L				3	4
Dissolved Oxygen (DO)	mg/L				4.2	9.3
Nitrogen Dioxide (NO_2) (as N)	mg/L	1.0/2.0	0.50	0.87		
Nitrate (NO_3) (as N)	mg/L		4.60	9.18		
Ammonia (NH_3) (as N)	mg/L	6.0/12.0	0.70	1.85		
NO_2+NO_3	mg/L		6.10	9.69		
Total Kjeldahl Nitrogen (TKN)	mg/L		1.39	2.70		
Total Suspended Solids	mg/L	15.0/25.0	7.0	25.0		
Turbidity	NTU	10/15	8.4	24.3		

(a) Sources: Water License W2007L2-0003 – Operational discharge criteria.- maximum average/maximum grab. Criteria are for total metals.

Notes: mg/L = milligrams per litre; µS/cm = micro Siemens per centimetre; °C = degrees Celsius; < = less than.

DDMI continues to manage operational seepage from the PKC. The majority of the seepage reports to collection ponds 4 and 5. Some of the seepage has occurred due to damage to the synthetic liner and ponding of water directly against the impoundment structure. Repairs have been made to the liners and long beaches are developing between the PKC pond and the perimeter dams. With regard to closure planning, the seepage issues observed to date have emphasized the importance of developing long beaches but it has also shown that the seepage water is very clear and of relatively good quality, in many cases seepage water quality is well within operational discharge limits.

The design review resulted in a change in the closure design concept for the PKC facility. The key design change recognizes that snow melt and rainfall will contact PK. As such, the design needs to focus on enabling accumulated water to exit the PKC in a controlled manner at a designated location and in a manner that minimizes the amount of any PK particulates that might be suspended in the outlet water.

The focus of the PKC closure design therefore shifted to the following:

- designing a water outlet that would enable water to exit the facility while minimizing the amount of suspended particulate kimberlite within the water;
- locating a water outlet for the facility that maximizes use of natural attenuation processes before water reaches Lac de Gras;
- optimizing the geometry of the final PK beaches to enable accumulated water to flow through the outlet; and
- engineering a closure surface for the PKC that recognized the dynamic processes of ongoing fines consolidation and thermokarst processes.

Preferred Design Concept

The preferred closure design for the PKC is currently at an initial conceptual engineering level. There is a general vision of what the facility might look like at closure but there are many engineering and environmental uncertainties that need to be addressed before this concept can be finalized and submitted for external review and comment. A general description of the preferred option based on what is known today is presented here. The uncertainties with the preferred option are discussed in Section 5.2.6.6.

The closure concept for the PKC is shown as an illustration in Figure 5-14.

Processed kimberlite will be deposited into the PKC in such a way that at the end of operations the PK beaches slope inward to a low point in the southeast corner. A surface water pond is expected to remain at this low point post-closure. The pond is expected to vary in size and geometry with seasonal changes in water levels, with ongoing consolidation and with freeze/thaw cycles of the PK beaches.

The characteristics of the PK beaches are expected to vary from the perimeter of the facility towards the centre. A large portion will be coarser, free-draining, consolidated materials that will extend from the facility perimeter. Near the surface this material will be well drained, but at some depth it will be saturated and at some deeper depth it will likely be both frozen and saturated.

Towards the centre of the facility there will likely be ponded surface water. At some depth the ponded water will change from being relatively clear water to being unconsolidated fine PK or slimes. It is expected there will be a sizeable depth of these slimes and then a growing depth of more consolidated material below.

A transitional zone will occur between the perimeter beaches and the pond shoreline. This transitional zone will be variably ice, ice lenses, thermokarst and consolidated PK.

A surface run-of-mine Type I rock will be placed over the beaches to as close to the pond as possible to protect against wind and water erosion. The Type I rock will be scarified and the area will not be targeted for re-vegetation so that it will not become an immediate wildlife attractant. Communities have also noted concerns with re-vegetation in the PKC. Pond shorelines are expected to be unstable for some time, so the PKC will need to be configured to exclude caribou and people from accessing the inside of the PKC.

A water outlet is located in the southeast corner. Upon exiting the outlet, water would travel through a network of streams and small ponds before reaching Lac de Gras. The outlet is at the same location as envisaged in the EA.

To create the outlet, a notch will be excavated in the PKC dam and liner, and filled with Type I run-of-mine rock. The concept includes developing the south barge road as a French drain during operations. The south barge road extends perpendicular to the PKC dam and abuts the dam at the location where the outlet notch would be excavated. In concept this French drain will direct free water from within the PKC to drain though the outlet.

With the installation of a mine water feed to the Processing Plant in 2010, the PKC has become an optional water supply for the processing plant rather than a required supply. As such, an evaluation during 2011 will assess the extent to which the volume of pond water, and possibly pore water, can be reduced and the potential impacts and benefits this reduction might have on operations and closure. Impacts with lower water levels include greater extent of PK exposed sub-aerially and more ice entrainment. Ice entrainment reduces the functional capacity of the PKC. Benefits include improved freezing rates and reduced seepage rates.

DDMI recognizes that there are significant design considerations and uncertainties that need to be addressed. These considerations are discussed in Section 5.2.6.6.

The concept drawing of the final PKC landscape, which illustrates the preferred design concept and DDMI's current thinking is presented in Figure 5-13. This figure is intended to serve as a basis for ongoing discussion and review.

The closure scope for the PKC also includes:

- removal of all pipelines and power lines;
- removal of reclaim barge; and

- decommissioning of collection Ponds 4, 5, 7 and 12 after acceptable water quality can be demonstrated.

5.2.6.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the PKC area is shown in Figure 5-15. A brief description of each activity is described in the following.

- *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 consider these ongoing operations.
- *Revised Water Management* – With the installation of a mine water feed to the Processing Plant in 2010, the PKC has become an optional water supply for the processing plant rather than a required supply enabling a possible change in water management.
- *Engineering/Environmental Studies* – Several engineering and environmental studies are planned to prove the preferred closure concept for the PKC, address uncertainties and reduce risks. Many of these studies are related to the physical and geochemical properties of the PK and are planned to be undertaken over the next three to five years. Additional information is provided in Section 5.26.
- *Community and Regulatory Engagement* – Continued engagement is anticipated to continually refine the closure plans for the PKC. In particular, engagement, which includes the integration of Traditional Knowledge, is envisaged for options and closure criteria for wildlife. Final engagement is anticipated around 2029/2030 to confirm permanent closure.
- *Final Design Concept* – A final engineering closure design concept for the PKC will be completed and submitted for review in 2015. This design will incorporate findings from engineering and environmental studies, research, community and regulatory engagement.
- *Detailed Engineering* – Detailed engineering to prepare final drawings and construction specifications for closure activities will be completed two years before the final closure work begins.
- *Placement of Final Surface and Wildlife Access* – Rock placement will be required to prepare final the PK surface, construct access routes around the PKC and re-slope access ramps.
- *Outlet Preparation* – Deconstruction of a section of PKC liner and preparation of an engineered water outlet will be required.
- *Decommissioning of Collection Ponds* – When outlet and seepage water quality/quantity have been confirmed, Collection Ponds 4, 5 and 7 will be decommissioned.
- *Infrastructure Decommissioning* – The reclaim barge, water and slurry pipelines, power and any associated surface infrastructure will be removed.
- *Performance Monitoring* – A specific performance monitoring program will be conducted starting in 2021 and is anticipated to last six years. This program will include monitoring

seepage and outlet water quality, dust deposition, ground temperature, settlement and wildlife interaction.

