Rio Tinto

Appendix III-1

Research Task Descriptions from Appendix VIII – ICRP V3.2

Appendix VIII Introduction

Note to Reader: The following was extracted from ICRP V3.2. Specific Task Reference Numbers have been added.

1. Introduction

This Appendix contains Version 1.0 of six research plans: one for each of the five closure areas (waste rock and till, processed kimberlite containment, North Inlet, infrastructure and the pit, underground and dike area), and one specific to community engagement and Traditional Knowledge.

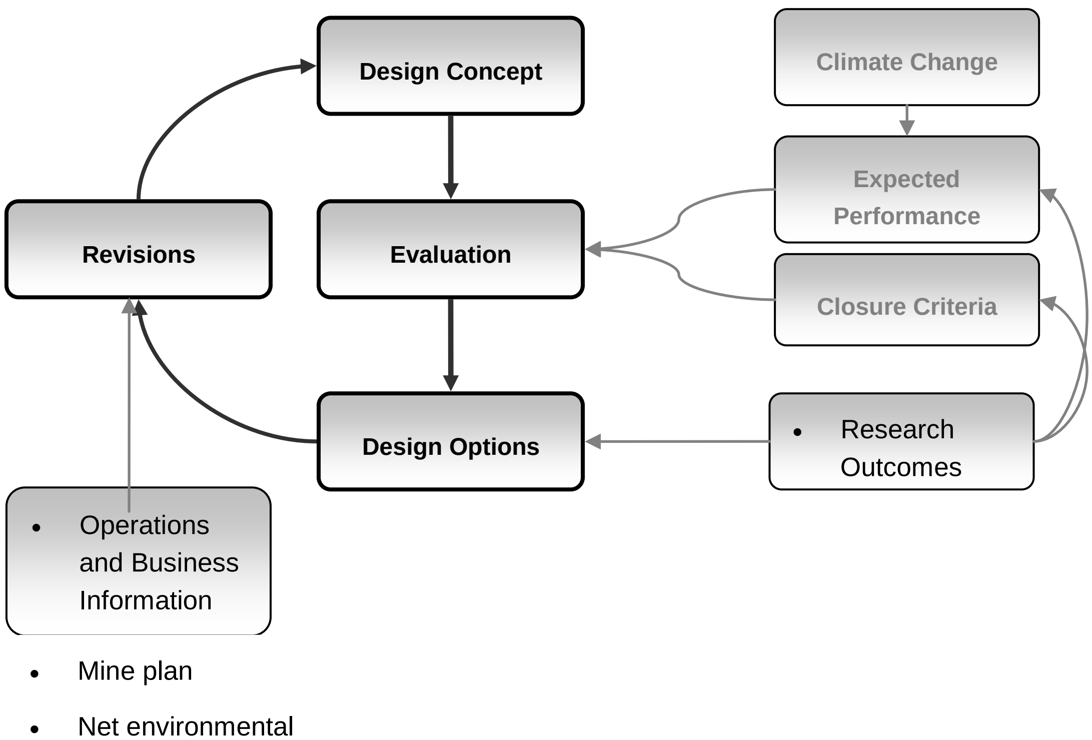
Reclamation Research Plans are used to reduce identified uncertainties associated with specific aspects of the closure plan. Generally the uncertainties identified in the Interim Closure and Reclamation Plan Version 3.1 fall into the following three categories:

- Final land use – Communities' preferences regarding final land use need to be understood to advance the closure plan. Specifically, community and Traditional Knowledge inputs are required for wildlife routes, target areas for re-vegetation, fish habitat design details and landform shapes.
- Chemical stability – There are uncertainties around how mine components will perform post-closure with respect to the release of chemical constituents. Closure design improvements will be in part guided by understanding of the long-term physical and chemical behaviour of these facilities.
- Closure criteria - There is uncertainty with the proposed closure criteria. Specifically, the criteria for chemical stability need to be defined to describe accurately exposure conditions that do not pose an unacceptable risk to people, wildlife and aquatic life.

Reclamation Research Plans are not an inclusive description of all the closure planning activities or tasks to be undertaken, they are specifically research plans.

Linkages between the research plans and the closure planning framework that Diavik Diamond Mines Inc. (DDMI) will use to guide the closure designs for the facilities are shown in Figure 1. The framework shows an iterative process of taking a design concept, evaluating the expected performance of the design against objectives and criteria, and considering options to improve the design. Information from the research plans will improve understanding of the expected performance of a specific design concept, focus closure criteria, and identify possible design options or alternatives. The design review iteration may identify requirements to revise Restoration Research Plans based on changes to uncertainties or risk.

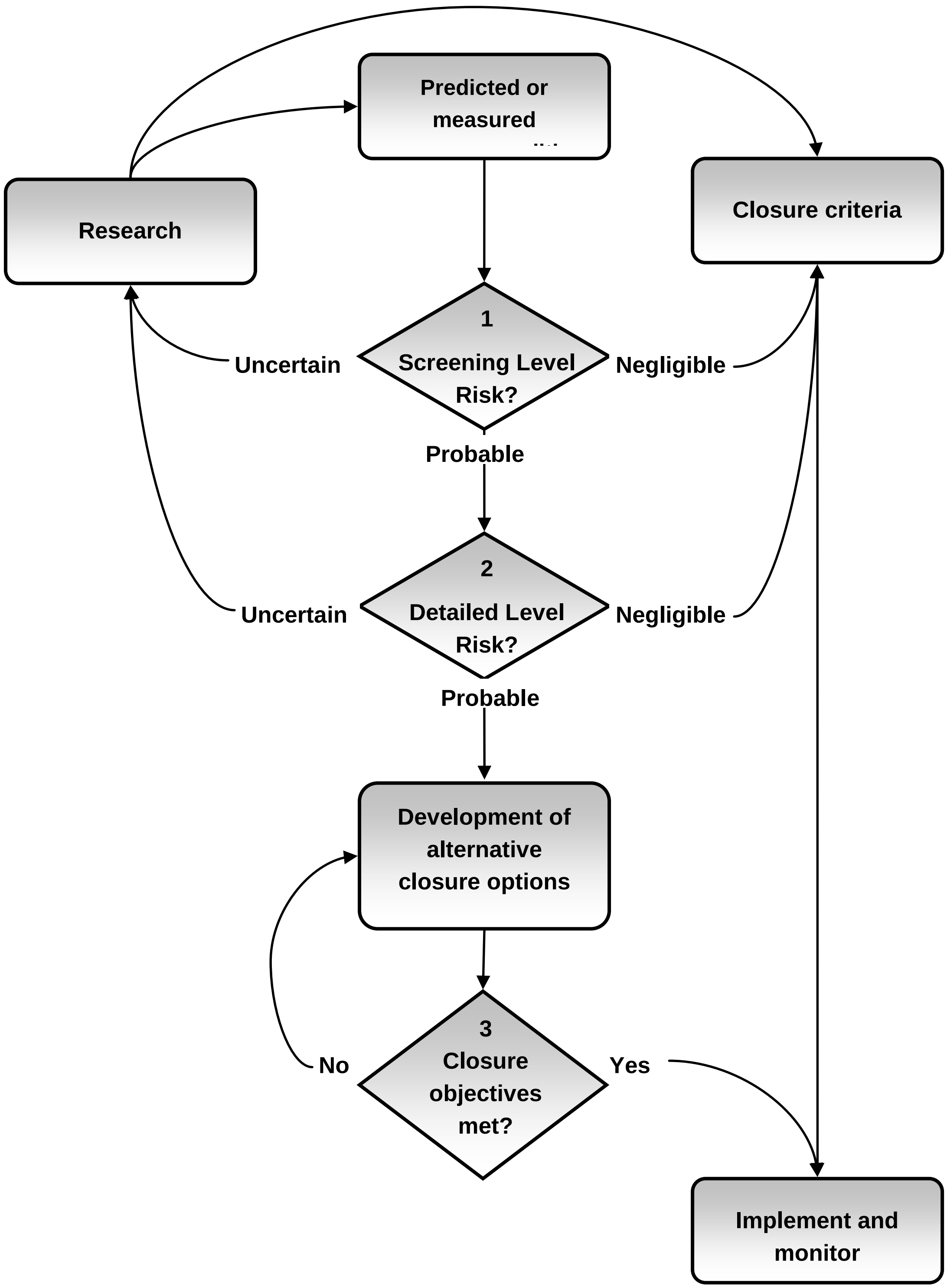
Figure 1 Closure Planning Framework – Linkage with Reclamation Research Plan



The Evaluation component of Figure 1 compares the expected performance of a closure concept with closure criteria. A closure objective that applies to all areas is that water/sediment/soil in the area is chemically safe for people, wildlife and aquatic life. A risk-based approach will be used for these evaluations.

The risk framework is shown schematically in Figure 2. It starts with either a predicted or measured exposure condition (i.e., expected performance). For example, this could be the quality of seepage from the Processed Kimberlite Containment (PKC), quality of sediments in the NI or quality of soils in the Waste Transfer Area. A Screening Level Risk Assessment is conducted to compare exposure concentrations with initial closure criteria for exposure to people, wildlife and aquatic life. Initial closure criteria are typically national standards or guidelines for protection of water or land use and are developed to be conservative (i.e., erring on the side of caution). This process provides a screening level indication of parameters of concern, parameters where additional monitoring or research may be required, and parameters where the risks are negligible. Parameters of concern are then evaluated in more detail.

Figure 2 Risk Assessment Framework Schematic



A Detailed Level Risk Assessment would move beyond the use of national standards or guidelines to use directly toxicological research literature. Receptor-specific and area-specific receptor parameters such as the amount of time an animal/person might spend in an area, food/water ingestion rates and body weight would be developed and applied. Where negligible risks from the Detailed Level Risk Assessment are determined, results will be used to revise the closure criteria. Uncertainties may be identified with the toxicological information, exposure concentrations or receptor parameters that may need to be resolved through research or monitoring before the actual risk can be determined. Alternatively, probable risks may be identified that require the development of alternative closure options or the adoption of contingency options.

Through this process closure options can be assessed and closure criteria developed concurrently. Initially the assessments will rely, in many cases, on predictions of post-closure exposure conditions. Ultimately, the assessments will use post-closure performance monitoring results as verification.

Included in Appendix VIII are Reclamation Research Plans that are designed to provide the required information based on today's knowledge and understanding of closure uncertainties and risks. As new research information is obtained and closure plans evolve, uncertainties and risks will also change, resulting in different research requirements. The Reclamation Research Plans are intended to be dynamic and are expected to change as new information becomes available.

Part L Item 3(f) of the Water License specifies that the research plan should describe how metal uptake in re-vegetated plant communities will be monitored. At this point in the closure planning, it is premature to emphasize research related to monitoring methods particularly when it has yet to be determined which areas will be targeted for re-vegetation or if metal up-take in plants is likely to pose an unacceptable risk to people or wildlife. Research related to monitoring methods is more appropriately defined when closure concepts have been finalized and closure criteria are better defined through risk-based criteria (see Appendix VIII-6).

DDMI will attempt to incorporate relevant information that may become available from other closure research work including closure research local to the Lac de Gras area. DDMI will specifically seek opportunities to collaborate on closure research with the Ekati operations. Opportunities for formal collaboration can only properly begin when both operations have approved closure research plans.

