RioTinto

Diavik Diamond Mines (2012) Inc.
P.O. Box 2498
Suite 300, 5201 – 50th Avenue
Yellowknife, NT X1A 2P8
Canada
T (867) 669 6500
F (867) 669 9058

Ms. Violet Camsell-Blondin
Chair
Wek'èezhíi Land and Water Board
Box 32
Wekweeti, NT X0E 1W0

24 April 2015

Re: Diavik 2014 ICRP Annual Progress – Version 1.1

Please find attached the Diavik Diamond Mines (2012) Inc. (DDMI) 2014 ICRP Annual Progress Report Version 1.1 containing the revisions requested by the Wek'èezhíi Land and Water Board on March 16, 2015:

1. *Add detailed scopes of work for each research task that is within 3 years of implementation and update the timelines for the completion of all research tasks. Identify which of those research tasks are required to develop final closure concepts.*
2. *For each engagement activity related to closure planning in Table 2.1 of the ICRP Progress Report, provide:*
   a. a list of attendees;
   b. an indication of whether materials were provided to the engaged parties (copies need only be provided at the request of the Board);
   c. a list of issues raised and DDMI's responses;
   d. key findings and how these inform the closure plan; and
   e. a list of unresolved issues, if any.

   DDMI should delete engagement activities from Table 2.1 that are unrelated to closure planning.
3. *Include a discussion about the impacts of leaving the waste rock pile uncovered, and provide enough information so that the Board can be confident that there are no unnecessary delays in placing the cover. DDMI should refer to the results of waste rock research to support DDMI's position on this matter.*

The information identified above is particularly important to inform a Board decision on the deadline for Version 4.0 of the ICRP. The Board will set the deadline after it has received the information requested above.

For a number of reasons, DDMI requests that ICRP V4.0 not be required before December 2016.

Please let us know if you require any additional clarification.

Regards,

Gord Macdonald

cc Sarah Elsasser (WLWB)
Ryan Fequet (WLWB)
Patty Ewaschuk (WLWB)

Attachment – 2014 ICRP Progress Report Version 1.1

Diavik Diamond Mines (2012) Inc.

Annual Interim Closure and Reclamation Progress Report – 2014 Version 1.1

Document #: CLSR-003-1014R1

24 April 2015

Contents page

Appendices list

1. Report Summary

- Version 1.0 of this report was dated October 31, 2014

- This Version 1.1 has been prepared at the direction of the Wek'èezhíi Land and Water Board (letter dated March 16, 2015) and includes:

  - Details on research scopes of work (Appendix IX).

  - Updated timelines for completion (Section 3.1 and 3.3) and identification of research tasks required to develop final closure concepts (Section 7).

  - Clarification of engagement activities (Section 2) and addition of (Appendix X).

  - Discussion about impacts of leaving the NCRP uncovered (Section 9)

- Community Engagement Summary

  - During 2014, DDMI communicated updates on closure planning and TK Panel activities through the Participation Agreement (PA) Implementation Committees.

  - TK Panel Session 7 was held at the mine site from 14-18 August 2014 to discuss options for re-vegetation (Appendix I-2).

  - Reviewed DDMI responses to previous TK Panel recommendations with Panel members; Panel recommendations will ultimately also be shared with community leadership, Closure Working Groups, community members and regulators (Appendix I-1).

  - Community update meetings are planned for late fall (Q4) of 2014, and therefore had yet to occur prior to submission of this report.

  - Conducted two literature reviews in response to TK Panel recommendations:
    - TK knowledge of vegetation in the Lac de Gras area (Appendix I-3); and,
    - Reclamation of disturbed sites in the north (Appendix VII-4).

- Reclamation research programs are progressing substantially on plan. There were two programs where timelines have slipped:

  - Task 1.5 Semi-Fluid Processed Kimberlite Study

  - Task 4.2.5 Screening Level Risk Assessment – PKC Geochemistry

  One program was advanced in schedule:

    - Task 5.6 NI Sediment Characterization Update

- A re-vegetation literature review specific to the north was completed by the University of Alberta, summarized in Section 3.4.2 and included in Appendix II-4.

- A likely schedule for the commencement of North Country Rock Pile closure activities is provided in Section 4.2.

- In 2014 DDMI reduced the environmental footprint of the mine site by continuing to remove equipment and items that are no longer required. A list of assets removed from site or landfilled as part of progressive reclamation is included in Appendix VI-1.

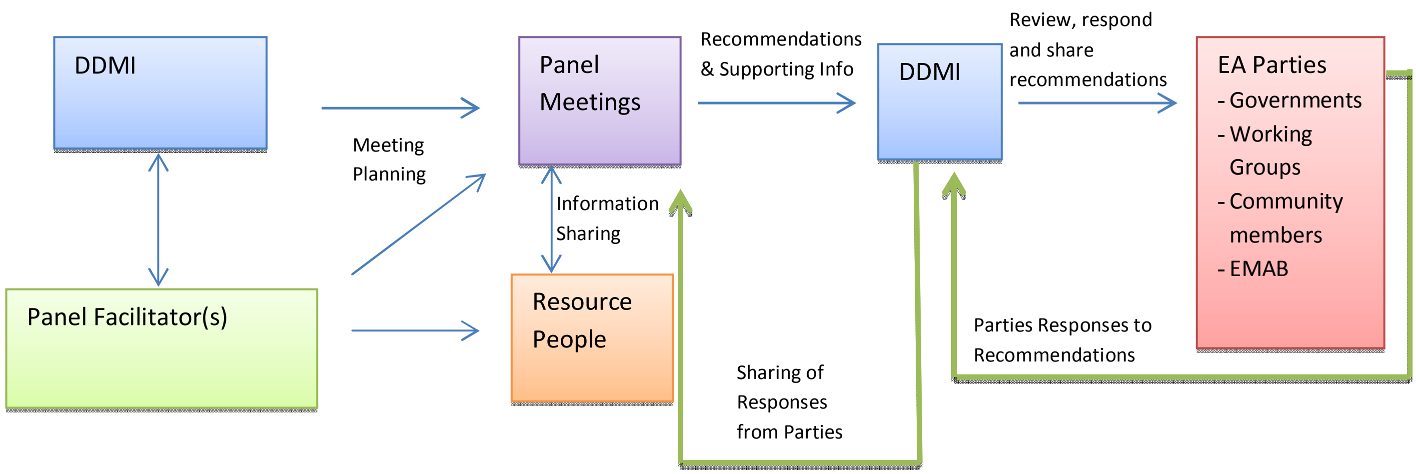
- The overall closure schedule is on track with final design concepts planned for completion in 2015 and ICRP V4.0 submission in December 2015.

- DDMI has provided an estimate of additional security for the closure of the A21 dike and open-pit as Appendix VIII-2.

2. Community Engagement

Diavik Diamond Mines Inc. (DDMI) has renewed Participation Agreements (PA) with each of the 5 community organizations that are signatories to the Environmental Agreement: the Tłįchǫ Government (TG), Kitikmeot Inuit Association (KIA), Lutsel K'e Dene First Nation (LKDFN), Yellowknives Dene First Nation (YKDFN) and the North Slave Metis Alliance (NSMA). During the renewal process, Parties expressed an interest in re-establishing the Implementation Committees provided for within the PA. As such, DDMI and partner community's engagement efforts in 2014 centered on these Implementation Committees and included updates on closure planning and TK Panel initiatives, where relevant or requested.

The Traditional Knowledge (TK)/Inuit Qaujimajatuqangit (IQ) Panel that was originally established under the Environmental Monitoring Advisory Board (EMAB) has largely focused on opportunities to incorporate TK/IQ into closure planning. Diavik began to directly administer the TK Panel in 2013, and the Panel met to discuss re-vegetation options at the mine site in August 2014. Recognizing that Panel members are not fully representative of their community organization, DDMI still envisions the following process for reviewing recommendations from the Panel. While this approach has generally been supported to date, challenges in meeting with community organizations to discuss TK Panel progress has resulted in DDMI sharing the Panel session reports, complete with recommendations and responses, with PA organizations.



DDMI considers the Water Board review processes as a valuable primary method of engagement on technical aspects of closure and reclamation (Diavik Diamond Mine Engagement Plan – November 2014). In 2014 the Annual Interim Closure and Reclamation Plan Progress Report – 2013 was distributed for written review and comment. DDMI responded to:

- 5 comments from Environmental Monitoring Advisory Board
- 5 comments from GNWT – Environment and Natural Resources

- 10 comments from GNWT Lands
- 5 comments from WLWB Staff

Appendix X includes a copy of the reviewer comment and DDMI responses as a record of this engagement.

DDMI values opportunities to share progress on closure planning and other initiatives with community members and leadership, and works with each PA organization to determine the most suitable method to achieve this. Community meetings with leaders, Elder senates and community members, PA implementation committees, open houses and school visits are some of the methods used to achieve this over the years. DDMI conducted a number of community engagements in partnership with the PA organizations during 2014. Table 2.1 lists community engagements where topics relating to closure (TK Panel, Environmental Performance update, ICRP) were presented or discussed. The list of attendees at any given meeting is not distributed publically. Issues raised, discussed and resolved or not resolved are similarly not recorded for public distribution. Any key findings that relate to the closure plan are discussed within Section 2 and attributed where permission has been explicitly provided.

Table 2.1: Summary of 2014 Community Engagements that included Closure Related Topics

Organization	Methods	Dates	Closure Related Materials
KIA Steering Committee	Conference Call	2014-08-22	Environmental Performance, TK Panel overview
KIA Leadership	Annual Update	2015-02-09	Environment Update, ICRP
Lutsel K'e - Community	Open House	2015-03-26	Environment Update, ICRP
LKDFN Chief/Council/L&W Staff	Open House	2015-03-26	Environment Update, ICRP
NSMA Environmental Analyst	Meeting	2015-03-27	Environment update, ICRP
TG Kwe Beh Working Group	Meeting Annual Update	2014-09-12 2014-11-13	Environmental Performance, TK Panel overview, ICRP
TG – Chief Executive Committee	Site Visit / Meeting Site Visit / Meeting	2014-03-11 2014-10-28	Environmental Performance, TK Panel overview

Organization	Methods	Dates	Closure Related Materials
Tlicho Investment Corporation	Meeting Site Visit / Meeting	2014-07-08 2014-10-28	Environmental Performance, TK Panel overview
YKDFN - Implementation	Meeting Meeting Meeting Meeting	2014-05-06 2014-09-09 2014-07-17 2014-10-31	Environmental Performance, TK Panel overview,
YKDFN Chiefs	Meeting (informal) Meeting Site Visit / WR Tour	2014-02-10 2014-02-19 2014-03-23	Environmental Performance, TK Panel overview

Progress

DDMI has had discussions with community representatives to determine how best to effectively engage with communities on various levels (organization, members, youth) and topics. The approach to conducting community updates was included in these discussions and DDMI is now working with the PA organizations to organize these update meetings in the communities during late fall (Q4) of 2014.

Diavik has arranged for two successful TK/IQ Panel sessions since the Panel was transferred to Diavik from EMAB during the summer of 2013. Each PA organization has been supportive of the TK/IQ Panel process and membership, and has been instrumental in assisting and preparing Panel members for each session. With having relatively consistent membership, the process and function of the TK/IQ Panel continues to evolve and strengthen each time the Panel meets. One change that Panel members requested of their PA organizations at the August 2014 session is for a shift in Panel membership that would see 1 Elder male, 1 Elder female and 1 youth from each PA organization to attend each session. Alternates for each would also be selected, and the Panel requested that participants have knowledge of the Lac de Gras area.

During TK Panel Session 6 (October 2013), discussions focused on a possible change to the reclamation plan and related considerations for the Processed Kimberlite Containment (PKC) area; a summary of that session and the Panel's recommendations were shared in the 2013 ICRP Annual Update (December). The revised closure plan for the PKC area was subsequently approved by the WLWB in May 2014. DDMI shared this news with the Panel during their August 2014 meeting, and provided a response to the Panel recommendations relating to the PKC closure plan (Appendix I-1).

During Session 6, the Panel identified an interest in having a session focussed on re-vegetation in the summer of 2014. They recommended that women be included in such discussions, as they are traditionally much more familiar with plants. DDMI organized TK Panel Session 7 as a site-based, re-vegetation discussion from 14-18 August 2014 (Appendix I-2). At DDMI's request, each PA organization arranged for a woman representative to assist with the Panel, and breakout sessions were scheduled to ensure that participants had a comfortable space in which to share their knowledge. Field work opportunities were also scheduled, and Panel members identified their priorities for this work. An EMAB representative was also available to attend part of the August 2014 session as an observer. The key questions posed to the Panel in relation to re-vegetation were:

- How do we re-vegetate to keep wildlife safe?
- Which habitats or plants create safety for wildlife?
- Where should different types of habitats or plants be placed?
- What should DDMI do with site roads?

Panel members and facilitators have incorporated a cross-cultural approach to learning that has demonstrated an increased understanding of the technical challenges associated with closure and has resulted in more practical recommendations from the Panel. A table of recommendations relating to closure that have been provided through TK/IQ Panel reports is included as Appendix I-1, with a summary of the primary recommendations for re-vegetation of the mine site outlined below.

The concept of re-vegetation was difficult for many TK Panel members to consider, largely based on a fundamental belief that nature is powerful and will heal itself, and that interfering with this process is disrespectful. After much discussion, many of the Panel members acknowledged that there is value in assisting the re-vegetation process, given that disturbance from mining is more extensive than the natural range of disturbance (e.g. flood). There was much discussion as to whether re-vegetation efforts should attract or deter wildlife. One of the most useful exercises during the session involved participants marking a map of the mine site according to the following 3 categories:

- areas you don't want wildlife to go (red);
- areas you want to encourage re-vegetation or re-growth (green); or,
- areas to encourage wildlife passage through modifications (e.g. landscaping) (blue).

The resulting map (Figure 2-1) that was developed by the women was most supported by the Panel and will serve as a useful tool for engaging community leadership and members on this topic. Generally, areas that are seen as contaminated and a risk for wildlife were coloured red (e.g. former fuel & waste storage areas, open pits), low use or natural habitat areas were coloured green (e.g. plant site, laydown areas, wind turbine pads) and landforms considered as obstacles or barriers for wildlife were coloured blue (e.g. north country rock pile, dikes). There was disagreement among some Panel members in relation to vegetation use in the north inlet area; members determined that they require more information on pond water quality before determining how this area should be classified.

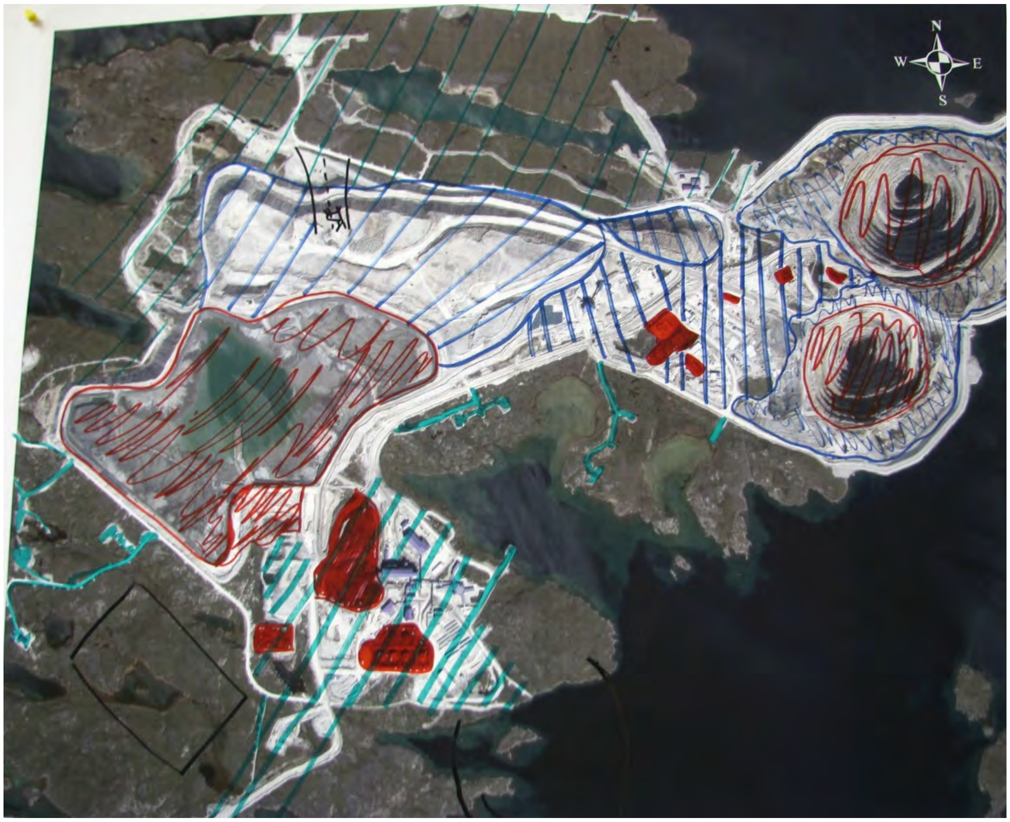


Figure 2-1: Site Map Indicating TK Panel's Preferred Re-vegetation Design for Closure

Panel members also evaluated three design options for site roads at closure (Figure 2-2). While the Panel's overall preference is to avoid further disturbance to areas of natural vegetation, all Panel members acknowledged that road berms should be pushed out to allow for safe wildlife passage (Option 3). It was determined that any loss to natural vegetation for this reason was acceptable. Similarly, Panel members felt that if development of A21 should proceed, the associated rock pile should be wider at the base to allow for a lower pile height. Again, while this would result in a greater loss of natural vegetation, the benefit of safe wildlife passage post-closure was viewed as more important than the vegetation loss.

Figure 2-2: Design Options for Site Roads at Closure

Two other areas of interest for the TK Panel were the airstrip and north country rock pile. Many Panel members felt that there is benefit in leaving the airstrip intact. There was discussion over the maintenance, liability and ownership requirements if the airstrip were to be registered, versus simply leaving it ‘as is’ and letting nature takes its course. Overall, many Panel members saw value in having an emergency landing option for future aircraft operations in this region. Lastly, the north country rock pile is considered a barrier and hazard to caribou in its current state. Past recommendations from the Panel have addressed considerations such as flattening the berms on top of the pile, smoothing the slopes and rounding the top edges of the pile. This session resulted in a desire to create safe access for caribou over the pile. This generally translated to creating access ramps on the north and southeast sides of the pile, together with a trail across the top of the pile that would connect these areas. However, Panel members are also interested in reviewing traditional caribou trail maps from DDMI’s baseline work to confirm that this is the best route for which to encourage caribou to use. The smooth surface and slope of the capped test rock pile was seen as acceptable for safe wildlife passage by members of the TK Panel, largely because there were no exposed large boulders that could injure caribou hooves and legs.

The Panel also requested that a literature review be conducted to identify the existing traditional knowledge available on plants in the Lac de Gras region (Appendix I-3). DDMI commissioned Thorpe Consulting Services (TCS) to conduct this high-level review, as they also serve as facilitator for the TK Panel. The goal of the TK literature review was to identify any existing TK on vegetation that could inform the Diavik closure plan and be used as a reference for the TK Panel and communities when considering ecosystem needs at closure, from an Aboriginal perspective. While much of the existing, documented TK is focused at species level, there were some learnings from this review that could help to inform DDMI’s closure planning process. Additionally, gaps in the TK literature were also identified and can be used to provide guidance to future efforts of various stakeholders related to TK research of vegetation. Most importantly, the review helped to identify “indicators” of healthy land or wildlife populations, as Aboriginal people’s survival relied on this knowledge when living on the land. Accordingly, many of these same indicators help communities understand the changes they see as a result of development. These same observations and indicators could therefore be useful in communicating closure plans and developing post-closure monitoring programs that are relevant and understandable to communities.

Challenges

As with 2013, the availability of community organizations and members continued to be a challenge for DDMI during 2014. There are numerous demands on each community, many of which are more pressing than closure planning. With limited resources, community organizations and members have to prioritize how best to allot their time. Given the relatively recent PA renewals, the focus of communities and DDMI in 2014 continued to be on Implementation Committees. Consequently, there were no meetings held directly with the Closure Working Groups that have been established with four of the five PA organizations. DDMI is still interested in continuing with this method of engagement in the future, provided that communities find it beneficial and are available to participate.

The TK/IQ Panel has provided a total of 96 thoughtful recommendations for consideration by DDMI and other parties, but Panel members have been clear that their views do not necessarily represent those of their community organization. As such, their recommendations are only to be considered as advice that requires confirmation from each community organization. This is a cultural consideration that is common in northern communities, but the challenge lies again in gaining timely access to community leadership to clarify their position on the TK/IQ Panel's growing number of suggestions. Panel members have expressed an interest in being involved in presenting back to their communities, but it is a matter of availability. Opportunities to use more formal and established methods, such as the WLWB review process for the ICRP annual updates, may be an option worth considering but this would need to be discussed further with communities.

Discussions with communities on closure options and how the site will look at closure can be challenging given that all maps and figures show the current mine site, visitors are confronted with large-scale infrastructure when at the site and there are few examples or experiences with large-scale reclamation areas within the NWT. DDMI recognizes this challenge and is evaluating possible methods, for use with community members and other stakeholders, which would better illustrate what the mine site could/would look like at closure. The ultimate goal of such a tool would be to advance closure discussions and increase the level of understanding of closure plans, options and challenges in order to more effectively obtain feedback.

Comments, ideas and recommendations relating to closure made through the above-noted venues and discussions with communities have been captured by DDMI in Table 2-1 (above) and Appendix I-1. Please note that all parties generally consider these as guidance at this point in time. This information has not been formally recommended, considered or incorporated into DDMI's closure plan; however, DDMI is interested in further discussions to confirm community preferences for closure options relating to each of these topics and is evaluating methods to more clearly illustrate how the mine site may look after closure.

3. Reclamation Research Update

3.1 Status of Immediate Research Tasks

The status of each immediate research task is summarized in the following table. Where documentation is available for a research task a reference is provided. If the documentation has not been previously submitted to the WLWB, a copy is included in Appendix II. The full research plans can be found in Appendix VIII of the Interim Reclamation and Closure Plan (ICRP) (Version 3.2).

Immediate Research Tasks		Status
1. Traditional Knowledge and Community Participation		
1.1 Wildlife Movement	1.1.1 Desktop study to review available TK for caribou and other wildlife in the Slave Geological Province	Complete. *Literature Review of Traditional Ecological Knowledge Related to the Resource Sector.* July 2011.
	1.1.2 More detailed discussions with members from each of the Aboriginal organizations to obtain more specific recommendations on preferred options and where/how to best incorporate these recommendations in the final closure design, while still taking into account technical considerations.	On-going. TK/IQ Panel discussions continue to evolve on this topic (Appendix I-1) and community updates should provide further insight into each Aboriginal organization's preferences.
1.2 Re-vegetation	1.2.1 Desktop study to review available TK for vegetation in the Slave Geological Province	Complete. Documented in Appendix I-3 *Literature Review: Traditional Knowledge of Plant Life at the Diavik Diamond Mine.* October 2014.
	1.2.2 A summary of DDMI 5-year research on re-vegetation is to be provided to Aboriginal organizations and combined with TK views on which of those species are suited to re-vegetation or are beneficial for wildlife.	Completed. Summaries of the Phase I and II studies have been provided in annual Wildlife Monitoring Program reports. A full summary of both phases, including plans to continue re-vegetation research, was included in the 2012 Environmental Agreement report. Appendix C of the 2014 Literature Review (Appendix I-3) identified species valued by Aboriginal organizations and noted which of these species have been tested

Immediate Research Tasks		Status
		in DDMI's re-vegetation research.
	1.2.3 DDMI hopes to discuss these topics in community-based workshops and with the TK Panel.	Initiated. The TK Panel site visit of 20 August 2012 included a visit to the re-vegetation plots and a discussion of results to date. The Panel expressed an interest in further re-vegetation discussions and this was conducted from 14-18 August 2014. Recommendations relating to re-vegetation are included in Section 2 and Appendix II-2. DDMI is working with PA organizations to arrange community visits where the results of this Panel session would be shared (Q4 2014).
1.3 Landforms	1.3.1 DDMI to work with Aboriginal organizations to begin developing more detailed images of what the mine will look like post-closure to assist community members in understanding what the mine site might look like. These images can incorporate different rock features, vegetation, or wildlife trails that community members may recommend.	Initiated. Both computer and clay models have been shared with community and TK/IQ Panel members over the past few years. Given the progress of the TK Panel, DDMI's intention is to capture the existing recommendations and develop a working model that provides a visual representation of the guidance provided to date. Ideally, DDMI is interested in developing a model that can be manipulated in real time to respond to stakeholder feedback. DDMI anticipates having a model developed by Q2 2016.
	1.3.2 DDMI will assess the technical feasibility and material availability to meet Aboriginal organizations recommendations for key landforms. A model that best represents the final look of the land will be constructed and shared with each of the Aboriginal organizations to obtain any further feedback.	Pending. Refer to status in 1.3.1.
	1.3.3 DDMI hopes to discuss the models in community-	Pending. Refer to status in 1.3.1.

Immediate Research Tasks		Status
	based workshops and with the TK/IQ Panel.	
1.4 Community Engagement	1.4.1 Development of a TK/IQ Panel under the Environmental Agreement	Panel established under EMAB in 2012. Administration of the Panel was transferred to DDMI in August 2013. The TK Panel has completed a total of 7 sessions since its inception, with results from the most recent session summarized in Section 2.
1.5 Semi-Fluid Processed Kimberlite Study	1.5.1 Initiate an independent toxicological and chemical assessment of semi-fluid PK material in relation to safety for people and wildlife.	Not started. This new research requested by the TK Panel in October 2013. It was to have been initiated in 2014 but has slipped to 2015.
1.6 Fish Habitat Design	1.6.1 engage TK Panel and communities on fish habitat designs for pit shelf areas	Not started. Currently scheduled for spring 2016 TK Panel session
2. Open Pit, Underground and Dike Area Research		
2.1 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 granite. The walls of the open pit represent the largest surface area of rock that will be 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.		Complete – documented in 2013 ICRP Update.
2.2 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 analysing 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.		Complete – documented in 2013 ICRP Update.
2.3 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		Complete – documentation in 2013 ICRP Update.

Immediate Research Tasks		Status
expected post-closure fish habitat use.		
3. Waste Rock Research		
3.1 Thermal	3.1.1 Based on the monitoring results from the test piles and waste rock as well as possible mathematical modelling, provide an estimate of the depth of annual thaw for the waste rock pile.	Complete – Documented in 2012 ICRP Update.
	3.1.2 Provide this estimate for scenarios assuming both a cover and no cover.	Complete – Documented in 2012 ICRP Update.
	3.1.3 Determine the effect of a climate change scenario on these initial estimates.	Complete – Documented in 2012 ICRP Update.
	3.1.4 Revise estimates with any changes in monitoring information, mathematical modelling or cover design parameters.	Pending any changes.
3.2 Hydrological	3.2.1 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 rock pile as seepage.	Complete – Documented in 2013 ICRP Update.
	3.2.2 Provide this estimate for scenarios assuming both a cover and no cover.	Complete - Documented in 2013 ICRP Update.
	3.2.3 Determine the effect of a climate change scenario on these initial estimates.	Complete - Documented in 2013 ICRP Update.

Immediate Research Tasks		Status
	3.2.4 Revise estimates with any changes in monitoring information or cover design parameters.	Pending any changes.
3.3 Geochemical	3.3.1 Based on the monitoring results from the test pile, thermal analysis and hydrological analysis provide an interim estimate of the geochemical loading rates in seepage from the waste rock.	Complete – Documented in 2013 ICRP Update.
	3.3.2 Provide this estimate for scenarios assuming both a cover and no cover.	Complete - Documented in 2013 ICRP Update.
	3.3.3 Determine the effect of a climate change scenario on these initial estimates.	Complete - Documented in 2013 ICRP Update.
	3.3.4 Revise estimates with any changes in monitoring information or cover design parameters.	Pending any changes.
4. Processed Kimberlite Containment Area Reclamation Research		
4.1 Geotechnical	4.1.1 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 consolidated.	Complete. Documented in 2012 ICRP Update.
	4.1.2 Laboratory tests for additional slimes characterization, could contribute to estimates of	Complete. Documented in 2012 ICRP Update

Immediate Research Tasks		Status
	consolidation rates and magnitudes.	
	4.1.3 Installation of thermistors in the beaches and/or slimes and collection of thermal data can provide an indication of permafrost development and the propensity for thermokarst topography.	Installation complete. Data collection and interpretation is on- going. To-date results are described in Appendix II-1 *Four-Year Hydrochemical Field Investigation of Processed Kimberlite Weathering.*
	4.1.4 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.	Complete. Documented in 2013 ICRP Update.
4.2 Geochemical	4.2.1 Annual or semi-annual sample collection from surviving/accessible piezometers (as accessible) to monitor changes to pore water chemistry and identify any potential elements of concern.	On-going. See Appendix II-1 *Four-Year Hydrochemical Field Investigation of Processed Kimberlite Weathering.*
	4.2.2 Pore water chemistry trend analysis and interpretation; to identify any changes in pore water chemistry over time and identify any potential elements of concern.	On-going. See Appendix II-1 *Four-Year Hydrochemical Field Investigation of Processed Kimberlite Weathering.*
	4.2.3 Laboratory and/or small scale field leaching experiments to monitor accelerated and in situ weathering of FPK and the resultant water quality.	Ongoing. See Appendix II-2 *Technical Memorandum – PK Tank 2014 Progress Report* and Appendix II-3 *Technical Memorandum – PK Static and Kinetic Tests.*

Immediate Research Tasks		Status
	4.2.4 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.	Not started.
	4.2.5 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 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.	Originally scheduled to start in 2014 this task now scheduled to start in 2015 will be combined with results from *Task 1.5.1 Semi fluid PK Assessment* and results from other areas (North Inlet, Waste Rock Pile, Pit, Re-vegetation) to develop a site-wide risk assessment framework.
4.3 Water quality criteria	4.3.1 A screening level risk assessment will be completed based on initial estimates of probable ranges of outlet 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 streams and or inland lakes along any seepage pathway and areas of Lac de Gras.	See 4.2.5 above

Immediate Research Tasks		Status
	4.3.2 Update water quality criteria, if required	To be initiated following 4.3.1
	4.3.3 Other scopes of work may be identified based on the results of the analysis described above.	See 4.2.5 above
5. North Inlet Reclamation Research		
5.1 Follow-up studies and testing from 2010 characterization program to isolate the source of measured biological responses	5.1.1 Estimate leaching potential of contaminants from NI sediment	Complete – Documented in 2013 ICRP Update.
	5.1.2Confirm sediment chemistry and toxicity in NI sediment	Complete - Documented in 2012 ICRP Update.
	5.1.3 Conduct additional chemical and toxicological testing on NIWTP sludge	Complete – Documented in 2012 ICRP Update.
	5.1.4 Conduct zooplankton sampling in NI	Complete – Documented in 2012 ICRP Update.
	5.1.5 Conduct preliminary Toxicity Identification Evaluation (TIE)	Complete – Documented in 2013 ICRP Update.
5.2 Conduct and document screening level risk assessment for NI water and sediment quality		Start delayed to wait for information from 2015 Sediment Characterization Updates (see Task 5.6)
5.3 Conduct and document detailed level risk assessment, if required		Pending outcome of Task 5.2
5.4 Develop risk management strategy, if required		Pending outcome of Task 5.2/5.3
5.5 Update water and sediment closure criteria		Scheduled to be updated along with revisit of closure objectives in ICRP V4.0.
5.6 Sediment Characterization Update		Not started – scheduled for 2015
6. Infrastructure Area Reclamation Research		
6.1 Re-vegetation	6.1.1 Continue monitoring of	Ongoing – progress report included as

Immediate Research Tasks		Status
	re-vegetation research plots	Appendix II-5 *Reclamation of Disturbed Sites at Diavik Diamond Mine – 2014 Annual Report.*
	6.1.2 Interpretation and documentation of field and laboratory monitoring results	See 6.1.1 above
	6.1.3 Assess information availability and applicability from Ekati	Complete. Documented in Appendix II-4 *Reclamation of Disturbed Sites in the North – Implications for Diamond Mines – A Literature Review.*
	6.1.4 Assess confidence in developing re-vegetation procedures	See 6.1.1 above
	6.1.5 Identify any additional research that may be required and long-term monitoring scope for existing re-vegetation plots.	See 6.1.1 above
6.2 Contaminated soils	6.2.1 Conduct and document risk assessment for options for management and disposal of petroleum hydrocarbon contaminated materials.	Complete – Documented in 2012 ICRP
6.3 Closure Reference Concentrations	6.3.1 Develop site-specific, risk-based closure reference concentrations; document and distribute for review	Will be a result from the site wide risk assessment described in Task 4.2.5 that is scheduled to begin in 2015.
	6.3.2 Update closure criteria	Not started
6.4 Post Closure Vegetation Metals Level Risk	6.4.1 Literature and field studies to determine metals levels in plant tissue from test plots.	Ongoing - work scope documented in 2013 ICRP Update.
	6.4.2 Compare these literature values with risk-based	Not started

Immediate Research Tasks		Status
	reference concentrations.	
	6.4.3 Determine if there is a need to further research this potential contaminant pathway.	Pending outcome of 6.4.1 and 6.4.2

3.2 Results Summary and Conclusions

The following sections summarize key results and conclusions, relevant to closure, derived from the reclamation research recently completed.

3.2.1 Traditional Knowledge and Community Participation

Results summaries related to community engagement and Traditional Knowledge are provided in Section 2.0.

3.2.2 Open Pit, Underground and Dike Area Research

No new results or conclusions with relevance to closure.

3.2.3 Waste Rock Reclamation Research

No new results or conclusions with relevance to closure

3.2.4 Processes Kimberlite Containment Area Reclamation Research

PKC geotechnical and geochemical monitoring continues to provide useful information that helped analyse closure options and will support more detailed water quality predictions in the future.

3.2.5 North Inlet Reclamation Research

No new results or conclusions with relevance to closure.

3.2.6 Infrastructure Area Reclamation Research

Multi-year research work in relation to re-vegetation is ongoing. The 2014 Progress Report is included in Appendix II-5. One complete task is a literature review study to evaluate reclamation projects conducted in the north and determine their potential application to current or future reclamation research and closure planning for the mine. A total of 226 references were examined as a part of this review. The following is a summary of the report that can be found in Appendix II-4.

Predictably, many challenges were found in relation to plant growth and reproduction given the harsh northern climate in which reclamation occurs. For diamond mines, low water content in substrates has been found to be the most limiting factor. Other physical challenges include: soil structure, erosion by wind and water, short growing season and grazing by wildlife. Limited knowledge of many northern species may also confound research efforts, including dormancy of seeds and shoot cuttings and optimal seasons to harvest. Lastly, mosses and lichens are critical for healthy tundra communities, but little is known on which types of moss and lichen establish best in northern climates, or how to propagate them.

Some successful examples of reclamation methods were also captured in this review; however, results indicate that site-specific conditions greatly influence the level of success of any given method. Identification of substrates available for reclamation, and knowledge of how best to combine such substrates to develop preferred soil properties is essential. Amendments to substrates are also important in developing appropriate soil structure and nutrient availability, as these are not commonly available in existing diamond mine substrates (e.g. processed kimberlite, lake bed sediments). Fertilizer is likely to be necessary, and optimum performance is expected if maintenance applications are used to assist with succession over multiple years. Salvaged topsoil from nearby areas of natural vegetation has proven very effective in multiple reclamation research projects. Erosion control methods have been developed that may assist with seed loss due to high winds common in northern climates. Microsites have also proven effective in protecting seeds and plants through the development process, but it can be a fine balance.

Despite increasing research efforts, knowledge of long term soil and plant community development is still limited, largely due to poor documentation and inconsistent monitoring. While natural recovery may occur, it would be slow; therefore, assisted recovery is recommended in the review for re-establishing soil and vegetation at disturbed sites.

3.3 Research Timelines

Research timelines have been adjusted based on results and progress to date and will continue to change as the research progresses. The following chart shows our current view of the research schedule for the immediate research tasks. Task descriptions for each of the task numbers are included in the research status table in Section 3.1.

There were three programs where timelines have slipped:

- Task 1.3.1 Landform Visualization Model
- Task 1.5 Semi-Fluid Processed Kimberlite Study
- Task 6.3 Site Wide Risk Assessment

One program was advanced in schedule:

- Task 5.6 NI Sediment Characterization Update.

Immediate Research Task		2015				2016				2017			
1. TK and Community Participation													
1.1 Wildlife Movement	1.1.1 Desktop study	Complete											
	1.1.2 Discussions												
1.2 Re-Vegetation	1.2.1 Desktop study	Complete											
	1.2.2 Discussions	Complete											
	1.2.3 TK/IQ Panel	Complete											
1.3 Landforms	1.3.1 Development												
	1.3.2 Assessment												
	1.3.3 Discussion												
1.4 Community Engagement	1.4.1 TK/IQ Panel												
1.5 Semi Fluid PK Study	1.5.1 Assessment												
1.6 Fish Habitat Design	1.6.1 TK Panel Review												
2. Open Pit, Underground and Dike Area													
2.1 Wall mapping		complete											
2.2 Geochmical loading		complete											
2.3 Fish use - exterior		complete											
3. Waste Rock													
3.1 Thermal	3.1.1 Initial estimate	complete											
	3.1.2 Scenarios	complete											
	3.1.3 Climate change	complete											
	3.1.4 Update estimates												
3.2 Hydrological	3.2.1 Initial estimate	complete											
	3.2.2 Scenarios	complete											
	3.2.3 Climate change	complete											
	3.2.4 Update estimates												
3.3 Geochemical	3.3.1 Initial estimate	complete											
	3.3.2 Scenarios	complete											
	3.3.3 Climate change	complete											
	3.3.4 Update estimates												
4. Processed Kimberlite Containment Area													
4.1 Geotechnical	4.1.1 Slimes analysis	complete											
	4.1.2 Slimes testing	complete											
	4.1.3 Instrumentation												
	4.1.4 Design review	complete											
4.2 Geochemical	4.2.1 Sampling												
	4.2.2 Trend												
	4.2.3 Leaching tests												
	4.2.4 Modelling	to be determined											
	4.2.5 Risk assessment												
4.3 Water quality criteria	4.3.1 Risk assessment												
	4.3.2 Update criteria												
	4.3.3 Gaps												
5. North Inlet Area													
5.1 Follow-up Studies	5.1.1 Leaching potential	complete											
	5.1.2 Sediment chemistry	complete											
	5.1.3 Sludge analysis	complete											
	5.1.4 Zoolpankton	complete											
	5.1.5 TIE	complete											
	5.1.6 Modelling	cancelled											
5.2 Screening level risk assessment		on hold											
5.3 Detailed risk assessment		on hold											
5.4 Risk management strategy		on hold											
5.5 Update criteria													
5.6 Sediment Characterization Update													
6. Infrastructure Area													
6.1 Re-vegetation	6.1.1 Monitoring												
	6.1.2 Interpretation												
	6.1.3 Ekati data	complete											
	6.1.4 Procedures												
	6.1.5 Gaps												
6.2 Contaminated soils	6.2.1 Management options	complete											
6.3 Reference Concentrations	6.3.1 Development												
	6.3.2 Update criteria												
6.4 Vegetation metals	6.4.1 Field measurements												
	6.4.2 Compare												
	6.4.3 Gaps												

4. Proposed Changes to Design Concepts

4.1 Pit, Underground and Dike Area

Closure activities related to the approved closure concept for the open-pits remain unchanged.

4.2 Waste Rock Area

No changes are proposed, at this time, for the North Country Rock Pile (NCRP) closure design concept. There is however better definition of a likely schedule. DDMI intends to develop the A21 kimberlite pipe starting with dike construction 2015-2018. As such once mining operations commence (2018) pre-strip material mined from A21 can be directly hauled and placed as cover on the NCRP. Final landform shapes will be determined in 2015 to allow any re-sloping to occur in 2016 and 2017 prior to till placement over Type III rock areas starting in 2018. A more specific plan and schedule is expected to be included with ICRP V4 in December 2015.