- *Engineering Inspections* – Inspections will 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 will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatics Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will 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 will be prepared and submitted for review and information.

5.2.6.5 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 following:

- the PKC structure is a significant landscape feature that did not exist pre-development and will remain visibly different;
- a permanent loss of the vegetation and associated wildlife habitat and some archaeological information that was covered by the PKC facility;
- an increase in the area of "human disturbed" category of VLC type;
- seepage/runoff water quality and quantity that will be different from pre-development water quality. Water quality in some inland lakes and streams could have significantly higher concentrations of dissolved and particulate elements than pre-development;
- some small inland waterbodies and ephemeral streams will be permanently covered by the PKC facility;
- the PKC facility may become a new attractant to caribou (e.g., for insect avoidance); and
- dust may be generated from the PKC facility and from new rock surfaces, which would be deposited on adjacent vegetation or waterbodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. Changes to the closure design concept may result in changes to residual effects, particularly with a more explicit inclusion of PKC water in the outlet water from the facility. These changes will be assessed when appropriate closure design and expected performance information are available.

5.2.6.6 Uncertainties, Risks and Research Plans

Several uncertainties are associated with the preferred closure approach. Many of these uncertainties will be addressed as part of the engineering design. Some key uncertainties that are expected to remain following the completion of the engineering design include but are not limited to the following:

- consolidation rates of the fine PK or slimes;
- surface stability, particularly near the pond shoreline;
- optimizations of the operation of the PKC for possible improvements in expected closure performance;
- effectiveness of a rock drain in removing free water from the facility;
- effectiveness of a rock drain in removing suspended particulate material from water;
- design elevation for outlet;
- outlet water quality/quantity;
- seepage water quality/quantity;
- requirements for excluding human and wildlife use of the area; and
- post-closure performance of the facility under current and possible future climate change.

Three primary closure risks have been identified by DDMI:

- outlet water quality/quantity that is not adequate for release into Lac de Gras;
- seepage water quality/quantity that is not adequate for release into Lac de Gras; and
- significant continued consolidation of the PK post-closure that could result in cracking and slumping of the surface, creating unsafe conditions for people and wildlife.

Closure Research

Specific research activities that are anticipated to provide specific input into the PKC closure design are described in Appendix VIII-4 and include the following:

- PK in situ physical properties;
- PK in situ geochemical properties;
- Optimization of PKC operations to facilitate closure; and
- Wildlife exclusion using Traditional Knowledge and science specifications (Appendix VIII-1).

5.2.6.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. These program details are not required for an ICRP but will be required and included for a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized in this Section 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 2007a) are included in Appendix XIII, Table 3D as general reference material. DDMI anticipates that there will 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 will include:

- seepage and runoff quality and quantity using a system similar to the SNP;
- TSP and deposition/quality measurements of any dust generated from the closed PKC;
- geotechnical inspections including observations of settlement, erosion, surface drainage and thermal condition; and
- wildlife use of the area.

In addition to area-specific monitoring, post-closure environmental effects will 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 will be drawn from the operations monitoring programs. The program and monitoring frequency will be revised, as appropriate, to focus on post-closure monitoring questions.

Post-closure maintenance requirements might include the following:

- repairs to PKC beach cover and pond shoreline areas;
- repairs to spillway or wildlife routes or barriers;
- repairs to drainage routes; and/or
- corrections to any identified wildlife hazards.

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

5.2.6.8 Post Closure Landscape

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

- rock cover for wind and erosion protections;
- a PKC pond;
- a PKC drainage outlet;
- re-establishment of drainage channels at Ponds 4, 5 and 7 (Figure 5-13b);
- specific barriers to access for people and wildlife (Figure 5-13b); and
- removal of all pipes, buildings, power lines and reclaim barge.

DDMI accepts that the final landscape could change, in particular wildlife routings, final contours and surface textures, as a result of future Traditional Knowledge considerations.

5.2.6.9 Contingency Plan

Contingency plans will need to be developed in more detail as the preferred closure design is advanced and uncertainties and risks are evaluated. Possible contingency actions have been developed based on the current understanding of uncertainties and risks (see Section 5.2.4.6):

- collect and treat outlet water until quality/quantity is adequate for release into Lac de Gras;
- collect and treat seepage water until quality/quantity is adequate for release into Lac de Gras;
- regular surface maintenance to repair surface cracks/slumps; and
- enhance passive treatment processes in drainage network downstream of PKC outlet.

5.2.7 Permanent Closure Requirements – North Inlet

5.2.7.1 Pre-disturbance, Existing and Final Mine Site Conditions

The North Inlet 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. No specific or unique environmental conditions were identified 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).

5.2.7.2 Closure Objectives and Criteria

Closure objectives applicable to the NI area include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-5). The guidance provided by INAC (2007a) relevant to the NI closure objectives is provided in Appendix XIII, Table 4A and the Environment Canada (2009) recommendations for closure practices are listed in Appendix XIII, Table 4B. These references are included to assist in the review of the DDMI objective for the NI.

Possible closure criteria are described in Appendix V, Tables V-1 and V-5. Closure criteria are intended to be used to evaluate success in achieving the objective. The intent a closure plan is to have closure criteria that are specific and measurable. As discussed in Section 5.2.2 it is recognized that some of the criteria in this ICRP 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.

5.2.7.3 Preferred and Alternative Closure Options

Closure of the NI has been included in plans since the initial mine design work in 1996 to 1998. The following chronology describes the closure option considerations related to the NI, and the resultant preferred option.

North Inlet Plan 1996 to 1998

The NI was identified as an integral component of the water treatment system. The NI was designed to function as both an initial settling pond and as an equalization basin before treatment in the NIWTP. From a closure perspective it was identified that, because the NI would receive dredged sediment, wastewater and backwash sludge throughout operations, it may not be appropriate to reconnect the NI to Lac de Gras at closure. This arrangement 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 (2007a), and those relevant to the NI are included in Appendix XIII, Table 4C. These generic options are provided as context for different approaches to close the NI.

Original Closure Designs – 2001 and 2006

The original closure design for the NI is documented in the I*nitial 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 side and one on the west side to create water containment; and a third intermediate dike to separate mine water in the west from dredged sediments and any settled solids in the east. The plan for closure 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 aquatic habitat, similar to Lac de Gras. If habitat could be established in the east cell, 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 run-of-mine rock. This rock would act as a permeable barrier that would allow water movement while containing sediments within the NI and preventing fish from entering the NI.