A summary of results and activities carried out under the Reclamation Research Plans will be reported by March 31 each year in the Annual Water License Report as per Water License Part B Item 4(r). The research plans will evolve to fit changing closure planning requirements. Modified research plans will also be submitted by March 31 each year as per Water License Part L Item 4.

Appendix VIII-1 Traditional Knowledge and Community Participation

1. Uncertainty

Many aspects of closure would benefit from community input and Traditional Knowledge (TK). These aspects were identified by community members when development of the mine was being considered. Some key aspects also present uncertainty from a scientific perspective, making input from community members increasingly important. These key aspects include wildlife movement, areas for re-vegetation, fish habitat and landforms.

1.1 Wildlife Movement

The main uncertainty to address is how and where wildlife should use or move through the area of the mine post-closure. The primary wildlife species of interest is caribou and it will be the focus of wildlife research, however other valued wildlife species will also be include. Preferred routes and habitat features, or deterrent mechanisms for wildlife need to be determined. Questions regarding possible attraction features for predators and prey, options to assist wildlife to avoid or move through old mine infrastructure, and potential for renewed use of, or man-made extensions to, historic trails are all matters of primary interest to community members. The safety of wildlife moving through the area of the mine is a key consideration for addressing these uncertainties and how best to assess this will be considered as part of the research plan.

1.2 Areas for Re-vegetation

Related to Wildlife Movement, areas for re-vegetation will be partially based on the need to attract or deter wildlife to/from various areas of the mine. Preferred routes and habitat features, or deterrent mechanisms for wildlife need to be determined to establish the areas and type of vegetation best suited for the identified purpose.

1.3 Fish Habitat

Fish habitat features will be constructed in the area behind the A154 and A418 dikes so that at closure, when the area is flooded, it will be used by fish from Lac de Gras. Diavik has developed designs for the fish habitat based on scientific knowledge. It is uncertain if Traditional Knowledge information regarding habitat designs might change or confirm the proposed designs.

1.4 Landforms

Aesthetic and technical considerations related to the final landscape at the mine need to be addressed for closure. The final shape and structure of some landforms at the mine site may influence both the aesthetic view of the area, as well as the functional use of those landforms. Uncertainties relating to water flow, areas for re-vegetation and wildlife movement, as well as the general appearance of the former mine site need to be accounted for when determining the preferred closure options for any development on the land.

Attaining community participation and incorporating community input and TK into the closure planning process is challenging. The main challenges associated with this process are ensuring representation of each Aboriginal group and obtaining agreement on recommendations that are suited to the Project. The preferred structure for obtaining this level of participation with each of the Aboriginal organizations has not yet been determined, but Diavik is working towards this goal (see Section 2.4, Community Engagement).

2. Research Objectives

Research objectives associated with each of the aspects identified in the Uncertainty section include the following.

- What are the key landforms that need to be assessed from a community perspective as they relate to wildlife movement?
- Where are the historic trails that caribou used approaching, leaving and on East Island?
- What is the preferred route(s) for caribou to move around or through the area of the mine?
- Are there any areas where prey may be more vulnerable to predation?
- What are the habitat features (either natural or man-made) that could assist in achieving the preferred routing, or reducing opportunities for predation – either to attract or deter animals from any area?
- What would be the appropriate closure specifications for the safe movement of wildlife?
- What types of vegetation are most suitable for the different species of wildlife?
- What are the areas of the mine that should be re-vegetated?
- What should the former mine infrastructure look like at closure to assist or deter wildlife passage and suit the surrounding landscape – includes rock piles, PKC, pit, dikes and roads?
- What are the preferred features for fish habitat from a Traditional Knowledge perspective?
- Is there an appropriate Traditional Knowledge approach to determining fish use for different habitats?
- Are there any considerations or recommendations that Aboriginal organizations feel should be taken into account for breaching the dikes?
- What has been done in the past to attain community participation and incorporate community input and Traditional Knowledge in to the closure planning process? What can DDMI learn and improve on from this?
- What is a suitable arrangement for obtaining direction and support on closure activities for Diavik with the Aboriginal organizations?

3. Research Plan

3.1 Tasks Completed (Before 2011)

Completed tasks related to wildlife movement include the following:

- workshop at the mine site with community members;
- review of closure considerations for mine site;
- tour of the site focusing on key landform features;
- helicopter survey of access areas to East Island for caribou; and
- discussion of options for wildlife to move around/through the mine site.

Completed tasks related to community engagement protocols include the following:

- initial meetings with leadership of each Aboriginal organization to explain idea;
- draft template developed that outlines the purpose of each topic;
- Diavik has identified lead contacts to Aboriginal organizations; and
- two Aboriginal organizations have identified their lead contacts.

Completed tasks related to fish habitat and reef design include the following:

- constructed shelf areas for reef development inside the dikes; and
- developed science-based designs.

3.2 Tasks to be Started (2011 to 2013)

Tasks related to community engagement protocols include the following:

3.2.1.1 obtain information on lead contacts for all Aboriginal organizations;

3.2.1.2 formalize engagement protocol with each Aboriginal organization;

3.2.1.3 obtain sign off from Chiefs/Presidents on final document; and

3.2.1.4 work with the key contact from each Aboriginal organization to establish the preferred method of engagement relating to closure; determine if proposed approach from Section 2.4 is acceptable.

Planned tasks related to the establishment of a Traditional Knowledge Panel include:

3.2.2.1 consult with Environmental Monitoring Advisory Board regarding existing provision in the Environmental Agreement for a TK Panel; and

3.2.2.2 determine structure, representatives and terms of reference for a Panel.

Planned tasks related to wildlife movement include:

3.2.3.1 conduct desktop review of available TK on caribou in the Slave Geologic Province;

3.2.3.2 discuss the options generated from the site workshop with each of the Aboriginal organizations;

3.2.3.3 record recommendations from each Aboriginal organization on their preferred option for wildlife movement and methods for deterring wildlife post-closure;

3.2.3.4 work to develop appropriate closure specifications for the safe movement of wildlife; and

3.2.3.5 distribute for review to Aboriginal organizations and the TK Panel.

Planned tasks related to determining areas for re-vegetation include:

3.2.4.1 conduct a desktop review of available TK on vegetation in the Slave Geologic Province;

3.2.4.2 summarize the results of the 5-year re-vegetation study at Diavik;

3.2.4.3 establish the preferred options for wildlife movement post-closure;

3.2.4.4 in consideration of the above point, determine the areas of the mine site most suitable for re-vegetation;

3.2.4.5 record recommendations from each Aboriginal organization on preferred areas and species for re-vegetation;

3.2.4.6 determine the need for any additional studies relating to re-vegetation; and

3.2.4.7 distribute for review to Aboriginal organizations and the TK Panel.

Planned tasks related to possible final landforms include the following:

3.2.5.1 review the conceptual closure picture introduced during the Environmental Assessment;

3.2.5.2 after wildlife and re-vegetation recommendations have been received from the Aboriginal organizations, assess the technical feasibility and material availability to meet these recommendations for key landforms;

3.2.5.3 in light of above considerations, construct a model to best represent the final look of the land in relation to natural areas around the mine and remaining landforms associated with the mine;

3.2.5.4 present the model to communities to obtain any further feedback and recommendations on possible further changes at the landscape level; and

3.2.5.5 document and distribute for review to Aboriginal organizations and the TK Panel.

Planned tasks related to community engagement include:

3.2.6.1 focus on community-based, facilitated workshops to develop more specific recommendations relating to closure options; and

3.2.6.2 encourage the development of a Traditional Knowledge Panel under the Diavik Environmental Agreement.

3.3 Remaining Tasks (After 2013)

Planned tasks are relating to fish habitat and reef design:

3.3.1 work with Aboriginal organizations to obtain recommendations on the design of reefs inside the dikes, external edges of dikes and any habitat considerations to take in to account when breaching the dikes; and

3.3.2 document and distribute for review to Aboriginal organizations and the TK Panel.

4. Findings of Research Completed

4.1 Wildlife Movement

Caribou will occasionally use disturbed areas such as roads, airstrips and tailings ponds to rest (Gunn 1998), returning to these areas after foraging on nearby tundra. This behaviour has been observed at other mines in the Bathurst range, such as Lupin and Ekati. It has been suggested that this is to take advantage of the view and to make it difficult for predators to conceal themselves, similar to their habit of bedding on frozen lakes in the winter. Further, these areas have fewer mosquitoes and blackflies (Gunn 1998). Although it is not clear that these disturbed areas are used preferentially compared to undisturbed areas (Gunn 1998), it is possible that the waste rock piles and PKC area may be used by caribou in this manner post-closure.

Eventually, it is possible that the waste rock piles and PKC will revegetate, providing forage for caribou and other wildlife. During winter, caribou forage primarily on lichen, which is slow to recover. Studies of caribou behaviour in relation to forest fires indicate that caribou select areas which have remained un-burnt for at least 50 years (Dalerum et al. 2007; Joly et al. 2007). Shrubs and forbs may colonize the waste rock piles in a much shorter period, and these may be used by caribou during the late summer and fall months.

In many respects, the waste rock piles and PKC dams are similar to the boulder associations present in the Lac de Gras area and the larger central Canadian Arctic (described and mapped in Matthews et al. 2001). Both Traditional Knowledge and aerial surveys in the Lac de Gras area have indicated that caribou avoid these boulder association areas.

At the initial site workshop in 2009 three options in particular were developed during the discussions by the Participants:

- Leave the rock piles and PKC as they are now. Participants stated that they view the East Island as “dead” because of the development so caribou will not return. Also, the current rock pile and PKC dams prevent access to most caribou due to the steep sides and large rocks.
- Cover the entire surface of the waste rock pile and PKC with fine, smooth gravel. This would allow access for caribou to pass freely over the waste rock piles and PKC. Further, the waste rock piles should be contoured to mimic the surrounding landscape.
- Design passages or corridors over or around the waste rock pile and PKC area. This would allow movement of caribou around, over and across the structures, but at specific locations. It was recommended that the general layout of these corridors should correspond to historic caribou trails on the island.

4.2 Fish Habitat – Reef Designs

Fish habitat has been designed for the A154/A418 pit area (Golder 2003, 2008 – see Appendix X-1 and X-2). The designs were prepared by fisheries biologists and engineers and reviewed by the Fisheries and Oceans Canada (DFO). Communities have provided general comment on the fish habitat designs.

4.3 Engagement Protocols

DDMI has developed a template for an Engagement Protocol for each of the Aboriginal organizations in order to clarify engagement needs and identify the appropriate contacts. Initial meetings have been held with leadership of each Aboriginal organization, with the concept being well received. Progress is being made to identify lead contacts for each organization.

5. Remaining Scope to be Completed

5.1 Detailed Scopes of Work (2011 to 2013)

5.1.1 Wildlife Movement

5.1.1.1 A desktop study is planned for 2011 that will involve a review of available TK on caribou and other wildlife in the Slave Geologic Province. Results from this work are expected to provide insight on traditional caribou trails in the area, and potentially information relating to vegetation preferences. This information can be used in combination with the options identified during the 2009 workshop to determine the best areas for caribou trails across the mine site.

5.1.1.2 In addition to the review, options generated during the 2009 workshop will need to be discussed in more detail with members from each of the Aboriginal organizations. The intent is to obtain more specific recommendations on preferred options and where/how to best incorporate those recommendations in the final closure design, while still taking into account technical considerations. DDMI would also like to work with the Aboriginal organizations to define appropriate closure specifications for the safe movement of wildlife including possible methods to deter wildlife from using areas if this is identified as a need.