4.3 Processed Kimberlite Containment

The revised PKC closure design submitted with the 2013 ICRP updated was approved by the WLWB. There are no proposed changes to the design concepts.

4.4 North Inlet

The approved closure plan for the North Inlet (NI) is to create a full connection with Lac de Gras to enable use of the NI by the fish of Lac de Gras, subject to confirmation that the conditions in the NI, particularly the NI sediments, are suitable and safe for aquatic life. The alternative, should conditions in the NI sediment be unsuitable, would be to limit the connectivity to water and exclude fish. This alternative is conditional on water quality conditions in the NI being suitable for exchange with the water of Lac de Gras. Current NI sediment investigations results indicate that a hydraulic connection would be more appropriate than a full connection. This is different than what was expected when the NI closure objectives were developed and approved.

Conditions in the NI can change over the next 10 years of operations. DDMI will continue to advance closure designs for both a full connection and a hydraulic connection. The decision on which design to implement can be made closer to the end of commercial production and with information about the condition of the NI sediments at that time. DDMI will repeat the NI sediment investigation in 2015 to further inform this closure decision.

4.5 Infrastructure

Closure activities related to the approved closure concept for the re-vegetation are currently unchanged, but are pending consideration of recommendations from the DDMI Traditional Knowledge Panel as well as the results of ongoing research.

5. Closure Objectives and Criteria

At this time there are no proposed changes to the closure objectives or criteria documented in ICRP V3.2.

DDMI has identified a likely need to revisit the closure objectives and criteria for the North Inlet with submission of ICRP V4.0. The closure objective NI-1 “Reconnect the North Inlet with Lac de Gras” is actually a closure option, not a closure objective, and will be re-considered in ICRP V4.0. MVLWB-AANDC (2013) defines a closure objective as a “*statement that describes what the selected closure activities are aiming to achieve”*, whereas a closure option is defined as “*a set of proposed alternatives for closing and reclaiming each mine component*”.

DDMI continues to look forward to participating, as appropriate, in the *Regulator’s Role Workshop* as proposed by WLWB for determining the role of regulators in developing closure criteria.

6. Progressive Reclamation

Efforts continued during 2014 to reduce the Diavik footprint by removing from site items that are no longer required. Appendix VI-1 lists assets removed from site (2014). Additionally, the following items with no salvage value were demolished and landfilled following established procedures:

- Three portable type buildings:
    - North Pit Muster
    - North Construction Offices
    - South Camp dorms S and W (200 rooms)
- Three foldaway type buildings:
    - Acid Storage Building
    - Dewatering Shop
    - SCAP Rebar Shop

7. Schedule

The overall closure schedule remains largely as described in ICRP 3.2 and revised in the 2012 Annual ICRP Update.

The WLWB Directive (March 16, 2015) asked DDMI to identify which of the research tasks are required to develop final closure concepts. All of the research tasks support the development of final closure concepts. However, they are not all expected to be critical to the development of a concept. More often the research is necessary to support a design detail (e.g. re-vegetation methods) or to confirm an expected design performance (e.g. PKC geochemistry). That is not to say that ongoing research (or changes to mine plans) might not identify critical failures in the design concepts, but that this is not anticipated.

With the approval of the PKC closure concept (WLWB Directive May 14, 2014) the closure concepts for nearly all of the closure areas have been finalized. Exceptions are the North Inlet and re-vegetation.

Research on re-vegetation methods (Task 6.1.4) and metal uptake in plants (6.4.1) are still to be completed and will inform closure re-vegetation, however it is DDMI's view that there is currently sufficient information to propose a final closure re-vegetation concept for review in ICRP V4.0.

Two closure concepts remain for the North Inlet;

- Full re-connection to Lac de Gras including fish; and
- Partial re-connection to Lac de Gras excluding fish.

The decision on the closure concept for the North Inlet is currently pending the results from Task 5.6 - NI Sediment Characterization Update.

For a number of reasons, DDMI requests that ICRP V4.0 not be required before December 2016.

8. Security Update

The WLWB approved and updated closure cost estimate on August 18, 2014. This updated RECLAIM estimate is included as Appendix VIII-1. The total estimated closure liability is $128,280,000.

In 2014 there were no significant changes to the mine site or the closure plan that would impact on this estimate. DDMI notes however that construction of the A21 dike will increase the site closure liability in 2015. DDMI has estimated this increase to be a total of $962,430 (see Appendix VIII-2) or $1,260,783 including indirect costs (contingency, etc.). Figure 8-1 below shows the closure concept for the A21 pit and dike. The estimate is based on the approved A154/A418 dike and open pit closure cost estimates.

Figure 8-1. Closure concept for A21 pit and dike.

9. Other Important Information

Water License W2007L2-0003 expires October 31, 2015. DDMI intends to request a License renewal term of 15 years in the renewal application so that the renewed Water License would include all terms and conditions necessary to effectively plan and implement all closure and post-closure activities with regulatory certainty.

The WLWB specifically requested that DDMI "*Include a discussion about the impacts of leaving the waste rock pile uncovered, and provide enough information so that the Board can be confident that there are no unnecessary delays in placing the cover. DDMI should refer to the results of waste rock research to support DDMI's position on this matter*." (WLWB March 16, 2015)

Leaving the North Country Rock Pile (NCRP) uncovered has the potential to impact on the quality of any long-term seepage. Results from the research work have been used to estimate long term seepage water quality with a cover system (Table 2) and left uncovered (Table 1). The estimating methods and details were included as Appendix II-5 to the 2013 ICRP Annual Update.

Table 1: Results for selected parameters from a scenario with sides re-sloped to 18º (3H:1V) and a 7 m thick active zone (no cover system). (From 2013 ICRP Annual Update – Appendix II-5 Table 6).

		NWR West (Type I)	NWR East (Type II)	CLAR (Type III)	QUAR (Type III)	SED (Type III)	CLR (Type III)
Al	(mg L^{-1})	0.0001	0.2776	31.5126	30.2985	32.6728	0.0002
As	(mg L^{-1})	0.013	0.042	0.014	0.014	0.015	0.013
Cd	(mg L^{-1})	0.0008	0.0025	0.0574	0.0552	0.0595	0.0007
Cr	(mg L^{-1})	0.0007	0.0024	0.0014	0.0014	0.0015	0.0007
Cu	(mg L^{-1})	0.17	0.16	1.79	1.72	1.86	0.16
Mn	(mg L^{-1})	1.64	5.39	17.4	16.7	18.0	1.61
Mo	(mg L^{-1})	0.036	0.118	0.001	0.001	0.001	0.035
Ni	(mg L^{-1})	0.16	0.52	16.54	15.90	17.15	0.16
Pb	(mg L^{-1})	0.005	0.008	0.031	0.030	0.033	0.005
Se	(mg L^{-1})	0.007	0.024	0.028	0.016	0.017	0.007
U	(mg L^{-1})	3.08	10.13	1.54	1.48	1.60	3.02
Zn	(mg L^{-1})	0.16	0.22	10.30	9.90	10.68	0.16
pH		6.5	5.4	4.3	4.3	4.3	6.5

Table 2: Results for selected parameters from a scenario with sides re-sloped to 18º (3H:1V) and a 3 m thick active zone in a Type I cover. (From 2013 ICRP Annual Update – Appendix II-5 Table 7)

		NWR West (Type I cover)	NWR East (Type I cover)	CLAR (Type I cover)	QUAR (Type I cover)	SED (Type I cover)	CLR (Type I cover)
Al	(mg L^{-1})	0.00041	0.00044	0.00043	0.00048	0.00042	0.00044
As	(mg L^{-1})	0.006	0.006	0.006	0.006	0.007	0.006
Cd	(mg L^{-1})	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Cr	(mg L^{-1})	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Cu	(mg L^{-1})	0.076	0.072	0.073	0.069	0.075	0.073
Mn	(mg L^{-1})	0.75	0.71	0.72	0.68	0.74	0.72
Mo	(mg L^{-1})	0.016	0.016	0.016	0.015	0.016	0.016
Ni	(mg L^{-1})	0.073	0.069	0.070	0.066	0.072	0.070
Pb	(mg L^{-1})	0.0025	0.0023	0.0024	0.0022	0.0024	0.0024
Se	(mg L^{-1})	0.003	0.003	0.003	0.003	0.003	0.003
U	(mg L^{-1})	1.41	1.34	1.35	1.27	1.38	1.35
Zn	(mg L^{-1})	0.073	0.070	0.071	0.066	0.072	0.071
pH		6.3	6.2	6.2	6.2	6.2	6.2

The estimates in Table 1 and 2 above demonstrate the anticipated positive impact of the cover system constructed over Type III storage basins on any long term seepage water quality. The benefit of the cover system over Type II (NWR East) and Type I (NWR West) storage basins are much less, as would be expected.

Currently, DDMI has scheduled cover construction to start in 2016/2017 with any required re-sloping to enable direct haul of till from the pre-stripping of A21 in 2018. A portion of the Type I rock from the mining of A21 will similarly be direct-hauled to the NCRP and placed over the till. This will occur in the period from 2019-2023 whenever there is an opportunity to fit the longer hauls into the mine schedule. Direct hauling till/rock is a substantial financial benefit to constructing the cover system concurrent with A21 mining rather than waiting until after the end of commercial production. As such there is a direct incentive for DDMI to not have any unnecessary delays in placing the cover.

10. Record of Revisions to be made in Version 4.0 of the ICRP

Following is a list of revisions to be made in Version 4.0 of the Interim Closure and Reclamation Plan. This list was taken originally from the WLWB Letter of September 26, 2011 and has been added to as new items are identified.

1. Re-visit the closure objectives for the north inlet to ensure they are closure objectives and not closure options – particularly NI-1.

2. Develop a monitoring plan, including estimated time periods.

3. Include a detailed explanation of how the mine would passively treat seepage in situ.

4. Provide a more detailed description of risks associated with each selected closure activity. For each reclamation activity, identify the preferred contingency and significantly increase the level of detail for this contingency. Ensure all uncertainties associated with the preferred contingency are addressed. For example, if using Lac de Gras water to dilute water in the pit area is DDMI's preferred contingency, describe how this would be achieved, clearly define the environmental costs and benefits (compared to water treatment or other contingencies), and address any associated uncertainties.

5. Estimate the quantities of contaminated soils/materials expected at the end of operations, in order to facilitate the remediation of potentially contaminated material (landfarming).

6. Provide a general description of the types and quantities of materials that the company plans to leave underground, based on available information. Also, discuss the risk that this disposal may contaminate groundwater or surface water and identify any uncertainties.

7. Identify potential benefactors of salvaged infrastructure (e.g. buildings, tanks, equipment, supplies, crushers, generators, etc.) earlier rather than later and provide more detail about current plans and options.

8. Include updated predictions of water quality at closure and the duration and magnitude of residual effects using the most current information. This must include an analysis, using the most current data available, to update the 1998 runoff water quality predictions. Identify ways to reduce water quality problems associated with runoff.

9. Include detailed performance and post-closure monitoring plans and updated predictions of effects using the most current information. (Consider hosting a workshop or information session on post-closure monitoring prior to submission of Version 4.0 of the ICRP).

10. Address the issue of air contaminants released to land and water during operations, in the context of closure.

11. Provide the proposed revegetation procedure.

12. Include final design of the waste rock pile slopes and a resloping plan.

13. Provide a more detailed description of how metal uptake in revegetated plant communities will be monitored (per Water Licence condition Part L, Item 3f).

14. Provide "a description of the Plan to assess and monitor any ground water contamination during post-closure" (Water Licence condition Part L, Item 1g).

15. Develop “a field-testing program and an implementation timetable to verify the effectiveness of the proposed impermeable closure cap for the Process Kimberlite Containment Facility and the Waste Rock Storage Facilities” (Water Licence condition Part L, Item 3g).

16. Clarify how wetlands will be used for the closure of the collection ponds and the PKC Facility. Discuss whether it is imperative that wetlands develop in order to achieve the closure objectives? Discuss procedure and timetable for development of the wetland.

17. Add "identify opportunities to enhance/diversify fish habitat in the North Inlet" to the reclamation research plan (RRP) outlined in appendix VIII-5 (assuming ongoing investigations support full reconnection of the North Inlet to Lac de Gras) ;

18. Include a closure plan for the A21 causeway (including closure objectives, preferred activities, etc.);

19. Ensure that all information in section 3 of the ICRP (Project Environment) is correct and up to date (e.g., geological info, climate data, traditional use information, etc.). Refer to a number of INAC comments for specific revisions.

20. Include a statement that, during temporary shutdown, the stationary surface and underground mobile equipment stored within the common parking areas would have drip/spill trays placed in appropriate locations to absorb fluids which could leak.

21. Define closure vs. post-closure.

22. Include improved diagrams of the waste rock pile, as described above in the outline for the Annual ICRP Progress Report.

23. Provide detailed and informative figures illustrating the final closure design of each mine component.

24. Provide additional detail about long-term water treatment, including: any required changes to the existing treatment plant; implications on the post-closure requirement for fuel, chemicals, and personnel; maintenance requirements; proposed disposal location for treatment sludge; etc.

25. List all sub-appendices in the table of contents, and include cover pages for all appendices and sub-appendices. Ensure all subsections and appendices are bookmarked correctly in pdf version of the ICRP.

Appendix I-1

Traditional Knowledge Panel Recommendation Tracking.

DDMI TK Panel Recommendations and Response Tracking - Landscape & Vegetation. (may include references to wildlife/wildlife habitat)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
1.0	A Way of Life, 25 October 2012, pg. 9	Ensure that any caribou trails are clean and clear of debris.	TK provides insights into caribou needs. Caribou are really sensitive about their feet and knowledge passed down over generations tells that it is important to make sure that any areas where caribou travel are clean so that their feet are well taken care of. From Renewing Our Landscape: Caribou feet are really soft so they prefer to travel on sand and eskers, and sometimes hills. Sand is really important. *Soft sand can be used to cover jagged rock at water crossings so that caribou can get into and out of the water safely.*	Respect Safety	Additional information on what is considered 'clean' is needed in order for Diavik to implement such a recommendation when designing caribou trails for post-closure use. e.g. TK Panel members have discussed the possibility of using fine PK as sand along wildlife access areas (Session 6), but Diavik would need to evaluate the properties of PK in relation to animal health before determining if its use is suitable for caribou trails.	Diavik plans to begin a toxicological study on PK material in 2015.
1.17	A Way of Life, 25 October 2012, pg. 17	A monitoring program that includes (western) science and TK/IQ is the most practical and preferred approach.	Provide an opportunity to continue practicing and integrating different ways of knowing and learning from each other. The mine's presence makes it necessary to develop cross-cultural ways of learning and sharing knowledge. Need to be creative in collaborating with Diavik. A successful program requires good communication and strong relationships.	Reciprocity Trust Shared learning	The TK/IQ Panel is Diavik's preferred method to consider and develop closure monitoring options that incorporate science and TK/IQ. Work to develop trust and communication protocols with the Panel and communities is a part of this approach.	Revise the document "Working Together" (previously created by the Panel under EMAB) to reflect the relationship of Diavik administering the Panel.
1.18	A Way of Life, 25 October 2012, pg. 24	Work with Aboriginal knowledge holders to investigate and experiment with the possible use of deflection zones (e.g. 20 miles away from the mine and another closer to the mine), based on knowledge of migration routes that may help to guide caribou movements away from the mine.	Humans do not control nature, but must take steps to provide for caribou needs when nature has been disrupted. There is no way that you can keep an animal out of its migrating route. Its either going north or south, and they follow different routes. They will go over anything in their path. Traditionally, spruce and other markers such as inuksuit have been used to direct caribou to certain areas. These could be used to try and reduce risks and stress on animals. If they are in a straight line, caribou will follow them and they won't go inbetween the markers, even if there is a large gap. From Renewing Our Landscape: East Island is a shelter for young and injured caribou; they get to it by swimming along the channel (on the north side of the island). South of the lake is jagged rock where caribou could get injured. The east side of the lake is better; there is a sandbar, muskeg and rocks and its good for caribou migration.	Respect Stewardship Reciprocity	Current mine activity levels appear to be sufficient to deter caribou from visiting East Island. Methods such as this may be effective as the mine transitions to closure and post-closure, depending on wildlife use preferences identified for mine site areas by community members.	Work with communities, regulators and potentially other industry representatives to determine wildlife use preferences for the area of the mine after closure.
1.19	A Way of Life, 25 Oct 2012, pg. 25; Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.6	Ensure that TK/IQ knowledge that has been shared in the past is incorporated into future planning, specifically in relation to caribou and vegetation.	Early work that was done for Diavik's Environmental Impact Statement and other planning processes included knowledge about caribou that should be reviewed and used. Include a review of Elder site visits and best practices from the Golder Associates literature review.	Recording knowledge Respect	Diavik is interested in incorporating historical information on caribou and other areas of the environment from the companies documents, as well as external sources such as the West Kitikmeot Slave Study and community TK archives, particularly with respect to mine closure planning. The literature review that was completed by Golder Associates was a first step in identifying the type of information that is available to the public.	DDMI plans to review historical information for the LDG area in relation to caribou use and movement. Literature review of TK relating to plants in the Lac de Gras area was completed in October 2014.
2.5	Renewing Our Landscape, 7 December 2012, pg. 35	Seasonality of monitoring must be taken into consideration when planning for post-closure monitoring.	Land, water and air are the three key areas of concern for Aboriginal people. TK monitoring seasons are: winter for hare, foxes, wolverine, etc; spring for caribou; summer for fish and water; fall for berries in muskeg and plants.	Seasonality	Diavik is interested in further exploring ideas for closure monitoring with communities. Seasonality should be accounted for in these discussions.	Plan for a discussion on environmental monitoring at closure with the TK Panel.
3.4	Renewing Our Landscape, 7 December 2012, Appendix D, pg.14; Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.5	Leave the airstrip intact with one or two small buildings nearby; do not revegetate it.	Excellent infrastructure for the north as an emergency landing strip for aircraft. A small building can provide emergency shelter, or shelter for those using the area for hunting or fishing.	Reciprocity Safety	Maintenance and liability issues are the key challenges with leaving the airstrip and/or a small building after closure. Diavik would be open to Transport Canada or another party acquiring this airstrip. Alternatively, Diavik would consider leaving the airstrip intact (no reclamation, no on-going maintenance/liability), were this to be preferred by communities & approved by the Board.	Review such considerations prior to finalizing this aspect of the closure plan.

DDMI TK Panel Recommendations and Response Tracking - Landscape & Vegetation. (may include references to wildlife/wildlife habitat)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
4.1.2	Checking Nets, 23-25 October 2012, pg.18; Closure/Reclamation and Landscape History Interim Report, 23-25 October 2012, pg.8	Diavik should carry out and make public a review of its use of TK/IQ in its environmental plans and programs. This review should document the successes and lessons learned from TK/IQ studies, and what changes or improvements in adaptive management can be attributed to TK/IQ.	Key concerns in relation to this recommendation are whether Diavik is doing what they said they would do, and community members are concerned with repeating themselves over the years without seeing any results from their suggestions. Community members feel that Diavik needs to demonstrate their use of TK, in respect to the Elders.	Respect Reciprocity	DDMI had a report prepared by Golder Associates titled "Literature Review of Traditional Knowledge Related to the Resource Sector - July 2011". Beyond this, DDMI does not feel that it is necessary to produce a separate report that documents where TK/IQ has been incorporated into its past processes. Many of these initiatives were established during the early years of the mine and it would be difficult to effectively represent the knowledge and provide lessons learned.	Looking forward, DDMI plans to use this response tracking system to document use of TK/IQ recommendations from the Panel. Past TK/IQ projects will be reviewed as necessary for individual topic discussions, e.g. re-vegetation.
5.4	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.5	Smooth slopes on the sides of roads and the airstrip so that they are less steep, and remove large boulders from these areas. Scarify engineered surfaces such as the camp areas, plant site, roads and laydowns. Revegetate to support biodiversity.	Consider revegetating the sides of the airstrip and roads so that they can filter runoff, but avoid revegetating the surfaces. Keep all roads to the pits and airstrip in tact to allow access for monitoring. Sides of old roads and the airstrip should be made less steep and revegetated to filter runoff. They should be relatively smooth and free of boulders so that wildlife can move over the areas safely.	Respect Safety	The current closure plan supports this recommendation and includes contouring of roads, restoration of drainage, surface scarification and revegetation. Some travel routes will be planned, connecting key areas of the old mine footprint for human and wildlife travel.	N/A
5.5	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.5	Remove equipment, unused buildings, pipes, toxic materials and non-biodegradable items from the island.	Panel members refer to traditional practices of always leaving a clean campsite and respecting the land for your use. Buildings, equipment and materials no longer needed should be redistributed to Aboriginal communities if requested.	Stewardship Reciprocity	An approved landfill exists at Diavik (within the rock pile) and will continue to be used for non-hazardous waste materials. Hazardous materials are backhauled off site on the winter road. An evaluation of building or equipment condition would need to be conducted in advance of providing any materials to communities; if the materials were deemed suitable, Diavik would be interested in communities acquiring such items.	Determine salvage options for mine site materials on a case-by-case basis.
7.1	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Do not disturb new areas and protect natural vegetation areas that exist on the Island (with the exception of planned development areas for A21, the rock pile for A21 and any future closure work that involves covering natural vegetation in order to flatten slopes for safe wildlife passage).	Panel members were able to visit areas of natural vegetation and most were happy with how these looked, and recognized the importance of preserving these, where possible. Comments: "I was looking for dust on berries and willows, but I saw that they were pretty clean; seeing it first hand helps." "The berries and leaves in the undisturbed areas look the same as before." "I feel peaceful and good after going out on site; I saw a fox and wolf and ground squirrels." " There were caribou trails at the south side of the airstrip; it looks good. Its good to see the land looks healthy." Panel members also recognized that it is important to balance preservation of natural vegetation with making sure that wildlife can pass through the site safely. For example, participants felt it more important to widen the base of any future rockpile associated with the A21 development, in order for the pile to be lower and less steep for wildlife movement.	Stewardship Natural condition Experiential learning Respect	Pending	TBD
7.2	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Study vegetation east and north of the Island to understand good caribou habitat.	Participants felt that tundra vegetation is very powerful; like there is something underneath that is helping it. They noted the importance of moisture for growth. Many participants felt that the environment is powerful, that nature will heal itself and that vegetation at the mine site will grow again on its own. Others felt that what has happened on East Island is not natural, so it cannot be left to Nature alone to heal; Nature needs help in this case. Still others noted that climate change will result in differences; e.g. willows are taller now at places where Panel members used to camp and different species are coming to the north (which Elders predicted in the past). Some participants thought that vegetation on the East Island is different from the mainland (and that this could be from human activity, introduced species or climate change).	Experiential learning Natural condition	Pending	TBD
7.4	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Test both natural vegetation and seeded plants (re-vegetation plots) for toxicity.	Vegetation itself was not seen as a concern; the worry is about hazards and concerns for caribou if they eat the plants. Panel members want to be sure that vegetation on the mine site is safe to eat and similar to that farther away on the mainland. Many participants noted that wildlife smell food before they eat it; they may roam around but not eat. Caribou are smart and this is is an indication that they know when plants are not healthy for them.	Reciprocity Natural condition Respect	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - Landscape & Vegetation. (may include references to wildlife/wildlife habitat)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
7.6	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Use fine crushed rock on passage-ways to protect the feet of the caribou (similar to what is on the sides of the airstrip right now – August 2014).	Participants noted that caribou are the most important species to look after and that they must be respected. From 1.0 (above): Caribou are really sensitive about their feet and knowledge passed down over generations tells that it is important to make sure that any areas where caribou travel are clean so that their feet are well taken care of.	Respect	Pending	TBD
7.9	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Create slopes on the sides of roads similar to that on the test pile to support safe travel for animals, and use crushed rock (like at the airstrip) on the surface.	All Panel members showed a clear preference for road reclamation that included a relatively flat top with downward sloping sides at a low angle. The material preferred for use in reclaiming such areas is crushed gravel. It was recognized that natural revegetation may be lost by pushing out the sides of roads in order to ease the slope, but this was seen as an overall positive because it allowed safe passage for wildlife.	Respect Experiential learning	Pending	TBD
7.10	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Transplant a variety of natural 'tundra mats' and compare them to seeded test plots; this will help natural recovery by maintaining the biodiversity of the area.	The re-vegetation plots were visited and Panel members found it interesting to see the different plants that were growing there (e.g grasses) when compared to the tundra beside the plots. Many also felt that there seemed to be little vegetation given that it had been 10 years. Researchers explained that growing grass allows the soil to build (nutrients, moisture, etc.) and is the first phase in helping other natural tundra plants to then establish. Panel members felt that there could be benefit in taking natural 'tundra mats' from areas being impacted by mine development (e.g. future A21 rock pile area) and re-planting them in re-vegetation areas.	Natural condition Seasonality	Pending	TBD
7.11	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Use the natural tundra mat to guide plant selection to ensure natural balance.	Similar to recommendation 7.2, it is seen as beneficial to "learn from Nature's quilt" and study the plants that grow together in various areas.	Natural condition Seasonality	Pending	TBD
7.12	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	When using fertilizers, use natural local fertilizers like droppings from local animals. The question of treated human sewage needs to be revisited.	Participants noted how caribou droppings have often resulted in better plant growth at traditional camp sites or other areas of the tundra. It was felt that use of such natural fertilizers may be beneficial in the re-vegetation work that Diavik will be doing. Participants were not sure how they felt about using treated human sewage as a fertilizer - a product that is readily available on site and has been used with some success in the re-vegetation test plots. Panel members would like to learn more about what is in the treated sewage before deciding on whether this is an acceptable fertilizer.	Natural condition	Pending	TBD
7.15	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	The re-vegetation maps developed in this session are not yet complete and more time needs to be spent discussing and finalizing these.	Participants worked hard to classify various areas of the site in terms of zones for which they would prefer to 1) deter wildlife use, 2) encourage plant growth or 3) engineer areas of safe passage or use for wildlife. The map developed by the women during a break out session was the most supported approach to date, but Panel members felt that this requires more discussion at both the Panel the community levels.	Intergenerational Stewardship Recording knowledge	Pending	TBD
7.16	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	The TK Panel would like to use maps that show the TK of traditional caribou migration routes as the basis for evaluating the "big picture" and identifying areas for sloping (modification) on East Island at closure.	Panel members recognized that it would be helpful to have access to some of the early work produced prior to mine development that identified the traditional trails used by caribou and identified by Elders during the Environmental Assessment. Participants felt that it would be useful to compile that information onto a map that could then be marked up to show the 3 types of zones to be considered for animal use of the mine area after closure (deter wildlife use, encourage plant growth or engineer areas of safe passage or use for wildlife).	Recording knowledge Respect Natural condition	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - Waste Rock Pile						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
2.2	Renewing Our Landscape, 7 December 2012, pg. 22	Do not allow water to pool on top of the rock pile	Once a small pool of water forms, it gets bigger and becomes a lake that attracts animals. Animals then start to use it. Because the Panel is concerned with the quality of water within or flowing from the pile, there is concern for the health of caribou and other wildlife.	Stewardship	Diavik is not planning to have a water pond on top of the rock pile at closure.	N/A
2.3	Renewing Our Landscape, 7 December 2012, pg. 23	Have a 'moat' around the rock pile as a way of being able to contain and monitor the water that is coming out of the pile.	Relates back to the concern of water quality coming off/out of the pile. Eskers have cold water flowing out of them because of the permafrost within the esker. The same is likely to happen with the rock pile as permafrost builds up within the pile over the years.	Stewardship	The existing collection ponds surrounding the rock pile serve this purpose and current plans have the ponds remaining until adequate water quality has been demonstrated.	N/A
2.6	Renewing Our Landscape, 7 December 2012, pg. 45; Appendix D, pg. 8	Some revegetation should be planned for the rock pile. Consider use of good, black soil from the tundra or other eskers in the area. Plant native shrubs such as dwarf birch and willow in the soil near the bottom and allow the remainder to revegetate naturally.	Respect for the land includes respecting natural systems - there is a reason for each plant being there. Introduced species can be harmful and quickly take over; preference is to use naturally occurring plants. Using soil from elsewhere may be acceptable because the Diavik island is a traditional place for caribou to roam and is a good feeding/resting area; another option is to use till from A21. Revegetation will take time but it is the right thing to do. Consider visiting old archaeological sites or other esker sites to view re/growth; exposure will dictate what grows where (shade, leeward, side, top).	Respect Stewardship	The current closure plan does not account for revegetation on the rock pile. Harvesting soils from outside the mine footprint is not being considered. Re-vegetation priority for DDMi is still plant site, laydowns and roads.	N/A
3.1	Renewing Our Landscape, 7 December 2012, Appendix D, pg.6; Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.4	Simulate an esker when considering the final shape of the rock pile.	Traditional stewardship means leaving things as natural as possible. Make it look as natural as possible by imitating the effects of glaciers and prevailing easterly winds on the surrounding landscape. This includes sloping the top edges so they are rounded, sloping the sides so they are less steep (similar to the test pile) and have varying levels of steepness. Place rock from the pile back into the pit. The top should be flat with berms removed so that caribou can walk safely as there would be fewer places for predators to hide; they may want to use the hill to get away from bugs. Big boulders should be removed, particularly at the bottom of the pile and on the north slope, as wildlife will likely get injured trying to walk over them. The north side should be the most gradual slope, as this will be the area for wildlife and people to access the top.	Stewardship	Simulating a large esker is a preferred approach to re-shaping the rock pile. Closure plans do not include placing rock back in the pit. Diavik anticipates that re-shaping efforts would eliminate the need for large boulders to be removed.	N/A

DDMI TK Panel Recommendations and Response Tracking - Waste Rock Pile						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
3.2	Renewing Our Landscape, 7 December 2012, Appendix D, pg.7; Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.5	Safe wildlife access needs to be considered for all seasons when designing the final shape of the rock pile. There needs to be soft material in areas where caribou will be; consider the use of PK material for animal paths.	Prevailing winter winds (NE) will result in a smooth snow cover that drops straight down on the lee side of the pile so need to consider TK/IQ in relation to snow drifts. In summer, caribou will go on top of the pile to avoid flies; consider having something for them to eat up there. In fall, caribou will swim across to the island from the northwest, following their old migration path; consider having a caribou ramp across the pile that connects with this access point. Use waste rock to slope the pile and consider an esker 8 miles NE of Diavik as an example. Refer to comment 1.0, Landscape for further information on suitable materials for caribou feet.	Seasonality Stewardship Respect	A caribou 'ramp' (safe access on, off and across the pile) for the rock pile is included in the current version of the closure plan. Additional ideas on design options to provide safe access for wildlife are being discussed with communities, along with technical considerations for design and performance. Diavik would need to evaluate the properties of PK in relation to animal health before determining if its use is suitable for caribou trails.	Diavik plans to begin a toxicological study on PK material in 2015.
3.3	Renewing Our Landscape, 7 December 2012, Appendix D, pg.12 & 13	Channel water flow to prevent contaminants from reaching Lac de Gras.	Consider using geotextile to line drainage channels downstream of the pile and revegetate these areas. Snow drifts and areas of accumulation need to be considered when planning for drainage. The lake water needs to remain healthy as the people of Kugluktuk live downstream.	Stewardship Reciprocity	Closure plans for the mine consider the use of drainage paths that allow additional time for water to travel over the tundra before reaching Lac de Gras. Diavik's closure goals include land and water that is physically and chemically stable and safe for people, wildlife and aquatic life.	N/A
5.1	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.4	Preference is to lower the height of the rock pile. However, if that is not possible, keep the rock pile height as low as possible while ensuring that contaminants within the Type II and III rock areas are contained.	The biggest concern that Panel members have is chemicals seeping from the pile into the lake or being injested by wildlife drinking the water. While the pile is considered an eyesore and Panel members would like to see it smaller (lower) on account of wildlife concerns, participants also recognize that it is most important for the pile to function well in containing chemicals from entering the environment.	Stewardship Respect	The rock pile has reached its maximum height and matches what was originally permitted for the mine, though capping materials will result in a slightly higher final elevation. Diavik's primary closure goal is to contain Type II and III rock and ensure that water quality from the rock pile seepage is safe for wildlife and humans.	N/A
5.2	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.4	Cap the rock pile with the best materials for biodiversity based on TK and science, using nearby hills as a reference.	Many Panel members believe that nature needs a helping hand; it will heal itself, but conditions to allow re-growth need to be created. Everyone recognizes that things grow slowly in the north, but that over time the area should heal. Panel members desire to see the land as close as possible to how it looked before is the main factor in guiding recommendations. While it is acknowledged that the area will never be the same again, efforts to reclaim areas in a way that resemble natural features is preferred.	Nature is self-healing Stewardship	Material availability will be an important aspect of closure planning. Diavik's preference is to use materials available at the mine site, without having to disturb other areas. Mine rock and till will be the materials available in greatest supply and these are currently being considered for use in capping the rock pile.	Investigate areas that have naturally revegetated around the mine site; evaluate species and substrates.
5.3	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.5	Experiment with different types of wetlands for filtering water that collects at the base of the rock pile.	Traditionally, people tried different things to solve problems and TK holders want to be involved in any new experiments. This method should be combined with current or alternate purification system(s) to treat remaining contaminants. There are opportunities for Aboriginal people to be trained to do this type of monitoring. Panel members recognize that it is not ideal to have a water treatment plant on site forever and that more natural treatment options, similar to many used in communities, are preferred in the long term.	Stewardship	Wetland drainage has been effective in this area in the past and that is what is currently planned for managing water from the rock pile.	Determine preferred drainage pathways, and possibly associated plant life, that would result in water that is safe for humans and wildlife.

DDMI TK Panel Recommendations and Response Tracking - Waste Rock Pile						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
EMAB-2	Environmental Monitoring Advisory Board TK/IQ Panel Recommendations from February 2013, Letter from EMAB, 8 Oct 2013, pg.2	EMAB recommends that Diavik incorporate into its ICRP research the following question: Will vegetation on the waste rock pile increase snow trap, which will increase run off and increase the chance of leaching?	TK/IQ Panel members have highlighted considerations for snow accumulation in relation to prevailing winds, but have not discussed this in relation to vegetation on the pile.	Stewardship	Not supported as current closure plans for the rock pile do not include revegetation.	N/A
EMAB-3	Environmental Monitoring Advisory Board TK/IQ Panel Recommendations from February 2013, Letter from EMAB, 8 Oct 2013, pg.2	EMAB recommends that Diavik shape rock piles in a way that directs freshet runoff away from Lac De Gras through natural wetlands in order to naturally filter the runoff.	Supports discussions of the TK/IQ Panel preferences of wetland treatment and diverting water away from Lac de Gras for as great a distance as possible.	Nature is self-healing Stewardship	Diavik supports this approach wherever possible but notes that runoff and seepage will eventually reach Lac de Gras. Suggest re-wording to: "...direct freshet runoff and seepage away from Lac de Gras and through seepage wetlands *for as long a distance as possible* ..." Diavik has also applied this recommendation to the proposed PKC closure option.	N/A
7.9	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Create slopes on the rock pile similar to that on the test pile to support safe travel for animals.	Panel members felt that it was not necessary to plan too much for the animals safe passage, as caribou will ultimately go where they want and will find the ramp, road or easy way. Preference was to align the path with the old migration route and to keep the slope similar to that of the test pile - as natural as possible. Boulder size and angles were also a concern. Panel members noticed some big, sharp rocks at the bottom of the north country rock pile that would need to be covered. It was seen as important to think about the slope in the winter too - how wind will deposit snow - not just when it is snow free. The berms on top of the rock pile were viewed as a barrier to caribou movement, so it would be preferred to remove them and also to remove the berm around the top of the pile.	Stewardship Seasonality	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - PKC						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
6.1	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Cover PKC area with a combination of natural sand and soil to ensure that the PKC is not over-heating the area (and melting permafrost) and to support natural re-vegetation	Concern was expressed that the dark colour of both the coarse PK and the liner would attract more sun (heat) that would result in permafrost melt. There was also a desire to see the area revegetated as Panel members expect that caribou and other wildlife will attempt to access the area after closure.	Stewardship Respect	The revised closure plan discussed in the October 2013 TK Panel session was approved by the WLWB in May 2014. The current plan includes a rock cover that would be lighter in colour and serve the same purpose as the sand and soil cover proposed by the TK/IQ Panel. The rock cover required to contain the Processed Kimberlite and protect it against wind & water could limit opportunities for revegetation.	Determine relative importance of overall function compared to specific material use with communities.
6.2	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	If there were eskers within the PKC area, reclaim these to their original state or as close as possible	A key goal expressed by the TK Panel was to return the landscape to a more natural state.	Natural condition	Need to consider technical requirements that would provide stability of the dam structure after closure. This is likely to limit the ability to re-design the PKC area with features such as an esker.	N/A
6.3	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Re-vegetate the PKC area according to baseline traditional knowledge and science	A key goal expressed by the TK Panel was to return the landscape to a more natural state. Panel members thought that vegetation may help to stabilize the ground.	Natural condition Nature is self-healing	The current closure plan does not include revegetation of the PKC area. It is unlikely that vegetation would help to stabilize the ground in this area given the substrate, cover materials and permafrost development, and also in consideration of the limited root systems of sub-arctic plants. Lichen development on rock/ boulders may develop over time.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.4	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Create wildlife habitat and stabilize ground with transplanted willow	TK/IQ Panel members first leaned toward deterring animals from using this area after closure, but the Panel came to realize through their discussions that caribou and other wildlife will attempt to access the area after closure. For this reason, the vision of the Panel for this area shifted to recreating habitat similar to what was present before the mine was constructed. A key concern that Diavik noted was the instability of the fine PK 'flatlands' or 'beaches' that are contained inside the PKC dam.	Natural condition	The current closure plan does not include revegetation of the PKC area. It is unlikely that vegetation would help to stabilize the ground in this area. Diavik would need to explore possible options and their associated risks if revegetation of the PKC was to be considered.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.5	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Create marshy areas with moss, lichen and berries	This type of vegetation would provide a food source and safe travelways for animals. It would also resemble what the area looked like before the mine was built.	Natural condition	The main focus in closing the PKC is to direct PKC seepage and/or runoff water to marshy areas on the tundra that have moss cover and allow for natural filtration. It is currently preferred to keep the flatland area within the PKC dams dry and sloped toward a planned pond. This would help to stabilize the PK underneath the cover material.	N/A

DDMI TK Panel Recommendations and Response Tracking - PKC						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
6.6	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Removal of the slime from the mine site upon closure.	Traditional laws and stewardship of the land imply that you do not leave human-made materials behind as it is harmful to water, air or animals. The removal of slime provides a level of comfort and certainty to northern communities that is not otherwise available. This preference is based on the acknowledged problems created by leaving the slurry/slime onsite, in particular safety concerns for people and wildlife and the uncertainties associated with impacts from environmental change (e.g., a rise in temperature and associated drought, permafrost melting, earthquakes) long into the future. Further, it provides an opportunity to return the landscape to a more natural state which is a key goal expressed by the TK Panel throughout sessions to date.	Stewardship	Diavik understands the motivation to remove the slimes from site. However, should the material prove to be non-toxic to people and wildlife, Diavik plans to leave the slimes on site. Should the material be used or accessible to wildlife (directly or indirectly) at closure, it would be beneficial to conduct a toxicological study on the material.	Diavik plans to begin a toxicological study on PK material in 2015.
6.7	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 5	Removing the slime offsite remains the preferred option until Diavik can demonstrate through chemical and toxicological analysis that the slime is not harmful to the environment (i.e. plants, wildlife, fish, and humans).	Upon discussion, Panel members stated that should the slimes prove to be non-toxic, they would be more willing to assess on-site containment options for this material. TK holders need to see for themselves that something is not harmful to the environment. Participants would want to be confident in the results of the scientific testing.	Stewardship	Should the material prove to be non-toxic to people and wildlife, Diavik plans to leave the slimes on site and determine the preferred method for containment that allows for safe use or passage of wildlife in the PKC area.	Diavik plans to begin a toxicological study on PK material in 2015.
6.8	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Return the lake and shoreline to their natural states, as much as possible (e.g. gradual slope)	This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.	Safety Respect	It is likely that the shoreline of any reclaimed pond will differ from a natural pond, but it may be possible to recreate some elements of interest to communities.	DDMI conducted a literature review to identify examples of re-vegetation efforts undertaken in northern climates. Completed in October 2014.
6.9	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Ensure that the shoreline (of the PKC lake) is stable and that rocks are of the correct size to be safe for wildlife, especially caribou.	This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.	Safety	Another closure goal for Diavik is to have land areas that are physically stable and safe for people, wildlife and aquatic life.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.10	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Line the lake bottom with granite, gravel and rocks and other natural materials that were there before	Create a more natural and stable lake bottom that would be safe for caribou use during the warm months.	Natural condition	One of Diavik's closure goals is to create a final landscape guided by pre-development conditions & TK. Consideration of materials available and suitable for use are evaluated as part of the closure planning process.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.11	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Re-vegetate the lake with water plants of this area	Such plants contribute to biodiversity as they are a food source for other fish and animals. Plants feed fish but may also clean the water that wildlife may to drink and birds are likely to land on.	Natural condition	Current closure plans do not include revegetating lakes with water plants. Because the water pond within the PKC would not be stocked with fish (see below), efforts would also not be made to revegetate lakes with water plants. DDMI prefers to construct this lake in a manner that would not attract wildlife or promote its use.	N/A

DDMI TK Panel Recommendations and Response Tracking - PKC						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
6.12	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Re-stock lake with fish and bugs	The desire of Panel members is to recreate pre-mine conditions. The limitations of water movement after closure were discussed in relation to elevation changes in this area; historic water flow patterns between Lac de Gras and the PKC area that would be necessary to support fish and bug life would be incredibly difficult to achieve.	Natural condition	Current closure plans do not include re-stocking fish and bugs in East Island lakes, and this includes the lake within the PKC area. Water flow patterns that would be similar to historic conditions and possibly allow for fish and bug life in the PKC pond are not planned for this area. As discussed, elevation changes from mine development would prevent this from occurring.	N/A
6.13	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Recreate small ponds along the drainage route to encourage settling and healing of the water and fish habitat	There is a strong belief expressed by the Panel that nature heals itself and that it can be disrespetful to interfere with nature, but that humans can help to create the conditions to support healing. Encouraging longer drainage paths that utilize small ponds increases the chance of having cleaner water when it reaches Lac de Gras.	Nature is self-healing	Diavik agrees with this recommendation and the proposed drainage path for a pond within the PKC area flows across the tundra, and passes through 3 small ponds along the way.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.14	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Support the drainage streams to encourage fish to migrate from Lac de Gras to the reclaimed lake	The desire of Panel members is to recreate pre-mine conditions. The limitations of water movement after closure were discussed in relation to elevation changes in this area; historic water flow patterns between Lac de Gras and the PKC area that would be necessary to support fish and bug life would be incredibly difficult to achieve.	Natural condition	The footprint of the PKC extends close to the shoreline of Lac de Gras which could make it very difficult to reduce the slope of the dam in some key areas. The elevation difference for the PKC area at closure will be significant when compared with the original lake in that area, making it very difficult to re-establish baseline conditions. Technical considerations also need to be taken into account; the dam walls still need to contain PK material that would remain after closure.	N/A
6.15	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Make the closure lake as similar to the original lake, as much as possible	The desire of Panel members is to recreate pre-mine conditions and plan for safe usage of the area by wildlife.	Natural condition	Material availability will be limited and Diavik prefers to use material available at the site, without disturbing new areas. It is likely that the shoreline of any reclaimed pond will differ from a natural pond, but it may be possible to identify and recreate some elements of interest to communities.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.16	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Provide sufficient travel-ways for caribou and muskox over the dam through re-sloping and topping with smaller material	This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.	Safety Respect Stewardship	The current closure plan does not include re-shaping of the PKC dams. Any proposed changes would need to be evaluated for possible risks and discussed with communities. The footprint of the PKC extends close to the shoreline of Lac de Gras which could make it very difficult to reduce the slope of the dam in some key areas. Technical considerations also need to be taken into account; the dam walls still need to safely contain PK material that would remain after closure.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.
6.17	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Recognizing that caribou may return, provide areas of soft materials that are good for caribou feet so that they may pass over the reclaimed site	TK holders care about the comfort of animals and want to avoid creating stress for them. This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.	Safety Respect Stewardship	The current closure plan does not include cover materials that would provide access over the PKC dams. Any proposed changes would need to be evaluated for possible risks and discussed with communities.	In consultation with communities, conduct further research and advance the plan for the PKC closure concept approved by the WLWB in May 2014.

