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Volume III

NWT Diamonds Project

Environmental Management

Overview - Environmental Management

Volume III describes the environmental management policies and plans that will be implemented during exploration, construction, operation, decommissioning and post-decommissioning of the NWT Diamonds Project. Environmental management is an important part of mine development. The goal of the Environmental Management Plan is to preserve ecosystem integrity as well as to prevent and mitigate potential environmental impacts associated with the project. Project activities have been designed in support of sustainable development to ensure that future generations will benefit from the resources in the Lac de Gras area.

The volume begins with an explanation of the approach used to develop environmental management plans. Environmental management procedures are consistent with BHP Environmental Policy and have been designed with particular concern for the northern environment. The Proponent will comply with all environmental legislation and regulations, and will communicate openly with governments and northern communities. The Environmental Management Plan integrates baseline environmental studies and traditional knowledge to minimize environmental impacts.

The Environmental Management Plan (EMP) has been organized to address each general biophysical component (e.g., air quality, wildlife) and each major project activity (e.g., waste rock and tailings management, hazardous waste management, reclamation). The EMP identifies valued ecosystem components, i.e., environmental components associated with scientific, social, cultural, economic or aesthetic values. Potential project-related impacts are addressed. The focus of each section is on management strategies to minimize environmental disturbance, prevent pollution and mitigate impacts. The proposed management strategies are based on best management practices that have been established using BHP Minerals' experience, accepted scientific practices, principles and technology, and where possible integration of traditional ecological knowledge.

Environmental monitoring is a key component of the Environmental Management Plan. The monitoring plan has been designed to

- ensure compliance with government guidelines and permit requirements
- determine the accuracy of predicted environmental impacts
- evaluate the effectiveness of mitigation actions.

The monitoring plan for each general environmental component is outlined in Section 10. The objectives of the monitoring plan and the monitoring parameters, frequency, methods and locations are described.

VOLUME III - ENVIRONMENTAL MANAGEMENT

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Table of Conformity

The following table indicates how the design and contents of the EIS conform to the requirements of the "Final Guidelines for the Preparation of an EIS" issued by the BHP Diamond Mine Environmental Assessment Panel in May 1995.

EIS Guideline Requirements	EIS Reference	
4.0 EIS Overview	EIS Summary, Volumes I - IV	
4.1 Study Strategy and Methods	Vol. II, Sec. 1.1	Methods
	Vol. IV, Sec. 1.1	Methods
Traditional Knowledge	Vol. I, Sec. 1.2	Indigenous Knowledge
	Vol. I, Sec. 5.1.1.4	Traditional Knowledge Meetings, Workshops and Studies
	Vol. II, Sec. 1.2	The Aboriginal Context
	Vol. II, Sec. 4.1.3	The Traditional Economy
	Vol. II, Sec. 4.1.4	Emergence of the Mixed Economy
	Vol. II, Sec. 4.1.5	The Current Economy
	Vol. II, Sec. 4.1.6	Concerns
	Vol. III, Sec. 1.2	Role of Indigenous Peoples & Knowledge in Environmental Management
	Vol. IV, Sec. 4.1	Local and Regional Perceptions of the project
	Vol. IV, Sec. 4.2	Aboriginal Employee Perceptions of the Project
	Vol. IV, Sec. 4.8	Traditional Economies/Lifestyles
4.2 EIS Presentation		
Conformity with Guidelines	Table of Conformity	
Keywords	List of Keywords	
References	Reference List	
Preparation	Acknowledgments	
Glossary	Glossary	
4.3 EIS Summary	EIS Summary Volume	

c) social and cultural patterns	Vol. IV, Sec. 4.1	Local and Regional Perceptions of the Project
	Vol. IV, Sec. 4.2	Aboriginal Employees Perceptions of the Project
	Vol. IV, Sec. 4.3	Employment and Income Impacts
	Vol. IV, Sec. 4.8	Traditional Economies/Lifestyles
	Vol. IV, Sec. 4.10	Community Well Being
	Vol. IV, Sec. 4.11	Cross-cultural Impacts
	Vol. IV, Sec. 4.12	Job and Education Aspirations
d) cultural sites	Vol. IV, Sec. 4.1	Local and Regional Perceptions of the Project
	Vol. IV, Sec. 4.15	Archaeological Impacts
e) land and resource use	Vol. I, Sec. 1.4.2	Land Claims
	Vol. I, Sec. 1.4.3	Regulatory Environment
	Vol. I, Sec. 5.4	Methods of Addressing Future Concerns
	Vol. IV, Sec. 4.1	Local and Regional Perceptions of the Project
	Vol. IV, Sec. 4.2	Aboriginal Employees Perceptions of the Project
	Vol. IV, Sec. 4.9	Land Users in Vicinity of the Mine
f) local, regional and territorial economy	Vol. I, Sec. 1.3	Project Economic Analysis
	Vol. II, Sec. 4.6	Competing/Complimentary Projects in the NWT
	Vol. II, Sec. 4.7	No Development Scenario
	Vol. IV, Sec. 4.1	Local and Regional Perceptions of the Project
	Vol. IV, Sec. 4.2	Aboriginal Employees Perceptions of the Project
	Vol. IV, Sec. 4.3	Employment and Income Impacts
	Vol. IV, Sec. 4.6	Local Economies
	Vol. IV, Sec. 4.8	Traditional Economies/Lifestyles
	Vol. IV, Sec. 4.13	Government Income and Expenses
	Vol. IV, Sec. 4.14	Economic Impacts

Acknowledgments

Preparation of the Environmental Impact Statement (EIS) for the NWT Diamonds Project involved a significant effort by many of Canada's leading consultants, specialists and support companies. The Proponent wishes to acknowledge the contribution that these groups have made and the high standard of work and support given to this project.

BHP, as Operator of the project and on behalf of the Proponent, initiated environmental studies and the community consultation process in 1992. Since the summer of 1993, Rescan Environmental Services Ltd. (Rescan) was contracted to conduct field sampling for the baseline environmental studies. Rescan, with BHP's direction, has also been responsible for document preparation and the coordination of the many facets of this study. Outcrop Northern Agency Ltd. of Yellowknife has been the principal consultant with respect to the socioeconomic assessment of the project. Various sub-consultants provided specialist services for components of this EIS document, including the following:

Consultants	**Contribution**
ARA Consulting Group Inc. Vancouver, B.C.	Economic Analysis
Agra Earth and Environmental Calgary, AB	Fish Habitat Evaluation
Applied Technical Services Victoria, B.C.	Benthic Invertebrates and Zooplankton Identification
ASL Laboratory Services Vancouver, B.C.	Water Quality, Sediment and Tissue Analysis
Jerry W. Bair Houston, TX	Communications, Government Affairs, Traditional Knowledge
Barb Brown Community Development Associates Vancouver, B.C.	Community Assessment and Community Mobilization
Barron Kennedy Lyzun and Associates Vancouver, B.C.	Noise Assessment
BC Research Laboratory Vancouver, B.C.	Toxicity Testwork

Consultants	**Contribution**
Bruce Geotechnical Consultants Inc. Vancouver, B.C.	Groundwater Modelling and Permafrost
Canadian Circumpolar Institute University of Alberta Edmonton, AB	Dene and Inuit Traditional Knowledge Literature Review
Chemex Laboratory North Vancouver, B.C.	Acid Base Accounting Testwork
Chris Hanks Victor, Colorado	Indigenous and Traditional Knowledge
Davis & Co. Vancouver, B.C. Yellowknife, NWT	Legal Services
Dene Cultural Institute Hay River, NWT	Traditional Knowledge
Dene Nation Yellowknife, NWT	Traditional Land Use Maps
EBA Engineering Consultants Ltd. Edmonton, AB	Geotechnical Engineering and Permafrost Assessment
Elemental Research Laboratory North Vancouver, B.C.	ICP/MS Low Level Water Quality Analyses
Fluor Daniel Wright Ltd./ Signet Engineering Pty Ltd. Vancouver, B.C.	Infrastructure and Process Design
Fraser Taxonomic Services Vancouver, B.C.	Periphyton and Phytoplankton Identification
Hamlet of Coppermine Coppermine, NWT	Indigenous and Traditional Knowledge
Inuvik Fisheries Consulting and Age Laboratory Inuvik, NWT	Fish Aging, Scales

Consultants	**Contribution**
Janet Kidd ABR Inc. Fairbanks, Alaska	Reclamation Literature Review and Research Design
George Kurilko LSA Richmond, Ca.	Socioeconomics
Lockhart Risk Management Vancouver, B.C.	Industrial Hygiene
Metis Heritage Association Yellowknife, NWT	Traditional and Indigenous Knowledge
Dr. Kevin Morin President Morwijk Enterprises Ltd. Vancouver, B.C.	Acid Base Accounting
MORWIJK Enterprises Ltd. Vancouver, B.C.	Geochemistry and Acid Generation Evaluation
Oikos Ecological Group Vancouver, B.C.	Ecosystem Mapping
Elizabeth Wyman Office Compliments Yellowknife, NWT	Long Distance Labour Commuting
Points West Consulting Vancouver, B.C.	Archaeological Assessment
Polster Reclamation Services Vancouver, B.C.	Reclamation
Sandwell Inc. Calgary, AB	Winter Road and Ice Assessment
SRK Geotechnical Engineers Vancouver, B.C.	Geotechnical Assessment for Open Pits and Underground Mines

Consultants	**Contribution**
Dr. Marc Stevenson Canadian Circumpolar Institute University of Alberta Edmonton, AB	Indigenous and Traditional Ecological Knowledge
The Training Group Edmonton, AB	Training Modules for Human Resource Assessment
Treaty 11 Band Council Rae-Edzo, NWT	Traditional Knowledge
UBC Mineral Laboratory University of British Columbia Vancouver, B.C.	Tailings Settling Testwork

Invaluable assistance was provided by specialist advisors in ecology, wildlife, fisheries, permafrost/terrain, tailings, air quality, hydrology and socioeconomics:

Advisors	**Contribution**
Dr. Peter Boothroyd Associate Professor Centre for Human Settlements University of British Columbia Vancouver, B.C.	Social Issues
Dr. Peter Byrne, P.Eng. Professor of Civil Engineering University of British Columbia Vancouver, B.C.	Tailings Structures and Seismicity
Dr. Bill Freedman Professor of Ecology Dalhousie University Halifax, Nova Scotia	Valued Ecosystems, Sustainable Development, Cumulative Effects, Ecosystem Linkages
Dr. Lionel Johnson Retired Arctic Fisheries Biologist Victoria, B.C.	Fisheries and Aquatics (Lake Trout Specialist)

Advisors	**Contribution**
Walter Keys President Intertec Management Ltd. Regina, Sask.	EIS Report Presentation
Dr. Peter McCreath, P.Eng. Hydrologist Clearwater Consultants Ltd. Vancouver, B.C.	Hydrology and Water Management
Dr. François Messier Professor of Wildlife Ecology University of Saskatchewan Saskatoon, Sask.	Grizzly Bears, Caribou and Wildlife Habitat
Dr. Holly Peterson Associate Professor Environmental Engineering Department University of Montana Butte, Montana	Air Quality and Dispersion Modelling
Dr. Wayne Savigny, P.Eng. Professor Geology and Geomorphology University of British Columbia Vancouver, B.C.	Terrain and Permafrost
Dr. David Sego, P.Eng. Professor of Civil Engineering University of Alberta, Edmonton, AB	Tailings in Northern Climates

For the socioeconomic analysis particular assistance was provided by:

- the staff of NWT Bureau of Statistics
- Mr. Bernie Scott, NWT Energy, Mines and Petroleum Resources
- Mr. Dan Westman, NWT Economic Development and Tourism
- staff of the City of Yellowknife and the Town of Hay River

- staff of RCMP, Yellowknife
- Human Resources Managers: Colomac, Lupin, Nanisivik, Polaris

A series of field sampling protocols were developed with the assistance of the Department of Indian and Northern Affairs' Regional Environmental Review Committee (RERC) in the fall of 1993. The environmental baseline studies protocol document was screened and amended by the RERC. The protocol document outlined the biophysical study parameters, methodologies, sampling frequencies and locations proposed for the baseline studies. Members of the RERC provided comments on the draft protocol document that were incorporated in the final baseline studies protocols. The following RERC members participated in the development of the protocols:

Department of Indian and Northern Affairs

Land Resources Division

Water Resource Division

Environment and Conservation Division

Environment Canada

Environmental Protection Service

Canadian Wildlife Service

Atmospheric Environment Service

Inland Water Directorate

Fisheries and Oceans

Government of Northwest Territories

Department of Renewable Resources

Department of Energy

Mines and Petroleum Resources

Policy and Directive Office

Education, Culture and Employment

Aboriginal Communities

Dogrib Treaty 11 Environment Committee

Yellowknives Dene Treaty 8 Environment Committee

Dene Metis Nation

NWT Chamber of Mines

The assistance provided by the above groups was greatly appreciated and particularly important in scoping the environmental baseline studies. A special acknowledgement goes to Environment Canada's Freshwater Institute in Winnipeg and particularly to Dr. Harold (Buster) Welch, Dr. Jack Klaverkamp and Mr. Chris Katopodies.

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Special mention should be made of the many people involved in the report preparation, graphics, art work and technical editing, in particular the staff at RESCAN, First Wave Publishing, Karen D. Lunde, Ken Cookson, and Timm Williams Design.

In summary, the Proponent wishes to thank all the many individuals named and unnamed that assisted in the preparation of this document.

Disclaimer

The material contained in this E.I.S. has been prepared in response to guidelines issued by the Panel established by the Government of Canada pursuant to the Environmental Assessment and Review Process Guidelines Order. The contents hereof represent the Proponent's best estimate of its prospects for developing the project on its mineral claim block in the Lac de Gras area, based on information currently available and believed by management to be reliable. Any estimates or forecasts of levels of production, ore grades and reserves have been prepared for purposes of the environmental review process only. They have not been prepared in accordance with securities regulatory requirements pertaining to disclosure of future-oriented financial information and accordingly may not be relied upon for investment purposes.

1. Approach to Environmental Management

The NWT Diamonds Project has undertaken extensive environmental management planning to ensure that its goal of sustainable development is achieved throughout all phases of project development. Environmental management plans are developed during the early stages of project planning and are consistent with BHP's Environmental Policy. This section focuses on the approach to environmental management and describes the specific operating policies and procedures designed to mitigate any potential environmental impacts.

BHP's company-wide environmental policy states the company's commitment to achieve a high standard of environmental care as it conducts its business. BHP managers at all levels are responsible for ensuring that organization structure and management systems support the BHP Environmental Policy (Appendix I-B1). The Proponent's policies, organization and reporting structures for environmental management, including environmental training and awareness programs, are outlined. The Proponent has attempted to give full and equal consideration to traditional knowledge in environmental management plans.

The Environmental Management Plan (EMP) contains the programs and policies that will be implemented to preserve ecosystem integrity as well as to prevent and mitigate any potential environmental impacts associated with all phases of project development, operation, decommissioning and closure. The EMP is based on information obtained from baseline studies conducted on site (1993 to 1995), available regional data and traditional environmental knowledge. The plan takes into account the northern setting of the project within a tundra environment.

1.1 Environmental Policy

The BHP Environmental Policy is based on the principle of sustainable development to ensure the highest level of environmental awareness and responsibility at its operations. BHP's approach to environmental management seeks continuous improvement in performance by taking account of evolving scientific knowledge, technology and community needs. Components of the policy specify the following:

- legal compliance, and, in the absence of adequate legal protection for the environment, application of standards that minimize adverse impacts from operations
- open communication with governments and communities, and contribution to policy and regulatory development
- awareness by employees and suppliers of the BHP policy and their environmental responsibilities in relation to BHP business

- establishment of management systems to identify, control and monitor environmental risks arising from its operation

- conducting of research and establishment of programs to conserve resources, minimize waste, improve processes and protect the environment.

The BHP Environmental Policy applies to all businesses for which BHP has operating responsibility. The company also endeavours to ensure that in those businesses where it does not have operating responsibility, comparable environmental policies will be applied. Before any joint ventures, mergers, acquisitions or divestitures are effected, BHP investigates potential environmental liabilities to ensure compliance with legislation and good industry standards, or to accurately appraise the costs and actions necessary to ensure compliance. The specific application of this policy to the NWT Diamonds Project will be discussed in the relevant sections of this document.

1.1.1 Legal Compliance

Federal and territorial laws govern the performance of the Proponent in the Northwest Territories. The Proponent will ensure that its operation complies with the requirements of legislation, regulations and agreements of the federal government, the Government of the Northwest Territories (GNWT) and the Inuit of the Nunavut Settlement Area. The Proponent will also abide by contracts, licenses and permit conditions governing the project.

A record of the legislation, regulations, contracts, licenses and permits applicable to the NWT Diamonds Project will be maintained on site. Project managers will be responsible for ensuring that the requirements are regularly reviewed and updated.

Legal, regulatory, contract, permit and license conditions may require specific reporting requirements. The timeframe, content and format of such external environmental reporting obligations will be provided in a site environmental performance manual.

1.1.2 Environmental Communication and Training

To date, the Proponent has consulted extensively with the federal government and the GNWT. For example, as a result of ongoing communication with the Regional Environmental Review Committee (RERC) during early project screening, the proposed road route from the plant site to Misery has been realigned to avoid disturbance to archaeological sites and wildlife dens. Ongoing liaison with government representatives will assist in the identification of other means whereby appropriate environmental management will minimize potential impacts from mine development.

External communication of environmental information related to the project will take place between the Proponent and the external environmental advisory group (Section 10), concerned citizens' groups and government agencies.

The Proponent has also undertaken an extensive communications program, discussed in detail in Volume I, Section 5, as part of its overall responsibility to promote public understanding of the project and to identify and address concerns of interest groups. Significant environmental concerns have been raised and communicated in the Proponent's consultation with Aboriginal communities and from the traditional knowledge studies to date. The Proponent will integrate this evolving information, where possible, in its Environmental Management Plan.

The Proponent will develop environmental training programs to ensure employee and contractor awareness in environmental matters and to foster responsible attitudes, behaviour and practices. All employees and contractors, at all levels, will be provided with adequate information to perform their jobs in an environmentally responsible, skillful, safe and competent manner. They will be expected to exercise all reasonable care with respect to the environment. The effectiveness of training and awareness programs will be evaluated regularly.

The introduction of bear safety courses is an example of the Proponent's efforts to provide employees with environmental training. In an effort to ensure that current exploration and proposed mine development cause minimal disturbance to local wildlife, and to avoid potentially dangerous encounters with bears, GNWT Renewable Resources officers have provided educational programs on bear safety measures for the workers. Over 200 employees and contractors have been trained on operating practices that will minimize encounters with bears, such as proper waste disposal and the installation of a bear fence at the exploration camp.

Employees will also be provided with environmental training on emergency preparedness, spill contingency plans, various responsibilities of mine staff in the event of accidental spills and environmental monitoring and management plans.

Employee concerns have resulted in their direct involvement in resolving environmental issues. For example, several Aboriginal employees at the exploration camp voiced concerns regarding the methods used in past studies of caribou. The Proponent arranged for the concerned employees to participate in the "fly-over" surveys to show that caribou are undisturbed during the counting exercise. Interest in any aspect of the environmental program usually gives rise to encouragement for the employee to apply for positions to assist and participate in the environmental program.

Environmental staff will communicate with and visit their professional colleagues at other BHP sites for the purpose of peer review, information sharing and broadening their knowledge and expertise on the range of environmental issues and solutions available within the industry.

Formal environmental reports provide an important avenue of communication within the company. Project staff will keep management informed on the status of environmental activities and issues through monthly reports.

1.1.3 Environmental Management Systems and Audits

The Proponent will ensure that organization structures and management systems are implemented in conformance with the BHP Environmental Policy and guidelines.

An environmental manager, along with support staff, will be based at the project site. With the assistance of the environmental manager, staff and operations personnel, the project management will ensure that the Environmental Management Plan is an integral part of project planning and operation. The environmental manager will ensure implementation of the Environmental Management Plan.

In consultation with the external environmental advisory group, the environmental management system will incorporate, among other issues and concerns, the following:

- avoidance or mitigation of heritage and archaeological sites
- minimization of disturbance to land and other natural resources, consistent with safe and efficient operations
- minimization of negative visual impacts
- minimization of disturbance to water bodies
- maintenance of biological diversity
- reduction or elimination of waste streams through sound waste minimization and recycling programs
- destruction, containment or disposal of remaining wastes so as to minimize environmental impacts
- monitoring and control of air contaminants and noise
- rehabilitation of disturbed sites

These issues and concerns are discussed throughout the sections of the Environmental Management Plan.

Inspections and audits of the project facilities and operations will be a central element of environmental performance monitoring and continuous improvement processes. Both internal and external environmental audits are regularly conducted at other BHP operations, with the intent of identifying environmental compliance issues and improving environmental control. The external environmental advisory group will review all audit reports as part of their role.

The Proponent will establish an audit and inspection scheme that may incorporate the following:

- an annual self-audit carried out by site management and technical personnel
- an environmental performance improvement audit carried out by BHP Minerals
- an environmental management systems audit to assess the adequacy of environmental systems
- an environmental compliance audit that uses a rigorous protocol to measure compliance with all legal, regulatory, contract, permit and license conditions and requirements.

The scope of these audits includes all issues related to environmental performance to identify, control and monitor environmental risks arising from operations. These may include, but are not necessarily limited to, all aspects of pollution and processes that result in emissions, effluent or wastes, land rehabilitation, site closure, permits, programs to enhance community and government relations, effects on natural systems, effects on archaeological or historical artifacts, and management systems. The frequency and scope of these audits will be determined either by BHP and/or project management according to the requirements of BHP's management system or as needed.

1.1.4 Environmental Improvement and Research

The Proponent will strive to continually improve its environmental performance. Environmental improvement actions arising from environmental audits will be incorporated into the annual site environmental improvement plan. Senior management will then initiate actions to address environmental improvement. Research and conservation programs are an important mechanism for addressing environmental concerns as well.

Cooperative environmental research efforts have already been undertaken with territorial government and Aboriginal entities. The Proponent has provided logistical and financial assistance for the GNWT Department of Renewable Resources' esker research station at Daring Lake. The objective of this research is to study the denning capacity of eskers in the area. The Department of Renewable Resources and BHP have exchanged research data on the eskers and on wildlife surveys in the area. This sharing of data enriches the studies of both parties without incurring additional cost. BHP is also undertaking ecosystem mapping of its claim block and providing financial assistance with regional grizzly bear studies. Both of these initiatives will contribute to a greater understanding of the biophysical features of the tundra environment. The Proponent has also initiated consultation with Aboriginal groups to integrate traditional considerations into the studies.

1.2 Aboriginal People and Traditional Knowledge in Environmental Management

"Today the world is different than it was when the elders were young. Native people need to create a new balance that incorporates significant scientific knowledge. Southern scientists cannot simply impose their views. They must be interlinked. Water chemistry is an area where scientists know more than we do. How dry is dry? How wet is wet? Scientific knowledge is good at quantifying impacts. It depends on the question as to what the appropriate blend of traditional and scientific knowledge should be at any given time" (Grant Blondin, Yellowknife).

The Proponent is in the process of determining strategies to facilitate the blending of traditional ecological knowledge with western science in environmental management regimes. It has been acknowledged throughout the EIS that Aboriginal people are capable of sound resource management and providing biological information for better understanding of native plant and animal species and sustaining their utilization. Accordingly, the Proponent intends to establish a balance in environmental management by incorporating local indigenous knowledge and Aboriginal participation into its own policies and management programs.

1.2.1 Aboriginal Considerations in Environmental management

As discussed earlier, Aboriginal people welcome the opportunity to utilize their environmental and ecological knowledge in management and planning. However, it is important to note that they also hope this knowledge will not be trivialized, as has happened sometimes in the past. Researchers have been known to conduct extensive studies of traditional ecological knowledge but then to dismiss individual components of it or to take various aspects out of context. Aboriginal fear that such information will be discounted, or worse, used against them, through government regulation in the form of hunting and fishing restrictions, for example, has led to difficulties in the collection and use of traditional knowledge for purposes of project planning. Knowing that outsiders having access to information sources does not guarantee the information will be used in the best possible way, Aboriginal people have classified many forms of traditional knowledge as confidential and proprietary in nature. The Proponent recognizes this problem and has agreed to respect the confidentiality of traditional knowledge by hiring

Aboriginal people to gather their own information for selective publication (Traditional Knowledge Agreement, Appendix I-C 2).

"There are (Inuit) people that (I am) learning from all the time because they've been around for a long time. They might not have their degrees, but certainly they know what they're talking about when it comes to living in the north and dealing with (things) that come along....Scientists, I think, are very knowledgeable, but on the other hand, they have to keep an ear open to be listening an not say ' well, what a silly concept' because it borders on something that they might not believe in. If some people have folklore or a belief that they don't agree with, (it) doesn't mean it is all wrong, it just might be that...because Inuks are very different from scientists... that doesn't mean that their concept is totally wrong....it just comes from a different angle" (Ida McWilliam, Coppermine).

The desire for maintenance of cultural diversity has also been heard many times during the Proponent's consultation program. Realizing that this diversity reflects the particular ways in which the Aboriginal groups have been able to utilize ecosystems in a sustainable way over long periods of time, the Proponent hopes to include as many perspectives as possible in its environmental management program.

1.2.2 Proponent's Approach to Integration of Traditional Knowledge

The Proponent is committed to a cooperative approach to "listen and learn" and will utilize traditional information when specifically given permission to do so pursuant to its agreement with the Aboriginal groups. The Proponent has implemented the following policies to integrate traditional knowledge into its environmental management strategy:

- The consultation program of "listening and learning", with greater focus on the workshop and interview approach, will be maintained. This type of forum will provide opportunities for scientists and Aboriginals to meet and exchange ideas. For example, elders and young hunters would be consulted about information pertaining to distribution patterns of caribou, as derived from knowledge about where, when and how to hunt them. Particular care will be made not to quantify the information scientifically, but rather to keep it in context and encourage the quality balance it provides to overall environmental management. The Proponent's recognition and acceptance of this difference in observation techniques will improve the management program and promote trust, cooperation and belief that co-existence of the two approaches is not only possible but mutually advantageous.

- The Traditional Knowledge Study with the Dene, Inuit and Metis will be continued. By designing a study that focuses on more personal consultations and within ethical considerations, the Proponent hopes to document the ecological aspects of traditional knowledge as a baseline study that will assist in the formulation of its management and monitoring plans with regard to caribou, fish and other wildlife, the traditional economy and other VECs. Again it should be stressed that, under this study, the proprietary rights of this knowledge will remain with the Aboriginal groups involved, and they will share only that knowledge they consider useful for management and monitoring. By enabling Aboriginal people to have control over their information and how it is gathered, cooperative research will be encouraged within a framework that is sensitive to their cultures and creates a broader understanding of environmental management.

- The summer employment for college students and training programs will be continued. It is the Proponent's intention to promote cooperation in the development of sound stewardship principles, to ensure that subsistence needs as well as the physical, cultural, social and economic needs of the Aboriginal peoples are met.

- An independent Environmental Surveillance advisory group will be established. Consisting of academic, Aboriginal and community members, this group will review the environmental management and monitoring program on an ongoing basis. As currently envisaged, the group will include four members with individual expertise in environmental engineering, wildlife, aquatics and ecology; two Aboriginal members versed in traditional ecological knowledge; and one member from the general northern communities (Volume 1, Section 5).

- Two of the other committees established under the Benefits Agreements, the Joint Implementation and the Culture and Education Committees, will assist in monitoring and provide advice to the Proponent (Volume I, Section 5).

- Monitoring programs will be initiated and maintained as outlined in Section 10.

"...People like scientists who are knowledgeable about wildlife..., some of them work for different government departments and if they get together with the people who are hunting from a particular area, maybe they could make up a pretty good team just to minimize some of the impact if they started working together" (Gordon Lennie, Metis, Yellowknife). The Proponent concurs.

1.3 The Environmental Management Plan

The Environmental Management Plan (EMP) for the proposed NWT Diamonds Project is comprised of the integrated policies and programs that will be implemented to preserve the integrity of the claim block ecosystem. The EMP deals with all phases of project development: exploration, construction, operation, decommissioning and post-decommissioning. The plan focuses on the management of water, process plant tailings, air quality, materials and wastes, traffic, aquatic life, site reclamation, decommissioning and closure. The EMP was developed through the work of scientists and other specialists, and incorporates traditional knowledge. It is based on the concepts of pollution prevention, Aboriginal consultation and minimization of negative environmental impacts.

The EMP is specifically designed to deal with local and regional subarctic ecosystems that are potentially affected by project activities. In the environment, where harsh physiographic conditions limit biological productivity, the preservation of water quality and suitable habitat is especially important for fish populations and migratory caribou. In turn, Aboriginal communities depend on the barren grounds and the tundra to provide them with food, medicines, materials, spiritual sites and travel routes, and thereby sustain their cultures and lifestyles.

The goals of the project EMP, in support of sustainable development, are to preserve ecosystem integrity as well as to prevent and mitigate any potential environmental impacts. These goals are consistent with BHP's Environmental Policy. To achieve the goals the objectives are are follows:

- compliance with legal environmental standards
- open communications with governments and communities
- establishment and maintenance of monitoring systems
- communication of employee and supplier responsibilities
- establishment of research and conservation programs to protect the environment.

The EMP is organized into sections for each general biophysical component (e.g., air quality, wildlife) and for major project activities (e.g., waste rock and tailings management, hazardous waste management). The EMP identifies valued ecosystem components (VECs), i.e., environmental components associated with scientific, social, cultural, economic or aesthetic values. Potential project-related impacts are addressed. The focus of each section is on management strategies to minimize environmental disturbance, prevent pollution and mitigate impacts. Single or multiple strategies are proposed to protect each valued ecosystem component.

The proposed management strategies are based on best management practices that have been established using BHP Minerals' experience, accepted scientific practices, principles and technology, and the integration of traditional knowledge of sustainable utilization of the environment. Management strategies are based on recognition of sensitive sites or time periods from an ecological perspective. Other strategies involve the prevention of the release of deleterious substances to the environment.

The management plan for each biophysical component or operational activity describes its management strategies. A more detailed discussion of the potential environmental impacts is presented in Volume IV. Another component of environmental management is the Environmental Monitoring Plan (Section 10). The Environmental Monitoring Plan has been designed to determine compliance with government guidelines and permit requirements, the accuracy of predicted environmental impacts and the effectiveness of mitigative actions.

1.3.1 The Environmental Management Plan and Sustainable Development

The Proponent's commitment to sustainable development is demonstrated in part in the EMP. Sustainable development, as defined by the Brundtland Commission, is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). Sustainable development sets forth goals of meeting the basic or essential needs of society, such as food, shelter, clothing and jobs, and extending to all the opportunity to satisfy their aspirations for a better life. Implementation of the EMP ensures that the project, managed in an environmentally, economically and socially responsible manner, is consistent with the goals of sustainable development.

The proposed diamond mining can contribute to sustainable development in three ways:

- if substantial portions of the resulting profits, taxes and wages are invested in durable sectors of the economy, particularly those associated with the wide use and management of renewable natural resources
- by minimizing environmental impacts that degrade the renewable resource base of the region, particularly that of caribou and fish
- by preventing the degradation of other, non-valuated ecological resources such as non-game birds, vegetation, wilderness and ecological integrity.

With respect to the first point above, the NWT Diamonds Project is providing funding to assist Aboriginal employees, their families and their communities to utilize new sources of revenue in ways that contribute to sustainable community development, particularly those associated with the wise use and management of renewable natural resources. The Proponent has contributed funding to projects such as "Community Mobilization" and grizzly bear studies. These programs, as well as the increased income that employees will receive and channel into their communities, may improve people's ability to participate effectively in community lifestyles and strengthen community sustainability.

Mine operations and processes have been designed to permit the reuse and recycling of materials, to minimize use and production of hazardous substances, to maximize economic efficiency and to protect the land and natural resources. Evolving communication and consultation on traditional knowledge with the external environmental advisory group will further advance the project toward sustainable development.

The EMP describes substantial management efforts towards protection of the Bathurst caribou herd, which, from economic and cultural perspectives, represents the most important renewable resource in the claims block ecosystem. In addition, the EMP pays close attention to the integrity of other resources that can potentially be harvested in a renewable fashion, such as lake trout and furbearers. The EMP also accommodates concerns for non-resource values related to ecological integrity, such as songbirds, small mammals and natural vegetation.

1.3.2 The Environmental Management Plan and Ecological Integrity

Ecosystem integrity is a measure of the overall health of the ecosystem. In a holistic sense, the EMP is designed to avoid any extensive degradation of environmental quality or ecological integrity caused by project-related land use, emissions or other stresses or disturbances. There are, of course, specific cases where local ecological damages cannot be avoided or mitigated, for example, the development of roads, open pit mines, the tailings disposal facility, the processing facility and the permanent camp. However, in those cases resulting in local impacts, management plans have been developed for the eventual reclamation or compensation for any longer-lasting damages to specific resources (such as fish habitat) or more broadly to ecosystem integrity.

Moreover, these local impacts to terrestrial and aquatic habitats represent an effect on a very small component of the larger landscape of the claim block ecosystem and of the subarctic tundra of central Keewatin. Since the EMP for the proposed NWT Diamonds Project is designed to prevent substantial damages to the ambient environment and ecosystems beyond directly affected sites, extensive threats to the ecological integrity of the larger ecosystem will be avoided.

As was described in Volume II, Section 1.3, the most useful indicators of ecological integrity of the claims block ecosystem are as follows:

- the presence of populations of large animals and top carnivores
- the presence of clean water, soils and atmosphere
- the occurrence of a natural, self-organizing ecosystem at all spatial and temporal levels.

These indicators are accommodated within the EMP as follows:

Large animals and top carnivores: Numerous, integrated components of the EMP are intended to ensure that self-sustaining populations of large animals and top predators are not threatened by the proposed industrial activities. The most prominent of these species are caribou, grizzly bear, wolverine, wolf, lake trout and grayling. Even with effective mitigative or preventative measures, some individual animals may still be directly impacted i.e. accidental collisions. However, the EMP is designed to ensure that these individual-level effects will not be frequent enough to threaten the viability of populations of these large animals and top carnivores.

Clean water, soils and atmosphere: The EMP contains measures to ensure that the chemical or physical qualities of the water, soil and atmosphere will not be degraded beyond directly affected sites. Consequently, the proposed NWT Diamonds Project will not cause extensive degradation of these indicators of ecological integrity and environmental stress.

A natural, self-organizing ecosystem: The larger area of the mineral claim block ecosystem is a natural, self-organizing ecosystem, complete with a full complement of native species and natural community types and associated wilderness values. Since the EMP is designed to ensure that extensive environmental and ecological changes will not take place due to project-related activities, these values will not be threatened in the mineral claim block ecosystem. The relatively small areas of directly affected terrestrial and aquatic habitats will not significantly detract from this extensive indicator of ecological integrity.

2. Air Quality Management Plan

Air quality has been identified as a valued ecosystem component and its management is addressed from two different viewpoints: ambient and workplace.

The main project activities that affect air quality during the operation phase include diesel fuelled power generation, heat production by the diesel-fired heating boilers (used in the winter for heating the permanent camp), processing in the primary crusher and reclaim areas, emissions from the main process plant and recovery plant, vehicle traffic, mining activities (blasting, ore handling) and waste destruction by solid waste incinerators. Potential air quality impacts result from particulate and gaseous emissions as well as fugitive dust.

The purpose of the air quality management plan is to minimize air emissions and to ensure that they are at or below regulatory and/or permit requirements, so as to provide a healthy environment for the workers and wildlife. This plan contains strategies to assess, minimize and control gaseous and particulate emissions. They include:

- utilization of appropriate emissions control equipment
- utilization of low sulphur fuels when practical
- minimization of fugitive dust utilizing appropriate control methods such as road watering, use of granite waste rock as construction materials, vehicle speed regulation and large vehicle size to reduce number of trips
- utilization of preventative maintenance and efficient equipment to ensure optimum performance and to minimize emissions
- establishment of appropriate monitoring programs to ensure the health and safety of workers as well as protection of the environment.

2.1 Air Emissions Control

The environmental management plan for protection of ambient air quality will consist of strategies to control or minimize gaseous and particulate air emissions. In order to assess the potential air quality impacts of the above activities, the emissions were modelled using the Industrial Source Complex 2 (ISC2) air dispersion model, developed by the United States Environmental Protection Agency (U.S. EPA). The ISC2 model predictions have been compared with the Canadian Ambient Air Quality Objectives (CAAQO) for nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and total suspended particulate (TSP). The modelling helps identify areas of concern, and thus areas where actions need to be taken.

The ISC2 computer dispersion modelling predicted the worst case scenarios resulting from equipment air emissions. The results of the dispersion modelling indicate that the concentrations of the modelled parameters (NO_x as NO_2, SO_2, CO, TSP) are well below the acceptable CAAQO at or beyond the mineral claim boundaries.

2.1.1 Ore Processing Areas

The primary air emissions from the ore processing areas (including the primary crusher, reclaim area, process and recovery plants), will be particulate. Particulates from the primary crusher and wide discharge conveyor will be captured by hoods and transported to a 15,000 Am^3/h high ratio pulse jet fabric filter and/or wet air scrubbers. Particulate will collect in a dust hopper. The collected kimberlite dust will be mixed with water and the approximate collection rate will be 317 kg/h. The particulate emission rate is estimated at 0.208 g/s (Fluor Daniel Wright Signet Ltd. 1994). The primary crusher will operate 24 h/d.

The reclaim area will contain a similar dust control system. Particulates from the apron feeders and reclaim conveyors will be collected by hoods and transported to a 13,000 Am^3/h high ratio pulse jet fabric filter and/or wet air scrubber. The dust handling mechanism (screw conveyor), dust collection rate and estimated particulate emission concentration are all identical to the specifications provided for the primary crusher.

The process plant and recovery plant will utilize high efficiency wet gas scrubbers to minimize particulate emissions to the atmosphere. Particulate emissions in the process plant will be captured by a series of locally positioned hoods at the high pressure roll crushers and the conveyors transporting the crushed product to the next process stage. The dust laden air will be ducted to a 50,000 Am^3/h high efficiency dynamic scrubber. Cleaned air will be exhausted to the atmosphere via an exhaust stack which will protrude 3 m above the roofline of the process plant building. The particulate emissions rate is estimated at 0.694 g/s, under normal operating conditions (Fluor Daniel Wright Signet Ltd. 1994). Underflow from the dynamic air scrubber will be pumped to a tailings line.

The recovery plant will also include a high efficiency wet air scrubber to remove particulates from the collected particulate laden air. Under normal operating conditions, the air flow rate will be 8,400 Am^3/h and the exhaust air particulate emission rate is estimated at 0.117 g/s. This dust collection system will only operate in conjunction with the process operation.

To achieve the NWT emission guidelines, the particulate emission concentration from the primary crusher and stockpile reclaim area fabric filters and/or wet air scrubbers, process and recovery plant wet air scrubbers will not exceed 50 mg/Nm^3. Other management tools include proper maintenance and process system feedback control loops. The scheduled maintenance for the fabric filters and wet air scrubbers will ensure reliable operation and minimize the likelihood of an upset condition. The wet air scrubbers will need a constant supply of water and as such will have low water flow alarms. In case of a power failure the entire plant will shut down and the particulate emissions from the ore processing areas will cease. The concentrations of particulate released from the processing areas in an upset condition will be more of a nuisance, especially for visibility, than a health risk.

2.1.2 Diesel Power Generation

The management of the diesel power generating stations at the permanent camp and at Misery will be similar. The diesel power plant at the permanent camp will initially contain four operating gensets (for the 9,000 tpd plant) while the power plant at Misery will contain two smaller operating units. All of these units will operate 24 h/d.

The ISC2 computer dispersion modelling predicted that the ambient ground level concentrations of particulate, sulphur dioxide nitrogen dioxide, and carbon monoxide will be within the acceptable CAAQOs at/or beyond the mineral claims boundary.

The air quality management plan calls for the utilization of point source monitoring in conjunction with computer dispersion modelling. The point source monitoring program will consist of emissions sampling for nitrogen dioxide, sulphur dioxide, carbon monoxide and particulate from a representative genset using acceptable sampling methods. The stack sampling data will also be used to monitor the operating performance of the gensets.

2.1.3 Diesel-Fired Boilers

Two 5,900 MJ/S diesel-fired boilers will provide heat to the various buildings at the main site during the winter months (September to April). The boilers will be located in the camp services building and heat a glycol/water solution which is circulated to the various buildings. The boilers will be designed to operate on No. 1 diesel fuel with the option of switching to No. 2 diesel at a later date. For a conservative (i.e., worst case) estimate of boiler emissions, it was assumed that the boilers operate on No. 2 diesel fuel containing 0.2 wt % sulphur, although 0.05 wt% sulphur fuel would be used when available in significant quantity.

Air emissions from the diesel-fired heating boilers vary on a monthly basis according to demand for heating at the permanent camp and process plant buildings. Preliminary heat balances indicate that both boilers will operate during the four coldest months of the year (December to March). One boiler will operate during the months of September, October, November and April. There will be no boilers operating during the summer months, May to August. During the operating periods it is estimated that each boiler will run at an average of 75% of full load. The air contaminant with the highest emission rate is sulphur dioxide followed by nitrogen dioxide, carbon monoxide and particulates. The boiler emissions were included in the ISC2 computer dispersion modelling discussed in previous sections.

Implementation of a burner maintenance program and good operating practice will ensure that air emissions are minimized. A stack emissions monitoring program, similar to that described for the diesel generation plant, will be used to confirm emission results.

2.2 Fugitive Dust Control

One of the objectives of the air quality management plan for the protection of ambient air quality is to minimize releases of fugitive dust. Fugitive dust will be most prominent during summer months near haul roads and waste rock piles. The haul road dust will be minimized through the use of granite waste rock in road construction and the use of road grading and watering when required during the summer months. Granite contains a smaller portion of silt which is the primary contributor to fugitive dust from haul roads. Snow cover and freezing will minimize fugitive dust released from haul roads during winter.

If necessary, wind erosion of the exposed waste rock dumps will be controlled by application of a surface binder and reclamation/revegetation. The conveyors and the intermediate coarse ore stockpile are both covered and fugitive dust emissions are thus minimized in these areas.

Blasting operations in open pits are estimated to produce 8 kg NO_x and 1 kg of SO_2 gaseous emissions per tonne of ANFO consumed (U.S. EPA 1985b). Blasting in the open pits may cause short term releases of fugitive dust. The short term puff of dust created by blasting is not expected to create an ambient air quality problem and the wind will dilute and carry the plume away from the open pits. Dust created by blasting will be controlled by blasting techniques, limiting blast sites, hole firing sequences and sufficiently stemming blastholes.

The air quality monitoring plan will utilize high volume air samplers to determine the ambient particulate concentrations, in order to assess the levels of fugitive dust and provide a basis for implementation of control methods.

2.3 Workplace Air Quality Control

The workplace (generally defined as indoor) air quality management plan describes activities to provide an environment that protects the health and safety of workers and minimize indoor air pollution. The management plan provides for the measurement and determination of a variety of parameters that affect the health and safety of workers, such as dust (process and fugitive), carbon monoxide and diesel exhaust fumes. The major project activities include ore processing, and underground and open pit mining. This is discussed in more detail in the Occupational Health and Safety section (Volume I, Section 2.11).

2.3.1 Ore Processing Area

The ore processing areas include: the uncovered run-of-mine (ROM) ore stock pile, the primary crusher, the covered intermediate coarse ore stockpile, the reclaim area, and the process and recovery plant. Ore processing, especially when dealing with dry materials, tends to generate dust. The majority of the dust will be captured by hoods after which the particulate is removed by fabric filters and/or wet air scrubbers prior to release to the environment. A small amount usually disperses within the plant areas, potentially causing a slight human health and safety concern. It is difficult to predict the extent of this dispersion until the processing area is in operation. Once in operation, it will become evident whether there is a concern or not. If there is a concern, then an assessment will be made using standard indoor air monitoring techniques to assess and quantify the possible effects on human health and safety.

Another concern in the warming shed, boilers room, truck repair shops and diesel genset areas will be carbon monoxide generation from fuel fired equipment. Carbon monoxide is heavier than air and collects in low lying areas. For frequently accessed areas, the management plan calls for installation of continuous carbon monoxide monitors, with a local alarm system, to warn personnel of high carbon monoxide levels. These systems are readily available, reliable and easy to maintain. In other areas, it is recommended that a Dräger detector tube or equivalent system be used to test for levels of harmful gases such as carbon monoxide, and if the concentrations are exceeding workplace criteria, appropriate ventilation systems will be utilized.

2.3.2 Underground Mining

Underground sources of air emissions that may cause a concern for human health and safety include diesel emissions from underground mining equipment and gaseous emissions from blasting. The major concern, in terms of air quality for the above-noted activities, is the creation of carbon monoxide. It is required by the NWT *Mining Safety Regulations* (MSR) that every worker be sure that the concentration of gases are below the occupational exposure limits. Dräger detector tubes or an equivalent system could be used to ensure the levels are below occupational exposure limits. Fugitive dust from the underground mining activity will be managed at the source as the regulations require utilization of water for drilling and water sprays to suppress dust areas after blasting.

Operation of diesel powered underground mining equipment will generate exhaust containing sulphur dioxide, nitrogen oxides, carbon monoxide and particulate. The equipment will be used in ventilated areas as required by the NWT MSR. An underground ventilation system will ensure a constant supply of fresh air for the miners. The ventilation system will bring approximately 123 m^3/s (261,000 cfm) of fresh air down a shaft to the bottom haulage area where it cycles through the working areas and is exhausted to the surface through a separate shaft. The ventilation rate is designed to remove fumes and ensure sufficient fresh air for underground workers in all reaches of the mine. Air testing will be completed as required by the MSR using Dräger detector tubes or an equivalent system to ensure that the concentrations are below regulations and do not pose a threat to human health and safety.

2.3.3 Open Pit Mining

Open pit activities that may contribute to a decrease in air quality include diesel fuelled vehicle emissions, fugitive dust caused by vehicle traffic, ore transferring operations and blasting. The effect of vehicle emissions will generally not be of concern to human health and safety because of the high dilution capacity of the atmosphere.

There is a concern that temperature (thermal) inversions, which occur a few times per year, could cause a trapping effect and a buildup of diesel emissions in the open pits. As the gas concentrations build up, a gaseous layer of contaminants may form at some distinct elevation within a pit. The actual level and thickness will depend on a number of parameters including windspeed, the depth of operations within the pit, and the number of haul vehicles and other equipment operating in and about the pit. It is predicted that in a temperature inversion condition, gas layers could form at a rate of approximately 0.16 m/h to 0.25 m/h (in thickness). One of the characteristics of a thermal inversion is the presence of a stable air mass. Modelling studies have shown that 91% of the stable conditions are 12 h or less and as such the layer thickness should be less than 3 m for the majority of the time. The longest stable period was 20 h, at which time it is predicted that the gaseous layer would be up to 5 m thick. If a gaseous layer forms, a Dräger detector tube system (or equivalent) will be used to determine if the environment is safe. If the concentration of air contaminants exceeds industrial hygiene criteria, the workers will have to be moved to a different location and elevation within the pit, or as other pits are developed, they may be temporarily transferred to a different pit. Generally, those working in haul vehicles will not be greatly affected as their cabs will be ventilated.

Visibility problems caused by water vapor exhausted from the diesel equipment during winter will be handled in the same manner. If, and when, the layer becomes a visibility problem, then workers will be relocated.

As mentioned previously, fugitive dust caused by vehicle traffic during the summer months (May to August) can be controlled by grading and watering the road and utilizing low fines granite waste rock for road construction. The heavy equipment operators in the open pits will normally remain within their air conditioned/heated cabs. The cabs are normally fitted with a filtered supply of fresh air, therefore, the exposure to fugitive dust will be minimized. Adequate control of haul truck speeds and the reduced number of trips afforded by use of large haul trucks will also assist in reducing fugitive dust from haul roads.

Summary

The air quality management plan is designed to ensure that the best available and most appropriate technology is utilized in the minimization of impacts. The plan encompasses process operation methodology, emission control equipment and the ongoing assessment of impacts to ensure that regulatory objectives and/or permit requirements are met in order to minimize impact on the environment. The management plan provides the necessary management framework to ensure that appropriate decisions are made, when monitoring indicates a specific need.

3. Water Management Plan

Water is a necessary resource for all operating mines in Canada. It is also an important component of the receiving environment and an agent by which potential contaminants can be transported from the mine site to the environment. Therefore, much of this EIS is focused on the NWT Diamonds Project's effects on water quantity and quality, on the likely secondary impacts of these changes on other valued ecosystem components and on the measures that will be taken to control these impacts.

The term "water management" refers to the practices undertaken during all phases of the project to regulate the movement of water in and around the mine site. Water must be managed for a variety of reasons, including

- compliance with operating permits
- smooth and uninterrupted operation of the mine
- control of impacts to water quality and quantity in the receiving environment.

This chapter is organized to reflect the principal issues surrounding water management planning, which include:

- management philosophy
- planning and design criteria
- water balance
- open pits
- tailings impoundment
- plant site
- waste rock dumps
- road construction.

Subject material contained in this chapter is closely related to material appearing elsewhere in this EIS. Baseline data on water quantity and water quality have been collected and are documented in detail in Volume II. Other relevant sections include Waste Management (Section 5), Hydrological Impacts (Volume IV) and Water Quality Impacts (Volume IV). Water management is an integral component of the mine development plan and hence the practices described below summarize material that appears in numerous sections in Volume I.

3.1 Management Philosophy

Mine development will result in localized changes to water quality and quantity. Several watercourses and lakes will be altered by mine development: five lakes will ultimately be dewatered, each prior to its underlying pit development, Airstrip Lake will be dewatered in order to access gravel resources, and Long Lake will be developed as the tailings impoundment. These waters provide habitat for fish and other aquatic life, and plans have been developed to provide compensation for the lost habitat (Section 8). The principal objective of the water management plan outlined below is to provide protection for other watercourses and lakes in the project area. These water bodies will not be altered to a similar extent by project activities. It is the intent of the Proponent to develop the project so as to minimize negative impacts to the associated valued ecosystem components (VECs).

Many aspects of water management (and, indeed, overall project development) are dictated directly or indirectly by the Federal *Fisheries Act* (R.S.C. 1985, c. F-14), which prohibits the alteration, disruption and destruction of fish habitat (Section 35(1)), and the discharge of deleterious substances[1] to waters frequented by fish (Section 36(3)).

Water and waste management plans have been developed to ensure compliance with the *Fisheries Act* and to provide compensation for fish habitat lost as the result of project activities including open pit development and tailings deposition.

3.2 Planning and Design Criteria

The design of structures for diversion, conveyance and storage of water must reflect both regulatory requirements and the standards of the engineering profession. Overall criteria for planning and design of water management practices are as follows:

- Hydraulic structures will be designed for the estimated 1-in-100 year flood event (i.e., the flood event with an annual probability of exceedance of 1%). The criterion for the emergency spillway from the Long Lake tailings impoundment will be more stringent.

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[1]The *Act* provides only a broad definition of the term “deleterious substance”. Courts have found substances to be deleterious to fish using a wide variety of evidence, including direct toxicity testing, known toxic characteristics of the substance deposited and expert opinion that the substance is likely to be harmful to fish.

- Where the potential consequences of hydraulic failure are the greatest (i.e., the tailings impoundment), post-closure hydraulic structures intended for permanent operation will be designed for the probable maximum flood (PMF) event.

Additional criteria are applicable to culverts installed along fish migration routes. Specific design criteria that will be incorporated into stream crossing designs are outlined in the Land Development Guidelines for the Protection of Aquatic Habitat (DFO and B.C. MOELP 1992).

Site-specific criteria have also been developed which apply to certain project activities such as lake dewatering. These criteria, which assist in managing impacts to the aquatic ecosystem, are discussed in the applicable sections below.

3.3 Water Balance

Fundamental to water management planning is an understanding of water movement throughout the project site flow patterns, flow volumes and occurrence. Water flow during mine operation is best illustrated in the form of a simplified water balance schematic (Figure 3.3-1). The four principal project components are the open pits the plant site including the camp, process plant, fuel storage and other surface facilities; the Long Lake tailings impoundment; and the waste rock dumps. The diagram also identifies the major water flows into and out of each component and shows the flows between components. Figure 3.3-2 shows the locations of the project facilities on an overall site plan.

The numbers appearing with each flow descriptor represent the approximate total average flow volume, in millions of cubic metres per year (10^6 m^3/a), for a mine production rate of 9,000 t/d (Years 1 to 9) and a production rate of 18,000 t/d (Years 10 to 25). It must be emphasized that these numbers are for illustrative purposes and serve principally to show the relative sizes of the different flows. Many of these flows will exhibit large intra- and inter-annual variability, particularly those that are dependent on variable climatic conditions.

Sections 3.4, 3.5, 3.6 and 3.7 provide detailed descriptions of the water balances for the four principal project components and the water management practices that will be implemented in each area.

3.4 Open Pits

3.4.1 Initial Lake Dewatering

Each of the five open pits will be developed to mine kimberlite pipes over which lakes currently exist. The water in these lakes must be pumped out prior to pit development. Methods by which this will be achieved are detailed in Volume I.