By 2006 the operational plans had changed. An intermediate dam in the NI was no longer required because 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 discharges 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 pore water and sludge leachate (de Rosemond and Liber 2005). The main disposal alternative considered was to discharge the sludge onto the waste rock pile to fill the voids in the waste rock. DDMI concluded that this alternative would increase the risk of poor-quality seepage from the waste rock area. The waste rock voids are important to facilitate convective cooling and permafrost development in the pile and to permanently store any water that infiltrates the waste rock pile.

The closure plan for the NI outlined in the 2006 ICRP (DDMI 2006) was revised to account for the elimination of the intermediate dike. 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 run-of-mine rock. This rock fill would act as a permeable barrier allowing movement of water but would preclude fish migration into, and sediment transport out of the NI.

2009 to 2010 Review

At the Options Workshop hosted by DDMI in May 2009 three closure options for the NI were discussed:

- a hydraulic connection to Lac de Gras that would allow movement of water to maintain water levels but would not allow movement of fish;
- an open connection to Lac de Gras that would allow full exchange of water and fish with Lac de Gras; and
- no connection with Lac de Gras to prevent water exchange with Lac de Gras

Advantages and disadvantages of these three options were discussed at the workshop and are summarized in Appendix IX-4. The general conclusion from the workshop was that the objective should be to reconnect the NI with Lac de Gras. Reconnecting the North Inlet with Lac de Gras is the closure objective for this facility.

The NI is an integral component of the site water management and water treatment system. It provides equalization of water volumes and a level of pre-treatment through particulate settling, volatilization and biological uptake. The NIWTP removes particulate material from the NI water through chemically enhanced coagulation/flocculation before it is discharged to Lac de Gras. Particulate material that is removed accumulates in the bottom of the clarifiers. This sludge is periodically removed, via pipeline, to the NI.

In the NI the sludge accumulates on the bottom as sediment. This accumulated sediment has the potential to impact on the suitability of the North Inlet for closure. Possible impacts could include physical and chemical alterations to the sediment that might make them unsuitable for fish, fish habitat or become a source of contamination to Lac de Gras.

The 2005 initial ecological investigation to characterize backwash from the NIWTP (de Rosemond and Liber, 2005) 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 pore water and sludge leachate.

A second investigation was initiated in 2010 to characterize the sludge material in the laboratory and the field. Field work was completed in August and laboratory testing with laboratory testing and analysis was expected to be complete by the end of 2010. Initial reporting on these results will be included with the March 31, 2011 Annual Water License Report.

Alternatives to disposing of the sludge in the NI have also been reviewed at a preliminary level. Alternatives include the following:

- disposal within the waste rock pile;
- disposal in PKC Facility;
- disposal within a new on-land facility;
- disposal by mixing with cover soils or hydrocarbon-contaminated soils;
- disposal within underground mine back fill mix; and
- disposal into the North Inlet followed by selective dredging.

A general description of each alternative and a preliminary review of advantages and disadvantages of each are included in Appendix X-5. Further investigations of alternatives will be dependent upon results from current or future sludge characterization studies.

Preferred Closure Design

The preferred closure plan for the NI is to breach the east dam and allow fish passage and water circulation. This plan will require adequate sediment and water quality within the NI. Sediment and water quality are not expected to be a concern, based on monitoring and studies to date. However, monitoring and evaluation during operations and immediately before reconnection will be conducted to confirm NI sediment and water quality.

When all water treatment requirements for the site have ended, the NIWTP will be used to treat the water in the NI and discharge the water to Lac de Gras. Lac de Gras water will be allowed to seep into the NI through the decommissioned NI west dam to replace the volumes removed for treatment. When the water quality in the NI is suitable, the breach will be excavated in the east dam to join the NI to Lac de Gras.

The east dam breach will be similar to the breaches planned for the A418 and A154 dikes: 30 m wide and 2 to 3 m deep. Like the fish habitat in the reclaimed dike areas, it is useful to limit water circulation to the NI to facilitate a higher primary productivity environment for fish.

The final landscape for the NI based on the preferred closure plan is shown in Figure 5-17.

5.2.7.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the NI area is shown in Figure 5-18. A brief description of each activity is described in the following:

- *Mine Water Treatment* – The NIWTP will continue to treat mine water until the completion of underground mining and decommissioning in 2023, according to the current mine plan.
- *Environmental Studies* – Environmental studies are planned to prove the preferred closure concept for the NI. These studies focus on the NIWTP sludge discharged to the NI and their ecological characteristics related to post-closure use by aquatic life. Characterization work initiated in 2005 will be repeated to identify 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 Concept* – A final engineering closure design concept for the NI will be completed and submitted for review in 2015. This design will incorporate findings from environmental studies, research, community and regulatory engagement.
- *Detailed Engineering* – Detailed engineering to prepare final drawings and construction specifications for closure activities will be completed two years prior before of the final closure work begins.
- *Decommissioning of East Dam* – When NI water and sediment quality have been confirmed, the east dam will be decommissioned by excavating a breach.
- *Performance monitoring* – Performance monitoring was initiated in 2005 with the initial sludge characterization work and will continue periodically to confirm the acceptability of the NI water and sediment quality before the east dam is breached. Monitoring will continue to document use of the area by aquatic life after the dam has been breached.
- *Engineering Inspections* – Inspections will be conducted before and after the east dam is decommissioned.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a 3-year cycle as a continuation of the Wildlife and Aquatic Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasize closure effects. A key program will be aquatic effects in Lac de Gras.
- *Reporting* – Reports describing the findings of post-closure performance monitoring, engineering inspections and effects monitoring will be prepared and submitted for review and information.

5.2.7.5 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 the following:

- water and sediment quality in the NI that may be different from pre-disturbance conditions in Lac de Gras, which could be long-term, low-level source nutrients and metals to Lac de Gras;
- primary productivity than may be higher in the NI than would be typical in Lac de Gras, and the NI may become a preferred fish habitat; and
- dust may be generated 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). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.7.6 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 risk identified by DDMI is that the NI water and/or sediment quality will not be adequate to be reconnected with Lac de Gras.

Closure research specific to this uncertainty is included in Appendix VIII-5 and relate to ongoing monitoring and evaluation of the NIWTP sludge.

5.2.7.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. These program details are not required for an ICRP but will be required and included in a Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for the NI are summarized in this Section and in 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 2007a) and are included in Appendix XIII, Table 4D for general reference. DDMI anticipates that there will 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 will include the following:

- water and sediment quality using a system similar to the SNP;
- geotechnical inspections including observations of settlement, erosion and thermal condition;
- 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 will 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 will be drawn from the operations monitoring programs. The program and monitoring frequency will be revised appropriately to focus on post-closure monitoring questions.

Post-Closure maintenance requirements might include the following:

- repairs related to stabilization or erosion; and/or
- corrections to any identified wildlife hazards.

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

5.2.7.8 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.