DDMI TK Panel Recommendations and Response Tracking - PKC						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
6.18	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Leave some areas steep to encourage snow accumulation for wolverine and other denning wildlife (e.g. wolf, bear, fox, ground squirrel, etc.)	This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.	Safety Respect Stewardship	This would be achieved with the current closure plan.	N/A
6.19	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	Open up sections of the dam to recreate natural water flow	The desire of Panel members is to recreate pre-mine conditions. The limitations of water movement after closure were discussed in relation to elevation changes in this area; historic water flow patterns between Lac de Gras and the PKC area would be incredibly difficult to achieve.	Natural condition	The footprint of the PKC extends close to the shoreline of Lac de Gras which would result in a very short pathway for water to travel and heal before entering Lac de Gras. This conflicts with previous guidance to route water overland for as long as possible, and DDMI's preference is the latter. Technical considerations also need to be taken into account; the dam walls still need to safely contain PK material that would remain after closure.	N/A
6.20	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	The TK Panel requests that DDMI starts to remove any new slime from site, effective immediately	The Panel felt it important to stop adding to the volume of slimes that has already accumulated on site.	Stewardship	DDMi is unable to immediately start removing slimes from site, as there is no alternative storage options available or permitted, nor is there an acceptable method of transport available.	N/A
6.21	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	The TK Panel requests that DDMI provide an overview of the sixteen closure options that have been considered and the preferred five options identified (including costs). Further,	The options, reasons and costs were important for the TK/IQ Panel to understand in consideration of their own assessment.	Reciprocity	The options were reviewed with Panel members, though cost information was not available at the time the information was presented.	Diavik provided the Panel with the additional information requested.
6.22	Processed Kimberlite Containment Interim Report, 24-28 October 2013, pg. 6	The TK Panel recommends that DDMI explore ways of treating and removing slurry/slime with other diamond mines in the area to make it feasible	The assumption here is that costs will be reduced by working together.	Stewardship	Should such measures be necessary in the future, DDMI would be willing to explore such options in cooperation with other mines.	N/A
7.7	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Create barriers and other means between the rock pile and PKC to discourage animals from going into the PKC area.	Diavik provided feedback to the Panel at the start of Session 7 that a number of their recommendations from Session 6 (PKC) would not be possible, so Panel members had to re-evaluate their preferred approach to managing this area after closure. Participants realized that more discussion is required to develop alternate recommendations for the PKC. However, Panel members also noted that it is important to consider having a barrier between the rock pile and PKC that would prevent or deter animals from going into the PKC area. Keeping a steep slope on the side of the rock pile that is beside the PKC was recommended by the Panel.	Stewardship	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - Wildlife Monitoring						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Tr aditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
1.1	A Way of Life, 25 Oct 2012, pg. 19	During July/August, a regular training session should be planned for Diavik staff in ways of properly respecting caribou and other animals	Cross-cultural learning is important when there are two ways of knowing wildlife. Scientists and Environment staff have a different way of doing work and understanding wildlife compared to that of TK holders. Respect for wildlife by TK holders means following the traditional laws that govern the relationship between humans and individual species. A successful monitoring program requires good communication and this can be challenging in a cross-cultural setting. Strong relationships and a special effort to understand the differences are key to success.	Respect Reciprocity Traditional Laws	Diavik staff and community assitants participating in the monitoring program undergo onsite and field training prior to initiation of the program. In addition standard operating procedures are revisited in the field throughout the process. In 2012 and 2013, Diavik invited community Elders and youth to particpate in the monitoring program to observe staff performance and evaluate procedures. Minor changes were suggested and are currently being reviewed.	Involve community members in caribou monitoring and share knowledge of different practices relating to wildlife.
1.2	A Way of Life, 25 Oct 2012, pg. 19, 25	When elders are brought to site for staff training exercises, youth delegates should also be involved	The youth are living in a changing and complex world now. They have skills that the Elders don't, and they can help in the future. Everywhere that the Elders are called upon to share knowledge or observe changes, the youth should be with them to both learn and share. Teaching stewardship is the reponsibility of each generation of elders.	Stewardship Intergenerational Social	Due to the nature of remote field work, seating capacity may be limited. Adding a youth component to this program limits Elder participation but has generally been supported by the communities.	When possible, invite Elders and Youth to participate in Diavik activities.
1.3	A Way of Life, 25 Oct 2012, pg. 19	The TK-Science camp at the mine site is an important place for developing skills and capacity in cross-cultural caribou monitoring	Elders feel that they can be creative in collaborating with Diavik in a cross-cultural setting that includes observations and knowledge exchanges at the TK/IQ Camp.	Reciprocity	Recommendation is outside the scope of the Caribou Behavioural Monitoring SoP. Such opportunities may be considered for future camps, depending upon the focus of the camp.	N/A
1.4	A Way of Life, 25 Oct 2012, pg. 19	The TK-Science camp (known as the CBM Camp) should be moved to a location north of Diavik on Lac du Sauvage. The setup must be in the Aboriginal way, not in a square, so that it's not threatening to the caribou.	In keeping with traditional laws governing relatioship with caribou, the camp should be closer to the caribou migration route in order to develop skills and capacity in cross-cultural caribou monitoring. Aboriginal camps on the land have a specific way of being set up, and this should be respected for the set-up of the TK/IQ camp.	Traditional laws	The camp site has been established in consultation with community members under a land use permit with the WLWB and will not be relocated. The footprint of buildings and other infrastructure will not be changed significantly, in order to reduce further impacts on the environment.	N/A
1.5	A Way of Life, 25 Oct 2012, pg. 19	Monitoring results should be reported back to the communities on a consistent basis.	Participants expressed frustration at the lack of communication (and involvement) with community members relating to caribou monitoring at the mine site to date.	Reciprocity	Diavik prepares annual wildlife monitoring reports and an Environmental Agreement (EA) summary report. Additionally, EMAB produces an annual report that summarizes findings and recommendations. Wildlife monitoring updates are also included in annual presentations to communities. Diavik welcomes any further recommendations on how best to ensure that this information reaches individual community members.	Continue to distribute annual reports (which include executive summaries) to community organizations and visit communities as available. Investigate and request feedback on more appropriate methods for communication of monitoring programs & results.
1.6	A Way of Life, 25 Oct 2012, pg. 19	It will be valuable to "check nets" and synthesize what's already been done by Diavik to incorporate TK/IQ into its processes, and document/share lessons learned from these experiences in order to avoid repeating work already done.	Participants felt that they are often repeating themselves (to same and different companies) about many of these topics/concerns. A sign of being respected is 'being heard'; so to have to continually repeat themselves, TK holders feel disrespected. There is value in reviewing what Diavik has done to incorporate TK/IQ into their work.	Respect	Unclear if recommendation is addressed to the TK/IQ Panel or Diavik. Diavik is open to sharing information about current and upcoming TK/IQ plans and programs with the Panel for their review. Literature reviews have also been done to determine TK/IQ use for closure planning and vegetation.	Confirm if the recommendation is to Diavik or to TK Panel members/facilitators.

DDMI TK Panel Recommendations and Response Tracking - Wildlife Monitoring						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
1.7	A Way of Life, 25 Oct 2012, pg. 20	Use pictures and/or other visual tools as part of the form for caribou behavioral scans.	Visual representation of the different behaviours of caribou is likely more accurate and would be helpful for people conducting the scans, especially new hires. People see things through a cultural lens and may interpret what is seen differently.	Reciprocity	An effort to take photos displaying various caribou behaviours was undertaken during the 2012 and 2013 monitoring seasons.	DDMI staff are evaluating opportunities to incorporate visual tools into the SoP.
1.8	A Way of Life, 25 Oct 2012, pg. 20	TK holders should be hired on a seasonal basis (i.e. spring through summer) to work with Diavik staff in caribou monitoring.	A TK holder on staff would be helpful in conducting cross-cultural training and monitoring considerations. Tradition requires TK holders to report their observations to each other and to discuss interpretation of those observations	Reciprocity	Most caribou monitoring is completed from August - October. DDMI brings Elders to site to participate in these monitoring programs each year.	Investigate options for transitioning caribou behaviour monitoring to communities, while continuing to include Elders in current monitoring programs.
1.9	A Way of Life, 25 Oct 2012, pg. 20	Community meetings are a good way to gather more information on how caribou are doing	This can be a means of extending traditional monitoring practices to include scientists. Both parties are able to share their observations on caribou in a face-to-face meeting. Such an approach provides a good opportunity for community members to learn about what is happening at the mine in relation to caribou. And mine employees have a chance to learn what the communities are seeing in their areas.	Reciprocity	Recommendation is outside the scope of the Caribou Behavioural Monitoring SoP**.** Diavik hosts annual community meetings that include discussions on caribou and other wildlife. Diavik has also coordinated and participated in many wildlife forums to discuss caribou health and management with numerous stakeholders.	N/A
1.10	A Way of Life, 25 Oct 2012, pg. 20	Caribou observation logs can also be used by community members when they are on the land	TK holders adapt and are willing to use new tools to carry out their stewardship responsibilities. Harvesters in the community may find the Diavik forms useful, and it may be helpful information for ENR.	Social	Recommendation is outside the scope of the Caribou Behavioural Monitoring SoP. Diavik can supply the field sheets to communities, if requested.	N/A
1.11	A Way of Life, 25 Oct 2012, pg. 20	Include more behaviors in the list for observation	Participants felt that there were other common behaviours not captured in the list. Community members are more familiar with different caribou behaviours and could help to expand the list and capture more detailed information. The intricate TK about caribou and caribou behaviour is required to inform good decisions. For example, caribou that are scared will often put their nose in the air, sometimes jump and then gallop fast; they are threatened because they do not know what is going on.	Reciprocity	Elders from the YKDFN, NSMA and Tlicho participated in caribou behavior surveys in the fall of 2012 and 2013. One additional behavior has been recommended so far: curious (approached).	Consider changes to SoP based on feedback from community members.
1.12	A Way of Life, 25 Oct 2012, pg. 20; Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.6	Include more categories for herd composition and behaviour; involve two individuals nominated by the TK Panel to assist with updating the SOP.	Community members see caribou herds differently than scientists. For example, there are leaders and followers within a herd. Participants felt this would be helpful information to record because the relationship between herd members is important to understand in making decisions to reduce impacts on caribou.	Reciprocity	Elders from the YKDFN, NSMA and Tlicho participated in caribou behavior surveys in the fall of 2012 and 2013. No additional categories have been recommended to date.	Plans to review suggestions and improve the information in these categories is being considered by Diavik.
1.13	A Way of Life, 25 Oct 2012, pg. 20	Utilize Aboriginal terms/concepts as identifiers	Participants expressed that there are Aboriginal terms that capture caribou activity or behaviour, perhaps more accurately than English terminology for them. Specific terms and concepts contain unique understandings important in governing the way we treat or 'manage' caribou. Specific terms and concepts contain unique understandings important in governing the way we treat or 'manage' caribou Addition of such terms to the data form may be helpful for community members participating in surveys.	Symbolism	This may be beneficial in the future, if caribou behavioural monitoring were to transition to communities.	N/A

DDMI TK Panel Recommendations and Response Tracking - Wildlife Monitoring						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
1.14	A Way of Life, 25 Oct 2012, pg. 20	Injured animals should be sent to ENR for assessment	It would be helpful to have as much information as possible about injured or dead caribou, so that community members are made aware of the cause. TK holders may have other ideas about how to safeguard caribou in the future.	Stewardship Capturing knowledge	Recommendation is outside the scope of the Caribou Behavioural Monitoring SoP. Diavik has a specific policy and procedures in place for reporting and handling of injured or deceased wildlife, and this involves ENR.	N/A
1.15	A Way of Life, 25 Oct 2012, pg. 20	Scientists and TK holders analyze dead caribou together	It would be helpful to have as much information as possible about injured or dead caribou, so that community members are made aware of the cause, can share information and learn the way that government analyzes caribou carcasses. TK holders and scientists can exchange ideas on causes and ways to prevent future deaths.	Stewardship Recording knowledge Reciprocity	Recommendation is outside the scope of the Caribou Behavioural Monitoring SoP. Diavik has a specific policy and procedures in place for reporting and handling of injured or deceased wildlife. Diavik staff do not analyze dead caribou themselves; it is done by ENR.	N/A
1.16	A Way of Life, 25 Oct 2012, pg. 20-23	Four key areas for monitoring: 1. Behaviours 2. Herd composition 3. Caribou health 4. Environmental conditions	These were identified as the key concerns of community members that are all factors considered in the traditional monitoring system; they should be monitored by Diavik. Indicators or signs of herd condition were identified within each of these areas.	Stewardship	Many of the indicators recommended that relate to herd composition, health and environment are more appropriate to be studied by government at a regional level. Behaviours and local conditions are included in the current SoP.	N/A
4.1.1	Checking Nets, 23-25 Oct 2012, pg.8; Closure/Reclamation and Landscape History Interim Report, 23-25 October 2012, pg.8	The TK/IQ Panel should develop a report that more fully represents our knowledge and practice for maintaining the well-being of the caribou. TK assumes that all who live on the land of the caribou have stewardship responsibilities and must take these responsibilities seriously.	Many planning and monitoring gaps exist in relation to caribou and Diavik that have yet to be addressed, such as: Aboriginal monitoring approach (harvest camp), stewardship (traditional caribou laws), movement & cumulative impacts (monitor migration with youth), behaviour and herd composition (response to	Stewardship	Recommendation is to the TK/IQ Panel, however Diavik does not view this as within the mandate of the Panel. The Panel could recommend considerations for planning and observing caribou well-being in relation to the development of closure plans & post-closure monitoring programs.	A future Panel session to discuss closure monitoring is expected and caribou will be a part of that discussion.
7.3	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Use traditional techniques (e.g. flags, trees) to keep caribou away from areas that are unsafe (both near and far from site).	Caribou will find their old migration routes, but they also make their own trails that change over time. Some participants recognized that it is important to try to encourage caribou away from harmful areas far before they reach the mine site/East Island. Others felt that it would be impossible to prevent animals from coming to the mine site area. Consideration for guiding caribou on the mainland or around the island is a possible topic for future discussions.	Stewardship	Pending	TBD
7.5	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Create safe passage for caribou over the rock pile and through the site following their old migration routes on the north and south east sides (refer to map developed during session).	Panel members felt that it was not necessary to plan too much for the animals safe passage, as caribou will ultimately go where they want and will find the ramp, road or easy way. Preference was to align the path with the old migration route and to keep the slope similar to that of the test pile - as natural as possible. There are some big rocks at the bottom of the rock pile that would need to be covered. It was seen as important to think about the slope in the winter too - how wind will deposit snow - not just when it is snow free. The berms on top of the rock pile were viewed as a barrier to caribou movement, so it would be preferred to remove them and also to remove the berm around the top of the pile.	Stewardship Seasonality	Pending	TBD
7.8	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Allow more time for the TK Panel to discuss options for keeping animals away from certain areas (e.g. fencing).	Inuksuit are used to mark caribou crossings (nalluit) in Inuit culture. Other cultures use different techniques as well - e.g. flags, trees. More discussion on traditional and modern methods that can be used to prevent or deter animal presence in certain areas of concern may be useful. For example, some Panel members felt that a fence would be beneficial, while others felt it may be harmful and hard to maintain over time.	Stewardship Recording knowledge	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - North Inlet						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
7.14	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Relating to re-vegetation, the North Inlet requires further discussion in terms of it being a no go zone, replanting zone or encouraging zone for wildlife.	The men and women had separate break out sessions to develop their ideas on how best to manage various areas of the mine after closure. Many of their ideas were similar, but the suggestions for the North Inlet differed greatly. Panel members recognized that more information is needed from Diavik relating to the water quality and closure plan for the North Inlet pond, before a decision can be made on vegetation and wildlife access.	Stewardship Reciprocity	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - General (including TK/IQ Panel Process)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
1.20	A Way of Life, 25 October 2012, pg. 25	Youth should be involved with the TK/IQ Panel and included in discussions about closure.	Youth live in a changing and complex world and have skills that the Elders do not. They need to learn about their culture and history, as well as about the mines. They will be the future caretakers of the land and the ones speaking for their communities in the future, so they must be a part of the discussions and decisions.	Intergenerational Social Stewardship	Diavik sees value in having youth participate in TK/IQ Panel sessions, where possible.	Youth involvement was incorporated into the October 2013 Panel session, and also plans to include youth in future sessions.
2.1	Renewing Our Landscape, 7 December 2012, pg. 9; 19 July 2012 e-mail from EMAB	Arrange for a visit to the mine site to see some of the structures that are being discussed for closure, specifically the North Country (waste) Rock Pile. Preference is to stay at a camp on the land, rather than in mine site accommodations.	In order to provide effective and helpful advice, Panel participants need to see areas in person. A fundamental principle in TK/IQ is that "being knowledgable" requires an experiential context of what is being discussed, as TK comes to the forefront of peoples minds when they are on the land that they are discussing. This helps to understand the area as it was traditionally and to comprehend the change and scale of the current landscape.	Recording knowledge Experiential learning	Diavik sees value in having TK/IQ Panel members visit the mine site. For safety reasons, visitors stay at the mine site accommodations.	In response to this request, a site visit and follow up meeting in Yellowknife was arranged for 20 & 21 August 2012. Diavik also began to hold TK/IQ Panel meetings at the mine site in October 2013, when the Panel began to be administered by Diavik.
4.1.3	Checking Nets, 23-25 October 2012, pg.19; Closure/Reclamation and Landscape History Interim Report, 23-25 October 2012, pg.8	Diavik to develop and maintain a tracking sheet for documenting progress on recommendations and action items and present progress to the panel at the beginning of sessions.	Desire for Panel members to see the results of their work and obtain a response from Diavik. Shared learning and acknowledging contributions of others is an important tradition. There is an opportunity to learn from their experience and any recommendations that are implemented. There may be a need to revisit recommendations that are either ineffective, or are carried out or interpreted incorrectly. It is also an opportunity to celebrate successes achieved by the Panel and Diavik.	Recording knowledge Respect Reciprocity	Diavik is committed to providing a response to all Panel recommendations. Diavik also requested that EMAB provide past Panel recommendations to DDMI for response.	This Excel spreadsheet is the proposed tracking system and was reviewed and supported by the TK/IQ Panel. Updates to this spreadsheet are done over time and communicated in person to Panel members, and shared with the public as necessary.
4.1.4	Checking Nets, 23-25 October 2012, pg.20	Women to have opportunities to participate in TK/IQ Panel – especially for discussions on caribou and vegetation.	Women have specific roles in Aboriginal communities and the knowledge they can contribute is different from that of men. There needs to be respect for the distinct knowledge of women, as Elder women have special gifts and understandings that are important for carrying out stewardship responsibilities.	Respect Recording knowledge	Recommendation is to the TK/IQ Panel or their community organizations. DDMI does not select Panel participants but could request community organizations to include women participants, as recommended by the Panel.	A request to add women participants for the August 2014 re-vegetation Panel session was sent to communities, as this had been suggested by the Panel in the past.

DDMI TK Panel Recommendations and Response Tracking - General (including TK/IQ Panel Process)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
4.1.5	Checking Nets, 23-25 October 2012, pg.20	Extend length of Panel sessions to 4 days.	Three days is not enough to review documents, learn about the context of the topic(s) and share new knowledge. The fourth day is key to completing the review and verification necessary to respectfully document knowledge and develop a complete document that all parties are happy with.	Recording knowledge Consensus Respect	A longer meeting is supported, provided that it results in an approved set of transcripts and recommendations by the end of the session.	Starting with the October 2013 TK/IQ Panel session, each Panel meeting is planned to be 4 days at the mine site. Transcripts are to be produced and presented to Panel members daily to be verified on-site, where possible.
4.1.6	Checking Nets, 23-25 October 2012, pg.21	Include Aboriginal words or terms in reports as appropriate. Keep wording in reports simple and make summary notes available soon after a meeting.	Some Aboriginal languages include concepts that are very precise and reflect a more complete understanding than what can be translated. Language contains distinct concepts unique to TK so the spiritual premise of certain terms contained within the language can often get lost in translation. Plain language should be used so that all people can understand it, regardless of their language or reading skills. It is important for participants to review their words and make sure	Symbolism Recording knowledge	TK/IQ Panel members should work with their interpreters and the facilitators to ensure that important Aboriginal words or terms are captured within transcripts and/or reports. Diavik makes efforts to report the results of their programs in different ways, for different audiences.	TK Panel reports are to use basic or plain language and efforts will be made to continue to make transcripts available daily for review.
4.1.7	Checking Nets, 23-25 October 2012, pg.21	An Aboriginal facilitator would be of benefit to the TK/IQ Panel.	Panel meetings should be organized in a way that fits with the Aboriginal way of knowing. This leads to improved communication, interpretation and understanding of the value of participants messages.	Respect	Diavik sees value in having an Aboriginal facilitator involved in the TK/IQ Panel sessions, provided that this approach continues to be supported by Panel members.	Joanne Barnaby has been contracted to co-facilitate TK Panel sessions.
4.2.1	Working Together, 23-25 October 2012, pg.8	Develop a TK/IQ Panel manual that would be regularly revised to reflect the Panel's process, topics and lessons learned over time.	There are few models for this type of organization or work so it is important to document the Panel's mandate, protocols and procedures. This approach should be recorded in an effort to develop best practices and learn from challenges. Panel facilitators would be responsible for updating the document, for review and verification by Panel members.	Recording knowledge Consensus Respect	Diavik supports the development of, and on-going updates to a TK/IQ Panel Manual. Discussions relating to Panel priorities and schedule should also be included in such a document.	Update the "Working Together" manual to reflect the change in administration of the Panel from EMAB to Diavik.
5.6	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.6	Identify opportunities for Aboriginal participation in closure activities.	The TK/IQ Panel identified landscaping, planting, design and experiments as ideal for Aboriginal participation. Training youth to assist with site activities at closure will be important.	Stewardship Respect Recording knowledge Intergenerational	Diavik expects that the majority of closure activities will be completed by Aboriginal people and companies, and plans to work with communities over the next few years to identify and realize such opportunities.	N/A
5.7	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.6	Engage the TK/IQ Panel in preparations for Elder programs at the mine site.	Panel members see an opportunity for them to assist with defining discussion topics, seeking input on how to prepare Elders and make full use of the visit and how to respectfully document their observations. The Panel can also advise on proper methods for Elder care during such site visits.	Respect Recording knowledge Reciprocity	Diavik is currently re-evaluating its approach to community engagement with communities. There may also be an opportunity for the TK/IQ Panel to assist with this process.	N/A

DDMI TK Panel Recommendations and Response Tracking - General (including TK/IQ Panel Process)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
5.8	Closure Reclamation & Landscape History Interim Report, 19-22 February 2013, pg.6	Ensure experts are available to TK/IQ Panel members as needed, based on discussion topics.	It is important for Panel members to have access to technical and/or scientific experts for the topics being discussed, so that they can learn as much information as possible and therefore make informed recommendations. Such an approach supports the cross-cultural learning style that the Panel follows and allows for quicker progress.	Reciprocity	Diavik views this approach as beneficial as well, and has supported the Panel with such expertise in the past.	Continue to work with the TK/IQ Panel facilitators to identify the required resources and expertise needed for each Panel session.
EMAB-1	Environmental Monitoring Advisory Board TK/IQ Panel Recommendations from February 2013, Letter from EMAB, 8 Oct 2013, pg.2	EMAB feels that Diavik is proceeding in the right direction in working towards answers to these and other questions but recommends that DDMI conduct on-site workshops or community consultations or a combination of both. When this work is completed then EMAB will review the results and if necessary we will convene the TK/IQ Panel in order to review the process, methodology, and results.	References DDMI questions posed by DDMI at the February TK/IQ Panel session relating to NCRP shape, reclamation of roads & laydowns, and revegetation.	N/A	October 2013 TK/IQ Panel session was at the mine site. Diavik consults with communities through Closure Working Groups and public meetings held within the communities. In accordance with a letter received on 7 August 2013, EMAB gave Diavik permission to administer the TK Panel.	N/A
7.13	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Complete the TK literature review report so that it can be used as a guide in the vegetation program and closure plan, and be available to communities.	As previously suggested by the Panel, there is value is compiling the existing TK that has been captured by community or company research in the past. Much of this information was compiled prior to Session 7, but a report was not completed. The Panel would like to see a complete report.	Recording knowledge	Diavik supports the completion of the literature review report that was initiated for TK Panel Session 7.	Literature review of the TK of plants in the Lac de Gras region was completed in October 2014.
7.17	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Have a women's only session in the field next summer to address vegetation and other issues of interest to them.	Some Panel members felt that there would be a benefit to holding a 'womens only' session in the future, as this may create a more acceptable space for sharing the knowledge that is specific to women.	Traditional laws Respect Recording knowledge	Pending	TBD
7.18	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Diavik must meet its commitments to support a minimum of two TK Panel sessions a year.	Panel members felt that momentum is necessary to keep the Panel engaged and not have to start from scratch every time they meet. Participants recognize the number of topics and discussions that should occur prior to closure, and that this will take time.	Respect Reciprocity	Pending	TBD
7.19	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	TK panel members need to verify TK recommendations with elders back home.	Panel members feel that the results of each session are important to be shared with Elders in their respective communities. While Diavik has a role to play in doing this as well, Panel members felt that they also have a responsibility to discuss each session outcome with respected Elders on a more informal basis, and incorporate any feedback they recieve into future Panel sessions.	Traditional laws Respect Recording knowledge	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - General (including TK/IQ Panel Process)						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
7.20	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Require one male and one female member from each community organization on the TK Panel (or formal alternates); where possible, members must know the LDG area (directed to Aboriginal governments).	Panel members recognize the different knowledge that males and females have, and that both types of knowledge must be recognized and incorporated into the TK Panel closure planning process. While there has been much success in keeping Panel members consistent over time (in an effort to build knowledge and familiarity with the mine and its closure plans), past participants have only been males. Incorporating females into the Panel will result in a change in Panel membership in the near future, but the value and depth of knowledge this change would bring is more important to Panel members than maintaining consistency of past membership.	Traditional laws Respect Recording knowledge	Pending	TBD
7.21	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Formalize our recommendations to Aboriginal governments to have youth participate.	All participants recognize the important role that youth play as future custodians of the land. Because of this, it is important that they are included in the closure planning process now, so that they are educated, aware and able to contribute to decisions made that will impact future generations.	Intergenerational Social Stewardship	Pending	TBD
7.22	Re-vegetation Report, TK Panel Session #7, 14-18 August 2014, pg.	Celebrate our TK Panel as a model for other mining companies.	Panel members are happy with the work they are doing. They recognize how unique the Panel is, and the opportunity it provides to contribute to future planning. Seeing the importance of learning from what works, it is felt that the process and results the Panel has developed should be shared with others.	Stewardship Respect Recording knowledge Intergenerational Reciprocity	Pending	TBD

DDMI TK Panel Recommendations and Response Tracking - Spiritual Considerations						
NUMBER	REFERENCE	RECOMMENDATION	CONTEXT	TK VALUE/CONCEPT	DDMI RESPONSE	DDMI ACTION ITEMS
Assigned by DDMI unless otherwise indicated in report	*Be as specific as you think is appropriate; for example a section or page of the document, a recommendation #, general comment, etc.*	*Recommendations should be as specific as possible and explain an action that you believe is necessary; supporting information or rationale should be explained in the "context" column.*	*Context should contain all the information needed to understand the rationale for the accompanying recommendation.*	*Distinct values/concepts that are contained in Traditional Knowledge and can help to guide decision process*	*Responses should be as specific as possible, relating the issues raised in the "recommendation".*	*Actions should be as specific as possible, relating the issues raised in the "recommendation"; where possible, a timeframe may be included.*
2.4	Renewing Our Landscape, 7 Dec 2012, pg. 25	Renew relationship with the area after closure.	Spiritual ceremonies to invite the spirits to return to the mine site will be requiredresponsibilities require people to make amends to the spirits of the land for the damage created by the mine. It is important that current and future generations maintain their relationship with their homelands that surround the mine. Aboriginal harvesters will travel where the caribou go, and provided that the area is made safe and accessible for caribou, they will go there again. For this reason, Aboriginal people's connection with the land needs to be renewed and/or maintained after closure.	Traditional laws Stewardship	Diavik is open to recommendations on how best to approach this with each of the five Aboriginal Participation Agreement communities.	To be determined
4.3.1	Closure/Reclamation and Landscape History Interim Report, 23-25 October 2012, pg.6	Visit burial, archaeological and heritage resource areas close to the mine.	Provide comfort to community members that important sites have been preserved and that this historical connection still exists with the land in this area; important for youth to know the locations and stories behind these sites.	Intergenerational Stewardship Experiential learning	This type of activitiy could be incorporated into plans to renew the community's relationship with the land in this area after closure.	To be determined
4.3.2	Closure/Reclamation and Landscape History Interim Report, 23-25 October 2012, pg.6	Conduct a tobacco (or other) ceremony when the company is ready to leave the island.	Heal and reconciliate the relationship with the land once all work is complete. The type of ceremony may be different for different cultures.	Symbolism Stewardship	This type of activitiy could be incorporated into plans to renew the community's relationship with the area after closure.	To be determined

TK Value/Concept	General Description	Sub-themes
Traditional Laws	Relationships and rules between human and nature that are to be followed (when practicing traditional activities)	Relationships Roles Responsibilities Accountability Sharing Verification Rules Animals People
Symbolism	Ways in which beliefs are represented, and may include ceremonies	Place names Language Spirituality Ceremony Offerings Prayer Creator
Reciprocity	Everything is shared for the greater good	Communication Sharing Perspectives/Lens Cross-cultural Respect Mutual benefit Teaching Learning
Intergenerational	Everything done today impacts our families in the future	7 generations Family Future Circle of life Continuity Borrowing
Stewardship	Responsibility to protect the land and its resources	Teaching Elders Learning Youth Responsibility Respect Future Stories Caretakers Connection

TK Value/Concept	General Description	Sub-themes
Respect	Essential to demonstrate; providing support and a positive view of all living things and people	Knowledge Elders Being heard Traditional Roles Creator Accountability Ceremony All living things
Recording Knowledge	Oral tradition/culture that is recognizing an increasing need to formally document historical knowledge	Verification Sharing Trust Stories Cooperation Listening Documentation "In our own words" Language Future Review
Seasonality	Life flows with the change in seasons	Change Adaptability Freeze/thaw Migrations Cycles Provisions of the land Variability Norms Climate
Natural Condition	The preferred state of the environment from a traditional perspective	Nature Harmony Respect Safe
Social	Changing societal values that are influenced by globalization & access	Evolving Relationships Priorities Teaching Hobby Way of Life Adaptability Development Globalization Access Technology

TK Value/Concept	General Description	Sub-themes
Safety	Traditional practices that protect the land and people	Respect Traditions Learned behaviour Accountability Responsibility Caretakers
Nature is self-healing	The land and water will heal itself, given the right conditions	History Respect Knowledge Spirituality Observation Connection
Consensus	Traditional leadership that seeks to find agreement	Respect Knowledge Observation Tradition Leadership
Experiential learning	Learning by observation and by doing	Elders Youth Knowledge Respect Understanding Observation

Rio Tinto

Appendix I-2

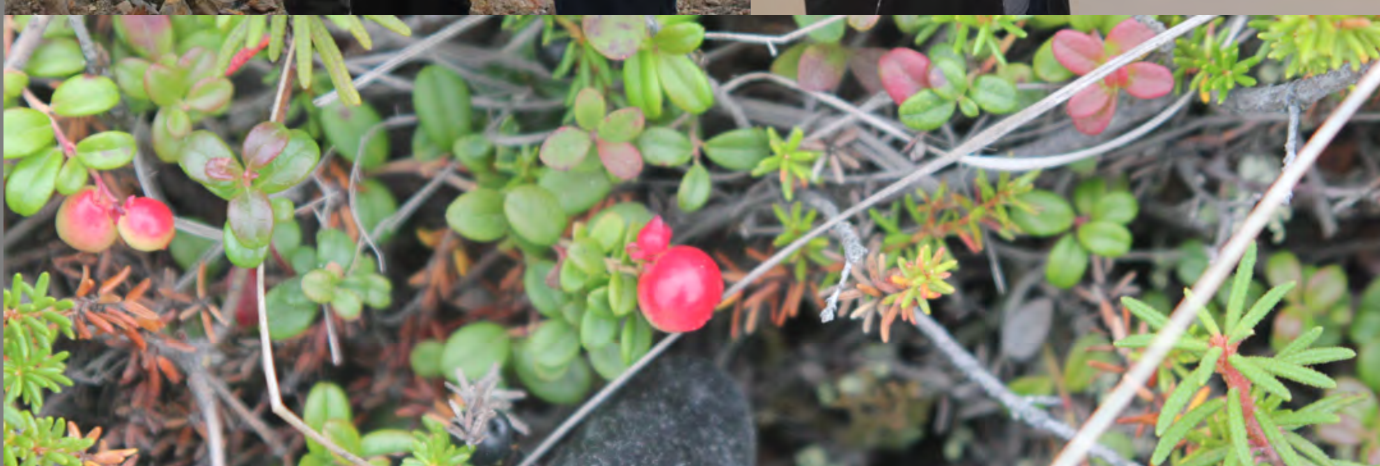
DDMI Traditional Knowledge Panel Session #7 – Focus on Re-Vegetation.

DDMI Traditional Knowledge Panel Session #7

FOCUS ON RE-VEGETATION

Diavik Diamond Mine

August 14-18, 2014



Thorpe Consulting Services

DDMI Traditional Knowledge Panel Report
Interim Report

Session #7: *Focus on Re-vegetation*

Diavik Diamond Mine
August 14-18, 2014

Facilitation

Joanne Barnaby, Joanne Barnaby Consulting
Natasha Thorpe, Thorpe Consulting Services (TCS)

Participants

Kitikmeot Inuit Association	Mark Taletok, John Ivarluk, Martha Ivarluk, Mona Tiktalek (interpreter), Henry Ohokannoak (interpreter)
Łutsel K'e Dene First Nation	Celine Marlowe, George Marlowe
North Slave Métis Alliance	Ed Jones, Wayne Langenhan, Joy Dragon
Tłı̨chǫ Nation	Joe Champlain, Louie Zoe (Gamètì), Peter Huskey (interpreter)
Yellowknives Dene First Nation	Morris Marten, Mike Francis, Mary Rose Sundberg, Berna Martin (interpreter)

Observers/Presenters

Diavik Diamond Mines Inc.	Dianne Dul, Gord Macdonald
C&E Consulting	Colleen English
Thorpe Consulting Services	Janet Murray (transcriber)

Interpreting equipment provided by Pido Productions.

Background

The TK Panel is mandated to assist Diavik Diamond Mines Inc. (Diavik) and work with local communities in facilitating appropriate and meaningful accommodation of Traditional Knowledge (TK). The TK Panel provides guidance in environmental management and monitoring as well as in closure planning at the Diavik Diamond Mine. From 2011 through 2013, TK Panels were assembled by the Environmental Monitoring Advisory Board (EMAB) to discuss select concerns related to the Diavik Diamond Mine. This session, held at the Diavik mine site from August 14-18, 2014 was the second in a series of TK Panel sessions now administered under Diavik rather than EMAB, but the seventh in the series of TK Panel sessions.

Session Purpose

This seventh session included a discussion of re-vegetation at both a small scale and landscape level for consideration into Diavik closure planning, particularly related to the roads, airstrip, North Country Rock Pile (NCRP), Processed Kimberlite Containment (PKC) area, as well as the regional Lac de Gras area.

The TK Panel drew upon their knowledge, as well as results from a preliminary literature review of documented TK of vegetation relevant to the Lac de Gras area. The TK Panel elaborated further on concepts, values, understandings, and complexities offered in earlier TK Panel sessions. They developed both recommendations and suggestions for future sessions that were presented to Diavik for their review and consideration.