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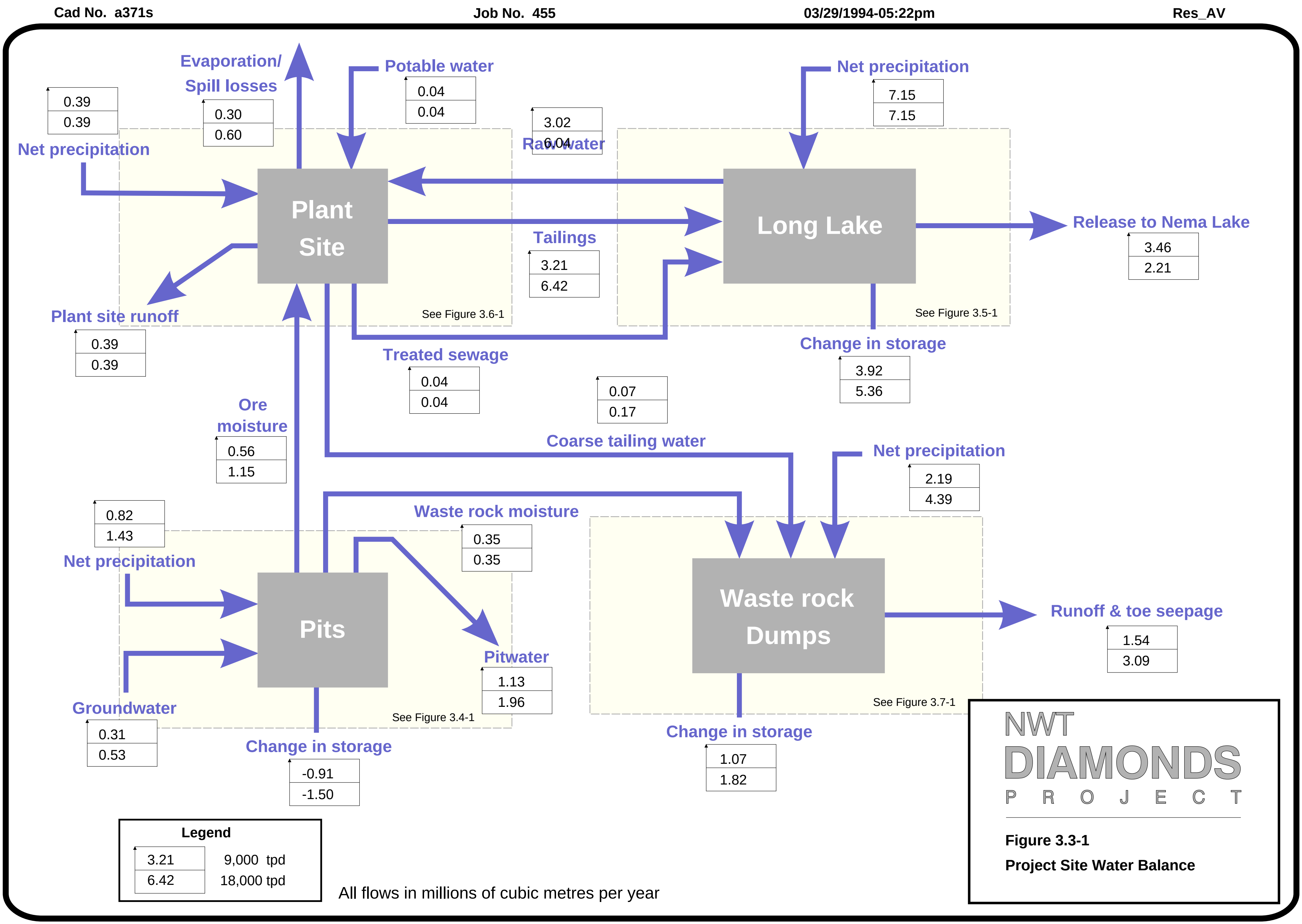

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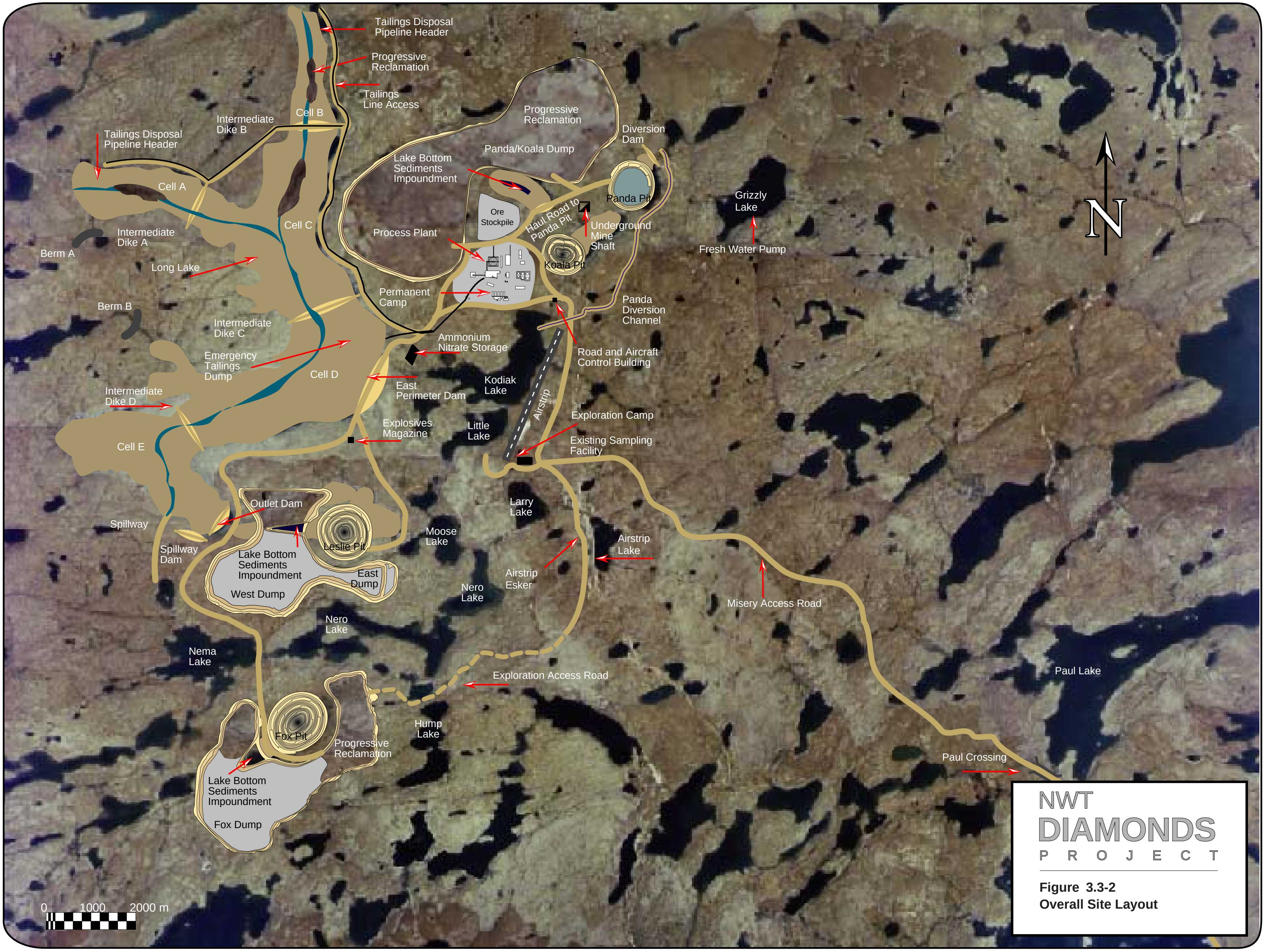

Figure 3.3-2
Overall Site Layout

The lakes to be dewatered are as follows (in order of dewatering): Panda, Misery, Koala, Fox and Leslie. In addition, Airstrip Lake will be dewatered to access gravel resources, and Long Lake will be partially dewatered before tailings deposition commences, in order to lower the lake level by at least 2 m. This is discussed further in Section 3.5.

3.4.1.1 Sediment Control

Water pumped from each of the five lakes overlying pipes will be routed to downstream watercourses. As dewatering progresses, the concentration of suspended solids may increase in the water remaining in the lake, due to the erosion of newly exposed lake bottom sediments. Release of water to the environment will be curtailed as the suspended solids (TSS) concentration in the residual lake water approaches the permitted discharge limit. Thereafter, water will be routed to a sediment impoundment, from where it will be released after sufficient settling has taken place to lower the TSS concentration below the permitted discharge limit. The water may be treated by adding flocculant to achieve this criterion.

Four sedimentation ponds will be required for lake dewatering purposes. The first will be constructed in a gully between the coarse ore stockpile and the Panda waste rock dump and will be used for both the Panda and Koala dewatering operations. Initial design studies have indicated that an approximate volume of up to 2.0 million m^3 could be available for storage of sediments and water, depending on dam height. The approximate surface area of the pond at maximum dam height will be 25 ha.

The approximate water volumes to be pumped from Panda and Koala lakes are respectively 2.0 and 3.0 million m^3 (Section 3.4.1). It will not be necessary to route all of this lake water through the sedimentation pond—the pond will be used only during the later stages of dewatering, as described above. The Panda/Koala pond will be capable of holding all of the expected turbid water and sediments pumped from Panda Lake and, after drawdown, all of the turbid water and sediments from Koala Lake. Oversizing this pond is necessary because it is not possible to accurately forecast when TSS in the lake water will approach the discharge limit during the dewatering operation. In addition, the total volume of recoverable lake bottom sediments and the required retention time to achieve clarification can only be roughly estimated.

Subsequent ponds will be developed at the Misery, Fox and Leslie pits. Sufficient area will be available to construct ponds that are similarly oversized at these locations, but experience gained during the first dewatering operation will be used to more accurately size subsequent sedimentation control systems. In the case of the Leslie pit, the dewatering operation may utilize the Long Lake tailings basin, which is adjacent to the pit.

Lake bottom sediments, which are unconsolidated, saturated and high in organic matter, will be deposited in the same sedimentation ponds. This material will be of potential use in reclamation and will be available to be excavated for this purpose as required.

The lake bottom sediments may be difficult to handle because of their high water content. The more competent material will be spread at the periphery of the pond, where it will dewater by gravity before being excavated for use in reclamation. Fine material will settle on the bottom of the sediment pond areas.

Sedimentation control of the Long Lake dewatering operation will not be required because the lake will be only partially dewatered. The lake volume will be reduced by about 12 million m^3, which is between 25% and 30% of the total lake volume.

Airstrip Lake will be dewatered to access gravel resources for construction, starting in the late summer of 1996. The lake will be dewatered into Larry Lake by excavating a stable channel in the esker separating the two lakes. The lake level will be lowered sequentially as required to access construction fill material. Since the lake will not be dewatered in a single operation, it is not anticipated that sedimentation control will be required, but, it will be implemented if necessary.

3.4.1.2 Changes to Streamflow

A second consideration for managing the dewatering operations is the extent to which the streamflow regime will be altered by the dewatering process. The dewatering operations will release water from lake storage, which will cause streamflow in receiving watercourses to increase above natural conditions as long as pumping continues. In effect, this increase will extend freshet-like conditions well into the summer. Short-term positive impacts could result from aquatic habitat creation. However, unlimited increases in streamflow cannot be accommodated without risk to aquatic resources due to excessive flow velocities.

Management of the flow regime will ensure that the normal cycle of discharge is not greatly disrupted. To ensure that flow velocity is not excessive during dewatering, a general guideline has been established that flow rates in the receiving environment during dewatering will not exceed one half of the estimated mean annual flood. This criterion provides a hydraulic basis for the design of an environmentally acceptable lake dewatering plan. Table 3.3-1 summarizes the hydraulic aspects of the dewatering plan. The effects of lake dewatering activities on streamflow are examined in detail in Volume IV, Section 2.3.1 (Surface Hydrology).

Table 3.3-1
Design Summary, Lake Dewatering Plan

Lake	Dewatering Design Flow (m^3/s)	Total Volume Pumped[1] ($x\ 10^6\ m^3$)	Pumping Time (months)
Long[2]	1.35	16.8	4.8
Airstrip[3]	—	—	—
Panda	0.44	2.0	1.8
Misery	0.44	1.7	1.5
Koala	0.44	3.0	2.6
Fox 1	0.44	4.3	3.8
Leslie	0.44	2.1	1.8

1: Includes static volume of lake plus allowance for estimated inflow to lake during pumping.
2: Long Lake will be partially dewatered in stages prior to tailings deposition (Section 3.5).
3. Airstrip Lake will be dewatered in stages to access granular resources (gravel).

3.4.2 Operational Pit Dewatering

During mine operation, inflows to the open pits will include direct precipitation (augmented by wind-transported snow), runoff from the surrounding catchment and groundwater seepage. Outflows from the open pits will include moisture carried with ore to the process plant, moisture carried with waste rock to the waste dumps, evaporation and direct discharge to sedimentation ponds by the pit dewatering systems.

For the purposes of water management planning, the following assumptions were made with respect to the above inflows and outflows:

- ore moisture is 15% by weight, based on observations made during the exploration program
- waste rock moisture is 1% by weight
- evaporation within the pits is negligible
- wind-transported snow increases direct precipitation by 10%
- groundwater inflow is as modelled for the maximum pit extent (Volume IV, Section 2.3.2).

A simplified schematic of the open pit water balance during mine operation is shown on Figure 3.4-1. The schematic applies to all five pits, although the relative magnitude of the flows will vary from pit to pit. Approximate annual average flows have been calculated for each of the water balance components for each pit. These figures are listed in Table 3.4-1.

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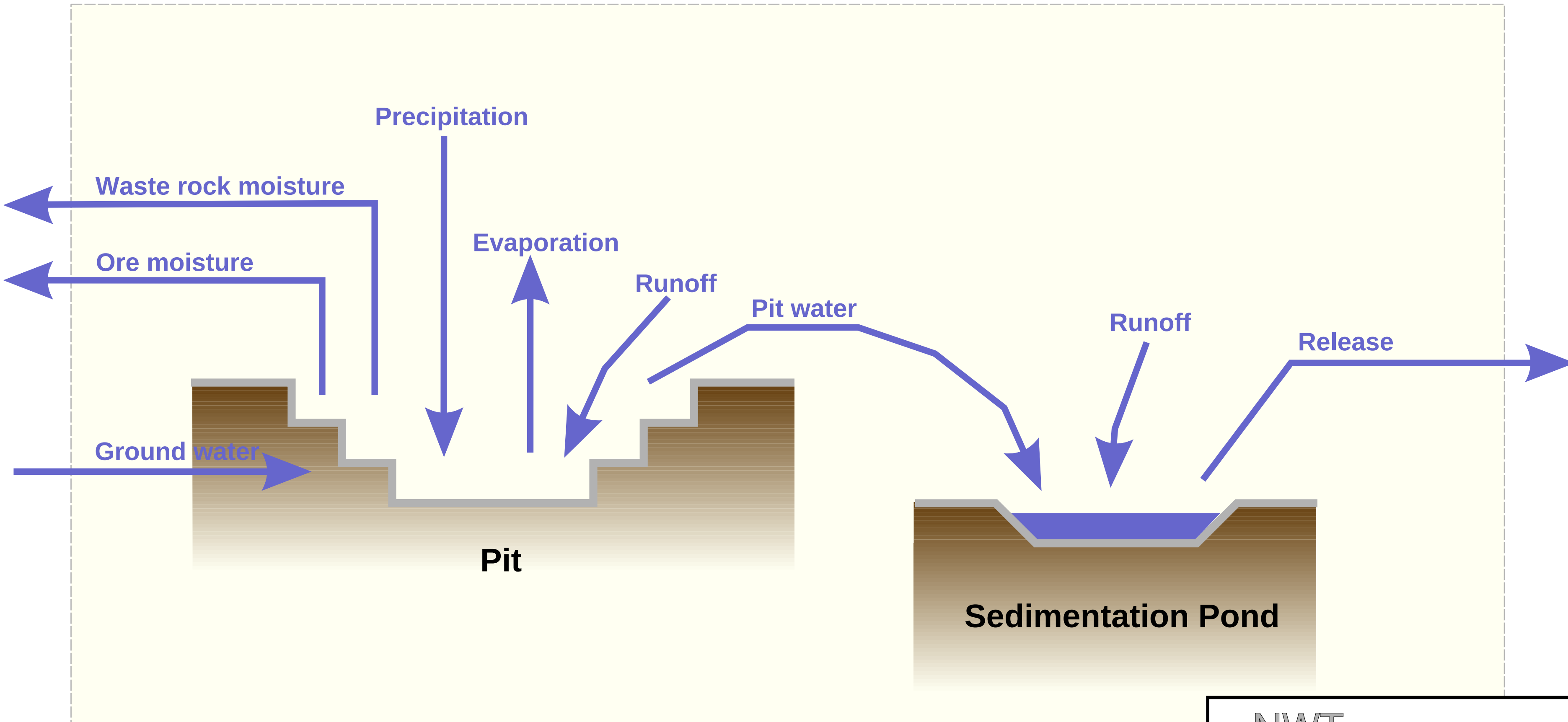

NWT DIAMONDS PROJECT

Figure 3.4-1
Open Pit Water Balance

Source: Rescan

Table 3.4-1
Open Pit Annual Water Balance Summary[1]

		Pit					
		Panda	Misery	Koala	Fox	Leslie	U/G[2]
Inflows ($\times 10^6$ m^3)							
Precipitation	(a)	0.16	0.10	0.12	0.20	0.29	—
Runoff	(b)	0.16	0.00	0.32	0.24	0.28	—
Groundwater	(c)	0.15	0.03	0.06	0.18	0.28	0.15
Total pit water	(a+b+c)	0.47	0.13	0.50	0.62	0.85	
Outflows ($\times 10^6$ m^3)							
Waste rock moisture	(d)	-0.18	-0.10	-0.08	-0.19	-0.23	-0.00
Ore moisture	(e)	-0.46	-0.09	-0.29	-0.48	-0.69	-0.16
Groundwater Storage change (d+e)		-0.64	-0.19	-0.37	-0.67	-0.92	—
Dewatering Flows (m^3/d)							
Average		1,300	400	1,400	1,700	2,300	—
Maximum[3]		27,500	6,100	42,900	37,800	48,400	—

1: All figures assume maximum pit extent.
2: U/G = Underground.
3: Max. daily pit water assumes 20 mm melt rate over pit catchment.
Waste rock moisture from µ/g assumed negligible.

Each pit will require a dewatering system. Pit water will be pumped to a sedimentation pond where water quality will be monitored. When the water is of acceptable quality, it will be released to the natural outflow channel. The sedimentation ponds will be those constructed to contain turbid water and lake bottom sediments from the initial lake dewatering operations. If required, flocculant will be used to increase the settling rate of suspended solids prior to release of the water.

Estimated quantities of water to be pumped from the pits vary from 130,000 m^3/a for the Misery pit to about 850,000 m^3/a for the Leslie pit. The total annual pit water flow will vary considerably over the course of mine operation, as only the active pits will be dewatered. With a mine production rate of 9,000 t/d (to Year 9), average total pit water flow will be about 1.1 million m^3/a. With a mine production rate of 18,000 t/d (Years 10 to 25), the total is estimated to be 2.0 million m^3/a. Note that the calculated pit water flows assume that each pit is at its ultimate extent and are thus maximum flows.

An estimate of required surface area for the sedimentation ponds can be made on the basis of the maximum estimated flows from each pit, which were calculated assuming 20 mm of snowmelt runoff from the entire pit catchment. For example, the estimated maximum inflow to the Panda pit is 27,500 m^3/d, or 0.32 m^3/s.

Assuming a minimum particle settling velocity of 10^{-5} m/s (this corresponds to fine sand/silt), a minimum required surface area of 32,000 m^2, or 3.2 ha, is calculated. The Panda/Koala sedimentation pond will be more than adequately sized for the pit dewatering operation, even during those years when both the Panda and Koala pits will contribute pit water to the pond.

For final design purposes, the sedimentation ponds will be sized to release water with TSS levels less than the permitted discharge levels during a 1-in-10 year, 24-hour event. Emergency spillways will be capable of conveying the 100-year flood (i.e., the flood with an annual probability of exceedance of 1%).

The estimates presented above are approximate. They provide an adequate basis for sizing the dewatering system for the Panda pit and preliminary information about the design of the Panda/Koala sedimentation pond. Dewatering systems and sedimentation ponds for subsequent pits will be sized based on experience gained during mine development.

The water management plan allows for flexibility in handling pit water. For instance, water collected in the Panda and Koala pits could be pumped to the process plant for use as process water, if feasible.

3.4.3 Post-Closure Pit Water Management

Following mine closure, the pits will be reclaimed as lakes. The pits will fill naturally at varying rates depending upon the size of the pit and on the amount of direct precipitation and runoff from the surrounding catchment. Seasonal deposits of ice and snow will form on benches in the pits and will melt as the pits fill.

Simplified water balances were prepared to estimate the amount of time required for filling of each of the open pits. There were four components to the water balance, including three inflows:

- direct precipitation on the pit, calculated as 310 mm/a over the ultimate pit extent
- runoff of 180 mm/a from the upstream contributory catchment
- groundwater seepage into the pit, which was assumed to start at its maximum estimated value (Table 3.4-1) and to decrease linearly to zero as the water elevation in the pit rose to the low point on the rim.

The only outflow from the pit was assumed to be evaporation from the free water surface of the pit lake, at 250 mm/a.

Each pit was assumed to start filling after all surface and underground mining of the associated kimberlite pipe ceases. This is Year 10 at Misery, Year 20 at Panda, Koala and Fox, and Year 25 at Leslie. In the case of the Panda pit, natural filling is preceded by five years of process plant tailings deposition, which will nearly fill the pit by the end of Year 25. Once the Panda pit fills, it will overflow into Koala pit.

Cone-shaped pits were assumed to approximate the surface area-elevation and volume-elevation relationships. This simplification is acceptable given the degree of uncertainty in the magnitude of inputs to, and outputs from, the system.

The estimated time required for complete filling of the pits varies considerably, from six years for the Panda pit to over 200 years for the Leslie pit (Table 3.4-2; Figure 3.4-2).

Table 3.4-2
Estimated Time Required for Infilling of Open Pits

Pit	Pit Bottom Elevation (m)	Pit Rim Elevation (m)	Pit Volume ($\times 10^6$ m^3)	Years to Fill
Panda	120	460	53	6
Misery	150	442	30	147
Koala	195	453	31	34
Fox	-30	443	91	153
Leslie	60	446	144	212

These estimates probably overestimate the actual time required to fill the pits. The actual evaporation rate is expected to be much less than 250 mm/a until water levels nearly reach the pit rim, where the lake water surface will be exposed to wind and solar radiation. When water balances were revised to incorporate a reduced average evaporation rate of 100 mm/a, pit filling times decreased by up to 13% (nine years in the Misery pit).

The option also exists to fill the pits more quickly, if this becomes a priority, by directing excess freshet flow from upstream watercourses into the pits.

3.5 Tailings Impoundment

Water management is an integral part of the tailings management plan. This section summarizes the water management aspects of the tailings disposal operation. Readers requiring more detail are referred to Volume I and to Section 5.2 in this volume.

The Long Lake tailings impoundment will receive tailings for 20 years, after which time the process plant tailings will be directed to the mined out Panda pit. The tailings management plan involves the release of as much clean water as possible

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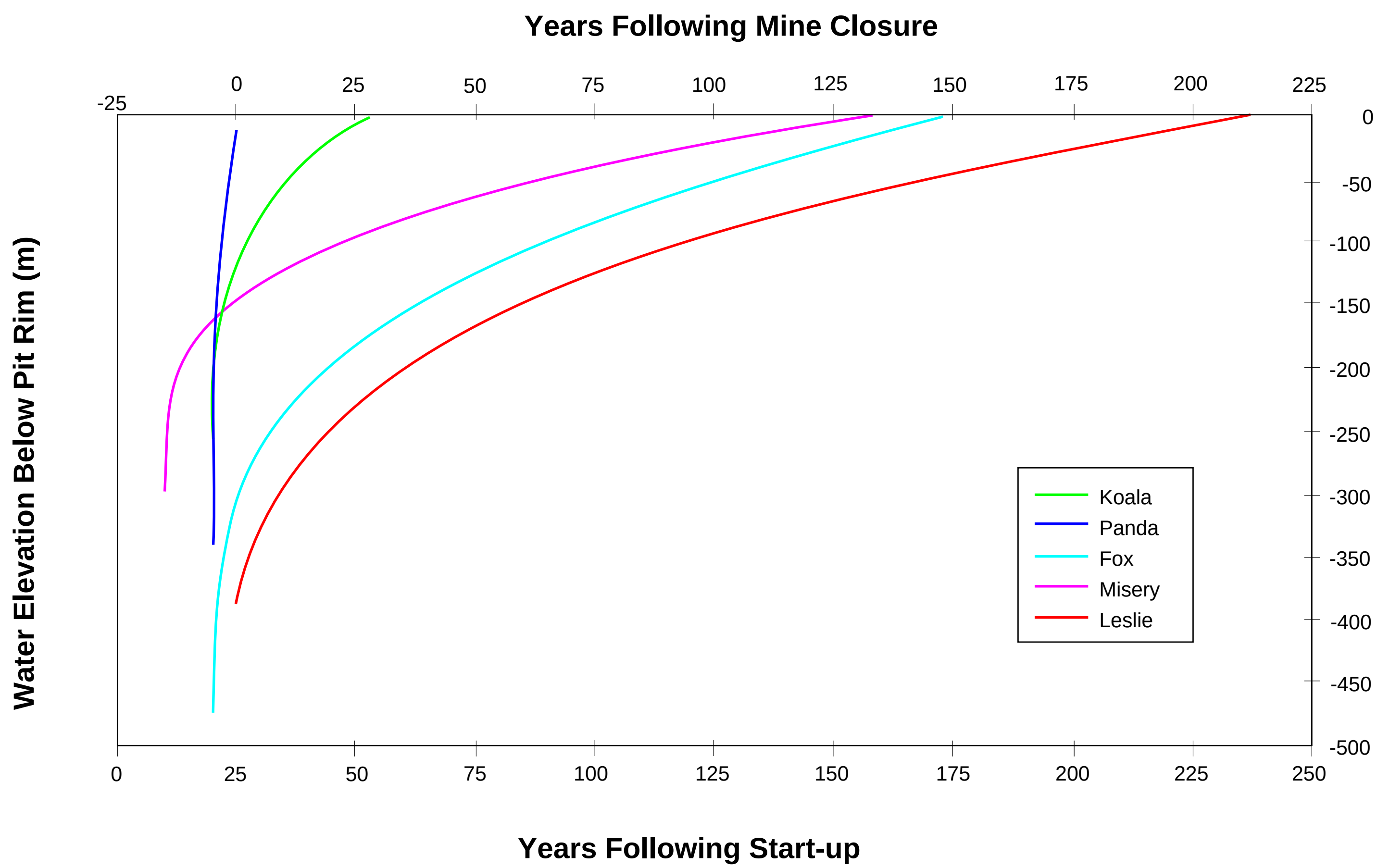

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Figure 3.4-2
Time Required for Pit Lake Filling

Source: Rescan

each year from the south end of the lake. This will be accomplished by constructing dikes to divide the impoundment into five cells, labelled A to E. Four of the Cells (A, B, C and D) will receive tailings. The fifth, Cell E, will serve as a clear water pond. Runoff and clear water from inactive cells will be routed to Cell E and then discharged.

3.5.1 Water Balance

A simplified schematic of the Long Lake water balance is shown on Figure 3.5-1. The major inflow is fine tailings from the process plant, which will be piped to the active cell (A, B, C or D). At a production rate of 9,000 t/d, the tailings slurry will include almost 500 m^3/h of water. When the production rate rises to 18,000 t/d, this flow will rise to almost 1,000 m^3/h. Other principal inflows are precipitation and runoff from the surrounding land surfaces. As much of this water as is practical will be routed around the active cell(s) to Cell E, from where it can be discharged. In addition, treated sewage effluent of 5 m^3/h or less may be piped from the sewage treatment plant into the impoundment (alternatively, it may be piped to Kodiak Lake).

All of the process water requirements will be met by reclaiming raw water from Long Lake. This water will be drawn from Cell C/D in the early years of production and from Cell E in later years. Water will be lost from the impoundment by evaporation. In addition, a significant amount of water will be stored permanently in the voids of the tailings solids.

3.5.1.1 Discharge of Excess Water

As a general rule, the intent is to discharge as much water each year as possible without limiting raw water supply to the process plant. The amount of water available for discharge will vary significantly from year to year, depending not only on operational parameters but also on climatological variability and water quality. Based on average operating and climatological conditions prevailing over the 20-year life of the impoundment, annual discharge volumes are calculated to be between 1.9 and 4.9 million m^3 (EBA 1995). The average discharge volume will be about 3.5 million m^3 during Years 1 to 9, and 2.2 million m^3 during Years 10 to 25. Because this analysis does not account for natural hydrologic variability, the actual range of release volumes will be greater.

Excess water will be discharged from Cell E in a controlled and monitored manner to a spillway channel at the south end of Long Lake. The released water will be conveyed to Nema Lake and will bypass Leslie Lake (where an open pit will be developed), Moose Lake and Nero Lake.

It is planned to draw the water level in Cell E down to at least a 448 m elevation each year before spring runoff. (This level is the same as the present lake level.) There is considerable flexibility in the release schedule, because the water storage

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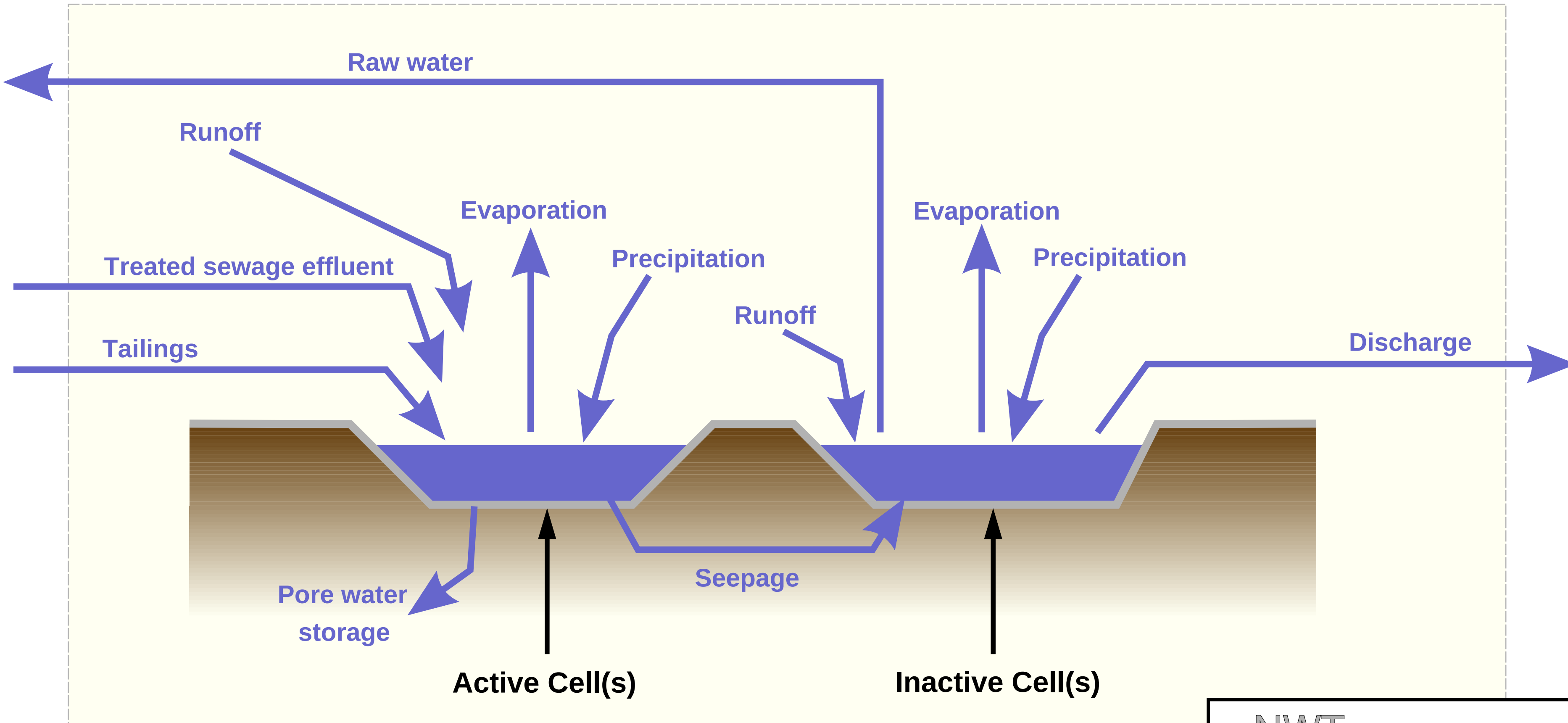

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Figure 3.5-1
Long Lake
Water Balance

Source: Rescan

capacity in Cell E will be very large. The release could be "flow-paced" to mimic flows in the receiving environment. Alternatively, water could be held through the freshet period and then released during the middle to late summer. This would enhance flows in watercourses downstream from Nema Lake, which could benefit the fisheries resource of the watershed.

3.5.2 Treatment Requirements

Once turbid water reaches design elevation in Cell D, clean water discharge from Cell E can no longer be ensured. The time taken to reach design elevation in Cell D has been estimated at 16 years, assuming an average annual precipitation (P) of 310 mm, open water evaporation (E) of 250 mm and runoff (R) of 180 mm. This suggests that for a period of several years before the Panda pit is ready to receive tailings (Year 20), it may be necessary to treat the excess water before releasing it to the environment.

The time taken to fill Cell D may be shorter or longer than 16 years, depending on actual rates of precipitation, evaporation and runoff during the project life. To examine the sensitivity of the water balance to these inputs, upper and lower bound estimates were made of annual average values for precipitation, runoff and evaporation. These estimates are discussed in Volume II, Sections 2.3 and 2.6.

Two additional scenarios for water management were then applied to the tailings impoundment. Under the first, it is assumed that actual conditions are wetter than the long-term average conditions suggested by the baseline studies and regional analyses. This scenario used upper bound estimates for precipitation and runoff, and the lower bound estimate for evaporation. The values for annual precipitation, runoff and evaporation were P = 350 mm, R = 240 mm and E = 150 mm.

Under the second scenario, it is assumed that actual conditions are more arid than estimated long-term averages. For this scenario, lower bound estimates were used for precipitation and runoff, while the upper bound estimate was used for evaporation. The values for annual precipitation, runoff and evaporation were P = 250 mm, R = 150 mm and E = 350 mm.

The water balance indicates that under the wet scenario, turbid water would reach design elevation in Cell D in Year 13 of operation. Under the dry scenario, turbid water would reach design elevation in Cell D by Year 20. It is concluded that even substantial differences between estimated and actual average hydrological and climatological parameters would not result in large changes to the water management plan for Long Lake. There appear to be, at a minimum, 13 years of operation before water management planning must consider the need to treat water before release. During this period, the water management plan can be optimized and an environmentally and economically acceptable treatment system can be developed, to be implemented if required.

3.5.3 Storage Requirements

Total water storage capacity in Cell E will be very large. Near the end of the operational life of the impoundment, storage of approximately 21 million m^3 will be available. This is approximately three times the estimated annual average runoff from the entire Long Lake basin.

Notwithstanding the available storage, an emergency spillway will be located at the south end of Cell E. The spillway will have an invert elevation of 457 m and will serve as a controlled discharge point from Cell E (Section 3.5.1). The spillway will be constructed with a bottom width of 15 m and will be capable of conveying a flow volume equivalent to the average annual total inflow to Long Lake within one week, with a corresponding reservoir rise of 0.6 m.

3.5.4 Post-Closure Water Management

Following mine closure, the tailings surfaces in cells A, B, C and D will be reclaimed. Cell E will remain as a small lake. The spillway dam will be breached to approximately 453 m. The resulting channel will be upgraded to a permanent streambed by lining with riprap and sizing it to accommodate the probable maximum flood (PMF) event. Runoff from Cell E will continue to discharge via the new spillway to Nema Lake. At this point, water will no longer be impounded by engineered structures. Over the long term, average runoff from Cell E will be approximately equal to present runoff from Long Lake, which is about 8 million m^3 annually.

3.6 Plant Site

The plant site water balance is shown in Figure 3.6-1. The balance can be divided into three separate components, as follows:

- *Process Water*: Inflows to the plant include raw water from Long Lake and ore moisture. Outflows include coarse tailings moisture to the Panda/Koala waste dump, fine tailings slurry water to Long Lake and evaporative losses.
- *Domestic Water*: Potable water will be drawn from Koala Lake during early stages of mine development, and then Grizzly Lake. Treated sewage effluent may be discharged with the tailings into Long Lake, or into Kodiak Lake.
- *Site Drainage*: Direct precipitation and runoff from the surrounding catchment will be routed to sedimentation ponds located on the plant site. Water will be released from these ponds when it meets criteria for discharge.

The largest flows into and out of the plant site will be associated with the Long Lake tailings and raw water reclaim. These flows will average 3.2 and

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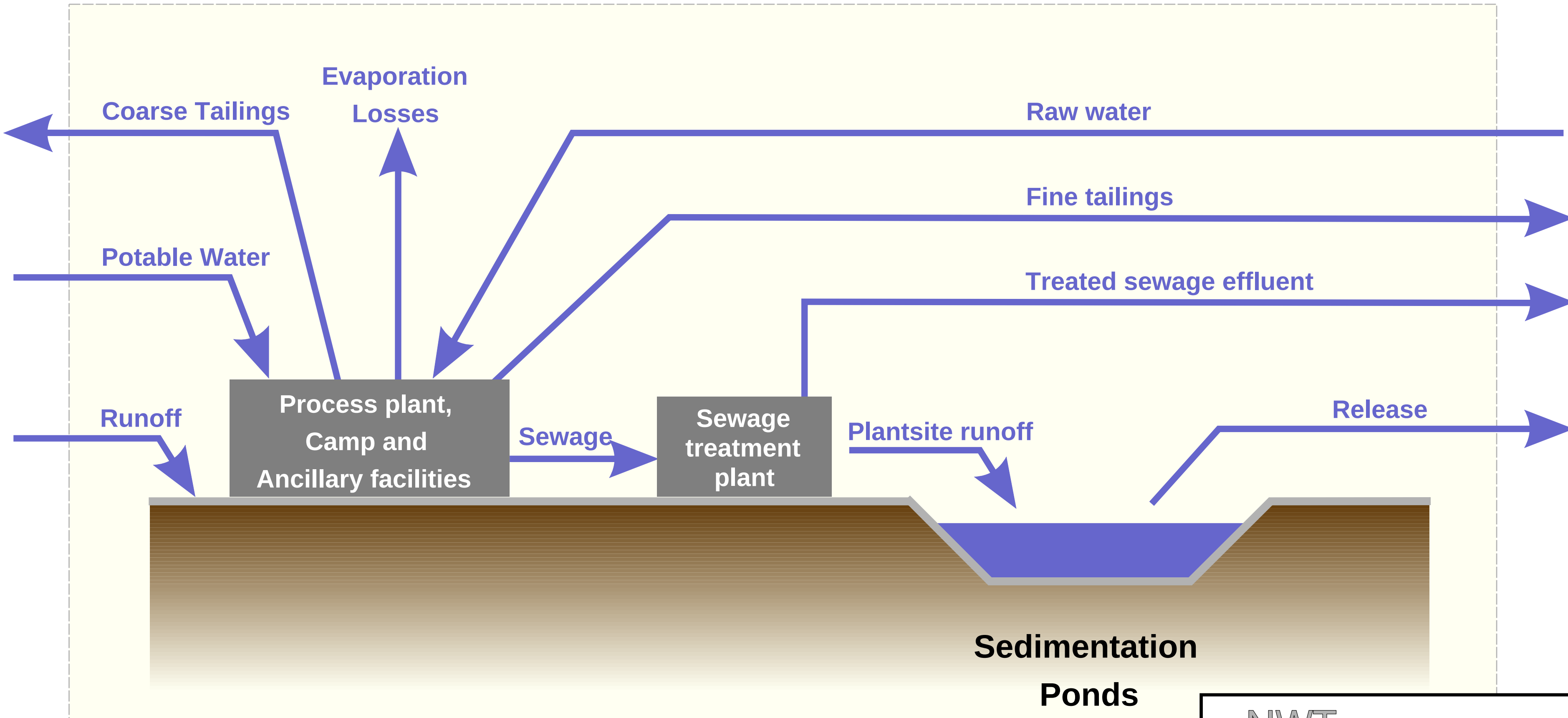

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Figure 3.6-1
Plant Site Water Balance

Source: Rescan

3.0 million m^3/a during Years 1 to 9, when mine production will be at 9,000 t/d. When mine production doubles to 18,000 t/d in Year 10, these flows will double.

Site runoff has been conservatively estimated at 390,000 m^3/a, by ignoring losses to evapotranspiration, and applying precipitation of 310 mm/a over an area of 125 ha.

3.7 Waste Rock Dumps

A simplified schematic of the water balance of the waste rock dumps is shown on Figure 3.7-1. Inputs include direct precipitation and waste rock moisture transferred from the open pits (Section 3.4.2). Precipitation has been calculated on the basis of an average annual precipitation of 310 mm falling on the maximum area of each dump. Runoff from the catchments surrounding the dumps will be minimal, since the dumps will rise above the surrounding terrain. For the purposes of this document, contribution of surface runoff from the catchments surrounding the dumps is assumed to be negligible.

When the snow melts in the spring, some water will run off the top and sloped sides of the dumps, and some will evaporate. Water will also percolate into the dumps, following pathways of least hydraulic resistance downward into the rock mass. Most of this water will be taken into permanent storage in the pores of the waste rock while the remainder will appear as seepage at the toe of the dump.

A thermal analysis (Appendix III-C4) of the dumps was performed to estimate how much water will seep from the dumps (Section 5.3). Assuming that half of the water falling on the dumps infiltrates into the dump (the other half runs off), the analysis concluded that water infiltrating into a perimeter zone 150 m wide in each dump would seep through the rock and exit at the toe of the dump. The remainder, which seeps into the center core of the dump, would freeze and be taken into permanent storage in the rock mass.

The increase in net water storage within the dumps will be equal to the amount of water transported to the dumps with the waste rock from the open pits (1% by weight), plus the percolating water that freezes in the dump. Runoff from the dumps is estimated as the fraction of precipitation shed from the surface (50%) plus the toe seepage. Table 3.7-1 summarizes these estimates. Annual runoff for Years 1 to 9, when only the Panda/Koala and Misery dumps will be developed, is estimated at about 1.5 million m^3. Just under one-third of this will be toe seepage; the remainder will be precipitation shed from the dump surfaces. Annual runoff for Years 10 to 25, when the Leslie and Fox dumps will be added, is estimated at 3.1 million m^3, 0.9 million m^3 of which is toe seepage. Note that the waste dump areas and runoff volumes have been calculated for the ultimate extent of the dumps.

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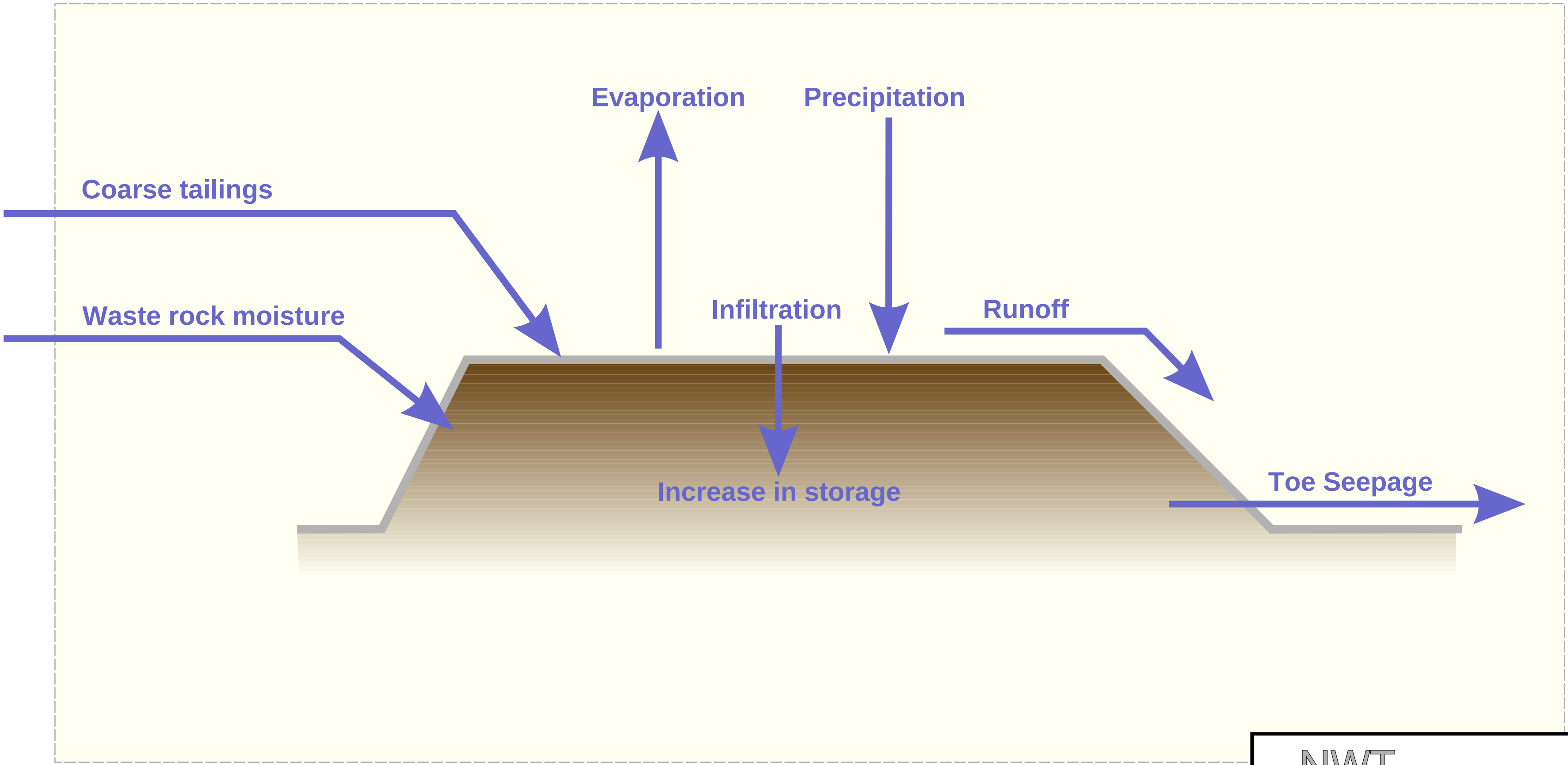

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Figure 3.7-1
Waste Dump
Water Balance

Source: Rescan

Table 3.7-1
Waste Rock Dump Annual Runoff Estimates

Waste Dump	Ultimate Surface Area (ha)	Surface Runoff[1] ($\times 10^6$ m^3/a)	Toe Seepage[2] ($\times 10^6$ m^3/a)	Total ($\times 10^6$ m^3/a)
Panda/Koala	**502**	**0.78**	**0.25**	**1.03**
Misery North	100	0.16	0.08	0.24
Misery East/South	105	0.16	0.11	0.27
Misery (total)	**205**	**0.32**	**0.19**	**0.51**
Fox	**428**	**0.66**	**0.26**	**0.92**
Leslie East	66	0.10	0.09	0.19
Leslie West	216	0.34	0.11	0.45
Leslie (total)	**282**	**0.44**	**0.20**	**0.64**
Total (9,000 t/d)[3]	**707**	**1.10**	**0.44**	**1.54**
Total (18,000 t/d)[4]	**1,417**	**2.20**	**0.90**	**3.10**

1: 50% of incident precipitation of 310 mm/a.
2: Toe seepage from 150 m perimeter zone.
3: Panda/Koala and Misery dumps only.
4: All dumps.

During mine operations, the dumps will be contoured to promote positive drainage. Except in areas where pooling of water is encouraged for reclamation purposes, this will increase the amount of water running off the dumps, reduce the amount of water percolating into the dumps and minimize surface pooling of water on top of the dumps.

Waste rock dumps will be reclaimed as completed during mine operation. Pore ice will accumulate upward into the rock mass from the ground beneath the dumps. Over the long term, runoff from the dumps is expected to equal or slightly exceed runoff from the surrounding land (180 mm/a).

The quality of runoff water from the dumps will be monitored periodically. Visual inspections will be carried out to detect evidence of suspended solids being carried from the dumps into nearby watercourses. In addition, water samples will be collected and analyzed for physical and chemical parameters including TSS, turbidity, total dissolved solids (TDS), pH, nitrate and ammonia (blasting residues). If the runoff water does not meet criteria for discharge as specified in operating permits, perimeter berms will be constructed to route the water to a collection point for further monitoring and/or treatment before release.

It is noted that the waste rock dumps will receive small inputs of material other than waste rock. Coarse tailings from the process plant, comprising about 10% to 20% of the total tailings output, will be directed to the Panda/Koala dump. These tailings will be stored in a portion of the Panda/Koala dump that drains into the Long Lake tailings impoundment. Other inert materials, such as broken concrete, scrap steel and tires, will be buried in the dumps. Disposal of these wastes with the waste rock is not expected to affect the quality or quantity of water running off the dumps.

3.8 Road Construction

Road construction activities will be managed to ensure that fish passage in watercourses is not impeded and the normal cycle of discharge is not greatly disrupted. A bridge with at least two metres of clearance will be constructed over the stream connecting Paul Lake and Lac de Gras, along the Misery access road. Culverts will be installed where the road crosses smaller watercourses. These will be designed according to guidelines to allow for the unrestricted migration of fish (DFO 1992; DIAND 1990; Katopodis and Gervais 1991; Katopodis 1991; Saremba and Mattison 1984). Round culverts will be used at most stream crossings, and open bottom culverts will be used over sensitive stream habitats. The appropriate design will be made on a site-specific basis after detailed engineering and fisheries surveys have been completed.

Summary

This water management plan, based on a thorough understanding of water movement resulting from operational and natural processes, has been designed to minimize impacts to the hydrologic system. The described plan combines strict compliance to applicable regulations with operational versatility to address specific environmental needs and will ensure that the hydrologic system, of which the NWT Diamonds Project is a part, will remain intact with regard to both water quantity and quality.

4. Materials Management Plan

The Materials Management Plan outlines the management of hazardous substances, spill contingency and emergency response and ammonium nitrate storage. The plan describes how materials will be handled and how an emergency plan will be designed to prevent potential health risks and environmental damage.

The strategies used in this plan are as follows:

- to minimize the use of hazardous substances
- to properly manage the use, transportation, storage, handling and disposal of hazardous substances, oil and petroleum products to protect human health and safety and to prevent release to the environment
- to implement an effective spill contingency and response plan.

4.1 Hazardous Substances

A hazardous or dangerous substance is one that poses a potential threat to the environment and/or human health and safety if improperly used, handled, stored, transported or disposed. A hazardous or dangerous substance is one that exhibits the characteristic(s) of corrosivity, ignitability (flammability), reactivity or toxicity. The Canadian Transportation of Dangerous Goods Regulations (TDG) divide all possible goods, including wastes, into two groups: dangerous goods and non-dangerous goods. Dangerous goods are those that meet or exceed one or more of a number of criteria based on properties or composition of the goods. Depending on which criteria are exceeded, goods are placed in one of nine classes: explosives, gases, flammable liquids, flammable solids, oxidizing substances and organic peroxides, poisonous and infectious substances, radioactive materials, corrosive substances and miscellaneous dangerous goods. A limited number of goods are exempted from the regulations, such as domestic garbage, sewage effluent and medical articles for personal use.

The use of hazardous substances will be minimized. Where available, non-hazardous products will be substituted. There are three important reasons for this substitution. First, it reduces the risks and potential exposure associated with handling hazardous substances. Second, non-hazardous materials are often cheaper in that they do not need to be managed from “cradle to grave”. Third, the costs associated with hazardous material releases and spill clean up can be very expensive.

Where hazardous substances are used, workers will be informed of potential hazards. Worker training and workplace control of hazardous substances are discussed in Volume I, Section 2.11.9.

4.1.1 Handling and Storage

In addition to compliance with NWT Mine Hazardous Materials Identification System (MHMIS) and good practice, all staff involved in fuel handling will be trained in fuel transfer, handling and storage, spill response and reporting procedures. Workers who handle hazardous substances will be trained in the safe handling procedures as described in the NWT MHMIS regulations.

Hazardous substances or materials will be segregated from incompatible chemicals, as well as from other non-hazardous materials. Storage areas will be designed to prevent liquid and dry chemical discharge to the environment. Controls include impervious pads, secondary containment and berms or sumps.

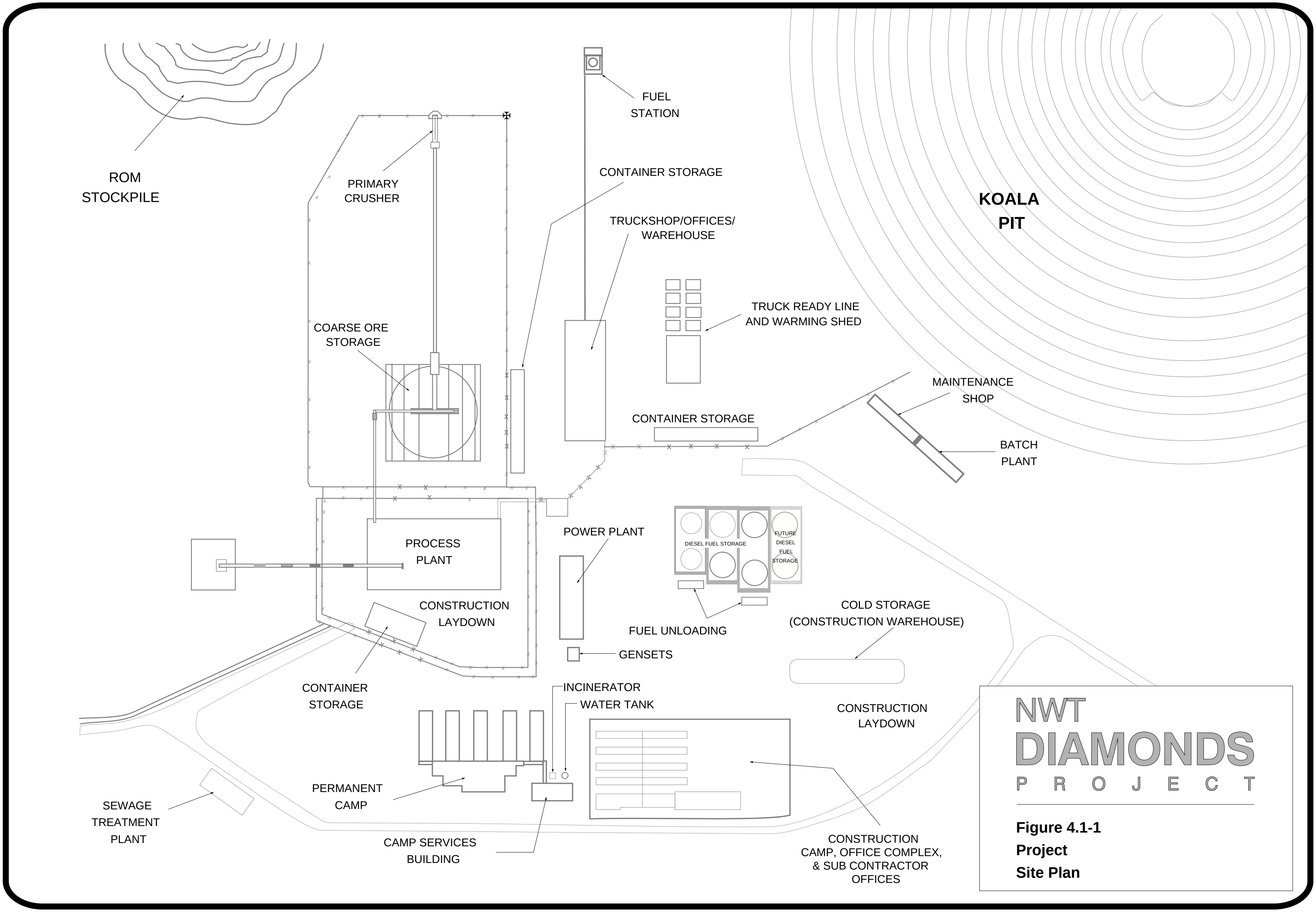
Stations for storing containment and spill clean-up equipment will be established in the plant site area and other strategic locations. In the event of a leak or spill in a storage area, appropriate measures will be taken immediately. A comprehensive Spill Contingency Plan which discusses prevention measures against spillage and the response plan to be implemented in the event a spill occurs is discussed in Section 4.2.

4.1.1.1 Fuel and Other Hazardous Fluids

Permanent Camp

The power plant and most mobile equipment will operate on No. 1 arctic grade diesel fuel. Sufficient site storage and distribution facilities will be provided to handle the quantities of fuel required for a full year's operation due to the limited duration of the winter road. Total diesel fuel requirements for the first three years of full operation are estimated to be approximately 52 million L/a, representing 1,400 tanker truck shipments per year. A central tank farm will be constructed at the plant site for bulk storage of diesel fuel (Figure 4.1-1), and will consist of eight tanks, installed two by two in adjoining bermed areas. Two of the tanks have already been erected to provide fuel storage for the ongoing exploration work. One tank will be set up initially at Misery and then be relocated to the plant site tank farm. Three more tanks will be installed during the construction phase, while the last two will be built later when needed. All of the tanks will be constructed on impervious lined pads and surrounded by berms to contain potential spillage and prevent ground contamination. The fuel storage area will meet all requirements of the National Fire Safety Code. The total effective storage capacity for the 18,000 t/d operation will be approximately 61,000 m^3.

In addition to fuel, lubricating oils and other miscellaneous fluids will be required. In general, glycol (antifreeze) and lubricants/oils will be shipped to site in bulk tankers over the winter road. Storage tanks for limited quantities of glycol, hydraulic fluids, transmission fluids and lubricating oils for mobile equipment



Source: Fluor Daniel Wright Signet

will be kept inside, with larger quantities stored outdoors in tankers. Other lubricants and greases will be shipped and stored in drums or shipping cubes. Significant drum and cube caches will be lined and bermed for secondary containment. The estimated annual requirements of oil and miscellaneous fluids are listed in Table 4.1-1.

Table 4.1-1
Estimated Annual Requirements
of Oil and Miscellaneous Fluids

Description	Trade Name	Quantity (L)
Engine oil - mobile equipment	CF4 15W40	80,000
Engine coolant - antifreeze	—	84,000
Engine oil - gensets	—	100,000
Hydraulic fluid	HYD 10WT	40,000
Transmission fluid	SAE 30T04	26,000
Differential/final drives	SAE 50W	28,000
Miscellaneous	T0430W	370
	SAE 10WT	2,800
Heating glycol	—	40,000
Aircraft de-icing fluid	U-CAR de-icing XL54	4,200

Approximately 500,000 L of jet turbine fuel will be stored in tanks adjacent to the airstrip. Fuel for piston-driven aircraft will be stored in drums.

Misery Facilities

By road, the Misery open pit mining operation will be located approximately 29 km east of the main mining area and the plant site. As daily commuting from the Koala site would be impractical, the Misery site will have its own diesel fuel storage and handling facilities. These facilities will include a 9,000 m^3 to 12,000 m^3 bulk fuel storage tank, a fuel unloading and transfer module, a haul truck fuelling station, a fuelling station for small and medium sized vehicles and day tanks at the primary use areas.

All significant storage and day tanks for fuel, lubricants, hydraulic fluids and glycol will be located in secondary containments to capture any potential spillage and prevent ground contamination.

4.1.1.2 Processing Reagents

Processing of diamond bearing kimberlite does not involve the use of chemical reagents common to other types of mining. In addition to non-hazardous ferrosilicon, two flocculants, Percol E10 and Percol 408 (or their equivalent), may be used. The flocculants remove suspended solids from the process water for use as reclaim water. Based on testwork to date, flocculant and coagulant consumption is approximately 53 g of Percol E10 and 121 g of Percol 408 per tonne of plant ore feed and will mostly be consumed in the process.