5.2.7.9 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 the current understanding of uncertainties and risks (see Section 5.2.4.6):

- Modify the decommissioning of the east dam to excavate a section and replaced with run-of-mine 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. The NI is expected to have a positive water balance.

5.2.8 Permanent Closure Requirements – Mine Infrastructure

5.2.8.1 Pre-disturbance, Existing and Final Mine Site Conditions

The mine infrastructure areas before the infrastructure was developed are shown in Figure 5-19. 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 exist 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. A list of buildings with estimates of size is provided in Section 4.4.7.

The same mine infrastructure at final development is shown in Figure 5-19c.

5.2.8.2 Closure Objectives and Criteria

Closure objectives applicable to the mine infrastructure areas include both site-wide objectives (Appendix V, Table V-1) and area-specific objectives (Appendix V, Table V-5). The guidance provided by INAC (2007a) relevant to the closure of the infrastructure areas is listed in Appendix XIII, Table 5A and the Environment Canada (2009) recommendations fro closure practices are listed in Appendix XIII, Table 5B. They are included to assist the reader in reviewing the objectives for the infrastructure areas.

Possible closure criteria are also described in Appendix V, Tables V-1 and V-6. Closure criteria are intended to be used to in evaluate success in achieving the objective. The intent of a closure plan is to have closure criteria that are specific and measurable. As discussed in

Section 5.2.2 it is recognized that some of the criteria in the ICRP 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.

5.2.8.3 Preferred and Alternative Closure Options

Closure planning began with the initial mine design work in 1996 to 1998 when many of the important design decisions related to closure occurred were made. 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 that mine infrastructure will be 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 (2007a) and relevant to the Diavik site are included in Appendix XIII, Table 5C. These generic options are provided as context for the reader regarding different approaches to infrastructure closure.

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). These references describe the following:

- removal of all equipment, buildings, pipelines, power lines and other items 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 re-vegetation; and

- re-vegetation options that included use of a top soil strategy, ameliorative strategy or an adaptive strategy.

2009 to 2010 Review

In 2009 DDMI reviewed the approach for the closure of mine infrastructure. For this area in particular planning for most activities can, and should, be done closer to final closure. Regardless, closure aspects were identified where early planning would be helpful and include the following:

- topography and final surface texture options for roads, laydowns, plant sites and airstrip;
- landfill location options on-site and off-site;
- infrastructure use and/or decommissioning options; and
- areas for re-vegetation.

Each of these aspects of infrastructure closure was discussed at the Options and Criteria Workshop hosted by DDMI in May 2009. The full list of outcomes from this workshop are included in Appendix IX-4 and a summary is provided here.

Site roads and laydowns areas are constructed from Type I run-of-mine rock. They typically have steep sides, safety berms, are up to several metres thick and can impact 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 would reduce footprint size for areas where the thicknesses are greater than about 3 m and wildlife access is planned. For areas where the thickness is less than 3 m, pushing the re-sloping outward would result in a minimal impact on footprint. Re-mining material should be focused on areas such as drainage crossings where excavation will be required to return natural stream flow routes.

Surfaces of road and laydown areas can be scarified to enhance microhabitats for vegetation, reduce erosion and integrate better with the surrounding landscape. However, scarified rock surfaces are difficult for people and wildlife to travel over. Smoother surfaces can be provided along a designed network for wildlife and human access through the closed mine site.

On-site versus off-site disposal of unwanted materials and debris from the demolition of mine infrastructure was discussed. Some viewed off-site disposal as preferable because it would remove all materials from site and would result in conditions most similar to 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.

The Comprehensive Study Report (pg. 111) includes a statement that:

> *"The approved A&R Plan will not allow burial of buildings, machinery and equipment on the mine site. It will include an estimate of implementation costs at various stages in the life of the mine."*

DDMI notes that this statement is not referenced and is not supported by an environmental, technical or legal basis for not allowing burial of buildings, machinery or equipment. In fact, DDMI currently has an approved, active, on-site landfill for disposal of inert materials.

DDMI requested an expert opinion regarding environmental trade-offs between on-site and off-site burial, as suggested by WLWB in their letter of May 19, 2010. This expert opinion is included in Appendix X-4, which includes a preliminary estimate of closure landfill waster volumes, and supports DDMI's view that on-site disposal is generally the better option.

Options that were considered for on-site disposal locations included the PKC, waste rock pile, pit bottom and underground workings. The PKC would be the most limiting location for a post-closure landfill because it would be challenging to cover suitably. Opposition to an in-pit landfill was expressed, and is 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 for 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 at this time. Underground tunnels and an area of the waste rock pile are DDMI preferred options for land fills for closure.

Post-closure reuse of mine site infrastructure both on-site and off-site in communities was discussed in general terms. There was a preference by all participants to maximize the reuse of the infrastructure and materials, with reuse in the North identified as a priority. Plans for on-site and/or off-site reuse will need to be promoted in the years before closure.

Re-vegetation efforts could be distributed equally over the mine site area or focused in target locations. The roads, plant site, laydowns and airstrip were identified as target areas for re-vegetation. Negative aspects of re-vegetation on waste rock and PKC areas include increased snow capture and wildlife attraction. DDMI would like to incorporate additional Traditional Knowledge studies on preferred wildlife routes through the area.

Preferred Design Concept

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 because it is more appropriate to develop specific plans and designs closer to the end of the mine life. For example, plans to reuse infrastructure on-site or off-site will depend on community and economic interest closer to that time.

In the three to five years leading up to the end of mine production, detailed decommissioning plans will be developed. These plans are expected to include strategies to:

- reduce on-site inventories of consumables leading up to the end of mine production;
- take advantage of back-haul opportunities in the final years of mine operations to remove any unused equipment or infrastructure that can be salvaged or sold for re-use;
- market/advertise the resale, reuse and recycle opportunities for equipment and materials that will become available, and develop with the end consumer a specific decommissioning plan for each; and

- develop a specific site decommissioning sequence to ensure availability of equipment and infrastructure to support closure activities and post-closure monitoring, inspection and maintenance.

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 and chemicals with preferred market in the North;
- if sale/reuse is not practical, recycling is the next preferred option, depending 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 waste rock landfill or underground tunnels, as appropriate; and
- materials that are not suitable for on-site disposal, such as hazardous materials, fuels, lubricants and ammonium nitrate including wastes generated during decommissioning will be hauled off-site and returned to suppliers or disposed of at approved facilities.

Non-hazardous materials with no salvage value will be disposed primarily in the landfill in the waste rock pile with smaller amounts in the underground workings. The landfill is shown in Figure 5-6b (existing) and 5-6c (final development) and has an estimated capacity of more than 2.3 Mm^3.

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.

Hazardous materials will be removed from site to a certified disposal location as appropriate for that material. When all hazardous materials and contaminated soils have been removed from the Waste Transfer Area, the area will be cleared of equipment and the fencing will be removed. The area will be inspected for any residual contamination before a rock cover is placed.

No areas of the mine site, outside the waste transfer area, are known to be contaminated with hazardous materials. There are also no areas or facilities where a known pollution problem exists.