This session included field work opportunities for both men and women to visit areas with natural vegetation, re-vegetation research plots, test rock piles, areas of natural re-vegetation and other structures (e.g. airstrip, roads, rock pile) around the mine site in addition to workshop-like sessions held on-site. The TK Panel has articulated that women traditionally held greater knowledge and experience with plants given their relationship with the land.

A preliminary review of publically available literature related to TK of vegetation was carried out in advance of the session and in response to a request from the TK Panel that previous works be considered. While the session integrated and expanded on high level concepts from this review, it was decided that many of the findings would not be presented as it was felt they would be more accessible by members of the TK Panel in smaller groups or field settings.

Session Goals

The first goal of the session was to provide an opportunity for TK Panel members to discuss re-vegetation options related to closure. The second goal was for the TK Panel to learn more about ongoing re-vegetation research carried out for Diavik by the University of Alberta, and for graduate students to learn from the TK Panel on how to improve their research. The third goal was to respect and build upon work already carried out and to learn more about how recommendations provided to Diavik in the past are being considered presently. The fourth goal was to develop recommendations relating to re-vegetation to provide to Diavik at the end of the session, which allows for TK to be considered in Diavik's closure plans.

Agenda

This four day TK Panel Session was structured into topics, as follows:

1. Identify the format, scheduling and plan related to the current session
2. Closure Plan overview and review recommendations and DDMI responses from Session 6.
3. Visit two re-vegetation test plot area (University of Alberta research), areas of natural vegetation and re-vegetation, test rock piles, etc.
4. Provide recommendations on re-vegetation based on four guiding questions:
    a. How do we re-vegetate to keep wildlife safe?
    b. Which habitats or plants create safety for wildlife?
    c. Where should different types of habitats or plants be placed?
    d. What should DDMI do with site roads?
5. Evaluate the session

Report Overview

This report first outlines six key themes discussed during the proceedings of the session, presents outcomes from the field work and closes with a recommendations made by the TK Panel. Appendix A includes photos from the work carried out onsite and in the field. Appendix B includes both the original and actual (i.e., revised) agenda preferred by the TK Panel. Appendix C contains a blank copy of the informed consent form that was signed by participants new to the TK Panel. Session transcripts that were reviewed and corrected by participants are assembled in Appendix D. A list of key points made in bullet form and posted around the room on flipcharts is contained in Appendix E. Maps created during sessions where the men and women broke into two groups to discuss re-vegetation are included in Appendix F.

A high-level review of the TK literature relevant to re-vegetation was presented by TCS (Appendix G). Diavik provided an update of the closure plan as well as a presentation to compare photos of caribou over time and locations of mining operations in the NWT and Nunavut in response to a request by the TK Panel (Appendix H). Recommendations made by the TK Panel during the session are shown in Appendix I.

Evaluation forms for the session were distributed and filled out; however, they were misplaced onsite and never recovered. Therefore, the evaluation results are not presented in this report.

Proceedings: Key Themes

Key themes discussed throughout the session included:

1. Respect nature by recognizing that nature is a powerful force, has the ability to heal, and can be assisted in healing – where appropriate and respectful;
2. Re-vegetation efforts should be guided by TK and results from current research by the University of Alberta. Specific focus should be placed on: areas people don't want wildlife to go; areas people want to encourage re-vegetation or re-growth; and areas to encourage wildlife through landscape modifications;
3. The relationship between vegetation and caribou should be the main driver for re-vegetation plans given the importance of caribou to people and the Arctic environment, their current state of decline, and the shift in their migration routes caused by human disturbances such as mining in the Lac de Gras area;
4. Landscape modifications such as adjustment to slopes, size of boulders, and re-vegetation should be considered together to encourage wildlife to move through a particular area such as the north slope of the rock pile or across the airstrip;
5. Re-vegetation should be considered at a regional and landscape level, and take any possible cumulative effects into account; and,
6. Mining companies in the Lac de Gras area should communicate and work together.

1. Respecting Nature

Much discussion during the first two days of the session focused on the ability of nature to heal itself and that interfering with a natural process can be disrespectful. The TK Panel explored whether re-vegetation efforts were appropriate, necessary or advisable. However, as the session progressed and more of a female perspective was integrated, the limits of this self-healing clear, especially in light of the extensive footprints left by the mining process. Many comments about "nature healing itself" were made by men in the plenary group, however, when the women were working together in a breakout session, a large number of recommendations were made regarding the value of re-vegetation. Specific ideas about where and why certain areas should be re-vegetated were shared. Nature will take its course, but there are ways that people can assist with healing.

People have seen how the environment naturally reclaims itself after fire and human disturbance, but the cumulative effects of each type of disturbance was also recognized. Despite increased fires, environmental change impacts such as longer growing seasons may assist with nature healing itself during the re-vegetation and reclamation.

2. TK and Research to Guide Re-vegetation Efforts

After the TK Panel asserted that the healing forces of nature are powerful and discussed whether re-vegetation efforts were necessary, the discussion moved towards reviewing past re-vegetation efforts and planning for future re-vegetation.

Participants observed the re-vegetation plots in the field, including those started ten years ago plus those currently managed by the University of Alberta. Students provided the TK Panel with a walk-through of the different kinds of substrates, soils, fertilizers, plants, and methods being used. The TK Panel discussed re-vegetation while in the field and when they returned back to the meeting room.

A broader issue as to whether re-vegetation should attract or deter wildlife was not resolved during this session. In areas where people wanted to attract wildlife, caribou were the species of issue and so enhancing growth of lichen and tundra mats were seen to be critical to ensuring forage. In addition, enhancing soils through natural fertilizer were seen as effective ways to re-vegetate. For places where wildlife species were not encouraged to return, no re-vegetation efforts were recommended.

Fecal pellets deposited during large migrations were seen to enhance re-vegetation and identified as a key factor in fertilizing the tundra.

The TK Panel divided by gender into two different rooms to have separate discussions around re-vegetation. Each group was asked to discuss areas as follows:

- areas you don't want wildlife to go
- areas you want to encourage re-vegetation or re-growth
- areas to encourage wildlife through modifications (e.g. landscaping)

The TK Panel produced two maps showing the results of their discussions (Appendix D). Both groups want to see the areas around the PKC, pits, tank farms and waste disposal areas as places where they do not want wildlife to go.

The women's group suggested replanting in areas that do not have toxins, such as along the airstrip and the area where the camp is currently located. In addition, this group suggested modifications such as sloping and minimizing boulders and replanting to encourage wildlife to move through versus linger in an area.

3. Re-vegetation and Caribou

The TK Panel focused on how caribou depend on the tundra for forage and how the caribou must be respected as part of re-vegetation efforts, in part because people depend upon caribou. The TK Panel also emphasized that caribou are very smart. Indeed, planning for re-vegetation is seen as planning for caribou.

Respect for caribou can be demonstrated through planning for and supporting traditional migration routes given that *caribou will find their old migration routes, caribou make their own trails*, and *the East Island is a main part of the caribou migration route that goes near Misery pit as well*. Lichen is known to be a critical food for caribou and suggestions were made to encourage lichen regrowth, specifically through the transplanting of tundra 'mats' abundant with lichen.

Implementing small-scale efforts such as re-vegetation, combined with large scale efforts such as diversion techniques (i.e., flagging, barriers, rocks) are ways to respect caribou. TK Panelists were less interested in providing guidance regarding re-vegetation at a species-level and more keen to share their understanding of complex and interconnected systems such as the vegetation-caribou dynamic. Accordingly, the TK Panel spoke at length of the need for a landscape and regional approach to closure planning requiring the co-operation and collaboration between mining companies operating in the region (e.g., Ekati and Snap Lake).

4. Landscape Modifications (Slope, Rock Piles and Roads)

One aspect of caribou "intelligence" is that they are known to follow a leader. Thus, the TK Panelists explained that if the leader could be diverted north of both the Diavik and Ekati diamond mines, then caribou could go around the mines to avoid potential harm. However, TK Panelists advised that it was impossible to keep caribou and other wildlife away from the reclaimed site altogether, so small-scale accommodations must also be implemented. Suggestions for landscape modifications to keep caribou safe include:

- removing berms and rounding off the edges of large rock piles and roads
- removing large boulders that may cause caribou to break or injure their legs
- preparing areas of the North Country Rock pile at the north and south-east sides with a slope and surface material similar to that of the current test pile
- not re-vegetating certain areas (e.g. PKC containment, fuel storage area) as outlined in the maps (App D)
- extend slope of roads outward to reduce the angle and allow for easier wildlife access
- the current slope and aggregate material on the side of the airstrip was also said to be good (i.e. acceptable) to encourage caribou movement

Participants explained that seasonality must also be considered when thinking about the slope and composition of the rock pile as snow cover, mud and other environmental features change throughout the year. Through traditional knowledge, people know that caribou seek high points on the landscape regardless of challenging terrain.

5. Regional Perspectives and Cumulative Effects

The TK Panel highlighted that re-vegetation must be considered on several scales ranging from replanting tundra mats to collaborating with neighbouring mining operations to modify the landscape to encourage wildlife movements either towards or away from certain areas. Participants struggled with discussing re-vegetation on a micro-scale without the necessary consideration of caribou migration in the 'big picture.' Understanding caribou migration routes - through TK maps shared in the past through to today - is critical to reclamation planning.

Along with emphasizing the importance of a regional perspective on re-vegetation and caribou migration, the TK Panel expressed concern about multiple mines operating in the Lac de Gras area. For the TK Panel, neighbouring mining companies working together will help everybody better consider cumulative effects in the 'big picture.'

Once the TK Panel went into the field, they saw evidence of caribou and abundant vegetation even though caribou migration routes have shifted.

6. Mines Should Work Together

In the same way that the TK Panel brings together people from five very different cultural groups, the TK Panel recommended that mining companies of the Lac de Gras region similarly collaborate particularly with respect to caribou. The fact that Dominion Diamond Corporation jointly owns the Diavik Diamond Mine and Ekati was assumed to be a driver in facilitating such co-operation.

Field Work

The agenda for this TK Panel session allowed opportunities for the Panel to spend time in the field to assist in understanding of vegetation and re-vegetation at the mine site. Various areas were discussed while reviewing a site map. The Panelists decided on visiting the following areas:

- Re-vegetation research plots (Phase I – 10 year plots and Phase II – current study)
  - observe and discuss results of the first 10 years of planting
  - learn about the different substrate (soil) types and species
  - discuss current research projects – purpose and methods

- Airstrip and the northwest approach, including shoreline and water vegetation
  - observe historic caribou trails & look for new ones
  - inspect the health of shoreline and water vegetation
  - check for dust on vegetation

- Natural vegetation in the north inlet and on the south side of the island (future A21)
    - check for dust on vegetation
    - examine berry growth and health
    - look for caribou trails or signs of feeding
    - see what types of plants are growing in these areas

- Test piles
    - walk the slope of a 'finished' pile
    - examine the capping materials on a flat, smooth surface
    - determine if caribou could safely walk on such a structure
    - see the natural re-vegetation occurring on the pile

- North Country Rock Pile and till pile
    - examine the slope and rocks on the sides and top of pile
    - inspect the edge and top of the pile in relation to caribou access
    - observe the north and southeast sides to identify areas where sloping could be done to assist caribou movement across the pile
    - feel and see the till material
    - observe natural re-vegetation occurring on the till pile

- A154 and A418 dikes and open pits
    - observe the areas inside the dikes for future shoal development to assist in fish spawning/use
    - see how deep and wide the pit areas are

Outcomes: Recommendations

The TK Panel collectively developed the following 22 unanimous recommendations related to re-vegetation at closure. These recommendations flowed from a common vision to have the mine site returned to the most natural state humanly possible. However, the recommendations also reflect a combined central view that nature can heal itself but would benefit from some help, especially since growth in the Arctic is very slow. The recommendations presented to DDMI at the TK Panel session (Appendix B) were assembled quickly and thus needed to be modified slightly for clarity or to avoid repetition. Below are the modified versions.

Note that the recommendations are divided by theme (e.g. landscape), numbered to reflect the TK Panel session identification (Session 7 for re-vegetation) and to subsequently identify each specific recommendation (e.g. 7.1).

Landscape and Re-Vegetation

7.1 Do not disturb new areas and protect natural vegetation areas that exist on the Island (with the exception of planned development areas for A21, the rock pile for A21 and any future closure work that involves covering natural vegetation in order to flatten slopes for safe wildlife passage).

7.2 Study vegetation east and north of the Island to understand good caribou habitat.

7.4 Test both natural vegetation and seeded plants (re-vegetation plots) for toxicity.

7.6 Use fine crushed rock on passage-ways to protect the feet of the caribou (similar to what is on the sides of the airstrip right now – August 2014).

7.9 Create slopes on the sides of roads similar to that on the test pile to support safe travel for animals, and use crushed rock (like at the airstrip) on the surface.

7.10 Transplant a variety of natural ‘tundra mats’ and compare them to seeded test plots; this will help natural recovery by maintaining the biodiversity of the area.

7.11 Use the natural tundra mat to guide plant selection to ensure natural balance.

7.12 When using fertilizers, use natural local fertilizers like droppings from local animals. The question of treated human sewage needs to be revisited.

7.15 The re-vegetation maps developed in this session are not yet complete and more time needs to be spent discussing and finalizing these.

7.16 The TK Panel would like to use maps that show the TK of traditional caribou migration routes as the basis for evaluating the “big picture” and identifying areas for sloping (modification) on East Island at closure.

Wildlife

7.3 Use traditional techniques (e.g. flags, trees) to keep caribou away from areas that are unsafe (both near and far from site).

7.5 Create safe passage for caribou over the rock pile and through the site following their old migration routes on the north and south east sides (refer to map developed during session).

7.8 Allow more time for the TK Panel to discuss options for keeping animals away from certain areas (e.g., fencing).

Rock Pile

7.9 Create slopes on the rock pile similar to that on the test pile to support safe travel for animals.

Process Kimberlite Containment

7.7 Create barriers and other means between the rock pile and PKC to discourage animals from going into the PKC area.

North Inlet

7.14 Relating to re-vegetation, the North Inlet requires further discussion in terms of it being a no go zone, replanting zone or encouraging zone for wildlife.

General

7.13 Complete the TK literature review report so that it can be used as a guide in the vegetation program and closure plan, and be available to communities.

7.17 Have a women's only session in the field next summer to address vegetation and other issues of interest to them.

7.18 Diavik must meet its commitments to support a minimum of two TK Panel sessions a year.

7.19 TK panel members need to verify TK recommendations with elders back home.

7.20 Require one male and one female member from each community organization on the TK Panel (or formal alternates); where possible, members must know the LDG area (directed to Aboriginal governments).

7.21 Formalize our recommendations to Aboriginal governments to have youth participate.

7.22 Celebrate our TK Panel as a model for other mining companies.

Other Considerations

The TK Panel repeated their concern that the waste rock pile (blast rock from the pits) will not be put back into the open pits upon closure. Members of the TK Panel would like to see the rock returned into the pits or, alternatively, at least partially fill the pit with rock. This discussion took place mainly during the Friday session (Appendix D) as the TK Panel met directly with senior Diavik personnel, Gord Macdonald.

The TK Panel understands that DDMI has committed to hosting sessions twice per year (as detailed in the Session #6 report). Panel members reinforced their desire to ensure that this schedule is met. The Panel noted that there are numerous topics to be discussed in relation to closure, so having only one session per year (as in 2014) made it difficult to maintain momentum.

There was limited time to discuss future sessions and so previous session discussions should guide the selection of future session topics.

There were some challenges with headsets during this session. The headsets during Session 6 were said to work much better.

Appendix A

Session Photos

1: Celine Marlowe

2: The TK Panel evaluates slope

3: The TK Panel looks closer at processed kimberlite substrate

4: Celine gets a closer look

5: Heading out into the field

6: The University of Alberta students explain their vegetation research to the TK Panel

7: Wayne Langenhan and Mark Taletok share their observations with Colleen English

8: The TK Panel considers areas for re-vegetation and landscape modifications

9: John Ivarluk

10: Wayne Langenhan and Ed Jones share a joke

11: Mary Rose Sundberg and Dianne Dul evaluate the rock pile

Appendix B

Proposed and Actual Agenda

Thorpe Consulting Services

Agenda (Draft v2)

Diavik Diamond Mines Inc.
Traditional Knowledge Panel
Session #7: Vegetation
August 14-18, 2014

<u>Thursday, August 14</u>

3-4 pm	Arrive at Site, Check-In, Orientation & Training, Snack, Sound Equipment Set-Up
4:30-6 pm	Welcome, Opening Prayer, Round Table Introductions, Review Draft Agenda, Workshop Purpose Overview
6:00 pm	Dinner

<u>Friday, August 15</u>

8:30 am	Recommendations Table Review (DDMI/Colleen) Results from TK of Vegetation Literature Review (NT) Group Discussion
10:30 am	Break
10:45 am	Group Discussion
11:30 am	Lunch
12:30 pm	Site Overview Tour with visit to U of A Site (and Presentation)
3:30 pm	Return to Camp and Round Circle (Panel)
4:00 pm	Close

Evening review of transcripts/notes with interpreters.

<u>Saturday, August 16</u>

8:30 am	Group Discussion: How do we re-vegetate to keep wildlife safe?
	Break
10:45 am	Group Discussion: Which habitats or plants create safety for wildlife?
11:30 am	Lunch
12:30 pm	Field Work

3:30 pm	Review of Days Key Messages / Recommendations / Notes
4:00 pm	Close

Evening review of transcripts/notes with interpreters

Sunday, August 17

8:30 am	Group Discussion: Where should habitats or plants be placed?
	Break
	Group Discussion: What should DDMI do with site roads?
11:30 am	Lunch
12:30 pm	Field Work
3:30 pm	Review of Days Key Messages / Recommendations / Notes
4:00 pm	Close

Evening review of transcripts/notes with interpreters

Monday, August 18

8:30 am	Review of Workshop Notes, Compile and Review Panel Recommendations for DDMI (NT/JB)
	Break
10:30 am	Present recommendations to DDMI
11:15 pm	DDMI Preliminary Response to Panel Recommendations
12:30 pm	Closing Prayer
1:00-3:00 pm	Lunch, Complete Evaluation Forms, Review Transcripts
5:00 pm	Return flight to Yk
6:00 pm	Arrive Yk (G&G Expediting)

Thorpe Consulting Services

Agenda

Diavik Diamond Mines Inc.
Traditional Knowledge Panel
Session #7: Vegetation
August 14-18, 2014

<u>Thursday, August 14</u>

3-4 pm	Arrive at Site, Check-In, Orientation & Training, Snack, Sound Equipment Set-Up
4:30-6 pm	Welcome, Opening Prayer, Round Table Introductions, Review Draft Agenda, Workshop Purpose Overview
6:00 pm	Dinner

<u>Friday, August 15</u>

8:30 am	Recommendations Table Review (DDMI/Colleen) Results from TK of Vegetation Literature Review (NT) Group Discussion
10:30 am	Break
10:45 am	
11:30 am	Lunch
12:30 pm	Site Overview Tour with visit to U of A Site (and Presentation)
3:30 pm	Return to Camp and Round Circle (Panel)
4:00 pm	Close

Evening review of transcripts/notes with interpreters.

<u>Saturday, August 16</u>

8:30 am	Debrief of Site Overview / “Garden” Tour
	DDMI Presentation: Vegetation Monitoring & Re-vegetation Research
	Group Discussion: How do we re-vegetate to keep wildlife safe?
	Break

10:45 am	Group Discussion: Which habitats or plants create safety for wildlife?
11:30 am	Lunch
12:30 pm	Field Work
3:30 pm	Review of Days Key Messages / Recommendations / Notes
4:00 pm	Close

Evening review of transcripts/notes with interpreters

<u>Sunday, August 17</u>

8:30 am	Group Discussion: Where should habitats or plants be placed?
	Break
	Group Discussion: What should DDMI do with site roads?
11:30 am	Lunch
12:30 pm	Field Work
3:30 pm	Review of Days Key Messages / Recommendations / Notes
4:00 pm	Close

Evening review of transcripts/notes with interpreters

<u>Monday, August 18</u>

8:30 am	Review of Workshop Notes, Compile and Review Panel Recommendations for DDMI (NT/JB)
	Break
10:30 am	Present recommendations to DDMI
11:15 pm	DDMI Preliminary Response to Panel Recommendations
12:30 pm	Closing Prayer
1:00-3:00 pm	Lunch, Complete Evaluation Forms, Review Transcripts
5:00 pm	Return flight to Yk
6:00 pm	Arrive Yk (G&G Expediting)

Appendix C

Informed Consent Form

Diavik Diamond Mines Inc. Traditional Knowledge Panel

Informed Consent Form

I (name) ______________ _________________on ____________________________, 2014 give permission for Diavik Diamond Mines Inc. and its contractors to take notes, photographs and / or audio and video recordings related to my participation in meetings, workshops and events related to the Traditional Knowledge Panel established for the Diavik Diamond Mine. I understand that my participation includes meetings and workshops held throughout each year either in communities in the NWT or NU or at the Diavik Diamond Mine.

Through my signature below, I understand that:

1. I consent to have my words, activities and responses regarding and related to my knowledge recorded on maps, in notes and photographs, and using audio- and video-recording equipment (collectively referred to as Traditional Knowledge Data);
2. I am free to choose not to respond to any questions asked or participate in any discussions without prejudice or penalty;
3. I can choose to be anonymous in my participation without penalty;
4. My representative Aboriginal Organization, DDMI and / or its contractors may use the information collected to contribute to operations and closure planning at the Diavik Diamond Mine;
5. DDMI and its contractors may share my information which I have verified and given permission to share in either reports and/or photographs and provide such information to my Aboriginal organization and other regulators:
6. I agree that my contributions may also be used for future educational, cultural, heritage, and environmental purposes that are outside the scope of the TK Panel and that my representative Aboriginal organization, DDMI and/or its contractors will make all reasonable efforts to consult me, or my descendants, before using my information for purposes not indicated above;

7. I will receive financial compensation for my participation in accordance with DDMI policy;
8. I am free to request that any information I share is removed, erased or deleted and that I will have the opportunity to verify draft video-documentaries, reports and maps to make edits before I sign them off and that final copies will be provided to me;
9. I also understand that DDMI cannot ensure the protection of the Traditional Knowledge from public release once the reports are released (e.g., via youtube.com, Facebook, other social media, or Aboriginal group websites);
10. The Traditional Knowledge Data will be summarized and integrated with scientific data into a report, which will be publicly available.

Signed this________ day of_____________ 2014, in _____________ Northwest Territories,

Signatures:

____________________ ________________

Participant Aboriginal Organization

_____________________ ______________________

Diavik Diamond Mines Inc. DDMI Contractor

Appendix D

Session Notes

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Day 1: Thursday August 14th, 2014

Start 5:00pm

Joanne Barnaby: Welcome everyone to the 7th session of the TK panel. As we told you earlier, the Inuit delegation is delayed but we're still hopeful they will make it this evening. However we are not going to start our session as planned until they arrive; we are just going to go over the agenda after we hear some welcoming remarks from Colleen and Gord.

Gord Macdonald: Hi, I am Gord Macdonald. I think I've met many of you, but not all of you. My title is Principal Advisor of Sustainable Development at Diavik, I have been with Diavik since 1998 so I have been involved in all of the aspects with respect to developing the mine and my responsibility now is actually working on the closure plan, so working on how to close it (the mine). I've been involved with most of the TK Panel sessions so far and the last one we had last year at site with some of you. I am looking forward to spending some time with you this weekend, with a focus on vegetation, certainly not an area of my expertise at all, so I am looking to learn a lot this weekend from you and some of the University Students. Please let us know if you have any questions not only about Diavik but logistically as well.

Colleen English: Hi, I am Colleen English again I think I have met most of you before as well I think. So I work with Gord and help out with coordinating the TK Panel and I used to work on site for about 10 years doing a mixture of mostly environment work and then some communities work as well. So I've done a lot of work with the University Students that are here at our re-vegetation plots and we're going to have those guys to help you out too; they are going to be our resource people for this session so you are going to meet a couple of the girls from the University of Alberta who are doing a lot of re-vegetation research for us at the mine site. We also have Dianne Dul who is at the back of the room here and she's our onsite environment gal who is here to help us out for the weekend.

Joanne Barnaby: Walk through the agenda and talk about the purpose. The purpose is to ensure the steps that Diavik takes to plant and to seed new plants is done in a way that makes the most sense to you and so you'll need to think about things like: do you want to attract certain animals to certain areas? If you don't want animals in certain areas, what can be done for that as well?

Natasha Thorpe: The reason we are having a session on vegetation is because this was one of the recommendations from the session in October (2013) - to have some time to really spend on vegetation for Diavik now that they are doing the closure plan.

The other thing that really came forward was to make sure there was really strong representation from women, particularly for this session, as many women have a lot of that special expertise or traditional knowledge about various plants and the landscape.

Ed Jones: Are all the workshops going to be held in this room?

Joanne Barnaby: Yes when we are inside we will be in this room. We will actually be spending quite a bit of time outside as well.

Ed Jones: I was just wondering I think when we start we should focus primarily on vegetation that caribou feed on because the other wildlife can look after themselves.

Joanne Barnaby: Yes the elders have made it very clear, elders from all over this region, that they are very concerned with the caribou.

Continuation of agenda.

George Marlowe: That's good that we are looking at vegetation but we also need to take or collect a little bit of vegetation from the island and also on the mainland too. Maybe we could use a chopper or something to get to the east side or north side on the mainland. But what about the fish: how is the vegetation under the water for the fish? We never mentioned that. I used to come here way in the beginning. I used to fish by the dock here at the time, there was not a pit here. I don't know how many of us were here, good fish, and we would bring it back to the trailer, the kitchen and fry them. But I don't know if I could do it now. So we have to know the vegetation under the water, too, for the fish. Vegetation on the island is different than the mainland. Even one ounce of oil spill or anything that spills on the ground you'll see something grow right there.

Colleen English: Good questions. We can definitely visit the shorelines if you wanted to go see some of the areas and look at the plants in the water. There are some areas where we can access the shoreline very safely and easily so we could include those in parts of the field visits. We don't have a chopper on site so we are kind of land locked. We are going to be contained to the east island for this session and so we will just do our best to hopefully hit up a couple of different areas on the island that we can reach and have people looked at the native vegetation there. We haven't seen, any that I know of, species be introduced up here. We have had a couple of bugs come up in fruit; so we had a black widow spider arrive here once in the fruit at the kitchen, and we got a big beetle in the truck shop once that came in on a tire. Those are the only two things that I've seen. The other interesting thing, that we'll take you guys around to show you as well, is that there is a lot of natural re-vegetation happening on its own on the side of the roads, on hill sides, on the side of buildings, as well as other plants and mushrooms underground.

Joanne Barnaby: Your question on grasses and lichen that caribou eat there was a study that Diavik did with a few elders including Albert Boucher and Joseph Judus. They visited areas that are close to the mine site that have dust from mining and they visited areas further away where there was no dust that they could see on the grasses and on the lichen. That work has been documented and there is a report here that you can take and Colleen will explain more about that project and what they learned and the recommendations that came from that work as well.

Wayne Langenhan: This is getting a little bit off track but the last time we were here and Gord was up here and we were talking about filling in that pond there (PKC), I never got any feedback as to what was coming off on that deal at all, which way it was going to go.

Joanne Barnaby: Thank you Wayne that is actually part of what we are going to cover tomorrow when we review the recommendations table and Diavik's responses to our recommendations so you'll hear that response then.

Louie Zoe: Things can grow and there are things that I don't think will grow.

Joe Champlain: It's not like before. They drink water from Whati and the forest fire came really close to the community. It wasn't like before.

Joanne Barnaby: We have had discussions in the past as some panel members felt it was inappropriate to work on Sunday morning so we need to decide that and whether you feel that's a problem and whether you want to make any changes to the schedule for that. Any thoughts on that right now? Are people okay with meeting on Sunday morning?

George Marlowe: Maybe we could do 10 rosaries prior to starting?

Ed Jones: I think we could maybe allot a half hour or something like that. We don't want to take up most of the morning. Also another suggestion is I hope we will be able to discuss the mine closure plans. I think it is very important for vegetation.

Joanne Barnaby: Yes maybe we could ask Gord or Colleen to bring us up to date on closure plans. The other thing we would like to ask you is there any interest in having a woman only session? Yes. If they do have a separate session we would ask that they present back to the whole group.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

George Marlowe: Wondering about the rock pile, it's still frozen underneath, what is going to happen if it thaws? I would like a presentation from Diavik regarding the rock pile.

Colleen English: Brenda McDonald from EMAB is planning on coming up on Monday, very interested in coming and hearing where everything is going.

Ed Jones: I have spoken to quite a few people and they were under the impression that EMAB was disbanded because they didn't seem to be involved for the past couple of years and I was wondering the same thing.

Colleen English: EMAB does still exist but they had a very big turnover in staff which slowed down their visibility and their involvement with people in the community. So they had a few months there where they were bringing a new person up to speed and getting the Board sorted again so it definitely did slow them down, but they do still exist, and the new Board is meeting over the next couple of days to set their goals as a board. Brenda can also share that with you so if you have questions for Brenda she comes on Monday.

Mary Rose Sundberg: I haven't been really involved in this kind of meeting but I have been to a lot of sessions where I interpreted so I am kind of aware of the reclamation plan and the vegetation but what I want to know is do you have a summary of the recommendations from the last few years, because I don't know if it is a good idea or not but I know some people do change, who is coming (to these meetings), so it would help if we had a summary of what has happened over the last couple of years.

Colleen English: Thanks for that, it's a good point. I think one of the positives of this panel is that we have had very consistent membership and it's been great to be able to build the relationship and the trust as well as that continuity of knowledge that people gain from that, but we will have the summary of all of the recommendations available for you tomorrow and specifically we will be walking through the rock pile ones and the PKC because those are the most current ones that haven't yet had a formal discussion and open communication between Diavik and the panel.

Natasha Thorpe: There is also on the side table here all of the previous reports of the TK Panel.

Celine Marlowe: What is under all those piles of rocks that I saw when I was coming in from the airport?

Colleen English: The original ground that was there was an esker and bedrock. That got mined out, to build roads on site so it actually got deeper. It's all rock in there and it's mostly the rock that has come out of these pits. There is also a landfill that is within this pile as well. So Diavik has an onsite landfill where all of the benign, approved materials that are able to go into a landfill are in that landfill. Any hazardous materials are not put in that landfill, we have a waste transfer area for those. In the landfill you will see things like metal or steel, scrape wires. Wood gets burned.

Joanne Barnaby: Break until 8:30 tomorrow morning and hope we have our Inuit friends with us.

Close 6:15pm

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Day 2: Friday August 15th, 2014

Natasha Thorpe: It feels much better now that we have our Inuit friends with us. Welcome everyone.

Louie Zoe: Opening prayer.

Natasha Thorpe: Start with our round table of introductions. Most of us know each other due to this being our 7th TK Panel meeting.

Then we will have a presentation from Diavik and we have been tracking all recommendations that you have made in a table and this is the chance for Diavik to more formally respond to all of those.

Round Table: Mark Taletok, Louie Zoe, Joe Champlain, Celine Marlowe, George Marlowe, John Ivarluk, Martha Ivarluk, Joy Dragon, Ed Jones, Wayne Langenhan, Morris Marten, Joanne Barnaby, Natasha Thorpe, Gord Macdonald, Mary Rose Sundberg, Valerie Miller –University of Alberta Graduate Student, Sarah Ficko- University of Alberta Graduate Student, Martin Robinson- University of Alberta Research Assistant, Dianne Dul, Tiana Shea- Environment, Andrew ***- University of British Columbia, Shaun Sinclair - University of Waterloo, Colleen English, Vanessa White - University of Alberta Research Assistant, Jasmine Lamar- University of Alberta Graduate Student, Ryan Dempster, Mona Tiktalik, Henry Ohokannoak , Berna Martin, Peter Huskey, Janet Murray

Natasha Thorpe: I wanted to remind people that everything is being recorded so that Janet can make sure she documents your words and stories that you share.

Gord Macdonald: *Provides overview of the closure plan for the whole site*. As we get to the rock pile and PKC we will go back and look at the recommendations and go over them a bit more. Water Board is the one that has to approve our plans. Plans have changed since 1998.

Overview of the island.

Pits – Refill with water to the level of the lake, make fish habitat on the outside of the pit which needs to be done first. Fill it up quickly to the lake level and then let it sit there, then test the water and once we all agree that the water is okay we will cut holes in the dyke so that water can move in and out and fish can move in and out.

Rock pile – Make sure that it is safe chemically first. When you take the rocks out of the pit they behave differently, so we need to make sure that the water around the pile (e.g. runoff when it rains) is safe. We need to make sure that the rock pile stays frozen. We asked how you want animals to behave in regards to the pile. We have built some dams around where there will be some seepage.

Colleen English: Early on in the days of the TK Panel it was decided that everything that you did really needed to be documented and there was a keen interest from all of you to have a response from Diavik to each of those recommendations. So we talked about developing a table that captures each of those recommendations and Diavik's response to those recommendations. Last time in October when we met we had the PKC session, so down here you will see a PKC tab and you click on that and up come all of the recommendations that you guys made, and then over here is the Diavik response which we will talk about, which Wayne was asking about, and then any action items that also need to come out of that for Diavik. So we have these for each of the topics that you have discussed already and probably some of the future ones that are sitting empty at the moment.

DDMI TK Panel Recommendation Tracking – Showing the panel recommendations and where Diavik has gone with them.

Gord Macdonald: So that is generally what we are trying to do. I mean one of the recommendations was to try and find a long path, a long drainage path, to direct water to. It doesn't really show on here but there is not really a lot of opportunity to find a long drainage path where the rock pile is located, because the lake is right there and then there is the North Inlet, but we do have the ponds on this end (southeast) that we will use, a pond on this end (northwest) that we will use, and the whole North Inlet so a lot of drainage goes to the North Inlet. So we have those ponds to use as Bobby's moat. As Colleen said we are intending on going with a particularly sloped access here (northwest) and an area all the way along here (southeast) that would be a place where caribou could get on and off the pile again. We were going to continue to keep this side (south) steeper because this will be going into the PKC so we wanted to discourage caribou from going down to the PKC and we were going to keep this wall (west) steeper as well. But in terms of the softer material we would like you to look at one of the test piles the students have been working on, it's re-sloped to the way we would see this being and it is a smooth material; it's not soft, I don't know how to interpret "soft material", but to us it looks like it would be safe for caribou to walk on. What we don't want is big loose boulders like you see there right now, but if you look at the pile, this one pile that we will show you, that's what we would see being here, along the crest and at the far end. So it would be good if you could have a look at that and see whether that's what you think would be safe for caribou or not.

In theory we could put down coarse PK, like somebody asked about, which is this really black material around the edge of the PKC and its sort of like a coarse sand

- it would always be loose, it wouldn't compact down to something firm. You know we could put some of that on here (rock pile), but we'd have to do a bunch of testing on whether we want to do that or not. So that's one material that could be used; but again I think in one of the recommendations there was also the concern, and it's a real one, of putting a black material on here in terms of temperature. Remember we are trying to keep this thing frozen and the black material would not be helpful for that. And the other material that is an option is till. We are going to be spending a lot of time talking about it this week because, I guess you guys will tell me if I am right or wrong, but I think it's a good material as a substrate for re-vegetation. We don't have a lot of it, so we probably want to use it for that versus for making a caribou route, unless it's necessary, so it would be a good one to look at and think about whether that's the best thing or the worst thing for that.

But in concept I think we are all heading down the same path, now we are getting down into the details about it.

Questions?

Mark Taletok: This rock pile, I've been hunting all my life and caribou always climb up to the highest spot when there is no wind and if they go to the higher part they stay there for a long time. I have been hunting all my life. The caribou always stand on the high part; the caribou wants to go on top. I know it's not easy; I've known the caribou go to the high part. While I was growing up I've known that even when a caribou is far when we look by binoculars, the caribou are far but if we start walking to the caribou, we will get there before the caribou move. I don't think there is caribou around and lots of caribou are coming to our town and they never did that before. And our land is really close the place where we used to live I've known I never go there in a long time because I've got no more dog team because I went to Edmonton and I couldn't go home because I've got no more dog team. And there used to be lots of caribou where we used to live and animals are smart and it can't be helped that they want to go to higher ground and towards the evening they always want to start feeding.

Gord Macdonald: One comment that I forgot to mention - I think it was from EMAB but I am not sure if it was from this panel through EMAB or if it was directly from EMAB - but they wanted us to do a study on the effect of having vegetation on the rock pile and whether that would increase snow and increase the amount of water that would get into the pile and you know you will see in the table when you see it, we are not going to take that one on as a research topic. We know that will happen if we put more vegetation on the pile, we will get more snow and we will get more water going in the pile and that's something we don't want to have. So from a water point of view, we want this to be as smooth as it can be so that the wind will blow as much of the snow off as it can to try and keep as little snow as we can get from melting on the pile and percolating into the pile. So vegetation would work against us for that.

John Ivarluk: Earlier you were talking about the open pit and the rock pile so at closing time why don't you put that rock pile - as much as you can - instead of filling it up with water, it's going to fill itself up sooner or later, but if you want to knock that rock pile off, why not fill that open pit with that rock pile?

Gord Macdonald: That question has gone around for years talking about whether we could do that or not. There are two reasons: one it's really expensive to move it back into there. It would be more money than all of the closure plan for the whole island to move that rock back into here, the other thing is that after the rock has been put out on the land we were talking about the chemistry so we don't want water contacting it and running off. If we put that rock back in here, once the water comes back in we will have the same problem with that water. So right now it is best left where it is. If we had been able to fill these up with rock it would have been something we had to do while mining. So that if you could imagine you mine one pit first and then when you are mining the next pit you move the rock over to the other one. We couldn't do that because we've got underground mining happening in each of these pits at the same time. We couldn't fill them as we went which would be the only economical way to do it.

And you asked about if these pits will fill up by themselves anyway; they will, but they will fill with ground water. That is water deep in the earth and the chemistry of that water isn't as good as the chemistry of the lake water. So we do want to fill them (open pits) up with lake water in order to keep the ground water down in the bottom so we have the good water at the top.

George Marlowe: I don't know if I'm going to make a right decision and since about 16 years now we've been talking about this and still we never got to a right decision yet. But I agree with John. We talked about the reason why with EMAB because where the pit is right now that's where the fish used to be and that's shallow. It's only about 10-20 feet at that time so if we put some rocks back again and then some of the current from the lake (from the bottom of the lake) some of it will cover the rocks now but right now if we put water in it its going to be about 70-80 feet maybe more and how about the fish I don't think it's good. We've been talking about that already. And now it seems like Diavik they want to put water in there but us and the Inuit, I support the Inuit because this lake and the river water goes to Coppermine River, right to their home town not us, not Yellowknife, Fort Rae or Lutsel K'e and that's why I support these people all the time. I said that time about 4 years ago I want to see what kind of vegetation from here to half way to Coppermine some place. What kind of plants are growing in the water now because it's running down. They said they would find it and I never heard nothing yet. So that's something we talked about already. We want to put rocks back in so that it's not going to be that deep. That's something we talked about already. That's why I said 16 years ago we never make the right decision yet. And that big pile there we said we were trying to knock it down but you guys buried a lot of old dirty stuff there. Now it seems like we don't want to touch it now. That's something we talk about too. We said to Diavik no more burying anything again on this island. If you bury anything again in the future we're going to have something in the office in Lutsel K'e. I'm going to have the papers saying there if there's anything wrong with that island there, drainage to the lake or river will pay fine, that paper will stay there, so we got the paper too so that's something we talked about already. So I don't want anything to be buried. Last time maybe four years ago we said all those trailers are going bus it and then bury everything I said no don't do that in the future it's not going to be good because the water that's still going to run out. 50 years maybe the water will run and rust from the metal. So I said no, no more burying anything after that.

The rock pile I know the caribou will go on and they said they would smooth it a little bit all the way around with moss on top but if you put it on top it will come down on both sides, so it would be good for caribou. Caribou at this time of year caribou like to stay on higher ground so not much flies.

Ed Jones: Gord I am wondering if you have checked or studied the work the mining companies have done in Saskatchewan on mined out pits? They refilled these pits with water, lake water and I am wondering if they have had any problems. Have you checked on any of this work they've done?