4.1.1.3 Miscellaneous

Welding gases/acetylene, MAPP (propane), oxygen, argon, etc., will be stored in isolated shipping containers, with small quantities available in securely stored receptacles around the plant site. These and other miscellaneous hazardous substances, such as paint and laboratory chemicals, will be properly handled and stored in accordance with good practice and recommendations on their respective MSDSs.

4.2 Spill Contingency Plans and Emergency Response

"*Any oil spill, if its not contained and disposed of right, it'll always be there, it'll never disappear. (Anti-freeze) creates stains on the land and seeps down into the water, into food, wildlife we eat, caribou, ptarmigan, things like that. Well they'll get sick and pass it onto other animals, you know, the foxes, and wolves and caribou, wolverines and grizzlies. It'll spread. It won't just be in one area. It'll spread because of migration and things like that*" (Jimmy Ross Miyok, Coppermine).

"*If anything happens up there, any oil spill, or something like that mining substance, it'll travel down river, its gonna (to) affect the community*" (Jimmy Ross Miyok, Coppermine).

This section outlines the general spill prevention measures, contingency plans and response plan to be implemented during mine operations. Detailed emergency response plans and appropriate training manuals are currently being developed. A successful Crisis Management Plan, such as the one BHP developed for the Island Copper Mine, may be used as the model for emergency response plans at the NWT Diamonds Project. This section also describes the current spill reporting procedures and the equipment that will be available for spill control. Potential spills of fuel/petroleum products, glycol, tailings and domestic sewage are addressed. Handling of ammonium nitrate (AN) is discussed in more detail in Section 4.3. The purpose of the spill contingency plans is to minimize health hazards and environmental damage through work force training to heighten awareness and promote safe handling of potentially hazardous materials.

4.2.1 System Component Failure Prevention Measures

Overburden and till will be available for use in the construction and reinforcement of emergency containment structures in the event of failure of the tailings handling and disposal system, domestic sewage treatment system and handling, transfer or storage operations for fuels, additives and AN.

Visual inspections of the tailings pipeline, tailings dam structures and domestic sewage system pipeline will be carried out regularly by operations personnel. Records will be kept of these checks. Backup generators will be installed to ensure power supply for the tailings pipeline heat-tracing systems to prevent freeze-up in the event of a general power outage. A Northwest Territories certified geotechnical engineer will inspect and monitor the tailings impoundment structures as required to ensure that stability is maintained.

A licensed sewage plant operator will be responsible for the wastewater treatment system and for regular visual inspections of the sewage pipelines. The operations manual for the sewage treatment plant, as provided by the plant supplier, will be followed.

Potential spills at the plant and the mine sites during fuel and chemical handling, transfer or storage will be kept to a minimum by:

- training personnel in proper fuel and chemicals handling procedures
- conducting specialized spill training for personnel associated with fuel/chemical handling
- regular inspection of storage tanks and hoses for evidence of leaks
- using lined and bermed fuel storage areas with sufficient volume to retain 110% of the largest tank volume within the bermed area
- using transfer hoses with double locking mechanisms
- manually and carefully measuring fuel/chemical content in the tanks when materials are being transferred
- cleaning up minor spills immediately
- maintaining additional fuel and chemical storage for emergencies.

In addition, the transportation company contracted to haul fuel/petroleum products to the mine site will be required to have a Spill Contingency Plan approved by project management prior to commencement of the contractual work.

4.2.2 Response Organization

A Spill Response Team will be designated and will comprise of an On-scene Coordinator or alternate, the Operations Manager, the Environmental Manager and personnel from the operational work force at the mine site. Since the on-site work force at any particular time is expected to be approximately 375, a large number of people will be available to assist with spill response activities. All personnel will be trained to notify the On-Scene Coordinator in the event of a spill. The proposed duties of the team members are outlined below.

4.2.2.1 On-Scene Coordinator (or alternate)

The On-scene Coordinator will ensure that all spill response personnel receive adequate training in order to fulfill their responsibilities as part of the Spill Response Team. In the event of a spill, the On-scene Coordinator will:

- evaluate the initial situation and assess the magnitude of the problem
- assess the requirements for personnel, equipment, materials and tools to contain the spill in light of the resources available immediately (the urgency will depend on the nature of the spill)
- activate the response plan and call in the response team, as deemed appropriate, to meet the situation
- contain the spill and evacuate personnel from the area
- have complete authority over the cleanup personnel and the spill scene
- develop the overall plan of action for containment and cleanup of the specific incident, and direct implementation
- ensure that the assigned responsibilities are carried out and coordinate the activities of the supervisory team members
- report the spill to the Operations Manager
- report the spill to the NWT 24-hour Spill Report Line.

4.2.2.2 Operations Manager

After notification of a spill, the Operations Manager will:

- assist in obtaining any additional resource not available on site for spill response and cleanup
- act as the project spokesperson when dealing with the public, media and government agencies.

4.2.2.3 Environmental Manager

The Environmental Manager will be expected to:

- provide technical advice on spill response activities and potential environmental effects
- advise on the effectiveness of various containment, recovery and disposal options
- develop a sampling scheme for the collection and analysis of samples to identify and monitor possible contaminant levels
- follow up on the effectiveness of the cleanup operation at the spill site and recommend further work, if necessary.

A flow sheet summarizing the responsibilities of the response organization is provided in Figure 4.2-1.

4.2.3 Initial Action Plan

All employees will be instructed in the procedures to be followed in the event of leak, spill or system failure:

- ensure personal safety and the safety of others
- assess the hazards to personnel in the vicinity of the leak or spill
- evacuate personnel from area, if necessary
- control the danger to human life, if possible without endangering additional lives
- assess whether the leak, spill or system failure can be readily stopped or brought under control
- where safe to do so, contain and stop the flow of the spilled material
- gather information on the status of the situation
- report the leak, spill or system failure without delay to the On-scene Coordinator.

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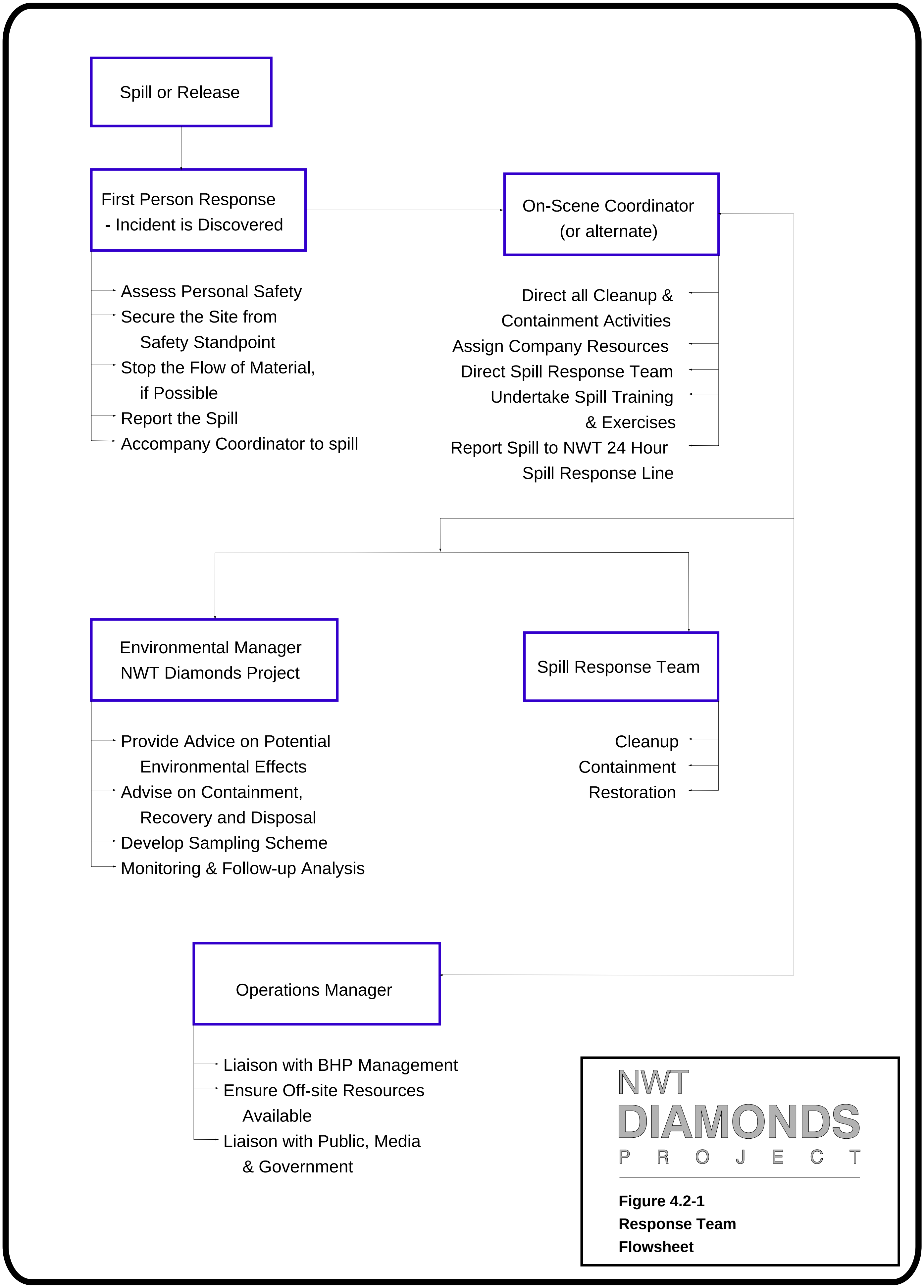

Figure 4.2-1
Response Team Flowsheet

Source: Rescan

4.2.4 System Component Failure Response Plan

4.2.4.1 Tailings Pipeline

The tailings pipeline will extend from the process plant to the Long Lake tailings impoundment for the discharge of tailings year-round. Any person finding a leak from the tailings line will report the incident immediately to the On-scene Coordinator. In case of a blockage, the dump valve(s) can be released to dispose of the tailings on the Long Lake lakeshore within the tailings impoundment area.

As most of the tailings line is located adjacent to Long Lake, leaks along the line would be contained within the tailings impoundment discharge area. Any leaks will be rectified as quickly as possible to minimize impacts on vegetation. If any tailings slurry is released in an area that could affect Kodiak Lake, action will be taken as soon as possible to contain the slurry. However, this is not likely as tailings lines will be on the north side of the road and will be sloped so any spills will be directed towards the north side of the road. The road effectively acts as a containment berm. If necessary, the On-scene Coordinator will summon the members of the Spill Response Team. The contained liquid fraction will be pumped to the tailings impoundment, while the solids fraction will be relocated to the impoundment area or disposed of at an alternative approved site.

In the event of a pump failure, the standby pump will be put on line. In the case of a main power plant failure, the standby generators will be started. To prevent freeze-up and/or damage to the tailings line during the winter, the backup generator will supply power to the pipeline heat-tracing system.

4.2.4.2 Tailings Impoundment Structures

Any containment structure leakage must be dealt with as quickly as possible to avoid or minimize environmental impact. Any person who observes seeps or flow from a tailings dam will follow the initial action plan, report the information to the On-scene Coordinator (or the alternate) and be prepared to accompany the coordinator to the appropriate location to point out his/her observations. The On-scene Coordinator will, upon notification, determine the scale of the problem, take appropriate measures and alert the necessary personnel.

If required, berms will be constructed to contain any released material resulting from leakage through a tailings dam while either temporary or permanent repairs are carried out on the structure. Any liquid portion contained within berms or impoundment basins will be pumped to the tailings pond. Repairs to the failed structure will conform to professional engineering practices and standards.

4.2.4.3 Domestic Sewage

Any problems observed in the sewage treatment plant, such as improper operation, pipeline rupture, pump/power breakdown, etc., will be reported immediately to the On-scene Coordinator. In the event of power failure, the standby generator will be promptly put into operation. Similarly, in the case of a pump failure, the backup pump will be put on-line. If there is any danger of wastewater becoming mixed with a body of freshwater in the event of a raw sewage pipe rupture, a containment structure will be constructed immediately. Alternatively, since the volume of effluent will not be large, it may be possible to store the leaked wastewater temporarily in an empty tank and then pump it to the sewage treatment plant. Any spillage inside the treatment plant will be contained therein and pumped back into the system.

Any pipe rupture or spillage from the treated effluent lines would not require such extensive action because the effluent would meet discharge criteria. Such spills would be dealt with under normal operating procedures.

4.2.4.4 Fuel/Petroleum Products

Any spill or leakage of fuel or other petroleum products during transport and storage will be managed through appropriate response procedures. Major spills or leaks could result from truck roll-over or sinking through the ice, or oil line breakage. The three basic response steps are to identify the source of the leak or spill, contain the spill and the source if possible and contact the On-scene Coordinator and the NWT 24-hour Spill Report Line. Appendix III-D3 describes the Echo Bay Mine spill contingency plan. Their plan differentiates between on-site spills and spills on the winter road.

Spills on Land

The procedure for containing spills on land (gravel, rock, soil, vegetation) is as follows:

- A soil berm will be constructed downslope of the fuel leak. Plastic tarps placed over and at the foot of the berm will permit spilled material to pool on the plastic for easy capture. Absorbent pads can be used for capture purposes. These pads can be squeezed into empty drums and reused. The larger pools can be pumped back into drums or empty storage tanks, “TIDY” tanks or bladders. Special care will be taken to prevent spills from entering any adjacent water bodies.

- Stains on rock will be soaked up with absorbent sheeting. The sheeting will be collected into empty drums for disposal.

- Any contaminated soil and vegetation will be removed and disposed of in an appropriate manner.

Spills on Snow

Snow is one of the best absorbents of spilled fuel oil, as the oil migrates into the snow until it becomes immobile. Contaminated, saturated snow can readily be removed to a recovery or disposal or recovery site.

The procedure for preventing a spill on snow from spreading is as follows:

- compact the snow around the outside perimeter of the spill area
- construct and compact snow dams
- locate the low point of the spill area, then clear channels in the snow to allow material not absorbed to flow into the low area
- once collected in the low area, shovel the spilled material into containers or pick it up with mobile heavy equipment, then transport it to an approved disposal or recovery site.

Spills on Ice

The seriousness of a spill on ice will depend on the strength of the ice and the floating or sinking characteristics of the material. If the spill does not penetrate the ice and the ice is safe to work on, snow will be compacted around the edge of the spill to serve as a berm, lined with plastic sheeting. Contaminated snow/ice along the edges of the spill must be immediately removed.

If the spill is able to penetrate the ice, then the situation is analogous to spills in open water (see below). If the material floats, the ice will be broken to install a containment boom. The ice between the spill and the boom will be collected and disposed of with the spilled material.

Spills on Water

Any spill on open water must be contained immediately to restrict the extent of the floating material. Several measures may be appropriate:

- Boom(s) can be deployed to contain the spill area, although the effectiveness of this action can be limited by wind, waves and other factors.
- Absorbent pads and similar materials can be used to capture small spills on water. Absorbent booms can be drawn in slowly to encircle spilled fuel and absorb it. These materials are hydrophobic (absorb hydrocarbons and repel

water) and are commonly relied on to recover any hydrocarbons that escape containment booms.

- Once a boom has been secured, a skimmer may be deployed to draw in hydrocarbons and a small amount of water. The skimmed material will be pumped through hoses to empty fuel drums.

- Culverts may be used to permit water flow while capturing and collecting fuel by using a board to control the water level. It can be staked and surrounded with absorbent material to capture the fuel on the water surface.

- If a truck slips through ice into the water below, the tanker will generally float since fuel is less dense than water. Buoyancy will be maintained by pumping unspilled fuel to another vessel until the truck can be retrieved. Efforts will be made to retrieve the contents immediately, if possible, failing which the vehicle along with its contents will be pulled out at a more opportune time.

4.2.5 Reporting Procedures

The actual Spill Contingency Plan documents, including the following chain of command, are actively and continually updated. The reporting sequence shown on Figure 4.2-1 is tailored for the operational stage. A similar structure will be in place during the construction phase of project development.

The Spill Response Team must be notified immediately of any spill. The following chain of command should be adhered to in the reporting process:

1. Immediate Contact – On-scene Coordinator.

2. Alternate Contact Person – If the On-scene Coordinator cannot be immediately contacted.

3. Alternate Contact Person – If unable to reach mine.

4. Government 24-hour Spill Reporting Line

A Spill Report form (attached to Appendix III-B1) should be filled out as completely as possible prior to calling the 24-hour spill reporting line.

Additional information or assistance can be obtained from the Mobile Environmental Response Unit, Government of the NWT Pollution Control Division, Department of Indian Affairs & Northern Development, Environment Canada and the RCMP.

4.2.6 Response Equipment

The available response equipment for spill containment and cleanups will consist of "spill kits," the existing mine support equipment present at the site and new standby equipment stationed along the Echo Bay winter road. The selected fuel/petroleum supplier will ensure that a Mobile Environmental Response Unit based in Yellowknife is available at short notice.

A minimum of five spill kits will be kept at strategic, well-marked locations at the project storage/transfer facilities. The items contained in the kits are listed in Table 4.2-1.

Table 4.2-1
Items Contained in Each Spill Kit

1 – 170 L, 16-Gauge Open Top Drum, c/w Bolting Ring and Gasket
1 – 1,220 mm x 1,220 mm x 1.6 mm Neoprene Pad (Drain Stop)
Plug N Dike Granular, 3.8 L
Splash Protection Goggles
2 – PVC Oil Resistant Gloves
1 Pkg. Polyethylene Disposable Bags (1.3 mm), 10 per Package
1 Shovel (Spark Proof)
1 Case T-12 76 mm x 3,650 mm Mini Boom, 4 Booms/Case
1 Bale 11P 256 430 mm x 480 mm x 12.5 mm Pads, 100 Pads/Bail

All mobile equipment at the mine site, such as dozers, loaders, excavators, pickup trucks, firetruck, etc., will be made available for spill containment and cleanup as required. Other portable equipment that would be used for spill response includes empty fuel bladders and tanks, plastic sheeting, shovels, hand tools, safety equipment (hard hats, goggles, etc.), pumps, hoses and portable radios.

Echo Bay Mines currently has equipment stationed along the winter road (at Yellowknife, Lockhart Lake, Lac de Gras and Lupin mine site) that would be made available to assist in the event of an incident. Even upon closure of the Lupin mine, it is planned the NWT Diamonds Project would purchase the balance of the assets of the winter road operation. In addition, all trucks hauling fuel are equipped with rolls of polyethylene. The type of equipment located along the winter road are listed in Table 4.2-2.

A Mobile Environmental Response Unit from Yellowknife (a potential contact may be Shell Canada) will be contacted, when necessary, to assist in spill response activities. This unit can be transported to the site from Yellowknife in less than three hours, weather permitting.

Table 4.2-2
Types of Equipment Along the Winter Road

Equipment Unit	Quantity
D6 Cats	6
Front End Loader	7
Winch Tractors, Low-boys and Hi-boys	3
Tractor/Trailer	4
Cherry Picker	1
Tractor with Product Pumps and Tankers	30
Rig Matt	6
Vacuum Truck-80 Barrel	1

4.2.7 Training and Spill Exercises

The Spill Contingency Plan will be tested through mock spill control and communications exercises to enhance preparedness and increase environmental awareness.

4.2.7.1 Training

All project personnel will be trained on the appropriate spill notification and reporting procedures to ensure rapid deployment of the Spill Response Team.

All members of the Spill Response Team will be trained and be familiar with the spill response resources, including their location and access, the Spill Contingency Plan and appropriate spill response methodologies.

All personnel involved with the NWT Diamonds Project will be familiar with spill reporting requirements.

Fuel handling crews will be fully trained in the safe operation of these facilities, spill prevention techniques and initial spill response, and similarly the staff involved in process, tailings and wastewater systems will be trained in their safe operation.

4.2.7.2 Spill Exercises

Regular spill exercises will be conducted to test the response of the Spill Response Team to fuel and other system failure spills. These exercises will be used to evaluate the ability to respond to spills and determine the necessity for improvement.

4.3 Ammonium Nitrate Storage and Emulsion Plant

This part of the materials management plan describes the management issues surrounding the storage of ammonium nitrate (AN), the manufacturing of emulsion and delivery of explosive products to the mining operations.

At a distance of 1.1 km west of the permanent plant, a site has been allocated for ammonium nitrate storage and manufacturing facilities, which will meet all current and anticipated environmental regulations (Figure 4.3-1). Because the project's life expectancy is approximately 25 years, these facilities have been designed for long-term use, high efficiency and peak demand output. A comparable structural design has been successfully used in the past at similarly remote locations.

An explosives supply and distribution company with experience at large-scale mining operations in northern conditions will be contracted to provide the required blasting services and meet all regulatory approval conditions. The selected contractor will be responsible for supplying process equipment; operating the emulsion plant; providing staff for all stages of transportation, storage, reclaim and blending of explosives; delivering explosive agents to the pit; and blasthole loading.

There are five primary stages of explosives processing (transportation, storage, retrieval, emulsion manufacturing and blasthole delivery), three of which will be based at the AN storage and emulsion plant site (Figures 4.3-2 and 4.3-3). Ammonium nitrate prill will be delivered in bulk over the winter road by suitable highway trucks. The unloading areas will be covered to provide shelter from the elements, contain AN dust and aid cleanup, thus reducing potential fugitive AN migration.

Minor amounts of blasting agent ingredients will be transported to the site in drums while most other ingredients will be delivered in bulk tanks, thereby reducing the handling requirements for empty drums and residue. Allowance for the storage drums has been made in a separate section of the AN storage building. Emulsifier wax, transported in bulk tanks, will be stored in a bermed area located in the emulsion plant.

Underground mining operations will also be supplied with bulk explosives from the explosives manufacturing plant. A separate system encompassing the manufacture, distribution and loading of repumpable bulk emulsion will be available when the underground work begins.

An explosives manufacturing laboratory in the plant will ensure that rigid quality control standards are met during all aspects of the manufacturing process. From the receipt of raw materials to the final discharge of finished product down the borehole, equipment and procedures will be maintained in full compliance with

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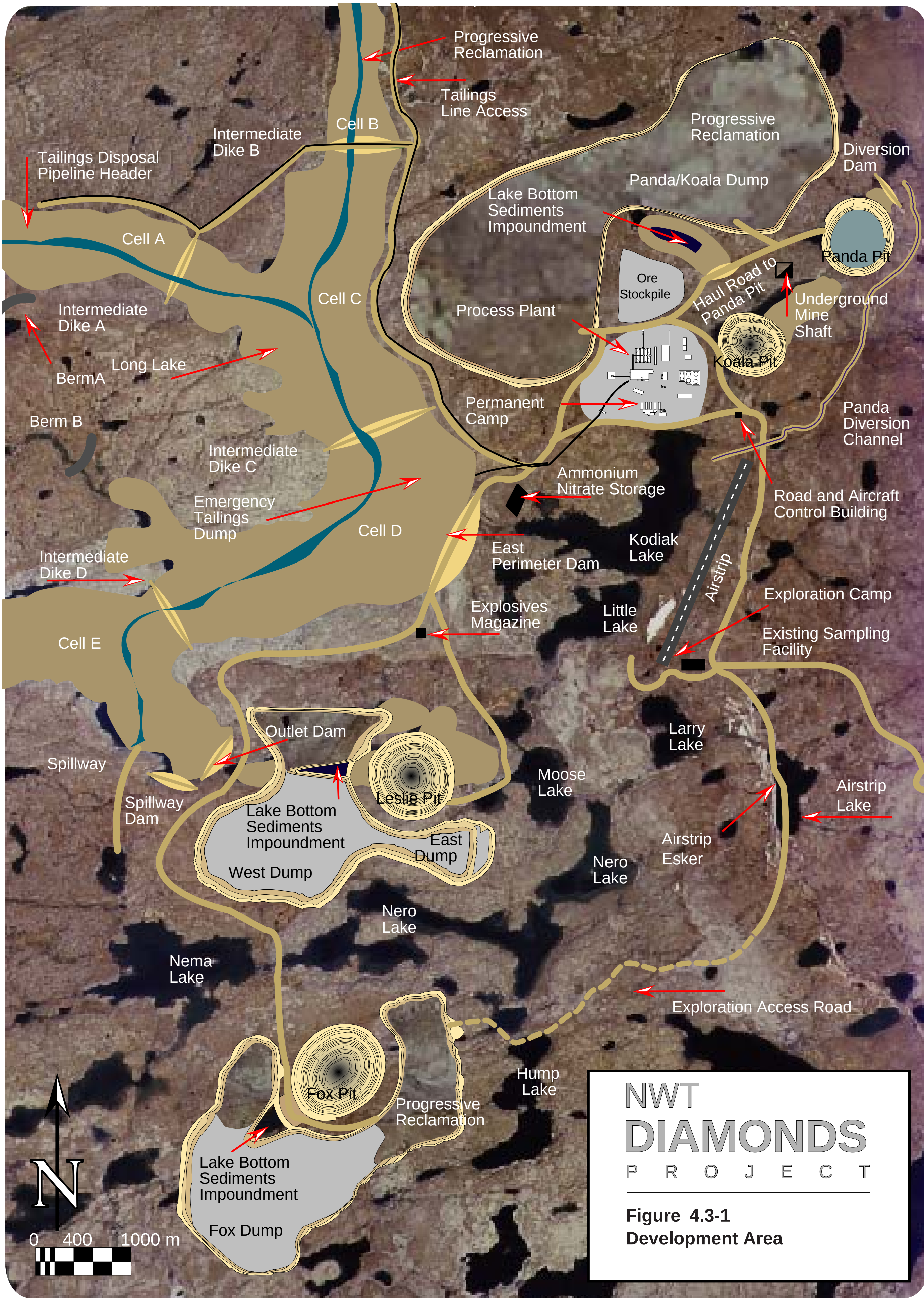
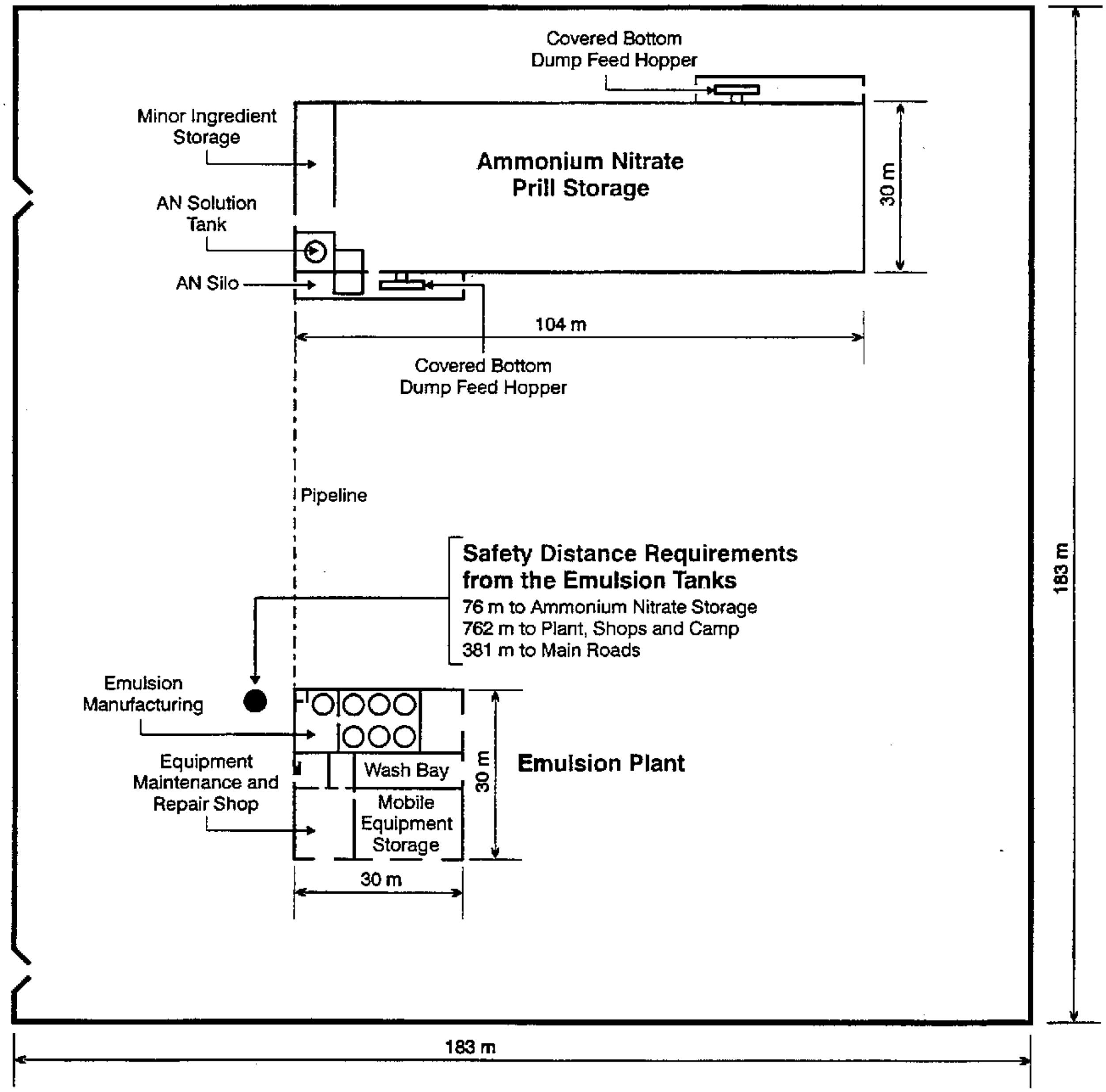


NWT DIAMONDS PROJECT

Figure 4.3-1
Development Area



Utility Requirements

Electrical Power	600 Volts 400 Amps
Product Fuel	1.1 million L/a
Truck Fuel	18 L/h
Boiler Fuel	900 L/d
Water Intake	4.3 m^3/d
Water Discharge	1.5 m^3/d

Mobile Equipment

4 x Explosives Mix & Transport Trucks 22 t
1 x Front-end Loader
1 x Forklift
1 x Crew Cab 4x4 P.U.
1 x Standard Cab 4x4 P.U.

Manpower

1 x Supervisor
1 x Plant Operator
3 x Operators

NWT DIAMONDS PROJECT

Figure 4.3-2
Ammonium Nitrate Storage Area Site Plan

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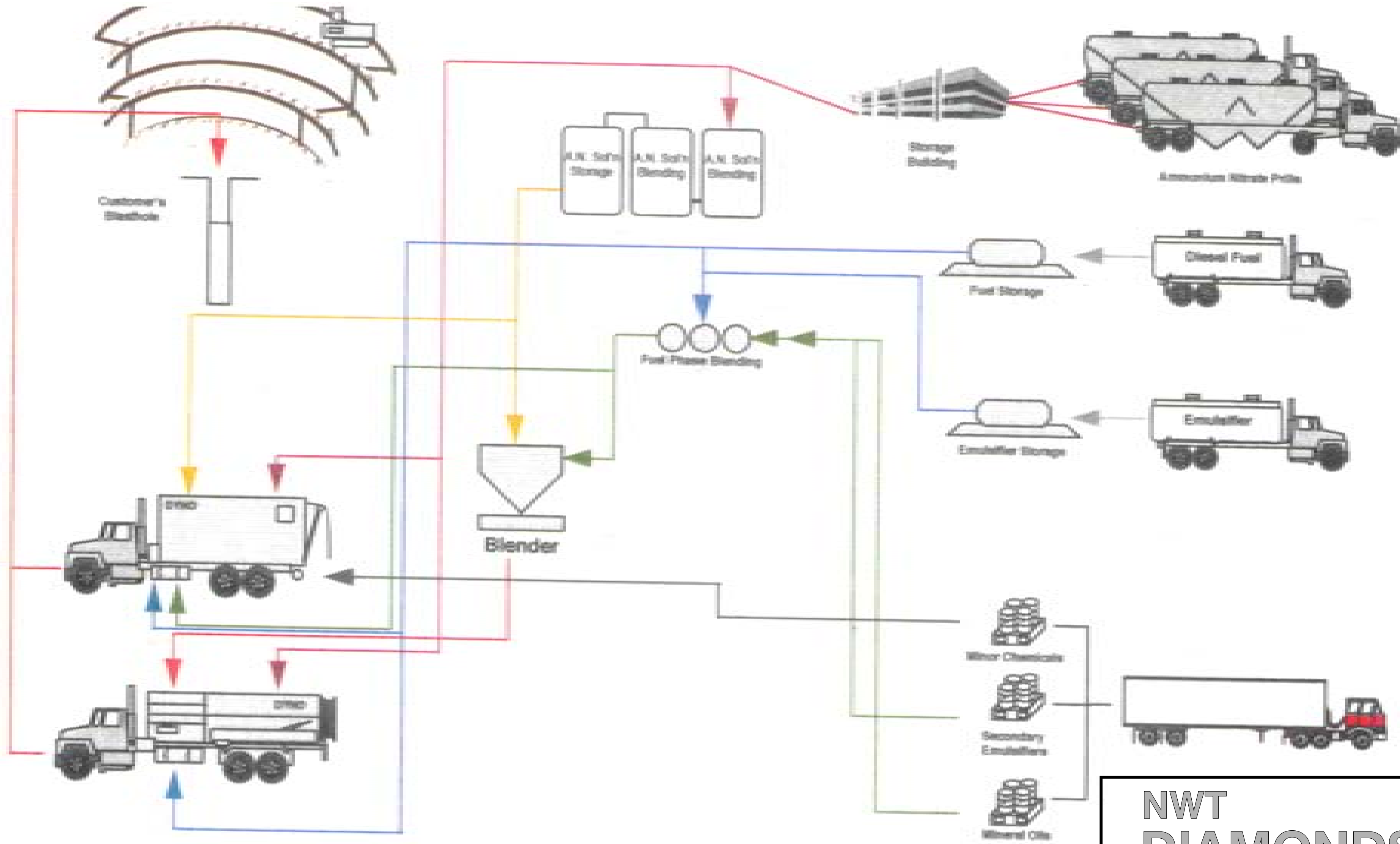

NWT DIAMONDS PROJECT

Figure 4.3-3
Explosives Process
Block Flowsheet

Source: Dyno Nobel

government standards. All bulk storage tanks will be constructed in compliance with the National Fire Code requirements. Tanks, pumps and hoses used in the transfer and/or storage of deleterious liquids will be securely contained.

The primary explosives plant effluent (washdown water) will be collected in a sump at the plant and periodically disposed of in the tailings pond containment. The actual volume of wastewater handled per year at this facility is estimated to be 720,000 L (60 L/t of explosive produced). A waste generation permit to dispose of ammonium nitrate waste will be obtained and kept up to date. Clean waste oils of various quantities from plant and operational equipment will either be used as fuel for the incinerators and warming shed heaters or consumed in the ammonium nitrate and fuel oil (ANFO) emulsions. All significant waste oil collection tanks will be stored in bermed containments or have secondary containment as required by codes. Waste management at the explosives manufacturing site will be reviewed and improved continuously through point-of-source segregation, better storage, on-site recycling and reduced consumption by applying innovative manufacturing technologies.

Based on information provided by explosives contractors, responsible care for the health and safety of employees and the environment would be reinforced with the implementation of a site-specific Emergency Response Plan (ERP), which would cover communication protocol, fire fighting, spill abatement and cleanup and evacuation plans. A second emergency plan, the Transportation Emergency Response Plan (TERP), would also be in place to coordinate a response to an emergency situation outside the mine property. This plan would be registered with Transport Canada under the *Transportation of Dangerous Goods Act* and Regulations. These emergency plans will handle all environmental releases, including storage tank failure, spills from product delivery trucks, spills from raw material delivery trucks, process spills and fire. The following materials are to be covered by these procedures:

- Nitrate Solution
- Ammonium Nitrate and Sodium Nitrate Prill
- Mineral Oil
- Sodium Nitrite
- Emulsifier Agents
- Emulsion
- Fuel Oil
- ANFO
- Nitric Acid
- Sodium Thiocyanate
- Granular Aluminum

The selected explosives contractor will be required to provide a comprehensive safety, health, and environmental compliance program, which will be strictly enforced in the execution of contract obligations. The contractor will be required to develop an environmental planning and implementation process through which potential problems will be identified and mitigative action taken on a site-specific basis. An environmental assessment audit will be conducted to identify areas for possible improvement. Information retrieved from the audit will be conducted to identify areas for possible improvement. Information retrieved from the audit will help to implement a productive program for establishing environmental guidelines and procedures. Accountability will be achieved through ongoing education and by monitoring all work procedures involved in the efficient delivery of products. Equipment and procedural standards will be maintained in full compliance with government standards from the receipt of raw materials to the final discharge of finished product down the borehole.

Restricted access to the plant site and explosives storage areas will be maintained in compliance with Government of the Northwest Territories (GNWT) mining regulations. This includes inventory control as well as prohibition of firearms, sources of ignition and unauthorized personnel entry.

Decommissioning plans, which will be developed in conjunction with the selected contractor, will comply with all the Canadian Council of Ministers of the Environment (CCME) National Guidelines for Decommissioning Industrial Sites as well as GNWT regulations.

Appendix III-B1, Ammonium Nitrate Storage and Emulsion Manufacturing Plant, provides a more detailed description of the transportation, storage, manufacture, retrieval and use of bulk explosives planned for the project.

Summary

This section described plans for the management of material. The plan focuses on producing a framework that puts environment and worker safety first. The plan uses legal requirements and experience to provide guiding principles. Finally, this management plan provides the basis for monitoring activities that will be incorporated into a larger environmental monitoring plan.

5. Waste Management Plan

This management plan describes how waste from mining activities (rock, tailings, run-off and chemical use) and from human activities (sewage) can be managed in such a way as to minimize the impact on surrounding areas.

The waste management plan contains four parts: materials reactivity assessment, waste rock and tailings, hazardous substances, and non-hazardous substances. Each of these parts deals with a waste product generated by the project which has the potential to affect the environment. Possible effects range from pollution to encouraging unwanted human/wildlife interactions. The activities described in this plan minimize the possibility of these problems.

5.1 Materials Reactivity Assessment

Environmental effects of mining operations are partly dependent on the geochemical reactivity of mine materials, including waste rock, tailings and mine walls. The reactivity of these materials determines the chemistry and quality of water which comes in contact with these materials. To ensure that drainage water does not negatively affect the environment, an understanding of materials reactivity is essential. By understanding materials reactivity, the NWT Diamonds Project will be able to operate within government set limits, as well as following the Proponent's environmental policies. As described below, the project has used government defined standards to measure reactivity.

5.1.1 Methodology and Sample Selection

The Canadian government has joined together with provincial governments, research organizations and mining companies to sponsor technical studies to better assess, predict and manage drainage chemistry at mine sites. The joint programs, coordinated by the Mine Environment Neutral Drainage (MEND) Program of Natural Resources Canada, have recommended various tests for predicting future drainage chemistry. As described below, these tests have been used for this Environmental Impact Statement (EIS). The detailed technical explanations of these tests and the results are contained in Appendices III-C1 to III-C3 of this EIS.

The MEND Program and its partners recommend a suite of "static" and "kinetic" tests for the prediction of future drainage chemistry. Static tests are one-time analyses of selected samples that determine the geochemical characteristics at the time of analysis. Kinetic tests involve repetitive testing of a sample, usually every week or every month, to determine how geochemical characteristics change through time.

Static tests typically require less than a day to complete, whereas kinetic tests typically require up to a year or more to complete. For this EIS, hundreds of static tests have already been completed, and kinetic tests are underway. As a result, predictions of drainage chemistry for the NWT Diamonds Project are currently based on static tests, even though these static tests sometimes exaggerate potential water chemistry problems. Kinetic test results will be used, when completed, to more accurately predict expected drainage chemistries.

For the NWT Diamonds Project, three static tests have been used, namely acid-base accounting (ABA), mineralogical examinations and short-term leach (SWEP) tests. Each of these tests will be described below and then the samples submitted for each test listed.

5.1.1.1 Acid-Base Accounting (ABA)

ABA is the primary static test in Canada for the prediction of drainage chemistry. This test has two basic objectives: first, to determine the maximum amount of acidity that may be generated by each sample; and second, to determine the amount of base (alkalinity) that may be generated by each sample. If the maximum amount of acidity exceeds the maximum amount of base, the sample is declared to be potentially acid-generating. This may not happen immediately and may require years before all the base is consumed and net acidity appears. Additionally, a sample may not actually release the maximum amounts of acidity and base detected by ABA because, as mentioned above, the static tests may suggest drainage chemistry problems that will never arise. This uncertainty is also the reason that static test predictions include the word “potentially.”

From a more technical perspective, ABA defines the maximum amount of potential acidity, or Total Acid Potential (TAP), based on a measurement of total sulphur in a sample. TAP is calculated under the assumption that all sulphur is in the form of completely reactive, acid-generating sulphide minerals such as pyrite. This is not always the case, and thus the expanded form of ABA used here identified non-acid-generating forms of sulphur such as gypsum (hydrated calcium sulphate). The potential amount of acidity attributed to the acid-generating forms of sulphur is known as the Sulphide Acid Potential (SAP).

ABA defines the maximum amount of potential base, or Neutralization Potential (NP), based on a measurement of the amount of sample that dissolves in acid. Since several minerals dissolve in acid, the expanded form of ABA used here included analyses of the amount of NP derived solely from typically fast dissolving carbonate minerals such as calcite (CaNP).

When SAP is subtracted from NP, the Sulphide-based Net Neutralization Potential is obtained (SNNP = NP - SAP). A negative value of SNNP indicates a sample may potentially become acidic someday. A positive value of SNNP indicates a sample may generate net alkalinity. Values close to zero are considered “uncertain” in their potential.

Similarly, when NP is divided by SAP, the Sulphide Net Potential Ratio is obtained (SNPR = NP / SAP). SNPR is now widely used in Canada and is replacing the use of SNNP in some places. SNPR is used for the NWT Diamonds Project, although the results of SNNP are included in the detailed technical results and are consistent with SNPR values (Appendix III-C1).

The critical value, or "criteria", for SNPR that separates potentially net acid-generating samples from net base-generating is different for various rock types. SNPR values <1.0 are often considered potentially acid-generating, whereas values >2.0 are often declared base-generating. Samples with SNPR between 1.0 and 2.0 are labelled "uncertain" and require kinetic testing for clarification.

As explained in Appendix III-C1, SNPR criteria for granite, schist, till, and lake sediments at the project site apparently lies between the common values of 1.0 and 2.0. However, as shown by the ABA results, the criteria for kimberlite apparently lies between 4.0 and 6.0. In other words, kimberlite may require four to six times more maximum base potential (NP) than Sulphide Acid Potential (SAP) to remain neutral or alkaline indefinitely.

The final aspect of ABA is known as "paste pH" in which pH is measured in a mixture of water and pulverized sample. Paste pH indicates whether the sample was acidic, neutral or alkaline at the time of analysis. As a result, it indicates the current status and the current drainage chemistry that may be associated with a sample.

When all of the preceding information is compiled, a table of interim criteria is created for deciding the current drainage chemistry and the future drainage chemistry (Table 5.1-1). This table is used with analytical results in Section 5.2, to classify each sample submitted for ABA.

At the NWT Diamonds Project, five kimberlite pipes will be developed: Koala, Panda, Fox, Leslie, and Misery. Surrounding the pipes is "host rock" which is typically granite or occasionally schist. Overlying each pipe and beneath the corresponding lake, till and lake sediments are often found. Portions of all these rock and soil units will be disturbed by mining. As a result, representative samples were collected of each unit around each pipe and submitted for ABA analysis. This led to a total of 220 samples (Table 5.1-2).

5.1.1.2 Mineralogical Examinations

A second type of static test involves the visual examination and identification of minerals in selected samples. The visual work is performed on "thin sections"

Table 5.1-1
Interim Criteria for Drainage Chemistry
at the NWT Diamonds Project

Category	Criteria for Granite, Schist, Till and Lake Sediments	Criteria for Kimberlite
Currently net acidic	paste pH <6.0	paste pH <6.0
Currently near neutral	≤6.0 paste pH ≤9.0	≤6.0 paste pH ≤9.0
Currently net alkaline	paste pH >9.0	paste pH >9.0
Net acid generating at some point	SNPR <1.0	SNPR <4.0
Uncertain	≤1.0 SNPR ≤2.0	≤4.0 SNPR ≤6.0
Neutral at some point[1]	SNPR >2.0 & ≤6.0 pH ≤9.0	SNPR >6.0 & ≤6.0 pH ≤9.0
Net base (alkaline) generating at some point[1]	SNPR >2.0 & pH >9.0	SNPR >6.0 & pH >9.0

1: Samples with <0.05%S sulphide have virtually no capacity for acid generation and thus were assigned an SNPR of 100.0 which prevents them from being assigned to the net-acid-generating and uncertain categories. This value of 100.0 is also consistent with SNPR values of samples with sulphide slightly above 0.05%S and is thus appropriate for calculations of population statistics.

Table 5.1-2
Samples Submitted for ABA Analyses
on the NWT Diamonds Project

	Unit	Number of Samples		Unit	Number of Samples
Koala	Granite	5	Leslie	Granite	6
	Kimberlite	36		Kimberlite	12
	Till	3		Lake sediments	1
	Lake sediments	1	Misery	Schist	5
Panda	Granite	12		Granite	6
	Kimberlite	24		Kimberlite	32
	Till	2		Lake sediments	3
Fox	Granite	50			
	Kimberlite	14			
	Till	7			
	Lake sediments	1		**Total**	**220**

which are portions of samples mounted on glass slides and ground to a thickness where light can pass through them. This allows the use of standard geologic and mineralogic techniques to identify and characterize minerals (Appendix III-C2). The objective of this static test is to determine the types and percentages of various minerals that are potentially net acid-generating, net base-generating, and relatively inert. For example, one assumption in ABA (Section 5.1.1) is that all measured sulphide occurs in a form capable of eventually generating acidity. Mineralogical examinations reveal whether such assumptions are reasonable and accurate. For the NWT Diamonds Project, five samples which had visible sulphide minerals were examined (Table 5.1-3).

Table 5.1-3
Samples Submitted for Mineralogical Examinations on the NWT Diamonds Project

Source	Unit	Number of Samples
Fox	Granite	1
Misery	Kimberlite	4

5.1.1.3 Short-term Leach Tests

A concern from the perspective of drainage chemistry is the amount of metals that can be released by rock and tailings into rainwater or surface water passing over and through them. One simple way to obtain this information is by simply rinsing samples with water once for a short time and then analyzing the rinse water for metal concentrations. These short-term leach tests represent the third static test used for the NWT Diamonds Project.

The technique used for this testwork was the modified special waste extraction procedure (SWEP). This technique is a legal procedure for industrial and hazardous wastes, but was used here simply as a convenient standard (Appendix III-C3). It involves:

1. crushing a sample until it passes through a 9.5 mm mesh, which is typical of the size used in kinetic testing

2. placing 50 g dry weight of sample in a bottle with a final volume of 1 L reagent-grade water

3. agitating the bottle for one hour

4. then filtering and analyzing the water. The aqueous concentrations as µg/L can then be back - calculated to a solid-phase content of readily leachable metals in units of mg/kg.

This static test is not a replacement for kinetic tests, which provide leaching rates over extended periods of time as a sample adjusts and reacts to its surrounding environmental conditions. Nevertheless, it provides an indication of metal release after short periods of exposure to air and moisture.

In order to obtain short-term metal leaching rates, a total of 14 samples (Table 5.1-4) were selected from the 220 samples submitted for ABA.

Table 5.1-4
Samples Submitted for Short-Term Leach Tests on the NWT Diamonds Project

Source	Unit	Number of Samples	Source	Unit	Number of Samples
Koala	Granite	1	Leslie	Granite	1
	Kimberlite	3		Kimberlite	1
Panda	Granite	1	Misery	Kimberlite	2
	Kimberlite	2			
Fox	Granite	1			
	Kimberlite	2			
				Total	**14**

5.1.1.4 Evolution of Aqueous pH Through Time

In addition to the three static tests explained above, testwork was conducted on eight water samples from drill holes in the Leslie area. These drill water samples were the highest recorded in the 1995 drilling program and had initial pH values between 9.5 and 10.6. The evolution of pH towards lower values over the period of four days was recorded and used to identify a potential control on alkaline pH.

5.1.2 Results of Static Tests

5.1.2.1 Acid-Base Accounting

The key results of ABA, as explained in Section 5.1.1, are the delineation of current conditions and the predictions of future conditions. Current conditions are based on paste pH, whereas future conditions are predicted from SNPR and paste pH (Table 5.1-1 and Appendix III-C1). For the NWT Diamonds Project, 220 samples have been submitted for ABA (Table 5.1-2).

The results indicated that only lake sediments are currently acidic (Table 5.1-5), but this acidity is thought to be from natural organic reactions rather than from oxidation of sulphide minerals. Alkaline conditions are currently prevalent (in more than 50% of samples from a unit) in all granites and till from Koala and Fox.

Table 5.1-5
Current Conditions Based on Paste pH
(see Table 5.1-1 for criteria)

Unit		Number of Samples	% Net Acidic	% Near Neutral	% Net Alkaline
Koala	Granite	5	0.0	0.0	100.0
	Kimberlite	36	0.0	100.0	0.0
	Till	3	0.0	33.3	66.7
	Lake sediments	1	0.0	100.0	0.0
Panda	Granite	12	0.0	0.0	100.0
	Kimberlite	24	0.0	100.0	0.0
	Till	2	0.0	100.0	0.0
Fox	Granite	50	0.0	28.0	72.0
	Kimberlite	14	0.0	57.1	42.9
	Till	7	0.0	14.3	85.7
Leslie	Granite	6	0.0	0.0	100.0
	Kimberlite	12	0.0	0.0	100.0
	Lake sediments	1	100.0[1]	0.0	0.0
Misery	Schist	5	0.0	80.0	20.0
	Granite	6	0.0	0.0	100.0
	Kimberlite	32	0.0	100.0	0.0
	Lake sediments	3	100.0[1]	0.0	0.0

1: The current acidity is believed to be from natural organic reactions rather than sulphide oxidation.

Predicted future conditions (Table 5.1-6) point to net acidic conditions primarily from a small fraction of Fox granite, from portions of Misery kimberlite and from lake sediments at Fox and Misery. Net alkaline conditions are predicted primarily for granites on a tonnage basis, with additional net alkalinity from some tills, kimberlites and a portion of the Misery schist. Most of the Misery schist, however, is uncertain in its drainage status. From this information, it is clear that most units cannot be assigned solely to one drainage category. In any case, on the basis of tonnage alone, most of the mined material at the NWT Diamonds Project is expected to generate alkaline drainage.

5.1.2.2 Mineralogical Examinations

The objective of this testwork is to determine the types and percentages of various minerals that are potentially net acid-generating, net base-generating and relatively inert in the five samples listed in Table 5.1-3. The four kimberlite samples were

Table 5.1-6
Predicted Long-Term Mine Drainage Conditions for Mined Tonnages (and Percentages) of Each Rock Unit
(see Table 5-1 for criteria and Appendix III-C for data)

Unit		Net Acid Generating-tonnes (%)	Uncertain - tonnes (%)	Neutral - tonne (%)	Net Base Generating-tonnes (%)	Total Tonnage to be Mined[1]
Koala	- granite	0 (0%)	0 (0%)	0 (0%)	54×10^6 (100%)	54×10^6
	- kimberlite	0 (0%)	0.54×10^6 (2.8%)	19×10^6 (97.2%)	0 (0%)	19×10^6
	- till	0 (0%)	0 (0%)	0 (0%)	17×10^6 (100%)	17×10^6
	- lake sediments	0 (0%)	0 (0%)	0.27×10^6 (100%)	0 (0%)	0.27×10^6
Panda	- granite	0 (0%)	0 (0%)	0 (0%)	105.0×10^6 (100%)	105×10^6
	- kimberlite	0 (0%)	0 (0%)	18×10^6 (100%)	0 (0%)	18×10^6
	- till	0 (0%)	3.7×10^6 (50%)	3.7×10^6 (50%)	0 (0%)	7.4×10^6
Fox	- granite	16×10^6 (6.0%)	5.2×10^6 (2.0%)	52×10^6 (20.0%)	188×10^6 (72.0%)	261×10^6
	- kimberlite	0 (0%)	0 (0%)	17×10^6 (57.1%)	13×10^6 (42.9%)	30×10^6
	- till	0 (0%)	0 (0%)	1.8×10^6 (14.3%)	11×10^6 (85.7%)	13×10^6
	- lake sediments	0.37×10^6 (100%)	0 (0%)	0 (0%)	0 (0%)	0.37×10^6
Leslie	- granite	0 (0%)	0 (0%)	0 (0%)	320×10^6 (100%)	320×10^6
	- kimberlite	0 (0%)	0 (0%)	0 (0%)	62×10^6 (100%)	62×10^6
	- lake sediments	0 (0%)	0 (0%)	0.59×10^6 (100%)	0 (0%)	0.59×10^6
Misery	- schist[2]	0 (0%)	26×10^6 (60.0%)	8.6×10^6 (20%)	8.6×10^6 (20%)	43×10^6
	- granite[2]	0 (0%)	0 (0%)	0 (0%)	43×10^6 (100%)	43×10^6
	- kimberlite	0.21×10^6 (6.3%)	0 (0%)	3.2×10^6 (93.7%)	0 (0%)	3.4×10^6
	- lake sediments	0.44×10^6 (33.3%)	0 (0%)	0.87×10^6 (66.7%)	0 (0%)	1.3×10^6
***Total Tonnes[3]**		**17×10^6**	**35.4×10^6**	**125×10^6**	**822×10^6**	**998×10^6**

1: Tonnage data provided by BHP Diamonds Inc., except lake sediments and till which were estimated from the lateral area of pipe to be mined and thicknesses of 0.6 m (for sediments) and average thicknesses from Section 2 (for till) as provided by BHP Diamonds Inc.
2: Reported tonnage does not differentiate schist from granite; this table assumes each unit will comprise 50% of total tonnage (86.0×10^6 t).
3: Total only for units sampled and reported in Appendix III-C; sediments and till for some pipes have not been analyzed.

predominantly composed of fine-grained material resembling mudstone containing mica and clay. Visible grains comprising <20% of the samples included olivine, quartz, garnet, biotite, serpentine and pyrite. The dominant form of sulphide was pyrite, often in the well-known, reactive form of framboids and specks. This justifies the ABA assumption in Section 5.1.1 and 5.1.2 that sulphide is reactive and capable of generating acidity upon exposure to air and moisture. Another reactive form of sulphide, marcasite, was also occasionally noted.

The four kimberlite samples were reportedly lacking carbonate, in general agreement with CaNP results (Appendix III-C2). Therefore, most of the bulk Neutralization Potential (NP) must predominantly reflect the unidentified minerals in the dominant fine-grained mudstone. One of the kimberlite samples had a relatively low NP and the only major mineralogical difference was the general lack of visual olivine. Consequently, the high NPs of kimberlite appear to be associated with the presence of this mineral.

In addition to the four kimberlite samples, one sample of Fox "granite" was examined (Table 5.1-3). This sample, collected from the only net acid-generating material identified to date in this unit (Table 5.1-6), was in fact a diabase dike inside the granite. Half the sample is composed of plagioclase, likely calcium rich, and 45% pyroxene and amphibole. These minerals neutralize acidity too slowly to be completely detected in the 24 hour NP test used in ABA, but can successfully neutralize acidity over longer periods of time. Therefore, although the diabase contains about 1% reactive pyrite and pyrrhotite, the 95% content of feldspar, pyroxene and amphibole will likely neutralize all acidity upon oxidation if rates of acid generation are relatively slow. At this time, the mine plan considers this rock to eventually be net acid-generating and it will thus be handled accordingly (Section 5.2). As with the kimberlite samples, no carbonate minerals were noted and thus NP is attributed to one or more other minerals.

5.1.2.3 Short-Term Leach Tests

Fourteen samples were submitted for the short-term SWEP leach tests (Table 5.1-4), as explained in Section 5.1.1. The results of the tests indicated that the short-term leaching of various trace and heavy metals is variable, but detectible from both granites and kimberlites.