A temporary camp, airstrip, power and fuel storage facility will be established, likely using some of the modular equipment remaining from the South Construction Camp. This camp will become the base for post-closure activities. A possible schedule is included in Section 5.2.5.4.

Collection Ponds will remain functional to collect site runoff during the mine infrastructure decommissioning. The NIWTP will be one of the last 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 with the pre-mining environment and surrounding landscape (Figure 5-20a). Disturbed surfaces will be contoured and scarified except where planned routes for wildlife or human movement have been identified (Figure 5-20b). Surfaces will be stable and safe.

Within the mine infrastructure area stream drainage channels will be re-established, and any culverts removed, for Collection Ponds 10, 11 and 12 and the airstrip (Figure 5-20c). A typical section indicating the closure concept for stream drainage channels is shown in Figure 5-21. This concept will apply for roads and Collection Pond dams.

The closure plan includes the re-establishment of boulder fields and partially vegetated land, to the extent practical. The following three strategies for re-introducing pioneer and more advanced indigenous vegetation on disturbed surfaces are being considered:

- *A topsoil strategy* requires placement of topsoil or an alternative "cultivable" material, followed by a conventional approach to establishing indigenous vegetation.
- *An ameliorative strategy* 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.
- *An adaptive strategy* establishes native species directly into the substrate, similar to the ameliorative strategy, but with less requirement for chemical and physical amendments of the substrate. This strategy is more cost-effective and uses varieties of native species, which have adapted to physical and chemical disturbances that may be present at some locations. It is particularly suited to the establishment of plants directly into mineralized substrates such that adapted varieties are required for these conditions.

5.2.8.4 Closure Activities and Associated Engineering and Environmental Work

The general schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine infrastructure area is shown in Figure 5-22. The following provides a brief description of each activity:

- *Accommodation/Power/Transportation Required* – Infrastructure is required to support mining operations (currently ending 2022), but will be required at a lesser intensity during closure activities (currently ending 2029).
- *Engineering/Environmental Studies* – Several engineering and environmental studies are planned to prove the final decommissioning and closure plan. These studies are primarily related to re-vegetation, 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, which includes the integration of Traditional Knowledge, is envisaged for options and closure criteria for wildlife, re-vegetation and on-site landfilling. Final engagement is anticipated around 2029/2030 to confirm permanent closure.

- *Final Decommissioning Plan* – A final plan for mine infrastructure decommissioning will be completed and submitted for review in 2015. This plan will incorporate all relevant findings from engineering and environmental studies, research, community and regulatory engagement.
- *Asset Inventory – A* detailed inventory of assets for sale/reuse, salvage, and recycling will be completed three years before the final closure work begins to initiate external marketing.
- *Commercial Arrangements – Sale/Transfer of Assets* – Specific arrangements will be made for sale, reuse, salvage or recycling of equipment and materials in advance of decommissioning.
- *Decommissioning of Process and Paste Plants* – All activities associated with decommissioning this facility will occur.
- *Decommissioning of Explosives Plant and Storage* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Accommodations and Other Buildings* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Fuel Storage and Power* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Waste Transfer* – All activities associated with decommissioning this facility will occur.
- *Decommissioning of Collection Ponds, and Pipelines* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Final Camp, Airstrip and Landfill* – All activities associated with decommissioning these facilities will occur.
- *Decommissioning of Processing Plant* – All activities associated with decommissioning this facility will occur.
- *Performance Monitoring* - Performance monitoring will be conducted starting in 2024. Monitoring programs will emphasise re-vegetation, hydrocarbon remediation, wildlife use, will and track success of equipment and materials reuse/recycle.
- *Engineering Inspections* – Inspections to confirm conformance will be conducted when each facility or area is/has been decommissioned.
- *Environmental Effects Monitoring* – In addition to specific performance monitoring, environmental effects monitoring will be conducted on a three-year cycle as a continuation of the Wildlife and Aquatic Effects Monitoring Programs. The frequency of specific elements and the completion date for monitoring would change based on results. Monitoring will continue from operational monitoring but will emphasise closure effects. Key programs will 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 will be prepared and submitted for review and information.

5.2.8.5 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 following:

- roads, plant site, laydowns and airstrip that will remain visibly different even after surfaces are re-contoured, scarified and/or re-vegetated;
- a permanent loss of vegetation and associated wildlife habitat, and some archaeological information that was covered by the mine infrastructure;
- an increase in the area of "human disturbed" category of VLC type, despite re-vegetation activities;
- localized runoff water quality and quantity that may be different from pre-development conditions;
- some small inland waterbodies and ephemeral streams that will be permanently covered by mine infrastructure; and/or
- dust may be generated from the scarified rock surfaces that deposits on adjacent vegetation or waterbodies.

An assessment of environmental effects at closure was conducted during the EA for the mine (DDMI 1998a). Residual effects are part of the initial assessment of the cumulative effects from all closure areas, which is summarized in Section 9. The identified residual effects fall within the general range of effects considered in the EA.

5.2.8.6 Uncertainties, Risks and Research Plans

Uncertainty associated with the preferred closure plan for the mine infrastructure areas identified by DDMI include the following:

- the amount of equipment and materials that will not be economically salvageable for reuse or recycle;
- the amount of non-salvageable material that can be safely disposed of on-site;
- results of the assessment of hydrocarbon contaminated material;
- areas (i.e. roads, laydowns, etc.) to target for Type I reclamation material;
- the most favourable re-vegetation strategy; and
- preferred wildlife movement through the area.

The risks identified by DDMI that are associated with these uncertainties are:

- the potential for insufficient on-site landfill capacity;
- significant amounts of hydrocarbon material that must be hauled off-site; and
- re-vegetation efforts will be unsuccessful.

The amount of non-salvageable material that will need to be disposed of in the on-site landfill, and the impact on the landfill capacity will be addressed by the marketing of assets for sale/reuse or recycle closure to mine closure. Closure research specific to other uncertainties are described in Appendix VIII-6 and include the following:

- field experiments to develop re-vegetation procedures; and
- development of standard operating procedures for the closure phase for on-site, non-mineral waste disposal.

Wildlife movement through the infrastructure areas needs to be considered and linked to the other closure areas. Research plans for considering wildlife movement are provided in Appendix VIII-1.

DDMI will address how roads, laydown areas, etc. will be used for reclamation source materials once uncertainties related to wildlife movement and re-vegetation target areas have been determined.

5.2.8.7 Post-Closure Monitoring, Maintenance and Reporting

Specific post-closure monitoring, maintenance plans and reporting requirements have not been developed. These program details are not required for an ICRP, but will be required and included in the Final Closure and Reclamation Plan. General post-closure monitoring and reporting plans for this area are summarized in this Section 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 2007a) are included in Appendix XIII, Table 5D for general reference. DDMI anticipates that there will be two types of post-closure monitoring programs: performance monitoring specific to mine infrastructure areas; and environmental effects monitoring which will include combined effects from all post-closure areas. The scope of the performance monitoring will include the following:

- re-vegetation success;
- TSP and dust deposition/quality measurements of dust generated from mine infrastructure areas;
- land farming of contaminated soils;
- monitoring levels of reuse, recycle versus landfill;
- runoff water quality;
- geotechnical inspections including observations of cracking, erosion and thermal condition as described above; and
- wildlife use of the area.