Gord Macdonald: Let me just get back to George's comment first. We are going to have to face these things as a group as we move forward on decisions, and we understand that not everybody is going to be in agreement with all of the decisions so on the question of putting rock back into the pit, we have had those discussions and I agree people have said why don't we put it all back in there. We've said we don't want to put it all back in there and the plan has been approved by the Wek'èezhì Land and Water Board. It is the same plan we had from the beginning saying we were going to do it this way and that's the way it's headed. About fish, you are right what we are targeting in this area (shoals inside the dikes) to make it useable for fish, but this area (pits) will be too deep to be really usable by fish. We are not expecting that fish will use water of that depth, they will swim through it but they won't use it for rearing or anything else; it would not be useful fish habitat where the big pit is.

On not land filling that was a good discussion that happened amongst all the communities and we did get very different opinions. The reason I am showing you this slide is that this is the landfill with the material you are talking about - old trailers and steel and things - going in there. I mean the other option is you take it all the way to Yellowknife and you put it in the Yellowknife Landfill and it becomes a problem that they don't have enough capacity for it. So there's a lot of good discussion about it, that it has to go somewhere, where is it going to go and the conclusion was this (the mine site) was the better place to put it. And again, that's the plan that was approved in 2012 by the water board; to put it here, cover it and it will become frozen in place just like the other rock.

We have been looking at putting water back into pits, it's a fairly common closure option for most mines or many mines, depending where they are. The challenges are usually about chemistry about the kind of water that is there depending on the ore body, whether it was a gold mine or in Saskatchewan uranium mines, and what materials are left in there and what the ground water is like around there. There aren't that many applications that are exactly like Diavik where we've got a pit with a lot of very good water right beside it so that it can be filled up without impacting on the lake. So if we take water out of the lake to fill the pit, you couldn't even measure the change in the lake level because it's such a big lake. Where other properties have the challenge of where they get the water from and how can they bring it in fast enough so that it's, so you get good water at the top or most of it instead of the ground water.

Wayne Langenhan: When water seeps in from the groundwater and goes to a certain level and then water you are going to pump water from the lake itself over top of the dyke into the pit, eventually sometime you'd open it up so that it was all part of the lake again but the residue from the blasting is on the walls of the pit so wouldn't that contaminate the rest of the lake if you were to open it up so that it would be all one?

Gord Macdonald: Yes and so we have done those studies, what we did is take sections of the pit wall and we built a collection tray along the bottom and washed the wall with water and collected the water that came off and measured the chemistry of that water to see how much blasting and other residues from the rock itself that were on the wall would get into the water. So we have a good idea what that would be. When you put that small amount with the huge volume of water that's going in here, there is almost no difference between the water in the pit and the water in the lake; again that's a calculation, it's done based on an experiment, so the real answer will be when we put all this water in here and we let it sit there and we measure it to demonstrate that it is safe before we connect it to the lake.

The North Inlet, as I mentioned before, it used to be an inlet into Lac de Gras and we put a dam at both ends so that we can raise or lower the water level to store water if we need to. So we can always pump the water out of the mine but if something happened - let's say the treatment plant broke down and the water's still coming in - then we can fill this up. We've got about 100 days of storage so we can continue to put water in here until the treatment plant was fixed and it went out. That's why we have this facility here really. You can sort of see it's a little bit dirtier color then the water on the other side, so some of that water that comes out of the mine has dirt in it and it will settle out in the North Inlet ahead of the treatment plant.

Water that comes out of the treatment plant has dirt in it so it settles sometimes before it goes to the treatment plant. We don't know if the north inlet will be safe for fish due to the sediments but that's something we can't deal with now because we don't know, in about two years we will be coming back to you to deal with this facility.

PKC-The kimberlite without the diamonds comes out of the plant, it comes out as a soft material and this is what we call fines and it's like sand, if you saw it on a beach you'd think it was sand. It comes out and forms a slope and then water drains off into here (PKC pond), so it separates first into the heavier bits and then into water. Then we also have something that's called course kimberlite that comes out in a truck and it's much bigger, doesn't have water with it and we use it within the facility for construction. It was the material that some people were talking about maybe we could build caribou roads with that material. But what we talked about last time was what's underneath the center of the pond - the slimes under the water. You can't stand on it, animals can't walk on it. It may be possible to put a layer of rock on top of it, just to separate it from everything else so it doesn't blow in the wind.

Wayne Langenhan: When you say that the water could overflow in that pond there and go down through a series of small lakes, I suppose that it is supposed to be a filtering system of some sort so you don't have to put it through a treatment plant. Would that water (after going through those) would that be of sufficient state of water quality to enter into the lake by the time it reaches there?

Gord Macdonald: Yes that is our current predictions and I expect that will be our closure criteria, that we won't be allowed to do it unless that actually happens. I know how we are going to test the water (scientifically) so it's safe, but we need to know how to get you comfortable that it is safe.

Two of the recommendations were to leave it as a beach; if we did this, I am certain a caribou would get stuck just like a person. So we want to make sure the pond water is deep enough so that the animals/people would swim instead of getting stuck. We are going to get an independent analysis for the material. We are struggling with putting vegetation back into the PKC. I don't feel we want to attract animals to there so I don't feel adding vegetation there is a good idea.

Wayne Langenhan: Has there been any thought to turning that slime into a solid by adding chemicals or something to it?

Gord Macdonald: We could add chemicals however the chemicals are not inert (stable) so we don't feel that is safe for the environment. Ekati has tried and it created other problems due to the chemicals.

Louie Zoe: What we discussed in here, we talked about wildlife and the open pit. I have a concern about no recommendation that's been put forward and what can be put back inside that open pit. In the barren land there's a big snow bank and the animal can fall off and we don't like to see the big rock pile. Maybe some of the rock pile can be put back into the pit and then see what happens,we see what is growing and maybe we can get it to where it can be clear. Once the water goes back in there we know that water is going to be deep. And we'll have to watch for things that live in the water like fish and all the things that being blasted and all the fish plant that is not inside the dyke so that's all the things that we need to think about. So we don't like to see that big rock pile it would be hard for animals and caribou to get on top of those big rock piles that might be dangerous for the caribou.

George Marlowe: Ever done testing on the north inlet and also the other lake PKC, both did you ever test the bottom separately? I'm talking about the mud. It's got to be different, and also the water too. I did a little bit of study on that water on the natural lake too. I helped out. I was there for a long time. There trapping with a dog team, but it's different then when I was there when I was young. When they raised that water it's different, so this one here is the most important part because it's an island, it's not like on the main land, and we all know that there are millions and millions of fish in there. Diavik is different, the water runs to Kugluktuk maybe 100 years down the road it might make them sick.

Gord Macdonald: Infrastructure- What do we do with all the buildings and the roads? Our commitment to the Land and Water Board is to remove all of this material, take whatever is salvageable, sell what we can, trucks, gensets, probably not the steel, buildings would go. So in the end there would be no buildings or anything left that you could see, there would be cement foundations that would get covered with rock. Also the wind towers, what to do with them? Roads- how do we smooth out the sides, or do we smooth out the sides?

I think about them all in different areas but we also need to look at the island as a whole.

10:00am 15 minute break

10:25am

Natasha Thorpe: *Why are we here as a panel? (Slide show)* We need to be able to look at the big picture and also the smaller picture. You are able to do that by seeing the small berries or shrubs, but also seeing how they fit in the big picture with all the other plants, berries and animals.

Joe Champlain: At this meeting everything that has been discussed before I can't read or write English and all these slides, I can't capture any reading. But what we are talking about is the mine, where its situated, and we don't want anything to be contaminated, the water not to be contaminated and also the wildlife. The water flows into the Coppermine River so we have to be in support of the Inuit so we want the water to be maintained and be as pure as possible and there is depletion in water in all areas. It would be good if the water was protected because the water flows into Nunavut and also to the people of Kugluktuk and we have to be in support of them and one another. How can we improve the closure plans so we have to be sensitive about the water? There is a depletion of water in all areas and also using the water in underground mining and also if they are going to fill up the open pit with water. And also the caribou - people live off of the caribou, we don't want to ruin the habitat or the life of the animal, and there is the forest fire and the smoke travelling long distances and maybe it ruins the growth in vegetation and maybe it's not good for the growth of the vegetation and the water. it might be a foreign topic so if we watch about these things and I am thankful that we are having these discussions about these topics. In this tundra and also in the boreal forest there's lots of forest fire, there is re-growth but what happens to the wildlife and their young ones? Thank you very much.

Natasha Thorpe: I think what you shared is a very strong understanding of the connection between vegetation and water. I know that sometimes you feel that you are repeating yourselves and when we look back at the literature you know it's been 20 years that people have been talking about forest fires. John Akana - who is not with us anymore - about 15 years ago he said as we see today, the tundra is becoming too dry from the lack of rain and because of that we seem to get more forest fires. In Lutsel K'e 15 years ago they were saying the reason why there is less caribou is because of the forest fires in that area, caribou vegetation is all burned around Nonacho Lake on the north side of McLeod Bay it is also burnt. The south side is not so burned and caribou come to the south side because of that. So it's something for us to think about: that connection between the land, how wet or dry the land is and how it will support vegetation or different plants now and into the future. One of the things you've talked about at every session is climate change and we're planning for closure into the future when climate change will still continue.

Mark Taletok: I would like to say a few things from our childhood days. From many days ago the vegetation on the land grows very nicely because there was lots of rain. Also as I was growing up I learned to know which plants are good to eat and which would upset your stomach and wild berries are very healthy but I am concerned about the ones growing close to the mine site. Because many years ago anything growing around the tundra and on the land like vegetation was very healthy, but today everything has been affected by development, because it seems like we are giving up our traditional land because it's going to be changing every year to year. It's not always the same year to year how the grass and the vegetation grows, some summers they grow very nice and healthy, some summers they don't grow at all. You know now a days with the climate changing everything is changing even the water habitats in Kugluktuk. It seems like the water is drying up; some of the ponds and lakes are drying up as well. We see it on TV too because there are more storms in the south, and we are hardly getting that up north now. So I guess that's a reality and we have to face that because of climate change because summer to summer is never the same. When vegetation doesn't grow healthy that's why wildlife move looking for better vegetation. Even the water habitats are drying up.

George Marlowe: Seems I like to hear from the Inuit but I don't understand. This summer, how much rain around the Ekati mine? Around Kugluktuk? Because Lutsel K'e we aren't having lots of rain, very dry. Me and my wife we go out on the land, she knows where there are lots of berries but this summer there wasn't much. It dried up. So it might be happening here too because there is no rain. You've got to have rain to grow so I don't know, this summer we don't have much rain.

Joanne Barnaby: Perhaps when we hear from the research team they might want to comment on how much rain they've had this summer.

I just wanted to explain that when we use the word literature in this case we are talking about the traditional knowledge that has been shared in the past that has been written down. We learned quite a bit about how individual plants are important to people and animals, and how plants have been used and also what kind of plants and berries grow and work together.

Mary Rose Sundberg: These issues have been talked about for many years and it's also good to see U of A helping with the project. In order to capture all info we should listen to recording and document info correctly. This should be done. Talking about this traditional knowledge since how many years back that we've been talking about this kind of issues. There is some information here that we can look at. Some of it is good. The university some of the information that they put together and Aboriginal knowledge they collect information on the traditional knowledge some of the books that have been put out, some of the Christian things, some of the information that has been collected it's not all correct, they don't ask the right questions. I just want to say a few things but first of all I just want to comment on the book that Natasha referred to. I understand the author did research on traditional knowledge in Behchokǫ area and all that information I am sure is pretty accurate info from Tłı̨chǫ Elders traditional knowledge but as Yellowknives Dene First Nation we've gone through that book we found approximately 30 items that are not accurate. We were very disappointed with this book because the author did not consult our people to make sure that the information put in there regarding our people, our legends, and our stories were accurate. So they are aware of that, my First Nation does have concerns about the quoting. I know the quote from the elders are correct but sometimes I was told that legends, even legends are different. They are told differently in each region or each community, the way they understand it and the way the oral history was passed down so it will obviously be a little bit different.

How long will this mine be in operation? Also will the rock pile get higher or are they going to create another one? Have they done similar research in other regions that are similar to the landscape in this area where maybe they can fill the pit halfway with rocks and then on top with water?

Natasha Thorpe: I wanted to respond to your first concern about making sure the words are right. From day one it's really, really been a priority to make sure we get the words right. To give you a little history, for the first four sessions every report that was written (on the table over there) we went through every word on the screen to make sure that the words were right and we made lots of changes. I am hoping that the panel remembers some of those days of going through word by word. The other way that we are trying to do things right here today is during the sessions. We've brought in Janet who has lightening fingers and she is typing out everything that is said. Ryan is making sure everything is recorded and then during the evenings Janet's listens to the recordings, makes sure that all the words are there, and then you have the homework the next day or later that evening to sit down with your interpreters to make sure that our records are right on the paper. I hope you understand that Joanne and I take our jobs very seriously and its more than a job, it's a responsibility from the heart to make sure that we get the words right and that they are your words, we're helping to get them out on paper.

The other questions about the life of the mine, Colleen will answer those.

Colleen English: To answer your question about the mine, it will operate until 2023 with or without A21, so 2023 would be the end of operations when closure would start. Rock pile is at its maximum height for operational needs but there will be some added for the finishing (capping), as in rocks. There is no mine in our exact situation that I know of at this time.

Gord Macdonald: The only one that I know of is a mine in the eastern United States that put rock in the bottom of the pit, like a very small depth of rock in the bottom of the pit before they flooded it. The reason for it was the rock was really reactive and the best place to put reactive rock - it's only reactive because it's exposed to the air - so a good place to put reactive rock is at the bottom of a water body where it won't get air. So that's what they've done, as their closure plan was to put that material in the best place to get rid of it, which is at the bottom of the pit and they flooded it. At the same time it hasn't been very successful because when they filled it up, they left a ramp down to the bottom, you don't just dump it off the top, they drove it to the bottom and left a ramp and so that ramp has always been exposed. So the water in that pit is nowhere near closable and so they've actually ended up creating a problem that they hadn't expected.

Mary Rose Sundberg: Where in the United States? Also there was another concern that I heard over the years, if they fill the pit with water from the lake how long will it take to fill and also will the lake level go down?

Gord Macdonald: We would fill it over a period of months and, in theory, the lake would go down but you couldn't measure the change because it would be so tiny. It was the Ridgeway Mine in South Carolina.

Mary Rose Sundberg: You can't put the rocks back into the pit because of the chemicals? Is that the reason why you can't put the rocks back into the pit?

Gord Macdonald: Its one of the reason's, I think it's less the blasting material and it's more the chemicals on the rock from being exposed to the air. The biggest reason is because of the cost of doing it. It's completely re-mining that pile, drilling and blasting.

Mary Rose Sundberg: Can you tell us how much because I can tell you that this mine has probably taken billions and billions of dollars so what's the cost that they are afraid of spending because the land that belongs to the people they just get less than pennies in IBA's. The mine has extracted I would say billions of dollars and if you are talking about cost it shouldn't cost too much. I don't think it would be too much to do. It is something I think we should consider because of the concerns that I heard over the years about this. How much would it cost to re-mine the rock to put it back into the pit?

Gord Macdonald: Sure I can try and come up with some rough costs. The biggest challenge with this one is we had this conversation before we built the mine, and with everyone back in 1998, because if this was a requirement - that we put the rock back in the lake - we would have developed the mine site differently. So it's one of those decisions that were made a long time ago and, whether you agree or disagree, whether we should have done it differently, its really unfair to try to get us to go backwards on that kind of a thing. But I hear where you are coming from and I will try to get you the numbers at least so you get a sense of how much money.

Mary Rose Sundberg: And also that community where that place in the United States.

Gord Macdonald: Yes I will.

Joanne Barnaby: About that rock pile, if that third pit is mined where would that rock go?

Gord Macdonald: Some of the rock would go to the covering of the North Rock Pile, but what isn't used up there will go down here on something called the South Country Rock Pile.

Joanne Barnaby: So there would be a new rock pile?

Gord Macdonald: Correct. And again, all of that was part of the original project approval plan to have a pile down there.

Joanne Barnaby: Any other questions regarding documenting the past work of the panel, and dealing with the four questions.

Wayne Langenhan: A big concern for me is what's going to happen to the airstrip? Is that going to be purchased by the territories, feds or torn up?

Gord Macdonald: It would but torn up and allowed to re-vegetate so it wouldn't be an airstrip anymore unless someone wants to take it on as an airfield. Can't leave it there as a registered airstrip due to liabilities.

Ed Jones: On the airstrip and the roads, you would do more damage to tear it up, why not leave it intact? What's the problem with leaving it intact?

Gord Macdonald: The only problem is it would need maintenance to maintain it as an airstrip. If it is left as a designated landing strip it would have to be maintained and someone would have to take on the liability. If you wanted to leave it for some kind of emergency landing that's also possible but somebody would have to say it's a designated landing strip. We could leave it and let it go to its own devices, that's fine to do, but in terms of somebody taking it on as a registered airstrip that is a challenge.

Natasha Thorpe: It sounds like the government needs to make that decision?

Gord Macdonald: Yes. That is possible, but we are planning for the most work and if that changes that's fine too.

Ed Jones: As you were saying, that's already been settled before the development of the mine so we can't back track now and we have to live with the agreement that we signed.

Joanne Barnaby: Ed are you thinking that you would like to see the landing strip useable as a landing strip in the future or are you just saying that it can be left and vegetation can grow back naturally?

Ed Jones: Well I believe that all the conditions have been agreed upon. We can't back track, we can't change the agreement now. We should have made an agreement or a condition that Diavik would maintain the airstrip and roads after the mine closure but we can't do that now. It's all said and done.

Natasha Thorpe: What we can do now, Ed, is provide guidance on re-vegetating those areas if indeed that's what people want to do. That's a key focus of our session.

Wayne Langenhan: When I was mentioning the airstrip I wasn't talking about maintaining it but it is just a flat place that could be used on emergency landing if need be and I don't see any reason to maintain it. It will stay there for years and years in sufficient condition to handle aircraft even if it's in a winter landing they would be able to find their way to that flat place.

Gord Macdonald: Better than nothing.

Louie Zoe: As we are talking about the airport, at the previous meeting we've talked about this that if it's dismantled, because we should leave the airstrip and also the trailer along with the airstrip for emergency landings.

George Marlowe: Myself when I'm thinking about this island here I remember a little bit about this island. I want to go back to the same place so that means that you have to tear up all that road, flatten the road, flatten the airstrip, torn up and then vegetation put back on it. Same with the rock pile. Somehow smooth it a little bit, put some dirt on it and grow some stuff again on it. If we don't do that, it's not like it used to be before. My grandson wants to buy a plane and I don't want my grandson to land on a landing strip that isn't maintained. So it's better to have nothing, for me it's like that. I want everything torn down that is possible to tear down. I don't want anybody to land on it; it could be an accident, alone here in the far north. It's not going to be like it was before but I want it as close as it can. Sometimes Diavik should take the middle aged people and see what they feel. The buildings, we are old, maybe the middle aged people have something that buildings could be used for.

Natasha Thorpe: Questions?

Celine Marlowe: The question I still have is about the rock pile. I remember I was translating for an elder and I remember when Diavik came to the community and that elder asked why the rocks couldn't be put in where it was taken from (back in the pit). I can't remember that person's name, and he said you can't put the rocks back. And my question is still why not? You took it out, why can't you put it back in and my question is still the same thing. I am hearing well it's going to cost too much to put it back, well you took it out so why can't you put it back? You want to get information from all of us here and we're telling you stuff and then it's like 'that's not the agreement that we made the first time', well why are we here then if you are not going to take our words for what we are saying? It's not only for me it's for all of us here. We are giving you what we want, what we're saying, you're putting it down and now it looks like well that wasn't the agreement that we had at the beginning. Well why are we here then? So whatever recommendations that these elders are saying and putting it down does that mean that it's nothing. How do you think these elders feel? That's how it sounds to me like for me that's how it sounds exactly. So whatever you take from the ground, put it back to where it was.

Gord Macdonald: Thank you for phrasing it that way, it is a challenge. What aspects are we able to or willing to change and which ones are we not willing to change. It's good that you are bringing it up and it's good that we are having that discussion. We are trying to ask specifically for input in areas where we do have the ability to make changes, where we do have options, but there are areas where we don't have that option anymore, or in our view that option doesn't exist anymore, which includes moving that rock back into the pit. I fully understand if you want to disagree with us on that but that is it we are trying to be clear in areas where we do have options and areas where we do not have the options to change. And if we are not clear, please ask us again. Going back to your specific question that somebody said that all of that rock can't go back into the pit, they are right it can't. All of that rock, once it's been blasted it takes up more space then it used to, so it's like a jigsaw puzzle that you pulled all apart but you can't put it all back together and expect it to fit in the same whole; it won't work. Now that doesn't mean you couldn't put part of it back in, so if someone was answering you saying it all couldn't go back in, they are correct; but some of it could go back in, other than it being a very expensive cost.

George Marlowe: After 2023 the pit, the three pits will be there and are going to fill up with water without putting the rocks back in. You should look at Misery Lake; after the narrows there are two places, very shallow, it's not like as deep as around here, and if you want to put this water here in the three pits, you're going to lower that lake over there, probably lower the water over there I'm pretty sure, because it's shallow right now. You will probably see some dead fish floating around because it's too shallow. And the other mines are going to put water back in those pits as well and that will make the lake go down, maybe not right away, but in 10 years it will when 5 pits have to be filled. If we put some of the boulders in, not all the way but some of the boulders back in, that's what we were saying before.

Natasha Thorpe: What Colleen and Gord presented back to you this morning is from quite a massive list of recommendations that we passed along to Diavik and they have a responsibility to respond to. For example, there were 19 recommendations that came out of our last session. My guess is there will be at least that many that we pull together as a group and present to them on Monday. So if anybody is interested, we have all of the recommendations and the responses from Diavik in a table. I just said to Colleen that it would be interesting to count up how many recommendations the TK Panel has put forward to date through 6 sessions and how many of those Diavik has been able to accommodate or has said yes or no. My hope is that these numbers might give you a greater level of comfort in moving forward. To echo what Gord has said, there are some things that can be accommodated and some things that can't. And my understanding - correct me if I am wrong here - is certainly this vegetation piece is somewhere that I think the TK Panel can really make a difference. It's something that we've seen Diavik be very support of. For example, I know in 2013 there was quite a large lichen study that they supported that the Tłįchǫ carried out, and that's in our review of all the documents we looked at.

I'm impressed to see these university students as well as this larger circle of elders try to move forward and make a difference, to put together some strong recommendations and to be involved from the very start in what things are going to look like in 2023 and beyond.

Lunch 11:30

Afternoon 12:30 – 3:30 Field work

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Day 3: Saturday August 16th, 2014

Natasha Thorpe: Welcome back to our second day of our 7th session. We thought we would start out with a debrief of the tour yesterday.

Mark Taletok: Good morning to you all. I was thinking of the rock pile, if they have a roadway for the animals because the animals were using a trail even if it's only one part on the south side. Even if they made a lower part for the caribou, it will be good for them. It's too bulky and too sloped.

Joanne Barnaby: So we just wanted to check and see if you had any thoughts about our time outside yesterday. Any ideas or questions you might have regarding the vegetation plots that we saw?

Mike Francis: The tour of the site was okay.

Louie Zoe: The visit that we took to the rock pile is a good slope for the caribou to be climbing up and climbing down. It would be good to get rid of the big bulky boulders; if there are big boulders the caribou might break their legs or ankle or damage their hooves. Also at the re-vegetation sites it would be good to identify which plants grow, and those areas seem to be looking good.

Joe Champlain: At the site seeing yesterday it seems to be good, rock pile the boulders within the rock pile and if we see these areas it's good to see these things and talk about them. At the rock piles that they created there might be fox dens in that area, so are they keeping an eye on fox dens within the island?

Celine Marlowe: About the vegetation, it seems like they are growing. Maybe just put more of it on the side. I think that area on the smooth side looks better then the rough side. The rock pile I don't know if everybody will agree but for me it's like nobody's going to be going out here after the mines close, so what if you just cover it all with rock in a slope like so that, you know, it's smoother and easier for the caribou to pass by if this is just an island. I have not been all around here yet so I am not familiar with this place around here but it is only for the caribou and wildlife around here. Because nobody is going to be around here after it's closed. I don't know but I was just thinking it's just an idea, put a slope so it would be smoother.

George Marlowe: For me it's a little bit different. When I look at the plan to replant for the wildlife it's different for me from the new one (re-vegetation plots) this summer and the one from 10 years ago. I have seen that some things are growing on the summer one but for the 10 years area- that's a long time - but there is still not much growing for the caribou and the people. When you want to re-plant for the wildlife on the island which what I think I see is the one outside I don't want no gravel on and you can see that's there from a long time. That one there you should just keep it the way it is right now don't put more gravel anywhere. Because when I look at it, there are bearberries, crowberries, blueberries I took some and ate some, so if I get sick you will know it! I'm not sick yet anyway. I don't think any more problems; it's a problem alright but the way it is right now we have to keep it that way but the elders are saying to put a road for caribou over the stock pile from the north end to the east. Where we looked at it, at the east end, and we should go look at the north end as well, maybe make a valley for the caribou to walk or to climb up but we don't want any more rough boulders there. Up there yesterday there was good wind, no flies see that's what the caribou like too. Let's keep it that way and just put a slope down and put some more for vegetation. I see that stuff they put 10 years ago, it didn't grow good, I don't see nothing. So that means that new one, I don't know if it is going to grow but anyway just try it as long as you get that lichen growing that is the main thing. I see geese there and I think the geese eat that and I see that ground squirrel there and I think he eats that too, the berries.

John Ivarluk: That rock pile, the way I see yesterday and the big rocks under it there and I don't think the caribou are going to go up that hill; there are too big rocks on the side of it. They would be going around that rock pile instead of going up. Unless they make a pretty good slope on it like the one at the last one (test pile) we have seen, that's a good decline there. And the vegetation and stuff just keep it the way it is. It will grow in the future about another 10 years or so, it takes a long time for the land to heal itself and re-grow. I've been going to Lupin for a long time to look at the tailings pond. It takes years and years to re-grow and it's finally starting to look back to the way it was.

Martha Ivarluk: The way they want to do the valley, its okay, the plants will grow in the future.

Ed Jones: I don't think that we should bother with re-vegetation. John just said that nature will heal itself and I believe in going along with that. As for the rock pile, I haven't given it much thought.

Wayne Langenhan: On that trip there yesterday to the plots I mentioned to Peter Huskey, I pointed out to him that there was already vegetation coming out of the side of the those big rock piles, the fireweed was growing so the re-vegetation has already started. The big rocks - as Ed mentioned before - I think the big rocks need to be moved. Also I had time to do a little bit of talking with our Inuit interpreter, Henry, and we spoke about re-vegetation. If you wouldn't mind I would like

Henry to be able to speak a little bit about the re-vegetation that he has seen in the north in the DEW lines and stuff.

Joanne Barnaby: I was going to invite the interpreters once we finished the circle.

Morris Marten: That slope we are talking about, the big boulders on the side, they should be pushed away or buried. We talked about the slope, it should go into a small lake then they could have the muskeg around it and that should help.

Mary Rose Sundberg: Good morning. Some of my observations was I think whatever the university students are doing and they are doing a good job and I think it's a good experience for them as well to hear what the elders have to say, combining the traditional knowledge and the scientific knowledge together it makes a difference in how you look at things and you have a deeper understanding of our way of life so I am glad you guys are doing that part. The slope that we looked at, I think it might work for the caribou from what I am hearing, if this is what we are going to do for the slope and for the caribou to come down on one end I don't know. I like what I see but it's going to take a long time. At what point are they going to stop testing and say it's okay and when are they going to re-plant? Are they going to use a certain way of re-plants, and when things start growing, whether its moss or lichen or grass or even flowers, are they going to test those plants to see if they have any chemicals in them? That's the plan, right? So I would like to know when they might start testing the plants to see if they have any chemicals in it. And I was kind of amazed to see some growth in the kimberlite plot. That is crazy. I don't know how that's happening but I think the vegetation in the tundra is very powerful, it can even go through rocks as you guys know. I think there must be something underneath it that is making it grow.

The slope that we looked at, I think it might work for the caribou from what I am hearing. If this is what we are going to do for the caribou to go up and come down, I worry from what I hear. How caribou travel on the land all over the place and I am afraid they might start traveling up all over. Trying to make a path for the caribou on the slopes but we are almost like trying to predict how they are going to travel. I would like to see the traditional knowledge from before the mine to see where the migration path was. Myself, I have never hunted in this area at all. I heard only stories, but I did work on the barren land before but never knew the information. I think is important because the caribou will go back to their same migration route usually they do so once this mine is not here; they are going to start on their own trail again but it would be nice to know where that route was so the slope can be developed on their trail.

Mona Tiktalik: For those the landscape in years to come the grass grow again the vegetation will grow again even in our communities the grass still grows because we are not too concerned about it right now. The willows are getting longer and longer each year and the nature will look after itself. The only concern I really have is the water flowing down to Kugluktuk.

Henry Ohokannoak: When I was talking to Wayne yesterday, I started growing up in the DEW lines back when the DEW lines first started in the 1950's when construction was going on there and all those DEW lines, they closed. They didn't do any reclamation in those sites so they just left the airstrips and the roads as they were and after so many years I still go back to the one DEW line where I grew up. The runway there the grass is all grown again, it's even more beautiful, prettier than the natural landscape. You know the weather is not as hot as down south but any kind of vegetation grows on the airstrip and roads. I won't be too concerned about removing the airstrip. Maybe some parts could be taken down, but the runway I wouldn't be too concerned about it.

Peter Huskey: The visit, the site-seeing we visited yesterday the re-vegetation I think it's a starting point, there's a little bit of growth and the rock (test) pile I think it's a good slope and I think it will be good and I think also the university students are doing a good job and maybe they could make themselves available to speak one-on-one.

Berna Martin: If it comes to the mining I am kind of afraid because of the example of Giant Mine. It looks kind of scary for me but that's how I feel but I know that everything will grow back naturally, but someday there will be berries. Can we pick the berries and eat berries again? I don't think I can ever go down to Giant Mine and that used to be a good place for berry picking. And the slope looks pretty dangerous for me, for the animals to go up. Even the caribou maybe can fall and break their legs but otherwise I am sure it will grow back way in the future. I think the university students are here to learn as much as possible and they should go one-on-one with the elders like Peter said and get to know each other and spend some time with elders and they could learn our traditional knowledge and we could learn from them.

Ed Jones: I just want to add something: it may surprise you to know that one of the main caribou migration route passes over the Misery Pit right now [at EKATI]. I think once it is mined out it should be backfilled with what was in it. And I think that is very important to note that.

Joanne Barnaby: We would like to focus on what to do to make it safe for animals, in particular for caribou. There was some discussion about whether the slope we saw yesterday was good and so we thought it might be a good idea to start addressing that issue and where to put those slopes, where traditional migration routes are on this island and see if we can identify a path for Diavik. We thought if we addressed that early in the day then we could move on to other issues for other animals. And look at the vegetation needs as well as questions of slopes.

George Marlowe: I would like to put something on -3 things maybe, - people talk about slope it's okay to walk on it in the summer time but it's different in the winter because every year I go to the barren land I used to go with dog team when I was young, now I go with skidoo. A slope like that and people know even though the slope is good it depends on if there is a north wind or a different wind as it creates a drop off on the side and caribou could fall off the edge because you can't see.

The vegetation growing I saw fireweed growing on the side of the rock pile. That means there is moisture under there and we need to talk about moisture. And when they plant lichen on the new one and on the old one I don't see any moisture and so it don't grow so we need to talk about the moisture. And caribou come from the north and they are supposed to be here already and they aren't so there is some reason why they are not here so there is something wrong.

Joanne Barnaby: Any other comments regarding the idea of trying to support the rebuilding of caribou trails?

Ed Jones: I forgot to mention that the Misery Pit is located on the EKATI site but perhaps we could remind EKATI to backfill that pit with material that came out and we support such a project and I think it's very important that you consider this.

Wayne Langenhan: If the migration does come back this way, I don't see much point in making trails because caribou will make their own trails so I don't think that's really necessary.

Joanne Barnaby: So you are not concerned about the big boulders being in their way?

Wayne Langenhan: I still think that some of those boulders should be covered over or if they have a crushing plant here, why don't they put them through the crushing plant and make them smaller and then put them back on?

Joanne Barnaby: I think we are talking about the same thing. We are not talking about trying to make a natural caribou trail, we are trying to figure out how we can follow fairly closely where they would go traditionally, normally before the mine came along, and just make it fairly safe to travel through using things like crushed rock. Any other comments? We've heard that caribou come in from the north, we should talk about where they would leave, which direction they would be going in?

John Ivarluk: I saw ground squirrels out in the field. Have you seen rabid foxes around here? If so, they eat those squirrels and the ground squirrels go all around and eat what is not good. That’s how the foxes get rabies - from the ground squirrels.

Colleen English: We had a rabies outbreak around here 5 or 6 years ago. And there was, in the end, there was 4 foxes that were identified with rabies. And then previous to that, back in 2003 or 2004, we had 1 rabid fox. 2009 was probably the last rabies outbreak.

Joanne Barnaby: Is there anyone that would like to try and point out on the map where the caribou migration routes were before the mine was built here? We all have those little maps in our papers we could mark them, we could use them to mark where you believe the traditional caribou migration trails were, or if somebody wants to use this big map and get up and show us where those trails were.

George Marlowe: *Marking on the map*

Joanne Barnaby: Anyone else want to share their knowledge and experience with the traditional trails, caribou trails?

Joe Champlain: I’m a hunter myself. When we talk about caribou we talk about their migration routes and also the Inuit, they hunt the caribou so they know the migration routes. The caribou has its own routes where its migrating; it has its own route, it creates its own trail but also it sees the hills and the valleys. Where the trail goes I think about it the north country rock pile it probably goes through the lower areas so they are not on the big rock pile. With the boulders along the side it can be really sloppy but less slope, a gradual slope, would be better because the caribou makes its own trail and once its moving the momentum of the caribou follows the leader. I like to see the open pit myself. To see how we can improve it, what would be the chemical difference if we were to put the rock back in the lake? And what kind of chemistry difference will it create. I am not saying it should be done my way, just to talk about it...

Joanne Barnaby: Rain information from Diavik

2013	2014	
April	14.9	4.42
May	16.0	37.2

June	50.6	12.0
July	55.6	33.8
Total	137.1	87.42mm
5.4”	3.4”	

George Marlowe: (Looking at the map talking about Ekati). Diavik could be blamed for something that Ekati did, due to the fish being able to travel far. Why do we have separate meetings here and separate meetings there when we are on the same lake? Tagged nine 7 or 8 pound trout in ?? Bay and 9 days later it was caught in Łutsel K’e. So we should all be working together on this.

Natasha Thorpe: I want to ask a question to clarify: are you saying with trying to direct caribou migration that there needs to be landmarks farther away instead of right here?

Joanne Barnaby: I know the Tłįchǫ elders have talked about building what they called caribou flutters or flags. Traditionally they would cut strips of hide and put them on poles as a way to direct the way they want the caribou to go. Around Colville Lake they use what they call caribou fences to channel the caribou so they could either spear them or snare them back in the old days. So those are old technologies that could be considered now and maybe we substitute the old caribou strips for Christmas trees from Wal-Mart. What is coming through here is the recognition that when we talk about meeting the needs of caribou, we’ve got to look at a bigger area than just the mine site. We need to also work in cooperation with other mines that are in the region and probably with the territorial government too and their caribou biologists and other people with responsibility for caribou to really feel confident that we can find the best way to support caribou returning to the area after the mines are closed. So we can talk about things that can be done here on the island but I think people are also saying that you can only do so much here; you also have to participate in a bigger discussion.

George Marlowe: If we put land marks for the caribou, artificial Christmas trees. That’s what I told them (Ekati), too - same thing. They all laugh but if it’s going to work, I am pretty sure it’s going to work, because me I got those ideas from my elders.

Natasha Thorpe: Behind the scenes there is a lot of discussion and research in looking at what is going on at Ekati. For example, yesterday I talked about how we looked at all those reports; many of those were from Ekati so that we could learn what the elders had already said about caribou, what they have already said about vegetation and tried to put that together and to prepare for the discussion later this morning about caribou and about other animals such as grizzly or fox. We looked at some of those reports to learn from the traditional knowledge about what has already been said.

Wayne Langenhan: This has been brought up before but I am going to bring it up again. At Lac de Gras is a very big migration, and they are being interrupted by mines. There are three operating mines and there is soon to be a fourth on Kennedy Lake. What was brought up before is that there is too many mines in a small area and what was said is that one should go down before another goes up. And this will probably save a lot of problems with trying to re-route the caribou migration. I think what is happening with the government letting this many mines go ahead is just causing more problems than its doing well. There are plenty of jobs here with the mines that we have and there are enough training jobs we don't have to open up anymore mines at the present. So one has to go down and be reclaimed before another can open up. I think if everyone in this whole panel, I think, leans in that direction it will probably help us, the land and probably the caribou out considerably. I think that there have been too many exploration camps and mines; there are too many around, it's getting so the caribou don't want to move there. They want to go south where the mines aren't, they see more caribou in Saskatchewan than they ever have before. They are trying to shy away from the mines and picking different migration routes and I think this could be solved, a great part of it could be solved, with the closure of one mine before the opening of a new one.

Colleen English: *Fox dens and where they are on the map.*

When do you stop testing? The research plots are run for 4 years, so we hope that we will have enough answers for that at the end. We are also going back to the 10 year plots to have another look at the growth and see if we have enough answers to complete that work. Plants grow slow in the north, so we may not have all the answers before we have to start doing the work If A21 goes through we will be using the till from there so we will be starting (reclamation) sooner than mine closure. We are also going to be testing the PK in 2015 from a toxicological perspective to see what chemicals are in that PK that may get into the plants, or if you think about if wildlife ingested any of it as a soil itself.

Joanne Barnaby: Should we move on to other issues around vegetation and whether there is anything that you are clear about in terms of where to put certain plants or whether there are other animal needs that we should look at and what direction should be given to meet those needs? I know there was talk about meeting the needs of foxes, bears and whether we should be encouraging the growth of plants and whether we should be using plants to help heal the water.

John Ivarluk: When we were out there yesterday I was telling you migration routes are never the same year to year, they change. The caribou know where to go so there is more grass. Just about the same thing with the animals, you could see the caribou trails over the years. It is not the only trail that caribou are going to take, its going to be different from year to year.

Joanne Barnaby: It has been said many times that if caribou see a big hill like that they will go on the rock pile because it's high and they would go there to get rid of the bugs so that's one of the reasons we were concentrating on the rock pile and what should be done to make it safe for caribou to go up there if they choose. We don't have to think in terms of that's the only place they are going to go, but they may go up there some years but not other years and that's fine.

Break 9:55-10:25

Natasha Thorpe: Starting at least 20 years ago the elders started marking on maps and shown the traditional caribou migration routes. While we don't have all that put together in a nice parcel for you today, we could try to pull that together for you so that we could present your information back to you in terms of where the traditional routes used to be. That might be helpful in terms of understanding how to keep caribou safe. Our challenge is that we have this session to really focus on vegetation and we can zoom in to an area as small as the plots that U of A are working on or we can zoom back out and look at the landscape as more of a quilt, more of a really varied landscape that has different pockets, different types of vegetation, lakes, rivers, streams and all the different types of plants that like to live in those areas, and all the different kinds of wildlife that prefer some of those plants and those areas.

We have a large group of students here with us this morning, and yesterday there were some very specific recommendations from you that might be helpful to them in terms of trying to integrate traditional knowledge into their otherwise scientific testing. For example, at that second stop George took me off the test plot to where there was undisturbed tundra - what the scientists would call the heath tundra so a mix of the crowberries and the blueberries and the cranberries and the moss and the lichen. Please correct me if I am wrong here but I understood him to say that to encourage lichen to grow - which is so important for caribou - what we need to do is take a square or a piece of mat from the tundra and put that in those test plots and see how the lichen grows using that natural environment. So as a panel of experts that's something that you need to let me know if I got it right. That's an example of a recommendation that could be made to replant or to re-vegetate this area.

