MINE SITE RECLAMATION GUIDELINES
FOR THE NORTHWEST TERRITORIES

Indian and Northern Affairs Canada
Yellowknife, NWT

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Preface

In the early 1980's, the Northwest Territories Water Board and the Department of Indian Affairs and Northern Development (INAC) began to include a condition that an Abandonment and Restoration Plan be prepared and submitted for approval as a requirement of water licenses and land leases. In 1990, the Technical Advisory Committee (TAC) of the Water Board in conjunction with staff of the INAC Land Resources Division drafted the *Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories*, 1990.

In 2002, the Department issued the *Mine Site Reclamation Policy for the Northwest Territories*, which lays the policy foundation for the protection of the environment and the disposition of liability related to mine closure in the Northwest Territories. The Policy serves four main objectives:

- Ensure the impact of mining on the environment and human health and safety is minimized.
- Reduce the environmental liability that falls to government to the greatest extent possible.
- Provide industry and the public with a clear signal of the government's expectations.
- Build positive and supportive relationships with the new regulatory authorities coming into operation in the North.

These Guidelines update and expand on reclamation processes and procedures introduced in the 1990 *Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories* and are intended to compliment the *Mine Site Reclamation Policy for the Northwest Territories, 2002*. They were developed in consultation with Aboriginal community members, scientific experts, mine representatives, regulatory authorities, and other affected parties. Consultation took the form of work-out sessions, technical meetings, one-on-one interviews, and written comments.

The political and legislative environment in the North is in a period of unprecedented change. If these Guidelines are to keep pace with the shifting operational environment, and political, legislative and technological developments, they must be a living document or they will lose their currency and effectiveness. To this end, Indian and Northern Affairs Canada (INAC), NWT region, will update these Guidelines annually by means of external and internal reviews and/or work-out sessions. A new updated version will be available in January of each New Year.

Acknowledgements

Many thanks are extended to the numerous individuals that provided valuable input required to produce these Mine Site Reclamation Guidelines for the Northwest Territories.

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1.0 INTRODUCTION

These Mine Site Closure and Reclamation Guidelines for the Northwest Territories are intended to provide guidance on how to develop, operate, and close mine sites in a manner that promotes effective reclamation. The guidelines build on the principles and objectives laid out in the Mine Site Reclamation Policy for the Northwest Territories (INAC, 2002) and principles adopted and adhered to by the federal government and industry, within the existing regulatory framework in the Northwest Territories. They do not repeat the principles and goals outlined in the Mine Site Reclamation Policy, but the same principles and goals apply. For example; land, water, wildlife and the land-based economy essential to the way of life and well-being of the inhabitants and users of the area must be protected and respected, the use of holistic and ecosystem-based approaches for reclamation and reclamation planning must be facilitated, and effective participation of local communities and the general public in achieving objectives must be facilitated. Key principles to bear in mind when planning for closure include: fully considering both traditional knowledge and other scientific information, to apply adaptive management principles making use of the best available information and technology, to promote environmental protection, and to apply the precautionary principle in the absence of conclusive information. These guidelines should be considered as one component of the overall resource management framework for mining activities in northern Canada.

Regulatory requirements typically include the submission of a Closure and Reclamation Plan for public review and approval by regulatory authorities. The requirement might take the form of an inclusion in the Terms of Reference for Environmental Assessment of a new project, a condition of a Water License, Land Lease and/or Land Use Permit for an existing project, and may also be a requirement of contractual agreements, such as an Environmental Agreement.

Enforcement of regulatory provisions related to mine site reclamation exists under various regulatory regimes including the *Territorial Lands Act* and its regulations, the *Northwest Territories Waters Act* and its regulations, *Arctic Waters Pollution Prevention Act*, and the *Mackenzie Valley Resource Management Act* and its regulations. Other applicable territorial acts and regulations are listed at the end of this document.

These guidelines are intended to assist and inform Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties as they develop Closure and Reclamation Plans, formulate regulatory terms and conditions, prepare interventions and review reports and/or documents related to mine closure and reclamation.

There may be additional considerations for mining ventures such as coal and uranium that are not fully addressed in these guidelines. For example, the Territorial Coal Regulations pursuant to the *Territorial Lands Act* should be consulted for coal ventures and reclamation of uranium mines in Canada falls under the jurisdiction of the Canadian

Nuclear Safety Commission (CNSC) pursuant to the *Nuclear Safety and Control Act (NSCA*) and regulations.

This section of the guidelines, Part 1, describes the primary concepts and general information that applies to the reclamation of all mine sites in the Northwest Territories. It provides information on the Closure and Reclamation Plan, summarizing what should be considered in a Closure and Reclamation Plan and how considerations change during each stage of mine development. Part 2 of these guidelines offers advice on the technical aspects of closing and reclaiming mine sites.

1.1 CLOSURE AND RECLAMATION PLAN

The Mine Closure and Reclamation Plan (CRP) is a document, prepared by the mine proponent, that contains and describes all of the studies and plans related to closure and reclamation of the mine site and all of the related mine facilities (a sample CRP Table of Contents is included in Appendix A). The CRP should address the physical stability, chemical stability and future land use for each component of the mine. Also, the CRP should present a list of alternatives and rationale for selecting the preferred reclamation activities; long term local community values, among other items, are to be considered.

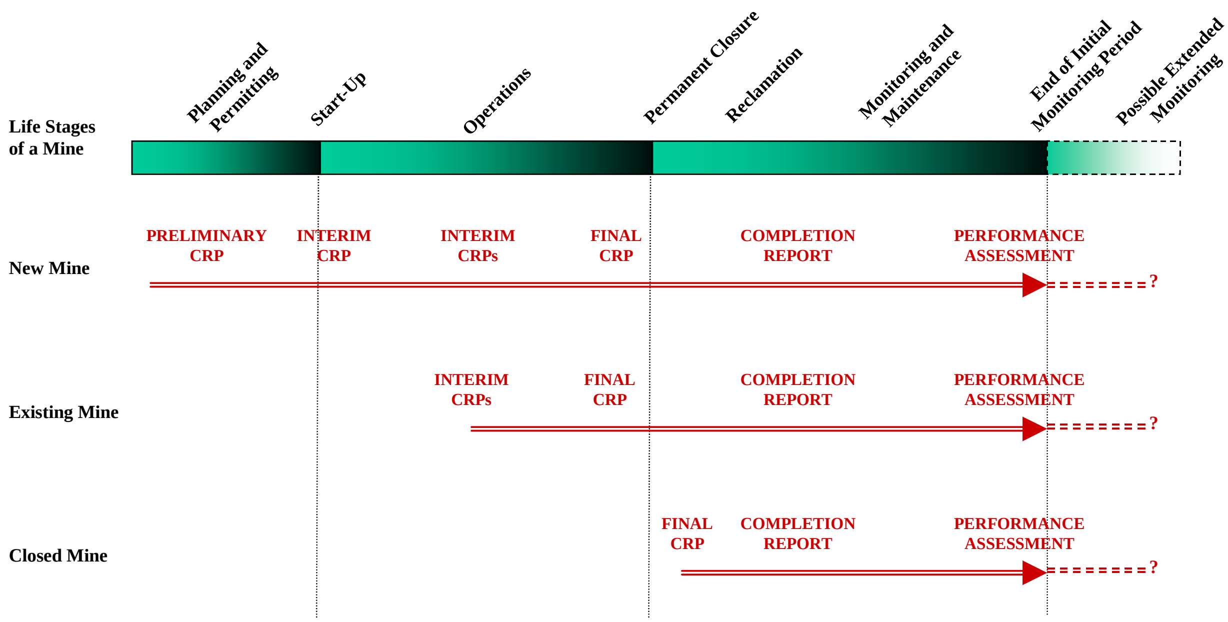
There are three primary stages of development of a CRP:

1. Preliminary CRP
2. Interim CRP(s)
3. Final CRP

In addition, there are two other documents that are of importance to the reclamation process that are prepared by the mine proponent after the delivery of the Final CRP. The Reclamation Completion Report documents the reclamation work completed, and the Performance Assessment Report compares the objectives planned against the objectives actually performed.

These stages of reclamation reporting are illustrated on Figure 3.1 as an example of how they might relate to progressive stages of the mine operating life.

Figure 3.2. Stages of Closure and Reclamation Planning Through Life of the Mine



Preliminary CRP

A Preliminary CRP is typically prepared in conjunction with initial mine planning and permitting. This often relates to the Environmental Assessment of a project. This is prior to the actual construction of the mine site and is, therefore, based to some degree on assumed future conditions. Community participation should be an important aspect of the plan.

The general purpose of the Preliminary CRP is to demonstrate how the mine site is proposed to be reclaimed and to describe the likely residual risks to human health and the environment.

To be effective, the Preliminary CRP should place emphasis on:

- Statements of reclamation objectives for the general site and major mine components
- Realistic descriptions of activities related to temporary or indefinite closure
- Conceptual descriptions and assessments of possible reclamation activities
- Initiate a reclamation research plan to flesh out suitable reclamation activities and to help form a northern information data base (include quality assurance and quality control procedures, management for engineering plans and drawings, baseline studies, aboriginal involvement strategies, accounts of new or evolving reclamation technologies, reviews of similar case studies, and other appropriate research or study plans)

- Credible evidence that the stated reclamation objectives can be achieved through the described activities
- Photographs depicting what the site looked like before operations began
- Identify any likely post-closure monitoring requirements and responsibilities for the described activities
- Conceptual projections of the likely post-reclamation risks to human and wildlife health and the environment (Risk Assessment)
- Reclamation liability costs and financial security estimates to a level of detail relevant to the information available

Interim CRP(s)

One or more Interim CRPs are typically prepared through the operating life of the mine. The first Interim CRP is generally a requirement of the initial regulatory approval of the project. Interim CRPs are generally prepared on a regularly scheduled basis, when there is a significant change to the mine plan, or according to key milestones in the mine life. The schedule is often specified in various regulatory approvals and/or in Environmental Agreements. Regardless, Interim CRPs are recommended to be updated within a timeframe that does not exceed 5 years, and more frequently for mines that are expected to have a shorter life. Updates based on reclamation research and planning activities should be prepared on a more frequent basis (e.g. annually).

The general purpose of the Interim CRP is to update preceding plans according to the current mine operating plan, updated or renewed community values, or advances in mine reclamation technology. Interim Reclamation Plans provide conceptual detail on the reclamation of mine components which will not be closed until near the end of the mining operations, and operational detail for components which are to be progressively reclaimed earlier in the mine life. The Interim CRP should include increased detail and more specific closure criteria regarding reclamation components as these become available and as those areas of the mine are developed (e.g. rock piles that are completed or reclamation test studies that have been conducted).