5.1.2.4 Evolution of Aqueous pH Through Time

As explained in Section 5.1.1, eight samples of Leslie drill water were collected and allowed to stand for several days. During this time, changes in aqueous pH were measured. This testwork showed that initial pH values as high as 10.6 fell below 9.0 within two days and stabilized around 8.0 to 8.3 after four days (Figure 5.1-1). This effect is apparently due to the ingassing of atmospheric CO_2 and the resulting formation and dissociation of carbonic acid (H_2CO_3). As a result, a key control of

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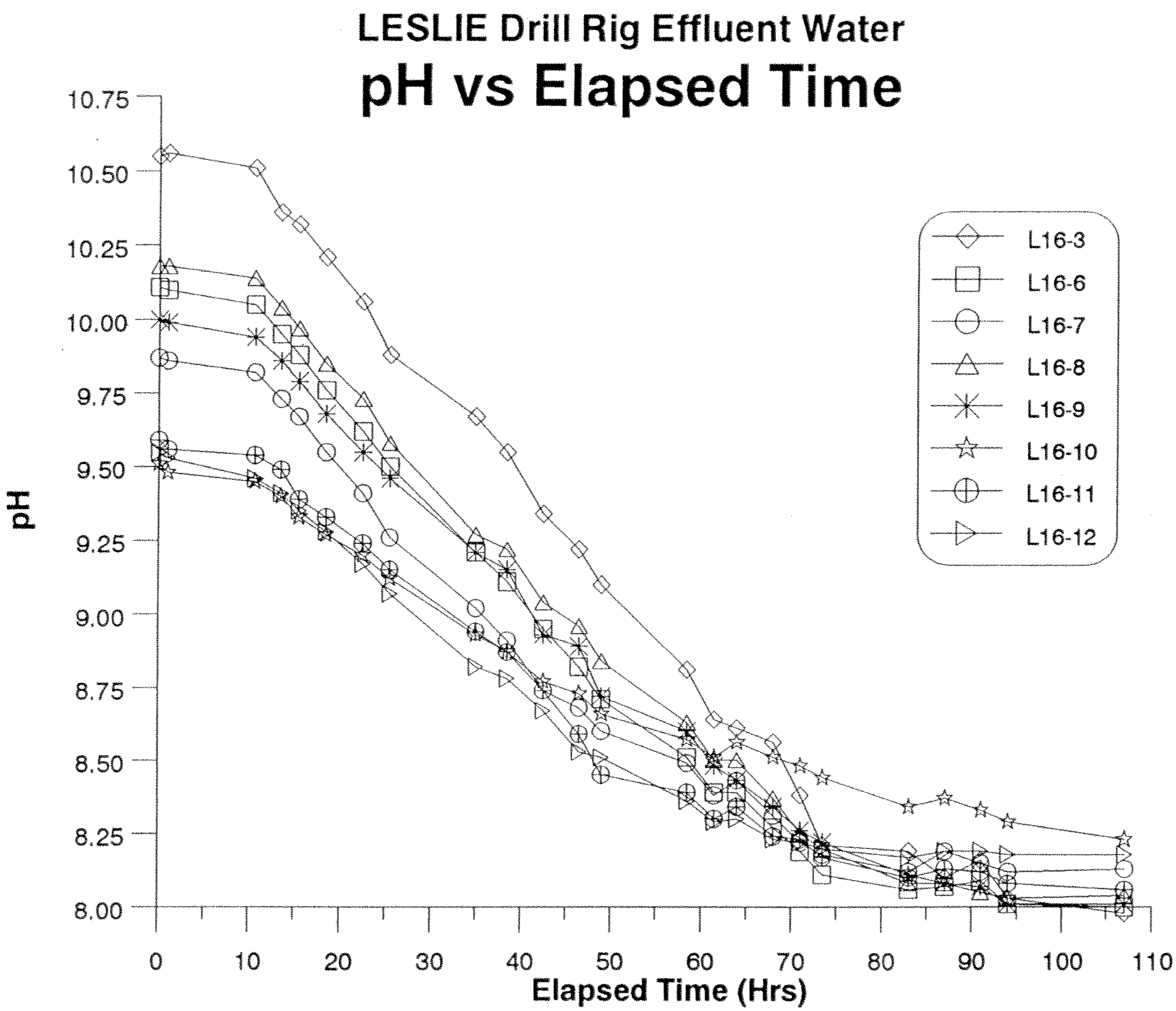

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Figure 5.1-1
Evaluation of Aqueous pH Through Time

Source: Rescan

alkaline drainage at the NWT Diamonds Project may lie in rapid and thorough aeration of drainage waters.

5.2 Tailings Management Plan

5.2.1 Tailings Management

The diamond processing plant will produce 133 million tonnes of mine tailings during the planned 25 years of operation. The tailings will comprise of ground kimberlite rock with no chemical additives except water treatment flocculants. Unlike other mine tailings in the NWT, they will contain a component of clay minerals that are slow to settle and consolidate in water. The proportion of clay minerals varies significantly from pipe to pipe and to a lesser extent within any individual pipe. The presence of clay results in potentially elevated concentrations of suspended solids in disposal ponds that must be managed to protect the downstream aquatic ecosystem. Design of the tailings management system is therefore constrained by requirements to discharge only that water which meets established criteria for metals, suspended solids, and other approved parameters, and to provide a stable, restored landscape at closure. Upon abandonment, natural precipitation must flow freely over the restored landscape into surrounding streams and lakes without risk of surpassing the permissible levels of relevant parameters. All of these considerations have been factored into the tailings management plans discussed below.

5.2.2 Tailings Properties and Behaviour

5.2.2.1 Composition

The composition of the fine tailings delivered to the Long Lake basin will vary widely. Typically, 75% of the tailings are composed of fine to medium sand and 25% are composed of silt and clay; however, silt and clay may occasionally be in excess of 50% of the tailings. The clay content is lowest in the tailings derived from the ore that originates from the Leslie pipe and highest in the ore that originates from the Fox pipe. Geotechnical properties of the tailings have been determined by testing at the University of British Columbia (Byrne 1994) and the University of Alberta (Sego 1995). The properties are summarized in Table 5.2-1 for Panda and Fox tailings – the two pipes from which underground samples were taken and processed. The high liquid and plastic limit of the fine portion of the tailings suggest the presence of smectite (montmorillonite) clay minerals. These minerals are the by-product of weathering of the source rocks within the kimberlitic zone.

Table 5.2-1
Geotechnical Properties of Tailings

Parameters	Panda Tailings	Fox Tailings (Flocculated Sample)
Specific Gravity	2.6	2.9
Fines Content (<0.074mm)	2-20%	35-70%
Plasticity Liquid Limit		83.4% (complete sample)
		248.5% (segregated slurry)
Plastic Limit		39.9% (complete sample)
		74.8% (segregated slurry)
Permeability (cm/s)	3×10^{-8} (at void ratio 1.5)[1]	
	2×10^{-7} (at void ratio 2.5)[1]	
	4×10^{-7} (at void ratio 1.5)[2]	
	2×10^{-6} (at void ratio 2.5)[2]	
Compression Index	3.5 - 4.5 (in 1-10 kPa range)[1]	
	~ 3.5 (in 1-10 kPa range)[2]	
	~ 0.67 (in 10-300 kPa range)[3]	
Coefficient of Consolidation (cm^2/s)	3×10^{-4} - 0.003 (in 10-300 kPa range)[1]	
	0.004 - 0.01 (in 10-300 kPa range)[2]	
Void ratio	6.0 (at 1 kPa)[1]	
	2.3 (at 10 kPa)[1]	
	1.7 (at 100 kPa)[1]	

Note 1. For fine tailings (20% <0.074 mm).
2. For mixed tailings (15% <0.074 mm).
3. For both fine and mixed tailings.

5.2.2.2 Settling and Consolidation

Tailings discharged from the pipeline will segregate readily into sand with some entrapped silt and clay, and segregated slurry that comprises most of the silt and clay sized fraction. The sand fraction is predicted to immediately form a beach that will be relatively dense and could support wide-track, light-vehicles. The slurry fraction will have a high water content with a solids content of approximately 20% by weight. This behavior is consistent with published data from South Africa for tailings with similar texture, plasticity and slurry density (Blight 1994) and was demonstrated in laboratory tests by Sego (1994).

The slurry component will be washed down the beach into a pond where it will settle and start to densify under its own weight, resulting in slow separation of consolidated slurry and water. For instance, if a 10 m high column of segregated slurry at a solids concentration of 20% were deposited, four years later it would have separated into an 8 m high column of consolidated slurry at a solids concentration of 23% and a 2 m high column of water. This consolidation behaviour, predicted using a finite strain consolidation model, is shown in Figure 5.2-1.

The smectitic clays can resuspend in water with slight disturbance, resulting in turbid water. The turbidity of the water will vary with season. The solids settle during the winter, when the water surface is shielded by ice and the water body under the ice is at a near constant temperature with increasing depth (i.e., it is isothermal). The tailings management plan proposes to maximize removal of suspended particles in the tailings slurry by filtration through a segregated coarse fraction of the tailings placed on the upstream face of the intermediate tailings retention dikes and using the freeze-thaw settling process (discussed in next section). A series of geotechnical tests are in progress at the University of Alberta to determine the fraction and source of tailings that can successfully filter the fine-grained particles in the tailings slurry.

5.2.2.3 Erosion Resistance

Tailings beaches created at Long Lake may be exposed to wind erosion for several years. The beaches consist mainly of sand, with small quantities of silt and clay. The sand is expected to be more resistant to wind erosion and will entrain sufficient silt and clay to develop a firm, dry surface that will not produce dust. An important objective of the tailings management plan will be to restore the surface with an engineered cover, so that tailings surfaces will not be exposed for an extended period of time.

5.2.2.4 Clarification by Freeze-thaw Process

Negative pore pressures are generated when water and ice coexist at temperatures below freezing. These negative pore pressures pull the sediment particles together as the sediment freezes, resulting in densification and a blocky soil structure. Freezing has been used successfully in pilot projects to densify fine tailings in the past at Suncor and Syncrude oil tar sands operations in Alberta (Dawson 1993, Sego 1993, Stahl 1993, Sego 1994). Testwork at the University of Alberta (Sego 1994) indicates that freezing of segregated slurry will result in coagulation of suspended particles to form larger particles that rapidly settle after the ice thaws. Systematic freezing might therefore be a useful technique to clarify turbid water. Freezing of the Exploration tailing pond over the winter of 1995 resulted in TSS reductions to under 20 ppm.

There are three sources of tailings from the process plant as follows:

1. fines (-1 mm) from degritting following primary and secondary scrubbing

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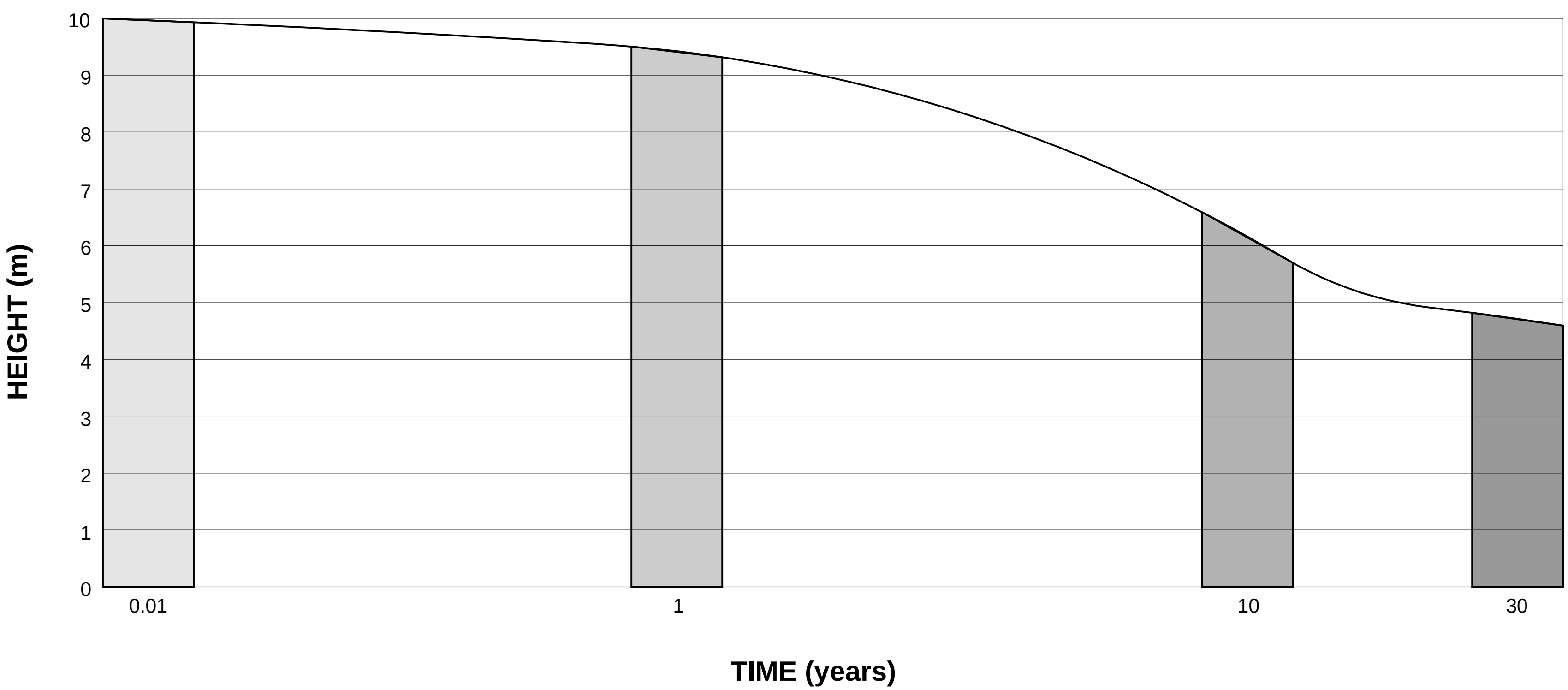

PARAMETERS USED IN FINITE STRAIN CONSOLIDATION ANALYSIS
(AFTER CARRIER ET AL, 1983)

A = 6
B = -0.35
E = 0.008
F = 4

UNITS = kPa, m, yrs

BASED ON CONSOLIDATION TESTS BY BYRNE (1994)
INITIAL VOID RATIO = 10

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Figure 5.2-1
Consolidation of 10m High Column of Segregated Slurry

Source: EBA Engineering

2. fines from heavy medium separation (HMS) waste (-1 mm)

3. coarse HMS and recovery plant waste (-25 to +1 mm).

A guiding principle of the tailings management plan is that any discharges to the aquatic environment meet all established compliance criteria established for metals, suspended solids and other approved parameters. It must also ensure a stable landscape at closure over which natural precipitation will freely flow without risk of exceeding permissible water quality.

The coarse sand and gravel sized fraction (-25 to +1 mm), comprising 10% to 20% of the tailings, will be trucked to a dry disposal location at the Koala waste rock dump. The remaining tails will be pumped to the Long Lake disposal facility after one of two thickening options. Option 1 proposes flocculation of the entire -1 mm tailings fraction, reclaiming water for process purposes and pumping the remainder for disposal. Option 2 calls for the -1 mm streams to be pumped to the sanding plant and cycloned. The cyclone overflow (-0.1 mm) will be flocculated, process water reclaimed from it and thereafter pumped for disposal after mixing with the cyclone underflow (-0.1 mm). For either option, average solids content of the -1 mm fraction has been calculated as 45% by weight. Two heat-traced, insulated pipelines one operating/one standby will transport the tailings to the discharge facility.

Long Lake will serve as the tailings disposal pond for the first 20 years of operation. Tailings generated beyond the 20 year period will be disposed of in exhausted pits that are formed from mined out pipes. The storage volume within the existing lake will be increased by construction of 2,300 m of perimeter dams that are designed for complete water and tailings containment. The dams have been designed with a permafrost core that is completely impervious to water or tailings. Four intermediate interior dykes will be constructed from waste rock to subdivide the basin into five cells. Sequential filling of individual cells will optimize available storage volume and increase the flexibility of the disposal scheme.

Water will be pumped from Long Lake to lower its level by 2 m before initiating tailings deposition. The upper portions of the basin will be filled first, progressively moving from the uppermost cells to the lowermost cells. This sequence is planned to confine the ponds of turbid water during the first 18 years of operational life, allowing continued discharge of clean runoff collected by cells lower in the basin before tailings deposition occurs at these locations.

The deposition plan provides 20 years of tailings storage in the Long Lake basin and at least 18 years of storage of turbid water. Excess turbid water beyond the 18 year period will either be treated to remove any deleterious substance prior to discharge or will be pumped to a surplus open pit for clarification and settling. The tailings surface will be progressively reclaimed as each cell within the basin is filled. All surface water will be drained and frost penetration will be encouraged to form a firm crust. An engineered cover of select waste rock, layered with coarse sand and gravel sized material will be constructed on the frozen surface. A final cap of organic soil, removed from lake bottoms will be spread on the surface. Revegetation of the surface will convert the tailings basin into a wetland environment.

The engineered cover will be sufficiently thick to contain the new active layer. Thermal modelling has shown that permafrost will form in at least 80% of the tailings within 50 years and 100% of the tailings approximately 150 years after the rock/soil cover is placed. Thus, all of the tailings that are hydraulically placed in Long Lake will eventually revert to a permafrost condition.

A drainage channel will be constructed over the restored tailings to conduct surface water to a residual pond that will remain at the south (lower) end for at least five years after tailings filling. The channel has been engineered to provide a non-erosive cover over the permafrost tailings. Runoff water conducted to the pond will be used in the process plant for a number of years after the basin has been restored. This will allow time for the restored landscape to stabilize and the water to flow clear naturally. The final stage of restoration of the Long Lake basin will begin near the end of the planned mine life when natural runoff is anticipated to meet all requirements of the water license and the spillway dam will be breached to form a permanent, uncontrolled outlet. Portions of the remaining basin may be selectively filled with waste rock.

Tailings generated after filling of Long Lake will be directed to exhausted mine pits. Either the Panda or Koala pits will be the first to receive tailings. The tailings will be discharged from a pipeline that extends at least 50 m into the pit in such a way that the tailings will consolidate leaving a water cover of at least 20 m. The water cover will increase with time as a result of consolidation. Once water level in the pit approaches its brim and if top layer water qulaity still does not meet discharge criteria, water will be pumped to an alternative pit or to a treatment facility and discharged. Water quality parameters within the lake that forms on top of the infilled pits will be monitored until the lake water meets the discharge criteria. These lakes will then be returned to the watershed.

5.2.2.5 Preparation of Tailings Disposal Facilities

Perimeter Containment Dams

Long Lake is situated at the headwaters of the Koala watershed which empties into Lac de Gras. The overall drainage basin that forms the present catchment for Long Lake is 45 km^2. Three perimeter containment dams are proposed to allow the water level of Long Lake to rise temporarily to an elevation of 457 m. The maximum embankment height is 462 m, which includes 4 m of extra embankment to provide thermal protection for the permafrost core, plus 1 m of design freeboard above the emergency spillway discharge elevation. The location of the perimeter dams is shown in Figure 5.2-2. They are referred to as the East Dam, Outlet Dam, and Spillway Dam. The Outlet Dam is located on the stream connecting Long Lake and Leslie Lake. The total length of the three dams is 2,300 m. The fill quantities required for dam construction and their sources are described in Table 5.2-2.

Table 5.2-2
Dam and Dike Fill Volumes

Perimeter Dam Fill Volumes				
	Volume (m^3)			
	Core	**Transition**	**Shell**	**Rip Rap**
East Dam				
- north leg	6,800	9,300	43,000	4,700
- south leg	42,100	35,500	147,000	14,000
Outlet Dam	24,700	22,400	95,000	8,700
Spillway Dam	37,900	26,300	108,000	9,100
Panda Diversion Dam	10,700	5,300	19,000	not required
Totals	122,200	98,800	412,000	36,500
Intermediate Dike Fill Volumes				
	Volume (m^3)			
	Rock Core	**Transition**	**Filter 1**	**Filter 2**
Dike A	335,000	46,000	46,000	
Dike B	168,000	29,000	29,000	
Dike C*	476,000	76,000	76,000	
Dike D	348,000	57,000		57,000
Totals	1,327,000	208,000	151,000	57,000

* Not required until tailings filling into Cell C is commenced.

<u>Material Sources</u>

Core	- Airstrip Esker
Transition	- Processed Quarry Rock(<150 mm)
Shell	- Mine Waste Rock
Rip Rap	- Processed Quarry Rock
Rock Core	- Mine Waste Rock
Filter 1	- Coarse (sand and gravel) Tailings
Filter 2	- Airstrip Esker

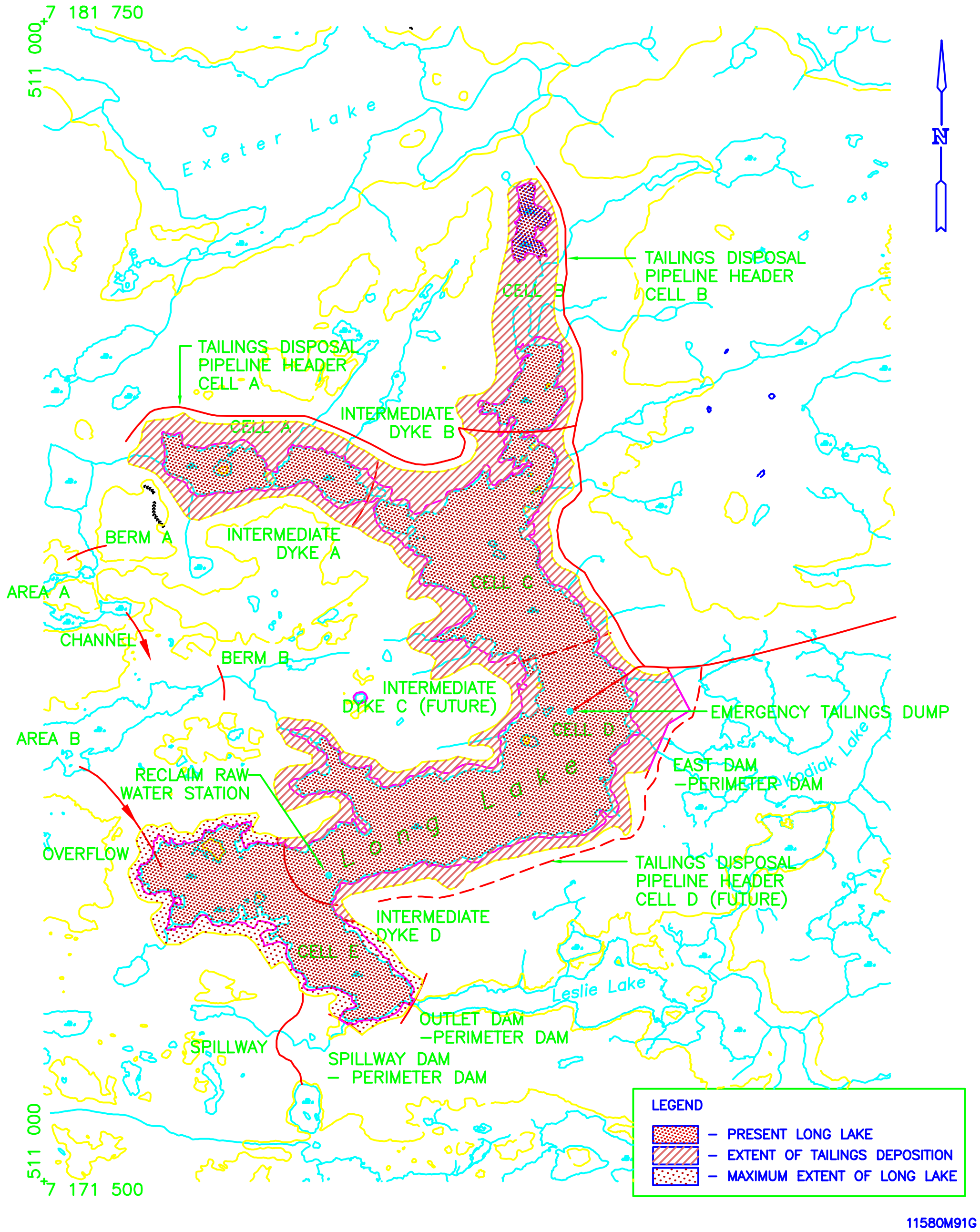

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Figure 5.2-2
General
Location Plan

Source: EBA Engineering

Design of the perimeter dams has been detailed in a comprehensive report (EBA 1995). The design basis was formed from geotechnical site data collected at all the dam locations during 1994. Soil and rock in the region were found to be under permafrost conditions everywhere except beneath lakes. The permafrost level under the outlet dam was found to be depressed.

Construction of 2,300 m of dams will need a large quantity of construction material. However, at the site the only embankment construction material available in useful quantities is quarry rock stripped as mine overburden, and to a lesser extent, glaciofluvial sand and gravel from eskers. These site-limiting factors dictate that the most appropriate design for combined water and tailings retaining structures is a frozen core embankment on a permafrost foundation. The design geometry and the construction schedule should be such that permafrost in the foundation as well as in the dam core will be sustained. The basic philosophy is that the permafrost soil core when placed as frozen ice-saturated sand will function as the seepage barrier for the dam, and the frozen foundation will effectively eliminate seepage through the foundation soils beneath the dam.

Typical design cross-sections for the perimeter dams are shown in Figure 5.2-3. Dams are proposed for construction during winter. The sand core will be pre-thawed and mixed with water to ensure complete saturation and thereafter placed in lifts in order to allow freezing prior to placement of subsequent lifts. Such a procedure ensures that the entire embankment will be frozen at the end of construction and the core will be ice-saturated. A rock shell will envelop the frozen sand core to contain seasonal summer thaw and provide protection against erosion.

The outlet dam being proposed at a location where there is a natural depression in the permafrost table, will be provided with thermosyphons to enhance heat removal from the foundation. These thermosyphons (Figure 5.2-3) will extract heat from the ground and dissipate it to the cold air thereby promoting formation of a frozen barrier cut-off underneath the dam before any water is allowed to rise against its upstream slope. Temperatures within the embankments and the foundations were checked over its 25-year design life for a condition of several consecutive warm years with statistical return period of once every 100 years, and were found to perform satisfactorily. The effect of heat from the reservoir on the frozen embankment and foundation was also investigated. Figure 5.2-4 shows the extent of frozen and unfrozen zones predicted within and below the embankment over the short term (one year) and the medium term (15 years) which shows that the frozen core and foundation will remain as an effective seepage barrier throughout the life of the structure and beyond.

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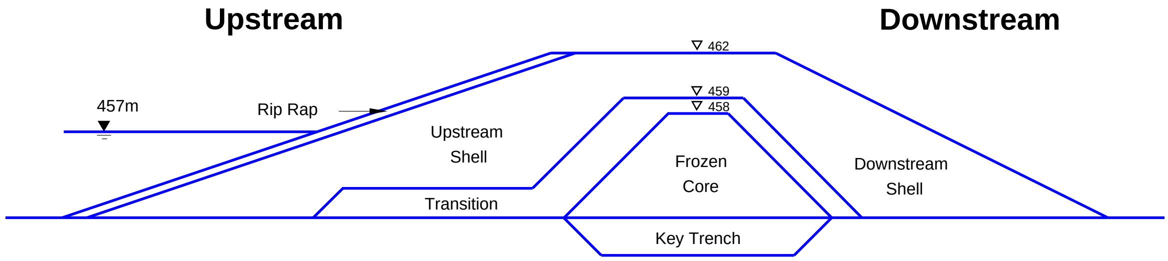
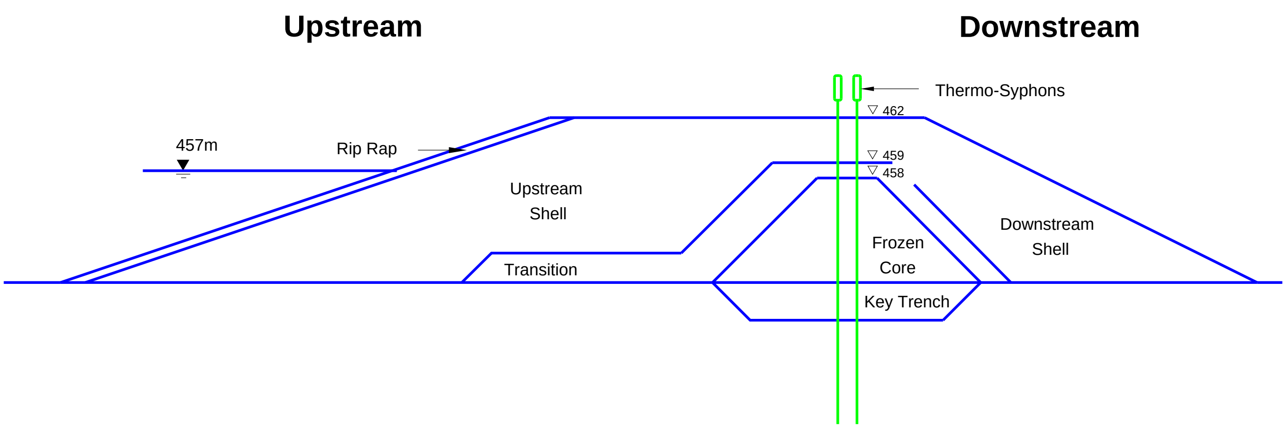


Perimeter Dam – Typical Cross Section
(Applicable to all Dams)



Perimeter Dam Founded on Talik – Typical Cross Section
(Applicable to Segment of Outlet Dam Only)

0 10 20
SCALE (metres)

NWT DIAMONDS PROJECT

Figure 5.2-3
Perimeter Dam
Typical Cross Section

Source: EBA Engineering

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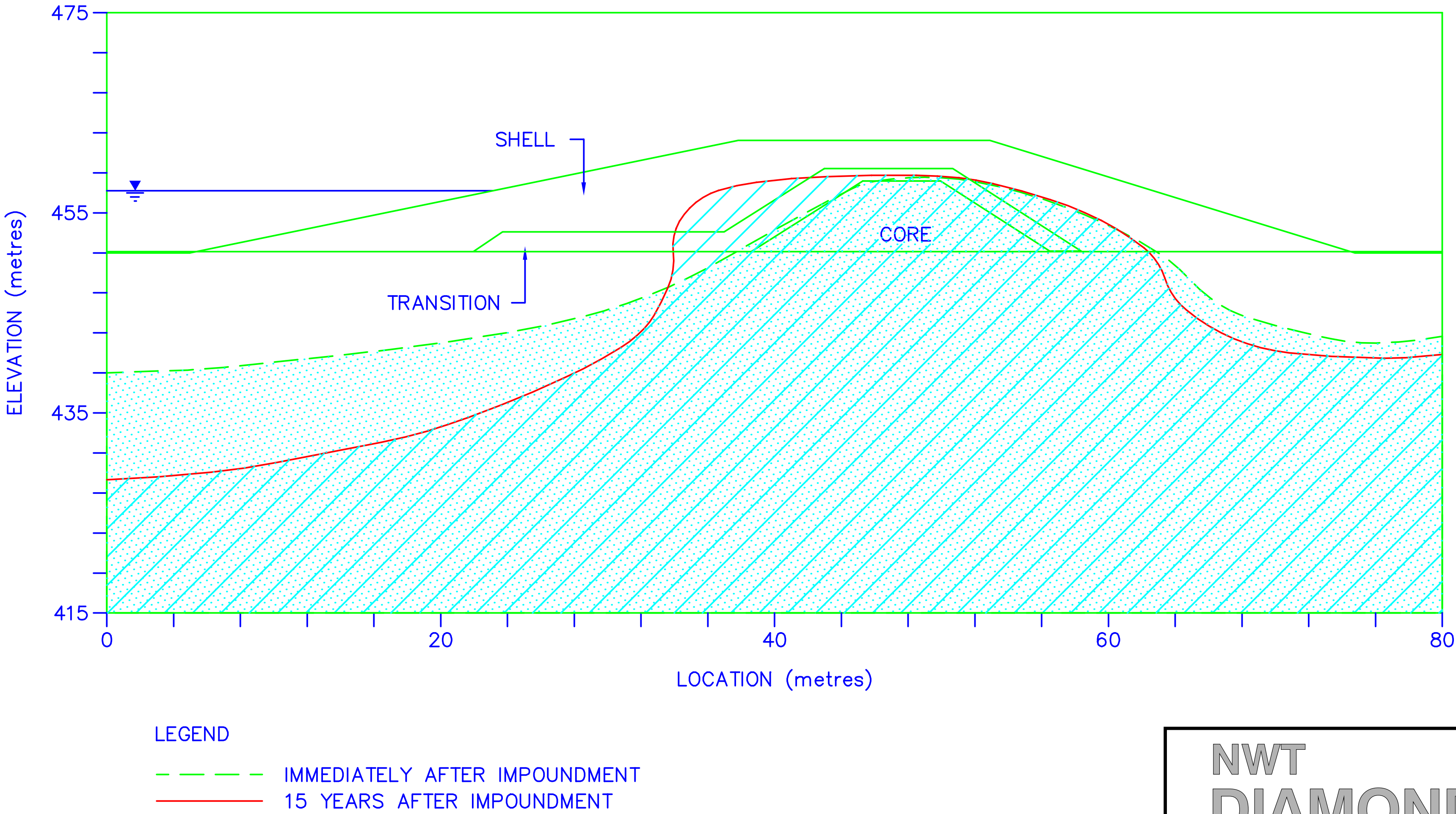

NWT DIAMONDS PROJECT

Figure 5.2-4
-2°C Isotherms in Perimeter Dam

Source: EBA Engineering

Intermediate Tailings Retention Dikes

The basin is planned to be subdivided into five cells by rockfill tailings retention dikes. The locations as shown in Figure 5.2-2, were selected at shallow water crossings. Dikes A and B will be constructed on potentially dry lake bed whereas the remaining two will be constructed in water. Three of the dikes (A, B and D) will be constructed before tailings are deposited and Dike C will be constructed just prior to tailings being deposited in Cell C, some five years after mine startup. The dikes will also serve as access roads for laying and maintaining tailings disposal pipelines.

The dikes will be constructed during the summer season by end dumping rockfill followed by two zones of filter transition material placed on the upstream face (Figure 5.2-5). To reduce risks of early contamination, the rockfill dike D will be surfaced with esker sand and gravel rather than coarse tailings. The dikes are designed either to provide full containment of tailings water or to act as a filter to remove suspended solids from water that seeps through the dam. At the beginning of each cell filling, a beach will be created against the upstream face of the dikes by depositing a layer of coarse rock which will not only help prevent passage of suspended solids but also seal the upstream foundation contact zone, thereby minimizing the risk of piping through the foundation. Water level behind the dikes will be controlled as planned, and when required, by transferring surface water to the next cell in sequential order.

Runoff Water Diversion Structures

It is prudent and planned to prevent runoff from coming into contact with tailings, thereby providing the opportunity to maximize release of natural runoff water from Long Lake without requiring treatment. Minor diversion works are planned to divert run-off that would normally enter Cells A and D directly to Cell E (Figure 5.2-2 and Figure 5.2-6, EBA). These diversions re-route runoff within the drainage basin and do not divert water into another watershed. Cell E will remain free of tailings, therefore runoff entering that cell will probably be suitable for discharge without treatment. The diversion structures consist of berms and channels as shown in Figure 5.2-2. The berms will be constructed of waste rock, with either a frozen sand core or a geotextile liner. They are planned not to sustain any continuous head of water but only to divert snowmelt and rainfall runoff.

5.2.2.6 Operation of Tailings Disposal Facilities

Long Lake Disposal

The basins are proposed to be filled from the upper end in cell sequence A, B, C and D. Cell E will not receive any tailings but will act as a final clarifier pond

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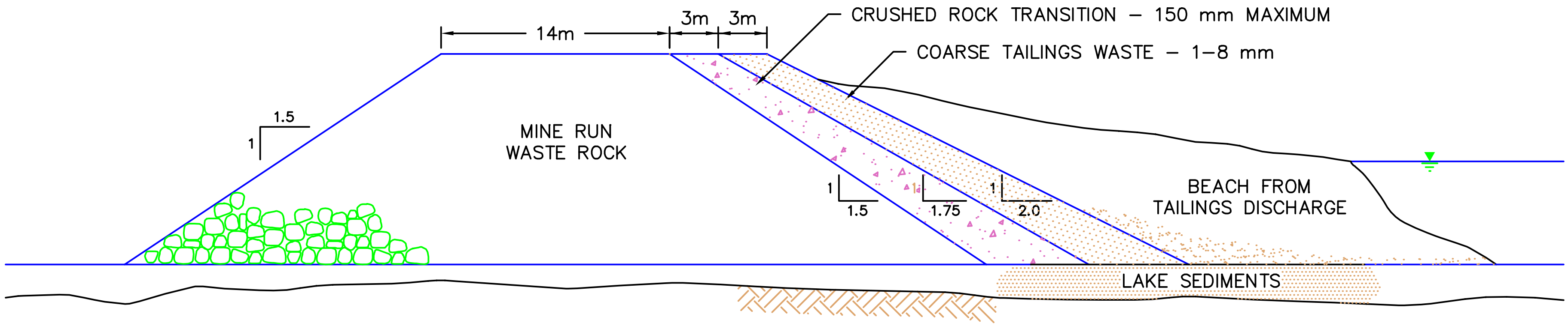
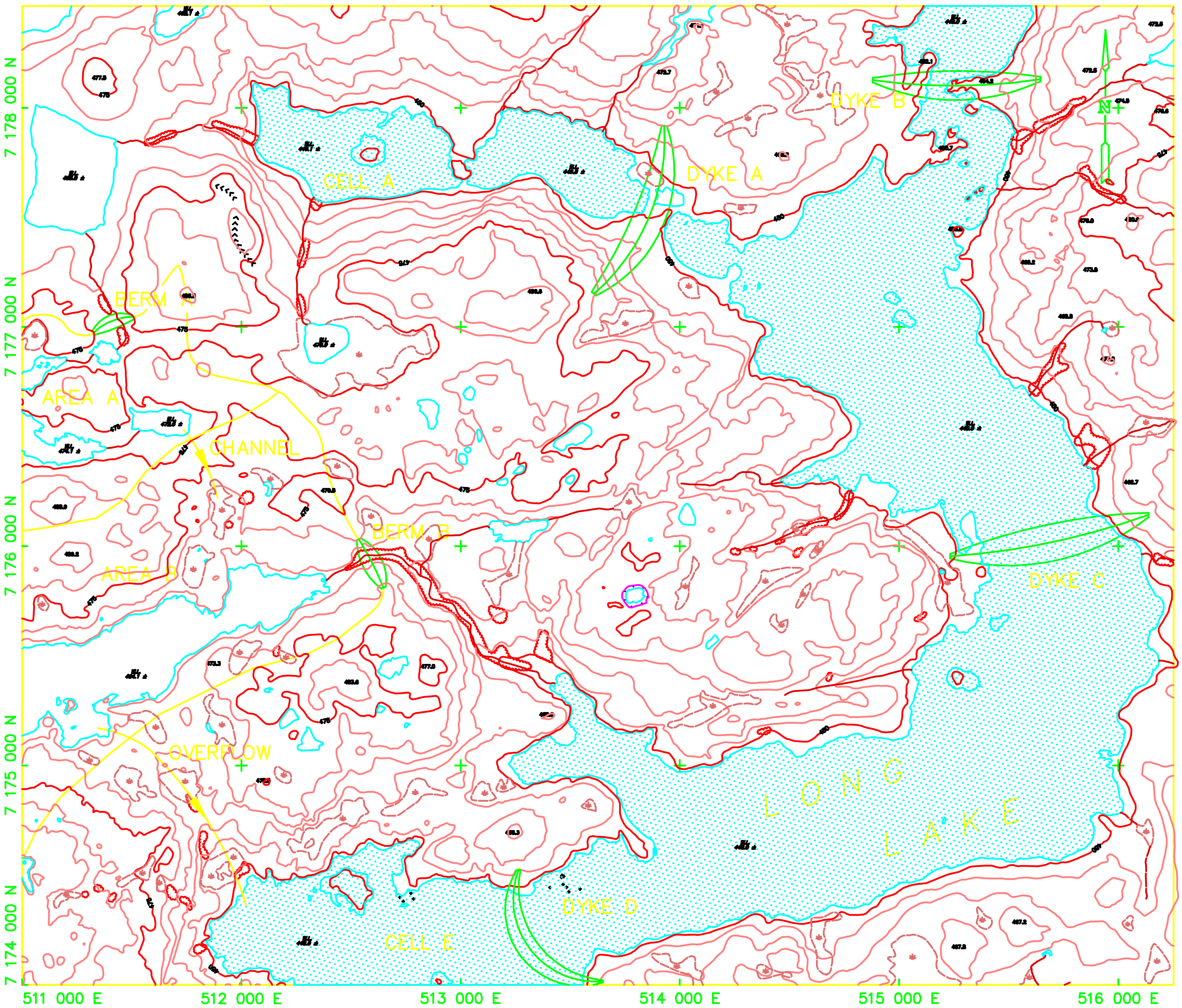


NWT DIAMONDS PROJECT

Figure 5.2-5
Intermediate Dike
Typical Cross Section

Source: EBA Engineering



NWT DIAMONDS PROJECT

Figure 5.2-6
Watershed Diversion Structures

Source: EBA Engineering

where water quality is monitored, and treated if required prior to discharge. At the time of mine startup, both Cells A and B will be ready to receive tailings.

The filling sequence is planned to follow the steps as described here. Cell A will be filled first by depositing on the upstream slope of the retention dike which will form a slurry of fines and act as a filter. Thereafter the discharge point will be changed to the upper end of the basin and slowly moved towards the dam to build consecutive beaches Figure 5.2-7. Tailings deposition methodology will be varied from summer to winter as shown in Figure 5.2-8 to accommodate severe sub-freezing weather. A long beach will be built in summer and a short beach will be maintained in winter.

The estimated beach profile has been determined from published data on behavior of similar tailings beaches at South African diamond mines (Blight 1994).

For winter operations, the discharge pipe will be moved down the beach to the shore of the pond to minimize ice entrapment, thus creating a new beach due to direct discharge of most of the tailings into the water. This will also minimize progressive ice buildup in the beach. During summer, however, the discharge point will be further away from the edge of the water to maximize deposition of fines. Winter discharge will result in some excess ice formation in the pond. The ice formation will thaw the following summer and will help to freeze-clarify the tailings slurry.

Once tailings discharge is started in Cell A, the unsettled slurry can be pumped during every winter season and discharged on ice over Cell B to initiate freeze clarification (Sego 1994). This phenomenon has been successfully tested and utilized at various operations and will be retested during the present project operations. An alternate plan proposes that the surplus slurry will be transferred (i.e., pumped) only after the water level in Cell A rises to 460 m, 2 m below the crest elevation of the dyke. Transfer of slurry from Cell A to Cell B will allow Cell A to be filled to an elevation of 462 m. Seepage through the intermediate dykes will also assist in filling up the cell with solids. When tailings deposition is commenced in Cell B, surplus slurry will again be pumped and sprayed over ice in Cell C during each winter season. Overtopping of slurry from Cell B to Cell C may also be allowed. Cell B will be filled to an elevation of 458 m before tailings deposition in Cell C is started. The same operational sequence will be followed as described above. Design average tailings elevations in Cells C and D are proposed to be 458 m and 455 m, respectively. Maximum possible water levels and final tailings elevations in various cells along the time required to fill up each of the cells are indicated in Figure 5.2-9.

Pit Disposal

Approximately five years after mine startup, the Panda pit will be exhausted. However, underground mining below the pit will require that it remains dry until

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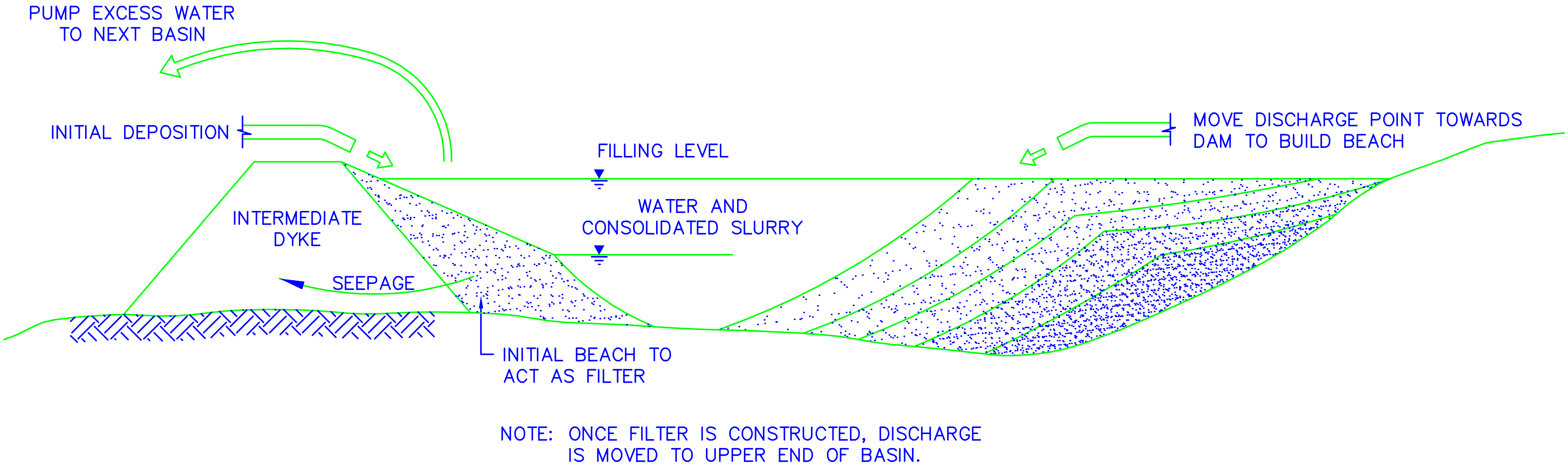
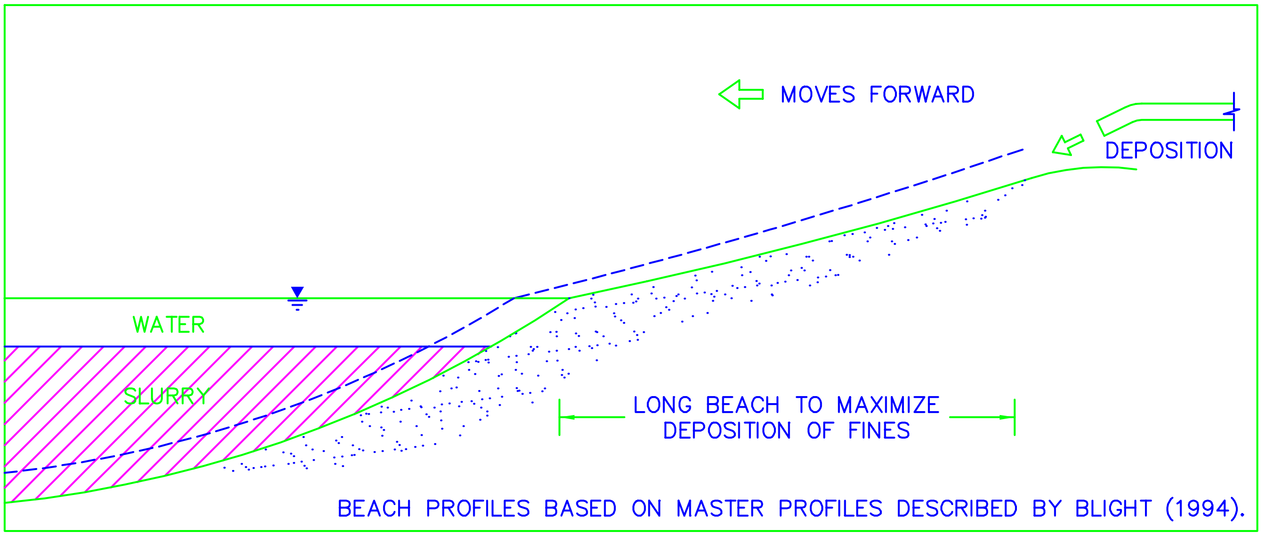


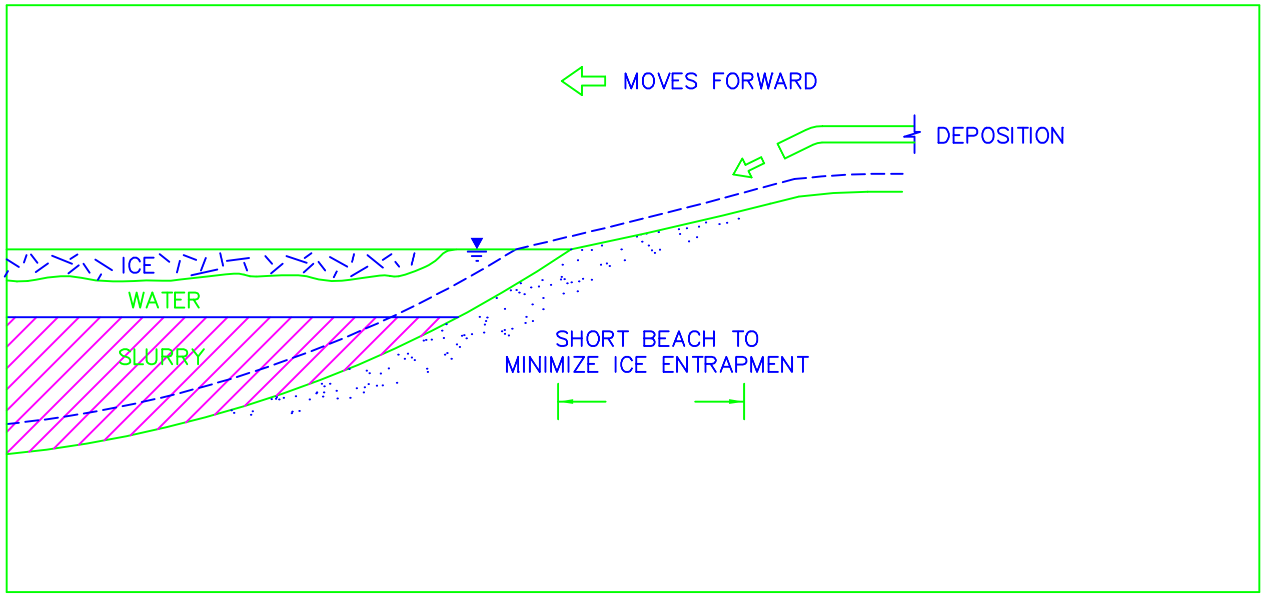
NWT DIAMONDS PROJECT

Figure 5.2-7
Tailings Disposal in Cell

Source: EBA Engineering



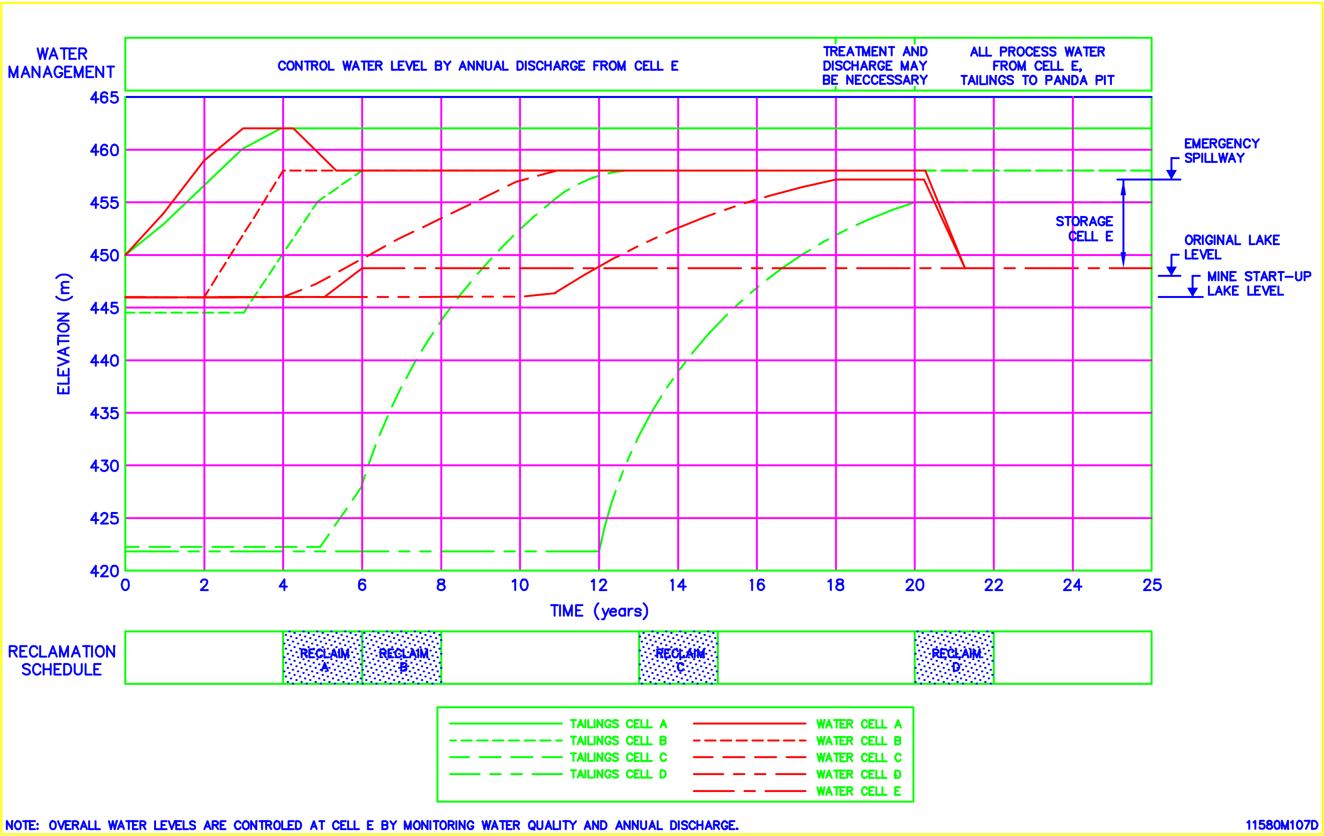
SUMMER DEPOSITION



WINTER DEPOSITION

NWT DIAMONDS PROJECT

Figure 5.2-8
Seasonal Deposition



NOTE: Overall water levels are controlled at cell E by monitoring water quality and annual discharge.

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Figure 5.2-9
Tailings and Maximum Possible Water Levels in Cells A to E

Source: EBA Engineering

about Year 20. At that time, three abandoned pits Panda, Fox and Koala will be available out of which only Panda and Koala are within close proximity of the process plant. At Year 20, tailings discharge can be directed to one of these pits.

Panda is the largest of the three coned shaped pits, approximately 700 m in diameter at the top and 340 m deep. The overall volume is 43 million m^3, thereby providing storage capacity for all tailings and water discharged from the process plant for approximately five years of production. This storage capacity will be sufficient for the remainder of the planned mine life. Other pits will be available to receive tailings if the planned mine life is increased.

The tailings discharge point will be located at least 50 m below the top of the pit. Tailings and water will initially cascade into the pit, building a water cover on the top of the tailings as they segregate and settle. The projected rate of rise of the Panda Pit water cover is shown in Figure 5.2-10. This rate assumes that no water is reclaimed from the pit and there is insignificant natural recharge by groundwater.

During tailings discharge to any of the pits, water requirements for the process plant will be derived from Cell E at Long Lake. Raw water for the plant can, however, be reclaimed from the pit when the water elevation is within 20 m to 30 m from the top in order to allow further deposition of tailings.

5.3 Waste Rock Management Plan

Although processing of kimberlite ores for diamond recovery differs significantly from more common base or precious metal operations, waste management is common to both. Open pit mining will generate large quantities of waste rock and the processing of the relatively low grade diamond ore will produce large quantities of tailings, both of which will require environmentally acceptable long-term storage. These materials have been characterized and grouped on the basis of geochemical static tests. Environmental management plans are developed for each group based on projected chemical reactivity and physical properties to ensure long-term environmentally acceptable storage.