In addition to area-specific monitoring, environmental effects post-closure will 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 will be based on the operations monitoring programs and will be 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; and/or
- correction of identified wildlife hazards.

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

5.2.8.8 Post Reclamation Landscape

The current view of the preferred post-closure landscape for the mine infrastructure areas is shown in Figure 5-20a and 5-20b and includes the following:

- removal of all buildings, fuel storage, pipeline and power lines;
- on-site landfill;
- remediation of stream crossings;
- contouring, scarifying and target re-vegetation; and
- specific access routes for people and wildlife.

DDMI accepts future Traditional Knowledge considerations may influence or change the final landscape, in particular the wildlife movement routes, final contours and surface textures.

5.2.8.9 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. A risk of insufficient designated landfill capacity in the waste rock pile was identified in Section 5.2.5.6. A contingency will be to assess environmental acceptability of an additional landfill location including a pit-bottom landfill. An alternative contingency will be removal for off-site disposal.

The possible need for long-term water treatment was identified as a contingency in the waster rock area (Section 5.2.5.9) and the processed kimberlite containment area (Section 5.2.6.9). If seepage water quality is not adequate for release to Lac de Gras and passive treatment options are also not suitable, then long-term water treatment will be a contingency option.

The mine site is currently configured with engineered collection ponds around both the waste rock and processed kimberlite containment facilities. If long-term treatment is required at one or both of these facilities then the appropriate collection ponds and existing pipelines will not be decommissioned. Collected seepage will most likely be pumped to the North Inlet on a seasonal batch basis. The frequency of pumping will depend upon the seepage volumes and the collection pond storage volumes. Water from the North Inlet can then be treated through the North Inlet Water Treatment Plant and discharged to Lac de Gras. The NIWTP would likely also be operated on a campaign basis in conjunction with pumping from collection ponds. NIWTP operating costs are around $0.10/m^3 water treated.

The need for long-term water treatment would delay or possible eliminate the opportunity to close and decommission the North Inlet and the NIWTP (Section 5.2.7) as both facilities would be required post-closure. The North Inlet would continue to be used as an equalization and settling basin as well as a disposal location for treatment plant sludge.

Again, if long-term treatment is required the maintenance of the collection system (ponds and pipelines) and the NIWTP would be conducted as required and in conjunction with periods of operations.

6. Progressive Reclamation

6.1 Definition of Progressive Reclamation

Progressive reclamation are closure activities that are done before permanent closure to advance the closure and/or decommissioning of areas or facilities that are no longer 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 can also reduce time for achieving reclamation objectives, and provides valuable experience on the effectiveness of measures which might be implemented during permanent closure.

All closure planning from initial mine design through to detailed closure design and 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 in Section 5. This section describes the physical closure activities that will occur before the end of commercial mine production (currently planned as 2022) that 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 the following:

- Infilling deep areas of original lake bottom between the pit crest and the inside toe of the dike in both A154 and A21 areas.
- Constructing of fish habitat features (reefs) in filled areas.
- Re-configuring disturbed portions of original shoreline as necessary.
- Backfilling underground workings as mining operations proceed to limit extent of open kimberlite excavations.
- Segregating waste by sulphur content during mining operations. This ensures site facilities are constructed using only Type I rock which eliminates the need for further closure activities for these areas and enables management of waste rock piles.

6.2.2 Waste Rock and Till Areas

Identified progressive reclamation activities in this area include:

- placing segregated waste rock into designated locations;
- keeping steep side slopes to enhance permafrost development;
- using direct placement of Type I rock on identified final Type III rock slopes;
- re-mining waste rock for underground backfill;
- re-mining Type III, if technical characteristics of material are suitable for backfill; and
- re-mining waste rock 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 the PKC area include:

- Changing the water management practices to draw makeup water from the NI may reduce the amount of ponded water in the facility during operations and enhance consolidation and permafrost development. Before the pipeline from the NI was added, water had to be stored in the PKC to ensure adequate supply for the processing plant.
- Constructing of south barge road to be used for long term drainage management.
- Depositing 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 –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;
- surface inventory of waste rock and till by rock type and re-mined for underground fill;
- waste rock and till area landscape from annual aerial photographs and surveying of "as-built" conditions relative to permanent closure design;
- seepage quality, thermal condition, slope stability of waste rock 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 2007a).

7.1 Definition of Temporary/Interim Closure

Temporary or interim closure occurs when a mine ends 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 2007a).

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 (2007a) 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;
- chemicals and reagents, petroleum products and other hazardous materials must be inventoried 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; and
- the reclamation security deposit must be kept up to date.

7.3 Temporary Closure Activities

The following are anticipated closure activities that may be implemented if an interim shutdown occurs. The extent to which any of these actions will be implemented will be in part dependent upon the anticipated duration of the shutdown.

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 have to be removed from the site if an extended shutdown occurs:

- 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.
- Geotechnical stability monitoring and maintenance would continue as per operations. The frequency may be adjusted based upon the duration of the shutdown and subject to Inspector approval. The open pit areas would be inspected to check for rock falls, 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 have to be removed from the site if an extended shutdown occurs:

- Dewatering of the open pit and underground would continue as conducted during operation.
- 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 the 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.
- Geotechnical stability monitoring and maintenance would continue as per operations. The frequency may be adjusted based upon the duration of the shutdown and subject to Inspector approval. All underground facilities would be inspected to check for rock falls, 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.
- Geotechnical stability monitoring and maintenance would continue as conducted during operations. Dikes would be inspected to check for slope stability, changes to inflows and overall integrity.

7.3.2 Waste Rock and Till Storage Areas

At the time of a temporary or interim closure the waste rock 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 the following:

- Access to piles would be blocked with boulder fences and/or berms.

- Warning signs would be placed around the perimeters toes.
- Geotechnical stability monitoring and maintenance would continue as conducted during operations. Piles would be inspected to check for slope stability and seepage.

7.3.3 Processed Kimberlite Containment Area

During a shutdown the following would be completed at the PKC facility:

- the 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 shutdown. 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 waste rock 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 before discharge to Lac de Gras.

7.3.5 Plant Site, Accommodation Complex and Fuel Storage

7.3.5.1 Processing Plant

Any stockpiled kimberlite ore remaining on surface at the start of a temporary shutdown would be processed before plant operations end. The plant would then be shutdown in a planned and sequential manner to prevent damage to equipment, piping and instrumentation.