5.1.1.3 DDMI hopes to discuss these topics in community-based, facilitated workshops as referred to in Section 2.4 of this report. The results of these workshops and the outcome of the recommendations will be recorded and distributed for review to Aboriginal organizations and the TK Panel.

5.1.2 Re-vegetation

5.1.2.1 A desktop study is planned for 2011 that will involve a review of available TK on vegetation in the Slave Geologic Province. Results from this work are expected to provide insight on the different types of plants and habitat in the area, and potentially information relating to wildlife use and/or consumption. This information may be used to determine the preferred plant species for re-vegetation from a wildlife use and consumption perspective, as well as identification of preferred habitat features and growing conditions for plant species.

5.1.2.2 The 5-year re-vegetation study conducted at Diavik also provides some insight on which types of plants, substrates and amendments are best suited to re-vegetation efforts. A summary of this data will be provided to Aboriginal organizations and it is expected that this information can be compared to Traditional Knowledge views on which of those species are suited to re-vegetation or are beneficial for wildlife.

A need for the Aboriginal organizations to identify the preferred options for wildlife to move around or through the mine site post-closure was noted above. The decision on which areas to re-vegetate will be linked to plans for wildlife movement or deterrence in the area of the mine site. Therefore, in addition to highlighting preferred routes for wildlife, Aboriginal organizations will also have to consider which areas of the mine site are most suitable or should be avoided for re-vegetation, with these movements in mind.

5.1.2.3 Similar to the process for Wildlife Movement, DDMI hopes to discuss these topics in community-based, facilitated workshops referred to in Section 2.4 of this report. The results of such workshops and the outcome of the recommendations would be recorded and distributed for review to Aboriginal organizations and the TK Panel described below.

5.1.3 Landforms

5.1.3.1 The aesthetic view of the land is important to community members who use the area. During the Environmental Assessment, Diavik provided a conceptual picture of what the mine site would look like after closure. It is worthwhile to use this picture as a starting point in discussing what Aboriginal organizations envision for the look of a closed mine site. With improved technology now available, DDMI can also work with Aboriginal organizations to begin developing more detailed images to assist community members in understanding what the site might look like. These images can incorporate different rock features, vegetation, or wildlife trails that community members may recommend.

5.1.3.2 After recommendations on wildlife movement, re-vegetation areas and general aesthetics have been received from the Aboriginal organizations, DDMI will assess the technical feasibility and material availability to meet these recommendations for key landforms. A model that best represents the final look of the land in relation to natural areas around the mine and remaining landforms associated with the mine would then be constructed. The model would be shared with each Aboriginal organization to obtain any further feedback and recommendations on possible further changes at the landscape level.

5.1.3.3 Again, DDMI hopes to discuss these topics in community-based, facilitated workshops referred to in Section 2.4 of this report. The results of such workshops and the outcome of the recommendations would be recorded and distributed for review to Aboriginal organizations and the TK Panel described below.

5.1.4 Community Engagement

5.1.4.1 As described in Section 2.4, DDMI plans to focus on community-based, facilitated workshops to develop more specific recommendations relating to closure options. The focus areas of these workshops would include wildlife movement, re-vegetation, landforms and fish habitat.

5.1.4.2 In addition to these workshops, DDMI is encouraging the development of a TK Panel under the Diavik Environmental Agreement.

Although the final decision on the structure and purpose of a TK Panel rests with the Aboriginal organizations, DDMI envisages a TK Panel that can be available to provide review, advise and make recommendations regarding closure aspects of the Diavik mine brought to the Panel. More specifically, what DDMI envisions for the TK Panel includes:

- a Panel consisting of two members from each of the five Aboriginal organizations that are a Party to the Environmental Agreement;
- preferably, 1 of the 2 members is considered a wildlife expert and the other an expert on water and fish;
- fees for the Panel would be fixed at a per diem rate, plus travel costs;
- the Panel would be accessible to any group requiring TK expertise; in this way, it would not only be available to DDMI and the Environmental Monitoring Advisory Board (EMAB), it could also be accessed by other mines, Boards and even government (should they require it);
- whichever group was requesting access to the Panel (e.g., DDMI vs. EMAB vs. Government) would pay the cost of the meetings; and
- groups would be required to use a facilitator when accessing the Panel, with the responsibility of bringing forward ideas to the Panel, recording opinions/outcomes and providing suggestions to all parties on how best to implement any opinions/outcomes from the Panel.

Current panels, such as those for Snap Lake and Colomac mines, provide good working examples and an opportunity to evaluate the strengths and weaknesses of each panel in developing the Terms of Reference for a TK Panel under the Diavik Environmental Agreement. It is DDMI's goal to learn from and build on past examples of efforts to obtain community participation and input into closure planning.

5.2 Conceptual Scopes of Work (After 2013)

5.2.1 Fish Habitat - Reef Designs

Construction of habitat features within the A418 and A154 dikes following the engineering design has started. Specifics of the reefs have not been finalized and will not be constructed until immediately before flooding. The design features of reefs being constructed inside the dikes would be reviewed by Aboriginal organizations to determine any habitat considerations that could be identified through TK. Recommendations would be recorded and considered in the final design of the reefs.

Additionally, DDMI is interested in working with Aboriginal organizations to identify any TK methods that may exist for determining fish use in different habitat areas. This information would be applied specifically for the outer edges of the dike and surrounding shoals.

Lastly, DDMI is interested in hearing any considerations or recommendations that Aboriginal organizations feel should be taken into account when the dikes are breached at closure.

DDMI hopes to discuss these topics in community-based, facilitated workshops referred to in Section 2.4 of this report. The results of such workshops and the outcome of the recommendations would be recorded and distributed for review to Aboriginal organizations and the TK Panel described below.

5.2.2 All Other Topics

Work scopes for tasks anticipated beyond 2013 are yet to be determined. Other scopes of work may be identified based on the results of tasks completed before 2013.

6. Linkages to Other Research and Life of Mine Plan

Specific linkages identified between other research and the Life of Mine (LOM) Plan include:

- Research from the test piles, including measurements of the thermally active zone depth in waste rock and PKC, may be used as information to be considered in the landform, wildlife movement and any re-vegetation of the rock pile and PKC areas.
- Information developed in support of closure criteria may be applicable to other closure management areas.
- Research on aspects of re-vegetation methods and materials conducted by DDMI.
- Further research on aspects of re-vegetation methods can potentially be coordinated with Ekati.
- Decision-making and planning relating to stockpiling of various wastes (vegetation, top soil, sewage sludge, North Inlet sludge and fine PK).

7. Project Tracking and Schedule

Projects are tracked by task. The expected task schedule is shown in Table 1.

Table 1 Planned Project Activities

Year	Activities
2011	• Desktop study on TK in SGP region – wildlife, vegetation. • Workshops with Aboriginal organizations re: wildlife movement/deterrence. • Summary of 5-year re-vegetation study at Diavik completed and communicated. • Engagement Protocols complete with each Aboriginal organization. • TK Panel established.
2012	• Workshops with Aboriginal organizations re: vegetation and landforms.
2013	• Construction of a closure model for the Diavik site. • Develop closure specifications for the safe movement of wildlife. • Identify any additional research that may be required.

8. Costs

Expected costs to complete the tasks described above are:

- Tasks completed (before 2011) – $250,000 plus in-kind costs;
- Task to be completed (2011-2013) – $400,000 plus in-kind costs; and

- Tasks remaining (after 2013) – to be determined.

9. References

Dalerum, F., S. Boutin and J. Dunford. 2007. *Wildfire effects on home range size and fidelity of boreal caribou in Alberta, Canada*. Canadian Journal of Zoology 85: 26-32.

Gunn, A. 1998. *Summer behaviour of Bathurst caribou at mine sites and responses of caribou to fencing and plastic deflector (July 1997)*. Final report to the West Kitikmeot Slave Study Society. http://www.enr.gov.nt.ca/_live/documents/documentManagerUpload/WKSS_Bathurst_Caribou_Behavior_2002.pdf

Joly, K., P. Bente and J. Dau. 2007. *Response of overwintering caribou to burned habitat in Northwest Alaska*. Arctic 60:401-410.

Matthews, S., H. Epp and G. Smith. 2001. *Vegetation classification for the West Kitikmeot Slave study region*. Final report to the West Kitikmeot Slave Study Society.

Appendix VIII-2 Open Pit, Underground and Dike Area Reclamation Research Plan

1. Uncertainty

Post-closure use of the open pit, underground and dike areas will be as aquatic habitat. Physical features, such as water depth, velocity and substrate type, and water quality conditions combine to define aquatic habitat. This Reclamation Research Plan examines aspects of both to obtain improved information regarding aquatic habitat requirements and expected post-closure conditions.

Final water quality in the flooded A418 and A154 pits were calculated to be similar to Lac de Gras water quality (Blowes and Logsdon 1998) based on information available at that time. Final water quality was governed by the water quality of Lac de Gras because the very large volume of this water reduced any influence from other contributing sources. The other contributing sources are primarily groundwater inflow and geochemical loading from the exposed pit wall surfaces and underground mine workings.

The initial water quality calculations were simple mass balance calculations. These calculations did not examine the vertical mixing conditions that will be expected to occur once the pits have been filled and the dikes breached, allowing circulation with Lac de Gras.

The initial calculations were also based on assumed distributions of different rock lithologies in the pit walls, initial geochemical reactivity estimates, and initial mine infiltration water quality, and did not include any geochemical loading associated with the underground mine workings. As these were initial estimates, there is a higher level of uncertainty in this information.

Fish habitat has been designed for the A154/A418 pit area inside the dikes (Golder 2003, 2008 - see Appendix X-1 and X-2). The designs were prepared by qualified fisheries biologists and engineers and reviewed by Fisheries and Oceans Canada. Communities have provided comment on the fish habitat work in general. A review to obtain any recommended modifications to the proposed fish habitat designs from a Traditional Knowledge (TK) perspective is include in the Community Engagement and Traditional Knowledge Reclamation Research Plan (Appendix VIII-1).

The exterior edges of the A154 and A418 dikes provide aquatic habitat during operations and also post-closure. The actual fish use of these exterior slopes has not been verified and is therefore a current uncertainty.

2. Research Objectives

The research plan is designed to answer the following questions:

- To what extent is vertical mixing expected to occur in the flooded area behind the dikes post-closure and would this impact on aquatic use of the surface (20 to 30 m depth) waters?
- What is the expected water quality of the pit and dike area a) after filling but before breaching the dikes and b) post-closure?
- Does the rate of flooding, within a practical range, impact significantly on expected water quality after filling or post-closure?
- Are fish using the exterior slopes of the A154 and A418 dikes?

3. Research Plan

Tasks completed (before 2011) include:

- Initial water quality predictions (Blowes and Logsdon 1998).
- Modelling of vertical mixing conditions (Appendix X-3).
- Water Quality Evaluation – Type III Waste Rock for Backfill (Appendix X-9).
- Initial water quality criteria for closure (Appendix V-Table V3).
- Ongoing monitoring of mine water inflow water quality and quantity (SNP Reporting).
- Ongoing research on estimating geochemical loading by rock sulphur content (Appendix VIII-3).

Tasks to be started (2011 to 2013) include:

3.1 Complete pit wall lithology maps;

3.2 Measure geochemical loading from pit wall;

3.3 Review science and possible Traditional Knowledge methods to evaluate fish use of dike exterior slopes; and

3.4 Evaluate fish use of exterior slopes of A154 and A418 dikes.

Remaining Tasks (after 2013) include:

3.5 Update predictions of final pit water quality using the modelling framework (Appendix X-3) with updated information on geochemical loading.