5.3.1 Review of Static and Kinetic Test Results

Results of ABA, mineralogical examinations, SWEP tests and paste pH have been reported in Section 5.1. As indicated, these static tests can exaggerate water chemistry problems since they are designed to determine the potential of chemical reactivity based only on mineralogy. Kinetic tests predict the long-term rates of reaction through an accelerated weathering process under laboratory conditions and are underway at present. In anticipation of kinetic test results, waste dump modelling has been done to incorporate actual site conditions, such as ice-core formation, into the waste rock management plan. Kinetic test results in

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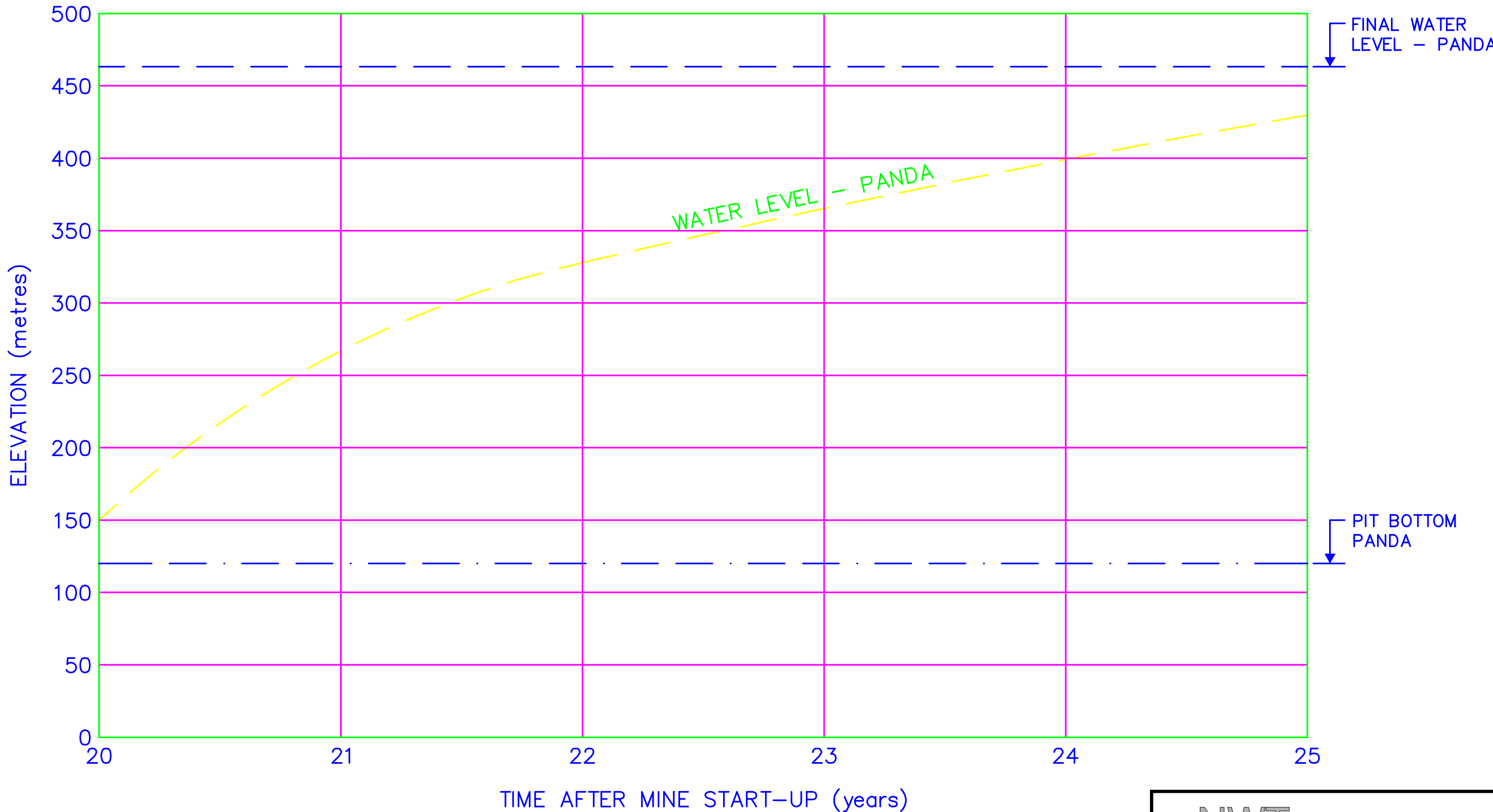

NOTE: PANDA PIT IS ASSUMED TO BE FILLED FIRST BUT ALTERNATE SIMILARLY SIZED PITS MIGHT BE FILLED FIRST.

NWT DIAMONDS PROJECT

Figure 5.2-10
Water Rise in Panda Pit

conjunction with active field measurements will be used to modify the plan if necessary.

5.3.2 Categories of Material

Waste rock has been categorized based on the results of geochemical static tests and summarized in Table 5.1-6. Although not conclusive, such tests provide an indication of material reactivity and allow for the separation of materials into groups each with their own disposal plan.

The kinetics of the actual drainage conditions will be slower than that reported in the static test results due to lower average temperatures, fragmentation and permafrost development; and thus, much less likely to provide a significantly reactive drainage.

5.3.2.1 Potential Acid-Generating Materials

Materials with acid-generating tendency has been estimated to be 16 million tonnes most of which originates from the Fox pipe. This represents 6% of the total material to be stored in the Fox waste dump. Operating controls during mining will blend this material with that of high neutralizing potential to eliminate future acid drainage concerns. Several characteristics about the waste rocks and their occurrences make the plan feasible:

- the amount of potentially acid-generating material is small compared to the total volume of the waste rock dump
- the net neutralizing potential ratio is high enough to provide a high factor of safety
- the identified potential acid-generating unit is diabase which is visually distinguishable from the host granite and is oriented such that it will be mined along with large amounts of potentially alkaline granite and dumped simultaneously. This would allow for easy blending and minimize the possibility of acid-generating hot spots.

A small amount of acid-generating kimberlite has been identified from the Misery pipe (210,000 tonnes). After processing, the fine tailings fraction will be deposited into Long Lake and the coarse tailings fraction in the Panda/Koala waste dump. Both these locations contain an excess of reactive neutralizing potential material.

At each pipe, small amounts of silty to gravelly lake bottom sediments as well as some glacial till overburden will be excavated and allowed to drain in impounded storage areas provided for this purpose within or adjacent to the waste rock dump. Although lake sediments have been classified as potentially acid-generating material, this reactivity has been attributed to organic reactions and not sulphides.

If reclamation research work proves that it is suitable plant growth material, then it will be removed for use as growth medium during the reclamation stage.

5.3.2.2 Neutral Material

One hundred and sixty million tonnes of material, or 16% of the total mined, has been classified as producing neutral or "uncertian" drainage and is not anticipated to present drainage concerns. This material consists of 92 million tonnes of granite or schist waste rock, 57 million tonnes of kimberlite tails and 11 million tonnes of till or lake sediments. Depending upon the pipe where these materials are mined, they will be disposed in the appropriate location. The kimberlite tailings will be deposited either in Long Lake or in the Panda/Koala waste dump. The 35 million tonnes of "uncertain" material will be subject to further testing to verify its drainage status.

5.3.2.3 Coarse Tailings

As described in Volume I, Section 2.5.8, 10% to 20% of the tails will be coarse material of the size fraction >1 mm, totalling approximately 13 to 26 million tonnes. Of this total, approximately 58% has been designated net alkaline and the remainder neutral (<1% is net acid producing and is described in Section 5.2.2). This material will be stored in the Koala waste dump and placed in the order in which it is processed. These tailings will be located at the centre of the waste rock dump which is expected to freeze as described later in the dump modelling section. This portion of the Koala dump is designed to drain towards the Long Lake tailings impoundment.

Six to 11 million tonnes of coarse tailings have been classified as neutral draining material. This graded, well draining material has been identified as useful for sub-soil and is included in the reclamation plan for use as cover on the final tailings facility. This material is further referenced in the reclamation section for usage primarily for revegetation purposes.

5.3.2.4 Potential Alkaline Drainage Generating Material

The bulk of the rock tested has exhibited the potential for alkaline drainage (822 million tonnes). Although useful for the neutralization of acid-generating material, site rocks have been found to contain aluminum in a form which is leachable in high pH solutions. Prediction of long-term drainage chemistry will be obtained from ongoing kinetic test work adjusted for site conditions.

Climatic conditions and slow weathering rates in the granites are expected to suppress the pH of any drainage solutions. In addition, aeration of waste rock dumps will occur naturally due to the high porosity of the active layer which has been shown also to depress alkaline pH. This, combined with the formation of an ice-saturated core in the waste rock dump which traps and stores percolating water, will constitute the basis of a passive management strategy.

Waste rock was used to construct the airstrip and the construction of the Panda diversion channel exposed bedrock along its length. The construction of these two structures provided an opportunity to study the quality of water passing through or over these structures. Water monitoring at these sites is presently in progress to provide an understanding of the on-site water geochemistry. In the unlikely event that alkaline drainage develops, mitigation will be implemented.

5.3.3 Results from Waste Dump Modelling

The construction sequence of a generic dump was modelled using site parameters. The temperatures within the dump and its foundation were found to stabilize at around -5ºC except near the surface layers where seasonal temperature variations would occur. This part of the model was not very sensitive to the method of dump construction (i.e., lift thickness or timing). Thereafter, water infiltration into the waste dump due to thawing snow and summer rains was modelled.

The thermal modelling shows that almost all water except water infiltrating near the perimeter of the dump would freeze before it escapes from the dump resulting in the formation of an ice-saturated core. The height of this ice-saturated core is expected to increase at a rate of 0.6 m/a. It has been estimated that the extent of the perimeter zone from which runoff would escape would be approximately 150 m in width and the seepage would amount to approximately 150 $mm/m^2/a$. Appendix III-C4 contains details of the thermal modelling.

Sloping the dump surfaces to maximize runoff and minimizing any large flows to the dump from surrounding water catchment areas were identified as effective preventative management techniques and have been incorporated into dump design. As part of the monitoring program, water emanating from the waste dumps will be analyzed. If water quality parameters are not satisfied, this water will be collected and discharged into the environment following necessary treatment.

5.3.4 Drainage Quality

As data from kinetic testing of the waste materials are finalized adjustments will be made. These data will be used for site monitoring and waste dump modelling. As described above, kinetic tests accelerate the natural weathering process and must be adjusted for actual site conditions to account for the following:

- The annual daily mean site temperature of -10.8°C considerably reduces reaction rates within the active layer of the waste dumps. Standard humidity cell tests are run at 20°C.

- Surficial contact area for precipitation percolating through an actual waste dump varies between 5% to 20%. This would reduce the concentration of contaminants in the leachate.

- Aeration of the drainage water and, in particular, assimilation of carbon dioxide has been shown to reduce the pH quite effectively in kimberlite drill water. Reduction in pH from 10.6 to 8.0 will result in dissolved aluminum concentrations below 0.001 mg/L.

- The extents of waste dumps are limited to 100 m from any receiving water body. This setback would allow for collection and redirection of drainage if required.

To summarize, waste rock management of reactive material is limited to only 58% of the finely ground kimberlite process plant tailings. Eighty to 90% of these tails will be stored in the Long Lake tailings facility (fine tailings) and the remaining 10% to 20% enclosed within the Panda/Koala waste dump. The remaining material to be mined consists of generally non-reactive granite and schist which may have the potential to produce a mildly alkaline drainage, the flow rate and chemistry of which has been modelled and will be refined with data from kinetic testing.

Climatic and environmental conditions help to reduce reaction rates and limit the waste rock exposure to an active thawed shell for a short time each summer. Promotion of ice-core development in the waste rock dump design combined with natural aeration of drainage water is the basis of a passive management plan. However, the dump design allows room for structures to capture and control any substandard drainage.

5.4 Hazardous Waste

Hazardous waste includes solid wastes such as lead-acid batteries and oil filters, and liquid wastes such as waste oil, spent laboratory chemicals and solvents.

This part of the waste management plan describes how hazardous wastes will be disposed. The activities described focus on environmental safety and recycling.

5.4.1 Disposal

Wastes generated from the use of hazardous substances will be collected and properly disposed. Disposal methods include backhauling by a licensed contractor to an off-site hazardous waste recycling or disposal facility, reuse of the spent material, or land disposal if the material is rendered non-hazardous. Where applicable, the hazardous substance supplier will have responsibility for the disposal of empty plastic or metal containers. All other containers will be incinerated or cleaned, crushed and buried in designated waste rock dump areas. A summary of disposal options for hazardous wastes is provided in Table 5.4-1.

Table 5.4-1
Disposal of Hazardous Wastes

Type of Waste	Disposal Method
Laboratory wastes	Add to tailings pond
Ethylene glycol and miscellaneous fluids	Recycle on-site, ship to off-site recycling facility
Used oil and grease	Reuse on-site, ANFO, ship to off-site recycling facility
Used oil filters	Drain, ship to off-site waste disposal facility
Used lead-acid batteries	Store on skids and ship to a recycling facility

5.4.1.1 Laboratory Wastes

The environmental and metallurgical laboratories will produce small quantities of chemical wastes. Each type of chemical waste will be collected in glass bottles and stored in the laboratory. Periodically, the lab waste will be added to the tailings stream. The volume of chemical wastes will be minuscule in comparison to the volume of the tailings stream. Because of this dilution factor, addition of these wastes will not affect the chemical nature of the tailings slurry in Long Lake.

5.4.1.2 Ethylene Glycol and Miscellaneous Fluids

Waste ethylene glycol (antifreeze) will be recycled on-site for reuse. Used antifreeze and other miscellaneous fluids (Section 4, Table 4.1-1), such as spent solvents, that cannot be recycled will be stored in containers at a secured on-site storage area and later transported to an off-site recycling facility.

5.4.1.3 Used Oil and Grease

Spent solvents or other chemical waste will not be mixed in with waste oil because of limitations to the recycling potential and disposal options for waste oil.

Used oil, primarily waste engine lubricating oil, will be used as supplementary fuel for the garbage incinerators, in furnaces as supplementary space heating purposes, or blended with power plant diesel fuel. Used oil will be temporarily stored in collection tanks with secondary containment. Used oil could also be used in ANFO emulsions. Waste lubricants and greases will be stored temporarily in secured drums for periodic shipment to an off-site recycling facility.

5.4.1.4 Used Oil Filters

Spent oil filters will be drained on-site, crushed, stored in drums, and then shipped to a licensed facility.

5.4.1.5 Used Lead-Acid Batteries

Used batteries will be stored with new batteries in the battery charging area. This area will be constructed of concrete, ventilated and installed with a sprinkler system. Used batteries will be stored in an upright position on skids until a sufficient number has accumulated for removal by a qualified contractor.

5.5 Non-Hazardous Waste

"*As long as sewage is properly treated it will not have an impact. They need to have a large enough plant. Anti-freeze and oil leaks must be taken care of right away. ...Old trucks and equipment should be back-hauled out of the mine site on the winter road*" (Doug Arden, Yellowknife).

This part of the Waste Management Plan focuses on non-hazardous waste management. The activities described are waste minimization, recycling, incineration and burial of wastes in a legally and environmentally responsible way.

Special care will be taken to minimize waste generation and to manage the disposal of any waste materials produced. On and off-site recycling and incineration will reduce the volume of non-hazardous solid waste at the project site. Remaining non-hazardous wastes will be buried in the waste rock dumps.

Effective disposal of waste reduces the potential for scattering of debris in the wind, discharges to the environment of noxious and unsightly material, the undesired attraction of wildlife and the creation of breeding grounds for insects and other organisms which may threaten human health.

The most significant non-hazardous wastes, in terms of volume, have been identified as treated sewage effluent and domestic garbage. Construction materials, plastics and rubber products are also discussed in this section.

5.5.1 Disposal

Wherever possible, materials will be reused and/or recycled. Other disposal options for non-hazardous materials include either incineration or burial in the waste rock dumps. A summary of disposal options for various types of non-hazardous waste is given in Table 5.5-1.

Table 5.5-1
Disposal of Non-Hazardous Wastes

Type of Waste	Means of Disposal
Domestic garbage	Incinerate
Permanent camp sewage treatment plant effluent	Treat and pump to either Kodiak or Long Lake
Misery camp sewage treatment plant effluent	Treat and discharge at depth into Lac de Gras
Sewage treatment plant sludge	Store in lake sediment impoundments, to be used for reclamation
Plastic or metal drums	Rinse properly and reuse or recycle off-site, or crush and bury in waste rock dumps
Used rubber products	Recycle off-site or bury in waste rock dumps
Construction debris, scrap steel	Recycle off-site or crush and bury in waste rock dumps
Unsalvageable used parts and machinery	Drain oil, clean and sell as scrap, or bury in waste rock dumps

5.5.1.1 Domestic Garbage

Combustible, non-hazardous domestic waste from the camp, power plant, security building, truckshop/offices/warehouse complex and mining areas will be placed in covered, "bear-proof" metal containers located at strategic locations around the mine site. Garbage will be incinerated daily in a 2 t/d capacity, diesel fuel-fired, dual chamber incinerator at the permanent camp. The incinerator will be operated in accordance with federal Operations and Emission Guidelines for Municipal Solid Waste Incinerators (CCME 1989). A second, small solid waste incinerator for combustible waste produced in the process plant will be installed within the double-fenced secured area. A third, small solid waste incinerator for combustible waste produced from the truckshop/office area will be installed near that facility.

This plan will address concerns of Aboriginal people that improper disposal of garage would attract scavengers, and thus upset ecosystem relations:

"*the only ones that I think would be coming are the crows (ravens) and seagulls...maybe the odd wolverine. They'd love it (garbage dump) with food. but most animals (will) tend to move away because they're not domestic animals...*" (Ida McWilliam, Coppermine).

Facilities at Misery Lake will include a waste disposal incinerator for garbage and other combustible non-hazardous waste. Ash from the incinerators and other non-combustible waste will be placed in waste rock dumps and buried under 1 m of waste rock. Clean wood scraps and corrugated cardboard boxes will be open burned.

5.5.1.2 Sewage Plant Effluents/Sludge

A sanitary sewage system and a completely enclosed sewage treatment plant will be housed in a heated, insulated building 250 m west of the camp (Section 4, Figure 4.1-1) for the collection and treatment of domestic wastewater.

The sewage treatment system will be comprised of primary and secondary levels of treatment. The final effluent will be pumped to either Kodiak Lake or Long Lake. The treatment process will be designed in accordance to the Guidelines for Discharge of Treated Municipal Wastewater in the Northwest Territories.

The aerobically digested sludge from the treatment plant will disposed of bi-monthly or as required in lake bottom sediment impoundments (Section 4, Figure 4.3-1). Volume I, Section 2.4.5 describes the impoundment design. Water released from these storage areas will be sampled and analyzed prior to discharge to ensure compliance with water quality limits.

Facilities at Misery Lake will include a separate sewage treatment system. The final effluent will be discharged at depth in Lac de Gras, according to Guidelines for Discharge of Treated Municipal Wastewater in the Northwest Territories. The sludge will be deposited in the Misery lake bottom sediment impoundment.

5.5.1.3 Miscellaneous Solid Wastes

Miscellaneous industrial solid wastes, such as empty plastic drums, scrap steel, leftover construction materials, used rubber products (tires, conveyor belting) and unsalvageable used equipment, will be returned to the supplier where this option is available. Other alternatives include shipment to a designated facility for reuse or recycling, or burial in the waste rock dumps.

Miscellaneous domestic solid waste, such as paper, aluminum cans and glass, will be recycled if feasible.

Summary

This plan described strategies to deal with operations and camp waste. The plan focuses on environmental and worker protection. In addition to the use of government regulations and literature resources, findings from research work conducted at the project site are incorporated. The section also explaines that a number of long-term tests are underway to further refine the management plan. Finally, the plan lays a foundation for the Environmental Monitoring Plan by describing measurable activities.

6. Traffic Management Plan

Three types of traffic will be associated with the NWT Diamonds Project: surface vehicles, aircraft and personnel on foot. This traffic will have the potential to affect air quality (fugitive dust and vehicle exhaust emissions), water quality and vegetation (accidents and spills), wildlife (contact and noise) and personnel safety. No marine transport at the project site is contemplated, although small boats will be used for environmental monitoring programs. This management plan describes how project activities involving vehicular, air and foot traffic can be conducted to minimize effects on the environment surrounding the project site.

The traffic management plan is designed to protect the surrounding habitat, minimize wildlife disturbance and maintain human safety. Strategies to control and minimize the effects of project activities are as follows:

- minimize the number of routes, roads, air corridors and foot pathways used for routine traffic
- minimize the volume of traffic through efficient utilization of vehicles
- control the traffic with prudent rules and practices.

The basic means of implementing this strategy will be to restrict access to the project site. This will be accomplished by prohibiting non-project related ground vehicles (public pickup trucks, etc.) from entering the project site at the Misery haul road from the Echo Bay winter road turnoff at Lac de Gras. Likewise, aircraft requesting permission to land at the site airstrip would be required to submit information as to the purpose of their trip, an indication of their cargo type and manifest of personnel on the aircraft. Exceptions to public access restriction from the site would be granted in emergencies.

6.1 Traffic Scheduling

All scheduling of supplies and personnel traffic to and from the project site will be coordinated by personnel at both the site and Yellowknife. During construction, traffic schedule coordination will also be carried out in Edmonton. Suppliers will be required to ensure that carriers are knowledgeable in the safe handling of the specific material being transported. All hazardous material shipments will be handled in accordance with government regulations.

6.2 Vehicular Ground Traffic

Vehicular ground traffic in the area of the project will include winter road traffic, inter-site road traffic and off-road (snowmobile) traffic. Other means of surface transport, such as off-site rail lines and public highways, will also be associated with the project; these facilities are fully regulated by government entities and will not be directly managed by the Proponent.

6.2.1 Echo Bay Winter Road

The easternmost kimberlite pipe included in the proposed project development, Misery, is approximately 3 km west of the existing, well-managed Echo Bay winter road. This road originates out of Tibbit Lake near Yellowknife and terminates at the Lupin gold mine, approximately 100 km north of the project site. It is envisioned that the Proponent will become a joint operator of this road with Echo Bay Mines Ltd. when the project receives approval. The existing winter road operation is described in Volume I, Section 2.9.1. The management plan already in place for the winter road addresses three key issues: personnel safety, spill prevention and preservation of the tundra.

Personnel safety is managed by allowing only drivers with a good driving record and a valid Canadian truck driver's licence to operate on the winter road. In addition, drivers are required to abide by the road-use rules set forth in the Echo Bay Mines Ltd. Highway and Winter Road Drivers' Policy and Procedures Manual (Appendix III-D1). The policy stipulates that trucks are always to travel in pairs and to have on board a functioning CB radio and emergency winter survival equipment. The presence of these items is confirmed before the trucks are allowed to depart from Tibbit Lake onto the winter road.

All winter road users, including site shippers/receivers and trucking companies transporting supplies, are required to adhere to the terms of a Transport Conditions Agreement (Appendix III-D2), which Echo Bay Mines Ltd. requires all users to sign. In general, winter road users must demonstrate minimum vehicle equipment and condition standards, a sound financial basis for maintaining minimum insurance levels and a good safety record.

Spill prevention is closely associated with personnel safety (accident prevention). Road spill mitigation is managed in accordance with the Echo Bay Transportation Emergency Response Plan. This plan (Appendix III-D3) is filed with the appropriate government entities in Yellowknife.

A tundra protection management program was established as part of the winter road operation approximately 15 years ago. As a result of this program, 28% of the winter road was routed over portages and 72% over lake ice. Within the portage sections above the treeline, about one-half of the road surfaces cross tundra, i.e., about 15% of the total winter road length. Truck traffic over the winter road is allowed to commence only when an adequate snow/ice cover has developed over the portage sections, and then only at reduced gross vehicle weights. As the snow/ice cover thickens during the winter, full gross transport weights are eventually allowed.

While wildlife disturbance and safety are always a concern, most wildlife are either hibernating or have migrated out of the area when the winter road is in operation. Beyond road speed limits, wildlife safety is in large part dependent on driver awareness and communication to alert other drivers to the presence of animals in the area. No significant environmental problems have been associated with the winter road operation to date. While incidents have occurred, they have been dealt with professionally and promptly without any lasting environmental impact.

6.2.1.1 Engineering Survey of the Winter Road

A survey of the winter access road to the NWT Diamonds Project site and the Lupin Mine site was conducted during the 1994/1995 winter season by Sandwell Inc. (Appendix III-D4). Specifically, Sandwell surveyed the ice thickness during the road opening in December 1994, the ice and snow thickness along the road to Lockhart Camp in January 1995 and the ice thickness along the road to the NWT Diamonds Project site in March 1995 (electronic ice survey). In addition, measurements of the dynamic response of the ice to a B-train fuel truck along the full length of the road, with particular emphasis at the portages, were completed at the end of March 1995.

According to long-term temperature records, the 1994/1995 winter was warmer than normal. As a result the ice thickness along the route was thinner than in most other years.

The conclusions of the winter access road investigation report were as follows:

- Diligent removal of snow early in the season will be required to obtain ice thicknesses in the order of 1.7 m to support 85 tonne loads, especially at the south end of the road.

- The current thickness required for hauling loads, plus the restriction on vehicular speed, especially at approaches to the portages and in shallow water bodies, appear to adequately address dynamic amplification and stresses in the ice.

- The maintenance of a wide road surface by using snowplows and snow blowers will significantly alleviate surface cracking of the road, which is caused by a combination of thermal and tensile stress.

- The flexural fatigue of the ice due to the frequent, repeated passage of loads will not be a consideration in the use and safety of the winter road as long as stress levels are held at 500 kPa or lower.

Complete details of the investigation are contained in Appendix III-D4.

6.2.2 Temporary Winter Road(s)

It is anticipated that temporary winter roads will be required from time to time during the life of the project to provide access to various outlying exploration programs. Winter road routings and basic design parameters will be developed and reviewed with appropriate governmental agencies to minimize the impacts on the tundra. Winter roads have been used extensively during the exploration phase and have had minimal impacts on the environment. The routings will avoid significant ecosystems susceptible to degradation, as outlined in Section 3.2. Vehicle use and type of traffic will also be controlled to minimize tundra, soil and vegetation degradation.

6.2.3 Inter-site Roads

The inter-site road management plan involves controlling the length and routing of roads, limiting the number and types of vehicles permitted on these roads and allowing only properly qualified drivers for each vehicle type to operate on the road system. There are two basic types of inter-site roads, service/access roads and pit/haul roads.

6.2.3.1 Service/Access Roads

These roads are designed to accommodate one- and two-way "public highway" sized vehicular traffic between various locations on the project site. The impact of the roads on the tundra will be managed in large part by using adequate fill material during road construction to maintain the integrity of the underlying tundra. Construction will also incorporate proper drainage control to maintain the surface hydrology of the area. Management of road drainage is discussed further in Volume IV, Section 2.4. The longest inter-site access road (approximately 29 km) will be from the process plant to the Misery pipe. The routing of the Misery haul road was selected to minimize impacts on wildlife and to avoid archaeological sites in the area through which it passes (Volume IV, Sections 2.1 and 3.3). Any additional access roads to outlying roads required in the future would also have to consider these routing criteria.

Limiting the creation of dust, noise and exhaust, and protecting wildlife, begins by controlling the amount of vehicular traffic. Since the project will be a 365 d/a, 24 h/d operation, vehicles will be in use at all times except during white-outs. The long haul trucks selected for ore haulage will be the largest practical size, thereby reducing trip frequency. Use of the access road to Misery will be minimized by making this area self-sufficient (i.e., its own camp, power plant, minor repair shop, etc.). If necessary during dry summer periods, road dust will be controlled by periodic spraying with water and possibly a dust wetting/binding agent. Road noise will be controlled by procuring, contracting and maintaining light, medium and heavy duty trucks to Transport Canada maximum noise level regulations (Volume IV, Section 2.8). Likewise, vehicular exhaust will be controlled by procuring, contracting and maintaining vehicles to applicable Canadian diesel engine emission standards.

Vehicle speeds also affect the amount of dust, noise and exhaust emissions generated. Therefore, site-specific speed limits will be set, posted and enforced to control these emissions as well as to protect the safety of personnel and wildlife. Temporary reduced speed limits will be enforced along stretches of road in areas where caribou are present during migration.

6.2.3.2 Pit/Haul Roads

Management of the pit/haul roads will be similar to the access/service road operations. The out-of-pit surface haul roads will also be built on fill to minimize impact on the underlying tundra. Although management of noise and wildlife safety is less of a concern for the pit/haul road traffic than for access/service road traffic, vehicles will still be procured, purchased and maintained to minimize noise. Speed limits will be posted and enforced to protect personnel and wildlife.

The operators of all inter-site vehicles will be properly trained and qualified for the vehicles they will use. Pit haul roads will generally have left-sided traffic to maximize the safety of large haul roads. Changeover locations will be well marked to avoid confusion. All personnel arriving at the site, whether driver or non-driver, will be given a safety orientation on the basic rules of the project's inter-site roads. The orientation will cover such rules as speed limits, mandatory seatbelt usage and animal awareness (Appendix III-D5). Those personnel operating mobile vehicles on the site will be confirmed as having a valid driver's licence and given a course on safe driving procedures. For special vehicle types, classroom and "behind-the-wheel" training will be provided to drivers by qualified instructors prior to issuance of an operator's authorization of the proper classification for the vehicle to be operated. Periodic refresher training classes will also be given to maintain driver proficiency.

Vehicle operators will be required to perform a basic vehicle safety check when a work shift is started, and to confirm that the vehicle contains the required on-board emergency and winter survival supplies. Vehicle operators who will be travelling on pit/haul roads will also be required to take a course and be certified on pit procedures (Appendix III-D5).

6.2.4 Off-road Vehicles

Off-road vehicle (snowmobile, snowcat) traffic will be managed to minimize disturbance to wildlife and impacts on the tundra (soil and vegetation) and to secure personnel safety. The main uses of this equipment will be for site environmental monitoring, exploration support, site security, reconnaissance and emergency assistance purposes. Personnel operating snowmobiles/snowcats will be given an orientation course on the rules of use of such vehicles, and will be advised of ecologically sensitive areas and dangerous locations around the site that should be avoided. Areas around the immediate plant site that are identified as being dangerous to snowmobile travel will be identified. Drivers and passengers will be required to sign-in/sign-out vehicles, travel most of the time in pairs and carry emergency and winter survival gear.

6.3 Air Traffic

Air traffic at the project site will include both fixed-wing aircraft (site-controlled and uncontrolled aircraft) and helicopters, which will be mainly uncontrolled aircraft. The fixed-wing aircraft will be of various types, ranging from 727/737 jets and Hercules C130 cargo planes, to mid-size DC-3s, DC-4s and HS-748/C48 propeller-driven planes, to small Cessnas and Twin Otters. All air traffic, including helicopter traffic, is subject to standard Transport Canada Regulations. In addition, all aircraft secured for project activities will meet all requirements of the BHP Corporate Aviation Department as discussed in Volume I, Section 2.11.7. A qualified air traffic radio operator will be on duty at the plant site. This radio operator will provide information to incoming and departing flights on local weather and runway conditions, issue safety hazard warnings and inform pilots of other known air traffic in the area. The airstrip will be routinely monitored and maintained. Surface maintenance will involve clearing snow and spreading sand. The airstrip will be monitored for wildlife prior to aircraft landings and departures, and any animals present will be cleared off.

6.3.1 Controlled Aircraft

Most of the air traffic to the site will be controlled aircraft originating from other airstrips/airports mainly in the NWT and Alberta. This type of air traffic requires that flight plans, weather conditions and minimum enroute and approach altitudes be filed with Transport Canada Regulations. All such aircraft will be required to provide prior notice of arrival to the project site's airstrip, usually in the form of a copy of the flight plan filed with Transport Canada at the airport of departure. These flight plans will form the basis for notification to Transport Canada of overdue aircraft and activation of its established search procedures.

Except for site permission to land and take off from the airstrip, all procedures for controlled air traffic are regulated by Transport Canada. Transport Canada has specified the landing approach alignments, minimum altitudes and minimum visibilities for various instrument approaches to the site airstrip (Appendix III-D6). In addition, each air transport firm that will routinely use the site airstrip is expected to have standard operating procedures for each aircraft type. An example of such procedures, for an HS748 aircraft, is contained in Appendix III-D7.

The ultimate decision for flight routes to and from the project site and minimum descent altitudes to be used resides with the aircraft pilot. The Proponent, however, will periodically make recommendations to project aircraft operators and pilots to develop flight guidelines that will minimize noise disturbance to sensitive wildlife/outfitter areas while maintaining the safety of the aircraft operator.

6.3.2 Uncontrolled Aircraft

Uncontrolled aircraft will consist of smaller fixed-wing planes and helicopters operating within and around the immediate vicinity of the project site. These aircraft will be used for access to remote exploratory sites, to conduct site environmental monitoring and to assist in emergency response needs. The site air traffic radio operator will ensure that contact is maintained with uncontrolled aircraft, and that controlled aircraft are advised of uncontrolled aircraft operating in the area. Unlike controlled aircraft, flight plans do not have to be filed with Transport Canada for uncontrolled local aircraft traffic. Because uncontrolled aircraft normally fly at lower altitudes, minimizing noise disturbance to critical areas is of more concern. Consequently, site project personnel will be assigned to work with the aircraft pilots to determine basic flight plans that minimize noise disturbance to the wildlife and outfitters in the area. Minimal requirements for helicopters and light aircraft are anticipated during operation.

6.4 Foot Traffic

Foot traffic beyond the immediate confines of the plant facilities is of concern during the “freeze” months with respect to personnel safety and in the “thaw” months with respect to impacts on the tundra and disturbance to wildlife. Safety concerns during the winter will be addressed by instructing personnel on winter survival techniques and limiting outside movements of personnel. In addition, personnel will be required to wear proper winter clothing and be encouraged to travel in pairs.

Foot traffic concerns in the summer will be addressed by instruction and postings on which areas should be avoided to minimize wildlife disturbance. In addition, foot traffic pathways will be established to the more frequent destinations to minimize disturbance to vegetation and wildlife.

6.5 Navigable Waters

Eight thousand lakes have been identified on the mineral claim block, the largest being Lac de Gras, Lac du Savage and Exeter Lake. Seven small lakes will be affected by the mine development. In addition, a small bridge will be constructed over the stream where Paul Lake flows into Lac de Gras. The approximate dimensions of the seven affected lakes are as follows:

Lake	Maximum Dimensions (km)
Airstrip	0.3 x 0.7
Long	1.0 x 8.0
Panda	0.5 x 0.6
Misery	0.3 x 0.6
Koala	0.5 x 1.2
Fox	0.5 x 1.6
Leslie	0.6 x 2.1

Each of these lakes is navigable by canoe or small boat only. The streams connecting to these lakes are small, rocky and characterized by low flows except during freshet. These lakes are not characterized as being navigable other than by portage.

As part of the mine development permitting process, application to the Canadian Coast Guard, under the *Navigable Waters Protection Act*, will be made, if necessary, concerning the dewatering of lakes, dam and dike construction, spillway and diversion channel construction, water crossings and road construction.

Summary

The traffic management plan has been developed to produce a framework that puts environment and personnel safety first. The plan uses legal requirements and experience to provide guidelines. Finally, the management plan provides the basis for traffic control activities that will be incorporated into the overall Environmental Monitoring Plan.

7. Wildlife Management Plan

Six valued ecosystem components (VECs) for wildlife were identified for the NWT Diamonds Project. The VECs were based on public and professional concern and cultural or economic importance. The six VECs identified were the Bathurst caribou herd (*Rangifer tarandus groenlandicus*), grizzly bears (*Ursus arctos*), furbearers, birds, small mammals and special habitats. These habitats include eskers, riparian zones, wetlands and cliffs.

Although there is a considerable body of literature on the effects of development on wildlife, the majority of these studies lack pre-development information, quantitative data on long-term effects and an assessment of the demographic consequences of disturbance (Donihee and Gray 1982). The latter is especially important in assessing the significance of environmental impacts. It is not sufficient to say that a development or specific human activity has altered the behaviour of wildlife. An interpretation of the importance or significance of this change in behaviour needs to be related to demography and whether the survival or reproductive success of the individual or of the population has been impaired. Therefore, long-term monitoring is an important component of any wildlife management plan.

The NWT Diamonds Project will provide a unique opportunity to assess the impact of development in the wildlife study area. Because baseline data have been gathered prior to development, the responses of wildlife during and after the project can be measured, the success of management plans can be monitored and, if necessary, additional measures can be implemented. Management can be truly adaptive, ultimately providing guidelines that will assist in ensuring that similar developments in the Southern Arctic Ecozone will also be developed in a sustainable manner.

All stages of the project, from construction to decommissioning, have the potential to affect the surrounding environment with impacts on air, water, land and wildlife. The foundation for the wildlife management plan is based on four strategies: habitat protection, minimization of wildlife disturbance, wildlife and human safety, and rehabilitation of disturbed areas. By implementing these strategies, the overall objectives of the Environmental Management Plan (EMP) will be achieved and operational effects should be minimized.

7.1 Habitat Protection

Strategies for habitat protection include management of important habitats and other tundra habitats, and reclamation.

7.1.1 Important Habitats

The important habitats that will be affected by the NWT Diamonds Project are eskers and, to a smaller degree, riparian and wetland habitats. The riparian zones and wetlands that may be affected are primarily those at the north end of Long Lake and within the corridor of the Misery haul road. As cliffs are not present within areas to be developed, nesting sites of raptors will not be affected. However, raptors are wide-ranging birds and could be affected by activities within the project area.

Most of the eskers within the wildlife study area have been surveyed and existing dens have been identified. These dens will be monitored periodically. If quarry sites are required, they will be selected with the aim of minimizing disturbance to denning areas. Wildlife use of the esker adjacent to quarries will be monitored. After excavation, the quarry site(s) will be recontoured to rehabilitate the esker to a usable form for wildlife.

7.1.2 Other Tundra Habitats

Operational activities will be conducted in a manner that minimizes the areal disturbance of adjacent undisturbed tundra. In addition, significant habitats will be avoided, where feasible. Areas of disturbance associated with exploration (temporary camps, land-based drill sites) will also be minimized. On-site winter roads established on land to support exploration activities will be constructed and maintained to reduce impacts to the underlying tundra. Most of these roads are typically built on lakes, which further reduces any impacts.

Off-road vehicles will not be used on site; therefore, there will be negligible damage to the tundra vegetation. On the other hand, it is possible that trails for recreational purposes will result in vegetation loss in these areas. An effort will be made to create trails that traverse resilient habitat such as cobble fields. This will prevent impacts to sensitive plants or communities if they should exist.

As part of the reclamation program, all disturbed areas associated with the above mentioned activities will be rehabilitated to a usable state for wildlife, as outlined in Section 9. In summary, roads left in an as-built condition will simulate esker-like structures, which will provide travel corridors and insect relief sites for caribou. Other uses are expected by small mammals and birds.

Where feasible, major stream crossings along roads will be re-established and revegetated using shrub transplants. This will provide shelter for birds and small mammals as well. Innovative dump designs (irregular and undulating surfaces) will promote diversity in microsites, plants and animal use. Revegetation research will add to these innovative approaches.

7.2 Minimization of Wildlife Disturbance

Disturbance to wildlife can occur throughout all stages of a project and is associated with many human activities. Displacement of wildlife from important habitats is one possible result of disturbance. Aircraft and noise are two major project activities that can cause disturbance and/or displacement. Habituation is possible whenever wildlife come into contact with humans and their activities. This can be positive if it permits wildlife to become accustomed to development, but can also bring wildlife into conflict with people or with other wildlife.

General measures pertaining to all wildlife species include management of vehicle movements and minimization of disturbance during sensitive periods. Road construction activities will be managed to minimize disturbance during migration. Baseline studies, habitat mapping and verification will assist in determining seasonally important habitats and times of use. During mine operation, vehicle movements and speed will be managed to accommodate caribou movements yet maintain mine production. Drivers will observe extreme caution at all times. Except when necessary, the only low-level flying will be for monitoring activities.

Hunting and trapping are forms of disturbance that can have major impacts on local wildlife populations. In general, wildlife populations at Lac de Gras have not been exploited by humans. Some migratory species such as caribou, waterfowl and wolves have been subject to hunting and trapping elsewhere within their ranges. Within the NWT Diamonds Project area, hunting and trapping will not increase during construction or during operation. Firearms will not be permitted on site except for safety purposes.

7.3 Bathurst Caribou

Management tasks specific to barren-ground caribou include the following:

- protection of migratory corridors and important habitats
- implementation of measures to divert caribou away from the diversion channel and tailings disposal ponds
- monitor water quality
- minimization of disturbance during spring migration.

7.3.1 Habitat Management

Habitat mapping and verification will identify use by and distribution of caribou. During migration, some eskers such as Lac du Sauvage, Exeter and Ursula are important travel corridors. Eskers also function as relief habitats during the summer insect season.

Linear developments that caribou may intersect during summer include the Misery haul road, site access and haul roads, the airstrip and the Panda diversion channel. Based on preliminary baseline information, caribou may intersect the Misery haul road during migration. Planning for the road corridor includes the identification and avoidance of important habitats. Important wildlife habitats (riparian, wetlands) and landscape features such as eskers and glacial-fluvial deposits will be avoided or mitigated where necessary. The Misery haul road will be 10 m wide and, on average, 2 m high, and will not create visual barriers for caribou.

Water quality in the Long Lake tailings disposal site could be of concern for wildlife consumption. Ongoing testing will assess the quality of water for wildlife.

Another concern is the stability of the freshly deposited fine substrate in the tailings impoundment and whether it will be adequate to support the weight of any caribou. Sections in the tailings pond could potentially be “quicksand” traps. If problems arise, the experience gained in diverting caribou from the diversion channel will be used to divert caribou from unstable tailings pond substrate areas. Ultimately, the tailings substrate will stabilize to support caribou passage.

Based on 1994 surveys, it is not likely that many caribou will frequent the area adjacent to the diversion channel. Also, development of waste rock dumps, the Panda and Koala pits and the plant site will limit access to the western edge of the channel. Despite the low probability of accidents, mitigation measures will be developed. Water levels will typically be low, and the slopes of sections of the diversion channel will be conducive to caribou travel.

Caribou will be diverted by taking advantage of their natural tendency to avoid habitats that pose visual obstructions. These tactics are likely to be successful. Traditional knowledge offers a variety of means to deflect caribou for purposes of hunting them (Arnold 1985). A number of methods will be evaluated during construction. Naturally shed antlers, marked with fluorescent flagging tape, is one deterrent that may be tested. Such barricades were used successfully to deflect caribou during tagging studies at Contwoyto Lake (Mitchell 1980). Another deterrent, inukshuks or rock piles, may also be used. These rock piles will not only divert caribou but also provide cover and may attract other wildlife such as ground squirrels and nesting birds.

The diversion channel is not located within or adjacent to a major migratory corridor. Deterring the few caribou expected in the vicinity of the channel will not alter the traditional migratory pathways of caribou. Further, archaeological evidence suggests that historical methods of hunting, including the use of stone fences and stone or sod cairns that simulate obstructions, have not led to the disruption of traditional movements of caribou or the extinction of specific herds (Klein 1980). In Yukon, caribou were documented to circumvent a snow fence barrier, after which they continued on their original direction (McCourt *et al.* 1974). Caribou in Yukon were also observed to follow trails, cutlines and winter roads for significant distances only if their orientation was similar to the orientation of caribou movement, and not to deflect from their traditional spring migration routes (McCourt *et al.* 1974).

7.3.2 Minimization of Disturbance

The fall and spring migration periods, which last approximately four weeks each and typically begin in late April and mid-October, are the times when the largest numbers of caribou pass through the Lac de Gras area, and when caribou may be most sensitive to disturbance. Employee education and awareness of such events are effective measures to prevent or minimize disturbance.

During construction of the Misery haul road, vehicle traffic will be managed so that it minimizes disturbance during the spring and fall migration periods. To accommodate migration and to allow caribou to habituate to traffic, drivers will observe extreme caution at all times. Radio communication will be important during these periods.

Hunting pressure on caribou will not increase as a result of the access provided by the Misery road during and after operation. As there will be no means of permanent surface access to the site, no outside traffic (private vehicles) will be able to enter the areas during the spring and fall migration periods. When seasonal access to the Lac de Gras area is available via the Echo Bay winter road, caribou will generally be in their wintering habitat to the south and west, below the treeline. In any case, no firearms will be allowed at the project site except for safety purposes.

Experience during the exploration period, at the Lupin mine and at other northern developments has shown that caribou readily habituate to nearby camps, human presence and linear developments. With such proximity, harassment could be possible. Harassment of caribou or other wildlife is and will be prohibited. Caribou will be diverted from the airstrip whenever necessary to ensure they do not pose a safety hazard during aircraft takeoffs and landings.

7.4 Grizzly Bears

Management tasks specific to grizzly bears include the following:

- identification and protection of seasonally important habitats
- minimization of disturbance from human activity, vehicles and aircraft
- prevention of bear/human conflicts.

7.4.1 Habitat Protection

Habitat mapping and verification will assist in determining seasonally important habitats for bears, including those that provide security cover. The protection of denning habitat has been described above. Important habitats will be identified for reasons of human safety and to prevent disturbance to grizzly bears. Persons working in the field will be advised and instructed when to avoid these habitats.

7.4.2 Avoidance of Disturbance

Operational guidelines will avoid disturbance to bears. Helicopters will remain at least 150 m away from habitats that have been identified as seasonally important for grizzlies.

Efforts to prevent bear-human conflicts were successful at the exploration camp and will be implemented at the permanent camp. These include providing education to all personnel and eliminating all attractions from the camp. All food wastes and garbage will be incinerated on site. Sewage will be treated and discharged with the tailings.

Education has been shown to be a significant component in preventing negative bear-human encounters (Banci 1991). All personnel, including contractors, associated with the NWT Diamonds Project will be required to take a bear safety course. Education will be through videos, slide shows and presentations.

Firearms will be restricted to a small number of personnel and for safety purposes only. Bear deterrents such as bangers and capsicum spray will be available to persons working in the field. Employees will be instructed on their proper use. The procedure in the event that a bear does approach the camp has been recommended by the Department of Renewable Resources. Attempts will be made to deter the bear by a person trained in the use of deterrents. If the bear is not deterred, a conservation officer will be called from Yellowknife to immobilize and remove the bear.

Two personnel trained in wildlife control will be designated to deal with wildlife issues. At least one person will always be present on site. These individuals will be trained in firearm use, in deterring wildlife and in humane wildlife captures.

Human activities will be kept predictable to allow bears in the vicinity to habituate. Bears seen from helicopters will be monitored, but they will not be approached at low altitudes. Particular attention will be paid to Misery Lake, as the potential for interactions is highest there.

7.5 Furbearers

Management tasks specific to furbearers, arctic and red fox (*Vulpes vulpes*), wolf, wolverine (*Gulo gulo*) and ermine (*Mustela erminea*) include the following:

- protection of important habitats such as eskers and other glacial-fluvial deposits and riparian and wetland habitats
- prevention or minimization of disturbance
- prevention of human/furbearer conflicts.

Measures to protect eskers and denning habitat have been described above. In the same way that vehicle management will minimize disturbance of caribou, speed control and other traffic measures will be implemented to protect furbearers present in specific areas. In all cases, feeding of furbearers and other wildlife will be banned; this will be supported by educational efforts. The prohibition on firearms will prevent hunting.

7.6 Birds

Management tasks specific to birds are as follows:

- protection of critical habitats during migration, staging, breeding and nesting
- minimization of disturbance, especially during critical periods of the life cycle.

Current and ongoing work will identify important habitats. If habitats necessary for survival are identified, such as staging, breeding and nesting, mitigation measures will be implemented. Such measures will include avoidance by aircraft, vehicles and humans during critical periods in the life cycles of birds.

A number of bird species take advantage of human activity, such as ravens nesting on fuel tanks, raptors nesting on buildings and waterfowl staging adjacent to roads. Such use will not be interfered with unless there is a concern for wildlife or human safety. Bird use of the development area will be monitored as part of the ongoing wildlife record.

Summary

This plan has outlined strategies and activities to be undertaken to protect wildlife and wildlife habitat within the NWT Diamonds Project area. These strategies include habitat protection, minimization of disturbance to wildlife, wildlife and human safety and rehabilitation of disturbed areas. Details have been presented on how these activities can be achieved. The strategies incorporate traditional environmental knowledge (i.e., deflection of caribou) and scientific information. Finally, the defined strategies provided input for the Environmental Monitoring Plan.

8. Aquatic Life Management Plan

Fish have been identified as a valued ecosystem component due to their intrinsic value as well as their importance as a food source. To a lesser extent, fish are valued for their associated recreation value.

The main project activities that will affect both lakes and streams in the NWT Diamonds Project area will take place during construction and operations. These activities include dewatering of lakes, exploration, road construction, culvert installation, tailings disposal, stream diversion and dam construction. Potential changes to the aquatic environment resulting from these activities are categorized as follows: habitat loss, habitat modification, shoreline modification, alteration of the hydrological regime, disruption of migration routes, habitat degradation and loss of fish due to biological sampling. The management strategies that will be implemented to prevent and mitigate each of these impacts are discussed in the following sections.

Preserving resident fish populations is primarily achieved through habitat protection, including both the physical environment and water quality. Fish populations could be affected as a result of harvesting by angling and biological sampling and by disruption of migration routes. This plan describes the measures proposed to restrict the removal of fish from lakes and to ensure that natural migration routes are maintained.

This management plan describes how project activities involving exploration, construction, dewatering of lakes and waste management can be undertaken without damaging the aquatic environment.

Strategies to control, minimize and offset the effects of project activities are as follows:

- establish a fund to be used for off-site fisheries enhancement
- mitigate stream habitat loss by provision of a diversion channel
- implement construction and operation practices that prevent habitat loss (culverts, erosion control features, bridge)
- restrict removal of fish from lakes in and surrounding the project area
- use non-destructive sampling gear such as trapnets and small mesh gill nets in the monitoring program.

By ensuring that fish habitat is protected, and harvesting is restricted, fish populations should be maintained in a reasonably natural state throughout the life of the project.

8.1 Habitat Creation and Enhancement

The management plan is designed to preserve fish and fish habitat in lakes not directly affected by project activities and to compensate for lost fish habitats. The entire aquatic system will be affected in seven lakes: Panda, Misery, Koala, Leslie, Fox 1, Long and Airstrip. The first five will be lost to dewatering prior to mining, Long Lake will be used for tailings disposal and Airstrip Lake will be dewatered to gain access to construction material. Streambeds upstream and downstream of these seven lakes will also be affected due to diversion of inflows, resulting in the loss of grayling spawning and rearing habitat. The total lake area lost will be approximately 891 ha, which accounts for approximately 0.06% of the area of all the lakes in the Coppermine watershed.

Mitigation of lake habitat loss will be achieved primarily through the establishment of a proposed habitat fund, which would be used for off-site habitat enhancement. Lost stream habitat will be offset by habitat enhancement measures, which will include the construction of a major water diversion channel before dewatering of Panda and Koala lakes. The Proponent has consulted with the Department of Fisheries and Oceans (DFO) to determine the most effective means of mitigating habitat losses. Within the Koala watershed, mitigation will focus on conserving the habitat in those lakes not directly affected. Fish populations in the lakes designated for dewatering will be harvested prior to or during dewatering, and the catch distributed among northern communities.

8.1.1 Habitat Fund for Off-site Habitat Enhancement

In April 1995, DFO suggested to the Proponent the establishment of a NWT Fisheries Habitat Fund to offset the loss of habitat due to the dewatering of six lakes and the infilling of a seventh. The Proponent would contribute to the establishment of such a fund, which would be applied to the enhancement of off-site habitat or to the improvement of productivity in areas beneficial to residents of the NWT.

In May 1995, the Proponent submitted a report entitled “Fisheries Mitigation Strategy for No Net Loss Policy” to DFO for review. It contained two parts: a scope and direct cost estimate for the creation of new fish habitat in a 3.5 km water diversion channel from upper Panda to Kodiak lakes, and a proposal to determine the value of a habitat fund. This value was based on detailed field studies that estimated the standing stock of fish in the affected lakes; the expected sustainable harvest over a 25-year production and 5-year recovery period; the estimated value of the sport fishery to NWT outfitters; and the value of an amount of purchased replacement protein equal to the foregone harvest. The 1995 value of the recreational and domestic fisheries was compounded at 3% per annum over 30 years to account for growth in value. In order to account for non-monetary values associated with the resource, a number of weighting criteria were derived for various cultural indicators of the system. These included a country food preference factor, the relative importance of fish in the overall diet of NWT residents, the importance of the "wilderness experience," local employment, the potential for growth of the sport fishery and the importance of the project lands to the regional traditional lifestyle. Mean weighting factors for the recreational fishery and social cultural components were applied to the compounded values. The current market price of the standing stock and the two compounded and weighted values were summed to yield a value for the habitat fund.

A second alternative suggested by DFO for determining a habitat fund is based on the amount of fish habitat being lost. Optimal lake trout spawning habitat (OLTH) was taken to be the most important type being lost in the affected lakes, and an estimate was made based on the cost of recreating this within a reasonable distance from the mine.

The amount of OLTH to be replaced was determined as part of the bathymetry and fish habitat investigations for the EIS. The area of existing habitat was estimated by visual assessment and mapping from the surface during netting operations and from the air by low level helicopter overflight of all shorelines (approximately 70 km) under ideal viewing conditions. Observations were confirmed using seven 100 m transects underwater in three lakes. The criteria for classifying OLTH include the presence of clean, coarse, cobble and boulder substrate, adequate depth, proximity to shore and steep drop-offs and adequate wind fetch to ensure good water circulation and oxygenation. Most of the lakes in the project area have extensive littoral cobble and boulder deposits, mixed with gravel in some areas, which extend offshore for several tens of metres. Beyond this rocky fringe, the substrate becomes uniformly fine grained silt.

Apart from OLTH, the affected lakes contain a large amount of lower quality habitat, which sustains the populations of other large fish and forage species. The fish studies conducted to date strongly indicate that a lack of nutrients and not habitat availability, is the factor limiting productivity in the study lakes.

For the purpose of estimating the volume and weight of waste rock required to create the replacement OLTH and the cost of sorting, moving and distributing it, the following assumptions were made:

- The waste rock is free, as a by-product of the mining operation.
- The new habitat would be created in a hypothetical existing fishless lake basin within a 10 km radius of the waste rock source.
- The thickness of cobble/boulder deposits on existing OLTH, based on diver observations, ranges from about 3 m near the shoreline to essentially zero at the interface with profundal sediments, giving a mean thickness of about 1.5 m.

- Hauling and placement of the waste rock would be done in winter over frozen land surfaces and lake ice.

The final value of an approved habitat fund and the method and schedule for setting it up will be determined in further discussions with DFO.

8.1.2 Panda Diversion Channel

A water diversion channel is being constructed from upper Panda Lake to Kodiak Lake to permit development of the Panda and Koala pits. The total length of the channel is approximately 3.5 km. The bed width along the channel will be 2.0 m except at locations where constructed pools are planned. The side slope recommended (width to height ratio) is 1.5 but may vary according to overburden conditions. Most of the excavation will be through bedrock; therefore, blasting will be required.

To offset the loss of fish habitat in streams being affected as a result of lake dewatering, the Proponent, in consultation with DFO, has incorporated fish habitat requirements into the design of the channel. The diversion channel will provide fish passage from Kodiak Lake to the northwest sub-basin of Panda Lake.

The diversion channel, unlike the natural streams, will not be subject to drying. As shown in Table 8.1-1, the diversion channel is two and a half times as long as the natural streams. At medium and low flows, the diversion channel will provide more useable habitat than is currently available. The plan of the channel area is shown in Figures 8.1-1 and 8.1-2.

Table 8.1-1
Habitat Dimensions at High, Medium and Low Flows

		Total Volume (m^3)		
	Total Length (m)	**High**	**Medium**	**Low**
Natural Streams[1]	1,570	22,326	6,850	2,996
Diversion Channel	3,530	12,423	9,723	9,327

1: Natural Streams = Panda-Koala, Koala-Kodiak, Long-Leslie, Leslie-Moose and Airstrip-Larry.