To be effective, the Interim CRP should place emphasis on:

- Renewed or updated statements of reclamation objectives
- Reclamation and progressive reclamation schedule
- Detailed descriptions of activities related to temporary or indefinite closure
- Detailed descriptions of contingency plans
- Renewed or updated descriptions of possible reclamation activities to a level of detail relevant to the information available (the level of detail should increase through the mine life due to new information)
- Updated reclamation research plan
- Increasingly convincing evidence that the reclamation objectives can be achieved by the described activities
- Updated photographs depicting what the site looks like during operations
- Detailed report on progressive reclamation activities

- Site specific closure criteria
- Updated post-closure monitoring requirements and responsibilities
- Renewed or updated descriptions of the likely post-reclamation risks to human and wildlife health and the environment relevant to the information available (Risk Assessments)
- Updated reclamation liability costs and financial security estimates to a level of detail relevant to the information available

Final CRP

The Final CRP should be prepared and approved before a scheduled permanent closure or immediately after an unplanned closure and provide detailed descriptions of the proposed reclamation activities. The general purpose of the Final CRP is to provide complete details, usually for regulatory approval, regarding the proposed reclamation activities such that they can be subsequently implemented. For large, multi-year projects, the Final CRP itself may include a schedule for updates to the plan while the work is being implemented.

To be effective, the Final CRP should place emphasis on:

- Final statements of reclamation objectives
- Closure criteria
- Detailed descriptions of possible reclamation activities to a “detailed engineering” or “issued for construction” level of detail
- Detailed descriptions and assessments of possible contingency plans
- Updated reclamation schedule
- Long-term information management in connection with post-closure activities
- Updated photographs depicting what the site looks like during closure
- Detailed post-closure monitoring and care and maintenance programs and responsibilities
- Detailed descriptions of the projected post-reclamation risks to human and wildlife health and the environment (Risk Assessment)
- Detailed reclamation costs and financial security estimates based on achieving approved reclamation criteria and objectives

Reclamation Completion Report

A Reclamation Completion Report is prepared upon completion of all of the reclamation activities or after completion of the primary reclamation activities in cases where some minor work continues. This report is similar in concept to an “as-built” construction report.

The general purpose of the Reclamation Completion Report is to provide details of the actual reclamation work completed, including progressive reclamation work completed over the term of the mining operations, with comparison to the plan presented in the Final CRP. This facilitates future assessment, maintenance and, if necessary, repair work.

To be effective, the Reclamation Completion Report place emphasis on:

- Engineered "as-built" reports
- Comparison of actual work conducted versus planned work for each reclamation component
- Updated photographs depicting what the site looks like after reclamation
- Environmental monitoring and mitigation plans and schedules
- Updated detailed reclamation cost liability and financial security estimates

Performance Assessment Report

A Performance Assessment Report is prepared at the end of the initial monitoring period. This is typically a number of years following completion of the primary reclamation work at a time when environmental conditions were initially projected to demonstrate that all, or the primary, reclamation objectives have been achieved. At this time the closure criteria, and any ongoing residual and/or environmental risks are re-assessed and the monitoring and maintenance plan is updated.

The general purpose of the Performance Assessment Report is to provide a detailed comparison of conditions at the site against the reclamation objectives and closure criteria. In some cases where the reclamation objectives and closure criteria have not been fully achieved or where this remains uncertain, there may be need to carry out an extended monitoring and maintenance program.

To be effective, the Performance Assessment Report should place emphasis on:

- Environmental conditions
- Human and wildlife health and safety conditions
- Updated photographs of the site
- Description of community participation in site monitoring and maintenance activities and management
- Updated assessment of residual risk to human and wildlife health and the environment
- Detailed comparison of current conditions with objectives and closure criteria for each reclamation component
- Detailed descriptions of monitoring, maintenance and contingency activities since completion of the reclamation work (since preparation of the Reclamation Performance Report)
- Proposed extended monitoring program, if appropriate
- Updated reclamation cost liability and financial security estimates

1.2 KEY CONCEPTS

There are several key concepts for preparation of an effective CRP:

- Design for Closure and Reclamation
- Follow an “objectives-based” approach that starts with clear statements of objectives and, based on the objectives, develop closure criteria
- Build consensus with Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties throughout the entire life of the project

DESIGN FOR CLOSURE AND RECLAMATION

Preparing an acceptable mine closure and reclamation plan prior to the development of a mine is part of *designing for closure and reclamation*. This concept requires proponents to look into the future and attempt to identify processes and forces that may act upon the mine components after mine closure and reclamation and to factor these processes and outcomes into the design and operation of any mine. The goal should be to minimize long-term care and maintenance and to eliminate perpetual care requirements. The operator must design, operate, close, and reclaim the mine so that the risk of negative impacts on the environment, wildlife, and humans is minimized or eliminated. Where deterioration of some residual mine components is inevitable, the operator should identify and plan for the required maintenance. There should be no ongoing intervention or operating activities, other than periodic inspections and minimal maintenance, after the mine has been reclaimed. Designing for a ‘walk-away’ scenario with minimal maintenance is particularly important in the NWT due to typical isolation of mine sites, and high transportation costs.

Designing for closure and reclamation consists of the following six objectives:

1. Mine components are designed and constructed in such a way that they achieve or can readily be modified to achieve the reclamation objectives and closure criteria
2. Reclamation costs are to be determined as part of the closure planning and these costs should be supported by the mining operation (the mine owner must provide adequate security to cover the cost of reclamation over the life of the mine to ensure the closure criteria can be met)
3. Reclamation planning should interact regularly with planning for the development and operation of the mine to ensure that mine operating activities do not unnecessarily increase the workload for reclamation or effectively compromise what might otherwise be promising reclamation activities
4. Reclamation activities are incorporated into the design
5. Progressive reclamation activities are incorporated into the operation of the mine
6. There should be co-ordination among Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties to ensure that the development of appropriate objectives, closure criteria, and activities are acceptable

OBJECTIVES-BASED APPROACH

Reclamation objectives and closure criteria are the foundations of an effective reclamation effort. These concepts can be used to provide the basis for:

- The general approach to reclamation of the site
- The evaluation and selection of reclamation activities
- Evaluating the success of reclamation activities
- Determining costs and financial security, through all of the above

Global Objectives

Global objectives are overarching objectives that will apply to all mine sites, regardless of the mine type or location. There are more site specific objectives that might only apply to certain mine components or mine sites (described in Section 2.0). Global objectives take into consideration the physical stability, chemical stability, and future use and aesthetics at the site after closure. These three broad categories are described in the following.

Physical Stability

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

Chemical Stability

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

Future Use and Aesthetics

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

- Naturally occurring bio-physical conditions, including any physical hazards of the area (pre- and post development)
- Characteristics of the surrounding landscape pre- and post- development (air photo documentation before, during, and after development is suggested)
- Level of ecological productivity and diversity prior to mine development and intended level of ecological productivity and diversity for post-mine closure
- Local community values and culturally significant or unique attributes of the land
- Level and scale of environmental impact
- Land use of surrounding areas, including the proximity to protected areas, prior to mine development and expected end land use activity for each area on site for humans and wildlife

Closure Criteria

Some component specific objectives may require an added level of detail to set precise measures of when the objective has been satisfied. These performance measures can be termed closure criteria. Criteria should be discussed at the onset of project development, and established where possible with input from Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties. Note that closure criteria may evolve as more information is gathered on-site (e.g. through reclamation research initiatives and Risk Assessments).

Some federal guidelines such as the Canadian Council for Ministers of the Environment (CCME), Metal Mining Effluent Regulations (MMER), or the Canadian Dam Association (CDA) have some general standards that should be considered when developing mine specific criteria.

BUILD CONSENSUS

The active participation of Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties in the development of the Initial, Interim, and Final CRP is very important to the effectiveness of the plan. While achieving consensus is desirable, it is realized that this may not be possible in all cases. It is important that at a minimum, all views and opinions of the parties involved are clearly and accurately documented and considered in the decision making process, whether consensus is achieved or not. The definition of long term objectives for protection of human health, wildlife, the environment and future land use should respect the values of those people who will be active in the area after reclamation is completed.

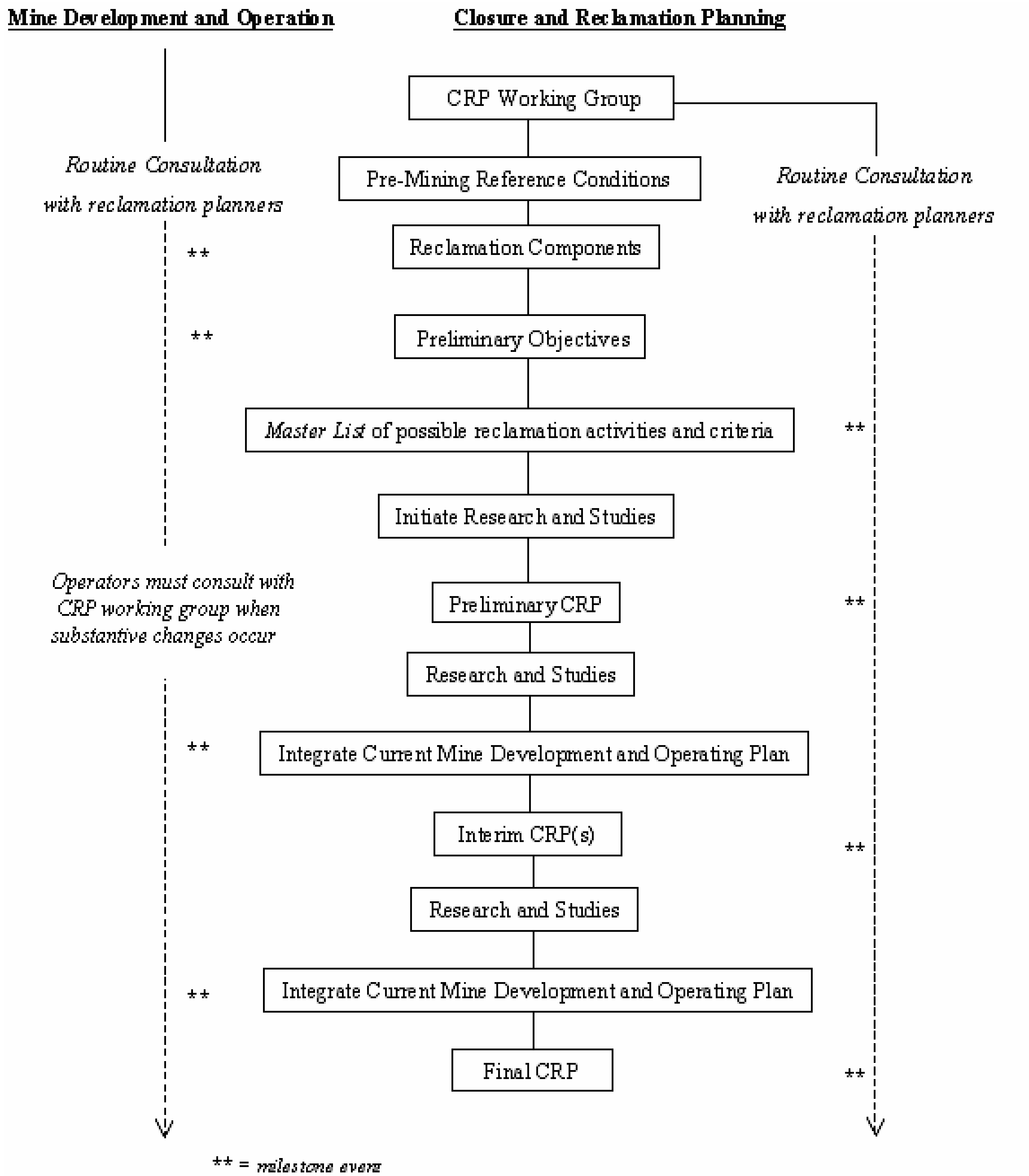
The specific approach for building consensus should be tailored to each project and each local community. For example, there are organizations, regulatory authorities and aboriginal organizations that have traditional knowledge policies and guidelines that should be adhered to. Translation may be required to facilitate effective communication with all working group members. There are several approaches that have been successfully undertaken in recent years that can provide some initial guidance:

- Form reclamation working groups and meet regularly with representatives of appropriate Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties to present information and solicit input
- Interview elders, local community members, and land users (e.g. to discuss current and future land use scenarios)
- Take care to talk to an assortment of community members such as Chiefs, elders, elected leaders, fishers/hunters, and youth for a fitting amount of time for the project or topic of interest; include both women and men to get a broad view of community view points and concerns
- Employ local residents to conduct reclamation activities and carry out monitoring requirements.

Note that an effort is needed by communicators to understand the models that individuals construct about how contamination occurs, and from this, determine how communication and management strategies should be employed. For example, some reclamation recommendations made by local communities may not align with scientists ideas of best practices. In these cases, the pathways and models that exist for both groups should be examined carefully – and communication efforts should respectfully build on existing perceptions that exist about how contamination happens. Figure 3.2 illustrates an example of a general process for reclamation planning.

Regardless of any unique aspects of an individual project, the reclamation planning process should capture each of the key concepts for a CRP. For example, the process illustrated in Figure 3.2 provides for the formation of a CRP working group with representatives of Aboriginal, Federal and Territorial governments; land owners; local communities; regulatory authorities; mining proponents; and other affected parties as the initial step of the process. This working group would carry through the entire reclamation planning process to provide guidance and consultation to the reclamation planners.

Figure 3.2. Example General Process for Reclamation Planning



1.3 TERMINOLOGY

It is important that the key words used in the CRP are well defined. Terms can sometimes lead to inadvertent miscommunications if not defined effectively because various parties may understand the terms differently. The CRP should be prepared using non-technical language wherever possible. Where technical language is unavoidable, these terms should also be defined. Translations of terms into appropriate Aboriginal language(s) should be included in the CRP or communicated wherever possible. A list of terms commonly used in CRPs that should be clearly defined includes:

- Closure
- Closure Criteria
- Objectives
- Progressive Reclamation
- Reclamation
- Remediation
- Restoration
- Rehabilitation
- Temporary Closure
- Traditional Knowledge

Suggested definitions for these terms and other reclamation-related terms are presented in the glossary of these guidelines.

1.4 TEMPORARY MINE CLOSURE

Temporary mine closure refers to the scenario where a mine ceases operations with the intent to resume mining activities in the future. Closures can last for a period of weeks, or for several years, based on economical, environmental, and social factors.

Temporary closure activities must maintain all operating facilities necessary to protect humans, wildlife, and the environment. The following measures should be implemented or completed upon temporary mine closure:

- Access to the site, buildings, and all other structures must be secured and restricted to authorized personnel only
- All mine openings must be guarded or blocked and warning signs must be posted
- All physical, chemical and biological treatment and monitoring programs must continue according to licenses, permits, and leases in order to maintain compliance
- All waste management systems must be secured
- An inventory of chemicals and reagents, petroleum products, and other hazardous materials must be conducted and secured appropriately or removed if required
- Fluid levels in all fuel tanks must be recorded and monitored regularly for leaks or removed from the site

- All explosives must be relocated to the main powder magazine and secured, disposed of, or removed from the site
- All waste rock piles, ore stockpiles, tailings, mine water and other impoundment structures must be stable and maintained in an appropriate manner (including regular geotechnical inspections)
- Drainage ditches and spillways must be inspected and maintained regularly (e.g. seasonally depending on snow and ice accumulation and melting) during the closure period and included as part of geotechnical inspections
- Facilities and infrastructure must be inspected regularly
- The reclamation security deposit must be kept up to date

Care and Maintenance staff should be present at the site and sufficient in number and expertise to care for the site and any potential problems that may arise. Sufficient equipment and supplies/reagents should be left on site for any maintenance or reclamation activities that may need to take place.

Compliance with all applicable federal and territorial laws and regulations, in addition to the operator's Land Use Permits, Land Leases and Water Licenses, must also be ensured.

1.5 CONSIDERATIONS FOR NORTHERN MINES

Reclamation planning may vary for northern sites compared with sites in temperate climates. Design, construction and schedules for mine operation and reclamation may be affected by the location, terrain, and climate of the given site. Also, special considerations for climate change, northern environmental conditions, community needs, and permafrost may be required.

LOCATION

Northern mines are often located in remote areas with restricted accessibility; limited road access or seasonal access. Boat or barge access may be available for coastal projects, while other operations may be restricted to light aircraft and/or winter roads.

There are few large centers or communities across the Northwest Territories. It is not unusual for a mine to be located several hundred kilometres away from the nearest center. The site location will often dictate the project's feasibility, and the potential high costs associated with reclamation need to be considered when planning for closure.

TERRAIN

The geologic and geographic setting varies greatly across the Northwest Territories and may govern the degree of natural resources that are available for reclamation purposes. For example, much of the Precambrian Shield that dominates parts of NWT has only a veneer of soil cover, generally less than two metres. Consequently, construction materials suitable for reclamation activities may not be readily available onsite or may be difficult to obtain. The supply will also be limited in permafrost regions.

Topography and local surface conditions may also dictate the accessibility of a site. Mountainous regions can limit site access and potential seismic activity may also require additional planning considerations. The degree of vegetation, boulder, and water cover at a given site are other factors to consider in reclamation planning.

CLIMATE

The climate in the Northwest Territories is characterized by long dark cold winters and short warm summers with extended hours of daylight. Lakes and rivers remain frozen for most of the year and the annual total precipitation is generally low. When temperatures rise, snowmelt is added to the spring freshet in a relatively short period and can result in rapid erosion.

Climatic factors can also limit the site's accessibility, thus affecting reclamation activities or schedules. Periods of ice freeze and thaw may limit accessibility where operations utilize open lakes for aircraft landing in the summer and frozen ground and water for airstrips and roadways in the winter. Harsh weather conditions such as extreme cold, fog, and storms may also dictate site accessibility.

CLIMATE CHANGE

Proponents should consider the possible effects of climatic change at northern sites. The long-term effects of climate change on the annual temperature range, total precipitation, seasonal variation, peak precipitation events, evaporation, permafrost, and hydraulic routing are difficult to predict. Consequently, where mine components have a medium or high potential for environmental impact if failure occurs, it is necessary to select design parameters, which are based on conservative interpretation of historic records and with consideration for the changes that may occur in the future.

Climatic changes may lead to permafrost degradation and the melting of frozen-cored structures; may instigate natural disasters such as flooding, landslides, or increased seismic activity; and may alter wildlife habitats and migration routes.

ENVIRONMENTAL CONDITIONS

It is generally accepted that northern lakes are relatively pristine and are sensitive to minor environmental changes, such as a change in the lake-water chemistry. The effects of water body reactions from environmental changes are not fully understood at this point in time. During development and operation at a mine site, a data base can be developed to better understand local conditions required for effective reclamation. Water is an extremely important element in Aboriginal culture – it must be protected.

Reclamation and mining activities may affect wildlife and plant life by altering habitats and through contamination from mine-related process reagents. There is a strong dependency and cultural respect for wildlife and plant life in the north. Humans rely on these animals and plants for their traditional lifestyles and survival, and changes that impact plants and animals could potentially impact traditional lifestyles. The health and well-being of caribou in particular is of great importance to Aboriginal culture. One ritual known as "paying the land" reflects one way that Dene people acknowledge their relationship to the land and ask respectfully for safe passage through that land. By leaving something on the land, an elder asks for the safe passage of people and animals in that region. It is important to note that they are also asking for safe passage of animals, not simply for humans. It involves knowing how to approach the land or animals before taking something from there, and may involve talking to the animals or the land to tell them about what is being done. Paying the land can be done with a variety of objects, including a branch, or tobacco.

PERMAFROST

Permafrost is defined as ground that remains at or below 0°C for a minimum of two consecutive years. It may consist of bedrock, unconsolidated sediments (gravel, sand, silt or clay), organic materials (peat), and ice.

The presence of permafrost at a mine site requires additional considerations with respect to project planning and reclamation. It is therefore important to understand what permafrost is, where it is likely to occur, and how it can affect mining structures and reclamation activities. Permafrost is present throughout Canada and can be classified by zones that represent varying degrees of permafrost coverage. Sources of additional literature and permafrost maps are included in the Additional Resources section of this guideline.

PART TWO: CLOSURE AND RECLAMATION OF MINE SITES

2.0 INTRODUCTION

This section of the guideline provides a summary of common reclamation items that should be considered in reclamation planning. Section 2.1 to 2.4 is organized under typical overarching mine reclamation issues. Section 2.5 to 2.12 is organized under individual mine components. Each section addresses the issue/component-specific: objectives, pre-mining planning options, progressive and post-closure reclamation options, northern considerations, and post-closure monitoring. Each of these items is described below.

Objectives: Objectives describe what the reclamation activities, specific to the mine component, are aiming to achieve. Note that component specific objectives may not be uniform across a given site. For example, access may be limited or prevented for one area but promoted or encouraged for another area depending on the selected end-use target. Additional objectives may be considered based on local community desires or site-specific considerations. These component specific objectives should lead to the development of closure criteria for that component. Global objectives; objectives that apply to all mine sites, are described in Section 1.2.

Pre-mining Planning Options: Pre-mining planning options are actions that can be taken at the planning stages of mine development (before mining begins), to minimize the overall impact on the site and to ensure a design for closure.