3.6 Water quality modelling will include all parameters that can be reasonably estimated using conservation of mass assumptions. The modelling will not include geochemical speciation, nitrification/denitrification, biological uptake, pH or dissolved oxygen.

3.7 Use model to evaluate impact of fill rate on water quality.

3.8 Use model to describe effects of groundwater flows into the flooded pit/dike area on post-closure water quality in the pit/dike area.

3.9 Conduct and document screening level risk assessment of predicted pit water quality.

Other tasks will be determined based on outcomes of current tasks.

4. Findings of Research Completed

Blowes and Logsdon (1998) provides predicted water quality for the A154 and A418 open pits in comparison with Lac de Gras water quality in Table 7 (copy attached). These initial estimates showed that the predicted water quality in the flooded pits is similar to Lac de Gras.

Initially mathematical modelling was completed of the vertical mixing processes that are expected to drive vertical mixing conditions in the pit area post-closure. Key findings were that the depth of vertical mixing was shallow relative to the pit depths and that the surface waters (top 20 m) became very similar to Lac de Gras water quality, effectively isolating the deep water in the pit area. It appears unlikely that events would occur where deep pit water would mix with surface water (see Appendix X-3). This modelling framework will be used in the future to update flooded pit water quality predictions.

Ongoing monitoring results from mine water inflows are included with the Surveillance Network Monitoring (SNP) regulatory reporting and Annual Water License Reports. Results continue to support initial estimates that show that mine inflow water will not be a significant determinant of surface water quality in a flooded pit. Ongoing monitoring will determine any changes from contact with underground mine workings, including Type III cemented backfill. Initial estimates indicate that the effect of using Type III versus Type I rock for backfill on water quality is minimal (see Appendix X-9). This information will be used to update flooded pit water quality predictions.

The research program for the waste rock area (Appendix VIII-3) is examining geochemical loading rates by rock type (% sulphur). When complete, these geochemical relationships will update the relationships originally used by Blowes and Logsdon (1998) to predict geochemical loadings from the flooded pit walls.

5. Remaining Scope to be Completed

Detailed Scopes of Work (2011 to 2013) include:

5.1 Geochemical loadings from the walls of the pit and underground workings are expected to be greater from areas with exposed biotite schist than areas with exposed granite. The walls of the open pit represent the larges surface are of rock that will washed by the flooding of the pit. The relative areas of granite versus biotite schist will be measured using photo imagery techniques and the results will be available for future updates to flooded pit water quality predictions.

5.2 Actual geochemical loading rates from pit or underground walls during flooding will be measured by spraying water over small sections of exposed granite and biotite schist and collecting and analyzing the wash water. These results will be compared with estimates from waste rock geochemical testing. The results will be available for future updates to flooded pit water quality predictions.

5.3 DDMI is working with Fisheries and Oceans Canada on a survey method for verifying fish use of the exterior slopes of the A418 and A154 dikes. This work may also be an opportunity to combine TK approaches. The information will be used to verify expected post-closure fish habitat use.

Conceptual Scopes of Work (after 2013) include:

5.4 Beyond 2013 the anticipated tasks relate to applying the results of reclamation research to update predictions of flooded pit water quality using the established mathematical modelling framework. The model is also expected to be used to evaluate the effect of different fill rates on flooded pit water quality and effects of post-closure groundwater flows on flooded pit water quality.

5.5 Predicted water quality conditions would then be used as the basis for a screening level risk assessment to determine if the predicted water quality is expected to pose an unacceptable risk to aquatic life. Outcomes from the assessment could include revisions to closure criteria, identification of additional research tasks and/or the need for a more detailed risk assessment (See Appendix VIII Introduction).

Other scopes of work may be identified based on the results of tasks completed before 2013.

6. Linkages to Other Research and Life of Mine Plan

Specific linkages identified include:

- Risk assessment framework is the same as general framework that will be applied to other closure management areas. Findings and information from this specific application may be applicable to other areas and the final closure assessment.
- Information developed in support of closure criteria may be applicable to other closure management areas.
- Information on impact of fill rates on water quality will be used in developing the pit fill plan.

7. Project Tracking and Schedule

Projects are tracked by task. The expected task schedule is shown in Table 1.

Table 1 Planned Project Activities

Year	Activities
2011	• Review science and possible Traditional Knowledge methods to evaluate fish use of dike exterior slopes. • Evaluate fish use of exterior slopes of A154 and A418 dikes. • Ongoing monitoring of mine water inflow water quality and quantity. • Ongoing research on estimating geochemical loading by rock sulphur content.
2012	• Complete pit wall lithology maps. • Ongoing monitoring of mine water inflow water quality and quantity. • Ongoing research on estimating geochemical loading by rock sulphur content.
2013	• Measure geochemical loading from pit wall. • Ongoing monitoring of mine water inflow water quality and quantity. • Ongoing research on estimating geochemical loading by rock sulphur content.

8. Costs

Expected costs to complete the tasks described above are:

- Tasks completed (before 2011) - $125,000.
- Task to be completed (2011-2013) - $75,000.
- Tasks remaining (after 2013) – to be determined.

9. References

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Golder. 2008. *Fish Habitat Design for the A418 Pit Shelf Area at the Diavik Diamond Mine*. Submitted to Diavik Diamond Mines Inc. December 2008.

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Appendix VIII-3 Waste Rock Pile Research (Seepage Quality, Quantity and Permafrost Development)

1. Uncertainty

This research plan is designed to improve understanding of the expected performance of the waste rock pile closure concept. The three areas of uncertainty are:

- quantity of water (seepage) that may be released from the dump;
- quality of any seepage water; and
- the rate, extent and persistence of permafrost development.

Characterizing better the seepage quantity and quality, and permafrost development in the dump will permit a more accurate prediction of closure performance. A more accurate prediction will ensure the closed dumps will not pose an unacceptable risk to people, wildlife or aquatic life.

The primary focus of closure research related to seepage and permafrost characteristics of waste rock is the Diavik Waste Rock Test Piles Project (Test Piles project). The Test Piles Project is a complementary laboratory and field study to measure and compare low sulphide waste rock and drainage characteristics. The project is a University-lead collaborative, multidisciplinary, multi-year project. The field portion is hosted by DDMI with researchers from the University of Waterloo, University of Alberta, and University of British Columbia. Additional funding is provided through the mining industry group International Network for Acid Prevention (INAP), Canadian government funding through the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Mine Environment Neutral Drainage (MEND) program.

Research from the Test Piles Project is focused on characterizing thermal regimes, gas transport, hydrology, microbiological populations and geochemical behaviour of low sulphide waste rock. The thermal regime (permafrost formation) is intimately linked to geochemical behaviour, and the hydrologic and gas transport regimes. The overall Test Piles research program includes academic research questions in addition to research specific to the behaviour and closure of the Diavik waste dumps. A summary of the Test Piles research related to closure is presented here.

2. Research/Study Objectives

Test Piles research related to dump closure aims to answer the following questions:

- How much drainage/seepage from the waste rock pile can be expected post-closure? What drainage quality can be expected?
- To what extent is water able to infiltrate through an unsaturated, coarse grained rock mass where interior temperatures may be below the freezing point of pure-phase water?

- If (discontinuous) zones of ice form within the pore spaces of the waste rock, how much water can percolate downward beneath the active zone that will form each summer on the top surface of a waste rock pile?
- If infiltration occurs, what are the flow mechanisms and what proportion of flow will report as seepage?
- For waste rock with an acid generation potential approximately equal to its neutralization potential, to what degree are the rates of oxidative dissolution of sulphide minerals and rates of dissolution of carbonates and aluminosilicate minerals influenced by the thermal state within the test piles?
- What will be the thermal evolution of the waste rock piles? How will permafrost development impact geochemical reactions and, therefore, drainage quality? What impact do a thermal and/or lower permeability cover have on permafrost and active development within the piles (and therefore drainage quality and quantity) of the piles?
- How effective are a Type I cover and a lower-permeability till layer in modifying hydrologic, thermal and geochemical conditions inside a waste rock pile?

3. Research Plan

3.1 Tasks Completed (Before 2011)

Completed tasks of the Diavik Waste Rock Test Piles studies related to closure include:

- Construction and instrumentation of six 2-m-scale experiments and three 15-m-high waste rock piles completed in 2007. One pile consists of Type I material, one pile consists of Type III material, and the third pile consists of a Type III core re-sloped and capped with 1.5 m of till and 3 m of Type I material as per the previous ICRP. Instruments and their purpose are listed in Table 1.
- Collection and analysis of waste rock samples for physical and geochemical characteristics.
- Tracer and applied rainfall tests for hydrologic characterization.
- Permeameter construction and experimentation to constrain hydrologic parameters.
- Ongoing data collection from installed instrumentation and initial interpretation of all data types (hydrology, geochemistry, thermal regime, gas transport regime).
- Instrument installation in three 40 m deep boreholes in the Type III dump. Instruments include air permeability probes, thermistors, gas sampling lines, suction lysimeters, and thermal conductivity probe access lines.

Table 1 Instrumentation and Measurement Purpose

Instrument	Target Measurement/Purpose
Air permeability probes	Internal test pile permeability to air flow
Basal drain collection lysimeters	Discrete collection of basal water flow (quantity) and quality
Basal drain collection lines	Bulk waster flow (quantity) and quality
Gas sampling lines	Internal test pile gas phase composition
Microbiology access ports	Internal test pile microbial populations (to answer academic questions rather than closure questions)
Suction lysimeters	Internal test pile water quality
TDR probes	Internal test pile moisture content / wetting front movement
Tensiometers	Internal test pile matrix water potential (unsaturated rock moisture tension)
Thermal conductivity probe access lines	Internal test pile thermal conductivity characteristics
Thermistors	Bedrock and internal test pile temperatures
2-m-scale experiments	Active zone (upper 2 m) water flow (quantity) and quality

3.2 Tasks to be Started (2011 to 2013)

In 2011 the Project will begin to transition from a focus on data collection and initial characterization to a focus on data interpretation and integration. Tasks include the following:

3.2.1 ongoing data collection from all instrument types in the test piles and the waste rock pile

3.2.2 installation of additional instrumentation in the waste rock pile;

3.2.3 interim characterization of geochemical loading rates for test piles;

3.2.4 interim characterization of gas transport regime and transport mechanisms in test piles;

3.2.5 interim characterization of hydrologic regime in test piles;

3.2.6 interim characterization of thermal regime in test piles and waster rock pile;

3.2.7 initial estimate of seepage water quantity and quality for a covered and un-covered waste rock pile under current and future climate change scenarios.

Task completion is dependent on timely delivery of data and interpretation by the University researchers.

3.3 Remaining Tasks (After 2013)

Data collection from all instrument types (led by University researchers) will continue through 2015, with interpretation and analysis extending beyond that time. Tasks to be completed after 2013 include:

3.3.1 complete data collection from all instrument types in the test piles and the waste rock pile;

3.3.2 deconstruction and sampling one of the Test Piles and direct observation of permafrost formation;

3.3.3 prepare instrumentation in waste rock pile for long-term monitoring;

3.3.4 final characterization of geochemical loading rates for test piles;

3.3.5 final characterization of gas transport regime and transport mechanisms in test piles;

3.3.6 final characterization of hydrologic regime in test piles;

3.3.7 final characterization of thermal regime in test piles and waster rock pile;

3.3.8 final estimate of seepage water quantity and quality for a covered and non-covered waste rock pile under current and future climate change

Similar to the tasks to be initiated from 2011 to 2013, task completion is dependent on timely delivery of data and interpretation by the University researchers. Results from specific tasks will be incorporated into closure plans when and where practicable.