Ed Jones: Natasha, you talk about encouraging lichen to grow, but you don’t have to encourage it, it will grow, let nature take its course. Why spend all this money and time on re-vegetation? I think that is a waste of time.

Natasha Thorpe: You beat me to the punch, I am always 5 steps behind you. I was going to say that we have this rainbow of ideas: we have one end of the rainbow where someone has 700 different plots to monitor (that’s a lot of sites!). So there is that extreme. There’s using traditional knowledge to try to mix with the scientific knowledge and find good ways of replanting. Then the whole other end of the rainbow - the Ed Jones side - and perhaps what we have heard from the DEW line experience that our Inuit experts have shared - let nature run it’s course. So this is your time to explore all of the colours of the rainbow. Everybody’s ideas are equally important and if we have - as a group - some very clear ideas that we want to share with Diavik or with U of A as well each other, this is the time.

George Marlowe: Ed was mentioning and I want to add a little bit to it that caribou, wherever they travel on the land, anywhere sometimes 10,000 or 15,000 caribou they travel. You’ve got to think about fertilizer, nobody mentioned about a fertilizer, caribou poop used to be all over the land and it fertilized the land so if the caribou don’t come here maybe it won’t grow. Maybe that is something the University students could look into that too.

Natasha Thorpe: Do you want that as a recommendation?

Mark Taletok: I just want to make a few comments because my hunting grounds were not too far from here. We are talking about the vegetation, we don’t have plants like white people do. Even our archaeological sites and camping areas and all kinds of plants grow. Even today I still see the same, even though I don’t go there anymore. My old tenting areas and also where we tied up our dogs and their droppings, the vegetation grows different there. We usually moved from camp to camp following the caribou herds because they don’t always use the same migration routes. In the middle of August the caribou usually start migrating there, for it is really nice for clothing. When the herds migrates, it starts like a big herd and goes for days but it’s not always the same year after year so we have to move from camp to camp trying to follow the caribou herds. We either go by boat and we look for the crossing areas in the lakes as well and we make *inuksuit* to remind the next time where they are going to be crossing in the lakes. We don’t use the modern boats, we use kayaks and in the crossing areas we use harpoons to harvest caribou. Back in the days it was easier we didn’t have anything to worry about; right now in the communities it’s getting very hard when you don’t have any means of going out on the land. You want to go out to your traditional camping areas, but we don't have any means, we don't have a dog team anymore and we don't have a machine.

The dump- like our garbage dump - was a bit too close to town but they moved it; it was an eye sore but its better now. My grandmother used to tell me (even though she is gone now) that there would be different kinds of species coming up to our area in the future and last spring I saw a different kind of bird; it was a yellow bird that I never saw before. As soon as I saw that bird it reminded me what my grandmother used to tell me about different species coming up in the future, up to our area and I truly believe what she would tell me growing up. I am not really concerned about the grass and growing as Mother Nature will take care of itself. Mother Nature is very powerful and grass will re-grow. I remember way back when there was no caribou migration. Our way, we lived off of ground squirrels even though we went to different lakes for fishing. We didn't see any caribou. So later on in the fall time when the lakes start freezing and the caribou start coming up, that's when we finally started getting caribou. The only thing that we lacked was trying to get nice clothing, winter clothing, because that summer there was no caribou herd that came our way.

Mike Francis: About caribou, old-timers used to say don't hit a caribou with a stick: if you hit it with a stick it would never be back again for 4 years. Same for the rabbit; if you hit it with a stick, it wouldn't be around for 4 years.

The caribou we live off so we have to respect and we have to care for it in a respectful way. When we harvest the caribou, when we skin the caribou, we don't just throw it; we lay it down gently. That's how our ancestors used to pass on tradition.

Natasha Thorpe: Thank you for sharing those old time stories.

Joanne Barnaby: We are hearing a lot from everyone that it's a waste of time to re-vegetate so I would like to hear from the women before we make that decision. Women do most of the berry picking, women pick most of the medicine and women have a lot more to do with the plants directly then men and so we could do a little break off session to hear from women and then get back together and present that. If we do that the men could stay together and talk about whatever you want to talk about. You could talk about caribou trails or you could talk about vegetation or you could talk about what to do with those areas for helping to clean the run off. The water and using plants to help that along. But I guess I am not comfortable in moving into the discussion much further about what to do with re-vegetation without hearing from women. Is everybody okay with that?

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Natasha Thorpe: The other thing we could talk about is whether or not it really makes sense to go out this afternoon to do some field work. Both groups can talk about this and where we should go. In the agenda we have time this afternoon to do field work and time tomorrow afternoon to do field work. However, one thing that I have learned from you over the years is that we need to be prepared and that we need to be ready before we go out so I want to encourage you to discuss whether or not you're ready to go out and where to go and what items you want to talk about. Because we could very easily prepare ourselves today, spend a little bit more time in break out groups and then be very specific about where we go tomorrow.

SMALL GROUP WORK

MEN'S GROUP

Natasha Thorpe: Boulders→warmth→ground squirrel tunnels→shade for caribou

Shade for grizzles→river valleys

Eskers→escape from insect's→dens for fox, bears, wolves→easy walking for caribou

Wayne Langenhan: Were there any pictures of this island taken prior to the mine of the vegetation?

Natasha Thorpe: Yes there are and we can show these. There is also a report from 1995-1996 by Page Burt and it's all about the plants and talks about the tundra being a quilt of different vegetation types and environments. There are some photos in here as well. This report was the "before picture" from the scientific point of view.

John Ivarluk: Are there pictures of caribou from then to now? Do you see a difference in their fur coat from then to now?

Natasha Thorpe: I am not the right person to ask because I haven't seen the pictures myself and compared them but Dianne - she is the onsite wildlife person - she might be able to answer that question. What I do know is that there has been many caribou monitoring programs both here and at Ekati and there's been a lot of research done to monitor the health of the caribou.

John Ivarluk: A long time ago, before, when we traveled by dog team before the skidoos before the miners got on the land, we used to go fur trading with caribou hide. That were really nice and beautiful and the meat was really nice and healthy looking and we got good prices. Now if we get a caribou from today, some of it is not even edible today from the mining companies, the materials that they left but promised to take out - they just leave it there and took off. The barrels, they rot and get in the water; I saw some fish floating in the lake in places from those barrels that contaminated the water. Today when I get a caribou, when I skin it, I could see some yellow spots on their joints, legs and elbows. It's inedible, might be good for dog food I don't know. There is very few caribou surviving these days. I really don't know if my great-great grandchildren will ever see any caribou.

Natasha Thorpe: I wonder whether there was something about the vegetation 20-30 years ago or what caribou ate that made them different then they are today. Does anybody remember the vegetation being different then than it is today?

George Marlowe: I go to the barren land- Artillery Lake - where I come from every summer with the family and we go on the land and I look at it every time I go with my grandkids and we sit down on the rocks or we look at the land and we see lichens what the caribou eat. I don't see anything change, nothing, I never see anything change yet. Where I come from, east side, all that area burned before and then this summer where we go for our spiritual gathering that one burned right to the lake. So I don't know what's left there, I haven't been there yet. I am going to go there and see if there's lots of lichens there. It's good land and I am going to look at it, what's left there, and if caribou comes back next year I don't know what they are going to eat but that's what we are thinking already. People say that lichen takes a long time to grow so maybe that's the reason why we don't get caribou too much in Łutsel K'e now. Since that area burned, since about 8-10 years now, we don't have caribou like before the fire in Łutsel K'e. That bay there, just full of caribou. Nobody cares to shoot them, that's too much, everybody's got meat. But now, we don't have anything like that now, nothing since that fire. You know those animals, those caribou, they are very smart.

They are not human, but they are smart. They know that in the bush there on the east side of Łutsel K'e, it's all burned. They know they got nothing to eat there so they know not to go there now. Since about 6-7 years now mostly caribou on the barren land now all winter now once they get there they are there until March, now all the boys have to go to the barren land to get caribou meet not only from Łutsel K'e but from Yellowknife too. Never used to be like that before when I was young. Now nothing so that means there is no vegetation for caribou. Maybe people say they grow slow; so we are going to find out anyway. When I get back we are going to go to Fort Reliance and see all that burned, I want to see what is left there.

Not too long ago, 3 weeks ago, I went with my friend to Nonacho Lake lodge and me and Celine we stayed there, he's got a plane so we fly half way to Stoney Rapids on the tree line. We stopped there. All burned and I look at it when we stopped, I look at the ground, there I walk up a ways. Nothing left, I don't even see one little piece of lichen there. Nothing.

We're talking about this island. I don't know why we are talking about the vegetation on this island; there is lots of vegetation on the other side, north side, east side, south side we've got lots all the way to Artillery Lake on the barren land. No fire, there's lots of stuff to eat there for the caribou. The way it looks after 2024, 2025 probably anybody comes back again. You probably see lots of grass grow, I think so, after everybody leaves you'll see some maybe different grass, but I don't know about that lichen; they say it grows slow. The bears and foxes they will be there all the time because they live there all year. If you go white fox trapping in the barren land, if you find a white fox den, boy you're lucky! You know that you are going to make money right there. It's true, that's how it goes so keep that den there, don't bother it, and it will grow again. I think the way I see fireweed there, on the boulders, on the side, something is going to grow after closure. That rock pile, somehow, just smooth it a bit for them whatever they want just to make a little trail.

Morris Marten: When I worked at MacKay Lake and I guided there for 14 seasons, the caribou usually come from the east side. And we used to have a pool to see what day the caribou come. It was usually 3rd week of July and our boss said to shoot 1 or 2. By the time we shoot them, there was no fat in them there because they were migrating and there was lots of hair on the lake and shore. They go to the south side of MacKay Lake to get their winter coat out and then they go back north and they come around this area. In the fall in mid-August, I noticed their fat was about 2 or 2 ½ inches thick. When I was out there I noticed, the kids want to shoot the bull and I said no you can't, but they said its limping maybe it is already shot. I said give me you spidy scope (binoculars) and his leg had swollen up. So I let them shoot it but I told them they had to tag it. I had no choice; I shot it and I cut the leg off and I shipped it back to the game warden for testing and the rest should be okay, nobody got sick yet.

Natasha Thorpe: I am wondering how people feel about the efforts to re-vegetate. Maybe we should talk about that a little bit, I hear some people saying that we shouldn't worry about it, that mother nature will look after itself, but others say that there are certain plants like lichen that caribou really prefer. Maybe we should be encouraging lichen. But if you were to give some recommendations to Diavik, what would you say about re-vegetating as they plan for closure? Would it be okay if we did a circle to answer that question?

Louie Zoe: Yes in a while we can give recommendations to Diavik. I would like to touch on the forest fire. There's an area near Whati, Gameti, there was a forest fire this summer and back in the 1970s there was a forest fire near our community. As we live on an island in Gameti the caribou used to migrate near our community. Since there was the forest fire they stopped coming. So as for lichen and the caribou food, it is very scarce; the caribou, the lichen it's all been burned. And with the burn there was lots of wildlife that burned. Also the woodland caribou, moose, the population increase with the wildlife and the food burned, while nature re-vegetates the food source I am worried about all the burn from the forest fire, the food for the animals was all burned and while it will re-grow, I don't think it will re-grow fast.

Diavik on this east island when the caribou migrates on to the island, this is their main passing point but since the mine situation is there, at the time where the caribou migrates across the way to BHP site at the Misery[Pit] when the caribou migrate into this area, and also within the same property, also near the Misery [Pit] the eskers exist and we visited that site and on that esker the caribou migrate so if they have an open pit mine and build a dyke and we've been to that meeting before I would just like to share that much with you for now.

So they are doing research on vegetation and all the North Country rock pile it would be good to see the open pit and also the water plant to see how it takes place.

Wayne Langenhan: I don't think from what I've heard from people I talked to here that vegetation is a real big concern. I think more of a concern are the hazards that might kill or maim a caribou, instead - the slopes, or some of the holes on the side of the big rock pile. That might be worth spending more time on I think. Vegetation, I myself believe - as well as others - that the vegetation will come back in with the birds, the animals, move it around. Eventually it will come back even if it takes 30-40 years, so maybe concentrate on the hazards to caribou instead.

Natasha Thorpe: I think one of the questions that the vegetation crew and Diavik is interested in is whether vegetation can be used to keep caribou safe. Can we plant certain things in certain places to direct the caribou away from an area or to attract them towards an area? Is that worthwhile?

Wayne Langenhan: What we are talking about here is actually a small island out in the barren land. There are hundreds of them, thousands of them, and I am pretty sure that eventually everything will fill in and take care of itself without too much vegetation being put in and the caribou won't come around where they don't like, and if there is no food around they will probably change their migration pattern by maybe a mile or two. It depends on what vegetation that they are following, which migration route and that when there is enough vegetation for them to get back to that migration route, they will again follow it if there is enough food for them. So I don't think it's that big of a deal. I don't see why we have to plant willows and such. It is a small island and thousands and thousands of square miles and eventually it will return to better than anything [people] can make.

George Marlowe: We are talking about vegetation and the caribou too. If they don't have any vegetation, they won't come around. They are really smart. We will see this year because every fall Bathurst herds they cross by Fort Reliance they cross from McLeod Bay towards the east and later we've got a bunch coming from Artillery Lake and then they all go to the same place, they move in together. And most of them they hang around Fort Reliance because it's about 30-50 miles square that's not burned. Now that area is all burned this summer from McLeod Bay to all the green we had it's all burned so we will see what happens this year. No fire from the tree line up so the caribou will probably stay there now. We are going to have ideas where they are. But I said again people say lichen burned it don't grow back again I will find out, there is a big trail people go on, if that area is burned and that lichen is burned that means there will be no caribou. We might see tracks but I don't think they will stay there.

It's a working area here, things don't grow in working areas. Maybe it's not going to grow. It seems like it's not changed but maybe no rain, it's really dry. It's pretty hard but we have to put something together.

Wayne Langenhan: You know we've discussed this a number of times the re-vegetation of this island and I mean we can kick this ball around any number of times but eventually we need to make a decision. I think this is why everybody should look into themselves.

Natasha Thorpe: We have the suggestion here to essentially take a vote on whether there should be active planting of the site in closure. Before we take that vote, there are two things I want to point out. One, there are some opportunities for community members to have seed development programs. For example, in Inuvik some of the aboriginal communities have a business where they're collecting native seed for grass and they are selling it back to Diavik and other companies. That's where the grass seed came from that you saw out there. Diavik very much wants to support aboriginal business development. This is an area where I think they were hoping there might be some interest. However if what we are hearing is that it doesn't make sense to plant anything that's one issue. But does it make sense to help Mother Nature along?

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Ed Jones: I think it would be better spent on what Wayne suggested: the sharp angular boulders. This is not about supporting a business selling seeds, this is about letting nature do what it needs to do.

Natasha Thorpe: I hear you loudly and you don't want to kick the ball around and I want to be respectful of your time, but I also want to be respectful to all. Do you want to take a vote?

George Marlowe: I like let Mother Nature heal itself. It don't matter who wants to put some seeds in it, it will not grow the same as Mother Nature does so for me healing itself is good.

Natasha Thorpe: One thing that can be done is to make the land rough instead of perfectly smooth and when I was looking through all of these traditional knowledge reports there was several times where elders said if there is a little pocket in the ground, that's where a little seed will start. So can we help Mother Nature make rough land, can we build areas so that there's more moisture like you were saying watching fireweed grow. Is that where we should be focusing our recommendations to Diavik?

George Marlowe: We could help the students to do those things. Rough land? Smooth land? We cannot tell you right now, we want to wait and see what the studies say as well.

Natasha Thorpe: Question "Should we tell Diavik not to plant lichen, grass, shrubs?" Yes for everyone? [Nods]

John Ivarluk: There's no way we could help Mother Nature because I have seen it down at the ocean, the caribou don't know if it's safe when the ice is freezing. Caribou go over that's how the caribou get stuck on the ice. They don't know the ice is very dangerous to cross over and you see lots of dead caribou on the ocean. So what can we do with nature? We can't help nature.

Mark Taletok: In some summers, the grass grows, the vegetation grow, and some places there are plenty of blueberries, cloudberries, crowberries. Every summer is not the same. Some summers are really good. Where I used to do my hunting, one summer nothing grow but it is healthy so in one summer when there was lots of forest fire and not much mosquitoes so it was so hot one summer there was hardly any mosquitoes but is was not very healthy for the caribou, and we could hardly see because the smoke was so thick that one summer we could hardly see. I hate to seethe animals suffering from that; I watched a caribou one summer fall over and die it was so hot because I have seen that happen once. I thought it was going to happen again but right now it is okay because of the rain so I think we should let Mother Nature take care of itself. Same for the foxes; some winters there are lots some there are not. My uncle was telling me that if there are too many lemmings they become rabid. If they want to come our way they come our way, we can't stop that.

Natasha Thorpe: I want to remind you that in past sessions you have recommended to Diavik to return the land to what it was before as much as possible. So that is one reason that Diavik is exploring different ways to replant. So when you tell them don't bother to replant I am not sure if that's saying something different than leaving the land as you found it.

The women will be back in about 5 minutes. Is there a volunteer to be the one to share what we discussed?

Ed Jones: I think that you should give them the bad news: that the men outnumber the women.

Natasha Thorpe: You can volunteer or I can "voluntold" someone.

Mike Francis: Renewable people 40 years ago put contaminants on the water and on the land and today because these contaminants two years ago I harvested a caribou on Gordon Lake and the heart was sticking to the ribs so I have taken a small piece of the meat and gave it to the renewable resource people and today there was no reports to the meat so some of the caribou are sick.

Natasha Thorpe: We took a vote on that first question but based on your expertise - you know about how water affects plants, you know about how the slope affects plants, you know about whether a hill is facing the south or the north whether there will be different vegetation - are there ways that we could help Mother Nature heal itself a little faster or a little better?

Ed Jones: I believe that nature knows more than we do, let nature take its course.

George Marlowe: I agree with Ed.

Wayne Langenhan: I think the way we could help nature to heal itself is to somehow when these mines come into production somehow make a smaller foot print on the land and maybe have a lot better planning on how the mines are going to be operated and the rock being moved around.

Morris Marten: I believe in nature because when we were out on Mackay Lake there was rain and lightning and there were about 30 caribous and in the morning there were 30 caribou cooked. I think the reason lightening struck them was because the hooves touch each other, that's what makes the noise.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Natasha Thorpe: There is a request for the interpreters to provide some of their input.

Henry Ohokannoak: Let Mother Nature take its course.

Peter Huskey: I think it would be a good opportunity for the University students to do their studies at the same time. Let them speak with the elders and have the two ideas - the traditional way and the scientific way so they have a better idea in the future what they are doing today is going to help for the future generations.

Natasha Thorpe: Are there any volunteers to present to the women when we come back please?

John Ivarluk: I would like to see a trip to the open pit, I would like to see the decline in the pit and how deep and how wide.

Natasha Thorpe: You would like to go into the pits.

John Ivarluk: Yes thank you.

Natasha Thorpe: Somebody said earlier that we could let the University students do their work and see what's growing and how there are ways to help Mother Nature heal itself and that's coming from the scientific way of knowing. Like Peter said, there is also the traditional knowledge way of knowing. Are there examples that you've seen - maybe out at a campsite or where the dogs were tied up for a couple of years - are there examples where you've see plants growing really well and why? Are there some of those lessons that we might apply from traditional knowledge?

We need to decide as a group if we are going out or staying in this afternoon.

George Marlowe: For the visitation we should look along the airstrip and walk along towards the lake.

John Ivarluk: The shoreline on the mine site is no different than the main camp, it's all rocky this place. I believe it the shoreline depends on how much snow we have in the winter and how much rain we have in the summer.

Ed Jones: I am trying to think of practical ways to do things and I believe we have already taken a vote on whether to re-vegetate or let nature take its course, we have decided that so where do we go from here. You're the facilitator, maybe you could make a suggestion.

Wayne Langenhan: As Ed said, we're not going to re-vegetate supposedly but I think that we should take a trip to the pits because there are people here who have not been to the pits to see them; pictures don't mean much, you have to see them. I think we need to look at that rock pile and see how to improve that for caribou and what hazards are there for when they close it up.

Natasha Thorpe: Test pile or the other one?

Wayne Langenhan: Other one.

Morris Marten: We should go check if there is any bear tracks, poop, and any other tracks, at the airstrip.

Mark Taletok: I want to go to the airstrip. Maybe there will be animals or tracks. It's very obvious that the caribou will come around, I am sure we will see some tracks. Because the island is surrounded by water it is cooler so they will come here. Even seeing the caribou tracks, it's always exciting.

Mike Francis: I think it's a good idea to check the airstrip for animals and tracks.

Louie Zoe: The re-vegetation it grows on itself and also it grows by nature and also visitation of the airstrip and once we take a look we can talk about these things. And also the rock pile, we've never discussed this and also take a trip to the open pits as some of us want to fill these with the rockpile. Maybe we should come to a conclusion and talk about these open pits also.

Joe Champlain: When we take a look at these areas, it's good to see them; although we see the photos we don't how big it is, and I've never seen these areas so I think it is good.

WOMEN'S GROUP

Celine Marlowe: *Asks about why we weren't using vegetables to create compost on site.*

Colleen English: If it were to get set up it would have to be in a contained building and then the other thing I talked about with Joanne was we would also have to think about temperature so it couldn't be outside because we actually wouldn't get enough good temperatures to actually start to turn that into any kind of viable soil in the timelines that we were looking at. So it would have to be something that was indoors, in an actively set up engineered compost. It is not set up on site now, it would have to be something that we could look at doing in the future if there was a need, or if we thought that we would be able to create it in the right time lines that we would need.

Dianne Dul: So that idea was about setting up compost on site I am just going to go around and record people's ideas here and that was by Celine.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Joanne Barnaby: That's a really obvious question to ask.

Celine Marlowe: All that food is going to waste and then everybody is complaining about how to do the vegetation, why can't they just have that? You're here to mine the rocks not the animals, so just let the animals be. You know they're not bothering.

Joanne Barnaby: I guess the worry was if there was compost outside that it would attract bears, foxes and other animals.

Celine Marlowe: This is an island maybe there is another island there that it could be put on.

Joanne Barnaby: It might be something that could be considered by Diavik in a modified way.

Celine Marlowe: I'm not going to say where what I was is this person kept putting in a container, like every day in the evening someone goes and puts it in there. We are an island with seagulls and animals get at it and whatever is there is there.

Joy Dragon: I have a question for the university students: How long does it take lichen to grow?

Student: 1-2mm or up to maybe 6mm a year depending on species but some of the rock lichen will take way longer than that, they won't even grow 1mm in a year.

Joy Dragon: That was my understanding. It takes a really long time to grow.

Mary Rose Sundberg: And then when you look at the forest when it's burned a couple of years ago the one side of McLeod Bay the whole land was burned and two years ago I went by there, because the second year I didn't go back, the next following year I went back and it was nice and green, it was all burnt and then it was nice and green again. So it just grew by itself again.

Student: What were the species in that burnt area, were they the same species or is it more things like fireweed?

Joanne Barnaby: Did you notice?

Celine Marlowe: I never went up there to check but I went there with my mom, I said I never knew there were raspberries up here and now they are growing here. There was some there - I know there was - but I didn't know there was some growing there. All up in the bushes in the burnt area. I kept saying there is more here, there is more here. So it's interesting going to see where it was burnt and the next time it was green. This time I am going to go and see what all is there. Is it only grass I never really looked before. So it is interesting.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Student: Do you ladies know what caribou mainly eat other than just lichen, are there other species that they eat and are they attracted by certain species?

Unknown: You know those small little purple plants, they grow faster than other flowers at home. One lady was saying they eat the small little flowers first those smallest tiny pieces first. The squirrel eats the green leaves. Just tiny little plants, maybe the size of your hand the purple flowers.

Unknown: Moss campion.

Unknown: The squirrels eat the leaves; you could even eat the purple flower a tiny little flower. I know they eat willows.

Dianne Dul: So what is the ladies' take on the re-vegetation? I know the men seem to think that if you leave it to nature and let it re-vegetate on its own, it is fine. Are there areas at the mine site that you feel that the effort should go into re-vegetating and in those areas what would you want to see re-vegetated? That's maybe what we should try and focus our discussion on.

Mary Rose Sundberg: Have they thought about not doing anything at all? Have they thought about trying to discourage animals going on the land to eat? I was just thinking because of our experience with Giant Mine they really contaminated that place and at one time I think they did a berry study in a 10 mile radius of Giant Mine and they found that there were some contamination in the berries but that was back in the 1980's when they did that test. Whether things have gotten better today because I don't think another test was done. But I wouldn't want any of my grandchildren or future grandchildren to ever pick berries on Giant Mine Site. Whether they clean it up to industrial or residential standards I would really discourage any of our people to pick anything in that area because it's already dead. They killed that land in that area, even though they are trying to clean it up, reclaim like what is happening here, we could never use it again. Maybe they can convince other people to try to put something there that the city is thinking of stuff to do. They are crazy to think like that, to encourage anyone to go there unless they want to die in a few years. That's what might happen. But with this place I don't know if you guys have thought about not doing nothing at all? The testing that you are doing is very important; it's good to get that information but at the end what if we just say we don't want no animals to come around here? Let's try not to re-vegetate and if it's going to happen naturally, let it happen naturally. I was just thinking about that this morning in the discussion that if we are trying to keep the animals safe as well we shouldn't vegetate, because if we put vegetation places where they may get hurt getting up there or going in that area or even we don't know how toxic these plants will be as well then we might end up saying it's too toxic we can't allow any animals to eat it even if they are eating it what's happening with those animals.

I'm also worried about these slopes that are being created. It looks so easy that an animal go denning in there. If they put dens in those pile or that waste pile, what would happen to that animal? From our experience even a dog team came close to and fell into a tailings pond. By the time they were up on the hill, by the time they got down to the lake to go across to N'dilo those dogs were already losing their hair. The hair was coming out to a point where eventually all those dogs died, all their hair came out and they died because they fell into that tailings pond. It's a good thing that guy didn't fall in, it was just his dogs. He just let the dog team go and they got out themselves and he walked on the land. That's what happened and I am thinking the grouse and the foxes and mice maybe you know that's out here and they make their home in there what's that going to do to the animal? So I am just thinking in those terms whether we should try to discourage animals from going in there. I wouldn't pick berries from around there even though they may taste good.

Joanne Barnaby: So if the plants are taking up toxins; that's really important.

Mary Rose Sundberg: So if they do find anything in those plants or flowers or grass or moss they aren't going to plant them right? They are not going to try to put them around?

Colleen English: A couple of things that I think you touched on that I'd like to respond to because you've raised some really good points and questions. One is that in relation to would we not re-vegetate if you guys suggested that, like if you came back and said look we'd rather just wait and see what happens naturally and we don't want you to encourage any growth of anything. Just like everything else that we've talked about, like every other piece of the mine that we've talked about, we have an approved closure plan and that involves re-vegetating so if we heard that very clearly from communities we would have to take it back to the Board. We have to take everything back to the Board, so the land and water board that oversees that piece of the closure plan we would always have to take those comments back and say this is what we've heard from the communities so we would like to change the plan. If it was bought into by all the communities then we would like to change the plan and that would have to get approved through land and water board. So we don't necessarily have complete control over that so we can propose to them based on what we heard - they are always very keen to hear that feedback piece from the communities and use that in their decisions - but it would ultimately be a decision that came down from the board as to whether or not we could change that aspect of our closure plan. So that's always something to keep in the back of our minds for the mine site.

So looking at the plants themselves, I think there is a couple of things we've done lichen studies as well where we have tested the metals in the lichen and the soils right on site as well as up to 40 km/25miles away and we've done about 50 different testing sites; 20 close to the mine, 20 farther away and 4 or 5 other ones that were identified by elders in between there, and those were all based on being key areas that caribou use. One of the things that we found from that study, from an elders perspective, they did find that the dust levels were higher and visible close to the mine site but that as soon as they got away from the mine site that the lichen looked good, the vegetation looked good, they didn't see that concern that they did close to the mine site.

They noticed a lot of the forage (the berries caribou eat and such) was still occurring in those far field sites, with less use closer to the mine site.

At the same time we did the scientific portion of that study looking at what are the metals levels in the lichen and in the soil because animals can ingest the soil when they are eating the plants so all of those levels were then put through what we call a risk assessment, which is when you say how long are caribou spending in the area, how much are they eating. And we went super conservative on the risk assessment so we said caribou stay here 100% of the time they eat all of their food here because we didn't know; there is no hard and fast answer about how much time they spend or how long they might be here or how much they eat. Having done all of that, there was 1 metal –aluminum, which is found naturally at quite high levels all throughout here - that came back as a higher level, but generally everything else was below risk so there was no risk in terms of caribou eating that metal like the metals in the lichen and the soil. Aluminum is something you'd find that all throughout the north, it's not about mining and we don't have any aluminum in our processes, it's commonly part of the environment at high levels.

Mary Rose Sundberg: Have you tested the natural growth around the site and how did that come out?

Colleen English: I think it was something like 14 out of 20 elements that were analyzed were below even detection limit. Don't quote me on this yet I have to check the report for exact numbers.

Joanne Barnaby: On the basic question of whether there should be a lot of effort put into re-vegetation is everybody in agreement that, that is not the priority that the natural process will take care of that. Are people comfortable with that?

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Colleen English: One of the things that I saw yesterday that I was curious about from your perspective is that you know when we went to the test pile that you guys walked up (the smooth one), it's got till and it's got rock on top and it's been about 8 years that pile has been sitting there covered. And you know when we went there was some sporadic fireweed, there's a couple of other little plants and then you go to the veg plots and you've got 10 years of growth on those veg plots that looks very different from that. That's where in my mind I am kind of asking so how much do you want to help, you know, is it enough when you look at that (test pile) and say that's 8 year of natural compared to (veg plots) that's 10 years of assisted. Is there a place in your mind that's either a happy medium, or is it that certain areas might need that help because maybe you want to see it be a bit more lush?

U of A: Our research isn't necessarily to develop the communities that are traditionally here but to kick-start that re-vegetation and provide some of the nutrients that the material needs and then those native species - those shrubs, lichens and the mosses - can come in naturally more easily on their own.

Lunch 12:10-1:10

Natasha Thorpe: I hear the session went well with the women as did the session with the men.

Men's two key questions

→Does it make sense to re-plant?

→Are there ways to help Mother Nature heal itself? The group is really looking to the University Students to help with this.

Recommendations

→Do not re-vegetate

→Walk around the airstrip (especially north by the shore of the lake – look for tracks, look at veg.

→Visit pits

→Visit rock pile to see how it can be improved for caribou (to look at hazards for caribou and how to make it better)

George Marlowe: The reason why we had the rock pile, the highest rock pile, is we're going to find out exactly where the caribou come from. If they swim across you see the airstrip somewhere around there, they probably walk maybe a little bit to the highest part. They might go once we make a trail then they will use that trail for sure, the other part for vegetation so something we said too. And for the pits, some of us have never been down there.

Natasha Thorpe: I am going to let Diavik respond but one thing I failed to mention was in previous sessions the TK Panel has recommended that the land be returned to the original state as much as possible so when I suggested that if they are not going to replant anything then that seems to be a little bit of a mixed message that we are giving to Diavik.

Gord Macdonald: On going by the airstrip to the north there do you want to go right to the edge of the water or do you want to stay on the land? On our site if you get within 3 meters of the water you have to have a lifejacket on. So we can go get some lifejackets that's no problem if that's where people want to go. You want to walk along the water's edge and look at the rocks and things.

Colleen English: So if it's okay with everyone going out on the airstrip if we could do that tomorrow that would be better because we also need to do an orientation and get lifejackets and all that stuff so if that's cool we can do that tomorrow; that would be great.

Gord Macdonald: We can go to a place where we can all look into the pit but we can't go and drive down into the pit. So we can go somewhere we can stand on the dyke and you can see all the shoreline and see all the way to the bottom of the pit but we can't actually take the bus into the pit. The bus doesn't go into the pit and it's still a working pit because they are bringing ore up from the bottom so it's an active work area, you can only go in there with operations clearance, which we don't have.

Joanne Barnaby: Women's → Main concern being the healthiness of the plants, don't want to rush growth because the plants may take up the chemicals if there are any in the soil.

Mary Rose Sundberg: One of the concerns I had was to maybe discourage animals from coming to this place because if we do re-growth, eventually the animals will eat that, the little animals and the big animals will eat it, and the caribou will come to us. We need to make sure that the caribou is healthy to eat and if we start helping to re-grow earlier then when it's closed and the caribou start eating all the food around this area then what I have a concern about is that we eat the caribou, we don't know how sick that caribou might be if we eat it. So the longer it takes to re-grow, like naturally re-grow, it might be a good idea, and also a way to try to discourage animals from going there is not to plant anything. Even though it may be a caribou migration path, maybe we can try to help the caribou to come over whichever way their path goes and just keep going hopefully. If there is nothing to eat there, they won't stop there. And the other was the slope, to leave it the way it is and make it as natural as possible but the boulders I fear the caribou will step on them and break their legs.

Joanne Barnaby: One idea was to make slopes around the rock pile except where we don't want the animals to go. For example, at the slimes/PKC area, find ways to discourage caribou and other animals from going into that area. The other issue that was brought up by Celine was the idea of composting. Even though it hasn't happened yet, there might be opportunities to start composting in a contained area, recognizing we don't want to draw wildlife here but it would help produce soil for the future.

People want to see the areas that are undisturbed, the more natural areas so where we go on our field trips they'd like to see an area like that. And they are thinking of this area down here (southwest) partly because Diavik is looking at using the natural water ways that are there to encourage future run off from the PKC to help clean the water before it gets to Lac de Gras so we were interested in visiting there. There is also interest in seeing the North Inlet area and looking at the till pile and what's happening with the vegetation there; we hear that it's really growing strong there, that's because they used the material from under the lake and it's got lots of nutrients in it so they wanted to see that. And the dyke, there was interest in seeing the dyke and recognizing that there might be another built if a third pipe is mined, so they want to learn more about the dyke system and how that works.

John Ivarluk: First thing I would like to add to is about trying to keep the caribou out of this area. Does she mean that there will have to be somebody here all the time providing the caribou stay out of this mine site for 5 years or so before they start eating from here?

Mary Rose Sundberg: No that's not what I am saying. I am saying the more we don't re-vegetate the area, the caribou will come anyway. Even though we make a path for them they will go anywhere, but I am really concerned if they eat anything in this area it might be contaminated and not safe to eat. If it's their food, and if they get sick, then we might get sick; if we don't replant then we don't encourage them to come.

Joanne Barnaby: There was lots of interest in the research that the students are doing and their testing and they want to keep hearing reports back on what's happening there, what they are finding out from those test plots.

Natasha Thorpe: I am hoping that we can make sure that we document our recommendations to U of A about what they should or could be doing. I use that example that George mentioned taking some mats from the tundra to see how they perform.

Mary Rose Sundberg: You guys have been having these session for many years and I think it's a good idea to try and get everyone's perspective, especially the women. I think this trip we're supposed to take a lot more women than we have here, but things happen. I would like to recommend that maybe we can have just a women's group up here and really concentrate on the plants and the berries and get that traditional knowledge from the older ladies, the elderly ladies, that are able to walk and able to travel. We need to bring these people up here, no disrespect to the elderly men, the men here. I believe in Dene law, everything is supposed to be equal. We are all equal people on this earth. Everybody has got their own role. The men have their role, they are the providers and then women have their role, they are the caretakers. I think I am an elder in training and I want to learn more from the elders.

Joanne Barnaby: Checking if we haven't missed anything from our separate sessions.

Colleen English: One of the things we missed from the women's group was they requested to see the PKC area because a lot of the men were in the PKC discussions last time but the women haven't seen it themselves. So we could tie in that southern area that the women requested and then go do an observation point to look at the PKC or we could actually see the PKC from on top of the rock pile. So if you wanted to, we could do the rock pile and the south side.

Joanne Barnaby: So does that make sense? We will do the rock pile and the PKC and then that southern area where the water drainage is and potentially where a new rock pile would be formed if there is a new pit.

Colleen English: View into the pits would be tomorrow as well with the dyke.

George Marlowe: What Mary Rose said, I like the idea of having only women coming here. The reason why I am saying, it is not all women work with caribou hide. Something that I am finding out from my wife that I never told her when we used to go hunting, when we were first married, when we collect the hide it was good. Lately every time I skin caribou I give it to her because she does a good job, takes the hair out right away. Now she looks at the hide when I am cutting caribou and this hide is not very good. I don't know why and she puts it away.

FIELD TRIP→South area, rock pile, PKC

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Joanne Barnaby: A round table to check with everyone to see if you have any thoughts on what you saw today and then spend some time talking about what we should focus on tomorrow so that you have time to think about that tonight.

Mark Taletok: Good afternoon. What I saw today is good. The rock pile was taken from the open pit, all the flowers are growing, it will be growing lots again in the future. We could see lots of flowers growing: there will be more in the future.

Mike Francis: The look around was good. I see no rabbits.

Joe Champlain: The things that we see, if there is improvement in the future when they work on this rock pile - the slope - can be much more favorable for wildlife would be good. If the slope could be like what we saw yesterday (test pile), that would be good.

Celine Marlowe: I was happy when I saw some foot prints of old caribou trails. Where we went on the high ground, I saw some old tracks there and I saw caribou droppings and I could see where it ate some of the leaf branches; there are some plants there they can eat.

George Marlowe: What I see there is really good but at the north end of the pile you have to make a slope, not really all the way, but make a caribou trail to pass up to higher and then another one at the south east end to come down, some kind of a slope for caribou. Then a second one is when I look at the waste material (PKC) there. Right at this time I don't want no animal to come down, don't make any pass for caribou to come down there. Leave it the way it is until maybe 2021. The third is maybe, where we went, the last one, you see where it's going to be a third pit in the ground. Some women pick berries, it looks really good. Something like that, they are going to have a stock pile there, though, right where we were, but I was looking at the other side at the small lake, try to keep it the way it is as much as possible for the animals to pass again.

John Ivarluk: From what I have seen up there, it looks pretty good for replanting itself, except if they could decline a little bit on the main high part, make a gradual slope on the rock pile. Otherwise everything looks pretty good the way it's been before the mine started.

Mary Rose Sundberg: What I saw up on the rock piles and the natural surroundings that we went over, especially on top of the hill, there we are talking about and thinking about the safety of animals. I am pretty worried about the animals because you see all these boulders and sharp rocks and that's not safe. Definitely something has to be done. The other things that I heard earlier when this whole process started the people wanted the landscape to go back to the way it used to be as much as possible. I think that is impossible to do, looking at what has been done but if that is one of the recommendations that is going to be done, I think we have to make it accessible for any animal to go on it. So that means we have to kind of round it off you know what I mean. Kind of make it like the landscapes that you see all around here, most of the lands around here are not just sharp it's like a slope so something similar to that has to be done. And when we were up there I don't know what the plan is but I see a lot of berms all around on the top, those berms right now as it is it's not high enough if they are trying to prevent animals to go over they can go over that berm easily. I don't know what the plan is for those berms on top it either has to be sloped off or else it has to get higher to prevent animals from going over.

The other natural areas that we went we saw a lot of berries and vegetation. Once the A21 goes ahead that means that whole area is going to look like the area up on the hill we went up on. Every time I come to the barren lands it makes me think about my grandfathers and all our past elders they used to travel on this land, they used to live up here, they used to have to come here to go hunting for their people, for the family, and working up in the tundra and the barren lands is very difficult - you have to be skilled, you've got to know what you are doing to work up here and I am thinking about all those things. They were powerful people, they were strong people to be able to work on this land and it saddens me at the same to see all that ugliness that's what it looks like the blasted rock and I am telling you like it is. I also hear all the good things that are happening to reclaim the land but I think just kind of happy that you guys have the elders involved in the TK. The land renews itself, each year it just replenishes itself naturally.

Ed Jones: I believe that once the remediation is complete there won't be any berms at the top of the piles and as for the caribou they won't be climbing any high walls they will be looking for the easy way to the top.

Wayne Langenhan: From what I heard around the table here, I don't think I have any more to add it has been covered.

Morris Marten: I see that those big rocks I was wondering about in fall time when it rains and caribou migrate and it's icy and they would just go tumbling down to the boulders, I guess they are smart enough to follow the shore line I was looking for a rabbit dropping but I haven't seen nothing and I had binoculars looking for ptarmigan and wildlife I guess they are not coming by yet.