Progressive and Post-Closure Reclamation Options: Progressive reclamation options are actions that can be taken during mining operations before permanent closure (to take advantage of cost and operating efficiencies by using the resources available from mine operations), to reduce the overall reclamation costs. Progressive reclamation enhances environmental protection and shortens the timeframe for achieving the reclamation objectives and goals, and reduces the financial security requirement. Post-closure reclamation options are actions that can be taken once mining operations have ceased indefinitely. Reclamation options should utilize the best available technology suitable to the site for each of the mine components.

Northern Considerations: This section describes some of the unknowns, or additional aspects related to reclaiming specific mine components unique to the north that should be thought-out during reclamation planning.

Post-Closure Monitoring: Post-closure monitoring describes actions that may be required to confirm that the reclamation objectives have been met once operations cease indefinitely. If it is determined that mine components failed to meet their objectives (as shown through the closure criteria not being met) maintenance measures and contingency plans will need to be activated and implemented. Where a catastrophic event or natural disaster occurs, additional monitoring and maintenance may be necessary. Consideration should be given to establishing monitoring programs with involvement from local communities.

All mines are unique and each has with it project-specific challenges and issues that may arise during its operation. Proponents of mining operations must be prepared to plan for site-specific needs, and are cautioned not to consider only those items that are presented in this document. The information provided in this section is not exhaustive; however, the intent is to provide some guidance on how to effectively reclaim a mine site. Additional resources at the end of this document provide further guidance for reclamation planning.

2.1 ACID ROCK DRAINAGE AND METAL LEACHING

At mine sites, natural weathering rates are typically accelerated by increasing the surface area of rock exposed to water and oxygen as a result of ground disturbance. Essentially, the disturbed rock is exposed to differing environmental conditions. This can result in Acid Rock Drainage (ARD) and/or Metal Leaching (ML) and the release of contaminants to the environment. ARD is a general term applied to any acidic leachate, seepage, or drainage arising from the weathering of undisturbed or excavated geological materials containing sulphide minerals or their weathering products. Weathering reactions can also increase the solubility of elements in rocks and soil, and lead to increased metal leaching. ML means the mobilization of metals into solution from rocks and soil under neutral, acidic, or alkaline conditions.

ARD and ML potential of the pit walls, tailings, over burden material, and other mine-related materials must be considered in order that appropriate water management plans can be developed. For example, permanently exposed (un-flooded) highwalls may act as a steady source of contaminants to the pit floor or pond. Flooding of pit walls or stored materials such as tailings that have been exposed for a period of time may facilitate release of stored oxidation or weathered products. Understanding the potential of ARD and ML in the early stages of the mine life will assist planners when designing for closure.

Objectives

- Develop and implement preventive and control strategies to effectively minimize the potential for ARD and ML to occur
- Where ARD and ML are occurring as a result of mine activities, mitigate and minimize impacts to the environment
- No reliance on long- term treatment as a management tool (e.g. effluent treatment facilities are not appropriate for final reclamation, but may be used as a progressive reclamation tool)
- Minimal maintenance required in the long-term

Pre-mining Planning Options

- Develop plans for impact prevention, operational material characterization, material handling, waste disposal, site reclamation, water management, monitoring and maintenance
- Methods to prevent ARD/ML may include:
  - Limit oxygen (e.g. water covers, dry covers, saturation)
  - Chemical intervention (e.g. coat/spray to limit sulfide exposure, bactericides to reduce catalyzed oxidation reactions, blend/layer materials to increase the distribution of buffering minerals, use alkaline additives)
  - Isolation of deleterious materials (e.g. segregate materials for controlled disposal or cellular pile construction, backfill waste rock or tailings into the underground workings or exhausted pit, encourage cold temperatures and/or permafrost to reduce reaction rates)
  - Dry stack filtered tailings or storing paste tailings on the surface
- Physical control measures used to manage a chemical problem should be designed to reduce the extent of the chemical risk
- Ensure comprehensive geochemical characterization analyses to determine potential for ARD and/or ML
- Run static and kinetic ARD/ML prediction tests (e.g. acid base accounting, laboratory testing with humidity cells and columns, field testing with cells and piles)
- Consider design and construction of covers and diversion works to minimize water infiltrations and runoff, and/or oxygen supply
- Modify mining and mineral processing (e.g. avoid or do not open pit mine high sulfide ores, use gravity/floatation instead of cyanidation for extraction)

Progressive and Post-Closure Reclamation Options

- Flood underground mine workings by plugging adits if permafrost conditions are not present and if a hydraulically competent plug can be installed
- Control acid water at the source, prevent contaminated water flows, and allow contaminated water to be collected and treated (this would be incorporated into the water management system)
- Divert or intercept surface and groundwater from ARD source
- Install covers and seals to prevent or reduce infiltration
- Induce or maintain freezing conditions to limit the formation and discharge of leachate
- Place acid generating materials in topographic lows or depressions where they are most likely to be submerged under water under natural conditions
- Mitigate consequences of ARD by the use of passive and active treatment systems, as appropriate for in-situ conditions
- Passive treatment measures include:
  - Chemical (alkali trenches, attenuation along flow path)
  - Biological (sulphate reduction, wetlands, metal uptake in plants)
  - Physical (physical removal-filtration by plants, attenuation)
- Active treatment measures may include:

- Chemical (Lime neutralization, Sorptive processes)
- Biological (Sulphate reduction)
- Physical (Solid/liquid separation)

Northern Limitations and Considerations

- There is limited long-term experience with ARD/ML mitigation measures in Arctic environments, however, there is a large body of knowledge on best management practices and technologies to draw upon
- Reaction rates are often slower due to the colder temperatures, such that the onset of acidic conditions can be delayed and feedback on the success of attempted mitigation measures is longer
- Cold temperature tend to slow the weathering processes, but may result in a large seasonal flush of contaminants at spring melt, and the potential for increased runoff from waste rock piles after closure, as precipitation no longer freezes into the expanding voids
- Extended daylight during the summer months enhances the active layer process
- There is increased oxygen solubility with decreasing temperatures
- Reactions are dependent on the movement of water, which may mean minimum amounts of contaminated water to deal with given the minimal precipitation and freezing conditions in the north
- Once ARD/ML is being generated in the Arctic, there tends to be a serious environmental impact because much of the Arctic is pristine, and many lakes display low background nutrient and metal levels
- Limited cost effective mitigation and treatment options are available, given the distances and transport costs
- Aspects of ARD/ML prediction, prevention, control and mitigation methods unique to the northern Canadian environment include:
    - Effect of unfrozen water in tailings as a transport mechanism
    - Effect of freezing point depression by process reagents
    - Use of covers in permafrost zones
    - Reaction rates or incomplete oxidation reactions of stored materials under cold climatic condition
    - Scale-up of standard laboratory test methods to predict performance under cold climatic conditions
    - Effects of cold climates on the efficiency of in-situ treatments such as lime addition and passive wetland treatment

Post-Closure Monitoring

- Inspect physical stability of the mine site to confirm that no erosion, slumping or subsidence that may expose potentially ARD/ML material to air and water are occurring
- Inspect any preventative and control measures (e.g. covers) to confirm that they minimize water and/or air exposure
- In the case of water covers, ensure that there is sufficient water supplied to maintain an appropriate water depth

- Confirm that the predicted water quality and quantity of chemical reactions is occurring
- Develop monitoring locations and frequency on a site by site basis, incorporating locations where possible contaminated drainage may be generated, and where drainage may be released to the water management system or to the environment (also include downstream/down gradient locations)

2.2 REVEGETATION

Revegetation of all areas affected by mining activities should be considered. This may involve the establishment of media to support vegetation growth.

Objectives

- Re-establish the pre-mining ground cover, which may involve encouraging self-sustainable indigenous vegetation growth
- Provide wildlife habitat where appropriate and feasible
- Assist with providing physical stability of mine components

Pre-mining Planning Options

- Determine baseline ecological conditions prior to disturbance
- Determine affinity for indigenous plants to uptake metals, determine if these metals are bioavailable and if they have synergetic/antagonistic effects
- Conduct local soil assessments to determine whether organic supplements should be used (e.g. peat, biosolids)
- Include native plant collection and propagation methods, successional processes, and final plant communities that provide biodiversity and sustainability to reclaimed sites in the research plan
- Conduct studies to characterize the local climate, temperature, precipitation, and wind as they relate to plant growth
- Strip and stockpile organic and fine-grained soils from disturbed areas, such as open pits, waste rock piles, infrastructure and tailings facility footprints, consistent with the need to maintain permafrost and use during progressive reclamation

Progressive and Post-Closure Reclamation Options

- Begin revegetation efforts as soon as possible for mine site areas/components (progressively reclaim)
- Contour, scarify, and seed area using native seed mixes to establish vegetative cover
- Apply gravel barriers or other underlying cover systems where desired to control or limit the upward movement of acidic pore water or heavy metals that may inhibit plant growth or for moisture retention near the surface
- Apply stripped/stockpiled soil or growth medium to a depth sufficient to maintain root growth and nutrient requirements
- Incorporate organic materials, mulches, fertilizers, or other amendments based upon local soil assessment

- Establish appropriate temporary or permanent wind breaks where necessary to establish vegetation
- Transplant vegetation that would otherwise be lost to mine disturbance where feasible
- Select indigenous vegetation for reclaimed sites that has a low potential for metal accumulation
- Re-vegetate with indigenous vegetation not used by wildlife or people if uptake of metals is a concern
- Place a gravel or coarse cover to discourage vegetation growth where desired

Northern Limitations and Considerations

- Revegetation success may be limited due to northern climatic conditions including mean daily temperature, frost free period, growing season, amount and timing of precipitation and the prevailing wind
- There may be a lack of viable/suitable soil and seed sources
- Information resources on revegetation of mine sites in the north (e.g. species, seed collection and availability, and soil development) may not be as readily available as southern sites
- It is important to reestablish the sites' indigenous species because there is a high reliance on the native vegetation by humans and wildlife as a food source

Post Closure Monitoring

- Inspect re-vegetated areas periodically following initial planting until vegetation is successfully established and self-sustaining in accordance with the agreed criteria
- Conduct soil analysis for nutrients and pH until the vegetation is successfully established and self-sustaining
- Inspect vegetated areas that may be obscuring possible cracks and other problems on dams and embankments
- Inspect for root systems that are penetrating protective covers or decaying/rotting providing tunnels for water to pass through protective covers
- Identify excessive vegetation stress or poorly established areas and implement contingency measures if required

2.3 CONTAMINATED SOILS

Contaminated soils refer to any natural media (soil, rock, sediment, or associated pore water) that may have been contaminated with controlled substances such as: fuel, fertilizer, chemicals, tailings, and ore-associated metals through accident or failure of management systems. Reclamation of contaminated snow and ice follow the same principles laid out in this section for contaminated soils.