Changes to these tasks may occur if the preceding tasks change because of budgetary, logistical or other factors, or results suggest different tasks are required to answer the research questions.

4. Findings of Completed Research

Data collection started in May 2007. Field data collection is an ongoing activity led by the University research group. Analysis and interpretation is often delayed. Preliminary interpretations of the available data include the following (University of Waterloo et al. 2009):

- the test piles are cooling but freezing and thawing annually;
- the till layer on one of the test piles acts as a thermal blanket, dampening thermal responses to ambient temperature changes;
- Type I and Type III piles are permeable to air with wind-induced gas transport enhancing oxygen transport;
- oxygen supply does not limit sulphide mineral oxidation;
- Type I pile sulphur concentrations are low and sulphide oxidation is balanced by acid neutralization (seepage remains circum-neutral);
- Type III sulphur concentrations are low, but at levels where sulphide oxidation rates exceed acid neutralization rates (pH fluctuates seasonally with near-neutral pH in the spring/early summer, dropping to pH ~4 towards the end of the summer);
- preliminary hydrology regimes indicate preferential flow is limited to high-intensity rainfall events; and
- the test piles have not attained dynamic equilibrium with to date, but are expected to by 2014.

Initial characterization and interpretations have been presented in numerous academic papers, conference proceedings and conferences, listed in the reference section. The 2009 progress report (University of Waterloo et al. 2009) was provided in early 2010. The research agreement between DDMI and the University, and the publisher's copyrights prevents DDMI from distributing data or reports directly. Data interpretations are available to the public upon publication of theses, peer-reviewed journal articles, and conference proceedings. DDMI can use the data and reports for internal purposes, including closure planning.

5. Remaining Scopes to be Completed

5.1 Detailed Scopes of Work (2011 to 2013)

In 2011 the Project will begin the transition from a focus on data collection and initial characterization to a focus on data interpretation and integration. Work scopes linked to tasks described in Section 3.2 are summarized below. Note tasks associated with water quality, water quantity and the thermal regime are dependent on timely delivery of data and interpretation by the University researchers. Results from specific tasks will be incorporated into closure plans when and where practicable.

Thermal:

5.1.1.1 based on the monitoring results from the test piles and waste rock pile as well as possible mathematical modelling, provide an interim estimate of the depth of annual thaw for the waste rock pile;

5.1.1.2 provide this estimate for scenarios assuming both a cover and no cover;

5.1.1.3 determine the effect of a climate change scenario on these initial estimates; and

5.1.1.4 revise estimates with any changes in monitoring information, mathematical modelling or cover design parameters.

Hydrological:

5.1.2.1 based on the monitoring results from the test piles and thermal analysis provide an interim estimate of the fraction of rainfall and snow melt expected to travel within the annual thaw zone and exit the waste rock pile as seepage;

5.1.2.2 provide this estimate for scenarios assuming both a cover and no cover;

5.1.2.3 determine the effect of a climate change scenario on these initial estimates; and

5.1.2.4 revise estimates with any changes in monitoring information or cover design parameters.

Geochemical:

5.1.3.1 based on the monitoring results from the test piles, thermal analysis and hydrological analysis provide an interim estimate of the geochemical loading rates in seepage from the waste rock;

5.1.3.2 provide this estimate for scenarios assuming both a cover and no cover;

5.1.3.3 determine the effect of a climate change scenario on these initial estimates; and

5.1.3.4 revise estimates with any changes in monitoring information or cover design parameters.

Changes to these tasks may occur if the preceding tasks change because of budgetary, logistical or other factors, or results suggest different tasks are required to answer the research questions. Furthermore, new research questions could arise that would require new tasks.

5.2 Conceptual Scopes of Work (After 2013)

Work scopes for the task to be conducted after 2013 have not yet been defined but the tasks include the following:

5.2.1 finalize estimates of post-closure thermal, hydrological and geochemical conditions for the waste rock pile;

5.2.2 final evaluation of the expected performance of a Type I and till cover, as compared with no cover, on seepage water quality and quantity;

5.2.3 evaluation of cost-benefit of a waste rock pile cover; and

5.2.4 document the results and interpretations from test pile program through scientific publications;

Other scopes of work may be added or amended as data is collected and reviewed.

6. Linkages to Other Research/Studies and Life of Mine Plan

Research associated with the Diavik Test Piles Waste Rock Project is related to long-term waste rock management, seepage management and dump closure. Information from this research may:

- support closure criteria for other closure management;
- identify progressive reclamation opportunities;
- contribute to optimizing pile aesthetics and/or wildlife access/exclusion; and/or
- influence waste and/or water management.

7. Project Tracking and Schedule

Progress reports are provided by the University research team annually (e.g., Appendix X-6). The research team meets with DDMI personnel at the beginning of each field season to discuss upcoming activities, and conference calls are held weekly during the field season to ensure task are being completed and research objectives are being met. The research team and DDMI mutually agree upon a comprehensive list of Project milestones and deliverables, which are required for ongoing funding.

A general project schedule for the field portion of the Project from Project inception is provided in Table 4.

Table 4 Field Activities From Project Inception

Year	Activities

2004	Preliminary earthworks and project planning
2005	Initiation of construction and finalization of design
2006	Construction of test piles and 2-m-scale experiment
2007	Completion of test pile construction and first season of data collection
2008	Data collection and installation maintenance
2009	Data collection and installation maintenance
2010	Installation of instruments in the full-scale dump, data collection and installation maintenance
2011	Data collection and installation maintenance; data analysis and interpretation
2012	Data collection and installation maintenance, data analysis and interpretation
2013	Deconstruction of one test pile, data collection and installation maintenance, data analysis and interpretation
2014	Data collection and installation decommissioning
2015	Data collection and compilation

8. Costs

In-kind costs and direct cash costs to DDMI from the Project initiation in 2004 to the end of 2008 were approximately CAD$ 3,680,000. Additional funding contributed by other sponsors (CFI, NSERC, INAP, MEND) is not included in this cost estimate.

An additional CAD$ 1,735,000 (approx.) has been committed by DDMI for 2009 to 2014, the expected completion date. Additional funding contributed by other sponsors is not included in this cost estimate.

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A description of the Diavik project was incorporated into Birdsall-Dreiss lectures presented at approximately 25 academic institutions in Canada, the United States, Australia and Germany.

Appendix VIII-4 Processed Kimberlite Containment Area Reclamation Research Plan

1. Uncertainty

This research plan is designed to improve understanding of the expected geochemical and geotechnical performance of the Processed Kimberlite Containment (PKC) closure concept. The two areas of uncertainty are:

- quality of the water that will be released through both the design outlet and seepage; and
- surface stability.

Characterizing better the geochemical and geotechnical properties will permit a more accurate prediction of closure performance. A more accurate prediction will ensure the closed PKC facility will not pose an unacceptable risk to people, wildlife or aquatic life.

DDMI has questioned the ability of a till layer within the approved PKC cover design to perform as an impermeable barrier given the unconsolidated nature of the material it is to cover. This research plan will also address this question.

2. Research Objectives

The research plan is designed to answer the following questions:

- To what extent are the slimes of the Fine Processed Kimberlite (FPK) able to consolidate? What is the proportion and influence of clay minerals in the FPK slimes?
- What is the thermal evolution of the PKC beaches?
- What is the water quality of the water in the slimes? Does the water chemistry change spatially and/or temporally? To what extent will this water be expelled during consolidation?
- What is the expected water quality of surface water that travels through the unsaturated PK beaches?
- What is the expected water quality and quantity in the engineered outlet and any seepage pathways?
- Would expected outlet and/or seepage water quality pose an unacceptable risk to people, wildlife or aquatic life?
- Will the till layer in the 2001 ICRP cover design perform adequately as an impermeable barrier?

3. Research Plan

3.1 Tasks Completed (Before 2011)

Completed tasks related to geotechnical characterization include:

- engage competent consultants (AMEC);
- data review of available geotechnical data related to consolidation and thermal regime;
- piezocone testing of the PKC beach; and
- piezocone testing of the PKC slimes.
- Completed tasks related to geochemical characterization include:

- geochemical characterization of Diavik kimberlites (Blowes and Logsdon 1998);
- engaged competent consultants: Alberta Innovates Technology Futures (AITF) and CANMET Mining and Mineral Sciences Laboratory (CANMET);
- preliminary sampling and instrument installation in FPK for pore water chemistry characterization;
- sampling for FPK mineralogical characterization related to in situ geochemical reactions and pore water chemistry;
- water sample collection from standpipe piezometers;
- preliminary interpretation of PKC geochemical mass balance;
- core sample collection for pore water sampling and mineralogical studies;
- pore water sampling from FPK beach sediments (core squeezing); and
- initial mineralogical evaluation of beach FPK for primary and secondary mineralogy.

Completed tasks related to water quality criteria include:

6 Developed initial water quality criteria (Appendix V, Table V7).

3.2 Tasks to be Started (2011 to 2013)

Tasks related to geotechnical characterization include:

3.2.1.1 interpretation and analysis of piezocone testing of the PKC slimes;

3.2.1.2 laboratory tests for slimes characterization, as required; and

3.2.1.3 installation of thermistors in the beach and/or slimes and collection of thermal data.

3.2.1.4 Contract an engineering review of the 2001 cover design performance, particularly the till layer.

Tasks related to geochemical characterization include:

3.2.2.1 annual or semi-annual sample collection from surviving/accessible standpipe piezometers (as accessible);

3.2.2.2 pore water chemistry trend analysis and interpretation; and

3.2.2.3 laboratory and/or small-scale field leaching experiments.

Tasks related to water quality criteria include:

3.2.3.1 conduct and document screening level risk assessment of outlet and seepage water; and

3.2.3.2 update water quality closure criteria, as required.

3.3 Remaining Tasks (After 2013)

3.3.1 thermal modelling including modelling of climate change scenario;

3.3.2 hydrological modelling;

3.3.3 predictions of seepage and outlet water quality;

3.3.4 conduct and document detailed level risk assessment, if required;

3.3.5 continued pore water chemistry sampling;

3.3.6 update closure criteria, as required.

4. Findings of Research Completed

4.1 Geotechnical Characterization

Results from the geotechnical characterization program are limited to interpretations from the 2008 piezocone program that characterized beach sediments. The 2008 work was conducted by Contec under the direction of Golder. Results include the following:

- FPK near the dams (beach deposits) are sand to silty sand with some minor zones of silty sand to sandy silt;
- in situ dry densities are typically around 1,000 kg/m^3, with occasional higher in situ densities measured (1,400 kg/m^3 and 1,990 kg/m^3) in frozen layers;
- frozen layers exist within the FPK beach deposits however the thickness of these layers were not identified;
- a marginal increase in density in the FPK beach with depth.

Results from the 2009 piezocone sampling in the slimes are not yet available. The work was conducted by Contec, under the direction of AMEC.