Joanne Barnaby: Thank you, we need to begin formulating the recommendations for Diavik, they have asked us several questions that we should try and address, we've got some consensus on some of the basic issues but we need to get more detailed. We were thinking that tomorrow we might be able to spend some time talking about what to do with the roads, we understand that you don't want a lot of time and money spent on re-planting but we still need some direction on what to do with things like the roads and the airstrip and if there is any more detail on what to do with slopes on the rock piles both the existing rock piles and a possible new rock pile in the future so that wildlife are safe and the ability of nature to re-vegetate in a natural way over time perhaps is taken into account as we give that advice.

So in terms of how we work tomorrow we can look at breaking into groups again if you want and spend part of the morning doing that, how do people feel about doing that again? Did that work okay today? So we can do that again tomorrow and we've still got plans for another field trip tomorrow by the sounds of it. If we end our field earlier tomorrow, I think we need to otherwise we only have one morning for recommendations, so we can start working on those recommendations after our field trip tomorrow because we haven't got a very clear set of recommendations out of the session yet. We have a good start but we need to make sure everyone is clear on what our recommendations are.

Natasha Thorpe: While you are going over your transcripts tonight I will try to make sense of the many sheets we have here [on the wall] and try to group them a little and see if they can help us with tomorrow thinking about recommendations. As you've been talking throughout the day I have been trying to write down some key points.

Done 4:10pm

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Day 4: Sunday August 17th, 2014

Joanne Barnaby: Good morning. Going over the recommendations handout.

Natasha Thorpe: Panel Recommendations to Diavik

74 71from panel, 3 from EMAB

46 Supportive response

5 Out of scope

23 Not supported (5 relating to slimes)

Joanne Barnaby: We wanted to bring this out because some of the recommendations that have come out now contradict previous recommendations. So we want you to be aware of that.

Natasha Thorpe: Around the room are the key points that have come out over that last couple of days.

Ed Jones: Before we go further I want to mention one of the recommendations that we made asking Diavik to perhaps add betonite to what you call slime and that would solidify the slime. Diavik states it would be too costly, but Wayne and I have discussed this and we were thinking they don't have to solidify the whole thing, they could solidify enough on the surface to support say the wildlife to walk on. Betonite if you don't know what that is, its' a clay material that when you wet it, it expands and seals and it would be the ideal I guess you would call it chemical but it is inert and you could solidify the surface of this and you wouldn't have to do the whole thing. As I said Diavik is complaining that it is too costly but they could cut the cost by doing the surface only.

Natasha Thorpe: Power point for Recommendations-Re-vegetation, Rock Pile, Roads and Airstrip.

George Marlowe: The Diavik island when I first came here way back in the 80's it was not that rough, it was a little bit smooth to walk around, like where we walked yesterday it was like that. So if you want to put a lay down to make it rough but it wasn't rough back then so maybe we don't want to do that. It wasn't rough it was nice to walk on before and maybe we just keep it that way. When I look at it yesterday we went to the highest part and we seen some caribou tracks up high so that means animals have been there already I don't know how many but they have been there. The slope there on the north is too big but the east end where the A21 there is going to be a pit again and yet where we were yesterday there is suppose to be a rock pile there but I think in 5 years when you are taking the rock pile out I think you shouldn't put it to high, flatten it as much as possible. When I look at the land there I think that's what they should do there, that means when it's closed you won't have to do too much on it. Smoothing the rock pile I can't make suggestions myself; we've got a lot of people in our home town, chief in council, the public so that's what's my idea and when I go home we will talk about it again.

Joanne Barnaby: If they make the new rock pile shorter, the rock pile would take up more space on the ground.

Mark Taletok: My comment is when I used to live inland we used to walk to the mine it got named Lupin when they started to build the airstrip I wasn't too happy because the caribou used to rest and feed there waiting for the weather to get cool out before they started walking and it's a really high area. My wife and I we used to walk to the mine site to visit, we walked around because it was closed and there used to be caribou that was hurt, I never used to kill them even though they were hurt because it was too close to the mine. I really pity the caribou because they get broken legs; it's been a long time now. They built the airstrip too high, the caribou used to rest and eat around that area and when Lupin started building the airstrip I used to think and I didn't like it. We used to have meetings before. We used to catch fish and we used to go fish in that area and we hardly go fish again because there were lots of white people and we were scared by them. The fish is migrating in the water they go by the shore in the fall. We used to use bow and arrow to hunt caribou there. And when they started making a road there we were not happy because that was where the caribou used to swim across there and a trail there for caribou to migrate. I learned there with bow and arrow to hunt. And sometime we used to see caribou in the evening when we had meetings we would go by that lake and they were deciding which places they were going to build the road.

Natasha Thorpe: Thank you Mark.

Joanne Barnaby: The concern yesterday was if we re-vegetate we encourage animals to come here and they might get poisoned by the plants then the people who eat them may as well. If we let the re-vegetation happen naturally it would take longer and hopefully by then it would be healthy.

Ed Jones: I don't care for the term 'encourage'; we don't have to encourage anything, it will happen naturally. And as for re-vegetation or anything like that, the animals are not going to eat anything that is poisonous or hazardous to their health so I don't think you need to worry about wildlife; they know what is safe to eat and what isn't.

Mary Rose Sundberg: I still have concerns regarding that but what I want to hear is the opinion of Diavik and the students here whether they think that either way, either to re-vegetate will be healthy or are they thinking about our opinions about letting is grow naturally or help it to grow or if we do help it to grow how healthy are these vegetation going to be so I would like to hear what Diavik would say and also the students that are helping.

Colleen English: Good question Mary Rose. Diavik does not have final say, we report to a Board and our water license is tied to our closure plan. Anything we do related to closure has to go through approvals under the land and water board that oversees Diavik's water license. So if we heard back very strongly from you, and if that was supported at the community level - like through your bands and organizations - that you didn't want Diavik to re-vegetate, then we would have to put that through the land and water board for approval under the current closure plan. I would say that it's unlikely that they would approve 100% no effort on re-vegetating around the mine site. I would think they would want to see some efforts made by the company and I would think that Diavik would probably want to do some initial assistance in terms of trying to re-vegetate a little bit. But you know it's easier for them to try to find a happy middle ground if we have that feedback from you and the communities, and what the current plans are.

The other thing we talked a little about in the break out session was the biggest concern about toxicity or chemicals in the plants relates back to what we use as the soil. We have committed to testing the processed Kimberlite, and the plants that are growing from the processed Kimberlite, and we want to know if there is chemicals that are obviously going to come into the plants through that. We need to know that because if it's not a good material to be using to grow plants or to have even just available for wildlife that are maybe just walking through, then we want to make sure that type of material is contained. So the plants aren't the problem, it's what they are growing in and what might cause the problem in the plant. So we want to make sure we are using the right materials to grow those plants.

Valerie (U of A): So for the research project, the focus is on understanding if the substrate materials we are using are safe for the plants, so one of our plots is being used to test if metals are being brought up into the plants and this research project is to provide some insight into how to help assist re-vegetation and then allow natural recovery to play a role as well.

Joanne Barnaby: Colleen could you comment on the question right now within Diavik on whether you want re-vegetation around the PKC and what your reasoning is for your position on that?

Colleen English: Some of that information on the side where we say we've got 74 recommendations and about 23 are not supported, a lot of those not supported ones came from the last session during the PKC, and a lot of it was related to the slime removal and the re-vegetation efforts within the PKC. Now there seemed to be differing opinions after the last session, but Diavik's view is certainly that we do not want to re-vegetate within the PKC; our preference is to contain that PK material under rock layers and have a small pond in the middle for the water to be able to get out. And the bulk of the reasoning for that is you saw the area yesterday and you saw how big that area is and the materials in there are very light - you felt them out at the re-vegetation plots - they can easily move by wind. So our preference is to contain that material so that it's not blown by the wind and disbursed around the mine site or elsewhere and to not focus on re-vegetation within that area.

Louie Zoe: As we are talking about the re-vegetation even out of the North Country rock just for instances our tour yesterday you saw the wildlife, there is growth on the land the food is easily accessible even the North Country rock pile. When the wind blows and the dust blows in all these crevasses and that's what goes into those crevasses maybe there will be growth. On our tour there is lots of food for the wildlife but if we improve our re-vegetation but if there is going to be A21 then there we will have to spread out evenly so that it's not too high.

Mary Rose Sundberg: Thank you what Louie said is correct it would be good to talk about these things in that manner but as for us living in Yellowknife, those who was involved in these meetings are not here with us so some of the things that we are talking about we're not very aware of so we're questioning these recommendations. It is very difficult as leaders to make a decision; there are still chief and councilors, we have to question them, and also from our communities we have an elder senate that represent these issue and topics we are talking about so we have to approach and question our elders senate. They are the keepers of our knowledge and they are our elders; we still have a lot of elders, it would be good to question our elders in our community. It would be good if we don't make a decision at this time but I thinking if we ask our elders that's what I think about, that I am just gathering information at this session. And I just want to share that with you. We have our elders at home and we should bring this question home to them within our communities and maybe Diavik can arrange that for us. At times they would have a community meeting and they talk with the elders and these things are taking place; the recommendations are put in place so they should be shared with the elders and I'd like to put it as a recommendation.

Joanne Barnaby: Its interesting because there are mixed feelings about re-vegetation and maybe we need more information from the elders back at home so maybe we can resolve the mixed messages the mixed feeling about going one way or the other with re-vegetation. There may be opportunities to have that discussion at the local level with some support from Diavik for encouraging that particular discussion on a broader basis.

Colleen English: We do meet with the communities but how we meet with them depends on what the community wants.

Natasha Thorpe: The photo I put up is where the testing is going on for what can grow in it and also if chemicals end up in the plants.

Morris Marten: What Louie had mention he is correct in saying wildlife food is out on the land in nature and when they blast and then move the rock then the dust goes in the wind, and when it rains it will seep into the ground and probably go into the water.

Joanne Barnaby: Discussion on Roads – picture of different options.

Colleen English: Mine site roads have big berms and they are like that because of the big trucks; regulations say that the roads have to be that big and the berms have to be that high.

At closure that can change. Slide shows three options: 1) high berms stay and the road is dug out in the middle, 2) create a dome shape by rounding the roads upwards, or 3) push out the road and berms to create a nice slope with a flat top. More of the tundra would get covered with the last option because of pushing out the material so that it's not so high.

The other thing that we can think about and discuss that Natasha highlighted as one piece of the recommendations that you've had in the past is whether or not to scarify, or rough up the surface of the roads, so that it makes it easier for plants or seeds to try to get in there and establish themselves.

Natasha Thorpe: In the past you have said not to rough up the roads, not to put vegetation on top of the roads, but to put vegetation on the side to help with filtrating water and stability.

Mark Taletok: If this is going to be the case my recommendation would be the last one (3). I don't like the idea of the first one (1) but that last two (2 and 3) I don't have any problems with as long as it's not a steep slope. It's too steep the first option (1). I know the vegetation will grow in time in the last two options (2 and 3). I still remember the old roads the grass is growing on the roads.

Joanne Barnaby: Any other questions or comments or other ideas.

George Marlowe: For the road now today the mine site at the highest part up the gravel pit you have to have the berm for safety. Without safety, workers could get hurt. On a mine site you have to have a berm for safety. I seen one accident and that was enough for me, I was close to the airport and they didn't put a berm on it and a driver didn't want to hit a caribou and went off the road and tipped over but landed on a soft fox den, it was lucky for him.

Natasha Thorpe: George what about closure when this place is no longer a worksite?

George Marlowe: For closure for me the bottom idea (3), the last idea a little bit flat and not steep, that's the one we chose for the same meeting with Ekati. That roughing up is too rough even for caribou and for people to even walk.

Joanne Barnaby: Is there any place after closure you would want to see berms.

Wayne Langenhan: I can't remember if there was a big culvert we saw whether it was at this mine or at another mine but there should be something for that if there are big culverts going underneath, I guess it was the other mine. I don't see the point of having berms once closed; I also don't see the point in scarifying because the wind and rain will take care of that.

Joanne Barnaby: Okay any other questions or comments?

Colleen English: If we head out this afternoon, a lot of you have said 'gradual, gradual, gradual' if you can look around when we are driving around and show me an example of what you think is 'gradual' and what would be a good slope for the sides of the roads? That would be really great if you could point that out as we are driving around.

Wayne Langenhan: On that small pile that we walked up, the test pile I think the angle on that would be sufficient.

Ed Jones: Joanne I think we're discussing a lot of things that nature will look after, just leave it and everything will be fine.

Joanne Barnaby: But Ed a lot of people are saying that they don't want to leave the roads high, they want them brought down and they want them sloped.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Ed Jones: Well I believe the weather will bring that down, flatten it or whatever, like I said nature will solve a lot of these problems, we are getting involved in something that nature will naturally look after, that's what I am trying to get across, over time look at the end of the remediation that's after closure and remediation is completed and years down the road you come back, you'll see a totally different picture and you'll say to yourself gee we worried about all these things and look at it now nature fixed it all remember in life everything will balance itself you should know that if you had some religious training.

Joanne Barnaby: Clearly there are different views on how much should be done. And in my own experience I lived around the Pine Point area where very little was done and they walked away and that's 30-40 years now and there is very little vegetation and very little wildlife returned to the area and it's still a waste land so my personal experience is you'd better do certain things to clean up the mess you made and the changes you've made to the land, you better do certain things to help nature recover. So that's my own personal experience.

Mary Rose Sundberg: A couple things I want to say the three choices we see on the board and I agree with the third choice (3) I think it makes more sense and is easier for animals and it won't be too high. And what we are trying to do here I understand what is being said here and I agree and I disagree all at the same time, for two reason, we need to help nature I guess to re-grow and I understand things do happen naturally time will take care of itself yes but what happened on this land is not a natural, man has made this big mess I'm sure they are happy with all the money but it's not a natural thing that happened here so we can't leave it to nature this company has to make sure like some people said to try to go back as natural as possible but that would never happen. I too live next door to 2, 3 mines in Yellowknife and they are doing reclamation right now. The government is saying, the city is saying oh eventually people can live here once we reclaim the land. I say I do not want my grandchildren; future generation to live on that arsenic there is no way they are going to get my people to live on that arsenic. Maybe some other people unknown to the land and once they start seeing grass and trees growing they are going to say wow cheap land maybe I'll buy this and build a house here. Let them do it I am going to keep this information to my grandchildren to my next generation to tell them to never to use that land again because that land is dead it's going to be a similar thing here that is why I have a concern about re-vegetating but I don't want to disrespect previous decisions that were made and I have respect for those elders and people that came here for this meeting they must have a good reason why they recommended those things. That's why I am saying the elder's senate. Yes I see the recommendation here where that information had to go back to the community and this is relayed to the people but if you don't take something like this and guide it right through, take this and go to the community and go to the elders senate, it won't happen. I live there, I sit on council. So we've got to make sure that this is guided right to the grassroots of the people and get their own opinion when you come to our community on a yearly basis. You've got to make sure this happens because sometimes it's easy to come to these meetings and then go home and we don't go back and present to the chief and council. Or we don't say these are all the important things that were said here. I want your opinion that's part of our job I will do that as well.

Joanne Barnaby: Thanks Mary Rose, Wayne.

Wayne Langenhan: I don't know how familiar the people are in here with the different mines but I know that when you are mining for a base metal such as copper, gold, iron, or silver whatever you are dealing with a lot of chemicals that are never ever used in a diamond mine. There are not big tailings ponds like around on these other mines you know such as Lupin or Giant Mine, Con Mine that were gold mines. Diamond mines you don't see that. The biggest diamond mine in the world is not as filthy as the smallest base metal mine in the world because of the toxins and chemicals that are used to process these ores to get the metals out of the rocks and such. Here is just a matter of crushing and picking. We have a by-product of kimberlite which is I don't think very toxic and so we are looking at a totally different picture here as to any of the mines like lead, zinc mines or silver like I said copper, gold whatever. So diamond mining is very, very clean mine operation, you don't have to worry about all these toxic chemicals flowing into the water system. There are a few that they use, mostly likely but they are in such a small quantity compared with the other mines that I don't think there is a big worry here about it. Mark he's been over to Lupin Mine with big tailings pond, Giant Mine, Ptarmigan Mine and Con mine all have big tailings pond's that are like Mary Rose said I would never build a house on those things I wouldn't care if they gave me the land it's just too much stuff in there but here this area is a whole different ball game.

Ed Jones: I don't think I should say anymore listening to the different opinions. I should keep my mouth shut, let me finish, I think it's well put by Mary Rose. I agree to disagree.

Sarah: What is an acceptable time scale by the elders if you want to do natural re-vegetation? How long is acceptable for natural re-growth to get to a point where you are comfortable?

Joe Champlain: During our discussions we are listening to and thinking about the wildlife when the wildlife eats its food, the wildlife will smell its food before it consumes it. Maybe three or four years just because they use haul trucks and there are fumes from the haul trucks.

Joanne Barnaby: Any other comments on how long people think for natural vegetation to come back or what we can expect there? I think people have a hard time with what's acceptable because whatever is natural is acceptable. The students are saying it's not natural anymore because of the mining activities so what can we hope for, what can we try and encourage so that it comes back in a good time.

Natasha Thorpe: Two comments from past reports were 100 years another was 30-40 years. Nature will take its course but so will the regulators. They will not let Diavik walk away. So you have the opportunity to help guide them in an area that is unnatural now.

Mark Taletok: My comment I wanted to say I know where we live its really nature going fast even roads and the tree's are growing around and the willows are really growing long. It's really full of willows even around our houses right in our town and just like it's really growing fast even nice flowers are growing. Sometimes we see different flowers in Kugluktuk going to Bloody Falls where we used to go fishing now it's really different because willows are growing in the trail and in the future I think it will be like Yellowknife willows. I always tell my wife that nature is growing faster than it used to be. Sometime I always think that people always lived long time ago because they always know if it was going to be windy, stormy, rainy and the people who used to live there camping and they left the camping places and now the willows are really long and I guess the nature is growing really fast even when we go by Honda, I never used to go by Honda because I just have dog team. Our water is getting low also in our river and we always see lots of rocks and we don't get much snow. And sometimes there are fountains coming out of places that there used to be no water but it used to be really cold and there was ice in between some surfaces but now it's too warm. And now you don't drink cold water anymore it's warm. The ice is melting away.

Joanne Barnaby: Clearly it is getting harder to predict with the climate change that is going on. I think everybody agrees that it's going to keep getting warm; there is probably going to be less water, lower rivers.

Break 10:10-10:30

MENS GROUP

Appendix D

Diavik Diamond Mines TK Panel – Vegetation

Natasha Thorpe: Using the map to show areas where RED- You don't want wildlife to go

GREEN-Encourage re-vegetation or re-growth

BLUE-Encourage wildlife through modifications

Unknown: That would be very hard because you can't tell the wildlife don't go here but you can go here. He's still going to go there.

Natasha Thorpe: It is true wildlife have a mind of their own and they are very smart - you've said that.. If we don't say something into a microphone it won't get recorded. Whatever you say will not inform your process.

We have one big map to mark but you also have your own maps if you would like to use those.

Natasha Thorpe: So George you are marking with a red pen. I will let you describe.

George Marlowe: Because they have waste kimberlite there, they have that cloth and the waste kimberlite on it so the water doesn't go down; they try to have the water not to go this way. That's why they have that cloth underneath. So 2021 you got 2 more years to work on it 2023 it will be shut down so me, yeah that for my waste they dump it there right now.

RED GM1

Wayne Langenhan: Okay we are going to do this in three different stages right, the red, blue and green. Okay so we are starting out here with what George said he doesn't want the wildlife to go through. This is the red zone. But that isn't really necessary, but we are starting out there with the legislators or whatever we call them here, they are bound and determined to put some grass or berries or something down here right, they want something grown here right. We were all in agreement yesterday that we'd let nature take its course so if we are going to put something down why don't we just put here and there and not all over.

Natasha Thorpe: That's fine this is your time do as you wish. So Wayne your suggestion is to mark all the red areas first. Is everybody okay with doing that?

RED W2

Wayne Langenhan: I think the pits are a little too deep for animals to crawl out so I marked around both pits and I will mark around the third pit, I think George got that third pit.

RED M3

Morris Marten: I don't want wildlife to go down there and start drinking that slosh water or whatever it is. And the bear will go there to cool off so it's better off to just barricade that place, that area.

Mark Taletok: For me the part that they marked red after myself the water is too close to there so I don't want any wildlife going into that area but it's going to be very difficult to try and protect the wildlife from going there. So maybe we put like Morris said earlier put a barricade around that area and so if I have been seeing this area whenever I come here and there is never any change in that area at all so I don't want caribou or any wolves or any other source of wildlife that goes to that area. I think it's going to be very difficult to try and prevent them from going there.

RED JI4

John Ivarluk: I believe this is one of the dangerous parts including the tank farm, the fuel is not too healthy for any wildlife. I believe there will be no planting in this part as well as in here.

Natasha Thorpe: No planting in the South East corner by the fuel tanks and also by the North West corner.

Louie Zoe: The mark that I made the PKC it probably seeps into the water and the wildlife if it's going to consume water, drink water to prevent the wildlife from getting sick so when the caribou migrate in this area it would be good if it's identified and make sure the wildlife don't come into contact with this area.

RED L5

John Ivarluk: Sewer line?

Thorpe: We can ask Diavik where the sewer out fall is but everything is treated first before it's released according to the water regulations, according to their licenses.

George Marlowe: How about a sewer line going to Lac de Gras?

RED MF6

Natasha Thorpe: Does anyone else want to mark no go areas to deflect or deter wildlife? Before we talk about some areas that we are okay with wildlife going to, such as the slope, mark areas that we would like to allow wildlife passage, or wildlife eating or wildlife moving through in a blue felt.

George Marlowe: I don't know too much about how steep the slope is here; I don't know how many feet so I can't say where the wildlife could go, what do you think? The deep slope here the wildlife cannot go on top unless they go on the road.

Natasha Thorpe: Right. So that is the way it is right now but you can give advice for closure about where they should make the slope more gradual. So if you mark on blue areas where you think it should modified, the slope, that would be helpful.

BLUE GM7

George Marlowe: You want to put another one here?

Natasha Thorpe: We don't need to put anyone's name on anything we can just highlight the areas.

BLUE GM8

Natasha Thorpe: Would you rather we not record names?.

Mark Taletok: No names.

Participant: I think we have to bear in mind at the end of mining the picture is going to look totally different and I don't know why we are drawing lines or making plans right now for the end of mining. We should be doing this in the later stage of remediation that's at the end of mining and into remediation. I think it's too early to be doing this stuff.

Natasha Thorpe: So just to remind everybody, it's not too early because they are starting next year or the year after with changes in the slope. They don't want to wait another 10 years before they do anything. They want to start as soon as possible, trying to heal the land.

Participant: The picture you are looking at is going to be totally different years down the road you're going to have a totally different picture.

Natasha Thorpe: Are there any other areas we want to make some modifications on slope?

Participant: I would like to say something before anyone puts anything else on here. At the beginning of the mine, the big shots come and visit the town letting us know that they were starting this mine and they put away so much money for the closing to clean up as much as possible after they are done. So why are we doing this for them?

Natasha Thorpe: The reason that we meet as a TK Panel, the reason that Diavik meets with communities, is to get you to document your wisdom, your expertise, your wants, your needs . . . it doesn't mean that they are going to do everything you say but if you say nothing then they will only use science, they won't use any traditional knowledge. So it's not perfect, I hear that sometimes this is frustrating, sometimes it's hard to see where all your hard work is going but I want to remind you that of

74 recommendations, 43 of those have been accepted by Diavik. So if you never said anything, you would have zero.

Participant: Yes it's never perfect, once you move a rock, it is never the same, not like the way it was before when you walked on the land. You've got no track there but when you move a rock it's not perfect anymore. Not like the nature. Yes that's what I am talking about at the beginning of the mine life, before they start, they make a statement that they will put it back as close as possible to nature the way it was when it first started. That I have been in the mine site before this it's never the same they just leave the garbage there and they take off.

Participant: In Ekati mining areas, they put metal fencing around, it's just like fish nets, it surrounding so that any caribou and any wildlife don't go into the camp so that way the caribou detour towards the east part of the mine. So that way the wildlife doesn't wander into the camp. That is working very good so when you see caribou coming around they go around the fence. So that would probably be the fastest solution for what we are talking about.

Natasha Thorpe: Thank you Mark for the good suggestions. That we wrote up last night was about the mines working together to coordinate ways of deterring caribou away.

Lunch and prayers 11-1pm

Dianne Dul: *Presentation:* Map for where all the exploration mines are, map for current mines.

Picture of the mine in 2000, pictures of the mine from 2000, 2001, 2002

Older caribou pictures 2000, 2003

New caribou pictures

Mentioned caribou behavioural monitoring that is done by Environment department with help from community members. Joy Dragon participated in this monitoring program in 2013 and Dianne asked her to explain what they did.

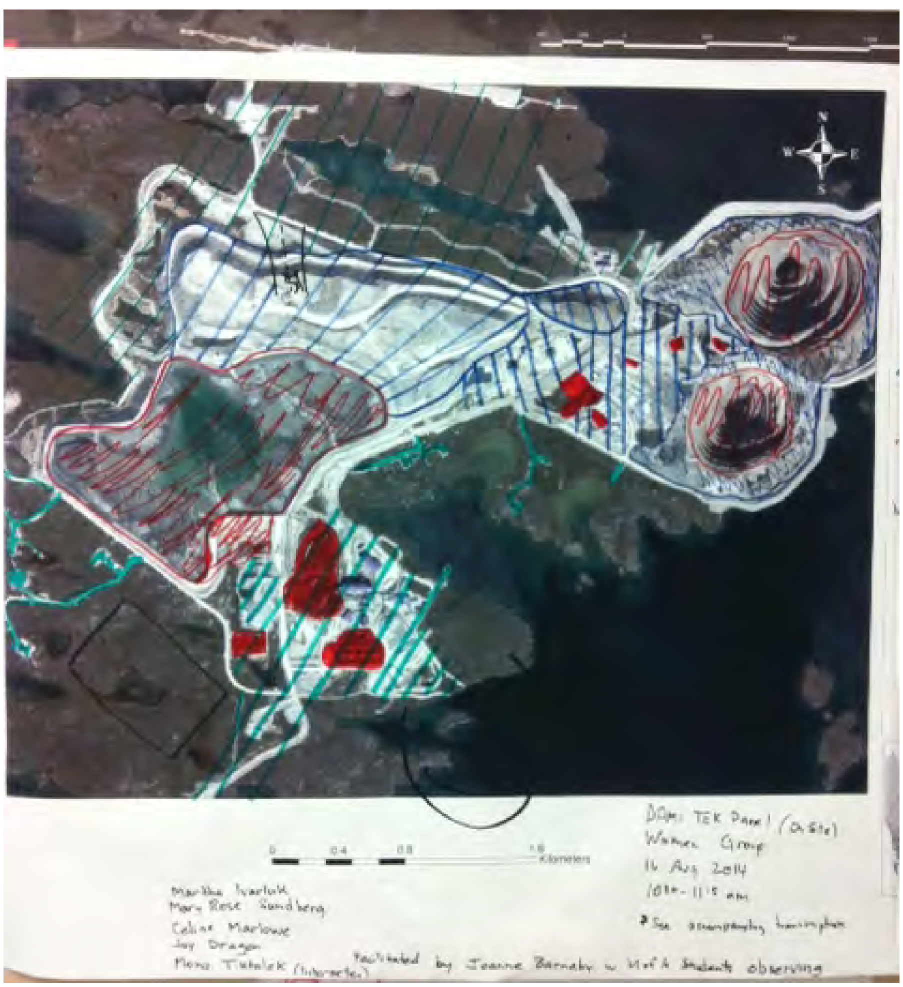
Joy Dragon: We came up here, it was a 4 day trip, and we toured around in the chopper around the site looking for caribou and monitoring the effects of the helicopter as well as the mine site area. We flew about 30 km out to the Northwest and came upon a herd of 3000-5000 caribou healthy herds. When we flew down we landed then we waited until the chopper blades stopped then we each took note of about 10 caribou and we watch them for 10-12 minutes and just observed if they resumed eating, if they laid down nothing seemed to bother them they all resumed normal activity. We reported back that the herds were healthy that the wildlife that we noticed around them there were plenty of wolves and one notable factor that I noted was that there were a lot of white wolves. And we saw some pups and some dens and then on the other day we flew to the Northeast about 60km out and again we came upon a large herd of about 3000-5000 caribou. All I reported back was that they were healthy herds with many wolf packs following them for me that's a good sign of a healthy herd with many wolves and pups and dens.

Dianne Dul: Caribou pictures

Natasha Thorpe: Thank you for the presentation Dianne.

Joanne Barnaby: Present to each other the work on the maps.

Mary Rose Sundberg: (Presentation of the women's work - the work is not transcribed but this is what came out of the work.)



Where we can do reclamation so that's the kind of things that we touched on this morning. First of all on the airstrip the green markers that we put to reclaim that area, there are no toxic's in that area the road is airstrip so we would like to re-grow the vegetation around that area. All the green markers are to encourage the re-vegetation and replant. So we would like to have things grow in that area, plants.

The blue markers maybe the animals would go through so we would like to do some modification and all the pile of rocks maybe they can kind of smooth that for to encourage animals on it. If there is a really steep pile of crushed rocks maybe they can put it down so we can encourage that animal to go through there.

And in this area the shop it seems like it's only buildings maybe they can have replants of vegetation and all the red markers and two open pits and PKC in that area we would not like the animals to go through that and there is storage of oil tanks and a waste field there, not good to go for animals and there is waste rock, maybe there is oil tank, gas tank that's been used, barrels once ice road gets here maybe they can haul that back. Where all the red markers hope the animals don't go in that area.

The North Country rock pile maybe the animals can go on top maybe where there's a den and where is the path that caribou migrate I think the elder know better and maybe we need elders help on that area. A21 once they have the open pit, we have to think about the waste rock pile they are going to have in that area we have to think about. The elders would know more where the animals come across this island. I would like to consult with the elders first.

Joanne Barnaby: Thank you very much Mary Rose.

Natasha Thorpe: Volunteers to speak. I think it is quite interesting that there are a lot of similarities in the red and blue.

George Marlowe: (Presentation of map)

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

We never did too much we just started talking, talking, we talked about the red line. I drew this red line and other people too so nobody will touch no animals will go there we wanted that and also I did the blue here at the North pile I want to put a slope down and we said that really having to flatten everything is not necessary. Don’t touch till 2021 between PKC and rock pile. And also from A21 pit there going to stock pile here that we said don’t put it to high, leave it as low as possible so the ramp from here will go up and down again not all over. It’s high so you could push it down towards the road. Red line here for that sewer they don’t want any caribou to go there. They don’t want any caribou to go to the north inlet.

Just about the same we could put it together. What shall we do?

Celine Marlowe: What you guys are saying is similar to what the ladies did. Are you going to agree to our map and your map because they are just about similar?

Wayne Langenhan: I did mention one thing about the new pit that’s going in why can’t they take some of the rock and truck it over to the other pits and build it up a bit and make it a little more shallow instead of building another rock pile?

Gord Mcdonald: Because we are still mining in those two pits. The underground continues till the very end. It’s not like the underground stops and A21 keeps going, they’ll both be mined at the same time so we can't go putting rock on the top of guys that are working underground.

George Marlowe: I think it's better to not touch those two pits because people are working in there. Keep it light as possible, don't put rocks or water in there right now. Only later on when closure but right now just keep it the way it is.

Natasha Thorpe: I want to clarify what George said we ran out of time.

Joanne Barnaby: The women did indicate which areas they wanted to encourage re-vegetation or natural re-vegetation. Do the men feel that is a problem or could you support that idea?

Wayne Langenhan: We didn't get far enough into that the re-growth putting the vegetation in but from what I can see on the women's map I could go along with that. Should we take a vote on that?

Joanne Barnaby: Wayne is suggesting we have a show of hands. I am just going to point out the areas that the women suggested for re-vegetation or encouraging natural growth.

Patches of red in the green and blue we would avoid for re-vegetation due to oils and such being stored there.

Vote on who supports the women's map? Against-1 For-12

Natasha Thorpe: No names on anything.

Ed Jones: Remind you that just because the majority says yes doesn't mean that should be the right choice.

Wayne Langenhan: I think I am going to differ with my colleague here, the majority takes it and that's that. The map here we all agreed to it so I don't know why we should have to draw anything on our maps but if Ed has a beef with it I think Ed should make his own map.

Ed Jones: I don't believe in re-vegetation and I don't believe we should deter any animals as they will go where they please.

Joanne Barnaby: I think we understand your perspective and that's fine and that can be noted.

FIELD TRIP 1:30-4:00

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Natasha Thorpe: I know everybody is pretty tired. Quick round table.

Celine Marlowe: It was really good to be out on the land again today I had a great time but it was kind of scary for me because when I was looking at that dyke because I didn't know how it was made but now that I have been on it and I am still interested in looking at the movie or if you have the copy of it I wouldn't mind to have one so I can look at it or even keep if you could so I could show it to my other grandchildren back home and tell them how interesting it is you know where his cousin is working.

George Marlowe: When I went on the field trip towards the south side of the airstrip I still see the caribou trails there and when you look at the trails and you look at the rock piles I really I mentioned that how far it is going to come down and it looks good and also I look at the land and Diavik started 10 or more years ago when I look at the berries cranberries and crow berries I was looking for how much dust was on them but I don't see any looks pretty clean and also I look at the willows and they were pretty clean. So that means and on the way there while we were walking I seen vegetation growing willows, fireweed and one part I saw blueberries leaves too came out so that means something is growing and it will grow now for sure so I am kind of happy with it the only thing we are not finished with the map, men.

John Ivarluk: Thank you for a pleasant morning and trip it reminded me of back in Lupin and safety comes first yes. It was nice pleasant out there I see they are doing really good at their job and I enjoyed it. We had a good experience and sometime I wish we had students up here see what we are doing so in the future they know what we are doing, what the miners are doing. I enjoyed the trip I will be glad when I get back home to tell the people what we did the last few days.

Martha Ivarluk: Thanks so much we went on the field trip. It really good to see the vegetation growing it will not grow if it is not good. I am so thankful I am here with the panel.

Ed Jones: I didn't go out this afternoon but I have been out to the airport and around the rock piles many times before. I am sure Diavik is going to live up the agreement of cleaning up and I can envision these rock piles being smooth at the end of mining and remediation. And I am sure they don't want to leave a mess, they've already put up a bond and I am sure they don't want to put up any more money than they already have put up as a bond so I believe they will clean it up as they should and I have no worries about that. I believe they will live up to their agreement.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Morris Marten: Since I got here I learned quite a bit, I didn't expect to see this it was very last minute when I got to come. I forgot my reading glasses so I brought my wife's. I learned quite a bit and to go out into the field now I know what you guys are talking about when you talk about the slope and when it rains you just need to watch out for a creek going down to the main lake. I hope in the future I can come back again.

Mary Rose Sundberg: You really have a different perspective once you see what we talk about a lot at meetings sometime when they have these annual meetings they have all these maps and all this stuff on the wall sometimes you can't really envision it unless you come and see it yourself. And I have been here a few times and I have been to the other place a few times and Snap Lake and I always love coming back because it really reminds me of my grandfather both of my grandfathers actually they were born in this area. My grandfather Itò Sangris was born on the north end of MacKay lake and my father was born on the south side of the MacKay lake so every time I come back here I feel like I've come home again and my husband and I also work in Gary Jaeb's camp over here for at least a couple of years so I always love coming back. Seeing everything that has to be removed or dismantled it seems like it's a huge job that still has to be done and right now I can't envision it all disappearing and they'll be nothing here. I kind of have some worries I know when you work on a big huge job like this obviously they have all the plans in place and regulations they have to follow but also we have to think about a lot of other stuff we seen whether some things can be donated to the communities those that can get to their communities somehow those things should be considered like the sleeping quarters some of them can be dismantled. When you see things first hand you get a better understanding and that's what I am thinking and what still has to be done and which area they need to work on. Some areas that they shouldn't touch at all because it doesn't look like we should do anything to it for a while. It will take awhile. Another important thing for me to do and everyone is we really need to consult back to people especially our elders I have so much more questions to ask them, maybe not in a formal meeting but if I see them I will ask them when I see them.

Mark Taletok: I myself I enjoyed the field work because it was very extraordinary to be outside because you can smell the grass. So I have been coming here a few times and this is the first time, first time seeing the end of the airstrip and going to check for fresh caribou tracks but there was nothing there. The caribou trails from previous years I saw. It is very obvious that the willows and vegetation really has grown. I guess the caribou don't come this way as much anymore. It was good to be out today it feels like being at home. You know when you go out and see the country side, the landscape it makes your soul feel better like it's always nice to see the land is healthy. I was trying to see if there was any kind of spill out there and there wasn't any gas or diesel. It is very clean out there. So I commend Diavik in keeping the site clean and it is nice that they invite us up here to do our traditional work here. One of my concerns is that those big heavy equipment that's going into the pits, I can see that they have good breaks and I would like to thank the organizers and the facilitators for taking us out on the land today thank you.

Mike Francis: We were seeing ground squirrel, we seen a fox carrying a ground squirrel we have been here for the last few days and we feel good, I feel good I haven't seen any diamonds.

Louie Zoe: It is true what people are saying we went to that airstrip and it is a good area for the animals to go up on top of the airstrip so it's not too high up for the animal's safety. So I hope the pile is not too high so it's good kind of safe place around that area a safe place for animals so it's not too high up. We see fox and we look at all the lakes and we seen the open pit which is really far down and we still have to think about what is going to go in there at closure, we are still going to have to discuss that.

Joe Champlain: We've seen a lot of things when we went on the sightseeing today I feel good looking at the landscape and the barren land. I seen two things I seen the fox and I look in the binoculars, I seen a wolf with the binocular but I don't think you guys seen it, it went so fast. I felt good having a tour of the airstrip, and the open pit. It looks good but we still have to talk about how it's going to be refilled, the open pit, we still have to talk about a lot of things about the closure. I hope I come back again for the next session.

Natasha Thorpe: I am sorry I wasn't out with you today. I look forward to hearing more about it.

George Marlowe: For the next session I remember that some people said they didn't remember what Kimberlite is. I know how it looks as I have been working at Ekati so I was thinking about A21 before you take it out before you blast maybe ask Diavik if maybe people could look at it - how it looks before the blast, after it is clear and ready to be blasted. It is a different color dark and that one there.

Natasha Thorpe: Reminder about copies.

Morris Marten: I need all the notes so I can talk with Alfred Baillargeon when I get back.

Ed Jones: Is it possible if you would consider replacing this type of headset and go back to the old type that we were using before at previous meetings? We have had trouble with this model. It seems to be a cheaper model.

Natasha Thorpe: That's on the record.

George Marlowe: This afternoon we were driving on the dyke, way back I don't know how many years ago we talked about the dyke for closure when it's time for closure they are going to take everything down light poles, and everything and they are going to make a door or something for water to come in. If anybody has any better ideas today or for the next one.

Joanne Barnaby: George thank you for that for remembering that because we should be talking about what other issues we need to address in the future sessions.

Ed Jones: I have heard you use that term we will revisit this topic and so on and are you trying to say well we will revisit this until we get it to your satisfaction? Is that what you are trying to say?

Joanne Barnaby: No we want to make sure it is to your satisfaction. In this session you know we picked up on the possibility of a change in direction right? So there's going to be times like that because over time you see things, you learn new things. Your understanding becomes deeper. You may want to reconsider ideas and recommendations that you have made in the past or you might want to simply say we are good with those.

Wayne Langenhan: I can't get this pit business out of my mind. The pits are very close to each other. I worked at Con Mine. We went down in a cage to the 2300 feet level where we would get off and load onto cars. The cars pulled by a loki would then haul us about a mile and a half down a drift to a place called the winds. There we would go down another shaft. The mine was about 5100 feet deep then. The two shafts were off set. What is the distance between the two shafts? Like are we going to put that waste pile up top there why couldn't the mine work off one shaft to link both the ore bodies? They used to have a network of ladders underground where you could climb for 3000 feet going up. I can't see if the distance isn't too far between the two pits why one shaft wouldn't serve both ore bodies? That way the waste rock that is coming out of the third pit could go in one of those pits so we wouldn't be burying a miner.