It is expected that the channel will establish an environment similar to that of an undisturbed stream. It will be monitored regularly to confirm its suitability for

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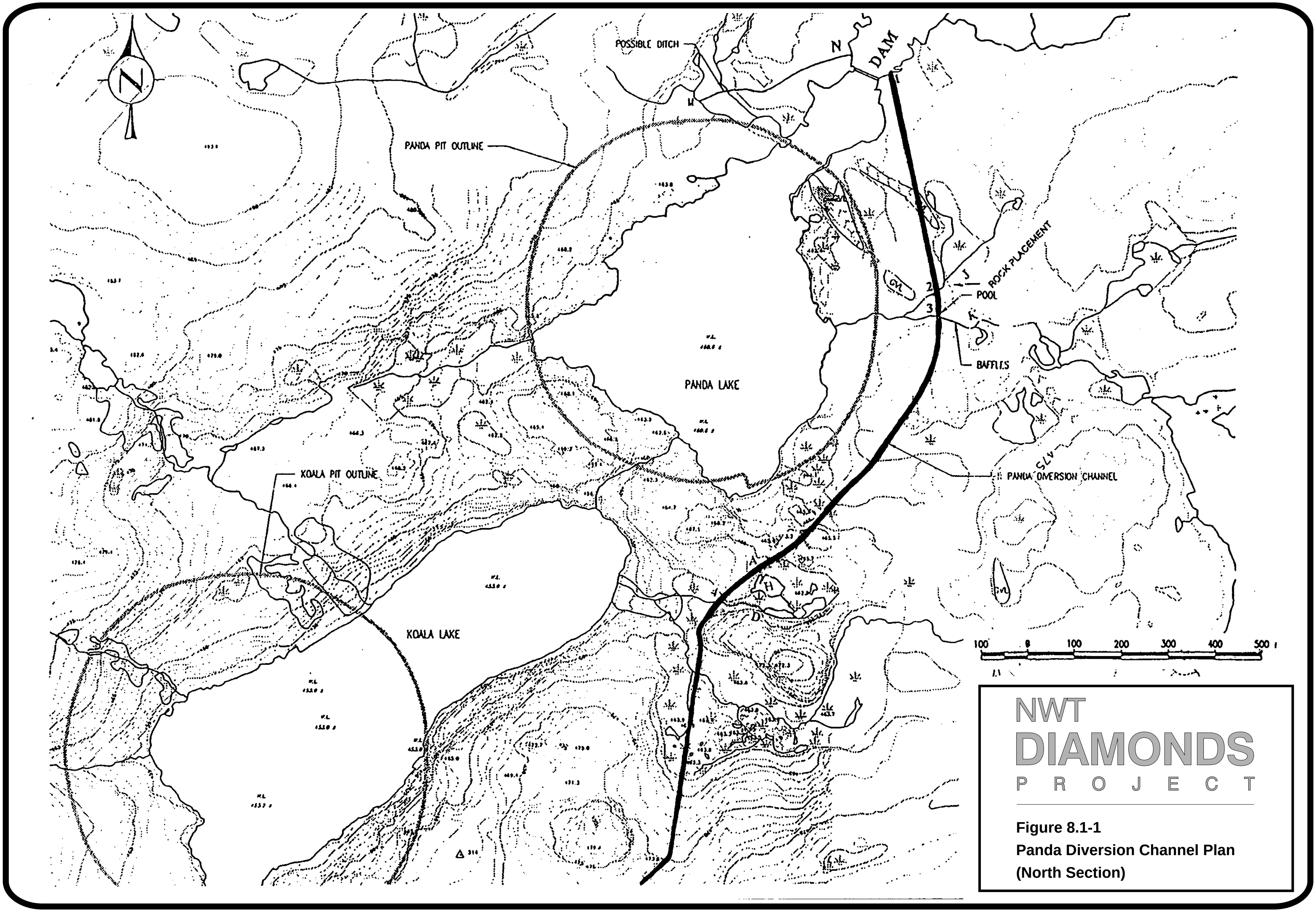

NWT DIAMONDS PROJECT

Figure 8.1-1
Panda Diversion Channel Plan
(North Section)

Source: Rescan

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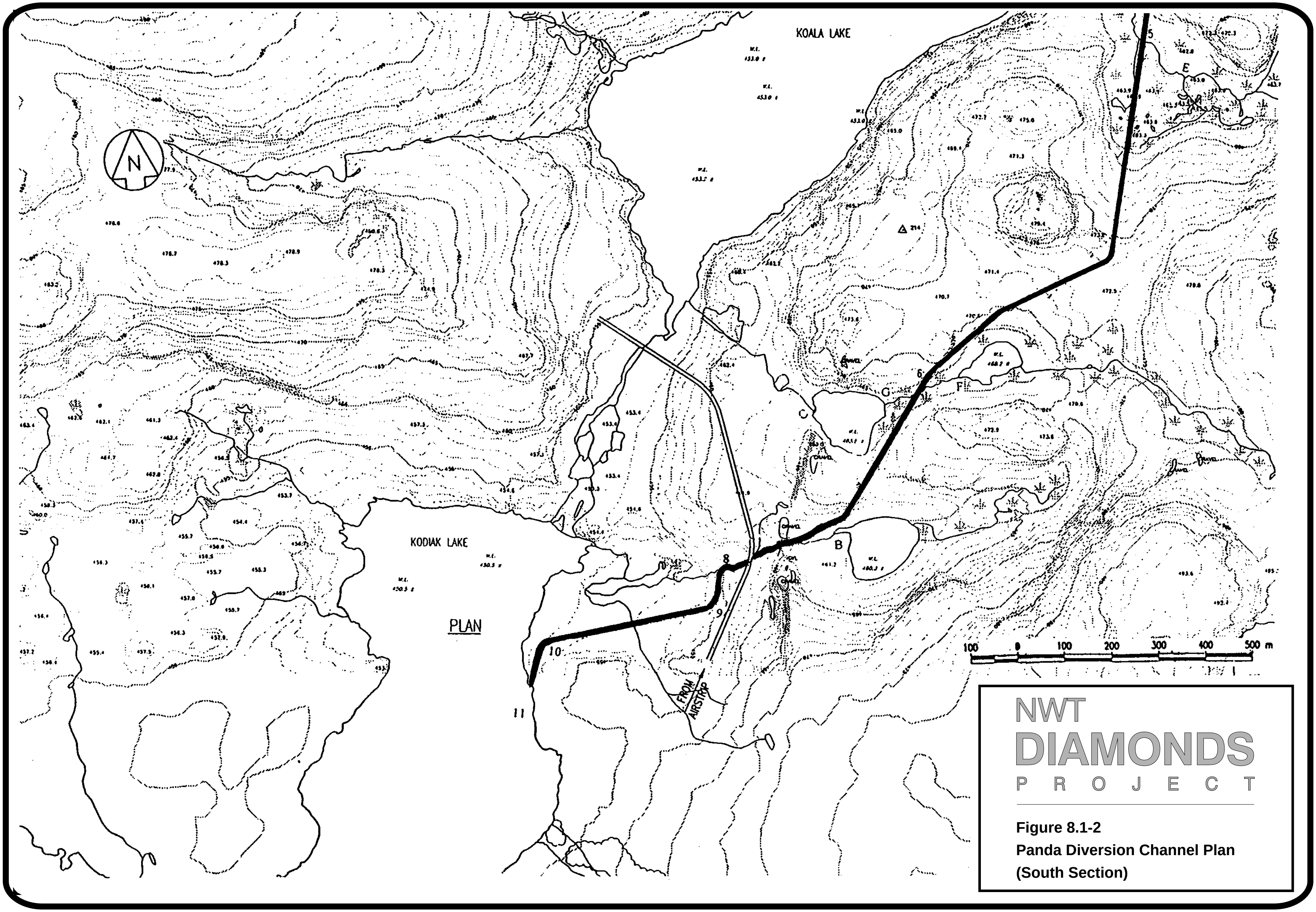

Figure 8.1-2
Panda Diversion Channel Plan (South Section)

Source: Rescan

supporting fish populations. Provision will be made to modify instream habitat where necessary.

8.1.2.1 Habitat Enhancement Structures

Several types of habitat enhancement structures have been designed and may be installed to increase habitat diversity along the diversion channel, according to recommendations made by DFO (Katopodis 1991). These include meanders, stream intersection structures and main channel structures. Meanders control erosion and provide back-eddy pools for fish. Stream intersections may include baffles and pools to provide resting places and easy access into tributary streams for fish. Main channel enhancements include pools placed along steeper gradients to facilitate movement and boulder placement to provide additional structure. Each habitat enhancement structure is described in more detail in Appendix III-E1.

8.2 Habitat Protection from Modification

The purpose of managing modifications to fish habitat is to minimize the effects of road construction, culvert installation, building of dams and diversion ditches and dewatering of lakes. The impacts of these activities will include increased turbidity and sedimentation, shoreline modification, fluctuations in water level and disruption of migration routes.

8.2.1 Turbidity and Sedimentation

Management strategies will aim at preventing increased turbidity and sedimentation in aquatic systems within the Koala drainage. Natural erosion processes are accelerated by disturbance of the soil and its associated vegetation. Increased turbidity is likely to result from the development activities proximal to lakes and streams. These activities include road, dam and culvert construction, tailings and waste rock disposal, stream diversion and the dewatering of lakes.

However, the natural filtration of tundra will allow particles to settle out. Also, drainage control structures will be developed around the plant/camp facilities, emulsion storage site and related facilities. The aim is to direct turbid water into temporary sedimentation ponds.

8.2.1.1 Construction in and Around Streams

Construction and operational practices will be followed that minimize sediment production and its release into nearby waters. Guidelines for the construction of stream crossings to maximize efficiency and minimize habitat degradation will be followed. Many erosion control designs for access roads and stream crossings are available from provincial and federal guidelines. The appropriate designs will be chosen on a site-specific basis after detailed surveys have been completed. Important considerations include the biological activity in the affected area and the properties of both the natural soil conditions and the aggregate used for the actual roadway. General principles will be followed to minimize erosion, as outlined in Land Development Guidelines for the Protection of Aquatic Habitat (DFO and B.C. MOE, Lands and Parks 1992). These principles include the following:

- planning the development to the existing terrain and site conditions
- scheduling development to minimize risk of potential erosion
- retaining existing vegetation where possible
- revegetating or protecting exposed soils
- diverting runoff away from exposed soils
- minimizing the length and steepness of slopes
- minimizing runoff velocities and erosive energy
- retaining eroded sediment on site with erosion and sediment control structures
- planning, inspecting, and maintaining erosion control structures.

Most designs incorporate the placement of coarse non-erodible material (riprap) over fine textured highly-erodible material. This protects erodible soils from exposure to high velocity runoff as well as providing a sediment trap for suspended sediments from upstream sources. Revegetation of exposed soils is also an integral part of erosion control and will incorporate the use of plant species that can establish quickly on exposed soils. Vegetation suitable for site reclamation is discussed in detail in Section 9.

8.2.1.2 Removal of Sediments from Process Waters

Management of the hydraulic regime, the provision of adequate settling reservoirs and, if necessary, the addition of settling agents to the water are all envisaged mitigation procedures to meet discharge criteria for suspended solids.

To eliminate turbidity in the drill chip return water during the 1994/1995 winter drilling program, a flocculant was added to increase the settling rate of solids. In addition, drill water was deaerated and discharged at the lake bottom to prevent turbulent mixing and redistribution of sediments. Finally, a diffuser was employed to prevent scouring of the immediate area at point of discharge. This or other methods will be employed to protect aquatic life.

8.2.1.3 Removal of Sediments Resulting from Lake Dewatering

Where project activities could result in the discharge of turbid water to the receiving environment, two methods are available to reduce suspended solids to meet discharge criteria. The methods are detention with natural settling and clarification.

The pumping of at least 2 m of water from Long Lake and dewatering of other lakes may generate elevated levels of suspended solids during advanced stages of the dewatering process. This could result from exposure of unconsolidated sediments to rainfall events and slumping of these particulates from below the boulder (littoral) zone toward the lake bottom. It is planned to direct any resulting turbid water to settling basins, where the solids will be able to settle before the supernatant water is discharged.

The liquid fraction of the tailings initially discharged to the upper (north) end of Long Lake will exfiltrate the rock-fill detention dam(s), losing some of its suspended solids. Within the downstream portion of Long Lake, there will be sufficient time and low velocity flow rates to permit natural sedimentation. Spring runoff from the Long Lake basin will be released downstream if it meets water quality discharge criteria. Should it exceed the criteria, it will be detained within the basin and released only after sufficient settling of suspended solids.

8.2.2 Shoreline Modification

Various degrees of shoreline modification will result throughout all phases of construction and development. Changes in shorelines will result in loss or change in the littoral habitat. Construction of ditches, channels, dams and docks may cause disturbances in spawning and rearing habitat, which may reduce the reproductive success of fish. Changes in wave patterns, or the normal cycles of drawdown and replenishment, may also result in shoreline modification, since areas that were once swept clean may now accumulate sediment. These changes may also affect habitat suited to the production of benthic organisms by exposing or flooding them during the main period of growth.

8.2.2.1 Minimizing Shoreline Disturbance

Shoreline disturbance will be kept to a minimum. Lake trout are particularly sensitive to shoreline development since they normally spawn close to shore and in specialized habitats (coarse rocky substrate, clean of silt and detritus). Shoreline development will be designed so as not to interfere with these critical habitats.

Shorelines can be modified by additional sediment loading from the drainage channel and culverts. Two mitigation strategies that will be implemented to minimize sediment deposition are as follows:

- laying riprap at intersections between ditches and culvert crossings (areas of coarse rock placed in the streambed to protect underlying fine sediments from high velocity water flow and, to a lesser extent, to filter out suspended sediments from upstream sources)

- minimizing the slope of the channel and culverts to create low water velocities thereby reducing erosion.

8.2.3 Alteration of the Hydrological Regime

The dewatering of lakes and the construction of dams, diversions and culverts will alter the hydrology of lakes and streams immediately downstream of project activities and create changes in the normal hydrological cycle. The dewatering of lakes will create the greatest change to the natural flow regime, since downstream lakes and streams will experience freshet-like conditions that might extend well into the summer dry period. Fluctuating flows could affect habitats used for rearing, spawning, feeding and migration.

8.2.3.1 Flow Regime Management

Management of the flow regime will ensure that the normal cycle of discharge is not greatly disrupted. To ensure that flow velocity is not excessive during dewatering, a criterion was established that flow rates during dewatering will not exceed one-half of peak spring discharge. The time required to dewater a lake will vary between four and 12 weeks, depending on the size of the lake. Although extended freshet-like condition are somewhat unnatural, longer use of the habitat by fish and benthos will be possible.

Culverts and other stream crossings will be designed according to existing federal guidelines for the protection of fish habitat (DFO 1992; Katopodis and Gervais 1991; Katopodis 1991). Water levels and velocities through culverts will be monitored and the flow regime altered to ensure that neither excessive nor insufficient discharges occur.

8.2.4 Disruption of Migration Routes

Dam construction and the dewatering of lakes will create barriers to fish movement. Fish passage will be obstructed between Panda and Kodiak lakes, and between Moose and Long lakes. Certain culverts may create barriers to fish movement if water levels and flows are altered. Culverts installed in permafrost regions are highly susceptible to complete freeze-up during winter, resulting in the blockage of both water and fish movement during the early freshet periods in spring. Arctic grayling and longnose sucker would be most affected by blockages, as they use streams for spawning in the spring.

8.2.4.1 Migration Route

The diversion channel between Kodiak and Panda lakes will compensate for migration routes lost as a result of dewatering Panda and Koala lakes. The channel has been designed to accommodate the needs of migrating fish. Water levels and velocities will be monitored regularly to ensure that they do not exceed the swimming capabilities of fish. The least powerful swimmer among the fish caught in the Koala watershed is the round whitefish. By designing flows to meet the needs of this species, the needs of other species should be met (Katopodis 1983).

8.2.4.2 Culvert Design to Permit Fish Migration

Fish migrate to access new habitats for continuing their life cycle (spawning grounds), to access more food or to avoid predators. Culverts installed along migration routes will be designed according to existing guidelines to allow for the unrestricted migration of fish (DFO 1992; DIAND 1990; Katopodis and Gervais 1991; Katopodis 1991; Saremba and Mattison 1984). Round culverts may be used at most stream crossings, and open bottom culverts may be used over sensitive stream habitats and streams with excessive discharge. The appropriate design will be made on a site-specific basis after detailed surveys have been completed. Proper stream crossing designs will ensure that fish do not experience, as a result of the stream crossing structure, excessive flow velocity, culverts displaced above the stream channel, insufficient flow through the structure or inadequate resting areas below the structure.

8.3 Harvesting of Fish

The removal of fish by angling or biological sampling will be restricted in order to preserve existing populations in a reasonably natural state. Permits will be required from DFO and the Science Institute of the Northwest Territories. Because of the low productivity in the aquatic system, fish populations could be seriously reduced if harvesting is not restricted.

8.3.1 Removal of Fish by Anglers

As the work force at the mine increases and roads are improved, lakes may become more accessible. Angling pressure in a number of lakes could increase. Fish in the region are slow growing and the replacement rate of large individuals is relatively slow. Therefore, the fish stocks are sensitive to exploitation. The level of angling pressure that can be withstood without disruption of the fish population is likely to be low.

Several factors will help to ensure that angling pressure on the local lakes will be minimized:

- Other recreational pursuits will be provided for in the permanent camp.
- Access to and across active mining areas, including roads, will be off limits to off-shift personnel.
- Other areas such as the airstrip and explosives plant will be off limits for safety reasons.
- Security zones required at diamond mining operations will further restrict personnel movement away from camp.
- No mechanized transport will be available for recreational activity, and Kodiak Lake will be the only lake easily accessible.

In addition, fishing restrictions during construction and operations are expected to result in minimal impact on the local fish populations.

8.3.2 Harvesting of Fish for Biological Sampling

Biological sampling will continue during exploration, construction and operational phases. The use of trapnets and gillnets to remove a wide range of sizes and species from the study lakes will not greatly alter the population structure although the fish density will have been lowered slightly.

Efforts will be made during all sampling periods to reduce mortality. Based on experience gained in 1994, the following steps are proposed:

- exclusive use of non-destructive capture methods such as small-mesh gillnets, trapnets and angling
- sampling intensity to be reduced during the day in warm weather (mid-summer) to minimize heat exhaustion, but may continue in the cool evenings
- experiment with the use of circular holding tubs (as opposed to rectangular tubs) to provide a less restrictive environment for the fish during sampling.

Efforts will be focused on spawning fish, as they are concentrated in large numbers in a small area and, of greater importance, their timing coincides with cold water periods, which greatly reduces sampling mortality.

8.4 Habitat Degradation

There is a low probability that the quality of the habitat in the project area will be degraded by chemical contaminants. These contaminants may enter the aquatic environment from vehicle accidents, potential waste rock drainage or tailings dam leakages. Spills of fuel, lubricants and antifreeze during transportation are potential hazards; however, the probability of occurrence is low.

The fauna in the streams and the benthic and planktonic components of lakes will be the most sensitive to chemical contaminants, as these organisms are likely to be the first to come into contact with these substances. Among the fish species, lake trout is probably the most sensitive, as it is an inhabitant of clear, cold, well-oxygenated water. Lake trout are also long-lived, and therefore may accumulate contaminants in their tissues. Long-term exposure to chronic levels of toxicity could reduce growth, fertility and longevity (Evans *et al.* 1991).

8.4.1 Spill Contingency Plan

Management of the aquatic life habitat will effectively consist of managing the source of contaminants. The waste management plan (Section 5) details measures taken to ensure the containment of possible rock drainage contaminants. Work force education and a spill contingency plan will prevent or minimize the impact of spill events.

Summary

The aquatic life management plan addressed aquatic issues surrounding project activities. The plan focuses on habitat protection at the physical environment and water quality level. A number of strategies and activities are described to ensure the protection of the aquatic habitat. The activities described in the plan are designed in accordance with legal requirements, scientific knowledge and respect towards Aboriginal values on fish use. Finally, a number of activities are described that will provide the basis for a monitoring plan. Aquatic monitoring will be an important component of the overall environmental monitoring plan.

9. Reclamation, Decommissioning and Closure Management Plan

Reclamation will be the major means of mitigating impacts associated with the development and operation of the NWT Diamonds Project. Reclamation is an integral part of mine planning and will be an ongoing process as sites become available. This will minimize the areal extent of land under active disturbance at any one time. In addition, progressive reclamation will provide opportunities to modify reclamation plans early in the life of the mine, which will enhance the effectiveness of the program.

The reclamation program for the NWT Diamonds Project has been developed to fulfill the requirements of Section 18 of the Territorial Land Use Regulations, Restoration of Permit Areas. Currently, wildlife (and fish) use of the mine area and limited Aboriginal use of the area are the predominant land uses. Accordingly, the reclamation design has been developed to re-establish these land uses within the context of an economic mining operation.

Reclamation research pertaining to the mine area and to other arctic, subarctic and alpine regions will provide a foundation for reclamation at the NWT Diamonds Project. Reclamation plans will be developed recognizing the importance of pioneer species and the concept of facilitating the development of sustainable plant communities. As such, the reclamation programs have been designed to encourage invasion of the disturbed sites by later successional species. By mimicking the manner in which natural processes reclaim disturbed sites, the planned reclamation program will ensure that the reclamation undertaken is self-sustaining and that it is in accord with the natural vegetation in the area.

The arctic/subarctic setting of the mine provides challenges and limitations in the rehabilitation of disturbed sites. Summers are short and often cool, precipitation is low and available moisture scarce, soil and air temperatures are low, and permafrost is pervasive all of which reduce effective organic matter decomposition and nutrient cycling. Plants that have adapted to this harsh environment are slow growing and may produce very limited seeds. The study of natural plant systems will provide clues to strategies for addressing these limitations in a successful reclamation program (Polster and Bell 1980).

The following sections provide an overview of the planned reclamation activities for the project. Existing and proposed land and resource uses in the area, and reclamation research in arctic and alpine areas as well as at the NWT Diamonds Project site, are presented. The mine site is divided into reclamation landscape units for the purposes of defining reclamation criteria for the different sites. These are then used to provide topdressing and vegetation establishment strategies. Further reclamation research conducted to date and research requirements are identified. Reclamation scheduling is presented within the context of mine development. Scheduling has been developed to provide reclamation opportunities throughout the life of the mine so that upon completion of mining, large reclamation liabilities do not exist. Reclamation maintenance activities are discussed in the monitoring program for the reclaimed sites.

9.1 Reclamation Goals and Objectives

"*Well, if they are closed down, and they do the proper clean-up and make sure that everything is cleaned up, and that everything is monitored, (as) it used to be at one time (then the land will recover). It would be pretty hard to put it back that way, but if they do the cleaning up the right way and do it right, then in a couple of years or so then the animals will be coming back...again*" (Stan Laroque, Yellowknife).

Three reclamation goals have been defined for the NWT Diamonds Project. The first goal is the provision of stable physical landforms. Mine designs have been predicated on the need to provide stable post-mining landforms. These will in turn support a diversity of post-mining habitats, which will provide for the productive use of lands altered by mining.

The second goal is to re-establish productive use of land. Currently, wildlife use of the area is the principal land use. Aboriginal use of the cultural and natural resources in the area, although limited, is recognized as an important land use. Details of land use patterns as they relate to the design of the reclamation program are explored in the following section.

The final goal of the reclamation program is to protect the water resources of the project area through effective designs of water management facilities and post-mining landforms. Waste management strategies have been developed to protect the quantity and quality of water in the area.

The following reclamation strategies have been developed from these goals for application at the NWT Diamonds Project. Reclamation at the mine will seek to:

- protect the environment through sound reclamation practices
- re-establish the pre-existing productive condition of the land or an acceptable alternative through revegetation or natural colonization
- re-establish the primary use (wildlife) by creating habitat and/or promoting habitat recovery
- minimize water quality impacts by designing and implementing landscape features and proper drainage control measures
- ensure that the abandoned areas do not pose safety problems or health risks.

These goals, and the strategies developed to achieve them, are discussed in greater detail in the following sections. The following critical elements have been identified as essential in meeting these goals:

- comprehensive biophysical baseline data collection
- review of literature pertinent to reclamation in subarctic and arctic environments
- identification of revegetation research needs for the NWT Diamonds Project
- assemblage of a research team
- design and implement a comprehensive research plan
- continual refinement of reclamation plans.

Detailed biophysical characteristics of the mine site area have been used to provide preliminary reclamation designs that are congruent with the surrounding area as well as designs for mine facilities such as water control structures. The limited amount of information on reclamation at the mine site has been supplemented with information gathered from similar settings and situations. A review of the literature applicable to reclamation at the NWT Diamonds Project has been conducted (Appendix III-F1). In addition, literature from Canadian sources has been used to provide information for the preparation of the following reclamation plans.

9.2 Land Use Objectives (Wildlife/Aquatic Habitats)

9.2.1 Existing Land Use Pattern

Existing land use for the project area consists of wildlife habitat and traditional hunting and trapping. The Bathurst caribou herd, consisting of approximately 486,000 animals (Heard 1989), moves through the area on their migration to and from arctic calving grounds, grazing as they travel. Eskers form important movement corridors for caribou and denning sites for bears and other furbearers. Barren ground grizzly bears use the sedge meadows as they forage for food. Fish are found in most of the local water bodies.

Exploration activities have been conducted since the discovery of diamonds. In addition, mining is carried out at the Echo Bay Lupin mine, 100 km north of the project area. There are no permanent settlements or roads within the project area, although the Echo Bay winter road passes near the project site.

9.2.2 Proposed Future Land Uses

Reclamation plans have been developed to return the site to a condition that will foster the return of wilderness uses. Although some loss of aquatic habitat will be associated with dewatering of local lakes, mitigative measures have been developed to reduce, control and compensate for it. Future use of the NWT Diamonds Project area is expected to include traditional wildlife use. No permanent road access is proposed for the area, and the winter roads are constructed only as required to service the mines.

Proposed future uses for specific mine site areas (reclamation landscape units) are discussed in the following section. However, it is suggested that the mosaic of landscape and vegetation patterns proposed for the development areas will support a variety of uses.

9.3 Reclamation Landscape Units

The following reclamation landscape units have been defined to provide a framework upon which the proposed reclamation programs can be built. These units are composed of similar surficial changes; therefore, reclamation strategies within each unit can be the same. For instance, reclamation design for the various waste rock dumps will be similar, as they will be constructed of similar materials using similar methodology, even though the dumps are located in various areas throughout the property.

Proposed final surface configurations (created landforms) are discussed for each reclamation landscape unit. In addition, proposed substrate development and vegetation patterns are presented for each unit. Both landscape configurations and substrates/vegetation patterns are suggested to foster the diversity of site types found naturally in the area. It is this mosaic of patterns that will foster a diversity of wildlife habitats and hence a diversity of wildlife.

It is important to note that the reclamation methodologies outlined in the following sections are preliminary. These will be refined according to changes in mine plans, environmental conditions, proven technologies based on site-specific conditions and research results.

9.3.1 Exploration Sites Unit

The exploration sites unit is composed of all surficial changes associated with exploration for diamonds in the area. Exploration will be an ongoing facet of the mining operations. Exploration activities create changes that are similar to those expected during mining operations but at a much smaller scale, resulting in similar reclamation options. Reclamation options following exploration activities are presented below under separate headings.

9.3.1.1 Camps and Pilot Plant Site

A camp and pilot plant has been constructed to support recent exploration activities. This site, which is adjacent to the airstrip, is expected to be used for the foreseeable future, although it will eventually be dismantled and removed. Satellite camps to support exploration are typically temporary and are used during the winter. At the completion of their uses, the sites will be cleared and all structures will be removed from the area. Disturbed areas associated with camps and facilities will be recontoured if necessary.

The pilot plant and the present camp have been constructed to ensure that the permafrost undergoes minimal disturbance, thereby preventing any degradation of layers underneath. This will allow the re-establishment of a vegetation cover suitable to the site being reclaimed.

Revegetation designs for camp and facility areas will depend on the substrate and final landform configurations. Natural colonization will be encouraged where necessary; however, in highly erosive areas revegetation using appropriate species will be used.

9.3.1.2 Underground Portals

Two underground portals were used during the bulk sampling program, Panda and Fox. The Panda portal area will be reclaimed as outlined below. The Fox portal area, on the other hand, is designated as a revegetation research area for the project.

Underground portals constructed in conjunction with the exploration programs will be sealed for safety reasons. This will be accomplished by plugging or by burial of the site using waste rock excavated from the decline if future access is not anticipated. Where future use of the site is contemplated, reclamation will be delayed until site usage is completed. Otherwise the site will be recontoured to conform with the surrounding terrain. The re-contoured surface may then be topdressed using available substrate suitable for plant establishment.

Revegetation designs for the Panda portal site will seek to re-establish the appropriate vegetation cover on the site. The design will take into consideration the surrounding terrain and vegetation communities. For example, the use of waste rock will simulate boulder fields.

9.3.1.3 Waste Rock Storage Sites

The existing waste rock storage sites will be sloped to match the surrounding terrain and vegetation communities. Material removed from the slope can be used to topdress the compacted surface of the dump. An undulating terrain will enhance micro-site diversity, which will foster a mosaic of plant communities and wildlife uses. For instance, knolls might function as relief sites for caribou from biting insects, while depressions could be revegetated using species suitable for such sites (using suitable soils).

If topdressing is available, it may be used on portions of the waste rock dumps (flats). If deemed appropriate, these areas will be reseeded using northern adapted species. In all cases, revegetation designs for the waste rock storage sites will be developed to enhance the mosaic of site types.

9.3.1.4 Water Control Facilities (Sedimentation Ponds)

Reclamation of water control facilities will attempt to restore normal flow patterns to the site. Where sedimentation ponds have been built, dams will be breached and a rock lined channel established. These areas will be contoured to blend with the surrounding terrain.

Revegetation designs will incorporate various revegetation methods: shrub transplants, reseeding and natural recolonization. The methods used will depend on the substrate (texture) or its erosive condition.

9.3.2 Mine Operation Units

9.3.2.1 Water Control Unit

The water control unit consists of all structures and facilities developed to control water during mine operation. This includes the Panda diversion channel, dams and dikes, lake drainage facilities and sedimentation ponds. Many of these facilities will be constructed early in the life of the mine and will be used throughout the life of the operation. As such, reclamation plans that address both interim reclamation measures and that are appropriate for the eventual decommissioning and closure of the mine are proposed.

Panda Diversion Channel

A diversion channel will be constructed to divert water around the Panda and Koala pits. In addition the diversion channel will serve as a fish habitat. As such, reclamation designs have been developed to provide suitable riparian vegetation on the shores and to provide an erosion controlling cover on the slopes. The channel incorporates enhancement features such as meanders in the streambed, an irregular shape to the top of the channel embankments and where topographic conditions allow, a variety of widths.

Upon closure, the diversion channel will be left in its as-built condition. During channel construction, portions of the tundra substrate will be dozed to the side of the channel. This material will be returned to the disturbed area to allow for natural colonization. The residual organic substrate provides a source of seeds and propagules, in addition to organic matter. Thus, reseeding is not considered to be necessary. Depending on the nutrient status of the substrate, fertilizer may be applied to these sites to enhance vegetation re-establishment. Other revegetation techniques such as shrub transplants (for example, willow, birch) will be investigated for use at suitable locations along the stream banks as well as channel banks.

Dams, Dikes and Lake Drainage Facilities

Dams and dikes designed to control the flow of water in the mine site area and aid in tailings disposal will be constructed at various times throughout the life of the mine. As in the case of the diversion channel, the dams and dikes will remain in an as-built condition upon closure. The dams and dikes will simulate esker-like structures to provide travel corridors and insect relief sites for caribou. Another option is to add non-reactive waste rock material atop the flat surfaces to blend with the surrounding. Temporary dams that control water to accommodate mining will be breached and covered with riprap, if necessary, to restore the natural drainage courses.

Pocket planting on the faces of the dams using suitable riparian vegetation may be used to enhance fish habitat and provide a suitable vegetation cover for these structures. By providing a suitable final shape for these structures during the construction of the facilities, reclamation can be conducted early and the vegetation can be well established by the completion of mining. Another revegetation option, depending on the texture of the substrate, is reseeding using northern adapted species. This would be appropriate for sandy or finer textured substrates.

Sedimentation Ponds

Sedimentation ponds will be constructed to collect sediment laden water and allow suspended solids to settle prior to discharge to the receiving environment. Construction and/or use of these facilities will be staged throughout the life of the mine as new pits are brought into production.

Revegetation of collected sediments will focus on development of wetlands and providing stable long-term waterways. Collected sediments will be retained in the facility unless removal is required to re-establish adequate permanent drainage. These materials will provide an ideal rooting medium for wetland vegetation such as sedges and cottongrass. In addition, willows, alder and dwarf birch could be established along the margins of these sites to recreate the natural wetland patterns.

9.3.2.2 Tailings Pond Unit

The Long Lake basin will be the depository of fine tailings from the process plant. Depositing the tailings in cells will allow reclamation of the pond area on a progressive basis as the cells fill and are completed. Three different landforms will exist on the completed tailings areas: uplands, dikes, dams and low wetlands. These are discussed below.

Uplands

Beach and Slurry

The surface of a full cell will consist partly of beached sand (tailings) and partly of consolidated segregated slurry. The exposed tailings will be covered with a layered sequence of coarse tailings, waste rock and reclaimed lakebed soil (Figure 9.3-1). Six million to 11 million tonnes of coarse tailings have been classified as neutral drainage generating material and can be used in this case. Beaches will consist predominantly of sand, with small quantities of silt and clay. They will support traffic soon after they are deposited, simplifying the reclamation process. Beaches will be covered by a layer of waste rock and coarse tailings trucked from the process plant. A final covering of reclaimed lake bottom sediments will be applied to assist revegetation. The beaches will have low moisture content, allowing permafrost to aggrade rapidly from the surface downward, above which an engineered cover will contain the new active layer.

The consolidated slurry has characteristics quite different from the beaches. The slurry will not be able to support summer traffic, even after consolidation. During winter, a thick layer of slurry will freeze. Innocuous waste rock will be placed on top of the frozen slurry to reduce the depth of thaw during the subsequent summer. As permafrost aggrades into the slurry, more coarse tailings and some waste rock will be added, until the active layer is contained within the cover material at all times.

Surface Water Collection

The beach and slurry reclamation cover will be graded to direct surface water to a new channel constructed along the side of the basin. The channel will closely follow the contact between the tailings cover and the natural valley slope (Figure 9.3-2), where the underlying tailings will be beach material rather than slurry.

A section of the proposed streambed is shown in Figure 9.3-2. The design is engineered to encourage development of a long-term, stable streambed with permanent erosion resistant cover over the underlying tailings. A thick sequence of rockfill and coarse, granular (dry) tailings will be used to prevent erosion and thaw of the underlying permafrost. The overall gradient of the streambed will be low, approximately 0.05%, allowing water to flow towards the intermediate

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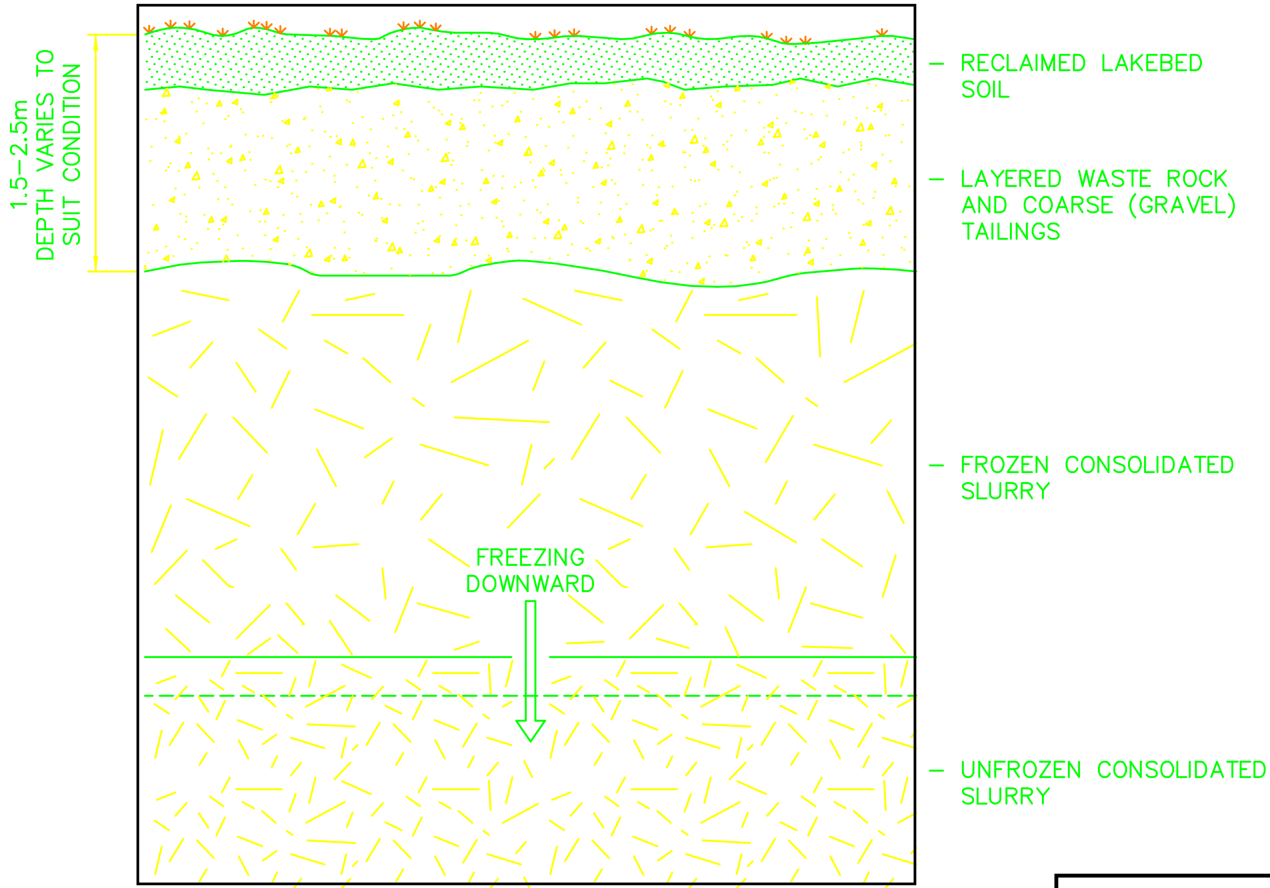

NWT DIAMONDS PROJECT

Figure 9.3-1
Tailings Cover for Reclamation

Source: EBA Engineering

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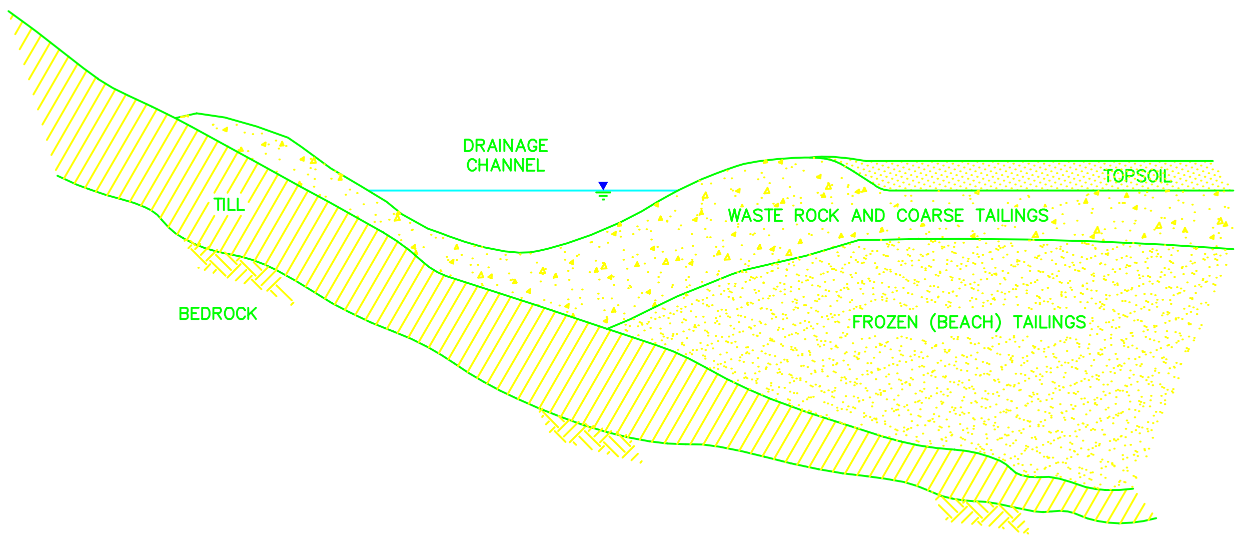

NWT DIAMONDS PROJECT

Figure 9.3-2
Surface Drainage Channel During Reclamation

Source: EBA Engineering

rockfill dike (Figure 9.3-3). A slot will be cut in the top of the dike to allow free passage of the water over the top. At that location the stream may be discontinuous; therefore the water will cascade over the face of the dike into the downstream cell. As the filling and restoration sequence continues, the streambed will be extended from cell to cell to the last intermediate dike at Cell E.

The suspended solids concentration of the water entering Cell E from the drainage channel will be monitored. It is anticipated that the water will run clear enough to meet guidelines within several years after the last tailings are deposited in the basin and the entire reclamation cover is in place.

Residual Lake Management

The lowermost cell within the basin (Cell E) will not receive tailings under the management plan. At the end of deposition, it will be a residual lake that will remain as a sedimentation and clarification pond until the restored tailings have stabilized and all surface runoff water runs clear enough to meet discharge guidelines. All plant process water will continue to be drawn from Cell E for five or more years after the tailings discharge is redirected to the first exhausted pit.

The annual spring runoff into the basin (Cell E) approximately balances the annual process water requirements. Cell E will act as a storage reservoir with annual water level fluctuation to accommodate process water requirements. Water discharge from Cell E is anticipated to be minimal during this operating phase.

At final closure, the spillway dam will be breached and riprapped to approximately elevation 453 m and will act as a permanent streambed. Water remaining in Cell E will either be allowed to discharge or be pumped to an abandoned pit, depending on the prevailing quality. Portions of the remaining basin may be selectively filled with waste rock. Outlet Dam and Spillway Dam will be left in place as built, as they are designed to ensure long-term stability.

Revegetation designs for the upland sites will be developed to create a dwarf shrub tundra. As with the wetlands, seeds, rhizomes and other plant parts contained in salvaged soils may well serve to complete much of the revegetation. Additional revegetation can be conducted by seeding with native pioneers and planting selected species.

Dams and Dikes

The intermediate dikes will extend about 0.5 m above the level of the tailings cover and serve as access roads until the end of the project. The East Perimeter Dam will have tailings against its upstream slope and will have an exposed downstream rock slope. The Spillway and Outlet dams will retain neither water

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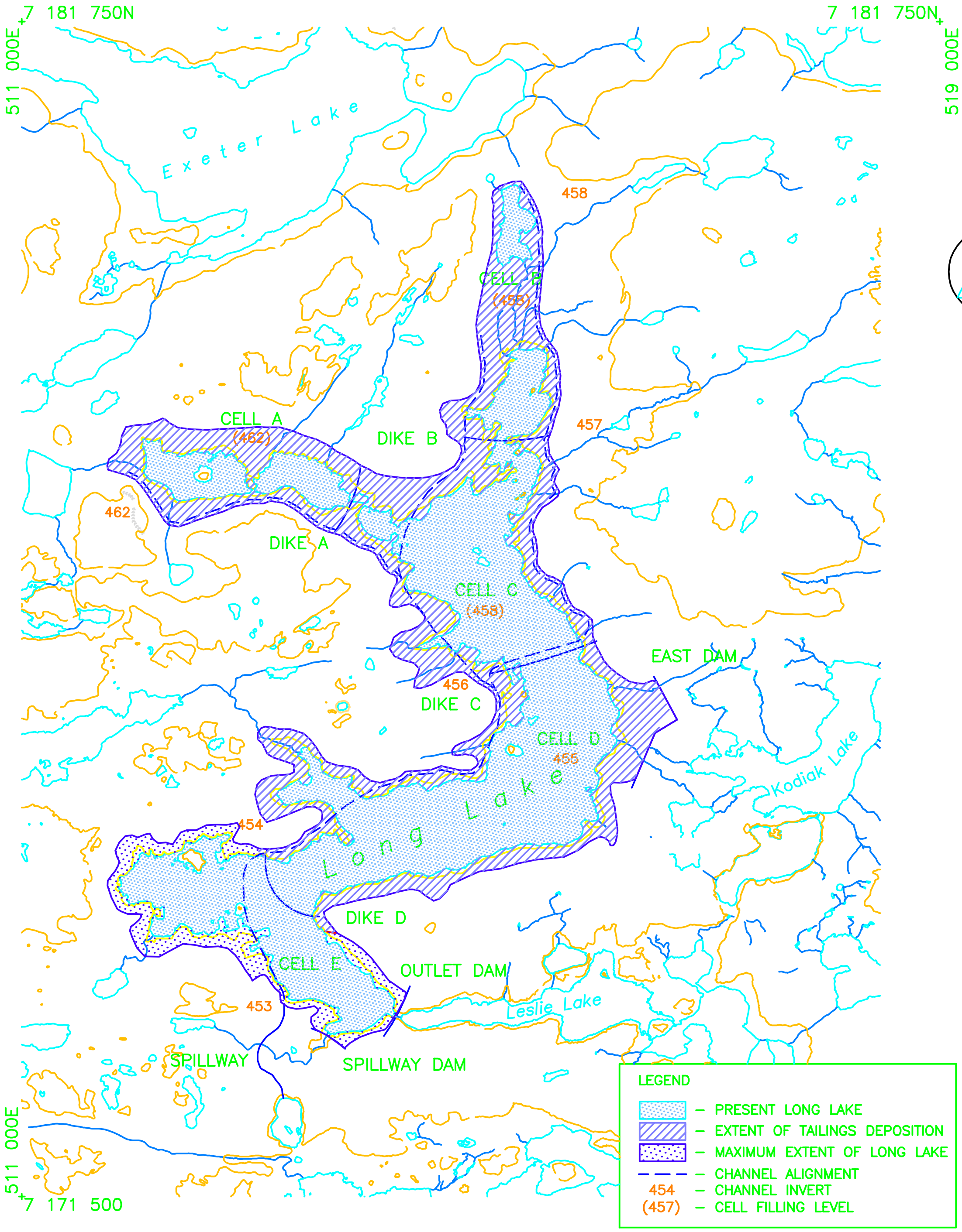

NWT DIAMONDS PROJECT

Figure 9.3-3
Layout of Drainage Channels After Reclamation

Source: EBA Engineering

nor tailings and will have their slopes flattened to blend into the resulting landscape.

Assuming that current climatic conditions prevail, permafrost will be sustained in perpetuity in all dams. Results of long-term thermal analyses, shown in Figure 9.3-4, indicate that dams retaining tailings on one or both sides revert to a stable core temperature of -4°C. Simulation of a potential “global climatic warming” scenario, similar to that discussed by Etkin (1990) of 0.3°C per decade, shows that in this climatic region there is little possibility that the permafrost will degrade. However, long-term preservation of the permafrost within the embankment is not required for the dikes and dams to remain stable after decommissioning.

Reclamation designs for tailings dikes and dams may be directed towards creation of esker-like structures, although without the gravelly, frost-free soil materials. These could then serve as movement corridors for caribou and other wildlife. Top dressing would not be required on the dikes or dams, as the materials used to construct these structures would be suitable for creation of esker-like habitats.

Revegetation of the dams and dikes will focus on the establishment of early successional, pioneering species. The use of reseeding, shrub transplants and pocket planting will be considered as revegetation options.

Wetlands

Recognition of the fact that tailings deposition will not form a plain but an undulating surface offers the opportunity to create a mosaic of different vegetation environments during reclamation. Depressional features would naturally be created in the low areas and depressions.

Revegetation designs for the depressional areas within the tailings pond unit could focus on the establishment of suitable wetland species such as sedges and cottongrass. Willows, dwarf birch and alder may also be planted around the margins of these sites to form a transition between the depressions and the upland sites. Additional revegetation could be conducted, if needed, using native seeds and container grown plugs of native sedges and cottongrass.

The depression sites may require the application of suitable soil materials. Organic soils and organically enriched mineral soils can be salvaged from the shores around Long Lake and from the bottom of the lakes to be dewatered.

9.3.2.3 Waste Dumps Unit

The waste dump areas constitute a large reclamation landscape unit, which has been broken into slopes and flats for discussion purposes. The waste dumps will be constructed as stable structures from waste rock, primarily granitic in nature.

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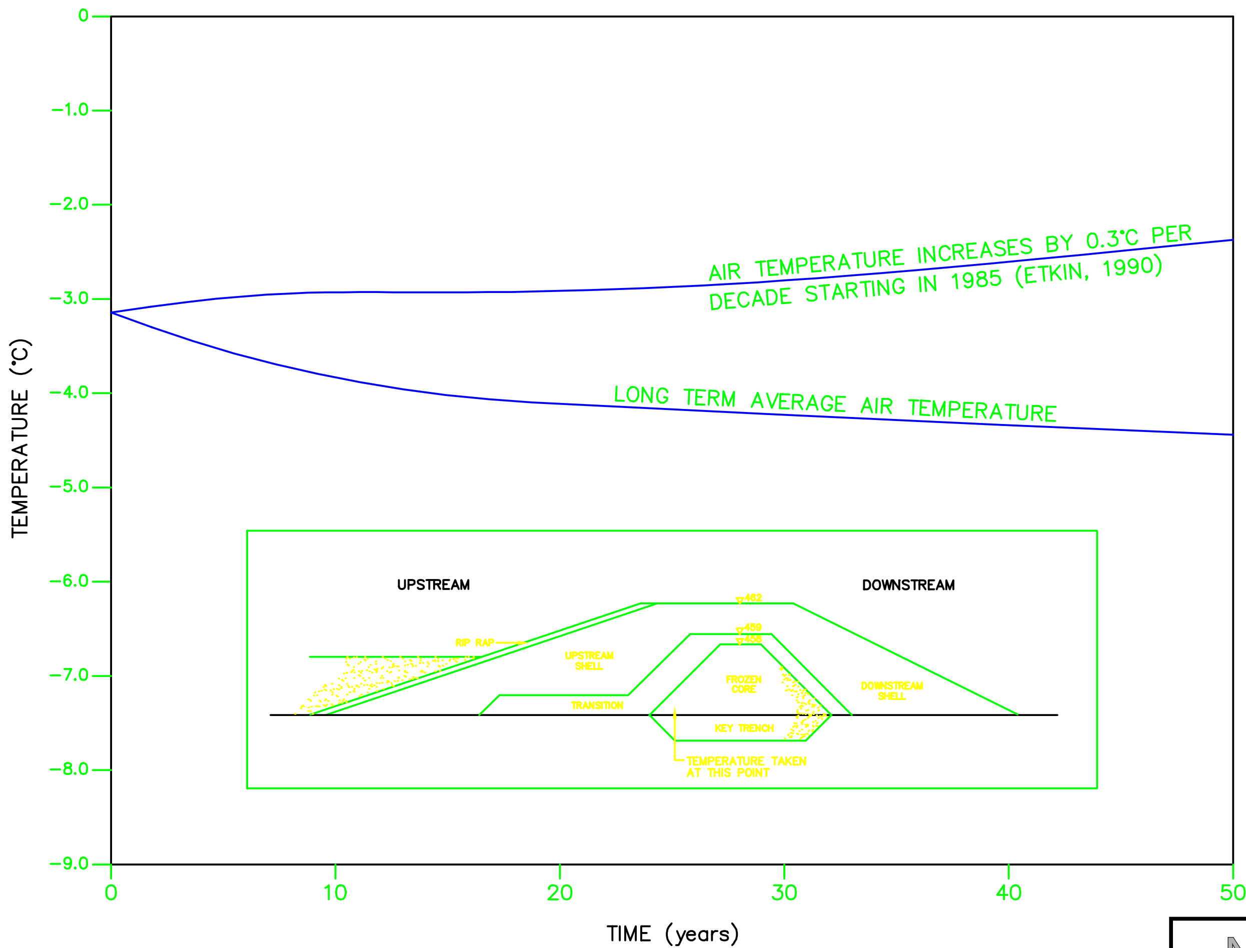


NWT DIAMONDS PROJECT

Figure 9.3-4
Permafrost Core Dam, Temp. History after Reclamation

Source: EBA Engineering

Coarse tailings, which will be primarily kimberlite, will be deposited in the Panda/Koala dump. In general, the following dumping strategies may be considered for reclamation:

- completion of portions of the dump perimeters up to the final dump elevations in stages, which would allow reclamation of the dump slopes in a progressive manner

- providing irregular dump outlines and profiles, which will create microhabitats to encourage plant and habitat diversity.

Slopes

The dumps will be constructed by end-dumping in lifts with overall dump slopes of 2:1. End-dumping will result in segregation of materials so that the large, coarse rock will tend to settle at the toe of the slopes. Dump slope reclamation designs are proposed to incorporate large rock habitats as well as sheltered draws and micro-valleys that could be used for cover by wildlife. Pocket planting may be done on the toe of the dumps to provide suitable sites for the establishment of vegetation that could be used by small mammals. These in turn serve as a food source for carnivores.

Topdressing materials salvaged in advance may be used to provide a suitable rooting medium in the draws and micro-valleys on the dump slopes. Topdressing the entire dump slope is not proposed because a diversity of sites is considered essential to a diversity of wildlife uses.

Revegetation of dump slope areas will be done by seeding pioneering species and planting plugs in suitable locations to create a mosaic of vegetation types, which will foster a diversity of use. Revegetation of the entire slope areas is not suggested, as some bare, rocky areas form part of the natural environment and thus are seen as being an important part of the arctic ecosystem (Johnson and Rowe 1977). Rocky areas adjacent to revegetated sites can serve as habitat for small mammals, while raptors may use large rocks as perches.

Flats

As with the slopes, the tops of dumps may be contoured to provide a diversity of landforms and thus a diversity of habitats. Knolls can serve as insect relief sites for caribou, while hollows that trap snow and retain more moisture can be reclaimed as sedge tundras and provide habitat for other wildlife species. Incorporation of a diversity of landforms and site types on the dump surface may result in greater utilization by wildlife compared to a flat dump surface.

The topdressing strategy for the tops of the dumps, if feasible, may provide for application of suitable materials such as pocket planting, in the hollows and sites where specific vegetation patterns are desired. Topdressing the entire dump surface is not seen as a reasonable approach for the creation of a diversity of habitats.

Revegetation designs for the flat tops of dump areas will continue the mosaic of patterns established on the dump slopes as discussed above. Stoney ridges and marshy swales may be developed on the dump surfaces (tops). Sedges, cottongrass and other wetland species may be established in the swales, while willows, alder and other mesic site species could be established along the margins of the waste dump in moist sites. Grasses and low shrubs may be established on drier sites to reflect the natural vegetation patterns on such sites in the area.

Lacustrine sediments will be removed from lake areas prior to mining. These sediments will be used as a source of topdressing. These sediments will be stripped during the winter so that frozen materials can be handled, thereby simplifying the operations. They will be stored initially in an impoundment adjacent to each pit.

9.3.2.4 Plant Site Unit

The plant site unit includes the process plant, permanent camp, airstrip, power plant and distribution facilities, and the associated infrastructure (water lines, sewage discharge lines, explosives storage sites, etc.). In most cases, these facilities will be constructed early in the life of the mine and be utilized throughout the planned operation. Although designs for these facilities should be developed on the basis of ease of final reclamation once operations cease, there may be opportunities for reclamation activities to be conducted early in the life of the operation and thus eliminate the need for reclamation at the end of mining.

All buildings, surface structures, fuel tanks, power lines and facilities will be removed from the area upon completion of mining operations with the exception of facilities associated with the airstrip, which will be retained for emergency purposes. Pile foundations will be left in place because their removal may result in permafrost degradation. Concrete foundations may be capped with waste rock. Recontouring will seek to restore drainages if possible and to return the land to a condition that is compatible with the surrounding terrain.

All sewage, tailings and water lines will be dismantled and removed, as will fuel storage facilities. Any contaminated soils will be identified and mitigation measures implemented.

The abandoned airstrip could serve an essential service as an emergency strip for aircraft.

9.3.2.5 Roads Unit

A variety of roads will be built to support the mining operations, although no permanent roads are planned to access the site from beyond the claim boundary. Roads will be built to a variety of standards, from winter roads used to access temporary exploration sites in the winter to haul roads used by large mining trucks for the movement of ore and waste. Roads will be built from a variety of materials including esker materials, waste rock and ice. Reclamation designs for proposed roads and the quarry sites developed for road construction are discussed below.

Quarry Sites

Quarries may be developed to access granular material for road and dam building and other construction materials from eskers. Sites utilized to remove granular materials from eskers will be designed to minimize surface disturbance and to enhance reclamation after use. These sites will be recontoured to blend with the surrounding terrain. The quarry sites may be revegetated using northern adapted species to provide an initial cover which will reduce wind and water erosion. This cover will be designed to promote invasion of the site by native species.

Mine Haul Roads

Mine haul roads will be constructed primarily from waste rock excavated during mining. These roads will be about 30 m wide at the crest and constructed to a standard that will allow safe and efficient operation of the large mining trucks. Many of these roads will be within the foot print of the open pits and waste dumps and will not require specific reclamation treatments. Some portions of these main roads will be outside other development areas. These will remain in their as-built condition at closure and will serve as travel corridors and insect relief sites for caribou. Reclamation designs for major mine haul roads will be aimed at simulating large, esker-like structures. Culverts will be removed and the natural drainages re-established. It may be necessary to cover these drainages with riprap to minimize sedimentation.

There are no plans to remove the Misery haul road at closure. The drainages will be re-established by breaking up the road and removing all culverts.

Access Road Systems

Access roads will be built between a variety of mine facilities and sites including tailings facilities, exploration sites and utility facilities. These roads will be built as needed throughout the life of the mine and will be decommissioned at various times over the life of the mine. As with the major roads, reclamation designs for the minor roads will be aimed at simulating esker-like structures by recontouring the materials used to construct the roads.

Recontouring will focus on removal of culverts and restoration of drainage patterns. Materials from the recontouring could be placed on the road surfaces to cover the compacted surfaces. Topdressing of recontoured roads is not deemed necessary.

Revegetation efforts will be directed towards establishment of suitable pioneering species of grasses and forbs and of appropriate shrubs in selected locations. Riparian vegetation could be established where these roads cross water courses.