4.2 Geochemical Characterization

Results from the geochemical characterization program conducted are not complete but include:

Geochemical characterization of the Diavik kimberlites (baseline) by Blowes and Logsdon (1998):

- Kimberlite material contains xenoliths of sedimentary material (mudstone and siltstone); sedimentary material comprises 2 to 5%, with the remaining comprised primarily of the ultramafic minerals olivine and pyroxenes and the weathering products of these minerals.

- Whole rock analyses indicated that kimberlite material contains greater concentrations of nickel (Ni), cobalt (Co), chromium (Cr), and magnesium (Mg) than the adjacent country rock.
- The mean sulphide content of the kimberlite samples was 0.34 wt%S and most pyrite is present as framboids.
- Abundant calcite is present in the samples and the kimberlites and are unlikely to generate acidic drainage, however framboidal pyrite has the potential to release sulphate, iron (Fe), and possibly other metals if exposed subaerially.
- pH values of greater than 8.5 generated in leach tests suggest that some dissolution of the mafic aluminosilicate minerals is occurring.
- Kinetic testing indicated a persistence of near neutral pH, sulphate concentrations of Ni, Co, copper (Cu), zinc (Zn) and sulphate that would require monitoring, a decline in calcium (Ca) (and the likely precipitation of gypsum), low Fe concentrations (and the likely precipitation of Fe-oxyhydroxides).

Preliminary mineralogical investigation of Fine Processed Kimberlite (FPK) by Canada Centre for Mineral and Energy Technology (CANMET):

- Most abundant mineral is olivine, followed by lizardite with biotite, calcite, quartz and garnet and an amorphous magnesium-silica-aluminum phase.
- Pyrite is present as grains and framboids.
- High neutralization potential and very unlikely to become acid generating.

Preliminary results from field sampling conducted by AITE (additional information collected during pore water program):

- The active frost-free zone is below 1 m on the beach and the active zone increased over the course of the summer.
- No frost was encountered in the slimes (from the reclaim barge).
- Groundwater flow across the East Beach of the PKC is downward at the toe of the dam and upward near the pond.
- There is an upward gradient in the slimes.

Pore water chemistry from cores and from piezometers installed in the beach and in the slimes:

- Highest concentration of dissolved metals, major cations and sulphate were measured in the unsaturated zone; elevated ion concentrations are likely due to weathering processes.
- Pore water collected from the piezometers installed in the slimes had the lowest concentration of dissolved ions.
- Concentrations of dissolved metals in the slimes were below the current Effluent Quality Criteria (except zinc, which exceeded the criteria at the deepest sampling location).

- Isotope analysis suggest sulphate in the pore water is derived from sulphide mineral oxidation.

4.3 Initial Water Quality Criteria

The Water Quality Criteria developed for closure are provided in Appendix V, Table V-7 and were based on criteria for drinking water and protection of aquatic life. The criteria were developed primarily from Canadian Council of Ministers of the Environment (CCME) Guidelines (CCME 1999) with some site specific adaptation. Values in Table V-7 in the column titled “Waters Entering Lac de Gras” have an assumed mixing factor of 23 (value used for operations discharge criteria) to illustrate how closure criteria should be developed. The mixing factor of 23 was also used to develop the operations discharge criteria and represents concentrations that Lac de Gras can reasonably accommodate such that surface runoff water quality that may be above water quality standards as it drains from the mine site, but ends up below water quality standards some reasonable distance into Lac de Gras.

5. Remaining Scopes to be Completed

5.1 Detailed Scopes of Work (2011 to 2013)

Geotechnical:

5.1.1.1 Interpretation and analysis of piezocone testing of the PKC slimes to determine consolidation rates and magnitudes. An estimation of consolidation rates and magnitudes can provide an indication of final landscape/topography, and the volume of pore water that may be expelled during consolidation.

5.1.1.2 Laboratory tests for additional slimes characterization, could contribute to estimates of consolidation rates and magnitudes.

5.1.1.3 Installation of thermistors in the beach and/or slimes and collection of thermal data can provide an indication of permafrost development and the propensity for thermokarst topography.

5.1.1.4 Contract a qualified engineer to review the 2001 cover design for the PKC. Specifically to provide expert opinion on the expected performance of the till layer as an impermeable layer over an unconsolidated PK material and provide a written report.

Geochemical:

5.1.2.1 Annual or semi-annual sample collection from surviving/accessible standpipe piezometers (as accessible); to monitor changes to pore water chemistry and identify any potential elements of concern.

5.1.2.2 Pore water chemistry trend analysis and interpretation; to identify any changes in pore water chemistry over time and identify any potential elements of concern.

5.1.2.3 Laboratory and/or small-scale field leaching experiments to monitor accelerated and in situ weathering of FPK and the resultant water quality.

5.1.2.4 Pore water chemistry modelling based on pore water chemistry trends, and laboratory experiments and/or small-scale field experiments that may include predictive/reactive transport modelling.

5.1.2.5 A screening level risk assessment using available PKC pond monitoring (SNP 1645-16) information, pore water chemistry information, and laboratory and/or field experiment preliminary results to estimate possible outlet and seepage water quality. This risk assessment will identify parameters of potential concern and may help focus characterization of sources (e.g., pore water, beach runoff) or processes (e.g., freezing, oxidation) governing the concentrations in the outlet and seepage water.

Water Quality Criteria:

5.1.3.1 A screening level risk assessment will be completed based on initial estimates of probable ranges of outlet and seepage water quality and quantity. Water quality criteria from Appendix V, Table V7 will be used as the basis for screening. Areas where exposure concentrations will be estimated include the streams and or inland lakes along any outlet or seepage pathway and areas of Lac de Gras.

5.1.3.2 Update water quality criteria, if required.

Other scopes of work may be identified based on the results of the analysis described above.

5.2 Conceptual Scopes of Work (After 2013)

Work scopes for the task to be conducted after 2013 have not yet been defined but the tasks include:

5.2.1 thermal modelling including modelling of climate change scenario;

5.2.2 hydrological modelling;

5.2.3 predictions of seepage and outlet water quality;

5.2.4 conduct and document detailed level risk assessment, if required;

5.2.5 continued pore water chemistry sampling;

5.2.6 update closure criteria; and

Other scopes of work may be identified based on the results of tasks completed prior to 2013.

6. Linkages to Other Research and Life of Mine Plan

Specific linkages identified include:

- information developed to support closure criteria for other closure management areas may be applicable to the PKC area and vice versa;
- information from this research may alter the operations plan for the PKC; and
- information from this research may alter the closure design concept for the PKC.

7. Project Tracking and Schedule

Projects are tracked by task. The expected task schedule is shown in Table 1.

Table 1 Planned Project Activities

Year	Activities
2011	**Geotechnical** Interpretation and analysis of piezocone testing of the PKC slimes; Laboratory tests for slimes characterization, as required; and Installation of thermistors in the beach and/or slimes and collection of thermal data. Engineering review of till layer in cover design. **Geochemical** Annual or semi-annual sample collection from surviving/accessible standpipe piezometers (as accessible). Pore water chemistry trend analysis and interpretation. Laboratory and/or small-scale field leaching experiments.
2012	**Geotechnical** Collection of thermal data. **Geochemical** Annual or semi-annual sample collection from surviving/accessible standpipe piezometers (as accessible). Pore water chemistry trend analysis and interpretation. Laboratory and/or small-scale field leaching experiments. **Water Quality Criteria** Conduct and document screening level risk assessment of outlet and seepage water. Update water quality closure criteria.
2013	**Geotechnical** Collection of thermal data. **Geochemical** Annual or semi-annual sample collection from surviving/accessible standpipe piezometers (as accessible). Pore water chemistry trend analysis and interpretation. Laboratory and/or small-scale field leaching experiments.

8. Costs

Expected costs to complete the required tasks are:

- Tasks completed (before 2011) - $300,000;
- Task to be completed (2011-2013) - $370,000; and

Tasks remaining (after 2013) – to be determined.

9. References

Blowes, D.W. and M.J. Logsdon. 1998. *Diavik Geochemistry Baseline Report*. Prepared for Diavik Diamond Mines Inc. September 1998.

CCME 1999. Canadian Water Quality Guidelines for Protection of Aquatic Life. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of Environment 1999. Winnipeg

Appendix VIII-5 North Inlet Reclamation Research Plan

1. Uncertainty

The North Inlet Water Treatment Plant (NIWTP) removes particulate material and phosphorus from mine water before discharging the water to Lac de Gras. The removed material forms a sludge that is disposed, via pipeline, at the bottom of the North Inlet (NI). There is uncertainty associated with the ecological characteristics of this accumulated sludge and the risk associated with reconnecting the NI and Lac de Gras. Results of this research will be used to guide closure planning for the NI.

2. Research Objectives

The research plan is designed to answer the following questions:

- What is the level of ecological and human health/safety risk for the disposal of NIWTP sludge in the NI now and at closure? Is management action required?
- What are the disposal alternatives for the NIWTP sludge?
- What NI sediment and water quality concentrations would be acceptable for exposure of people, wildlife and aquatic life?

3. Research Plan

Tasks completed (before 2011) include:

- initial ecological characterization of NIWTP Sludge (de Rosemond and Liber 2005);
- sludge disposal alternatives (Golder 2010 - Appendix X-5); and
- field sampling for 2010 characterization of NI sediments and NIWTP sludge.
- analysis and Interpretation of results from 2010 NI sediment and NIWTP sludge characterization;

Tasks to be started (2011 to 2013) include:

3.1.1 follow-up studies and testing from 2010 characterization program to isolate the source of measured biological responses.;

3.1.2 conduct and document screening level risk assessment for NI water and sediment quality;

3.1.3 conduct and document detailed level risk assessment, if required;

3.1.4 develop risk management strategy, if required; and

3.1.5 updated water and sediment closure criteria.

Remaining Tasks (after 2013) include:

3.2.1 characterization of NI sediments and NIWTP sludge (2015);

3.2.2 conduct and document screening level risk assessment – NI water and sediment quality;

3.2.3 conduct and document detailed level risk assessment, if required; and

3.2.4 finalize water quality and sediment criteria.

4. Findings of Research Completed

The initial ecological characterization of the NIWTP sludge (de Rosemond and Liber, 2005) did not identify any material properties that would be expected to prohibit the establishment of productive aquatic habitat. de Rosemond and Liber (2005) conducted standard toxicological and chemical testing of the sludge, sludge leachates and sludge pore water. Ammonia was identified as the main constituent of toxicological concern in the sludge, sludge pore water and sludge leachate with concentrations ranged from 15 to 30 mg/L in the pore-water

A second investigation was initiated in 2010 to characterize the sludge material in the laboratory and the field (Golder 2011 - Appendix X-10). The study design involved sampling five stations within the North Inlet and three reference stations in Lac de Gras. Surface sediments from each station were assessed for sediment chemistry, toxicity and benthic invertebrate structure; sub-surface sediments from the NI stations were assessed for sediment chemistry. NIWTP sludge was also assessed for sediment chemistry and toxicity. Field work was completed in August and laboratory testing with laboratory testing and analysis was expected to be complete by the end of 2010

Results of this assessment indicate that the NIWTP sludge, four of the five NI samples, and all three reference samples contained elevated concentrations of some parameters that were identified as being potentially toxic to aquatic life. However, elevated concentrations present in reference sediments were not associated with adverse biological effects and therefore corresponding elevated concentrations could not always be clearly associated with the adverse biological effects that were observed for the sludge and NI sediments. Results of the sediment toxicity tests and benthic taxonomy analyses showed that NIWTP sludge was toxic in standard sediment toxicity tests, and that sediments from 4 of the 5 NI stations were also classified as toxic and had impoverished benthic invertebrate communities.