Objectives

- Remediate any sources of contamination that may have been created during the development and operation of the mine site in order to protect humans, wildlife, and environmental health
- Prevent significant release of substances that could damage the receiving environment

- Remediate contaminated soil such that the area is compatible with future uses of the surrounding local area

Pre-mining Planning Options

- Consider environmental practices/operating procedures that eliminate or reduce the use of harmful substances or require materials less detrimental to the environment
- Minimize the volume of contaminated soil that needs remediation and prevent the spread of contaminants to surface and subsurface flow by cleaning up all spills immediately
- Identify the types of contaminants that will be present at the site (diesel fuel, heating oil, gasoline, etc.) and the types of media that will likely require treatment (soil, bedrock, groundwater, surface water, mine water, free product, ice, snow, or mixtures of these materials)
- Identify optional treatment and remediation technologies (destruction, immobilization, separation)

Progressive and Post-Closure Reclamation Options

- Excavate and remove contaminated soil and place into a designated and properly managed containment area on-site
- Treat contaminated soil in-situ (bioremediation, soil leaching, washing, etc.)
- Immobilize contaminated soil (cement solidification, lime/silicate stabilization, etc.)
- Excavate and relocate contaminated soil to approved facilities off-site

Northern Limitations and Considerations

- There may be climate challenges with respect to bioremediation of hydrocarbon contaminated soils in the north (e.g. short cool summers reduce the ability for bioremediation)
- Cold climates may reduce immobilization by freezing
- Some processes generate a large amount of heat which may cause permafrost degradation (an insulating pad constructed to reduce heat loss may be required)
- Because of the remoteness of many northern mine sites, removal of materials can be logistically difficult (expensive and seasonally dependant)

Post Closure Monitoring

- Carry out periodic inspections to investigate the quality of air, groundwater, discharge water, and water body sediment where contaminated soils have occurred
- Carry out periodic inspections to investigate thermal degradation, and physical stability where contaminated soils have occurred
- An assessment of residual contamination should be carried out to confirm the success of the remediation

2.4 PHYSICAL STABILITY

Design and analysis of mine components requires material properties such as compressive strength, shear strength, durability and hydraulic conductivity. Stability of earth and rock structures is also governed by the in situ pore water pressures and hydrogeological conditions. The geometry of earth and rock slopes is typically designed to optimize production costs. Construction methods must ensure that the structures are built according to the design requirements and will perform safely during operations.

Objectives

- Ensure physical stability of residual earth structures for environmental, human, and wildlife safety
- Physical stability of remaining earth structures is compatible with, and will not be compromised by, the post-closure land use

Pre-mining Planning Options

- Minimize the number of earth structures required at closure
- In order to improve stability in open pits, rock piles, tailings embankments, and rock cuts the following measures should be considered:
    - The presence or absence of permafrost
    - Removal of weak or unstable materials from slopes and foundations
    - Slope flattening (slope stepping results in overall slope flattening by creating intermediate berms)
    - Off-loading the crest of the slope
    - Constructing toe berms such as a free draining stabilizing counterweight at the toe of the slope or to contain stockpiles of materials having low shear strength where permafrost does not exist (toe drainage must not be impeded)
    - Drainage measures including pumping from relief wells at the toe of a slope or installation of horizontal drains
    - Biotechnical measures such as vegetation to prevent surface erosion and shallow failures

Progressive and Post-Closure Reclamation Options

- Implement construction control, including: surveys, grouting, foundation preparation, material quality control, compaction control, and instrumentation monitoring
- Conduct reclamation risk assessments for design criteria of dams, spillways, and covers
- Reclamation design criteria for dams, spillways, and covers should consider the following:
    - All stability analyses should be based upon conservative estimates of material strengths and seismic accelerations

- Stability analyses should consider angle of friction and cohesion values obtained at critical moisture contents for the materials
- The character and shear strength of all structural components including rock, soil, liners, and sub-grade soils or rock should be presented in the site characterization and baseline data of the design report and all relevant test work should be fully documented
- Stability analyses should consider all kinematically possible failure modes and solifluction should be addressed for slope stability and cover designs where frost susceptible soils are involved
- Consideration should be given to the potential for long-term changes in material strength due to weathering, frost action, degradation, seismic events and chemical changes
- Maximum runoff should be the most critical runoff (precipitation plus snow melt)
- All dams and associated structures should be designed, constructed, and maintained as stated in the procedures and requirements set out in the "Dam Safety Guidelines" published by the Canadian Dam Association
- Spillway design should include consideration of the effects of the failure of water diversion structures during the critical design events
- Where there is risk of thawing in the long term, stability should be demonstrated for frozen, thawing and fully thawed conditions

Northern Limitations and Considerations

- There is a large range of seismic conditions across the north that should be considered
- There is a large range of thermal ground conditions across the north that should be considered
- The effects of climate change could be more dramatic in permafrost regions
- Remote mine site locations and limited accessibility may be an additional consideration for designs; reliance on synthetic "man-made" materials such as geo-synthetic liners should be minimized

Post-Closure Monitoring

- A consistent monitoring record from a constant point of observation from pre-mining through to post closure should be maintained
- Inspect to ensure there are no ongoing deformations that could lead to instability, unsafe conditions or compromise the post-closure land use
- Trigger levels for monitoring and maintenance will be site-specific and consider designs and natural setting (this should be developed in the CRP)

2.5 UNDERGROUND WORKINGS

The surface expression of an underground mine typically include shafts, raises, stope surface openings, portals, adits, declines and in some cases, subsidence or other surface disturbances.

Objectives

- Minimize access to underground workings and surface openings to protect human and wildlife safety
- Maximize the stability of underground workings so that there is no surface expression of underground failure
- Prevent collapse, stress transfer and flooding of adjacent mines
- Ensure that underground workings do not become a source of contamination to the surface environment
- Minimize potential for contamination and, if required, collect and treat
- Resurface, re-slope and contour as required to blend with surrounding topography or desired end land-use targets

Pre-mining Planning Options

- Minimize number of openings to surface
- Use a mining method that results in a stable surface
- Use mining method that preserves the ground thermal regime (this is critical in areas where mining takes place adjacent to a large body of water or talik)

Progressive and Post-Closure Reclamation Options

- Seal all drill holes and other surface openings, especially those connecting the underground workings to the surface
- Backfill with benign tailings and waste rock
- Backfilling wood-lined shafts may not be acceptable because excessive settlement may occur as the wood decays
- Backfilling shafts and raises with demolition waste may not be acceptable because of the potential for hang-ups and future settlement upon collapse of the hang-up
- Secure underground shaft or vent raise openings using concrete to ensure permanent closure; wooden barricades are only suitable for temporary closure
- Secure adit openings using concrete, steel, rockfill (backfill the drift 2x width to height), or by collapsing a section of the adit to control access for situations where water quality issues are not a concern to ensure permanent closure; wooden barricades are only suitable for temporary closure
- Construct a reinforced concrete wall or a plug of weakly cemented waste if the barricade is for access control only

- Flood and plug workings to control acid generation and associated reactions if appropriate (engineered designs must consider hydrostatic heads and rock mass conditions – reinforced slabs should be avoided)
- Construct pillars to retain long-term structural stability after mining activities cease and to sustain their own weight and, if applicable, the weight of unconsolidated deposits, water bodies and all other surface loads
- Permanently support boundary pillar if practical and necessary
- Avoid the use of fencing for barricades in remote northern mine sites where regular inspection is not feasible
- Use inukshuks to deter wildlife where appropriate (guidance from local communities and Elders should be sought)
- Use ditches or berms as barricades except in areas of continuous permafrost; where continuous permafrost exists, inukshuks, fencing or some other method may need to be considered
- Remove all hazardous materials from the underground shops, equipment, and magazines (fuels, oils, glycol, batteries, explosives, etc.)
- Contour to establish natural drainage patterns and blend in with the surrounding topography or re-contour the surface to prevent natural surface and groundwater flow from becoming contaminated by mine water where appropriate

Northern Limitations and Considerations

- Permafrost will provide an inherent stability to the workings when freezing conditions are maintained
- A change in local topography (e.g. re-contouring) may influence ground thermal regimes as a result of snow accumulation that in turn may lead to ponding and permafrost degradation
- Flooding may result in instabilities due to the loss of the strength associated with ground thaw in areas of permafrost
- Thermal regimes may be conducive to freeze-back where permafrost has been degraded depending on the amount of groundwater circulation and local heat balance

Post Closure Monitoring

- Inspect sealed access
- Check for surface expression (subsidence) of underground failure
- Test water quality and monitor volume from controlled discharge points of workings to ensure water quality is performing as predicted and not adversely affecting environment
- Identify mine related drainage discharge points (volume and quality) that were not anticipated
- Conduct geotechnical assessment of the overall safety and risk within the subsidence zone
- Install and check thermistors where appropriate to monitor freeze-back in permafrost areas and to confirm that the ground thermal regime is not degrading
- Special monitoring provisions will be required for mines which have become flooded

and are retaining water under pressure by means of plugs such as: visual inspection, piezometers, seepage measurement weirs, and sampling to check water quality parameters

- Inspect passive water treatment systems for maintenance requirements
- Periodic backfilling of areas of subsidence may be required
- Inspect groundwater plumes and hydrogeology

2.6 OPEN PIT MINE WORKINGS

Open pit reclamation also include quarries, open cuts, and major trenches in areas where mining has occurred. Sand and gravel mines are not specifically addressed in these guidelines although some of the principles may also apply.