The following preparatory measures would be taken before 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 Processing Plant include:

- minimal heating would be maintained to the Processing Plant to prevent equipment freezing;
- the raw water supply to the Processing Plant would be turned off;
- power and process air supplies to the Processing 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 if a long-term shutdown of the Processing Plant occurred:

- 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 waste rock 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 Processing Plant would be discharged and left open; and
- the entire Processing 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 could 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 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 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 the following:

- 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 a lower risk of fire.
- All non-critical facilities and equipment requiring power and/or heating would be shutdown. Computing facilities including networks and databases would 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 waste rock 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

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. Any changes in monitoring and reporting that may be appropriate during interim closure would be submitted to the WLWB and Inspector for approval before implementation.

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 the following:

- piezometers;
- thermistors;
- inclinometers;
- extensometers;
- survey pins; and
- seismographs.

Visual inspections will also be conducted routinely 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 the following:

- 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 near the fish habitat areas include the following:

- 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 Waste Rock and Till Areas

Geotechnical monitoring of the waste rock 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 waste rock 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 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 regularly during interim closure. In addition, all tank levels and fuel tanks, will be monitored as in operations.

7.4.6 Infrastructure

Infrastructure will be inspected and maintained regularly 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. Specific schedules would need to be developed before any temporary shutdown. The following includes typical schedule considerations.

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 stop. Compliance with all permits and licenses will continue. 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 waste rock 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 chemical reagents, explosive materials and solvents would be inventoried.

8. Integrated Schedule of Activities to Permanent Closure

The integrated schedule of activities currently envisaged for advancing and implementing the preferred closure plan for the mine site is shown in Figure 8-1. 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 waste rock area is an active facility. It will continue to receive waste rock from open-pit mining through to 2011.
- *Re-Mining for Backfill* – Waste Rock 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 treat 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* – In 2010 the PKC will become an optional water supply for the processing plant and 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* – Several engineering and environmental studies need to be undertaken to confirm 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, and community and regulatory engagement.
- *Detailed Engineering* – Detailed engineering to prepare final drawings and construction specifications for closure activities would be completed two years before the final closure work begins.
- *Wildlife Access and Contouring – Waste Rock and Till* – The detailed engineering design will be used to guide the re-mining work on the waste rock area to achieve final surfaces and access routes through the area.
- *Inventory of Assets* – Detailed inventory of assets for sale/reuse, salvage and recycle would be completed three years before the final closure work begins 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 and 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 and re-sloping of access ramps and other features.
- *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 and sealing of surface access locations for A418/A154 underground in preparation for flooding.
- *Decommissioning of Processing and Paste Plants* – Activities associated with decommissioning these facilities.
- *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 and 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 waste rock 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

Residual environmental impacts of the post-closure mine site were first assessed during the Environmental Assessment (EA) for the Project (DDMI 1998a). In the 1998 EA, environmental impacts were assessed for the construction, operation, closure and post-closure phases of development (DDMI 1998a). The assessment was based the closure concepts at the time and predicted environmental changes. Specifics of the closure plan have evolved since 1998 EA (see Section 5).

Expected post-closure residual effects will become better defined over time. When the closure concepts are finalized, closure performance will be predicted and the predictions will be used to assess residual environmental impacts. After closure activities are complete actual results from performance and environmental effects monitoring will be used to assess environmental impacts.

The assessment results from the 1998 EA remain relevant as a preliminary assessment of residual environmental impacts. The development has proceeded largely as described in 1998 and with only a few exceptions (dust deposition and wildlife zone of effects), environmental conditions remain within the EA predictions. DDMI plans to use the same approach that was developed for the 1998 EA to assess residual environmental impacts at closure. These methods remain valid and relevant and a continuity in methodology from development assessment to post-closure assessment will provide helpful contrasts. The main difference in evaluating post-closure residual affects for the post-closure assessment will be that predictions of post-closure site and environmental conditions will be largely based measured environmental conditions rather than predictions. However, in some cases forecasts of environmental conditions will still be required and will be based on both measured post-closure conditions and information collected over the life of the mine operations.

Information and data collection is ongoing (see Appendix VIII), and will be used to update predictions of environmental conditions at closure. Closure designs will also evolve from initial concepts to final design concepts. DDMI will update the residual environmental impacts when the final closure design concepts are complete.

This section summarizes the approach used in the 1998 EA to assess environmental effects, as well as the results of the original assessment 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 ecological importance and importance to the people who would be affected by the mine development. The EA was structured to provide focused, understandable and relevant information about the type, extent and magnitude of potential environmental effects. The following general approach was used to assess potential environmental effects in the EA:

- 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. The post-closure phase will be discussed here.

In conducting the *Comprehensive Study Review* for the Project the Responsible Authorities required sufficient information to determine if the proposed project would have significant adverse environmental effects. To address this information requirement, the EA described potential effects according to their magnitude, duration and geographic extent.

Potential effects on the environment were analyzed at the local, regional and cumulative scales. The size of each of these study area scales varied with the potential effect being assessed in order to capture the context necessary to best understand and quantify the potential effect. In general, the potential effects in the immediate vicinity of the mine were assessed with respect to the local scale, which was typically the East Island and adjacent water. For the regional scale the study area sizes were more varied. For example, the drainage basin of Lac de Gras (3,559 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.

The 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 LSAs were assessed as local in geographic extent. If an effect extended beyond the LSA, it was considered to be a regional effect. In some cases, effects have the potential to extend even farther and were considered "beyond regional." Typically the cumulative effects were assessed using the RSA or the beyond RSA.

Magnitude describes the amount of change in a measurable parameter or variable relative to baseline conditions (e.g., 1996 conditions). 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.

A brief description of the local, regional and cumulative study scales used, as well as the rationale for selection of the study scales is provided in Table 9-1. The criteria used to define the magnitude of each characteristic is defined in Table 9-2.

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 LSA was selected as the area where ambient particulate concentrations and deposition rates would likely be the greatest. The RSA 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 LSA was selected for assessing direct effects from the Project, while the RSA 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 LSA provides a framework for assessing effects on sedentary species with small seasonal ranges, and the RSA provides a framework for assessing effects on species that 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 LSA 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 RSA 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.

Table 9-1 Brief Descriptions of the Local, Regional and Cumulative Study Areas Used for Assessing Potential Effects in Each Discipline (continued)

Local Study Area	Regional/Cumulative Study Area	Rationale for Selection of Study Areas
Heritage Resources		
The East Island.	The East and West Islands and adjacent mainland to the north and east.	The LSA corresponds to the area potentially affected by the footprint of the Project. The RSA 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 LSA 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 RSA 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 comparing 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

Table 9-2 Definitions for Magnitude and Duration (continued)

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)
Pore water Release; Dike Leaching; Mine Water Discharge; and East Island Runoff	Negligible	Concentration 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

Table 9-2 Definitions for Magnitude and Duration (continued)

Sub-Section	Magnitude	
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
	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 regional and local study scales are visually presented in Figures 9-1 and 9-2. The RSAs are shown in Figure 9-1 and the LSAs for wildlife, vegetation and terrain, fish and water, heritage resources and air quality are shown in Figure 9-2.