The adverse biological effects observed for the NIWTP sludge and sediments from the NI were not attributable to a single stressor. It appears that a combination of organic or nutrient enrichment contributed adverse biological effects at some NI stations whereas metals may have been a contributing factor at other NI stations. The lack of suitable benthic habitat in areas of the NI where the layer of unconsolidated material on the sediment surface was relatively thick was also a factor. Despite the adverse biological effects associated with NI sediments, there was evidence of a resident zooplankton community in the water column within the NI.

Although effects were observed within the NI, it is unlikely that opening the NI to Lac de Gras would adversely affect the water quality of Lac de Gras. However, with respect to whether the NI could be opened up at mine closure and allowed to return naturally to fish habitat, the results obtained from the 2010 study were insufficient to adequately address this question.

Golder (2010) (Appendix X-5) conducted a preliminary review of alternatives to depositing the sludge in the North Inlet. The alternatives included the following:

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

Further investigations of alternatives will be dependent upon results from current or future the sludge characterization studies.

DDMI initiated a more extensive characterization in 2010. The field component included sampling of the NIWTP sludge, sediments and benthic invertebrates within the NI and sediments and benthic invertebrates from a reference location (Site FF1 from the Aquatic Effects Monitoring Program). Sediment and sludge samples were submitted for standard toxicity, chemical and particle size testing. Benthic invertebrate samples were submitted for taxonomic enumeration. Results are not yet available.

5. Remaining Scope to be Completed

Detailed Scopes of Work (2011 to 2013):

5.1.1 As follow-up from Golder (2011): a) estimate leaching potential of contaminants from NI sediment, b) confirm sediment chemistry and toxicity in NI sediment, c) conduct additional chemical and toxicological testing on NIWTP sludge, d) conduct zooplankton sampling in NI, and e) model acceptable NI water quality conditions for a partial breach to Lac de Gras as a closure alternative.

5.1.2 Chemistry, toxicology and benthic invertebrate results for the sludge and NI sediment will be compared to results from the reference area and national standards/guidelines for aquatic sediments. Results will be interpreted by applying guidance from the Fisheries and Oceans Canada *Framework for Addressing and Managing Aquatic Contaminated Sites Under the Federal Contaminated Sites Actions Plan* (Chapman 2010).

5.1.3 The framework follows the risk assessment approach of: 1) Problem Formulation; 2) Screening Levels Risk Assessment; 3) Detailed Level Risk Assessment; and 4) Risk Management. The framework is specifically designed for aquatic sediments and follows a stepwise approach using results from one step to determine subsequent steps. The results from the 2010 study should be sufficient for the first two steps and possibly a preliminary Detailed Level Risk Assessment, if required.

This analysis is expected to answer the first research question “Does the disposal of NIWTP sludge in the North Inlet pose an unacceptable human or ecological risk, now or at closure, such that management action is required?”

5.1.4 If it is determined that immediate operational management action is required, the preliminary review of disposal alternatives (Golder 2010 – Appendix X-5) will be used as a starting point to develop a possible risk management strategy. If risks are identified for closure, appropriate management action would also include alternative closure designs that would mitigate risks.

5.1.5 Results of the risk analysis will also be used to develop initial closure criteria for NI sediment and water quality. Inherent in each level of the risk assessment framework is the explicit consideration of sediment and water quality conditions that do not pose unacceptable risks. This information will be used as a basis to define initial closure criteria for the NI and will answer the third research question: “What are the NI sediment and water quality concentrations that would not pose an unacceptable risk to people, wildlife and aquatic life?”

Other scopes of work may be identified based on the results of this risk analysis.

Conceptual Scopes of Work (after 2013) include:

5.2.1 Work scopes for tasks anticipated beyond 2013 include repeating the field and laboratory study conducted in 2010 and updating the risk assessment, risk management strategy and closure criteria as appropriate, based on the results.

Other scopes of work may be identified based on the results of this risk analysis.

6. Linkages to Other Research and Life of Mine Plan

Specific linkages identified include:

- the risk assessment framework is based on the general framework that will be applied to other closure management areas. Findings and information from this specific application may be applicable to other areas and the final closure assessment;
- information developed in support of closure criteria may be applicable to other closure management areas;
- information from the NI sediment characterization of ammonia oxidizing microbial communities may be a source of information for the risk assessment; and
- outcomes of any risk management strategy may alter the operations plan for the NIWTP and/or the closure plan for the NI.

7. Project Tracking and Schedule

Projects are tracked by task. The expected task schedule is shown in Table 1.

Table 1 Planned Project Activities

Year	Activities
2011	• Implement follow-up studies and testing from the 2010 NI Sediment Investigation
2012	▪ Conduct and document screening level risk assessment – NI water and sediment quality. ▪ Conduct and document detailed level risk assessment, if required. ▪ Develop risk management strategy, if required. ▪ Updated water and sediment closure criteria.
2013	• No tasks currently scheduled.

8. Costs

Expected costs to complete the tasks described above are:

- Tasks completed (before 2011) - $150,000;
- Task to be completed (2011-2013) - $150,000; and
- Tasks remaining (after 2013) – to be determined.

9. References

de Rosemond, S. and K. Liber. 2005. *Ecological Characterization of the Effluent Produced by the North Inlet Water Treatment Plant at the Diavik Diamond Mine*. Prepared for Diavik Diamond Mines. April 1, 2005.

Chapman, P.M. 2010. *Framework for Addressing and Managing Aquatic Contaminated Sites Under the Federal Contaminated Sites Actions Plan (FCSAP)*. Prepared for Fisheries and Oceans Canada by Golder Associates Ltd.

Golder (Golder Associates Ltd.). 2010. *Alternatives for North Inlet Water Treatment Plant Sludge*. Prepared for Diavik Diamond Mines Inc. December 2010.

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Appendix VIII-6 Infrastructure Area Reclamation Research Plan

1. Uncertainty

1.1 Re-vegetation Methods

Complementary field and laboratory (greenhouse) studies lead by the University of Alberta, are ongoing. Funding for the project has been provided by Diavik and the National Science and Engineering Research Council (NSERC). Little research has been conducted on re-vegetation of disturbed mine sites in the North American arctic. Establishment of native plant cover is often slow in arctic environments, particularly if adjacent native seed sources are not present (Bishop and Chapin III 1989). Research is focused on improving knowledge of soil and plant characteristics and processes on disturbed and reference sites at the mine to develop ecologically and economically effective methods to enhance the re-establishment of tundra communities following mine closure (Naeth and Wilkinson 2008).

1.2 Contaminated Soils

During normal mine site operation spills from heavy equipment and vehicles, primarily of diesel fuel and heavy hydraulic oils, and occasional antifreezes results in some finer hydrocarbon-contaminated materials being collected for land-farming in the Waste Transfer Area. An approach to managing and disposing of hydrocarbon-contaminated materials is required in support of closure planning. An uncertainty relates to the contaminant levels and disposal approaches that would not pose an unacceptable risk to human and ecological receptors.

1.3 Closure Reference Concentrations

Specific closure criteria are not available in the form of NWT or Federal Standards for some parameters, mediums or valued ecosystem components. Where there are NWT and/or Federal Standards they may or may not be relevant to the Diavik site. Reference concentrations can be developed using a standardized approach. Reference concentrations once developed can be compared with predicted or measures post-closure concentrations and assist in understanding the significance of a result.

1.4 Post-Closure Vegetation Metals Level Risk

Communities and the Environmental Monitoring Advisory Board have identified a potential concern that post-closure vegetation that colonizes naturally or that has been established through a closure re-vegetation program may accumulate metals to a level that would pose an unacceptable risk to wildlife or people. Metal uptake in vegetation that would cause an unacceptable risk to wildlife and people is currently uncertain.

2. Research Objectives

The research plan was designed to answer the questions in Sections 2.1 to 2.3.

2.1 Re-vegetation Methods

- Which substrates are most effective for enhancing soil properties and native plant community development?
- Which soil amendments are most effective at enhancing substrate properties (texture, organic matter and nutrient contents and water holding capacities), native plant establishment and community development?
- Which groups and individual native plant species can establish and survive on a variety of soil substrates and amendments?
- What is the effect of microtopography including boulders, rocks, soil mounds and pockets on plant emergence and establishment?
- Which methods are most effective in establishing native shrubs with wild collected seed and stem cuttings?
- What is the effect of stem cuttings collection time on shrub establishment and survival?
- Is there an effect on stockpiling salvaged topsoil on its prospective use as a soil amendment and source of native propagules for reclamation of disturbed sites?

2.2 Contaminated Soils

- Can petroleum hydrocarbon-contaminated soil be disposed of on-site in a manner that would not pose an unacceptable risk to human and ecological receptors?

2.3 Closure Reference Concentrations

- What are appropriate site-specific risk based reference concentrations for water, soil, dust, plants and prey that will not pose unacceptable risks to wildlife or people post-closure?

2.4 Post-Closure Vegetation Metals Level Risk

- How likely is it that post-closure vegetation (naturally colonized and revegetated) would have metals levels greater than the risk-based closure reference concentrations?
- If it is likely, how can post-closure metal levels in vegetation be better quantified?
- If post-closure metals levels in vegetation remains as a high risk contaminant pathway, how can post-closure metals levels be monitored?

3. Research Plan

3.1 Tasks Completed (Before 2011)

Re-vegetation:

- establishment of re-vegetation research plots;
- initial testing of substrates, amendments and plant species;
- installation of climate stations;
- collection and testing of softwood cuttings; and
- soil sampling and vegetation assessment.

Closure Reference Concentrations:

- initial reference concentrations; and
- initial closure criteria.

3.2 Tasks to be Started (2011 to 2013)

Re-vegetation:

3.2.1.1 continued monitoring of re-vegetation research plots;

3.2.1.2 interpretation and documentation of field and laboratory monitoring results;

3.2.1.3 assess information availability and applicability from Ekati;

3.2.1.4 assess confidence in developing re-vegetation procedure; and

3.2.1.5 identify any additional research that may be required and long-term monitoring scope for existing re-vegetation research plots.

Contaminated Soils:

3.2.2.1 conduct and document risk assessment for options for management and disposal of petroleum hydrocarbon contaminated materials.

Closure Reference Concentrations

3.2.3.1 develop site-specific, risk-based closure reference concentrations;

3.2.3.2 document and distribute for review; and

3.2.3.3 update closure criteria.

Post Closure Vegetation Metals Level Risk

3.2.4.1 literature review to determine potential metals levels in plant that may be used for re-vegetation and that are expected to colonize naturally;

3.2.4.2 compare these literature values with risk-based closure reference concentrations; and

3.2.4.3 determine if there is a need to further research this potential contaminant pathway.

3.3 Remaining Tasks (After 2013)

3.3.1 document and distribute re-vegetation procedure;

3.3.2 document and distribute hydrocarbon contaminated soils procedure;

3.3.3 if expected exposure concentrations of metals in water, soil, dust, plants or prey are identified as posing an unacceptable risk to wildlife or people, then specific research plans may need to be developed to address associated uncertainties; and

3.3.4 if metals levels in post-closure vegetation remains a high risk contaminant pathway, determine appropriate post-closure monitoring methods as per Water License Part L, Item 3f.