Objectives

- Minimize access to protect human and wildlife safety
- Allow emergency access and escape routes from flooded pits
- Implement water management strategies to minimize and control migration and discharge of contaminated drainage, and if required, collect and treat contaminated water
- Meet water quality objectives for any discharge from pits
- Stabilize slopes to minimize erosion and slumping
- Meet end land use target for resulting surface expression
- Establish original or desired new surface drainage patterns
- Establish in-pit water habitat where feasible for flooded pits

Pre-mining Planning Options

- Insulate stripped overburden with rockfill so that the exposed soil slopes can be immediately protected to avoid ongoing erosion, sedimentation and instability
- Excavate rock and soil slopes that will remain above final predicted pit water level to their final stable slopes prior to deepening pit
- In order to improve stability in open pits, consider removing weak or unstable materials from slopes and foundations, flattening slopes, and off-loading the crest of the slope
- Install thermistors to monitor thermal regime around pit, especially if pit is constructed adjacent to a water body or talik
- Have storage and treatment facilities in place prior to stripping of the open pit where overburden and/or overburden melt-water quality is poor
- Divert surface drainage to minimize pit water handling and treatment requirements until the pit water reaches acceptable standards for discharge to the environment after closure

Progressive and Post-Closure Reclamation Options

- For multiple pits, sequentially backfill with waste rock and/or tailings as operations proceed
- Backfill open pits with appropriate materials (e.g. waste rock, tailings)
- Flood the pit (natural or accelerated)
- Allow gradual slope failure of pits involving rock masses, or slope pit walls
- Block open pit access routes with boulder fences, berms, and/or inukshuks (guidance from local communities and Elders should be sought)
- Post warning signs (with visible symbols placed close enough so they are visible from one to another) and fences or berms around the perimeters for actively managed sites (not acceptable for remote sites into the long-term)
- Long-term fencing to prevent access may only be appropriate if the mine site is located close to a community where regular access for maintenance is possible and where there is a higher risk of access by the general population
- Cover slopes with rip rap thick enough to provide insulation or stabilization to minimize erosion or permafrost degradation
- Stabilize exposed soil along the pit crest or underlying poor quality bedrock that threatens to undermine the soil slope above the final pit water level
- Backbrush area to improve visibility
- Plug drill holes
- Maintain an access/egress ramp down to water level for flooded pits
- Contour to discourage or encourage surface water drainage into pits where appropriate
- Cover exposed pit walls to control reactions where necessary
- Collect waters in pit that do not meet the discharge criteria and treat passively (active treatment is not acceptable for the long term) or passively treat waters in the pit
- Breach diversion ditches and establish new water drainage channel
- Establish aquatic life in flooded pits

Northern Limitations and Considerations

- Changes in the permafrost conditions, and groundwater regimes, may ultimately affect physical stability, the mitigation measures in place, and site water balance
- Thaw in permafrost regions is a critical consideration where slumping and sediment release could result in failure of upper pit slopes
- In permafrost areas, there is the potential for initiating permafrost degradation by excavating trenches or ditches if adequate thermal and erosion protection is not present
- Snow drifts in pits may alter the hydrology
- High evaporation rates may exceed input rates for reclaimed pit lakes
- Poor visibility of pits during winter conditions could be hazardous to travel in the north (mostly by snow machines)

Post-Closure Monitoring

- Identify areas that are not stable
- Check ground conditions to confirm permafrost conditions are being re-established as predicted
- Sample surface water and profiles of flooded ponds/pits
- Ensure that there is sufficient water supplied to maintain an appropriate water depth for flooded pits
- Sample water quality and volume at controlled discharge points of pit lakes
- Sample quality of groundwater seeping from pit walls to assess potential for contamination of mine water due to melting permafrost and ARD/ML from pit walls
- Identify and test water management points (including seepage) that were not anticipated
- Inspect barriers such as berms, fences, signs, and inukshuks
- Inspect fish habitat in flooded pits where applicable

2.7 WASTE ROCK AND OVERBURDEN PILES

This component is made up of waste rock, overburden, and low-grade ore material that may be extracted in developing and operating the mine and supporting infrastructure. Waste rock and overburden piles are typically placed in piles for permanent storage unless used in the construction, operation or closure of the site.

Objectives

- Minimize erosion, thaw settlement, slope failure, collapse or the release of contaminants or sediments
- Build to blend in with current topography, be compatible with wildlife use, and/or meet future land use targets
- Build to minimize the overall project footprint

Pre-mining Planning Options

- Select the location and design for waste rock, overburden, and ore stockpiles to complement the desired reclamation objectives and activities
- Segregate deleterious materials for controlled disposal or cellular pile construction
- Salvage overburden materials from stockpiles for use in reclamation
- Construct waste rock piles and overburden piles in lifts with slopes where individual lifts can be set back to provide long-term stability
- Construct rockfill toe berms to contain overburden stockpiles and maintain stability
- Select site that avoids low strength foundations and consider slope angle
- Construct sediment collection ponds for use during operation
- Construct waste rock and overburden piles such that they do not straddle a watershed divide or are not in the path of stream flows that drain to medium-large watersheds

- Select a site within the same drainage catchment as the proposed tailings containment area or alternatively, in the same drainage basin and upslope of the open pit, so runoff is captured and treated with pit water
- Locate waste rock piles in the upper portion of the watershed where runoff effects can be minimized
- Construct internal drains to prevent water table rise
- Manage waste rock by exploring options to control ARD/ML (see section 2.1)
- Design and construct rock piles to encourage and maintain permafrost

Progressive and Post-Closure Reclamation Options

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

Northern Limitations and Considerations

- Permafrost aggradation into rock piles might occur in permafrost regions
- Ice and snow incorporation into rock piles may lead to instability if thawing occurs
- Foundation thawing may cause instability

- Long term aggradation of ice rich soils may be a problem that needs to be addressed in design
- Severe northern conditions (such as climate) may affect cover performance
- Piles may alter wildlife routes or mobility; actions to improve safe wildlife passage may be required

Post Closure Monitoring

- Periodically inspect areas where stabilization measures may be required
- Periodic inspections by a geotechnical engineer to visually assess stability and performance of waste pile and cover(s)
- In the case of water covers, ensure that there is sufficient water supplied to maintain an appropriate water depth
- Periodically inspect ditches and diversion berms
- Examine ground conditions to confirm predicted permafrost conditions are being established as predicted
- Check thermistor data to determine thermal conditions within waste piles to confirm predicted permafrost aggradation/encapsulation were applicable
- Test water quality and measure volume from controlled discharge points of workings to confirm that drainage is performing as predicted and not adversely affecting the environment
- Identify water discharge areas (include volume and quality) that were not anticipated
- Evaluate/confirm success of revegetation activities; meets technical needs (maintains physical stability) or aesthetic needs (blends with surroundings) and meets end land-use targets

2.8 TAILINGS IMPOUNDMENT AND CONTAINMENT SYSTEMS

Tailings containment systems include: embankments, such as dams or dykes that retain tailings or non-compliant water related to the tailings and slurry, surface paste, and dry stack facilities. Impoundment areas may contain a variety of materials – tailings, waste rock, domestic sewage, or collected surface water – in varying quantities and chemistry. Typically, tailings impoundment areas are the last point of control for the site water management system; where discharge to the environment occurs. A good understanding of the contributions to the tailings impoundment is needed to predict the volumes and quality of effluent that may need to be managed after operations. Appropriate monitoring during operations will facilitate an updated effluent management plan.

Objectives

- Stabilize slopes surrounding the tailings impoundment or containment system for flooded and/or dewatered conditions
- Minimize catastrophic and/or chronic release of the tailings based on associated risk
- Minimize wind migration of tailings dust
- Minimize the threat that the impoundment becomes a source of contamination (e.g. tailings migration outside of contained area, contamination of water outside of contained area)

- Blend with local topography and vegetation where appropriate
- Discourage human and wildlife access from physically and chemically unstable tailings sites

Pre-mining Planning Options

- Construct dams and structures, or their shells, with benign materials
- Use a mill process that removes all reactive materials from the tailings
- Use a treatment method to remove contaminants from supernatant
- Modify mill process near end of operations to produce benign tailings for use as cover material
- Build decant towers and pipes such that they do not pass through dam structures
- Select the appropriate site location; tailings impoundments should be located towards the upstream end of the drainage catchment to minimize the volume of water that must be diverted around the facility and the volume of runoff that has to be handled from the adjacent slopes
- Minimize environmental impacts by locating tailings facilities within the same drainage catchment as other mine components such as open pit and waste rock dumps rather than affecting a new watershed (this will also improve water use and treatment efficiencies)
- Thicken tailings to reduce the overall volume of tailings requiring transport to the impoundment and volumes of water requiring recycling back to the mill
- Consider placing PAG or leachable materials into impoundments/areas that will be permanently flooded, capped, or frozen
- Separate deleterious minerals for controlled disposal elsewhere or blend with alkali material to control ARD/ML
- Determine water chemistry and physical properties of the tailings to determine suitable reclamation technique

Progressive and Post-Closure Reclamation Options

- Stabilize embankments by removing weak or unstable materials from slopes and foundations and/or construct toe berms to flatten overall slope
- Breach water retention dams and drain impoundments, avoid post closure impoundment of water when possible
- Use a natural body of water that has sufficient storage capacity to hold the tailings and allow a natural unimpeded flow via the drainage outlet if a permanent water cover is used (this may not be viable if the supernatant water quality does not meet discharge water quality standards)
- Increase freeboard and/or upgrade spillway to prevent overtopping and possible erosion by extreme events
- Relocate and/or deposit tailings into underground mine workings or into flooded pits, depending on water quality considerations
- Flood to control acid generation and related reactions
- Cover to control acid generation and related reactions and surface erosion
- Promote neutralization reactions by use of alkaline materials for acidic tailings
- Divert non-contact runoff away from the tailings facility to avoid contamination
- Promote freezing of tailings mass into permafrost if suitable conditions exist

- Collect waters that do not meet the discharge criteria and treat passively, active treatment is not acceptable for the long term
- Remove structures, decant towers, pipes, and drains where they already exist
- Plug decant towers, pipes, and drains with high slump (relatively liquid concrete which will flow to fill all voids) or preferably, expansive concrete, as a last resort
- Assess the soil around pipes for stability under the hydraulic gradients through the embankment, as this may be a potential zone of piping failure
- Avoid using diversion structures and ditching, especially in permafrost soils (diversion structures are not the preferred option into the long-term)
- Where diversion dams and channels are necessary, maintain them indefinitely to meet long term stability and hydraulic design requirements; design diversions and spillways for extreme events suitable for long term stability
- Provide frost protection cap over the phreatic surface for water-retaining dams
- Ditch, berm, fence, or use alternative methods to deter access of motorized vehicles if compatible with end-use plans
- Establish indigenous vegetation, soil, riprap, or water cover to control erosion

Northern Limitations and Considerations

- Ice depth and scour need to be accounted for in tailings cover design
- Permafrost may aggrade back into the tailings in order to provide stabilization both physically and chemically in continuous permafrost regions
- Long-term climate change will need to be assessed for dams reliant on frozen cores
- Tailings that are not flooded may freeze over time, concentrating residual contaminants in the unfrozen brine; ‘cryoconcentration’ can result in the eventual release of small volumes of higher contaminated fluids
- Physical disruption of covers may occur as a result of tailings freezing over time
- There may be loss of impoundment capacity or space due to ice entrainment or build up
- Wind erosion of tailings may be more significant in some areas of the north due to higher rates of sublimation and limited tree/vegetation cover

Post Closure Monitoring

- Conduct periodic dam safety and stability reviews of structures that remain after closure
- Inspect seepage collection systems for water quality flows
- Inspect and maintain dam structures and/or spillways associated with flooded tailings over the long term
- In the case of water covers, ensure that there is sufficient water supplied to maintain an appropriate water depth
- Check for degradation or aggradation of permafrost for tailings containment structures where permafrost was used in the design
- Monitor pond water level and quality to confirm closure targets

- Evaluate/confirm success of revegetation activities; meets technical needs (maintain physical stability) or aesthetic needs (blends with surroundings) and meets end land-use targets
- Assess dust dispersion and vegetation uptake with wind dispersion of tailings

2.9 BUILDINGS AND EQUIPMENT

Mine site buildings may include: an ore processing/concentrator plant, head frame, maintenance shops, offices, warehouses, fuel tanks, fuel tank farms, assay and analytical labs, process reagent and explosive storage, boiler houses, power generation plants, and camp facilities. Equipment may include: all surface and underground mobile equipment, shaft installations, distribution piping, and conveyors.