The duration of potential environmental effects were broadly divided into following three classifications:

- **Short-term effects** lasting for less than three years (i.e., effects generally associated with the period of intense construction activity before 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).

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, including ecological context and reversibility.

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 RSA. 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. For example, 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 potential effects of the mine.

With information on geographic extent, magnitude and duration an effect is assigned an effect level classification, as illustrated in Figure 9-3. Effects classifications with a level designation of “IV” are all long-term duration and Level IV effects are considered post-closure residual effects. Level IV effects are further defined by geographic extent as follows:

- Level IV Local Effect;
- Level IV Regional Effect; and
- Level IV Beyond Regional Effect.

The Responsible Authorities furthered this classification system 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 assessment remains as a reasonable preliminary assessment of residual impacts.

Following is a summary of material presented in the Diavik Diamonds Project Environmental Effects Reports:

- Air and Climate (Cirrus 1998);
- 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 1998).

These documents provide 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, which will result 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 (e.g., rock hauling, blasting, dumping, crushing) 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 in the relevant sections below.

The mine has been designed for very efficient use of energy and energy recovery which minimizes greenhouse gas emissions. Nevertheless, 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

Disturbed vegetation recovers slowly in conditions typical of arctic environments. Even with re-vegetation efforts, effects of the mine development on vegetation are expected to remain as residual effects post-closure.

The main effect on vegetation resulting from mine development is the reduction in the aereal extent of all VLC types (Figure 9-4). The VLC and water types within the LSA directly affected by the mine development are listed in Table 9-3. Locally, the magnitude of this effect would be high. Within the RSA this direct loss of VLC from the mine development would be less than 1% and considered negligible. Additionally, because no uncommon plant species or plant communities were identified within the mine development footprint, vegetation loss would be low in the ecological context.

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)		
	km^2	%	km^2	%	km^2	%loss of Vegetation Land Cover Type in LSA	% loss of Vegetation Land Cover Type in RSA
Heath Tundra	8.70	38	1,674.77	38	3.38	39	0
Heath Tundra 30 to 80% Bedrock	1.65	7	83.51	2	0.75	45	1
Heath Tundra 30 to 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	1,304.04	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**	**4,403.32**	**100**	**11.57**	**51**	**<1**

Notes: LSA = Local Study Area; RSA = Regional Study Area; km^2 = square kilometre; < = less than.

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 LSA. The geographic extent of these changes would be restricted to the LSA, 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 mine development, existing grizzly bear habitat availability would be expected to be reduced (through reductions in habitat suitability and effectiveness) by greater than 1% within the LSA but by less than 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 LSA.

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 mining activities end 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 RSA, resulting in a low magnitude regional impact. Greater than 1% of the total bear habitat in the LSA are affected which is equivalent to a moderate magnitude, local impact. However, the percentage of habitat affected post-closure would be less than during full development.

9.2.3.2 Raptors

Cumulative effects to raptors at full development were anticipated to be moderate in magnitude, based on predicted impacts on areas currently providing high to very high raptor nest site potential. This assessment 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 1998d). The magnitude of effects and overall impact rating would be reduced at post-closure because of the removal of sensory disturbances (i.e., zone of influences) 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 suitable nesting habitat 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 compared to predevelopment conditions. Steep slopes and variable aspects could result from waste rock 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 waterfowl staging and nesting habitat availability was expected to be reduced (through reductions in habitat suitability and effectiveness) by greater than 1% within the LSA but by less than 1% within the RSA, 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. These remaining physical impacts may result 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 the local and RSAs 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 RSA and 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 that encompasses the mine development, the level of measured habitat reduction shows localized shifts in habitat use but no measurable effect on broad seasonal distribution. The duration of this effect on caribou is expected to be mid-term (three to 30 years) and limited to the operations phase. With the removal of the operations stressors of noise and smell the indirect changes to habitat use are expected to be significantly reduced and only direct habitat losses will remain post-closure.

Mortality

The likelihood of injuries to caribou was projected to be very low once the mine sites are closed and post-closure landscapes are 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 RSA is anticipated to be low under all conditions. It was assumed that hunting will remain the only significant source of human-caused mortality in the RSA and that hunting mortality will not increase as a result of mine development and operation.

Energetics

Under the post-closure scenario, the predicted paths of least resistance for fall migration returned to the predevelopment route. In the model it was assumed that movement through altered terrain in the mine sites might involve traversing or going around difficult terrain. The magnitude of effects on fall migration was predicted to be slight in the RSA. The overall energy cost of migration for individual caribou encountering the post-closure mine site resulted in an increase of less than 1%.

9.2.3.5 Carnivores

Mine-related decreases in habitat availability for both prey species and 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 East Island. Red foxes were expected to exhibit a high degree of tolerance to mining activities and might remain as residents on less disturbed portions of East Island, assuming that an adequate prey base also remained. Wolves and wolverine were expected to be less tolerant of mining activities, and might avoid the East Island more than foxes. In either case, these localized shifts in habitat use off the East Island during operations would not represent a measurable shift in the distribution of these species within the RSA. 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 wolf and fox populations in the RSA 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 RSA. 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 RSA, and the loss of East Island sites would not measurably affect regional denning potential. Direct mortalities from vehicle kills and the relocation of animals were also expected to be minimal, given the environmental management strategies adopted for the mine development. 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 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. Mine-related mortalities are not expected to occur post-closure.

9.2.4 Fish and Water

9.2.4.1 Water Quality

The effect on water quality in Lac de Gras from flooding and breaching the open pits at closure is classified as Level I local effect for both drinking water and the protection of aquatic life. The magnitude was predicted to be negligible to low at for the local geographic extent.

Flooding the open pits at closure is not expected to have an adverse effect on groundwater quality. As mining proceeds, the quality of groundwater improves 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 was expected to increase in trophic status during operations. This has also been confirmed by operational monitoring. Effects of increased trophic status include an increase in algal growth, and likely increases in fish growth rates, improvements in fish health. There is also the potential for an increase in the abundance of some aquatic species and a decline in the abundance of others but these effects have not been observed to date. Trophic levels are predicted to decline back to background levels post-closure when mine water discharge ceases.

Containment of runoff during operations effectively prevents 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 may locally 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 waterbodies. Phosphorus levels in the post-closure runoff could substantially increase the trophic status of affected East Island lakes. However, when runoff reaches Lac de Gras, water quality in Lac de Gras is expected to remain 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., less than 1% change) is predicted for flow in the Coppermine River downstream from the outlet of Point Lake.

9.2.4.3 Fish Mortality

An effect from angling on fish mortality was the only effect of the mine development that was identified in the EA as lasting beyond closure. 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 the permanent loss of four fish-bearing lakes on East Island would be an effect of high magnitude and mid-term duration. 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 because 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 a portion 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 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 was predicted to 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; 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, and 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 physical location of the sites 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 gained. Although at the local level, effects would occur at a high number of precontact quarries, the magnitude of effect would not be high when viewed from the context of regional level of data. Given the nature of heritage resources, the confidence placed in the likelihood of the predicted effects occurring is high.

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