4. Findings of Research Completed

4.1 Re-vegetation Methods

Data collection started in 2004. Field data collection is an ongoing activity, often with delayed analysis and interpretation. Preliminary interpretations of the available data include the following:

- Plan densities and cover continued to increase through increased 2009.
- Native grass cultivars and some native forbs successfully established but dwarf birch did not establish from seed.
- Treatments that performed well in the first few years are not necessarily the ones that had the highest densities and cover in 2009, and cover was influenced by treatment substrate and soil amendment.
- Processed Kimberlite (PK) continues to be a poor substrate for plant growth, regardless of soil amendment or species sown.
- The addition of salvaged top soil, North Inlet Water Treatment Plant sludge or sewage sludge is consistently a component of the top three performing treatments for any given substrate.
- Spring seeding resulted in greater plant cover than fall seeding across all soil treatments.
- Grass-dominated seed mixes consistently perform better than those dominated by forbs or shrubs.
- Shrub cuttings had poor survival. Best were crowberry followed by bear berry and cranberry.
- Of the seeded species sweet pea established in low densities. Fireweed was the most abundant species and established naturally.
- Water erosion of seed, cuttings and topsoil was an issue in some plots.

References that are directly or indirectly linked to DDMI's re-vegetation efforts are included in the References section. Annual progress summaries of the re-vegetation studies are included with the Annual Water License Reports submitted to the WLWB.

4.2 Closure Reference Concentrations

A similar program was conducted in 1998 (Mucklow and Swanson 1998) and will be used as a starting point for this work. Table 5 attached from Mucklow and Swanson (1998) is a relevant result from that work.

5. Remaining Scope to be Completed

5.1 Detailed Scopes of Work (2011 to 2013)

5.1.1 Re-vegetation

Monitoring of re-vegetation research plots will continue through 2011 when emphasis will shift from data collection to documentation and interpretation. Findings from this initial research will then be combined with information availability and applicability from Ekati research, and any other recent research to assess confidence in specifying a re-vegetation procedure for closure. It is possible that there will still be some uncertainties with aspects of the re-vegetation procedure that will need to be addressed with additional studies and/or trail applications. Specific outcomes, in addition to an initial re-vegetation procedure include recommendations for future research tasks and recommendations regarding continued monitoring of the existing research plots.

5.1.2 Contaminated Soils

Apply a risk-based approach to consider management and disposal options for contaminated materials. The assessment will be based on existing site information for typical hydrocarbon contaminant levels and include development of a risk assessment problem formulation and preliminary identification of risk management options for managing contaminated materials. Key findings from this work will be used to inform both operations and closure management approaches to hydrocarbon contaminated materials. It is also expected that the assessment will provide information to establish preliminary hydrocarbon closure criteria.

5.1.3 Closure Reference Concentrations

A literature and data review will be completed to nominate chemicals of potential concern, receptors, toxicity reference values and risk estimate equations generally following the approach used in Mucklow and Swanson (1998). This document will be circulated for review/revision. DDMI then suggests developing receptor-specific and area-specific receptor parameters such as time an animal/person might spend in an area, food/water ingestion rates or body weight jointly with communities and government. This could be an excellent opportunity to merge both science information and Traditional Knowledge (TK) to make a best representation of these parameters for northern populations. Listings of the types of information required would be distributed to so that all participants can contribute whatever information they might have. DDMI will then take the outcomes from these first steps and complete initial calculations of risk-based criteria. These criteria will be compared against possible water/dust/rock/prey/vegetation concentrations to identify parameters and media of greatest risk. Documentation of these results will be distributed for review. Derived reference concentrations will be considered for inclusion as site-wide closure criteria.

5.1.4 Post-Closure Vegetation Metals Level Risk

Communities and the Environmental Monitoring Advisory Board have identified a potential concern that post-closure vegetation that colonizes naturally or that has been established through a closure re-vegetation program may accumulate metals to a level that would pose an unacceptable risk to wildlife or people. The derived Closure Reference Concentrations (see Section 5.1.4) will be combined with a literature review of potential metals levels in vegetation to determine if post-closure vegetation is likely to pose an unacceptable risk to people or wildlife. If expected exposure concentrations in post-closure vegetation are identified as posing an unacceptable risk to wildlife or people, then specific research plans may need to be developed to address associated uncertainties and possibly monitoring methods.

5.2 Conceptual Scopes of Work (After 2013)

Work scopes for tasks anticipated beyond 2013 include:

5.2.1 Finalize specific procedures for site-wide re-vegetation

5.2.2 Finalize procedures for management/disposal of hydrocarbon contaminated material.

5.2.3 The need for potential work scopes related to post-closure metals levels in vegetation will be determined pending outcomes of the 2011-2013 tasks.

Other scopes of work may be identified based on the results of tasks completed before 2013.

6. Linkages to Other Research and LOM Plan

Specific linkages identified include:

- Thermally active zone depth in waste rock and PKC measured in research plans for these areas may be used as information for hydrocarbon risk assessment.
- Risk assessment frameworks applied in this research plan are the same as general framework that will be applied to other closure management areas.
- Information developed in support of closure criteria may be applicable to other closure management areas.
- Research on aspects of re-vegetation methods can potentially be coordinated with Ekati.
- Decision-making and planning relating to stockpiling of various wastes (e.g., vegetation, top soil, sewage sludge, north inlet sludge, fine PK).

7. Project Tracking and Schedule

Projects are tracked by task. The expected task schedule is shown in Table 1.

Table 1 Planned Project Activities

Year	Activities
2011	• Continued monitoring of re-vegetation research plots. • Conduct and document risk assessment for options for management and disposal of petroleum hydrocarbon contaminated materials.
2012	• Interpretation and documentation of field and laboratory monitoring results. • Assess information availability and applicability from Ekati. • Develop site-specific, risk-based closure reference concentrations.
2013	• Determine if post-closure vegetation is likely to pose an unacceptable risk to people or wildlife. • Assess confidence in developing re-vegetation procedure. • Identify any additional research that may be required and long-term monitoring scope for existing re-vegetation research plots.

8. Costs

Expected costs to complete the tasks described above are:

- Tasks completed (before 2011) - $350,000 plus in-kind costs;
- Task to be completed (2011-2013) - $150,000; and
- Tasks remaining (after 2013) – to be determined.

9. References

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The following Tables are from Mucklow and Swanson (1998).

TABLE 5 RISK-BASED REFERENCE CONCENTRATIONS (RBRC) FOR PLANTS, PREY, WATER, SOIL AND DUST FOR WILDLIFE RECEPTORS

Chemicals	Risk-Based Reference Concentration for Plants (mg/kg dry weight)	Risk-Based Reference Concentration for Prey (mg/kg dry weight)	Risk-Based Reference Concentration for Dust (ug/m^3)	Risk-Based Reference Concentration for Soil (mg/kg dry weight)	Risk-Based Reference Concentration for Water (mg/L)
Caribou					
Barium	170	n/a	2400	4000	130
Cadmium	8	n/a	370	200	20
Chromium (III)	28000	n/a	1000000	680000	68000
Cobalt	12	n/a	690	300	30
Copper	150	n/a	17000	3800	380
Lead	81	n/a	1300	2000	200
Molybdenum	1.6	n/a	180	40	4
Nickel	400	n/a	46000	10000	1000
Uranium	17	n/a	1900	410	41
Vanadium	2	n/a	230	50	5
Zinc	1600	n/a	180000	40000	4000
Northern Red-Backed Vole					
Barium	21	n/a	420	850	2.6
Cadmium	1.2	n/a	76	50	0.5
Chromium (III)	3400	n/a	180000	140000	1300
Cobalt	1.6	n/a	130	68	0.6
Copper	19	n/a	3000	780	7
Lead	10	n/a	220	410	4
Molybdenum	0.2	n/a	28	7	0.1
Nickel	50	n/a	7800	2000	19
Uranium	2	n/a	320	84	0.8
Vanadium	0.2	n/a	38	10	0.1
Zinc	200	n/a	31000	8200	77
Red Fox					
Arsenic	n/a	0.4	n/a	n/a	n/a
Barium	n/a	80	500	2800	6
Beryllium	n/a	3	n/a	n/a	n/a
Cadmium	n/a	5	90	160	1
Chromium (III)	n/a	13000	216750	460000	3250
Cobalt	n/a	6	158	225	2
Copper	n/a	72	3600	2600	18
Lead	n/a	38	270	1350	9
Manganese	n/a	420	n/a	n/a	n/a
Mercury	n/a	6	n/a	n/a	n/a
Molybdenum	n/a	0.6	32	23	0.2
Nickel	n/a	190	9450	6750	47

TABLE 5 RISK-BASED REFERENCE CONCENTRATIONS (RBRC) FOR PLANTS, PREY, WATER, SOIL AND DUST FOR WILDLIFE RECEPTORS

Chemicals	Risk-Based Reference Concentration for Plants (mg/kg dry weight)	Risk-Based Reference Concentration for Prey (mg/kg dry weight)	Risk-Based Reference Concentration for Dust (ug/m^3)	Risk-Based Reference Concentration for Soil (mg/kg dry weight)	Risk-Based Reference Concentration for Water (mg/L)
Selenium	n/a	0.9	n/a	n/a	n/a
Strontium	n/a	1250	n/a	n/a	n/a
Uranium	n/a	8	387	280	2
Vanadium	n/a	0.9	45	32	0.2
Zinc	n/a	760	38025	27000	190
Oldsquaw					
Barium	1100	480	4700	12500	140
Cadmium	78	11	320	280	9
Chromium III	54	7	190	190	6.5
Cobalt	38	5	200	130	4.5
Copper	2500	350	26000	9000	300
Lead	200	28	310	740	25
Molybdenum	190	26	2000	670	23
Nickel	4200	570	43000	15000	500
Uranium	870	120	9000	3100	100
Vanadium	620	84	6400	2200	74
Zinc	780	110	8100	2800	94
Ptarmigan					
Barium	120	n/a	2300	1300	100
Cadmium	2.7	n/a	160	29	7
Chromium III	1.8	n/a	91	20	5
Cobalt	1.3	n/a	96	14	3
Copper	87	n/a	13000	940	230
Lead	7	n/a	150	77	18
Molybdenum	6.5	n/a	950	70	17
Nickel	140	n/a	21000	1500	370
Uranium	30	n/a	4400	320	77
Vanadium	21	n/a	3100	230	55
Zinc	27	n/a	4000	290	70

Rio Tinto

Appendix III-2

Updated Work Scopes

Closure Research Work Scope Update – March 2016

Research Task 2.4 – Updated predictions of flooded pit water quality.

Recently Dominion Diamond Corporation (DDC) completed extensive modelling of pit lake water quality, in particular the internal wind driven mixing conditions and maintenance of stratification conditions, as part of the Jay Project Environmental Assessment. DDMI intends to build from these modelling learnings and apply them to models of water quality for each of the A21, A418 and A154 pits. Estimates of initial flooded water quality will be updated by applying the results of the wall washing experiments, pit wall lithology mapping and ongoing mine water inflow and quality and quantity monitoring. A range of lake fill rate and initial groundwater fill level scenarios will be considered.

Research Task 2.5 – Screening level risk assessment of flooded pit water quality.

Estimates of water quality conditions in each of the flooded open-pit areas from Task 2.4 will be screened against previously developed site-specific risk-based closure criteria to identify any parameters of potential concern. Outcomes from the assessment could include revisions to closure criteria, identification of additional research tasks and/or the need for a more detailed risk assessment.