Objectives

- Ensure buildings and equipment do not become a source of contamination or a safety hazard to wildlife and humans
- Return area to its original state or to a condition compatible with the end land-use targets

Pre-mining Planning Options

- Locate buildings on bedrock or thaw stable soil foundations to minimize need for foundation preparation and disturbance of terrain
- Use inert waste rock pads placed on top of tundra surface for structures having low foundation loads, such as camp, offices, and warehouses
- Avoid stripping tundra surface where possible
- Locate heated structures such that the degradation of underlying permafrost is reduced or eliminated

Progressive and Post-Closure Reclamation Options

- Dismantle all buildings that are not necessary to achieve the future land use target
- Raze/level all walls to the ground and remove foundations
- Cover remaining foundations with materials conducive to vegetation growth
- Remove buildings and equipment during the winter to minimize damage to the land where appropriate
- Remove floor structures over basements and cellars
- Remove and dispose concrete in an approved landfill if it contains contaminants such as hydrocarbons or PCBs that may pose a hazard over time
- Where approved, break or perforate concrete floor slabs and walls to create a free draining condition in order that vegetation can be established
- Backfill all excavations below final grade to achieve the final desired surface contours to restore the natural drainage or a new acceptable drainage
- Cover excavated sites which have exposed permafrost with a rock cap to prevent thermokarst erosion

- Reduce dust emission during demolition of buildings that contain or contained asbestos, hazardous chemicals or other deleterious material
- Remove buried tanks, where they already exist, to prevent subsidence
- Bury materials in the unsaturated zone or below the active layer
- Decontaminate equipment (free of any batteries, fuels, oils, or other deleterious substances) and reuse or sell (local communities may have interests in some of the materials)
- If sale or salvage of equipment is not possible, dispose of decontaminated equipment in an approved landfill or as recommended by the regulatory authorities
- Cut, shred or crush and break demolition debris to minimize the void volume during disposal
- Maintain photographic records of major items placed into landfills, as well as a plan showing the location of various classes of demolition debris (e.g. concrete, structural steel, piping, metal sheeting and cladding)
- Leave non-salvageable materials and equipment from underground operations in the underground mine upon approval from the regulatory authorities
- Remove all hazardous materials and chemicals prior to demolition to national approved hazardous material treatment facilities, recycle, reuse, or dispose of in an appropriate manner upon approval from the regulatory authorities (check for PCBs in fluorescent light fixtures, lead-based paints, mercury switches or radioactive instrumentation controls)
- Backhaul materials for recycling or disposal to a southern location

Northern Limitations and Considerations

- Caution should be taken in permafrost zones where buried material can potentially be pushed to the surface years later
- Maintaining permafrost under buildings and roads may be important to ensure physical stability of the infrastructure (heat, from buildings and processing plant, may create enough heat to affect the underlying ground conditions)
- The breakdown of materials left on northern sites will be slow due to cold temperatures
- Remote sites are hampered by restrictive and perhaps seasonal factors such as transportation (ice roads, water access), climate, and hours of daylight; logistics such as timing activities and disposal options should be considered
- Local residents and communities may also identify a desire to maintain certain buildings for emergency, or community, purposes (ownership liability will need to be considered)

Post Closure Monitoring

- Maintain all buildings and equipment left onsite
- Inspect disposal areas periodically to establish if buried materials are being pushed to the surface as a result of frost heaving

2.10 INFRASTRUCTURE

Infrastructure may include roads, airstrips, electrical power supply systems, bridges, culverts, railways, ports, barge landings, and ore handling facilities.

Objectives

- Ensure infrastructure does not become a source of contamination
- Return area to its original state or to a state compatible with the desired end use
- Restore natural drainage patterns where surface infrastructure has been removed
- Restore the natural use by wildlife

Pre-mining Planning Options

- Construct airstrips as part of site access roads to minimize the project footprint
- Evaluate alternative access road options such as winter roads and alternative alignments
- Evaluate terrain sensitivity along route alignments, potential environmental impacts and construction mitigation requirements
- Avoid or minimize bridge crossings
- Where possible, use gentle slopes in road verges to facilitate wildlife passage during operation and after closure

Progressive and Post-Closure Reclamation Options

- Remove structures including bridges, culverts, pipes, buried wires and power lines and fill ditches in if no longer required and evaluate the area for potential contaminants
- Reclaim areas to the original topography and drainage or to a new topography or drainage compatible with end land use targets
- Scarify abandoned road/runway surfaces to promote revegetation of indigenous species
- Leave roads, airstrips, bridges, or railways intact if it is in the public interest to do so (ownership liability will need to be considered)
- Flatten berms and slopes at the side of roads to facilitate wildlife passage

Northern Limitations and Considerations

- The scheduling for dismantling infrastructure components should be carefully considered in the context of the need for their use during the reclamation and monitoring period
- Mine sites in the north may result in opening up the area by providing access to other land users (e.g. tourists, hunters, prospectors)
- Maintaining permafrost under roads and pads may be important to ensure physical stability of the infrastructure
- Local residents and communities may also identify a desire to maintain certain infrastructure for emergency, or community, purposes (ownership liability will need to be considered)

Post Closure Monitoring

- Maintain access infrastructure to support on-going reclamation and closure monitoring
- Monitor wildlife/fish use of area to ensure mitigation measures are successful
- Monitor other land users access and activity in the area
- Check stream crossing remediation and any degradation associated with decommissioned roads such as erosion or ponding of water

2.11 LANDFILLS AND OTHER WASTE DISPOSAL AREAS

Landfills and other waste disposal areas may include industrial and domestic waste, sewage, chemicals, and water treatment sludge.

Objectives

- Control erosion and effects to the ground thermal regime
- Prevent inadvertent access
- Ensure waste disposal areas do not become a source of contamination
- Return area to its original state or to a state compatible with the desired end use

Pre-mining Planning Options

- Minimize the use of hazardous chemicals
- Take inventory of chemicals to be used
- Locate hazardous waste facilities and other waste storage areas away from waterways to minimize environmental impacts that could result from spills
- Do not excavate or cut ice-rich soils to construct a landfill
- Assess suitability of using abandoned quarries, borrow pits, underground mine workings, and tailings impoundments for inert waste disposal to minimize footprint

Progressive and Post-Closure Reclamation Options

- Some low level contaminated soil may be used progressively to cover landfills if the entire landfill is designed to be ultimately encapsulated in permafrost
- Remove hazardous waste to an approved hazardous material storage facility
- Dispose of wastes in quarries, borrow pits, underground mine workings, tailings impoundments, and waste rock piles
- Burn domestic waste in an incinerator during operation and at closure as part of camp maintenance
- Burn waste oils, solvents and other hydrocarbons on-site with an incinerator if approved (chlorinated substances should not be burned)
- Cover landfills and other waste disposal areas with erosion resistant material (e.g. soil, riprap, vegetation)
- Divert runoff with ditches or covers
- Ditch, berm, fence, or use alternative methods to limit access to waste storage areas

- Contour/blend to match the natural topography or a new desired topography and re-vegetate with indigenous species to meet the end use land targets
- Consider surface application of sewage for revegetation

Northern Limitations and Considerations

- Many northern sites do not have local sources of impervious soils to use as a landfill barrier and rely on permafrost as the barrier
- If permafrost is present within the landfill, the cap should sometimes be sloped to allow runoff where it is not necessary to prevent infiltration of precipitation
- Conventional landfill designs using an impervious liner may be more appropriate than utilizing frozen ground conditions to encapsulate the waste - especially for mine sites located in the discontinuous permafrost area

Post-Closure Monitoring

- Sample water treatment sludge periodically to determine the chemical characteristics, sludge stability, and leachability under the proposed long-term storage conditions
- Test water quality and quantity to measure the success of the mitigation measures for waste disposal areas
- Identify any unpredicted sources of potential contamination
- Check the ground thermal regime (by means of thermistors) and cover performance to check if permafrost has aggraded into the landfill and if the seasonal active zone remains within the cover
- Check for cracking or slumping of the cover and for underlying waste material pushing its way up through the cover

2.12 WATER MANAGEMENT SYSTEMS

The components of a water management system may include embankments, ditches and culverts, pipelines, and storage tanks associated with fresh water supply, diversion of uncontaminated water, and collection/treatment and discharge of non-compliant water.

Objectives

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

Pre-mining Planning Options

- Minimize reliance on long-term diversion ditches
- Plans should be designed to be robust to address development plans of other mine components and compatible with the long term end-use targets

- Construct pilot channels to assess ice build up in water passage channels

Progressive and Post-Closure Reclamation Options

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

Northern Limitations and Considerations

- Designs should account for snowfall and snowdrifts that may accumulate in topographic lows
- The flow capacity of the water passages may be affected by ice build up and debris in the channels
- May need to incorporate management of water under ice and snow conditions; this is particularly difficult during spring melt when flows can be large, ice and snow may obstruct flows, and visibility and access to those flows may be limited
- Long periods of snow or ice cover makes passive systems more difficult to implement
- Water in the north is considered pristine and aquatic organisms may be particularly sensitive to water quantity and quality changes
- Land and water are vital parts of the Aboriginal identity and culture and a traditional lifestyle is dependent on a healthy aquatic ecosystem

Post-Closure Monitoring

- Periodic inspections are required in the post-closure period to assess the performance of the existing water management structures
- Check the performance of erosion protection on embankment structures such as rip rap or vegetation and the physical stability of water management systems including permafrost integrity where applicable
- Check water quality and flows to ensure system is working as predicted
- Conduct ongoing inspection and maintenance of passive or active water treatment facilities associated with non-compliant mine water or runoff discharges
- Sample surface and groundwater if site specific conditions dictate
- Check the smell and taste of water and fish (guidance from local communities and Elders should be sought)

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GLOSSARY OF TERMS

Abandonment: The permanent dismantlement of a facility so it is permanently incapable of its intended use. This includes the removal of associated equipment and structures.

Active layer: The layer of ground above the permafrost which thaws and freezes annually.

Backfill: Material excavated from a site and reused for filling the surface or underground void created by mining.