Winter roads will be constructed to provide access to a variety of sites, including exploration sites. These roads are mostly constructed on lakes, where available. As roads constructed in this fashion cause minimal damage to the tundra, there are no formal plans for the reclamation of these roads, although a monitoring plan will be developed.

9.3.2.6 Pits Unit

The mine development plan involves five diamondiferous pipes, four in the Koala watershed and one approximately 29 km to the southeast. Each pipe is overlain by a lake and thus has to be dewatered before open pit development can commence.

The reclamation design for the pits unit will provide for refilling the pits with water. The first pit to be exhausted will be Panda, approximately five years after the mine start-up. However, plans for underground mining below the Panda pit will require that it remain dry until about Year 20. After this, it is planned to dispose of tailings into the mined out pit. A simplified water balance was performed to estimate the amount of time required for infilling each of the open pits (Section 3.4.3). Inflows were assumed to include direct precipitation into the pits, runoff from the individual catchment areas and groundwater seepage. The only output from the system was assumed to be evaporation. Based on these inputs and outputs, the time required for filling the pits completely was determined to be approximately 6, 34, 153, 147 and 212 years for Panda, Koala, Fox, Misery and Leslie pits, respectively. Water quality management issues arising at the end of pit fill-up period are addressed in Section 3.

As part of the pit rehabilitation program, pit slopes that might continue to pose a danger could be protected with windrows of waste rock, if necessary, rather than constructed metal fences, which would require maintenance at some point in the future. Such windrows would discourage access by migrating caribou and at the same time provide a rocky berm congruent with the surrounding terrain. Lake productivities would be limited due to small amount of littoral development possible in the lake on account of the steep pit slopes. However, pit slopes that extend above the eventual high water level may provide the opportunity to create nesting habitat for raptors (Cairns 1980). The opportunities for habitat enhancement will be further explored as the mine develops.

9.4 Reclamation Substrate Development

Healthy plant communities develop on suitable substrates. In arctic environments, soils develop slowly over many centuries as the parent materials break down. The establishment of effective plant communities on the disturbed sites will be greatly enhanced by the provision of suitable soils in which to grow. The following sections discuss the substrates that may be available at the mine for eventual use as topdressing for the establishment of vegetation communities. Proposals of how these substrates might be collected, stored and eventually utilized in a cost effective manner are presented. The key to effective reclamation programs that will lead to the establishment of productive ecosystems on the reclaimed lands will be the planning and execution of effective substrate development programs.

9.4.1 Material Availability

Detailed assessments of the availability of different reclamation topdressing materials within the proposed development areas have yet to be undertaken. Detailed inventories of available soil materials will be made early in the life of the mine. In particular, the suitability of soils in the initial development areas will be assessed and strategies for their salvage and use developed. This is further discussed in Section 9.7.2.

9.4.2 Material Characteristics

There are three principal materials that may be suitable for use as reclamation substrates: lake sediments (organic and glacial till) collected from the lakes dewatered prior to pit development; organic materials collected from fens and bogs in the development areas; and organically enriched mineral soils and overburden found in the development area. The soils inventory planned for 1995 will define potential areas for salvaging organic materials, taking into account economics of recovery, as these materials are found in pockets and are very limited in quantity.

Lake sediments will be stripped and stockpiled in an impoundment adjacent to each mine pit (Volume I, Section 2.4.5). Evaluations of the potential use of this material will be done during reclamation work early in the life of the mine, at a time when a variety of options for this material are available.

Organic soils are those found under sedge tundras and in wet and marshy areas of the mine development area. Peaty soils will increase the moisture holding capacity of reclaimed sites and assist in the establishment of wetlands. The organics contained in peat soils will also provide some measure of nutrient retention and assist in nutrient cycling. Evaluations of the characteristics of peat in terms of its use as a reclamation substrate will be made early in the life of the mine and detailed plans for the utilization of this material developed on the basis of these evaluations.

Organically enriched mineral soils are present on drier sites than the peats. These soils are found on glacial tills, morainal materials and fine textured lacustrine deposits and gravels where plant growth has resulted in organic material accumulation in the soil profiles. Although these areas are often stoney, soils collected from the surface of development areas will have the benefits of organic enrichment, as well as seeds and propagules. These soils will be beneficial in the establishment of plant communities on mesic sites in the reclaimed landscape. Rocks and cobbles collected with these soils will increase the micro-site diversity of the reclaimed environment.

9.4.3 Application Strategy

The simplest and most cost-effective strategy for the application of topdressing is to spread it on the reclamation sites as part of the stripping operation. This could be done using dozers, with the topdressing materials either frozen (winter) or thawed (summer). As mechanically spread substrate does not generally result in even layers, it incorporates micro-topographic relief in the soil layer and aids in the establishment of micro-sites, thereby enhancing site diversity. In addition, rocks and other organic debris included with the soils will increase substrate diversity.

9.5 Reclamation Vegetation

The reclamation project will start with the basic ecosystem building blocks and create the initial steps that will allow the natural processes to effect vegetation re-establishment most. The initial step is to provide the conditions needed for establishment of later successional stages. Limits to plant growth are defined and ameliorated. Preparation of a suitable seedbed by providing microsites in which the seeds of pioneering species can lodge, germinate and grow is often one of the key steps in establishing vegetation. Proper seedbed preparation reduces the compaction and assists erosion control and runoff accumulation, while the establishment of nitrogen fixing species (i.e., *Alnus, Dryas, Oxytropis*) may assist in providing the nitrogen required by other plants. The key species in the early successional stages of site restoration are then identified. The establishment of pioneering vegetation is thought to provide more suitable conditions for growth of later successional species. The reclamation research program will seek to determine what species are needed in the successional establishment of vegetation on the mining sites and then use this information in the design of reclamation programs. As many species could provide these essential ecosystem services, it is prudent to design systems that allow a diversity of species to establish, such as those proposed for the mine area.

9.5.1 Initial Vegetation Cover

Pioneering species of northern adapted and native vegetation will be developed as the initial cover for sites disturbed by mining. As there are different pioneering species for different site types (wet, mesic, dry), and a diversity of site types is planned for the reclaimed landscape, various seed mixes will be formulated and developed as the initial cover. The pioneering species used as the initial cover will modify site conditions and assist in the invasion of reclaimed lands by later successional species.

Selected northern adapted species have been shown to be effective pioneers in other northern reclamation programs (Hardy BBT 1989; Kidd 1995; Kennedy 1993). Table 9.5-1 lists species cited as being "northern adapted" by various authors. Three different mixes of northern adapted species are being considered for revegetation cover of disturbed sites. The three seed mixes presented in Table 9.5-2 are composed of species that have been shown to be effective in the revegetation of disturbed sites in northern latitudes. Initial seed compositions by mix are included. These will be adjusted based on substrate type, cost and availability. Other species may also be added to the seed mix as they become available. It should be noted that long-term persistence of these species is not critical to the success of the reclamation program, as the initial cover is designed to promote later successional species.

9.5.2 Permanent Cover

Reclamation monitoring will be used to evaluate the success of natural invading plants. In general, reclamation programs do not require reseeding of later successional species on the reclamation sites, as invasion will occur in a reasonable timeframe. However, where slopes are steep, such as on the waste dumps and tailings pond dams, and where natural seed and/or propagule sources are unavailable, some planting of later successional species may be required.

9.5.3 Establishment Procedures

A variety of methods can be used for the establishment of vegetation. Although the northern adapted species used in the formulation of the above seed mixes may be readily available, collections of native seeds and development of sufficient stocks of these for use in reclamation at the NWT Diamonds Project may be recommended for reclamation purposes if these natives species are to be used. Many northern and alpine species exhibit reduced seed production and a diversity of germination requirements as an adaptation to the extreme environment

Table 9.5-1
Native (N) and Agronomic (A)
Northern Adapted Species

Hardy BBT (1989)	
Agropyron pectiniforme (A)	*Agrostis scabra* (N)
Alopecurus arundinaceus (A)	*Arctagrostis latifolia* (A/N)
Calamagrostis canadensis (N)	*Deschampsia caespitosa* (A/N)
Festuca ovina (A)	*Festuca rubra* (A)
Hierochole alpina (N)	*Phleum alpinum* (N)
Poa alpina (N)	*Poa pratensis* (A)
Trisetum spicatum (N)	
Kidd (1995)	Kennedy (1993)
Agropyron trachycaulum (Revenue) (A)	*Agropyron riparium* (Sodar) (A)
Arctagrostis latifolia (A/N)	*A. trachycaulum* (Revenue) (A)
Deschampsia caespitosa (A/N)	*Agrostis alba* (A)
Festuca ovina (A)	*Alopecurus pratensis* (A)
Festuca rubra (Arctared) (A)	*Dechampsia caespitosa* (Nortran)(A/N)
Phleum pratense (Climax)(A)	*Festuca ovina* (A)
Poa arctica (N)	*Festuca rubra* (Arctared, Boreal)(A)
Poa glauca (A/N)	*Medicago sativa/falcata*
Poa pratensis (A)	(Anik, Drylander, Rambler)(A)
	Phleum pratense (Engmo, Climax)(A)
	Poa compressa (Cannon) (A)
	Poa glauca (Tundra) (A)
	Poa palustris (A)
Polster (1994) (Gulf Mt. Klappan)	Polster (1994) (Whitehorse Copper tailings)
Festuca rubra (Boreal)(A)	*Agropyron desertorum* (Nordan)(A)
Festuca longifolia (Durar)(A)	*Agropyron riparium* (Sodar)(A)
Alopecurus pratensis (A)	*Agropyron trachycaulum* (Revenue)(A)
Phleum pratense (Climax)(A)	*Festuca longifolia* (A)
Trifolium hybridum (Aurora)(A)	*Festuca rubra* (Boreal)(A)
Trifolium repens (A)	*Lolium perenne* (A)
Poa compressa (Reubens)(A)	*Medicago sativa* (Rambler)(A)
	Phleum pratense (Climax)(A)
	Poa compressa (Reubens)(A)
	Poa pratensis (Geronimo)(A)

(continued)

Table 9.5-1 (completed)
Native (N) and Agronomic (A)
Northern Adapted Species

Grasses and Legumes Used in Alaska A. Richardson (pers. comm.)	
Grasses	
Alpine Bluegrass (Gruening)	*Poa alpina*
American Sloughgrass (Egan)	*Beckmannia syzignache*
Annual Ryegrass	*Lolium multiflorum*
Beach Wildrye	*Elymus mollis*
Bering Hairgrass (Norocoast)	*Deschampsia beringensis*
Bluejoint Reedgrass (Sourdough)	*Calamagrostis canadensis*
Creeping Foxtail (Garrison)	*Alopecurus arundinaceus*
Crested Wheatgrass (Nordan)	*Argopyron desertorum*
Glaucous Bluegrass (Tundra)	*Poa glauca*
Hard Fescue (Tournament, Scaldis)	*Festuca ovina* var. *duriuscula*
Kentucky Bluegrass (Nugget, Merion, Park)	*Poa pratensis*
Meadow Foxtail	*Alopecurus pratensis*
Polargrass (Alyeska, Kenai)	*Arctagrostis latfolia*
Red Fescue (Arctared, Boreal, Pennlawn)	*Festuca rubra*
Reed Canarygrass (Vantage)	*Phalaris arundinacea*
Siberian Wildrye (Kamalinskii 7)	*Elymus sibiricus*
Smooth Brome (Polar, Manchar, Carlton)	*Bromus inermis*
Timothy (Engmo, Korpa, Adda)	*Phleum pratense*
Tufted Hairgrass (Nortan)	*Deschampsia caespitosa*
Legumes	
Alsike Clover (Aurora)	*Trifolium hybridum*
Red Clover (Altaswede)	*Trifolium pratense*
Siberian Alfalfa	*Medicago falcata*
White Dutch Clover	*Trifolium repens*
White Sweet Clover	*Melilotus alba*
Yellow Sweet Clover	*Melilotus officinalis*

These species are commercially available and therefore might be considered “agronomic”.

Table 9.5-2
Initial Vegetation Seed Mixes

Species	Percent by Weight
Dry Sites	
Arctared Creeping Red Fescue	5.02
Sheep Fescue	7.03
Revenue Slender Wheatgrass	29.67
Sodar Sreambank Wheatgrass	19.85
Climax Timothy	2.40
Nordan Crested Wheatgrass	25.75
Aurora Alsike Clover	10.28
Mesic Sites	
Revenue Slender Wheatgrass	40.27
Arctared Creeping Red Fescue	15.34
Climax Timothy	7.33
Durar Hard Fescue	16.21
Reubens Canada Bluegrass	2.93
Geronimo Kentucky Bluegrass	3.39
Norton Tufted Hairgrass	1.98
Aurora Alsike Clover	12.55
Moist Sites	
Meadow Foxtail	19.92
Redtop	2.01
Nortran Tufted Hairgrass	4.59
Alyeska Reed Polargrass	25.30
Climax Timothy	7.58
Arctared Creeping Red Fescue	15.87
Geronimo Kentucky Bluegrass	5.26
Aurora Alsike Clover	19.47

in which they grow (B.C.M. of E.M.P.R. 1977-1994; Hardy BBT 1989 and 1990; Meidinger undated). In many cases, good seed crops are produced on an irregular basis and seeds may not be universally viable. Often , arctic and alpine species reproduce by vegetative means under normal circumstances, and seed production may be restricted to particularly stressful situations or situations where environmental conditions favour seedling growth and development. The expenditure of scarce energy resources on the development of seeds is commonly not a preferred strategy for northern or alpine species (Bliss and Wein 1972; Peterson and Peterson 1977).

Table 9.5-3 presents a variety of seeding methods that may be considered for the NWT Diamonds Project. These methods have been used in a variety of northern operations (Kennedy 1993) and may be appropriate to the establishment of vegetation at the mine.

Table 9.5-3
Advantages and Limitations of Seeding Methods

Seeding Method	Advantages	Limitations
Hydroseeding	Useful for steep slopes Can add tackifier/binders Can be helicopter applied	Seed not in soil Costly Relatively slow Needs water Heavier seeding rates
Broadcast Seeding (includes hand seeding)	Useful for large areas Can be helicopter applied Relatively inexpensive Can use available equipment	Seed not in soil except by harrowing Not very accurate Heavier seeding rates May have uneven distribution
Drill Seeding	Seed placed in soil Good seedbed prepared Can use lower seeding rates	Restricted by land based operations and access Need specialized equipment Seed spread in rows
Air Seeding	More even than broadcast Seed may not be buried except by harrowing	Costly equipment Restricted by land based operations and access

Fertilizer will be required for the effective establishment of the initial cover. Arctic and alpine soils are typically deficient in essential plant nutrients (nitrogen and phosphorous). In addition, the cold temperatures associated with the sub-arctic climates slows the process of organic matter decomposition and nutrient cycling. For these reasons, the application of fertilizer with the initial seeding is suggested. Balanced fertilizer treatment will be determined based on the results of the topdressing suitability assessments.

Transplanting sods from sites slated for future development may be considered as an option for revegetation and has the advantage of avoiding the costs and uncertainty involved in growing containerized stock. In addition, salvage of plant materials that would otherwise be lost to development may be useful in maintaining species that would be particularly difficult to culture under artificial circumstances. Experimentation during the early years of mining will be required to determine the most effective means of establishing vegetation on mine site disturbances.

Pocket planting, where a pocket of soil, with or without established plants, is placed in a suitable “pocket” in the reclamation substrate, can be an effective means of establishing islands of vegetation. As with sods, pocket planting has the advantage of including soils with all of the essential soil micro-organisms. Soil organisms, both micro and macro, are critical to the development of functioning ecosystems. These organisms are essential to establishment of nutrient cycling, organic matter decomposition and, in some cases, plant growth and development.

9.6 Reclamation Research

A wide body of information is available on the reclamation of disturbances associated with mining or other types of development. Research of specific reclamation encountered at the NWT Diamonds Project will be an integral part of the mine reclamation program. The current reclamation research program has been developed to provide information on specific reclamation questions and is described below. In addition, future reclamation research efforts will be designed to develop vegetation establishment procedures, assess substrate characteristics and identify ongoing requirements throughout the life of the mine. These are discussed below.

9.6.1 Current Reclamation Research Program

A reclamation research program has been initiated for the NWT Diamonds Project. The research program will be an ongoing effort throughout the mine operations. Results from the studies will be incorporated into the reclamation planning to further refine rehabilitation techniques. The current program is based on the establishment of test plots with the following objectives:

- To evaluate three types of “topdressing” materials as plant growth material: lake bottom tills, esker alluvium and organic tundra materials. A variety of seed mixes of northern adapted and locally collected species will be evaluated for emergence and viability.

- To investigate shrub transplants and tundra plug transplants using the topdressing described above.

- To incorporate and evaluate various landscape features for wildlife habitat, such as rock piles, rock cliffs and esker simulations.

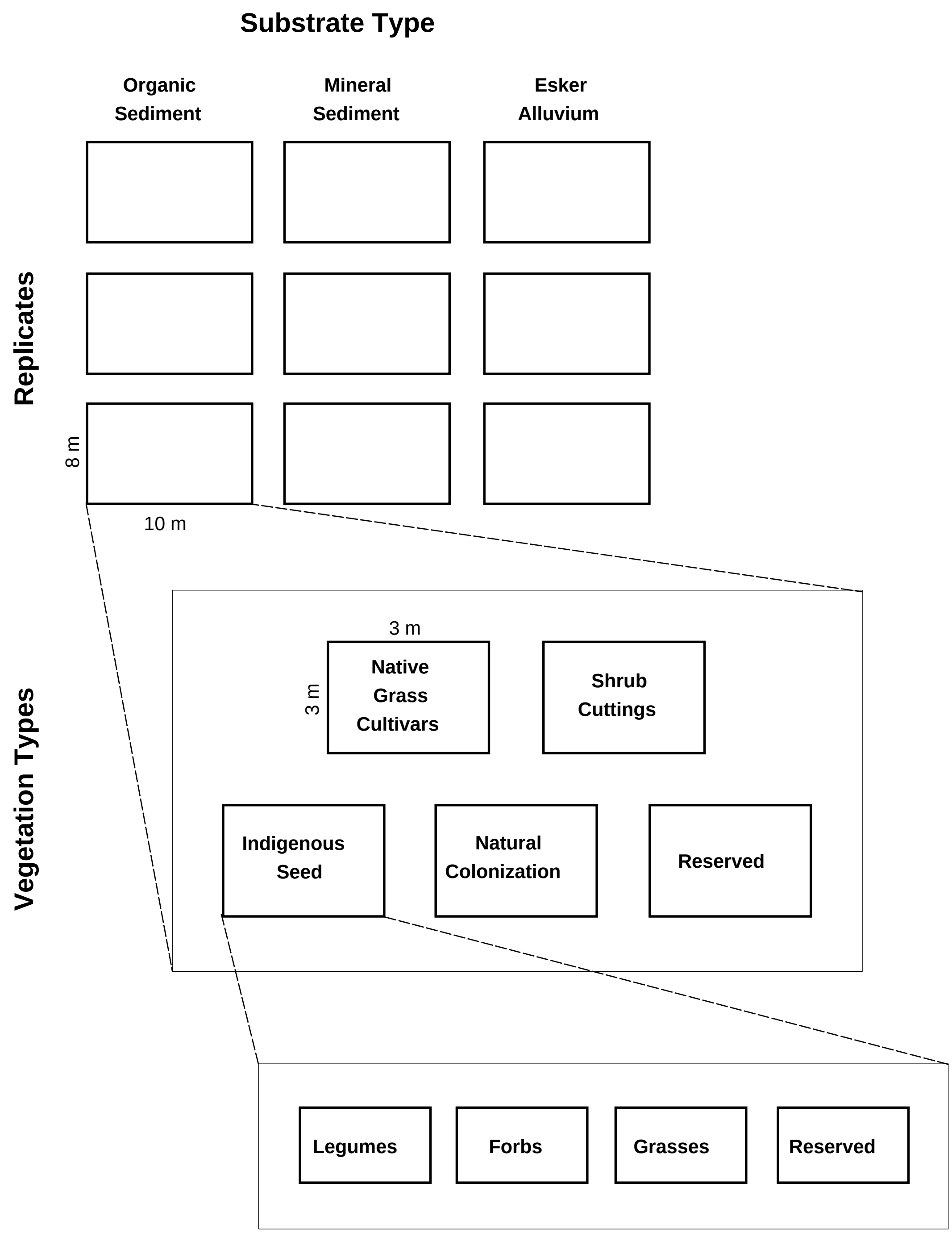
- To evaluate slope stability and erosion control.

The revegetation techniques will be evaluated testing three topdressing materials (noted above) and four plant cultivation treatments: natural colonization, northern adapted seeding, indigenous species seeding and shrub cuttings. This will provide a total of 12 treatments, which will be tested in a two-factor randomized block design (Figure 9.6-1). Each topdressing material will be applied in three replicate 8 x 10 m blocks, with the four plant cultivation treatments applied in 3 x 3 m plots within each block, for a total of 36 quadrants. A 2 m buffer zone will be established between quadrants to minimize contamination across treatments. All plots will be fertilized with a high nitrogen/phosphorus fertilizer (20-20-10 NPK) at a rate of 400 kg/ha.

The northern adapted seed mixture will consist of species adapted to arctic environments and known to be valuable to wildlife as forage or cover. The species selected for testing will depend on availability but may include Tundra Bluegrass (*Poa glauca*), Alpine Bluegrass (*Poa alpina*), Alyeska Polargrass (*Arctagrostis latifolia*), Arctared Fescue (*Festuca rubra*) and Tufted Hairgrass (*Deschampsia caespitosa*). The seeds will be broadcast at a rate of 22 kg/ha. The native seed mix will emphasize legumes (*Hedysarum* spp., *Oxytropis* spp. and *Astragalus* spp.) and other forbs such as *Artemesia* spp. and grasses. Shrub cuttings will be collected from plant communities in the vicinity of the project area and may include Willow (*Salix* spp.), Dwarf Birch (*Betula nana*), Dyas (*Dryas octopetala*), Cranberries and Blueberries (*Vaccinium* spp.) and Crowberry (*Empetrum nigrum*). Finally, to monitor the rate of natural colonization, control plots will be established, which will not be planted with native grasses or local species.

Previous revegetation studies at high latitudes have shown that shrub cuttings have a higher survival rate when planted in the early spring, and seedling establishment is more successful when seeds are applied in the fall. Therefore, plant cultivator treatments will be done in two phases. Treatments involving shrub cuttings will be applied in the spring, whereas the grass cultivars and locally collected seeds will be applied in the fall.

Additionally, the soil properties will be determined. Three replicate soil samples will be collected from each substrate type for analysis of physical, chemical and biological properties. Vegetation response of all plant cultivation will be assessed using percent cover along three permanent transects within each quadrant using the line intercept method. Stem density and percent survival will be measured in each quadrant in the shrub cuttings treatment, and seedling density for indigenous species will be assessed.



NWT DIAMONDS PROJECT

Figure 9.6-1
Revegetation Plot Design for the Pilot Project

Source: BHP

9.6.2 Proposed Future Reclamation Research

Operational reclamation trials are proposed early in the life of the mine. Disturbances created during the exploration and mine development phase could serve as sites for operational trials. Operational reclamation seeks to provide effective reclamation of disturbed sites while at the same time providing needed reclamation information. The following operational research programs are proposed for the mine area.

9.6.2.1 Species Suitability for Reclamation

Concurrent with the soils material inventory, an assessment of plant species that may be suitable for reclamation at the mine will be required (Bell and Meidinger 1976). A review of available literature has provided an initial stratification (Table 9.5-1) for preparation of the seed mixes presented in Table 9.5-2. These mixes could be tested on the disturbed areas associated with development of the mine. Directed assessments of species in the mixes could be conducted on the established stands. Research on native species suitably conducted at northern industrial sites such as oil and gas sites (Brusynk and Westworth 1985; McCown and Simpson 1977) as well as other northern mines will be sought to improve upon the current level of understanding. Once information on candidate species has been collected, laboratory and field testing programs will be undertaken. These will be directed at determining species performance under different circumstances and assessing the potential for use in actual mining situations.

9.6.2.2 Establishment Procedures

Reclamation research on effective procedures for the establishment of selected species on mine site disturbances will be conducted in conjunction with species suitability assessments. Germination experiments in growth trials would be used to determine suitable conditions for germination purposes. The effectiveness of seeding native species on mine wastes will need to be assessed to ensure that appropriate techniques are available when they are needed (Homoky 1987). Transplanting and plug planting will also need to be tested and procedures amenable to the project location and situation be developed. In many cases, reclamation of exploration disturbances can serve as test sites for reclamation trials. Operational use of various establishment techniques could provide information on the effectiveness of these procedures in the NWT Diamonds Project situation.

9.6.2.3 Metals Uptake/Wildlife Interactions

Laboratory based growth chamber experiments will use native vegetation grown in lake bottom sediments to determine metals uptake. Plant tissues could then be analyzed for metals content and the results compared with metals concentrations in the original sediments. This information would be used to predict the potential metals loadings on grazing wildlife and ultimately on predators.

9.7 Reclamation Scheduling

Scheduling of reclamation activities as an integral part of mining activities is required to achieve efficiencies of cost and effort and to take advantage of reclamation opportunities. In addition, appropriate scheduling of reclamation work can control some potential problems resulting from surficial disturbance and return the disturbed lands to a productive state as soon as possible after disturbance.

9.7.1 Initial Reclamation Program

Reclamation of disturbances created during the exploration and development of the mine will provide an opportunity to develop and improve the planned reclamation program. The development of "operational" reclamation trials is an effective means of gathering essential reclamation information while at the same time conducting useful reclamation work. This approach has been taken with great success at a number of northern and higher elevation mine sites in Canada.

Procedures designed to reclaim exploration disturbances during the development of the mine will constitute the initial reclamation program at the mine. This initial program will provide information that will be used during operational reclamation programs. In addition, by completing as much of the outstanding reclamation as soon as possible, the reclamation liability associated with the initial mining operations will be reduced.

9.7.2 Operational Reclamation Program

Operational reclamation will be initiated on commencement of mine operations. The first step in the operational reclamation program is to identify and characterize potential topdressing material. Based on this, the second step is to salvage the suitable soils prior to developing a particular area. Soil salvage will be limited to those areas planned to be immediately developed in order to avoid exposing bare soils to erosion and to minimize the amount of soils that will have to be stockpiled before use.

Reclamation will be completed in a progressive manner throughout the mining areas. Similarly, cells in the tailings ponds can be reclaimed early in the life of the mine while other areas, such as the final dumps, will have to be reclaimed later in the mining sequence. The use of the Panda pit for tailings storage will speed the final reclamation in this area as the pit will be submerged upon completion and there will be no need for specific reclamation operations on the materials stored within it.

Reclamation scheduling during the operation of the mine will seek opportunities to combine operations and thereby, reduce costs and enhance effectiveness. Soil stripping and placement as well as waste rock dump and tailings pond (cell) construction, as discussed above, are examples where mining operations can be organized to provide enhanced reclamation and mining opportunities. Detailed schedules for the operation of the mine have been presented as part of the mine plans (Volume I, Section 2.4.2). These schedules show the progressive nature of the reclamation work at the mine.

9.7.3 Temporary Shutdown

"Temporary shutdown" is sometimes also called "planned shutdown". By definition, temporary shutdown means stoppage of mining and milling operations at a mine due to economic or operational requirements. At the same time, it is also assumed that mining operations will recommence when the problems are resolved.

In the present case, the progressive reclamation program will ensure that, should market conditions dictate a temporary shutdown of the mine, all outstanding reclamation liabilities are minimized and the condition of most disturbed areas is such that a period of inactivity will not result in environmental degradation. By incorporating reclamation needs into the design and construction of facilities, not only will the reclamation be enhanced (more microsites and more biological activity in freshly worked soils) and environmental values maintained (less erosion/siltation potential), but these sites will be left in a stable condition in the event of a temporary shutdown.

Many of the design features of the mine, including the construction of the tailings disposal cells in Long Lake and of the waste rock dumps in progressive stages, will serve to ensure that reclamation of these sites can be completed in a timely manner. This will minimize the potential for adverse impacts associated with unreclaimed sites. For example, the waste rock stripped from the initial mining of the Panda open pit will be used to construct the northern portion of the Panda dump to the ultimate limit and thereafter to advance the active dump face south to the contiguous Koala dump, allowing the northern portion of the dump to be reclaimed early in the life of the mines. This strategy will buffer the effects of a temporary shutdown on the surrounding environment.

In addition to the built-in design features as mentioned above, the following steps will be undertaken in the event of a temporary shutdown:

- All mine openings that may be a safety concern will be protected from inadvertent access.
- Access to the property and all associated facilities will be restricted to authorized personnel only.

- All mechanical and hydraulic systems will be left in a no-load condition.

- Specific monitoring programs will be continued as deemed necessary. This will be determined prior to the shutdown period.

- All hazardous and non-hazardous substances, other than tailings and waste rock, will be made secure.

9.7.4 Decommissioning and Closure

Once all economically viable ore has been removed from the kimberlite pipes and processed in the plant, the NWT Diamonds Project will be decommissioned and closed. This will include removal of all machinery and equipment, burial of foundations, disposal of fuel drums and other containers used for similar purposes, removal of culverts and restoration of water flow patterns, and adequate treatment of garbage and waste generated at the campsite, all in accordance with the relevant sections of the Territorial Land Use Regulations of the *Territorial Lands Act*. Areas deemed to be unsafe such as mine openings will be protected from public access. Contrary to the common approach of starting site decommissioning, several years after the end of operations, the NWT Diamonds Project plans to undertake the reclamation program right from the initial stages of mining and continue it throughout the mine life. As a result, at the time of decommissioning reclamation will be limited to those sites where activities have, by their nature, had to be conducted until the end of the operation. All other sites will have been reclaimed during the operational reclamation programs.

Progressive reclamation of mine disturbances will ensure that existing reclamation liabilities at closure are minimal. Since the life and operational aspects of the mine may change, the reclamation plan will be re-evaluated as the project progresses. Monitoring of rehabilitated sub-sites during mining operations can measure the rehabilitation success or identify the need for additional remedial work to meet the closure objectives. Thus, by completing most of the reclamation well before the decommissioning and closure, assessments of the performance of the reclamation work will be made while there are personnel and equipment on site to rectify any deficiencies. This will significantly reduce the need for post-closure reclamation work.

Summary

This section has presented the information and activities needed to develop a reclamation, decommissioning and closure management plan. The focus of the plan is to return land affected by the NWT Diamonds Project’s activities to its original use. The principles used to develop the activities to carry out the plan are based on environmental regulations and experience from other projects. Finally, the management plan describes a process that can be monitored.

10. Monitoring Plan

The monitoring program is an integral component of the Environmental Management Plan. The monitoring plans described herein encompasses three distinct approaches: environmental, operational and socioeconomic. The environmental aspect is designed to measure natural changes in the environment (air, land and water) and the effectiveness of mitigation measures. Operational monitoring is included in the plan to track those variables important for day-to-day operations of the process plant, camp facilities and mining operations. Finally, the socioeconomic monitoring will provide input on statistical and attitudinal analysis of employment and purchases, and compliance with agreements.

The monitoring plan focuses on the valued ecosystem components identified during the Proponent's communications program, from the results of the environmental baseline studies and from the public scoping meetings. The monitoring plan is based upon the management strategies designed to protect the environment.

Monitoring requires measurements that are statistically valid with adequate reference control to effectively distinguish project-related impacts from natural changes in the environment. The environmental program is intended to be flexible and adaptive in design so that it can be re-defined and improved in response to changes in the program development plan, the regulatory environment and the natural environment.

Monitoring will be conducted throughout all phases of project development and will be integrated into all project activities. The plan also includes provisions for monitoring of post-closure reclamation activities.

Goal and Objectives

The environmental monitoring plan is designed to determine whether the NWT Diamonds Project is achieving the goals outlined in the Environmental Management Plan. The following monitoring activities are intended to achieve these goals:

- maintain compliance with government environmental guidelines or permit/licence requirements
- measure the performance of operations and the effectiveness of mitigation strategies
- monitor natural cyclic changes
- monitor the accuracy of the project impact predictions.

Structure

There are four monitoring sections to this plan: water, land, air and socioeconomics. The land section addresses the components of wildlife, vegetation and reclamation. Except in the case of socioeconomics, the monitoring programs are subdivided into plans for environmental parameters and operational parameters.

Each of the four sections is structured to include an overview of the monitoring plan for each area, followed by a description of the parameters, methods, locations and frequency of monitoring.

Use and Reporting

The results of the monitoring activities will provide data required by government and regulatory agencies to assess project impacts and compliance with applicable laws and regulations. These results will also be useful to the regulator in assessing standards of environmental performance for future projects.

As indicated above, the results of the monitoring activities will be used to modify individual components of the Environmental Management Plan, if necessary. Ongoing operating process parameters will be monitored and recorded to assist in maintaining quality control and provide a production data base for internal use. An important use of the monitoring data will be for modelling purposes. Modelling plays an important role in designing management plans for air quality, water quality, hydrology and permafrost. Socioeconomic monitoring will provide input to the development or refinement of government/industry sponsored training programs and to business and government planning.

Reporting will depend on the type of monitoring activity. Annual reports summarizing the various components of monitoring activities will be available. Communities will be kept informed as part of the Proponent's ongoing dialogue. The Proponent will provide periodic summaries to interested parties upon request. Reporting to regulatory agencies will be dependent on specified regulations.

Environmental Surveillance

An independent environmental advisory group, consisting of academic, Aboriginal and community members, is proposed to review the environmental program on an ongoing basis. It is intended that the group would include four members with individual expertise in environmental engineering, wildlife, aquatics and ecology; two members from the Aboriginal community to provide indigenous ecological knowledge; and one member from the general public (northern community).

It is recommended that the group be mandated to provide an independent review of the monitoring program to ensure the quality and adequacy of the sampling program. The group would specifically review field sampling and laboratory procedures to ensure proper quality control and quality assurance. At least once per year the group would tour the NWT Diamonds Project and conduct an environmental reconnaissance-level survey. The group would provide an overview report, to accompany an annual environmental assessment report, both of which would be available for review.

This type of surveillance model has been successfully employed since 1970 at BHP's Island Copper Mine, on Vancouver Island in British Columbia, approximately one year before commencement of operations in 1971. This large-scale project remains in operation today, and the surveillance committee will continue to perform through and beyond decommissioning and closure of the mine. This group consists of technical advisors, namely professors representing various disciplines from the Universities of British Columbia, Victoria, Simon Fraser and Alberta. The technical advisory group proved to be invaluable to the environmental program associated with the Island Copper Mine.

The suggested membership of the advisory group proposed for the NWT Diamonds Project reflects an evolution in environmental surveillance in that non-technical individuals along with the public will be represented. The proposed group would not include government or regulatory personnel. Provided that the surveillance committee concept is accepted, details of the various appointments, remuneration and operating terms-of-reference will be determined.

10.1 Water Monitoring

The water monitoring plan has two components: environmental monitoring, designed to measure abiotic, biotic and physical parameters associated with aquatic life, water quality and hydrology; and operational monitoring, which specifically emphasizes the water control aspects of project activities.

The NWT Diamonds Project could potentially affect the water quality of two drainage areas in the upper portion of the Coppermine watershed. Since the Coppermine River hosts substantial wildlife and aquatic populations, which are used by guide outfitters and the community of Coppermine, water quality has been identified as a valued ecosystem component. Frequent monitoring of water above and below development sites will identify and assess potential mine related impacts using data from upstream and downstream monitoring station. Also, water flows around the project site (including water released from the tailings impoundment and pumped from the pits) and water flows in the receiving environment will be monitored to meet compliance and minimize impact to the receiving environment.

10.1.1 Monitoring Plan

The monitoring plan is designed to provide adequate data for monitoring a range of water management parameters related to all phases of the NWT Diamonds Project. Monitoring activities for this plan will address the key issues associated with water quality and quantity relating to both the environmental and the operational components. Table 10.1-1 summarizes the water monitoring plan.

The environmental water quality monitoring program encompasses those activities and parameters to meet regulatory discharge requirements and in general, to protect aquatic life. The activities will focus on the following:

- components within the aquatic ecosystem which support and sustain fish life and the aquatic habitat
- biotic and abiotic parameters that will indicate the health and quality of the water environment
- water level and stream flow.

The operational portion of the water monitoring plan will provide a constant record of information to assist in maintaining process operations and regulatory reporting if necessary. The specific process activities to be monitored include the following:

- potable water use
- process water use
- sewage effluent discharge.

10.1.2 Parameters to be Monitored

The following environmental water parameters will be monitored:

- water levels and flow
- total and dissolved metals, nutrients and physical parameters
- periphyton, lake and stream benthos, zooplankton, larval drift, juvenile and mature fish.

The following operational water parameters to be monitored:

- Potable water — Quantity used; Quality (TSS, bacteria, pH)
- Reclaim water intake — Quantity used from Long Lake
- Tailing Slurry discharge — Quantity discharged for, % solids, pH, dissolved metals

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Table 10.1-1
Summary of Water Monitoring Plan

Component	Parameters	Method	Location	Frequency*	
		Environmental Program			
Water Quality	Metals, nutrients, physical parameters	Lake: 5 depths (Go-Flo sampler)	4 lakes [1]	mid-summer	annually
		Stream: surface (Go-Flow sampler)	5 streams[2], diversion channel, + Long Lake outflow	seasonal	annually
Lake Biology	Lake benthos	Ekman Grab (3 depths) (community structure, diversity)	4 lakes	mid-summer	annually
	Zooplankton	Night vertical net hauls (community structure, diversity)	4 lakes	seasonal	annually
	Fish	100 m small mesh gillnets (ageing, weight, length, tagging, diet, trace metal content, longterm population estimates)	4 lakes	mid-summer	annually
Stream Biology	Periphyton	Colonization plates (community structure, diversity)	4 streams[3]	seasonal	annually
	Stream benthos	Hester-Dendy sampler (community structure, diversity)	4 streams	seasonal	annually
	Larval drift	Drift nets (12-24h sets) (community structure, diversity)	4 streams	seasonal	annually
	Juvenile fish	Electroshocking (presence/absence, abundance)	4 streams	early summer	annually
Hydrology	Water level	Staff gauges, pressure transducers	2 streams + diversion channel	ice-free period	annually
	Water flows	Swoffers	2 streams + diversion channel	ice-free period	annually

1: The four lakes are Vulture, Kodiak, Nema and Slipper.
2: The five streams are Vulture-Polar, Kodiak-Little, Nema-Martine, Slipper-Lac de Gras and Misery-Lac de Gras.
3: The four streams are Vulture-Polar, Kodiak-Little, Nema-Martine and Slipper-Lac de Gras.
* Subject to adjustments based on data analysis over time.

(continued)

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Table 10.1-1
Summary of Water Monitoring Plan

Component	Parameters	Method	Location	Frequency*
Operational Program				
Potable Water	Quantity	Flow Meter	Intake	Daily
	TSS	Lab Chem		
	Bacterialogical			
	Cl^-			
	pH			
Process Water Reclaim	Quantity	Flow Meter	Intake	Daily
	TSS	Lab		
	pH			
Tailings Discharge	Quantity	Flow Meter	Tails Pumpbox	2 x Daily
	%/Solids*	Lab		
	pH			
	Metals			
Sewage Eff.	Quantity	Flow Meter	Discharge	Daily
	TSS	Gravimetric		
	BOD	5 day standard		
	pH	Meter		
	Cl			

1: The four lakes are Vulture, Kodiak, Nema and Slipper.
2: The five streams are Vulture-Polar, Kodiak-Little, Nema-Martine, Slipper-Lac de Gras and Misery-Lac de Gras.
3: The four streams are Vulture-Polar, Kodiak-Little, Nema-Martine and Slipper-Lac de Gras.
* Subject to adjustments based on data analysis over time.

- Sewage Plant — Quantity discharged, treatment (TSS, BOD_5, Cl, etc.).

As water is used extensively in the project, it is important that the parameters reflect all aspects of water use and their impact.

10.1.3 Monitoring Methods

The proposed environmental monitoring activities will be carried out as described below.

Staff gauges will be installed at each site to measure surface water depths. Water levels will be monitored by pressure transducers. Swoffers will be used to measure water flow. The data will be stored in dataloggers which will be downloaded monthly. Periodic flow measurements will be conducted during the open water season in order to maintain a record of trends in the stage-discharge relationship at eac+h site. The location and zero elevation of each staff gauge will be surveyed in order to prevent data loss in the event of damage to the staff gauges by ice or high water.

To measure water quality, sampling will be similar to the approach taken in the 1994 baseline study (Volume II, Section 2.4). For lake sites, this includes using acid washed Go-Flo® sampling bottle to collect water samples from five depths.

Water samples will be sent to a laboratory and/or analyzed on site for total metals, dissolved metals, nutrients and physical parameters (Table 10.1-2). Sampling a wide range parameters serves a dual purpose. First, this is done to maintain consistency with those monitored during the baseline study. As such, future water quality trends can be gauged against baseline conditions to determine if water quality is deviating from pre-development conditions. Second, the entire scope of parameters will be sampled in order to monitor trends of metals or physical parameters that did not exhibit elevated concentrations during baseline studies.

Lake monitoring involves sampling of organisms that reflect aquatic health. Invertebrates will be sampled since they are indirect indicators of primary productivity, important diet items for fish and reflective of water and habitat quality. Zooplankton communities will be sampled using a vertical haul net, and benthic invertebrates will be sampled using an Ekman grab. Fish populations will also be evaluated since they comprise the top trophic level and are indicators of overall ecosystem integrity. Fish will be captured to assess population characteristics of all species using short-term (~40 min), day and night, small mesh (38 cm) gill-net sets to minimize mortality. Net dimensions will permit fish capture from all possible depths. Fish will be marked and tagged, ages determined, and

Table 10.1-2
Environmental Water Quality Monitoring Parameters and Appropriate Detection Limits

Parameter		Detection Limit (mg/L)*
Physical Tests		
pH		N/A
Conductivity		1.0 µohms/cm
Temperature		0.1°C
Dissolved Oxygen		0.1
Total Dissolved Solids	(TDS)	1.0
Total Suspended Solids	(TSS)	1.0
Hardness	(as $CaCO_3$)	0.08
Turbidity		0.1 NTU
Alkalinity		1.0
Acidity		1.0
Anions		
Chloride	(Cl^-)	0.02
Fluoride	(F^-)	0.01
Sulphate	(SO_4^{-2})	0.5
Nutrients		
Nitrogen	(N)	
Ammonia	(NH_3)	0.005
Nitrate	(NO_3)	0.03
Nitrite	(NO_2)	0.001
Phosphorus	(P)	
Total P		0.002
Dissolved P		0.002
Ortho-phosphate		0.002
Total and Dissolved Metals (ICP/MS)		
Aluminum	(Al)	0.001
Cadmium	(Cd)	0.0002
Calcium	(Ca)	0.01
Chromium	(Cr)	0.0005
Cobalt	(Co)	0.00005
Copper	(Cu)	0.0005
Iron	(Fe)	0.01
Lead	(Pb)	0.0002

* Units are mg/L unless otherwise indicated.

(continued)

Table 10.1-2 (completed)
Water Quality Monitoring Parameters
and Appropriate Detection Limits

Parameter		Detection Limit (mg/L)*
Total and Dissolved Metals (continued)		
Magnesium	(Mg)	0.0005
Manganese	(Mn)	0.00005
Mercury	(Hg)	0.00005
Molybdenum	(Mo)	0.0002
Nickel	(Ni)	0.0005
Silver	(Ag)	0.00001
Uranium	(U)	0.00001
Vanadium	(V)	0.0005
Zinc	(Zn)	0.0005

* Units are mg/L unless otherwise indicated.

lengths and weights measured. To determine diet and trace metal content, stomach and tissue samples will be collected from a small subsample of fish captured.

Stream monitoring will involve sampling of representative organisms from each trophic level during the open water period. Periphyton communities reflect stream productivity since they comprise the primary trophic level. Periphyton communities will be evaluated using colonization plates. Invertebrate communities will be sampled since they are an important food item of stream dwelling juvenile fish. Benthic invertebrates will be sampled using Hester-Dendy artificial substrate units. Larval drift samples will be collected from each stream mouth using drift nets. Invertebrate drift reflects benthic production and the availability of preferred food for grayling. Juvenile and larval fish abundance are indicative of overall habitat quality since they are consumers and they require high-quality habitat. Juvenile fish presence/absence and abundance will be determined by electrofishing a representative reach of each stream.

Operational monitoring of the potable water, process water and sewage effluent quantity will be accomplished by process flow meters. For water quality assessments, the water will be sampled using appropriate bottles and these will be analyzed by an external or on-site lab for various chemical and physical parameters.

10.1.4 Monitoring Location

Monitoring locations for environmental purposes, will focus on potentially disturbed sites, areas downstream from disturbances and control sites (Figures

10.1-1 and 10.1-2). Disturbed sites include Kodiak and Nema lakes. Nema Lake will receive discharge from the Long Lake tailings impoundment and Kodiak Lake is proximal to plant activities, air and road traffic, and immediately downstream of two dewatered pits and the Panda diversion channel. Sites downstream of disturbances include Slipper Lake and Slipper-Lac de Gras, Kodiak-Little, and Nema-Martine streams. Slipper Lake and Slipper-Lac de Gras stream are the terminus of the entire Koala watershed. Vulture Lake and Vulture-Polar stream are designated as control sites as they are the headwaters of the Koala watershed and removed from site activities.

Additionally, water quality will be monitored at the Panda diversion channel, Misery-Lac de Gras stream and Long Lake outflow. These areas are outflows of disturbed areas where biological productivity is not expected in the short-term. Hydrology will be monitored at the Panda Diversion Channel and Nema-Martine and Slipper-Lac de Gras streams.

For operations processes, monitoring locations will vary throughout the site. Typically the process and potable water would be sampled at their respective intake. The tailings and sewage effluent would be monitored at the discharge.

10.1.5 Monitoring Frequency

The environmental water monitoring program will be based on an annual schedule for all activities.

Surface water flow monitoring will commence at spring thaw (usually early to mid-June) and continue until freezing, in late September to early October. Samples for water quality analysis will be collected mid-summer in lakes and seasonally in streams during periods of open water. If determined necessary, some sites may be monitored during the winter. After several years of monitoring, parameters that do not show elevated concentrations will be eliminated from the sampling program. Lake monitoring of organisms will take place annually in mid-summer. Stream monitoring will occur seasonally during the ice-free period. If data indicates no substantial change in the monitored parameters, frequency may be re-adjusted accordingly.

Operational water monitoring will take place on an ongoing basis in conjunction with operational needs on a monthly-weekly-daily or shift basis.

10.2 Land Monitoring

The land monitoring plan is concerned with issues of permafrost, wildlife and wildlife habitat, vegetation habitat, reclamation, quarry resources, tailings structures, quarries and dumps. Similar to the water monitoring plan, the land monitoring plan is divided into two parts, environmental and operational.

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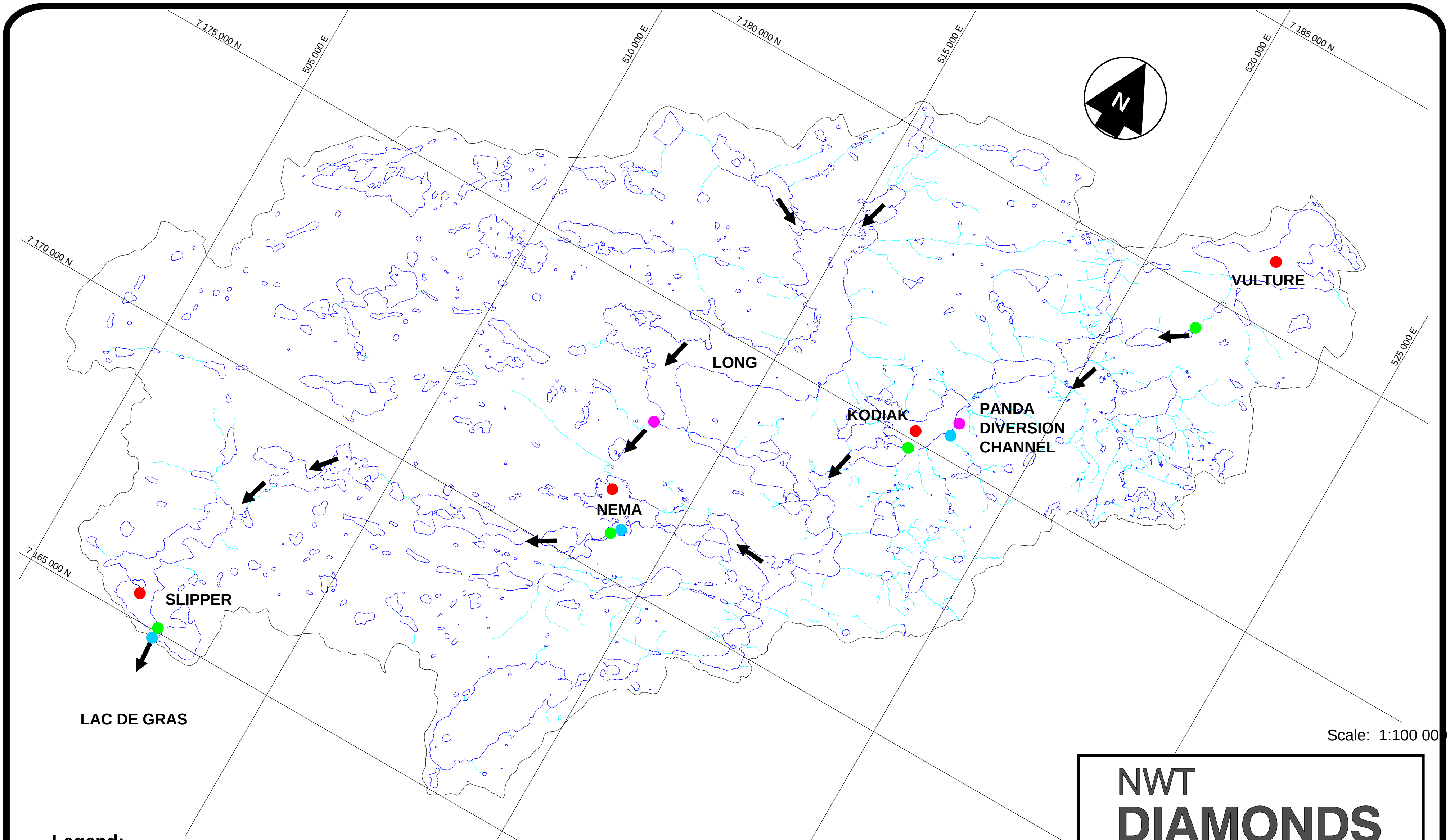

Legend:

- Water quality sites only
- Biology and water quality lake sites
- Biology and water quality stream sites
- Hydrology sites
- Direction of flow

NWT
DIAMONDS
P R O J E C T

Figure 10.1-1
Proposed
Monitoring Sites

Source: Rescan

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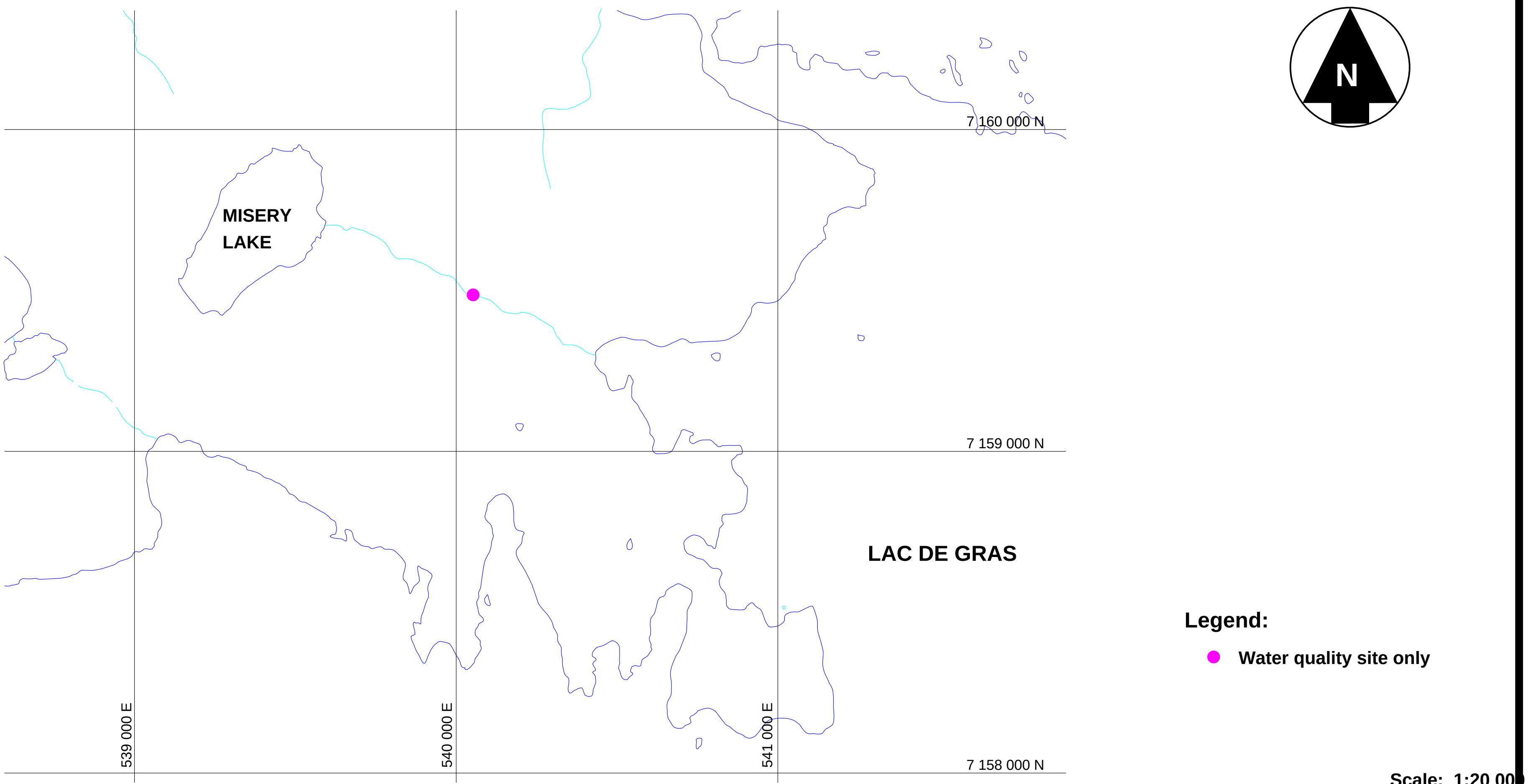

NWT DIAMONDS PROJECT

Figure 10.1-2
Proposed Monitoring Sites, Misery Watershed

Source: Rescan

10.2.1 Monitoring Plan

The environmental monitoring plan considers four main ecosystem components: permafrost, wildlife, reclamation and revegetation. The monitoring activities planned for each are described in the following sections. The operational monitoring plan focuses on specific sites affected by project activities. The overall land monitoring plan is summarized on Table 10.2-1.

Table 10.2-1
Summary of Land Monitoring

Component	Parameters	Method	Location	Frequency
Permafrost	ground temperature and thickness of permafrost layer	thermistors	7 sites and tailings	continuous (automated monitoring)
			dams, dikes and road structures	during construction
Wildlife	all wildlife	employee observation	camp and associated facilities	during project duration
	bears	Continued observations of radio collared bears	wildlife study area	5 years to correspond with GSGP Regional Study
	caribou migration	aerial transects	wildlife study area	Spring and fall
Reclamation	vegetation	surveys	reclaimed sites	depends on natural successional processes
	wildlife use	monitoring	reclaimed sites	
Vegetation	ecological map	land mapping protocol	wildlife study area	ongoing as part of baseline studies
Operational	Disturbed Areas	Survey location and quantity of practical stability of dumps and dams	Quarries, pits, dumps, dams, roads	Annual or more frequent depending on variable and need

10.2.1.1 Environmental Land Monitoring

Permafrost is an important environmental component that affects the stability and ecology of the land. Long-term performance of dams, embankments and tailings impoundments depends on sustaining the permafrost condition. If degradation of the permafrost occurs, it has the potential to cause instability in the active layer of soils.

A permafrost monitoring program was initiated in 1994. Activities related to permafrost monitoring are based on the following:

- to understand the permafrost in undisturbed areas on the project site in order to design surface infrastructure (dams, roads. etc.)
- to identify ground thermal changes that indicate change in the permafrost condition under engineered structures
- to monitor the formation of permafrost in the tailings impoundment.

Wildlife

Wildlife and wildlife habitat monitoring activities have been developed to assess the effects of project development on wildlife and their habitats over time. Baseline information collected during 1994 and results from ongoing studies during 1995 will form the basis for the design of the wildlife monitoring activities.