Background: An area near the site under evaluation not influenced by chemicals released from the site, or other impacts created by onsite activity.

Baseline: A surveyed condition and reference used for future surveys.

Benign: Having little or no detrimental effect.

Berm: A mound or wall, usually of earth, used to retain substances or to prevent substances from entering an area.

Best Management Practices: Any program, technology, process, operating method, measure, or device that controls, prevents, removes, or reduces pollution and impact on the environment.

Biodiversity: The variety of plants and animals that live in a specific area.

Bioremediation: The use of microorganisms or vegetation to reduce contaminant levels in soil or water.

Borrow Pit: A source of fill or embanking material.

Care and Maintenance: A term to describe the status of a mine when it undergoes a temporary closure.

Closure: When a mine ceases operations without the intent to resume mining activities in the future.

Closure Criteria: Detail to set precise measures of when the objective has been satisfied.

Contaminant: Any physical, chemical, biological or radiological substance in the air, soil or water that has an adverse effect. Any chemical substance with a concentration that exceeds background levels or which is not naturally occurring in the environment.

Contouring: The process of shaping the land surface to fit the form of the surrounding land.

Cryoconcentration: Concentration of solutes due to exclusion by ice.

Cumulative Effects: The combined environmental impacts that accumulate over time and space as a result of a series of similar or related actions or activities.

Decommissioning: The process of permanently closing a site; removing equipment, buildings and structures. Rehabilitation and plans for future maintenance of affected land and water are also included.

Disposal: The relocation, containment, treatment or processing of unwanted materials. This may involve the removal of contaminants or their conversion to less harmful forms.

Drainage: The removal of excess surface water or groundwater from land by natural runoff and permeation, or by surface or subsurface drains.

Effluent: Treated or untreated liquid waste material that is discharged into the environment from a structure such as a settling pond or a treatment plant.

End Land Use: The allowable use of disturbed land following reclamation. Municipal zoning and/or approval may be required for specific land uses.

Erosion: The wearing away of rock, soil or other surface material by water, rain, waves, wind or ice; the process may be accelerated by human activities.

Frost Heave: Annual ground displacements and differential ground pressures due to the freezing of water within soils.

Ground Thermal Regime: Temperature conditions below the ground surface. A condition of heat losses and gains from geothermal sources and the atmosphere

Groundwater: All subsurface water that occurs beneath the water table in rocks and geologic formations that are fully saturated.

Hydrology: The science that deals with water, its properties, distribution and circulation over the Earth's surface.

In Situ Treatment: A method of managing or treating contaminated soils, sludges and waters "in place" in a manner that does not require the contaminated material to be physically removed or excavated from where it originated.

Inukshuk: A stone representation of a person, used as a milestone or directional marker by the Inuit of the Canadian Arctic.

Landfill: An engineered waste management facility at which waste is disposed by placing it on or in land in a manner that minimizes adverse human health and environmental effects.

Leachate: Water or other liquid that has washed (leached) from a solid material, such as a layer of soil or water; leachate may contain contaminants.

Migration: The movement of chemicals, bacteria, and gases in flowing water or vapour.

Mitigation: The process of rectifying an impact by repairing, rehabilitating or restoring the affected environment, or the process of compensating for the impact by replacing or providing substitute resources or environments.

Monitoring: Observing the change in geophysical, hydrogeological or geochemical measurements over time.

Objectives: Objectives describe what the reclamation activities are aiming to achieve. The goal of mine closure is to achieve the long-term objectives that are selected for the site.

Passive Treatment: Treatment technologies that can function with little or no maintenance over long periods of time.

Permafrost: Ground that remains at or below zero degrees Celsius for a minimum of two consecutive years.

Permafrost Aggradation: A naturally or artificially caused increase in the thickness and/or area extent of permafrost.

Permeability: The ease with which gases, liquids, or plant toots penetrate or pass through soil or a layer of soil. The rate of permeability depends upon the composition of the soil.

Phreatic surface:

Progressive Reclamation: Actions that can be taken during mining operations before permanent closure, to take advantage of cost and operating efficiencies by using the resources available from mine operations to reduce the overall reclamation costs incurred. It enhances environmental protection and shortens the timeframe for achieving the reclamation objectives and goals.

Reclamation: The process of returning a disturbed site to its natural state or one for other productive uses that prevents or minimizes any adverse effects on the environment or threats to human health and safety.

Rehabilitation: Activities to ensure that the land will be returned to a form and productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Remediation: The removal, reduction, or neutralization of substances, wastes or hazardous material from a site in order to prevent or minimize any adverse effects on the environment and public safety now or in the future.

Restoration: The renewing, repairing, cleaning-up, remediation or other management of soil, groundwater or sediment so that its functions and qualities are comparable to those of its original, unaltered state.

Revegetation: Replacing original ground cover following a disturbance to the land.

Risk Assessment: Reviewing risk analysis and options for a given site, component or condition. Risk assessments consider factors such as risk acceptability, public perception of risk, socio-economic impacts, benefits, and technical feasibility. It forms the basis for risk management.

Run Off: Water that is not absorbed by soil and drains off the land into bodies of water.

Scarification: Seedbed preparation to make a site more amenable to plant growth.

Security Deposit: Funds held by the Crown that can be used in the case of abandonment of an undertaking to reclaim the site, or carry out any ongoing measures that may remain to be taken after the abandonment of the undertaking.

Sediment: Solid material, both mineral and organic, that has been moved by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Seismic: Relating to an earthquake or to other tremors of the Earth, such as those caused by large explosions.

Sump: An underground catch basin in a mine where water accumulates before being pumped to the surface.

Supernatant: The clear liquid that floats about the sediment or precipitate.

Surface Water: Natural water bodies such as river, streams, brooks, ponds and lakes, as well as artificial watercourses, such as irrigation, industrial and navigational canals, in direct contact with the atmosphere.

Sustainable Development: Industrial development that does not detract from the potential of the natural environment to ensure benefits for future generations.

Tailings: Material rejected from a mill after most of the recoverable valuable minerals have been extracted.

Taliks: Unfrozen zones that can exist within, below, or above permafrost layers. They are usually located below deep water bodies.

Temporary Closure: When a mine ceases operations with the intent to resume mining activities in the future. Temporary closures can last for a period of weeks, or for several years, based on economical, environmental, political, or social factors.

Thermokarst: A landscape characterized by shallow pits and depressions caused by selective thawing of ground ice, or permafrost.

Traditional Knowledge: A cumulative, collective body of knowledge, experience, and values built up by a group of people through generations of living in close contact with nature. It builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Waste Rock: All rock materials, except ore and tailings that are produced as a result of mining operations.

Watershed: A region or area bordered by ridges of higher ground that drains into a particular watercourse or body of water.

Water Table: The level below where the ground is saturated with water.

RELEVANT LEGISLATION

Mine Reclamation & Closure in the NWT is subject to a number of statutes. The primary Acts and Regulations applicable in the Northwest Territories at the time of publishing these guidelines are listed. It is incumbent upon the proponent to ensure compliance with all pertinent legislation including conditions set out in updated versions of existing policies, regulations, and guidelines.

FEDERAL

Canadian Environmental Assessment Act and Regulations
Canadian Environmental Protection Act and Regulations
Fisheries Act and Regulations
Arctic Waters Pollution Prevention Act and Regulations
Northwest Territories Waters Act and Regulations
Mackenzie Valley Resource Management Act and Regulations
Territorial Lands Act and Regulations
Transportation of Dangerous Goods Act and Regulations

TERRITORIAL – NWT

Commissioner's Lands Act and Regulations
Environmental Protection Act and Regulations
Environmental Rights Act and Regulations
Mine Health and Safety Act and Regulations

APPENDIX A

EXAMPLE OF GENERAL CONTENT OF A CLOSURE AND RECLAMATION PLAN

Part I: Translated Summary

Part II: Introduction

1. Purpose of the CRP
2. Approach to Development of the CRP
3. Closure and Reclamation Planning Team
4. Definition of Terms
5. Approach to Inclusion of Long-Term Community Values
6. Approach to Inclusion and Management of information (such as research/studies, engineering plans, 'as built' drawings)

Part III: Project Description

1. History of the Site
2. Pre-Mining and Reference Environmental Conditions
3. Overview of Mine Development and Operating Plan
4. Description of Mine Facilities
5. Acid Rock Drainage/Metal Leaching Potential
6. Current Environmental Conditions
7. Permits and Authorizations Held

Part IV: Temporary Closure

1. Definition of Temporary Closure
2. Temporary Closure Principles and Goals
3. Temporary Closure Activities
4. Temporary Closure Management and Accountability Structure
5. Temporary Closure Monitoring, Maintenance and Reporting Program
6. Temporary Closure Contingency Program
7. Temporary Closure Schedule
8. Temporary Closure Costs

Part V: Permanent Closure and Reclamation

1. Definition of Permanent Closure
2. Permanent Closure and Reclamation Plan
    a) Reclamation Principles
    b) Consideration of Community Values
    c) Breakdown of the Project Into Specific Reclamation Components (reference Part II of these Guidelines)
    d) Reclamation Objectives and Closure Criteria
    e) Listing and Assessment of Possible Reclamation Activities
    f) Selection of Preferred Reclamation Activities
    g) Synthesis of Preferred Activities into a Reclamation Plan
    h) Management and Accountability Structure
    i) Uncertainties and Information Needs
    j) Monitoring, Maintenance and Reporting Program
    k) Contingency Program

    l) Costs
3. Progressive Reclamation
    a) Definition of Progressive Reclamation
    b) Candidate Facilities/Areas and Reclamation Activities
    c) Proposed Thresholds for Success
    d) Progressive Reclamation Schedule
    e) Management and Accountability Structure
    f) Progressive Reclamation Contingency Program
    g) Progressive Reclamation Costs
4. Permanent Closure and Reclamation Schedule
    a) Schedule Assuming No Progressive Reclamation
    b) Schedule Assuming Successful Progressive Reclamation
    c) Schedule Contingency Program
5. Projected Environmental Conditions After Permanent Closure and Reclamation
6. Assessment of Post-Reclamation Risks to Human and Environmental Health

Part VI: Financial Security

1. Schedule of Key Project Milestones for Financial Security Planning
2. Closure and Reclamation Cost Liability Schedule Through the Mine Life
3. Basis of Financial Security
4. Financial Security Schedule Assuming No Progressive Reclamation
5. Financial Security Schedule Assuming Successful Progressive Reclamation

Part VII: Supporting Documents

1. Environmental Studies
2. Reclamation Research Reports
3. Community Participation Reports
4. Engineering Investigation and Design Reports
5. Detailed Assessments of Possible Reclamation Activities
6. Risk Assessment/Impact Assessment Reports