To assess statistically significant changes to wildlife distribution or habitat use which may be attributable to project activities, the monitoring program will use scientific principles.

The following activities that will be undertaken for wildlife monitoring:

- monitoring the distribution and movements of the Bathurst caribou herd within the study area
- habitat mapping and verification to determine seasonally important habitat for herds
- documenting and mapping the use of denning sites and occurrence of furbearing species in the study area
- The use of eskers and other glacial-fluvial deposits by wildlife in the study area.

Reclamation

Monitoring activities that describe wildlife and vegetation habitats are important in the development of reclamation activities. Activities that are of value to both wildlife and reclamation monitoring are as follows:

- wilderness use of re-claimed areas after reclamation
- use of eskers and other glacial-fluvial deposits by wildlife, for denning, travel, feeding and security.

Vegetation

To describe vegetation, an ecological map of the wildlife study area will be created.

10.2.1.2 Operational Land Monitoring

To assess the production, extraction and relocation of ecological or waste materials, the following operational activities are included in the land monitoring plan:

- Quarried construction material
- Quantity of mined ore and waste rock
- Waste rock dump construction
- Tailings deposition and stability of structures
- Road construction
- Solid waste disposal.

The operational land monitoring plan for all activities will consist of an annual or more frequent measure and location plan detailing the change from the previous period for each material considered. This information will be used for engineering planning purposes.

10.2.2 Parameters to be Monitored

The parameters associated with the environmental portion of the land monitoring plan are summarized on Table 10.2-1 and described below.

As stability and permanence are the primary criteria for permafrost, ground temperature and thickness of the active permafrost layer will be parameters used.

To assess the impact of project activities on wildlife and their habitat, it is necessary to determine changes in distribution and behavior. To achieve this, the following parameters will be monitored:

- wildlife sightings
- seasonal use of habitat
- the distribution and location of caribou.

For reclamation, the goal is to return the site to useful wildlife habitat. The parameters used to assess the effectiveness of the reclamation program will include vegetation establishment and growth, and wildlife use of natural and created habitats (including wetlands).

The parameters associated with the operational part of the land monitoring plan include disturbed areas:

- stability of dams and dumps
- extent of disturbance
- quantity of tailings.

10.2.3 Monitoring Methods

To determine ground temperature and the thickness of the active permafrost layer, ground temperature sensors will be used. The method involves drilling a borehole 10 m to 15 m deep into the ground and installing a thermistor cable. A typical installation includes ten thermistors on each cable and each senses the ground temperature at a specific depth. The spacing of the thermistors varies with a higher density near the surface where maximum seasonal temperature variations occur.

Data collection will involve both automated and manual methods. The automated stations consist of a thermistor string connected to a datalogger. Manual measurements will be collected to supplement the automatic monitoring and to evaluate the permafrost condition below thaw-sensitive structures (such as dams).

A number of wildlife monitoring methods will be used. The methods range from simple observation of wildlife activities by employees during their daily activities, to more systematic data collection.

The distribution and movements of the Bathurst caribou herd as they cross Lac de Gras during migration and their use of the area during summer will be measured and described. To accomplish this, transects will be flown and measurements will be similar to that described in the baseline studies. The focus of these measurements is to document the location of migration corridors and the use of habitats within the wildlife study area.

Dens in eskers and glacial-fluvial deposits will be identified. These will be monitored if they are located within close proximity of the development area (8 km). These habitats will be assessed using a helicopter and on-ground methods, as described for the baseline studies. A majority of habitat mapping will be completed during the baseline studies and during the initial phases of project development. This may be sufficient for monitoring, however, on a periodic basis these will be updated as mining advances.

Radio collaring has been initiated as part of the SGP regional study. Radio collared bears within the wildlife study area will be monitored. This will map and verify seasonally important habitats for bears. These maps will be updated on a periodic basis.

An ecological map of the wildlife study area (180,000 hectares) is being developed using a land mapping protocol. Little work has been done with respect to vegetation and ecosystem mapping in the Northwest Territories, thus this methodology, developed for terrestrial ecosystems in British Columbia (includes terrain and vegetation mapping), is being used. This methodology has been used to develop ecosystem maps with other jurisdictions (provinces and the United States) that transcend political boundaries. It is the basis for ecological mapping in Canada.

The methodology employs standard terrain mapping methods (Howes and Kenk 1985) overlain with biogeoclimatic ecosystem classification (Pojar *et al.* 1986). This provides a direct integration of surficial materials, soils, vegetation and wildlife habitat. Thirty preliminary 1:10,000 large map sheets covering the 180,000 hectares have been produced, primarily based on aerial photographs and a limited amount of field typing conducted in summer of 1994. Final ground truthing is currently being completed. The composite 1:100,000 maps showing vegetation communities has been included in this report in Volume II.

This product will provide a comprehensive ecosystem inventory that can be used for minimizing impacts and for assessing potential disturbances. It is a planning tool for exploration, development and monitoring. For example, haul roads and construction sites could be located to avoid critical ecosystems and important habitats using these habitat maps. Additionally, these maps will aid in reclamation planning to identify plant material resources and their locations. Sensitive plant communities and those habitats most important for wildlife will also be identified.

Reclamation monitoring relies on a natural successional process, and should require little or no maintenance. As reclamation processes are initiated, the types of vegetation that establish and the use of reclaimed land by wildlife will be measured.

Operation land monitoring methods consist of material quantity surveys and tailings dam and waste dump stability analysis.

10.2.4 Monitoring Locations

Figure 10.2-1 describes the location of the environmental land monitoring activities. Ground temperature measurements are currently being collected in undisturbed terrain at seven sites around the project area. They are located around Long Lake, at the Airstrip esker and adjacent to the proposed plant site and Phase I tailings impoundment. These stations have been established to monitor ground temperatures in different types of terrain and also to monitor the natural variations in ground temperature.

During the construction phase, additional stations will be installed within the dams, dikes and road structures to monitor the permafrost within these structures.

Thermistors will also be installed into the tailings to monitor the rate at which permafrost forms. If structures are built on the current control monitoring stations, new undisturbed sites will be selected for use as control sites.

Monitoring activities involving caribou migration and habitat use by bears will focus on the wildlife study area. However, for some specific measurement (such as diversionary methods around the tailings pond), the location will be at the camp and its associated facilities.

Finally, reclamation monitoring will be done wherever areas have been reclaimed throughout the project area.

Operational land monitoring locations comprise the areas of current project activities.

10.2.5 Monitoring Frequency

Environmental monitoring aspects are as follows.

The monitoring of permafrost will be continuous. The use of automatic dataloggers makes this activity relatively easy. Manual measurements will be taken to supplement the automatic monitoring.

Monitoring of caribou will be on a yearly basis when they are migrating (in the spring and fall). It is expected that the monitoring program will be conducted for the initial 5-years of operation or until a significant level of monitoring data has been collected at which time frequency will be re-evaluated and modified accordingly.

Reclamation monitoring will commence as soon as reclamation activities are initiated. This will continue until the reclamation process is complete.

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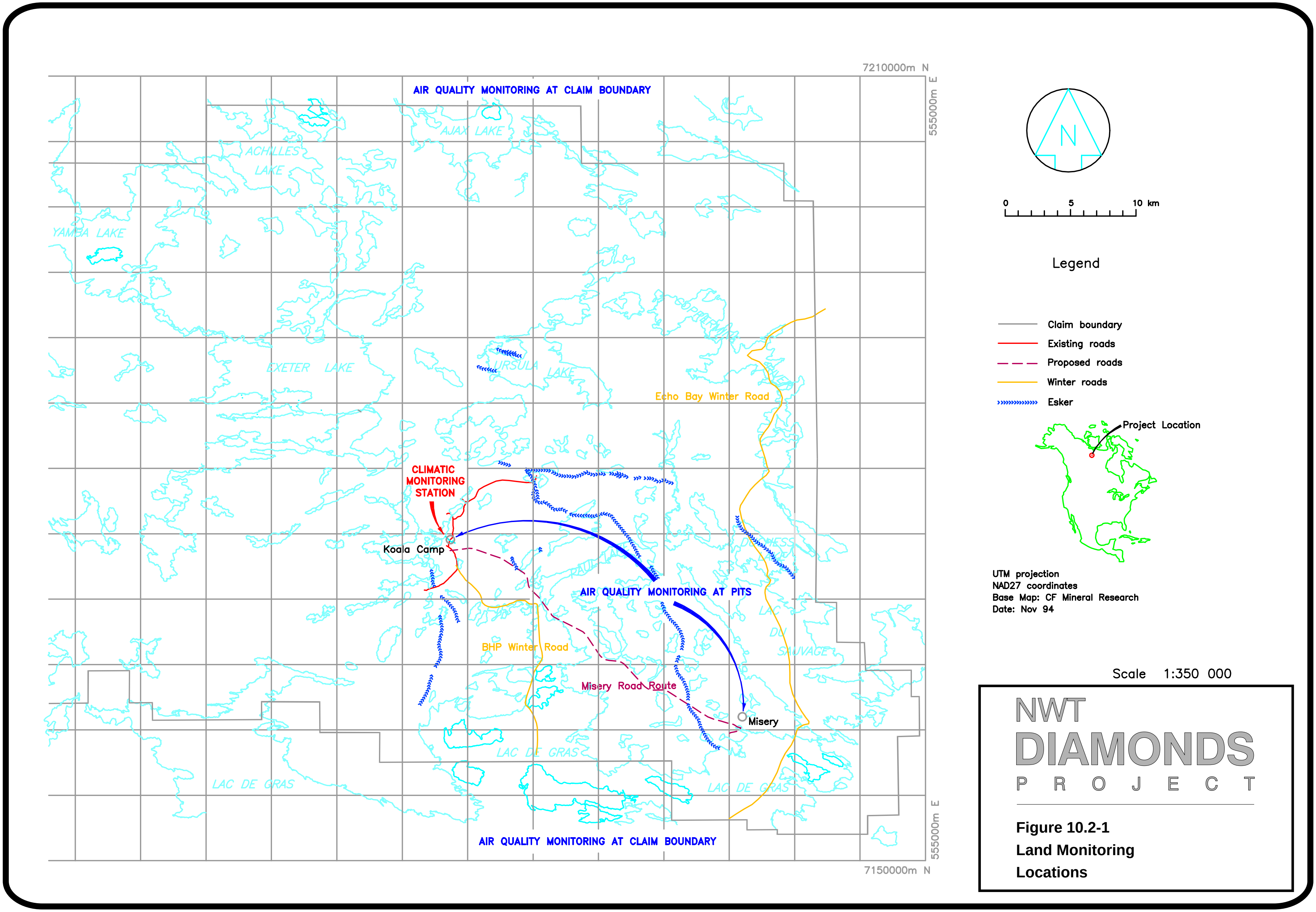

Figure 10.2-1
Land Monitoring Locations

Source: Rescan

Operational land monitoring frequencies will vary as development activities progress.

10.3 Air Monitoring

Since both climate and air quality have been identified as VECs the following monitoring program addresses all of the major sources of air emissions and the ambient air quality.

Variations in climate have the potential to affect a wide range of environmental processes including the dispersion of air emissions, streamflow, groundwater levels, growth of vegetation as well as the activity of most organisms. While activities at the NWT Diamonds Project are unlikely to change the climate, it is important to monitor the climate to be able to distinguish between changes potentially caused by project activities versus naturally occurring processes or other environmental phenomenon.

10.3.1 Monitoring Plan

Mining activities will produce gases and particulate matter. While climatic factors will determine how those materials will be dispersed and diluted, ambient air quality monitoring will assess the potential impact on human and biological health. Air quality concerns will also be addressed in the work place (with respect to occupational health and safety standards). Air quality monitoring will assess whether the project conforms to regulatory objectives and/or permit requirements and assess whether the project impact predictions are accurate. From an environmental management perspective, the air monitoring program is presented and discussed with respect to two general points of view: environmental monitoring and operational monitoring.

The air monitoring plan is summarized in Table 10.3-1.

10.3.2 Parameters to be Measured

Environmental air quality monitoring will consist of ambient and climatological data collection. To effectively monitor climate, it will be necessary to measure site specific parameters such as temperature, wind speed, wind direction, relative humidity, precipitation and rainfall. This information will be used in various models including air dispersion modelling, design of infrastructure and refinement of water management plans.

The Canadian Environment Protection Act Ambient Air Quality Objectives (CAAQO) form the basis for air quality monitoring. The ambient air monitoring plan is designed to assess whether the ambient air quality for NO_x, SO_2, and TSP at the mineral claim boundary is met, and to provide adequate protection against negative effects on soils, water, vegetation, materials, animals, visibility, personal

Table 10.3-1
Summary of Air Monitoring

Type	Parameters	Method	Location	Frequency
Environmental Monitoring				
A) Climate	Temperature, wind speed, relative humidity, rainfall and precipitation	Automated weather station with CR10 datalogger	Koala Camp	Sensor reading taken every five seconds with hourly and daily summaries saved to final storage. Monitoring to continue until project closure.
	Snowfall	Nipher Snow Gauge	Koala Camp	Daily over winter until project closure.
B) Ambient Air Quality	Total suspended particulate (TSP)	Dust cannisters to measure deposition		Summer months for first year of operation, and as required thereafter.
	NO_X, SO_2	Low volume air sampling with wet chemistry	At mineral claim boundary	As required to verify predictive modeling results.

(continued)

Table 10.3-1 (completed)
Summary of Air Monitoring

Type	Parameters	Method	Location	Frequency
Operational Monitoring				
A) Stationary Emission Sources	NO_X, SO_2, CO, Particulate	Isokinetic stack sampling for particulates, constant rate sampling and wet chemistry for SO_2, grab sample and wet chemistry for NO_X, wet chemistry for CO	Diesel genset and boiler stacks (stationary sources)	Once per year during operation phase or when fuel quality changes
B) Industrial Hygiene	CO	Wet chemistry and/or auto analyzer	Powerhouse, boiler room, vehicle maintenance areas	Continuous until project closure
	NO_X, CO, O_2	Gastec or Dräger system	Open pits and underground	As required during thermal inversions and underground operations
	Particulate	Low volume portable air sampler	Personnel sampler for equipment operators	first year of operation, and as required thereafter
	TSP and Respirable dust (PM10)	High volume air sampling	Site area	first year of operation, and as required there after
C) Thermal Inversion in open pits	Temperature profile, wind (speed and direction)	Anemometer, thermistors	Open pits	In winter during inversions

comfort and well being. Although there is no CAAQO for PM10 (the fraction of respirable dust <10 µm), it will also be measured to provide data for the occupational health and safety program. Carbon monoxide (CO) will not be monitored because results of dispersion modelling predicted concentrations three orders of magnitude below CAAQO.

The operational air quality monitoring will consist of stack testing for the stationary sources, industrial hygiene air sampling and a study of meteorological conditions coincident with thermal inversions in the open pits.

The parameters to be measured by the stationary source (gensets and boiler) testing program include NO_x, SO_2, CO and particulate. These parameters are commonly used to ascertain the performance of diesel generators, industrial boilers and incinerators.

Air quality criteria for the workplace (industrial hygiene) may be found in the NWT Mine Safety Act-Mine Safety Regulations (Chapter M-16). The regulations stipulate maximum allowable 8-hour, 15 minute and ceiling exposure limits. The workplace monitoring objective is to assess and ensure that the employees are not exposed to airborne concentrations in excess of these regulations. The parameters to be monitored are NO_x, SO_2 and O_2.

The extent to which thermal inversions will occur and their affect on open-pit air quality is difficult to predict. To further understand the meteorological conditions which lead up to the formation and dispersion of inversions in open pits, vertical temperature gradients and wind speeds will be monitored.

10.3.3 Monitoring Methods

The methods used to perform the air quality environmental monitoring are all standard. The automated weather station monitors each of the parameters on a five second basis and hourly and daily averages are generated and logged. This data is downloaded to a portable computer on a monthly basis and can be used to update various models.

The deposition of TSP will be measured using metal cans mounted on poles approximately 1.5 m from the ground. The containers will accumulate TSP for one week at which time the weight of the TSP will be determined. Based on the cross sectional area of the container, a TSP deposition rate can be calculated in units of grams per week per square metre.

In order to calibrate the air dispersion models the NO_x and SO_2 concentrations will be monitored using low volume air sampling and wet chemical methods. The sampling will typically draw air through a series of glass containers (impingers), full of an absorbing solution. Wet chemistry will then be used to determine the ambient air concentrations of NO_x and SO_2.

The operational air monitoring program includes air sampling for stationary sources (diesel gensets, boiler and incinerator), industrial hygiene sampling and meteorological monitoring for thermal inversions.

Stationary source monitoring provides valuable information as to whether or not the equipment is operating efficiently and if it achieves emission objectives. The monitoring method used to determine TSP from a stationary source consists of an isokinetic sampling system. Isokinetic sampling draws gas from the stack at the same rate at which the gas is exiting, thereby increasing the capture efficiently. The TSP is captured on a filter and in a absorbing solution, usually deionized water. Tests are usually performed in triplicate

Constant rate stack sampling (usually less than 10 L/min) can be used to determine SO_2 concentrations for the genset and boiler. The testing is usually performed in triplicate and each test is approximately one hour. Sampling for NO_x usually consists of capturing a grab sample of stack gas in an evacuated glass bomb containing a small amount of absorbing solution. After a specified reaction time the absorbing solution is analyzed for NO_x. Again, the analysis is performed in triplicate. Stationary source sampling for other parameters such as CO can be performed using a variety of wet chemical methods.

Industrial hygiene sampling methods for CO will consist of either wet chemistry or use of a autoanalyzer. Several types of colorimetric devices are also available for workers to wear. These devices are classified as personal protective equipment and may be included in the occupational safety and health program. Autoanalyzers will be installed to provide warning of a potential CO buildup in certain areas.

A Gastec or Dräger type of sampling system will be used to monitor air quality underground and in open pits. This type of sampler is based upon a colormetric change on a solid media. The NO_x, CO or O_2 concentrations may be read off of a graduated glass tube. A specific type of detector tube is used for each parameter. Open pit monitoring will only be necessary if and when a thermal inversion has trapped equipment exhaust.

Low volume air samplers will be attached to various equipment operators as part of the industrial hygiene air monitoring program. The low volume samplers draw air at a rate of between 1.7 L/m and 2.0 L/m through a 37 mm diameter membrane filter. The compact and portable air sampling pump is powered with a rechargeable battery and is typically worn on the worker's belt for the duration of a shift.

TSP concentrations will be measured using high volume air samplers. TSP is collected by drawing a known volume of air through a 20 by 25.4 cm filter at a rate of 1.13 m^3/min. The filter is weighed for any weight increase and the TSP concentration is determined. A HV air sampler may be powered using the regular 110 V electrical system, or a gas powered generator.

The measurement of PM10 (suspended particulate of <10 µm in diameter) is similar to monitoring TSP except that the inlet for the high volume air sampler has been designed not to allow particles larger than 10 µm to collect on the filter.

To monitor the meteorological conditions which characterize a thermal inversion, a anemometer will be installed on the crest of one of the open pits. The anemometer will be attached to a datalogger programmed to record the hourly average wind speeds and directions, along with the daily maximum wind speed. The vertical temperature gradient will be monitored by releasing a thermister attached to a helium balloon from the bottom of the open pit. The rate of ascent of the helium balloon will be controlled using a small winch and the temperatures from the thermister will be stored in a lightweight, portable datalogger.

10.3.4 Monitoring Locations

Figure 10.3-1 shows the location of monitoring activities within the project area. Climatic monitoring will be carried out at a single station at the Koala camp. Ambient air quality parameters will be measured at locations that assess regional impacts (*i.e.*, at/or near the mineral claim boundary).

For the operational air monitoring program samples from the stationary sources (diesel genset and boiler) will be extracted directly from the respective stack using specialized sample probes. The industrial hygiene monitoring for CO will take place in the power house, camp services boiler room and vehicle maintenance area. Personnel monitoring for particulate will be performed for several different groups of equipment operators. Climatic monitoring for inversions will take place in the first open pit which reaches a depth such that the inversion begins to trap diesel exhaust emissions inside of it resulting in degraded air quality.

10.3.5 Monitoring Frequency

The monitoring frequency is different for each parameter. Climate monitoring using an automated weather station will be continuous until project closure. Dust deposition monitoring will collect samples every seven days during the summer of the first year of operation. After the first year of operation the sampling will continue only as required. Low volume sampling for NO_x and SO_2 will be performed as required for calibration of the air dispersion models.

Stationary sources of emissions will be tested once per year during the operational phase of the project. Industrial hygiene air monitoring for CO will be continuous until project closure. Monitoring for NO_x, CO and O_2 will take place underground throughout the underground mine development and in the open pits when a thermal inversion has persisted for long enough to begin to degrade the air quality. Personnel monitoring for particulate will begin during the summer months of the first year of operation, and continue as required afterwards.

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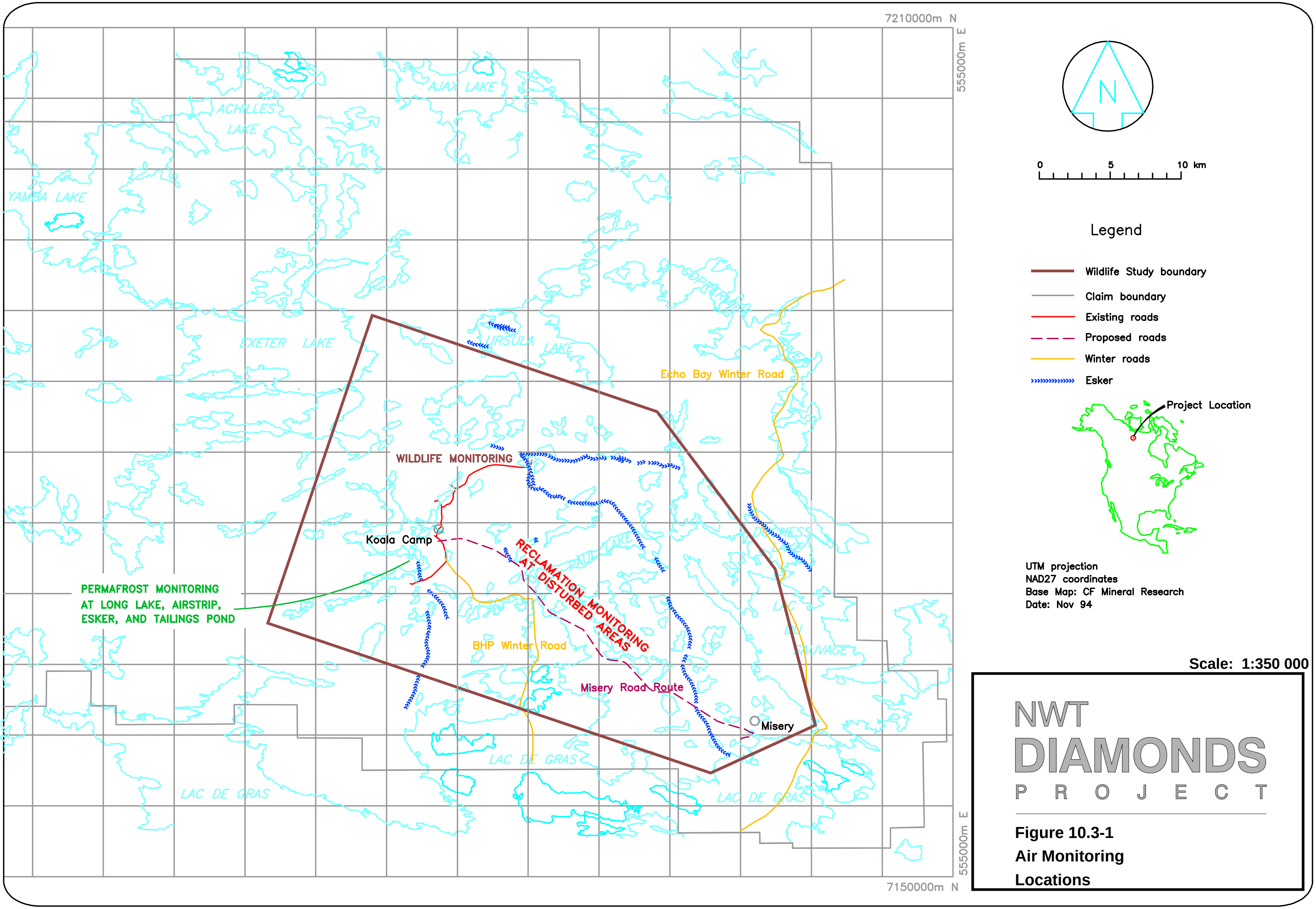

Source: Rescan 1995

The meteorological monitoring for thermal inversions in the open pits will commence when any one of the pits is deep enough to allow an inversion to effectively trap diesel emissions and it is confirmed air quality has been affected. Thereafter, monitoring will be done intermittently when thermal inversion occurs to collect sufficient data to be able to predict the meteorological conditions (wind speed, vertical temperature gradient) associated with the formation and degradation of a thermal inversion.

Ambient air quality monitoring results will be compiled and used for confirmation of modelling results and to compare with ambient objectives. Industrial hygiene monitoring results will provide a record of regulatory compliance and enable any potential workplace improvement opportunities to be identified.

10.4 Socioeconomic Impacts Monitoring

As discussed in Volume IV, Section 4.3, the project's activities will provide jobs and revenue to local communities. It is hoped that the project will have a net positive impact and that the benefits provided will ultimately strengthen the local communities.

The economic benefits of the NWT Diamonds Project to the NWT relate directly to the number of NWT residents employed by the project, and the level of goods and services purchased and made in the NWT.

The employment and purchasing policies of the NWT Diamonds Project have been designed to ensure a high NWT content level. However, these policies can only produce the desired results if the potential beneficiaries of these policies are committed to economic gain in the NWT. This commitment requires the following actions:

- commitment by local Aboriginal people to participate in the wage economy
- participation by the potential labour pool in government- and industry-sponsored educational and training programs
- cooperative working relationships between businesses and financing organizations (from banks to government grant programs)
- a competitive business attitude by local service and supply companies
- involvement by territorial and municipal governments to enhance the potential involvement of their constituents with the project
- the creation/maintenance of a healthy business climate by the federal, territorial and municipal governments that will allow the Proponent to optimize the life of the mine.

Although the economic monitoring of the project will start with a review of direct employment and purchases, this review will not be done in isolation from other programs needed to ensure positive economic impacts. For example, in conjunction with employment numbers, the monitoring program will look at the availability, participation and success rates of the project's training programs. These programs are central to the Proponent's plan of building and maintaining a strong Northern workforce.

10.4.1 Objectives of the Monitoring Program

The objectives of the monitoring program are as follows:

- to measure the level of NWT employment and business participation in the project and to compare these data with baseline data to determine ongoing impacts
- to confirm compliance with any Benefit Agreements with Aboriginal organizations
- to monitor the accuracy of predicted impacts from the project
- to use the results of the monitoring programs to review and, if appropriate, modify the corporate employment and purchasing policies.

10.4.2 Parameters to be Monitored

The main parameter to be monitored for economic impact will be expenditures by the Proponent in the Northwest Territories. These expenditures will be broken down into two categories: direct employment and purchase of goods and services. Within each of the categories, parameters to be measured will include the following:

Direct NWT Employment

- numbers employed and related income by geographic location
- numbers employed by job category
- in-migrants employed by the project
- statistical review of participation and success rates of training and educational programs provided by the Proponent.

Purchase of Goods and Services

- total value of NWT purchases by geographic location

- types and values of NWT purchases by category (i.e., transportation, fuel, equipment, etc.).

10.4.3 Monitoring Methods

Two monitoring methods will be used, statistical and attitudinal. Statistical analysis of employment and purchases will establish levels, while attitudinal monitoring will provide reasons for the observed levels or changes in levels.

The compilation of statistics will be an ongoing function of the Proponent's human resources, purchasing and accounting departments. Data on employment by location and job type, as well as purchases by location and type, will be routinely compiled.

Attitudinal monitoring will provide explanations for the statistics. The attitudinal monitoring will be done via regular contact with groups such as communities, Aboriginal organizations, business organizations, government agencies and education institutions and other groups that are directly affected by the project.

The statistical and attitudinal monitoring activities together provide a more complete understanding of ongoing economic impacts by the project and the reasons for these impacts. For example, statistics may show a decrease in NWT resident employment. Attitudinal monitoring may show, first, that few people are participating in training programs and, second, that the reason they are not participating is that they do not want to travel long distances to attend these programs.

10.4.4 Monitoring Locations

Statistical and attitudinal monitoring will be done for the locations likely to be most affected by the project. These include Rae-Edzo, Rae Lakes, Wha Ti, Snare Lake, Dettah, N'dilo, Lutsel K'e, Coppermine, Yellowknife and Hay River.

10.4.5 Monitoring Frequency

Employment and purchase impacts will be monitored on an ongoing basis so at any given time the company is able to determine levels of NWT employees by location, job type, income and in-migration, as well as NWT purchases by amounts, location and type.

Attitudinal monitoring will also be ongoing, based on a schedule of meetings/visits as deemed necessary by the various interest groups, and agreed to by the Proponent. At least once a year the Proponent will prepare a statistical report of its NWT employment and purchase levels.

10.4.6 Monitoring Compliance with Aboriginal Benefit Agreements

The involvement of Aboriginal people in the Proponent's monitoring program is incorporated in the Benefits Agreements (Volume I, Section 1.4.2). It is anticipated that the monitoring programs of the Benefits Agreements will be implemented through committees on employment, job-training, business opportunities, education, traditional knowledge and cross-cultural training. These monitoring programs (depending on the degree of impact for each group) will potentially involve the Dogrib Treaty 11 (the communities of Rae-Edzo, Rae Lakes, Snare Lake and Wha Ti), the Treaty 8 Dene (the communities of Dettah, N'dilo and Lutsel K'e), the Inuit (the communities of Coppermine, Cambridge Bay and Umingmaktok) and the Metis. The dynamics of these working relationships must be ongoing and future-oriented to deal with events as they unfold.

Each committee will be responsible for setting up its own procedures, standards of review, monitoring approaches and timetables for meeting. As currently foreseen, the purpose and activities of each committee may be as follows:

- Employment and Training Committee (ETC) – to assist the Proponent in defining the parameters of preferential hiring, job upgrading and apprenticeship. The ETC will meet as often as necessary and be responsible for monitoring the training and employment policies. The committee will also assist in the review of the Proponent's progress in career development, employee turnover, cross-cultural education, innovative employment practices and available government programs. The ETC will submit periodic reports on the status of its progress. An Aboriginal employment coordinator will be hired to assist in the employment programs and help in monitoring procedures.

- Business Opportunities Committee (BOC) – to assist the Proponent in its evaluation of potential business needs and Aboriginal participation therein. The BOC will meet as often as necessary and will identify opportunities to supply goods and services to the project. The committee will monitor these opportunities and ensure that they are made available to Aboriginal peoples and their businesses. The BOC will review and analyze the Proponent's requirements for goods and services for the development and operation of the mine, and will review awarded contracts with local businesses to help them improve their future methods of bidding. Periodic reports will be submitted.

- Culture and Education Committee (CEC) – to assist the Proponent in the administration of educational grants provided by the Proponent and ensure that traditional knowledge and culture are treated with dignity and respect. The CEC will review and monitor the qualifications for scholarships, criteria and recruitment procedures and report annually on the number, type and amount of scholarships. The committee will ensure that traditional knowledge and values are factors in selecting the potential candidates. Where cross-cultural sensitivity training is required or guidance is needed by the Proponent, the Committee will provide the necessary information. Heritage sites and preservation will also be monitored by this committee.

- Joint Implementation Committee (JIC) – to assist the Proponent in ensuring that all the programs are being implemented, provide for dispute resolution and address non-compliance difficulties. The JIC will clarify areas of responsibility of all the committees, review submitted reports and generally monitor the implementation of all the programs contemplated in the Benefits Agreements. The committee will meet regularly and will supervise the preparation and implementation of a program of consultation and communication with the Aboriginal peoples on an ongoing basis to ascertain current concerns. The JIC will also determine the means of assessing the effectiveness of the monitoring procedures implemented by all the committees.

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Keywords Index

Glossary and Abbreviations

Glossary

Abiotic Factors Environmental influences that arise from non-living entities, e.g., climate.

Ablation Till Unstratified rock material resulting from ablation processes that cause the accumulation of debris on the ice surface.

Aggrade To spread or grow (permafrost).

Air Contaminant Any solid, liquid, gas or odour, or combination thereof, which, if emitted into the air, would create or contribute to the creation of air pollution.

Air Pollution A condition of the air, arising wholly or partly from the presence of one or more air contaminants, that endangers the health, safety or welfare of persons; interferes with normal enjoyment of life or property; endangers the health of animal life; or causes damage to plant life or to property.

Allochthonous Materials formed elsewhere than in their present place.

Alluvial Clay, silt, sand and gravel material deposited by running water.

Ambient Air Quality The surrounding air quality present at a particular site.

Amorphous Substances lacking any crystal structure or order; usually used with reference to oxides or organic matter.

Anthropogenic Caused by human activity.

Appendages Any considerable projections from the body of an animal.

Arctic Air Inversion A layer in the troposphere in which there is an increase in air temperature with height. This differs from normal conditions in which temperature decreases with height from the surface.

Atmospheric Stability	The ability of the atmosphere to resist or enhance vertical motion.
Audiometric Testing	A series of tests to determine a person's auditory threshold for a given stimulus.
Authigenic	A mineral formed by precipitation within the water column or sediments, as opposed to mineral(s) imported from erosion elsewhere.
Back	The ceiling or roof of an underground mine opening.
Backfill	Waste rock material used to fill the void created by mining an ore body.
Basal Till	Unsorted glacial debris at the base of the soil column where it comes into contact with the bedrock below.
Basic Rock	An igneous rock, relatively low in silica and composed mostly of dark-coloured minerals.
Bedrock	The more-or-less solid, undisturbed rock in place either at the ground surface or beneath superficial deposits of gravel, sand or soil.
Bedrock Geology	The study of the origin, composition, structure and history of bedrock.
Benthic	Pertaining to the bottom region of a water body.
Benthos	Assemblage of animals living in or on the bottom sediments of a lake and dependent upon the decomposition cycle for most if not all of its basic food supply.
Bifaces	A stone tool used by ancient peoples. A type of artifact that has been chipped from a larger stone on both sides.
Biodiversity	The variety of organisms that exist on the planet and the varieties within these species and the ecosystems they inhabit.
Biogenic	Arising from or associated with biological sources.
Blasthole	A hole drilled for purposes of blasting rather than to obtain exploration or geological information.

Bulk Sample	A large sample of mineralization, frequently involving hundreds of tonnes, selected in such a manner as to be representative of the potential ore body being sampled. Used to determine metallurgical characteristics, verify grade and obtain diamond quality information.
Carat	A unit of weight for precious stones (200 milligrams).
Carnivore	A flesh-eating mammal.
Catch Per Unit Effort (CPUE)	The number of fish caught per 24-h soak time per 100 m of gillnet; or per 24-h soak time for trapnets.
Cilia	Fine cytoplasmic threads projecting from the surface of a cell.
Clarification	Process of cleaning dirty water by removing suspended material.
Classify	A mineral process that separates minerals according to size and destiny.
Climatology	The study of the long-term, prevailing weather conditions in a given area.
Concentrate	The product of the crushing, grinding and cleaning process contains valuable mineral and from which most of the waste material in the ore has been eliminated and discarded as tailings.
Core	A long, cylindrical piece of rock recovered by diamond drilling.
Crater	A circular depression formed by extrusion of volcanic material and its deposition in a surrounding rim.
Craton	A portion of a continent that has attained stability and has not been subjected to major deformation for a prolonged time, typically since Precambrian or Early Paleozoic time.
Critical Depth	The depth in a lake at which sufficient light penetrates to enable photosynthesis in plants to equal their respiration.
Crusher	A machine for crushing rock, such as a gyrating crusher or a cone crusher.

Cumulative Effects	Effects cause by the interaction of project components or activities with other activities of the past, or effects that are occurring simultaneously or sequentially.
Debitage	Pieces of stone removed during the manufacture of stone tools.
Decibel (dB)	The basic unit for measuring the magnitude of sound pressure levels. The entire range of audible sound pressure (a range of more than 10 million to one for individuals with normal hearing) can be compressed into a practical scale of sound pressure levels from 0 to 140 dB. One decibel is the minimum difference in loudness that is usually perceptible.
Decline	An inclined underground opening connecting levels to allow machine access from level or from surface; also called a ramp.
Decommissioning	The process by which a mining operation is shut down and closed.
Demographics	The analysis of factors such as births, marriages, diseases and other vital statistics, which allow the assessment of a population in a given area.
Dendogram	Tree-like diagram indicating resemblance among members of a group of organisms or sites.
Deposit	Any collection of earth material accumulated through the activities of water, wind, ice or other agents.
Detritivore	An organism that eats detritus.
Detritus	Unconsolidated material composed of both inorganic and dead and decaying organic material.
Development	Work carried out to provide access to the mineral ore of value and to construct the facilities required for production operations.
Diabase	A common basic igneous rock usually occurring in dykes or sills.
Diagenesis	The sum of all chemical, physical and biological influences on sediment composition.

Diamond	The hardest known mineral, composed of pure carbon.
Diatom	Common name for Bacillariophyta; a type of phytoplankton.
Diatreme	A breccia-filled volcanic pipe that was formed by a gaseous explosion.
Dike	An earth-fill structure similar to a dam designed to impound water or saturated material such as tailings.
Dip	The angle at which a structure or rock bed is inclined from the horizontal as measured at right angles to the strike.
Diurnal	Daily.
Dorsal	Pertaining to the back.
Dorsal Fin	A fin on the back of a fish, usually central in position and supported by rays or spines.
Drift	A horizontal, or nearly horizontal, underground opening that follows along the length of a rock formation, as opposed to a crosscut, which crosses the rock formation.
Dry	A building, with showers and storage for work clothes, where miners change and wash.
Dump	A pile or heap of broken rock on surface.
Dyke	A long and relatively thin body of igneous rock that, while in the molten state, intruded a fissure in older rocks.
Ecology	The study of the interactions between organisms and their environment.
Ecosystem	A community of interacting organisms considered together with the chemical and physical factors that make up their environment.
Ecosystem Approach	A holistic, interdisciplinary method of studying a system that seeks to integrate biophysical and socioeconomic factors with input from a variety of sources.
Ecosystem Integrity	A measure of the overall health of an ecosystem.

Emission Rate The rate at which a source releases air contaminants.

Englacial Contained, embedded or carried within the body of a glacier or ice sheet.

Environment The interrelated physical, chemical, biological, social, spiritual and cultural components that affect the growth and development of living organisms.

Environmental Assessment and Review Process (EARP) The process used by the federal government to consider the environmental implications of all proposals for which the federal government has decision-making authority.

Environmental Impact Assessment (EIA) A process designed to identify, predict, interpret and communicate information about the impact of an activity on human health and well-being, including the well-being of ecosystems on which human survival depends.

Environmental Impact Statement (EIS) A detailed document that describes the potential environmental consequences of a proposed activity.

Environmental Quality Objectives Goals or purposes toward which an environmental control effort is directed, including goals or purposes stated in quantitative or qualitative terms.

Ephemeral Stream A stream that lasts for only a short time.

Epiclastic Pertaining to mechanically deposited sediments consisting of weathered products of older rocks.

Epilithon Periphyton attached to submerged rocks.

Esker Sinuous ridge of weakly stratified gravel and sand deposited by a stream flowing in (or beneath) the ice of a retreating glacier, and left behind when the ice melted.

Euphotic Zone A zone near the water surface into which sufficient light penetrates for photosynthesis to take place.

Eutrophic Nutrient rich waters with high primary productivity.

Face The end of an underground drift or crosscut, or of an open pit bench, in which mining is progressing.

Facies The set of characteristics of a rock that reflects the conditions of its origin and that distinguishes it from

	adjacent or associated units.
Fault	A break in the Earth's crust caused by tectonic forces that have moved the rock on one side with respect to the other; faults may extend for many kilometres or be only a few centimetres in length; similarly, the movement or displacement along the fault may vary widely.
Fecundity	Potential ability of an organism to produce eggs or young.
Fin Ray	An articulated or jointed rod that supports the membrane of a fin.
Flake	A piece of rock intentionally removed from another rock that may be further modified to become a tool, or left unmodified as debitage or detritus.
Flowsheet	An illustration showing the sequence of operations, step by step, by which ore is treated in a mineral separation process.
Fork Length	Distance from the proximal tip of the head to the tip of the middle ray of the caudal fin.
Freshet	Increased volume of flow over a relatively short period of time (e.g., snowmelt).
Frost Boil	An unsorted circle of fresh soil material formed by frost action and commonly found in fine-grained sediments underlain by permafrost.
Fry	Young fish, newly hatched, after the yolk has been used up and active feeding has commenced.
Fumigation	A meteorological condition occurring when a strong radiation inversion begins to break up as the Earth's surface begins to warm up during early to mid-morning. Fumigation conditions can cause high ground level pollutant concentrations for short time intervals; for instance, the plume from a stack may be carried to ground level within a few hundred metres of the stack by convective currents.

Gaussian Dispersion	The dispersion of a pollutant after it leaves the top of the stack; often follows a pattern similar to the so called "bell-shaped curve."
Geology	The science concerned with the study of the rocks that compose the Earth.
Geomorphology	The study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features.
Glaciofluvial Deposits	Unconsolitated rock material deposited by meltwater streams flowing from glaciers.
Granite	A coarse-grained (intrusive) igneous rock consisting of quartz, feldspar and mica.
Granitoid	A granitic rock.
Gyratory Crusher	A machine that crushes ore between an eccentrically mounted crushing cone and a fixed crushing throat.
Heavy Medium Separation (HMS)	A unit process in which crushed ore is washed in rotary drum scrubbers to break up agglomerated ore particles and remove soft fines and clay minerals.
Herbivore	An animal that feeds on plants.
Holistic	A total interrelated system perspective.
Host Rock	The rock surrounding an ore deposit.
Hydrology	The study of the properties of water and its movement in relation to land.
Hypabyssal	Kimberlite magma that has remained at the base of the pipe and crystallized *in situ*.
Hyporheos	Organisms that live in the interstitial spaces within the sediments of lakes and streams.

Ice Wedge Polygon A large polygon characterized by borders of intersecting ice wedges, found only in poorly drained areas of permafrost regions and formed by contraction of frozen ground. The fissured borders may be either ridges or shallow troughs underlain by ice wedges.

Igneous A rock formed by the solidification of magma.

Index Gill Netting Standard sampling design (used in the 1994 project area) where small-mesh gillnets are set perpendicular to shore beginning at depths of 2 m to 3 m.

Indigenous Knowledge Working definition from the Inuit Circumpolar Conference (1993): *"... comprised of information and concepts about the environment and ecology that are known, but usually not formally recorded by individiuals who belong to a particular culture group that has occupied an identifiable territory over a long period of time. It inlcudes facts, concepts and theories about the charactistics which describe the objects, events, behaviours and interconnections that comprise both the animate and inanimate environments of indigenous peoples."*

Insolation The rate of radiation from the sun received per unit of the Earth's surface. Insolation is a strong determining factor for atmospheric stability.

Invertebrates Collective term for all animals without a backbone or spinal column.

Isolated Find An archaeological site with a single artifact.

Isostatic Adjustment Adjustment of the lithosphere of the earth to maintain equilibrium among units of varying mass and density; excess mass above (e.g., a glacier) is balanced by a deficit of dense mass below, and vice versa.

Kame A mound, knob or short irregular ridge composed of stratified sand and gravel. The deposit can be formed by a subglacial stream as a fan or delta at the margin of a melting glacier, by a superglacial stream through a hole on the surface of the glacier, or as a ponded deposit on the surface or at the margin of sedentary ice.

Kettle A depression in a glacial deposit formed by the melting of a detached block of ice buried in the deposit.

Kimberlite	An ultrabasic igneous rock that consists mainly of the mineral olivine and is found in volcanic pipes. The name is derived from Kimberley, South Africa, where the rock contains diamonds.
Labile	Rocks and minerals that are easily decomposed.
Lacustrine	Pertaining to, or produced by, a lake.
Lag	A residual accumulation of coarse rock fragments on a surface after the finer material has been blown away by winds.
Lake Overturn	Vertical mixing of layers in a body of water brought about by seasonal changes in temperature.
Lamproite	The only other diamondiferous volcanic rock type known besides kimberlite.
Lapse Rate	The rate of temperature decrease with height in the atmosphere. Lapse rates have been used as an index for vertical stability. The usual lapse rate for the troposphere is -0.98%°C per 100 m of elevation gain.
Larva	The immature stage, between egg and pupa, of an insect with complete metamorphosis.
Leaching	A natural process by which groundwaters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally.
Leq	The maximum allowable noise exposure level for a specified length of exposure time.
Level	A system of horizontal underground workings connected to the shaft; the basis of operations for excavation of ore above or below.
Limnology	The study of fresh water, including biological, geological, physical and chemical aspects.
Lithic	Of or pertaining to stone.
Littoral	Region of a lake from the highest water level to the depth at which photosynthesis ceases.
Lodgement Till	A till carried at or deposited from the underside of a glacier; commonly containing stones oriented with their

	long axes generally parallel to the direction of ice movement.
Lotic	Flowing freshwater environments (e.g., streams and rivers).
Macrophyte	A macroscopic photosynthetic organism growing submerged, floating or emergent in the water.
Mesotrophic	Waters with moderate primary productivity.
Microclimate	The weather variations in a very local area.
Mineral	A naturally occurring, homogeneous substance having definite physical properties and chemical composition and, if formed under favourable conditions, a definite crystal form.
Mineral Claim	A portion of land held by either a prospector or a mining company under federal or provincial law.
Mitigation	An activity aimed at avoiding, controlling or reducing the severity of adverse physical, biological and/or socioeconomic impacts of a project activity.
Mixing Height	The effective depth of the atmosphere, measured from ground level, through which the dispersion of pollutants can take place.
Moraine	A mound or ridge of unstratified glacial sediments, chiefly till, deposited by direct action of glacier ice.
Ndè	A Dogrib term usually translated as "land". As defined by the Dene Cultural Institute: *"Ndè is much closer to the scientific concept 'ecosystem', however, where ecosystem is based on the idea that living things exist in association with non-living elements, the Dogrib term Ndè is based on the idea that everything in the environment has life and spirit. Ndè includes both the spiritual and physical aspects of the land, people, animals and their habitats."*
Oligotrophic	Nutrient deficient waters with low primary productivity.
Open Pit	A surface mine, open to daylight, such as a quarry. Also referred to as open-cut or open-cast mine.
Ore	A mineral, or group of minerals, that can be extracted from

	the ground at a profit under existing economic conditions.
Ore Body	A natural concentration of valuable material that can be extracted and sold at a profit.
Otolith	Inner ear bone found in bony fishes (flat and oval in structure).
Outcrop	An exposure of rock or mineral deposit that can be seen on surface i.e., not covered by overburden or water.
Oxidant	A compound capable of receiving electrons from the decomposition of matter.
Oxidation	A process of decomposition; electrons that hold matter together are transferred to another compound called an oxidant.
Pectoral Fins	The most anterior or uppermost of the paired fins of a fish.
Pelagic	Inhabiting the open water of a lake, in contrast to the lake bottom (benthic region).
Periphyton	Community of microbiota (algae, bacterial, fungi, rotifers, nematodes, protozoans and detritus) that are loosely attached to submerged substrata that may be inorganic, organic, living or dead.
Phytoplankton	Small floating plant life in aquatic ecosystems, sometimes microscopic.
Pipe	The vertical conduit along which gas and magma ascend to the surface, usually filled with breccia and may be mineralized; a more or less vertical, cylindrical ore body.
Piscivorous	Fish eating.
Planktivorous	Plankton eating.
Plant Site	A centralized area containing the process plant, permanent camp, equipment maintenance facilities and other infrastructure required to support the mining and diamond production operations.
Plunge Pool	The water occupying a deep hollow scoured in the bed of a stream at the foot of a waterfall; also, the hollow or basin itself.

Portal	The surface entrance to a tunnel or adit.
Post-decommissioning	The time after which an operation has closed and equipment and facilities have been removed from the site.
Primary Production	Production by photosynthetic organisms.
Primary Productivity	Rate at which energy is stored by the photosynthetic activity of plants.
Process Plant	A building in which crushed ore is washed, screened, concentrated and sorted for the recovery of diamonds.
Profundal	Region of a lake lying below the euphotic zone.
Proponent	The organization, company or institution planning to initiate a project.
Pupa	The stage between larva and adult in insects with complete metamorphosis.
Pyrite	The most widespread and abundant of all the sulphide minerals and occurs in all kinds of rocks; a common yellow mineral with a brilliant metallic lustre.
Pyroclastic	Pertaining to clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.
Quaternary Geology	Rocks from the Quaternary, a period of the Cenozoic era, which began two to three million years ago and extends to the present.
Radiation Inversion	A condition in which rapid cooling of the ground by radiation causes ambient temperatures to increase with height.
Raise	An underground opening driven upward from one level to another.
Reclamation	An activity aimed at rehabilitating a disturbed site to some level of ecological productivity.
Recruitment	In biology, an addition to the population by reproduction of new individuals.
Redox Conditions	A measure of electron activity of an environment (i.e., sediments); high redox conditions mean oxygen-rich environments, low redox conditions mean oxygen-poor

	environments.
Residual Effects	Effects that persist after mitigation measures have been applied.
Retouch	A type of modification used in the manufacture of stone tools.
Riffle	Shallow areas in a stream or river section characterized by increased habitat heterogeneity, sediment size, stream velocity, and sometimes oxygen content.
Rock	Any natural combination of minerals; part of the Earth's crust.
Rock Mass Rating (RMR)	A geomechanic classification of a rock slope or drill core that provides quantitative data for the purpose of mine design and ground reinforcement. RMR values range from 0 (very poor rock) to 100 (very good rock).
Rotary Drill	A machine that drills holes by rotating a rigid, tubular string of drill rods attached to a bit. Commonly used for drilling large diameter blastholes in open pit mines; recovers chips rather than rock core.
Run-of-Mine	Typical excavated ore or waste rock that has not been upgraded, sorted or otherwise processed.
Salmonid	Family of freshwater or anadromous fishes; dominant family in northern waters of North America (includes lake trout, round whitefish, arctic grayling).
Sample	A small portion of rock or a mineral deposit, taken so that the metal content can be determined by assaying.
Sampling	Selecting a fractional but representative part of a mineral deposit for analysis.
Scoping Sessions	Public meetings where all relevant issues and concerns related to a proposed project or activity are identified.
Scrubbing	A gravity concentration process that separates high density particles, including diamonds, from low density, non-diamond material in a conventional separating cyclone.
Secondary Production	Production by consumer organisms.

Setae	Bristles or "hair" of invertebrates.
SGP	Slave Geological Province
Shaft	A vertical or inclined excavation in rock for the purpose of providing access to an ore body. Usually equipped with a hoist at the top, which lowers and raises a conveyance for handling workers and materials.
Sill	An intrusive sheet of igneous rock of roughly uniform thickness, generally extending over considerable lateral extent, that has been forced between the bedding planes of existing rock.
Solifluction	The slow downslope movement of saturated earth materials resulting from alternate freezing and thawing of ground ice.
Sorted Circle	A dominantly circular form of patterned ground, developed singly or in groups, that has a sorted appearance commonly due to a border of stones surrounding finer material.
Sound Level Meter	The basic instrument used to measure sound pressure variations.
Standing Crop	Amount of living organic matter found in a given area or volume of water at a given time; expressed as number per unit area or unit volume.
Steady-state Noise	Noise that may be characterized as having a steady magnitude (usually measured in dBA) and a prolonged duration. Examples would be noise generated by fans, diesel power plant engines and any other heavy equipment at normal operating state.
Stockpile	A supply of material, for example, blasted rock or crushed ore, set aside for future use.
Stope	An excavation in an underground mine from which ore is being or has been extracted.
Striation	One of a series of fine parallel straight lines cut into a bedrock surface by rock fragments embedded at the base of a moving glacier, or cut on the rock fragments themselves.

Sublevel	A system of horizontal underground workings, normally within stoping areas only, required for ore production.
Supraglacial	Carried at the top of a glacier or ice sheet.
Surficial Geology	The study of material at or near the surface of the earth, usually unconsolidated soil or rubble.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Tailings	Ground waste material and water (slurry) rejected from a mill or process plant after most of the valuable minerals have been extracted.
Tailings Pond	An engineered storage site used to confine tailings.
Talik	A layer or body of unfrozen ground below the active layer in a permafrost area.
Thermocline	Layer in a thermally stratified body of water in which temperature changes rapidly relative to the remainder of the body.
Thermokarst	The process by which characteristic karst-like landforms result from the thawing of ice-rich permafrost, forming cave-in bogs, caverns, pits and other small depressions.
Thickener	A large, round tank used in mineral processing operations to separate solids from liquids; clear fluid overflows from the tank and rock particles sink to the bottom.
Thorax	In insects, the group of three segments behind the head that bears the three pairs of legs and (when present) the wings.
Till	Unstratified rock material deposited directly by glaciers, consisting of a mixture of clay, silt, sand, gravel and boulders ranging widely in size and shape.
Traditional Environmental Knowledge (TEK)	As defined by the Dene Cultural Institute: *"...a body of knowledge and beliefs transmitted through oral tradition and first hand observation. It includes a system of classification, a set of empirical observations about the local environment and a system of self-management that governs resource use. Ecological aspects are closely tied*

	to social and spiritual aspects of the knowledge system."
Traditional Knowledge	As defined by the Dene Cultural Institute: *"Knowledge and values which have been acquired through experience, observation from the land and from spiritual teachings, and handed down from generation to generation."*
Trim Line	A sharp boundary line defining the maximum upper level of the margins of a glacier that has receded from an area.
Trophic Levels	Functional classification of organisms in an ecosystem according to feeding relationships, from first level autotrophs through succeeding levels of herbivores and carnivores.
Turbidity	A condition of reduced transparency in water caused by suspended colloidal or particulate material.
Utilidor	Enclosed and heated corridor for utility piping, electrical conduits and personnel access.
Valued Ecosystem Components	Environmental attributes or components identified as a result of a social scoping exercise as having scientific, social, cultural, economic or aesthetic value.
Waste Rock	Barren rock or rock too low in grade to be mined or processed economically.
Xenolith	A foreign inclusion in an igneous rock.
YOY (young of the year)	Juveniles during the period from the last larval stage to adulthood, or one year of age, whichever comes sooner.
Zone	An area of distinct mineralization.
Zooplankton	Small floating or weakly swimming invertebrate animals in freshwater and marine ecosystems.

Abbreviations

Ampere	A	Kilometre	km
Annum	a	Kilometres per hour	km/h
Billion years	Ga	Kilopascal	kPa
Canadian dollar	$ or CDN$	Kilovolt	kV
Carat	ct	Kilovolt-ampere	kVA
Carats per stone	ct/stone	Kilowatt	kW
Centimetre	cm	Kilowatt hour	kWh
Cubic metre	m^3	Kilowatt hours per tonne	kWh/t
Cubic metres per hour	m^3/h	Kilowatt hours per year	kWh/a
Cubic metres per minute	m^3/min	Less than	<
Cubic metres per year	m^3/a	Litre	L
Day	d	Litres per year	L/a
Days per week	d/wk	Litres per hour	L/h
Days per year	d/a	Litres per minute	L/min
Degree	°	Litres per second	L/s
Degrees Celsius	°C	Megahertz	MHz
Gram	g	Megajoules per litre	MJ/L
Grams per cubic centimetre	g/cm^3	Megapascal	MPa
Grams per kilowatt hour	g/kWh	Megavolt-ampere	MVA
Grams per litre	g/L	Megawatt	MW
Grams per tonne	g/t	Megawatt hour	MWh
Greater than	>	Metre	m
Hectare	ha	Metres per day	m/d
Hertz	Hz	Metres per minute	m/min
Horsepower	hp	Metres per second	m/s
Hour	h	Metric tonne	t
Hours per day	h/d	Micrometre (micron)	µ
Hours per year	h/a	Milligrams per litre	mg/L
Kilogram	kg	Millimetre	mm
Kilograms per cubic metre	kg/m^3	Million years	Ma
Kilograms per hour	kg/h	Minute	min
Kilograms per tonne	kg/t	Month	mo
Kilograms per year	kg/a	Parts per million	ppm
Kilojoule	kJ	Percent	%

Plus or minus	±	Revolutions per minute	rpm
Second	s	U.S. dollar	US$
Square kilometre	km^2	Volt	V
Tonne	t	Water gauge	w.g.
Tonnes per cubic metre	t/m^3	Watt	W
Tonnes per day	t/d	Week	wk
Tonnes per hour	t/h	Year (annum)	a
Tonnes per year	t/a		