Natasha Thorpe: Dianne just ran out to get a copy of that map so I see people getting quite tired and they have homework tonight too so we can take a look at it when she comes back and I am suggesting that maybe we wrap up for the day. We will see you back around 7 to hand over the transcripts. And we will return to Wayne's question tomorrow morning.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Day 5: Monday August 18^{th}, 2014

Natasha Thorpe: Welcome back to our final day of our 7^{th} session. I hope everybody is well rested and ready to do some hard work today. We have the challenge today of pulling together the key points that we have talked about the last few days. This morning we are going to go through some of the recommendations that we think we heard over the last few days. But this is where your hard work and patience and guidance will really make sure that we get the words right in these recommendations. I am going to hand it over to Joanne but two things I am hoping you can keep in mind: Please make sure that we get the words right and please make sure that we haven't forgotten anything.

We have Brenda McDonald from EMAB who will come into the room within the next hour or so and otherwise Diavik will not be here, the U of A students will not be here this morning. This is your private time to work freely and work hard.

Once we are done we will invite Diavik back in the room and present the recommendations to them. They will then give a short response and from there those recommendations will add to the 74 that are already in this table and they will provide a formal response, a written response, for your next session, session #8. Any questions or thoughts before we move into today's work?

Joanne Barnaby: If something is not as clear as it should be please make suggestions for making it clearer or stronger. If I forget something please let me know. The way I organized the draft comments and responses are following the four questions that were in our agenda that Diavik asked us to address, so to remind you here are the four questions.

Presentation of Recommendations to discuss

The four questions

General Responses and Comments

In Camera Session

Joy Dragon: Presentation to Diavik on Recommendations including General Responses and Comments

Gord Macdonald: Thank you very much that was very well said and actually quite clear. Natasha do you want to go back to the beginning and we will just walk through and Colleen jump in if you've got any comments as well. In general I thought all the recommendations were quite clear. Toxicity in here I am presuming you mean the effect of eating vegetation on caribou or on people? When you say toxicity it's not toxicity to the plant, I am guessing that its toxicity to something that might be eating the plant.

Joy Dragon: Yes and no.

Gord Macdonald: So the way it's written it's a bigger ask then you think; to actually try and expose caribou or people to something that's toxic is kind of a difficult study to do.

Joy Dragon: I think if they find something dead or in the case of the rabies outbreak that happened that would be reported back and tested.

Gord Macdonald: So what we would normally do, it is built into the re-vegetation work, is to do chemistry analysis on the re-vegetation to see if it's different in those areas versus somewhere else and use that information to infer, I guess to suggest, whether it is good or bad.

Natasha Thorpe: I think just to clarify Gord and Joy I think the idea with that one was to test both out on the tundra and in the seed plots on site to make sure or to monitor what's in the plants, what's toxic in the plants, and I understand you are already. We looked at a slide where you are already doing that but there is a want to do that both out on the field as well as on those test sites. Is that right panel? Okay good.

Colleen English: Another question I had for number 1, we talked yesterday about the roads and what the ultimate shape of the roads at closure would look like, so everybody had sort of pointed to the bottom one (3) where the road kind of expands out and the slopes are made more gentle, but that would disturb new areas by pushing those roads out. We talked about as soon as you push the road out to reduce the slope you are going to cover more tundra. So I just want to clarify if number 1 is still, I guess, if the road option we talked about yesterday is still okay in relation to your recommendation number 1?

Natasha Thorpe: Please jump in here but I think there is an understanding like say with the rock pile for A21 and the other roads that to keep the rock pile height down we would have to go out further at the base but other than that and for the roads, the request was to decrease as much disturbance as possible.

Gord Macdonald: So maybe add that in, 'except for flattening out roads'. That would be helpful.

Natasha Thorpe: Is that okay with the panel if we add that about the roads?

Changing Recommendation #1 to add except for areas such as roads, A21 and the rock pile for A21.→ All in favour

Celine Marlowe: So that first one are you saying that you will accept the road for the mine gravel on the side of the roads and not do nothing about the rock pile, is that what you are saying?

Gord Macdonald: No what we are saying is we understand you don't want us to disturb new areas I mean other than in areas we're already planning to disturb areas, like with the A21 rock pile, but also in places where you want us at closure to flatten out the roads. Those will, when we flatten them out, those will cover more vegetation but we understand that that's okay.

Celine Marlowe: Okay thank you.

Gord Macdonald: Also just to be clear with everyone, I'm not trying to go through this and say whether we are accepting or not accepting each recommendation, I am really just trying to ask questions to make sure I understand them. The next time we meet is when you can expect us to come back to you and tell you whether we agree or disagree or what we are going to do. I am not quite good enough to answer these questions on the fly.

Natasha Thorpe: This is a good opportunity meeting face to face with Diavik so that you can make sure that they really understand what you are trying to say. So it's a great exchange between everybody.

Gord Macdonald: So there were a couple of places where I have seen reference to caribou maps and I am wondering how much. So we did a lot of that back in baseline, like before the mine was here. We have a whole bunch of maps from a whole bunch of different sources; elders included, communities included, scientists included that we've used as the basis for how the animals used to interact with the island before development but I am getting that this group probably hasn't seen those things, so I think that would be a good starting place is to take those and say how does it build from there? Try not to start with nothing, start with something that was already there and let us know if you think that's still true and more importantly how you think, we've also experienced how it's changed with the mine site and then the next question would be what will happen once the mine is not active anymore, will they come back to those routes or not?

The fencing question is always a good one; we've always received mixed information about whether to fence or not to fence, and the challenges with it. I think that is a good one for the panel.

Natasha Thorpe: I just realized we didn't write down about the material on the side of the airstrip exactly like it is now, the slope and the sides but there was discussion about that being a recommendation for the sides of roads but we didn't as a panel close the loop on that one. We might need to revisit that one.

Gord Macdonald: You will have to educate me on a mat.

Natasha Thorpe: A tundra mat.

Gord Macdonald: So you cut out a piece of, a chuck of tundra and then put it on to the…

Natasha Thorpe: So maybe where you are widening roads or putting on a rock pile that's where those mats would be harvested.

Gord Macdonald: Okay.

Gord Macdonald: Do we count as local animals? Its treated sewage, disinfected sewage. So that's no. So is that actually a recommendation to not use sewage or are you being silent on it? Because I could easily read "naturally local fertilizer" as including people.

Mary Rose Sundberg: I can't remember why we said we didn't want to use that, it maybe because they put a lot of; you have to clean it right it goes through a cleaning process. It doesn't seem like its right to do that. I think it was because there was going to be other things in it that we didn't want to use.

Joy Dragon: There's a student here that knows a little bit about this stuff we are going to get her perspective. How do you feel about that being used as a fertilizer for this process?

Valerie (U of A Student): I use sewage in the green house and in the field and we've done some tests on it and we haven't found anything harmful in the sewage and it's quite good for vegetation. We find plants grow very well, it's almost comparable to the natural materials. We're still studying if it's a good fertilizer but based on initial results it seems quite good and not very harmful at all.

Joy Dragon: Would the panel like to revisit that recommendation of using the treated sewage as a fertilizer at a future session?

Gord Macdonald: Its not uncommon for people to not want to use sewage for vegetation, it's not an uncommon thing, I just want to be clear that that's what you mean.

Natasha Thorpe: My question is does what Valerie said change your mind or is this recommendation still the same?

Valerie (U of A Student): I would just like to add to that, that we would like to use materials like soil as amendments but there is very little onsite, even if we mined A21 so we are trying to find other materials that we can use and most are very, very limited. Sewage is a material on site so we don't have to ship things in, so it reduces some of the effects so that's why we've used sewage.

Joanne Barnaby: I think there isn't a level of comfort with it yet but its perhaps something the panel can discuss in the future sessions.

Change recommendation #12 to add no human sewage – this issue will be revisited

Gord Macdonald: So I will read that as being not from people.

So I though the TK Literature review was complete?

Joanne Barnaby: Just very preliminary findings, there's quite a bit more that has to be done to complete it and make it useful and accessible to others and we haven't had a chance to review it with the TK Panel yet as well.

Gord Macdonald: Okay. So I do understand where you are going with cumulative effects but before you go writing letters to Ekati and ENR I think we're going to have to think through this thing, because this panel's mandate is specific to Diavik so it's quite a challenge to open that up to others and it's probably inappropriate that you do it, it's probably more appropriate that we do it. This panel certainly can't be in the position of making recommendations to Ekati and that's well beyond the scope of this panel. I understand what you are saying that it's all blended and I understand the idea of trying to get, I don't even know if Ekati has a TK Panel, but to try and have this panel together with another panel or this panel together with their operations. I understand that but it would have to be done through us versus this panel approaching anybody specifically.

Same thing with regulators - you're going beyond your mandate here, to be saying what you think regulators should do.

And the map one I think we touched on earlier and I think we have some early information for you on that one.

As long as you are reporting back to your own organizations if that's what you mean by direct to Aboriginal governments. I have no problem with you advising that to your organizations, who you think should sit on this panel and what you think makes sense, that's perfectly reasonable and that's who we approached to do these things.

Yeah so on 21, I think we are just a little bit early on that one. We still need to get back to you with more information about the North Inlet, I think, before we can go much further in terms of deciding whether it's a go or a no go zone. So I think it might be a bit early for that one.

Again both those other two on the maps I think they're sort of similar to the other ones.

One 23, I think it links also back to future sessions. I do definitely get the sense, particularly from this session much more than the last session, that you guys are getting ahead of us. You're providing us with more information than we've been able to process into the closure plan. What it really needs, and I think you're ready for it now and I think we're ready for it now, is to take all of this information and come back to you with how we think the island will look. Like some actual images that you can look and review and see if it fits with these ideas. And I presume it will give you a lot more ideas as well but it's getting kind of difficult to be talking in pieces of the map. We need to put it all together and show you where we're at in terms of all of these recommendations as a new starting place to move forward from, instead of always looking at these maps of the developed site. I think we need to start looking at maps of a closed site with the kinds of information that we are all heading towards taken into account on the map.

You are way ahead of us, yes. You are giving us more information then we can possibly process.

So on the first one with the pits and the underground, I understand. I would want to go underground, too if I were you guys. It's not that we can't do it, we just need to plan for it that is all. If that's what's important, we can make that happen and its certainly easier to get into the pit, it's much more difficult to get into the underground. Only its more difficult for you guys; there's a level of training everybody has to go through before you can go underground, but again if we plan for it we can do it.

Here's the women only again. Here's my suggestion on this… I guess I'm answering this one, I guess I'll leave it because otherwise I'm answering it.

Big picture I agree, that's back to where I was talking before that's on us to come back to you with the big picture and get your review of that big picture.

Monitoring is definitely next to the big picture, monitoring would be next on my list. How to get good monitoring programs, information from you guys on monitoring programs that, formed, that the communities could implement. So that when we say everything is going well (scientifically), we say the water is good to release to the lake that we could then, you know, have a group of community members - whether they are elders or the panel - could come up and give us their opinion on whether it's good to release or not to release.

On the PKC, this idea of you guys making a recommendation, us considering it and in this case not accepting it, I fully expect that this has a loop back that you then come back and say, 'well okay that was our idea, you didn't accept it, now where are we going' and can we look at that again and for sure that's exactly what it should be as we refine the program going forward, and I think that ties into the big picture one.

Yeah we've always found, expected there's two opportunities for Aboriginal people at closure, one is actually doing the work and the other is monitoring its success. I will be interested to hear more about what the healing ceremonies are or would be and how we can build that in.

I am surprised you want to meet more frequently. I get the feeling we are exhausting you, and you are telling me you want to do this more often. Do we really think, I mean the last one was October, it's now August, do we really think we would have done another session between these two? It's a lot of time.

Wayne Langenhan: We have endurance.

Gord Macdonald: Clearly more endurance than I have.

Okay, I mean okay we will think about that. Knowing what's happening next year, we definitely want this full panel up and I definitely would like it to be about the big picture but we do also have a traditional knowledge camp planned for next summer, what some of you might know as the fish tasting or the aquatic effect monitoring program. So there are already two programs planned next year so I think it would be a struggle to fit in a third next year but let's go one session at a time anyway.

Linking back to the communities we'd really appreciate your advice and support on how to do that. I think we've got, you guys have a much better understanding of what's going on the site and what we are doing with closure than almost anyone I think in your communities, and we struggle to get that information back to your communities. How we can link you guys into that and help you relay that message and validate that feedback coming back to us would be very helpful.

I am not sure how much we want to share all of the good things you've done with other mining companies, we are kind of protective of you guys.

See diamonds - that's an interesting question. That would be in Yellowknife versus here, at the sorting facility in Yellowknife - and that would be an even bigger challenge then getting underground - but it's a fair ask. You may not like the terms and conditions that come with the ask but, yeah I mean that's a good point. Are you just looking for a tray of diamonds to see what they look like?

Celine Marlowe: The ones that just come out.

Gord Macdonald: Yeah, yeah before they are polished, it's a shiny rock, yeah. You've seen the pictures on the wall I'll show you the pictures on the wall but yeah we could. You won't see them in the rock (ore).

Celine Marlowe: This is how it looks before it's polished.

Gord Macdonald: Yeah we can for sure do that but if you want to just look at the kimberlite, the black stuff and expect to see a diamond in there, you will be looking for a long time before you are going to find one. I mean I'll show you right now there is a picture out on the wall what they look like but we could get some to physically put on the table for you, along with all the security guards and everything that comes with it.

George Marlowe: Just that elders like John said, I don't know why we are talking here for I never seen a diamond, where it come from what kind of rocks or what. They don't know about kimberlite and the rocks, they don't know because like me I was working at Ekati I seen it myself me because I was there but those people they have never seen it.

Gord Macdonald: When we had an open pit it was much easier to see it because we could actually go and walk on top of it but in the underground it's very difficult to actually see the kimberlite so maybe when A21, if A21 happens, that would give us something that we could do, because it used to be that we went down in the pit and walked on the kimberlite. Believe me we are mining diamonds, only diamonds, no other minerals.

Just in closing thank you very much for your efforts I know it is a lot of work, you do put a lot of energy into these days and these facilitators really do run you into the ground with getting all the information out of you, so we really appreciate your time and especially taking up a weekend of your time for coming up, so thanks very much.

Colleen English: Can I ask one more question too? You mentioned that the recommendations about the balance of men, women and the youth as more of an internal recommendation, but we do communicate with your organizations when we are leading up to a session. So if you are communicating that back, do you still want Diavik to also be saying, as a reminder, the panel recommended that this should be the content of the panel? (Panel confirmed that this would be preferred) I just wanted to double check that thanks.

Natasha Thorpe: One last question the panel wanted to ask Diavik was what material are they going to use to build the dyke for A21?

Gord Macdonald: The rock from the North Country Rock Pile that we were standing on top of. They take that and some of it is just like it is there - big boulders like that - but most of it goes through that big building at the bottom, the crusher, and it gets crushed into very specific types of material, but it all comes from that big rock pile. So I guess we really are putting the rock pile back into the lake then.

Where we are going to take the rock from the pile for A21, we want to try and line it up with where we want to flatten the slopes out for caribou so that it makes it easier for doing that.

Joanne Barnaby: Are there panel members who wanted to say anything further, regarding our recommendations, George?

George Marlowe: Diavik said that they are going to use the highest rock pile but after you build the dyke you are going to have to take some more rocks out again. What are you going to do when you take the next rocks out we don't want it too high?

Gord Macdonald: How about we come back to you with that? I mean right, it's that square box really where it's shown on the map there; that rock is going to go on the south part of the island. But I would be happy to come back to this panel, it's still quite a ways away before we'd be mining that rock, to how we can lay out that rock pile so that it's as close to what you want at closure. So then we don't have to move it around and if you want it lower and flatter versus taller and skinnier, that's actually easier for us than tall.

George Marlowe: I think it's a good idea I think the panel do a lot of work, I know it's hard all the time I think they should get a little bit more money. Me I said me you, you've got good wages already. So in the mean time I am asking for a little bit more higher again for the elders. The elders are tired, we are sitting here and you know how much I get, only few hundred dollars a day not much you, you get that in an hour.

Joanne Barnaby: Some of the elders just before we invited you in were talking about all of the work that they still feel they need to do and the importance of scheduling the work out over the next few years and so we appreciate your feedback on the topics that would be timely for you but they do feel, even when they were working under EMAB meeting 4 times a year, that there was still much more work to be done. So there’s a lot of concern that the number of sessions have been cut back so much and you know part of it is we have to re-orient; you’re in this job full time, they come in you know with long periods in between and sometimes we find we are going back over old ground because that momentum gets lost and there’s a feeling that we’re always short of time. We would like to have addressed other topics as well this time and there wasn’t enough time to do that. We would like to have, for example, finalized the Working Together document and the Checking Nets and we, the panel, is feeling quite proud of the work that it’s done and we feel that it has been helpful and useful to Diavik and that you should be equally proud of that and share that with other people who are working in northern and with aboriginal communities. So we’d like to see that out there and so you’re feedback on those documents as well as our own chance to finalize them would be very good.

Gord Macdonald: So just one I guess opposite to that view. I understand the question of momentum and I am also trying to think forward -it’s a long journey still and I kind of want some energy at the end as well as at the beginning, so I am trying to pace you guys that it is a longer journey and we want you involved all the way through rather than just now. So I also don’t want you to try and tackle every question out there when we still have a long time to go and things might change along the way. So it’s a longer journey than you might be thinking.

George Marlowe: About the Ekati we talked about Ekati about having a meeting together but I know it’s hard for you to say yes but the reason why we said that was because of Misery. It’s blocking you for the caribou migration that’s the reason why we said that but it’s not over yet when I get home I am going to talk to my chief and councilors and I think Akaitcho is still having a meeting in Yellowknife. That’s something that I am going to bring up too.

Gord Macdonald: Just don’t say it was our idea.

Colleen English: Also just to let you know, you again probably don’t see it, but we are linking in with Ekati all the time. We are sharing the information between Diavik and Ekati. As an example, I met with Ekati before I came up here to meet with you guys and let them know what we were doing and they’ve done some veg work last year that you guys saw some of the results from in the literature review, and we talked about some of the learning’s from that and the people that were involved in that. Similarly, I have committed to following up with them to let them know some of the outcomes from this session. So that does go on behind the scenes, between the companies, just so you are aware of that as well.

Gord Macdonald: And I don't know if you guys know but Ekati now owns 40% of this mine so Ekati pays for 40% of what you earn here. It's not like we don't know each other.

Joanne Barnaby: As you can appreciate people from the communities have a different perspective and so when they see things going on over there, recognizing that you are a separate mines, you have separate management, you may have some ownership cross-over, there's bridges at other levels that people would like to form. Communications around issues of common concern, some of these overlap areas, some of the common concerns around retracing old caribou routes and how that can be supported in the future with closure planning. If the confidence was there that, that discussion can happen at a bigger level and that it was a more cohesive discussion recognizing that the caribou move around and other animals move around and migrate, water flows and fish swim that would help I think. So if there are opportunities for joint initiatives that would be great.

Mary Rose Sundberg: I just want to emphasize 4 points that you don't seem to agree with the way you are talking: 1 I know it's really important to include the women like I said the women are the care takers and they are closer to the land then we really think. They know a lot about plants and healing plants so they have a different perspective so what we want is to make sure that they are involved - just one women from each region or another idea was when you come to our community on an annual basis you take the time to have an extra day just to meet with the women and there you can pose some of those questions that we've been working on last few days. That's another way of trying to get their feedback and what they think. It's very important because some of these women that you are going to be talking to they used to live on the land day and night and these ladies are still with us today. We're lucky they are still with us and they have a lot of knowledge about this area.

So I wanted to mention that and we know that we have no control over the regulators and the boards but we want to make sure that they understand that before they start approving all these mines left right and accepting their water permits and everything, you guys already know this but we are telling you again because we know how important it is and these social issues that are happening in our communities. I was telling them that in the 80's and early 90's we had presentations from Africa and Australia and they were telling our people this is going to happen to you guys when the mining industry starts in your land. They told us that crack cocaine is coming, the cash stores are coming a lot of social problems are going to come.

We didn't believe them at all at the time, I never believed them but I remember what they said, how they emphasized the importance of preparing yourself for this kind of industry to come to your community and one of the things that they also said that I never mentioned is when a person gets a lot of money sometimes they are not able to manage that, or they don't know how to budget themselves. So much money comes and it's going every time they come back to the community. One guy said he worked at the mine for 10 years, he made approximately 1 million dollars and he has nothing to show for it except for his vehicle and then the other thing they said to us was your people or someone who works here because they are getting so desperate being in debt, they are so indebt they are working here but they are so in debt that they are going to find ways to steal diamonds. They are going to try to smuggle it out for other people. That hasn't happened yet, maybe it has I don't know but they said those things will happen they are going to find ways to steal diamonds to take out because maybe someone will just say here I'll give you $10,000, you're in debt I will loan you this money don't worry about it. A few years later oh you owe me money you want to do me a favour here. That's what they said to us that's what's going to happen here.

So when we talk about we don't what no more mines we know we have no control over those regulators but we want to start telling them that this is happening to us in our communities and we do have IBA's that comes with just little pennies they gave us, that doesn't cover what is happening to our people especially the people in Yellowknife we are just next door to all this that is happening so that's what we mean by that.

Healing the land even though we are not the ones that are working on the land, ripping at the land, digging into the land we are not the ones doing that but we are somehow involved because this is our land and we allowed it. A healing ceremony is so important we did that once with Giant Mine and we decided that we are going to do it every year so it's paying respect to the land it is a ceremony that you should learn about from our elders, they know what that is all about that is just giving respect to the land and saying we are sorry for what we have done to you. It's going to take a long time to heal but we're helping it and giving respect back to the land.

You're telling us to slow down because this is a long process he said it's a long journey, we realize that but a lot of things have come up because sometimes research takes a long time as well. This is probably not going to take a few years it's going to take longer than that so there's a lot of things that questions what's coming up. It's not for next year, it might be for next 5 or 10 years so when we request more meetings it's because the more we educate people the more we talk about it maybe some other things might come up that we as a group has not thought about. So I just wanted to touch on these things I think it's very important that you know where we are coming from and I am sure you are going to see the minutes and the rest of the recommendations regarding what I just said.

Gord: Thanks that was very helpful.

Ed Jones: I would like to add to what Mary Rose said I wonder if Diavik would consider as Wayne suggested some time ago that they would have a happier crew if they gave short courses in money management skills that would help the employee plus the communities.

Gord: I am the wrong person to ask that question to but I will past it on. It's not a new idea and it was certainly done earlier on in the mine life, I don't know if it's been done more recently.

Joanne Barnaby: Alright so if there are no more comments from the panel I thank you very much for coming in and taking the time to hear the recommendations and you'll receive a more complete report soon. We do have a bit more to do before we finish off today so I would suggest that we move into that. One of the things that we wanted to do of course is do a round table, give everyone a chance to make some closing statements, Joe Champlain had approached me on the first day and said he wanted to share a little bit about his life when he lived out here and he's been very respectful in not jumping in when we are dealing with agenda items and so I would like to offer him that opportunity to do that before we leave and then invite the members to make their closing remarks. And you are welcome to stay.

Joe Champlain: Thank you for as I listen Mary Rose I am thankful that she shared her wisdom with us and also she had a good sharing and also I have never traveled to these meetings before. The thing I saw and the way the mine operates I've seen it with my own eyes and I am thankful for that. Yesterday even Sunday they gave us time to pray the rosaries even for that I am thankful. As of today I remember in the past is totally different so I just wanted to speak to that piece today everything is simplified and in the past we had to struggle for as I remember it, today we use airplanes to transport, in the past it wasn't really like that. In the past if people wanted to go to certain place people would use dog teams, as I remember our elders used to talk to us, they used to walk on the land and that's how they survived. They lived off the caribou, the fish that's all they did was hunt and for at that time there was hardly any employment, so people would go long distances to go trapping, and with the trapping they would earn money. We were in poor condition in the past and sometimes in the morning we would have nothing to eat and if other people had something to eat they would share their food with each other, with other families and at that time we had no child care, or old age pension, that's how our elders survived and our ancestors they traveled in this area this is where we used to hunt and trap and as I remember it when I was just a young child the men would go trapping for the white fox I remember that and they would communicate with the Inuit and they would trade their dogs because some dogs were healthier than other that's how they would help one another also with caribou clothing.

And also the people from the Yellowknives and Łutsel K'e they would travel amongst each other and all the elders that live on the land and people would travel to Whati and beyond Mackenzie to Wrigley and visit one another and that's how sometimes people would meet one another. Although Great Bear Lake is quite a distance people would meet and also from Fort Simpson that's how people used to travel on the land and with the dog team and those things that I remember I just want to share with you. That people used to really struggle in the past. When I see the barren land when I was a young boy and the white fox and our elders and our forefathers went to barren lands so they could harvest the white fox and when they tell their stories even with the firewood they cut fire wood within the tree line and then they would load it up on their sleds and they would go into the barren land with a load of wood. The only time they would make a fire is to cook their food and because they want to preserve their firewood they have to work in the harsh climate like that.

That's how the stories were being told but as of today we still rely on each other the white people and the aboriginal peoples all though it is a long distance between communities, the long distance is shortened by the travel of the airplane you know people can go a long distance and meet one another shaking hands and hearing one another stories, I am thankful of that because of one another sharing our stories and we share our stories and it's very important that we do this and while I am telling my stories you know the women were very pitiful, they were always trying every day even and the women would go on the tundra and on barren land to try and gather wood and also the women would care for the small babies. I used to see this with my eyes and we grew up in a tent and even with our caribou blankets sometimes it's not very warm but as I remember as a child because a women once told me that I am going to go gather wood watch my children and when I seen these small children they were in a tent, these they had to be tied up so they don't go near the stove that's how they were raised and there is no store bought food there's only caribou meet and blood soup and they used to eat marrows and that's what I witnessed and that's how some of our elders told us stories and they walked on this land with their two feet and that's how, you probably know the stories but I just want to share that story with you.

Diavik Diamond Mines TK Panel – Vegetation

Natasha Thorpe: Thank you Joe for taking us to the land. So we are coming to the end of our four days of work, we've got about half an hour before we need to clear the room so I wanted to have the chance for us to have our own closing ceremony and invite anybody to start that would like to.

Wayne Langenhan: I would just like to say thank you for all of those who attended I know some of you come from a long way like Mark there and I think it was a pretty good session I think we got some pretty important work done here this time. Thank you to the facilitators for all their hard work and sleepless nights and I would also like to thank the people at Diavik for the free room and board because you know you would pay good money for that in Yellowknife. I wish you all a safe flight home or drive whichever way you are going and hope to see you back here in the next meeting. Thank you.

Morris Marten: I am sorry I was suppose to take you out for lunch but I haven't got my credit card on me besides that I'm short on change so I couldn't take you out.

Joanne Barnaby: And your wife is at home waiting for you.

Mark Taletok: Although I am becoming an elder it is very grateful to see my fellow elders here we have a similar culture and I was listening to this person who was talking about living on the land, even though when I was growing up I used to lived in a tent, when I was growing up there was no sleeping bags all we had was traditional blankets that were made with the fur. The first time I saw a man made blanket boy it was pretty and beautiful, and then my grandmother used to look after me very well and she used to tell me to try and help the fellow Inuit, our traditional clothing's were warm. The clothing we have today is good for nothing because the caribou skins clothing we used to have kept us warm. I would like to thank each and every one of you in this room today and I'm going to remembering our meeting here so have a safe trip home don't go hungry go hunting and help one another and give a little gift to each like even a tea pot, it's the thought that counts. Whenever someone gives me something even if it's really small I am always very, very thankful to that person. If my hunting is successful I will pay them back with a little bit of meat. Now a days it seems our children have to stay in the house all the time, they are afraid of going outside, they don't go to outpost camps anymore. We hardly use our traditional ways anymore and I still talk to my grandkids in my traditional language. I would like to thank Diavik for giving us a roof, giving us a lot of good food and I would like to thank all the organizers that put the meeting together.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Mike Francis: Thank you during this session although it's not long we had a good meeting some of the things that we had no knowledge about now I gained some knowledge so that's good.

Louie Zoe: As they said we had a good meeting and they are correct in saying for future generations they are walking in our footsteps and we are making a trail for them and setting a journey for them and the youth. I am thankful for the facilitators and transcriptionists and also for the women with supporting one another and working on the maps I am thankful for that, even though we put in these recommendations the things might be touched upon and we don't know how long into the future we are going to be able to be working together but in the end we should all come together and you know work with the recommendations, that's what we are here for. I am thankful for everyone here and I hope everyone has a safe trip home.

Joe Champlain: Thank you we had a good stay a good night's sleep and good food and we were well taken care of and there's a lot of good knowledge and wise words being shared here today and also they're saying people would have a safe trip home and they are correct in saying that but although you come home, go home safely you have to take care of himself that's what the elders often say if someone becomes ill or sick we can't do nothing but if we travel amongst one another.

Celine Marlowe: Thank you for being here and I want everybody to have a safe trip home I know everybody is anxious to get back to their grand children because I am for sure and I have respect for everyone that was in this board meeting here and I would like to thank everybody from the bottom of my heart.

George Marlowe: First of all I have to say thank you to the translators and the facilitators. I've been to this kind of meeting lots and I think the way I see it we got something's done on the board there, a lot of things. I think Diavik will think about it I know they will support everyone of them I guarantee don't throw our words away. But I thank you very much for staying here, beautiful students over there too; I wish I was young again. So I thank you to everybody.

John Ivarluk: Thank you and I would like thank this man here for making this gathering here available to all of us. It's been very nice to see all of you again familiar faces ever since I started meeting with people like these people here. It's not my first time to see a mine site still working they are doing a great job but I really hope to keep Nunavut clean thank you.

Martha Ivarluk: I would like to thank you for bring us here to participate in this meeting. I would like to wish each and every one of you a safe trip home and I would like to thank you Diavik for giving us good accommodations while we are here.

Appendix D
Diavik Diamond Mines TK Panel – Vegetation

Ed Jones: I don't have much to say I want to thank you for exchanging ideas I was quite surprise that Diavik was still in operation because we don't have many meetings to keep in touch.

Joy Dragon: Thank you to everyone who I met and the facilitators and especially to the interpreters and the translators and the students for being open to questions and open to learning it shows a good spirit.

Mary Rose Sundberg: Mahsi cho for giving me an opportunity to be involved me in this process. I have definitely gained a lot of knowledge from every one of you. With this knowledge I will definitely talk to my people and most importantly to my grandchildren so that they can pass this information on to their own children and grandchildren. I think it's important that they know the process and what has to be done to replenish the land again. We want to make sure that reclamation is done properly so I am glad I was involved in whatever I had to offer. So I am happy about that and the other thing I want to say every time I come to the barren lands I feel so comfortable. The other day when I said I saw ugliness out there I don't mean the healthy land. The healthy land makes me feel like I am at home but when I see rock piles and all that grey ugly things that's what I mean by ugliness. So don't get me wrong I love this land and I always love coming here because my family was born in this area so it's really close to here. And I didn't really that I also do have relatives through Henry and Mona I have aunty and uncle that live in Cambridge Bay so they know them and they are related through in-laws. I found that out and I am so happy to meet them, my aunty has been living in Cambridge Bay for over 40 years.

All the work that we are doing here and everybody's contribution is very important even though sometimes we don't agree with each other somehow at the end we always manage to say okay we will think about that. The other thing I think it's important too I didn't realize that Ekati owns 40% of this mine so I don't see any problems trying to work together if the two companies are working together in that capacity. I am sure Ekati is not going to say no I do not want to work with you guys I am sure they are going to be open so you have to keep an open mind and tell them the importance of we're trying to save you guys money actually if we work together so you have to think about it that way as well. I felt like I was on a holiday for some reason I think it's because I don't have a cell phone, phones ringing.

Joanne Barnaby: I just want to once again welcome Brenda McDonald and we look forward to re-establishing close communications with EMAB and helping you to stay in touch with the traditional knowledge part of your mandate and in terms of bringing that forward in the system that you are working within and so I wanted to give you a little opportunity to say a few words to the panel before we break.

Brenda McDonald: Thank you Joanne, I represent EMAB the executive director. First of all I would like to say thank you to Diavik for the invitation to attend this session. Just looking around the room at all the notes and all the discussion I would have thoroughly enjoyed being here the whole weekend but at least I made the last day and I caught the over view and some of you I know, I have worked with you in the past so it's always good to see old friends. And I am very passionate about the work I am doing and I would like to see this relationship with the TK Panel renewed and strengthened and how we can assist and build a strong relationship with the TK Panel in meeting our mandate protecting the environment and working with Diavik and with the communities and with our elders to take all the knowledge combined so that we protect the environment in the end. So I just want to thank you all and I look forward to meeting you very soon, we can get together and I would really like for my board to meet the panel and listen to some of the good discussions that have taken place over the last few sessions since it's been out of EMAB's hands thank you.

Peter Huskey: I want to say thank you to Joe for sharing his story it's a very powerful story for me because I bet each one of us has a story like that. Our ancestors used to roam on the land just like this I will share a little story with you about my great grandfather his name is Bear Lake Chief he was born in Fort Norman but he was a fur trader for Hudson's Bay in the old Fort Rae area. He used to have 7 cabins along the way and he is buried just north side of Gameti it's called Lac Saint Croix in English its Lake of the Cross. He guided a priest Emile Petitot in the 1800's there's a book on that and also he guided an archeologist from Iowa State University the archeologist name was Frank Russell and he guided him from the current Fort Rae area all the way to somewhere in the tundra but that guy reported it took him four months to harvest 5musk ox. Just a small story like that takes you a long way back and each one of us has our stories like that. So I am thankful for Diavik and also for the facilitators and elders participating from each region to have input into this tradition knowledge panel I have been involved in the past and I am very grateful to be here and I am thankful for each and every one of you and to the University Students keep up the great work.

Henry Ohokannoak: I just want to thank Diavik, facilitators for giving me a chance to come here it's my first time up here at Diavik Mines. It was a pleasure staying here giving us a room and I just wanted to thank everyone for having us here.

Berna Martin: Thank you again for being for here for this session and thank everyone; Joanne, Natasha and Diavik and those people here Pido Productions, the transcriber that works here and the interpreters. I know it's hard sometimes it's very challenging. This was a good group of people that were together and share together, we laughed together and we shared stories I really enjoyed that. I wish you all the best and safe trip home. We try to accomplish too much, it's never an easy subject to talk about the mine that we experienced though our community of Yellowknife what we went through but the landscape that our ancestors, my parents parent's that raised us around this area that looking into the landscape thinking back about them like my uncle Joe Champlain said I am glad for the students being here until the next session that we see each other again.

Natasha Thorpe: Thank each and every one of you for taking time away from your families and coming here to meet with this very diverse family it's a very big honor for me and I am sure for all of us to work across cultures across genders across scientists and non scientists and when I really walk away from this session having heard so much of your stories about mother nature not wanting to interfere too much but also respecting nature enough to want to help move things along I think that somehow nature is involved in all of us working together and helping the land heal and move us along. It's not new that we've been working together like Peter tells a story from the 1800's and Joe and Mark and others have talked about other ancestors meeting in the same area many, many years ago so even though we come from very different places I see a very together, moving forward with a very strong voice. I just want to express a very big thank you to the interpreters, to our scribe Janet it's really hard work and these guys don't get much of a break at all. They work long hours every day we are here so that they can get the words right and back to you so I am just really grateful I feel like they go the extra mile and lastly I just want to say that while they are going the extra mile last night was walking out and seeing a table with one person from each of the 5 groups just laughing and sharing stories and that just really warms my heart I think not only the work that we do in this room but the relationships that are built outside of this room are very special relationships and I really respect you for moving those forward. Thanks again it's an honor to have facilitated this session for you again.

Joanne Barnaby: I just wanted to add my thanks to everyone, every time I get a chance to work with elders it's really hard for me to say no. It's been my life's passion and I feel really privileged to learn from you and to try and relay the very deep knowledge and very deep love you have for the land and to take care of your traditional responsibilities with taking care of the land. I really honor that and cherish that and thank you for working so hard to carry out those responsibilities.

Colleen English: Thank you for all of your time and your efforts this weekend and it sounds like you enjoyed it and I think we had some good opportunities out on the land as well as in this meeting room.

Appendix E

Session Poster Points

DDMI TK Panel Session #7

August 14-18, 2014

Quick Summary of "Poster Points" (i.e. highlight notes / key points taken on sticky notes and put up on poster sheets around the room)

Caribou

Must respect the caribou
There is a ball in the caribou intestine; you sew this into your ammunition bag when you are hunting and it brings
Caribou follow a leader
Caribou know where the vegetation is good
Animals won't eat anything poisonous; they know what is safe and what isn't
Caribou are smart
Mid-August is a good time to hunt caribou for clothing
We don't hunt caribou that are close to the mines
Don't hit caribou with a stick or you will scare them away for four years
Caribou might have trouble if there is ice on the rock pile

Caribou Migration

Caribou will find their old migration routes
Migration routes change so our hunting routes change too
Caribou routes are always changing; they know where to go
Caribou make their own trails; we don't need to plan too much
Inuksuit are used to mark caribou crossings (*nalluit*)
Caribou route goes right over Misery pit; the pit should be put back as it was
The East Island is a main part of the caribou migration route that goes near Misery, near EK'ATI
Caribou are going away; they migrate into Saskatchewan or over to Rankin Inlet; they are changing their migration routes
Caribou should be here right now – something is wrong

Caribou and Wildlife On-Site

Caribou will find the ramp, road or easy ay so don't worry
I was happy to see caribou tracks and droppings on the mine site
We cannot prevent animals from coming here
I feel peaceful and good after going out on site; I saw a fox and wolf
I saw fox and ground squirrels here (but no diamonds!!!)
There were caribou trails at the south side of the airstrip; it looks good

Caribou and Vegetation

If caribou don't have food, they won't come around; they are smart animals
We need to focus on caribou and vegetation
It is unhealthy for the caribou in summers when nothing grows
When there is nothing to eat, the migration routes change; it has been 6-7 years now that the caribou have stayed in the barrens
I don't see changes in what caribou eat (around Artillery Lake)
There is not much for caribou to eat at the test plots, 10 years later

Vegetation

Don't disturb new areas
Return the East Island to the way it was, as much as possible
Replanting and regrowth will take time
Even though it will regrow, it won't be as much as before
We need to improve conditions for regrowth
As the wind blows dust will go into crevices and then things will grow
Moisture is very important for growth; you need moisture underneath (e.g. for lichen)
Some summers there are good berries; others there are not
Can we pick the berries here again? I don't think so
The berries and leaves in the undisturbed areas look the same as before
Vegetation on the East Island is different from the mainland (it could be human activity or introduced species)
Grass will grow after the mine closes but I'm not sure about the lichen
Vegetation is not a concerns; the worry is about hazards and concerns for caribou
Wildlife smell food before they eat it; they may roam around but not eat
I was looking for dust on berries and willows, but I saw that they were pretty clean; seeing it first hand helps

Fire

There is an impact of ash and smoke on vegetation from fires
There is no more caribou in Gameti because of the fires
It has been 8-10 years since there have been many fires and not as many caribou coming around
Wildlife and their food burn in fires; I worry about the burns
Smoke keeps mosquitoes away
Fire destroys the land and vegetation
At McCleod Bay, Nanacho Lake is all burned; if the caribou don't go to Fort Reliance, we will know this I why; even from Fort Resolution to Artillery Lake
It is painful to see animals suffer but what can I do? (smoke hurts caribou)

Climate Change

Weather is getting warmer; this is nature
In the future, it will be like Yellowknife in Kugluktuk; nature is growing plants faster than it used to
Where we live, nature is going fast, changing, willows are growing fast, we see nice flowers now
It is harder to find cold drinking water; the ice melts away faster and the water is warmer
Water levels are decreasing and we can see more rocks along the shore
The water went down, there is no rain, there is more forest fire; things are different today and I worry
Willows are taller now at places we used to camp
EK'ATI road now has lots of trees because of climate change
More caribou are drowning now
There are different species coming to our area (e.g. a yellow bird); this was predicted by my Grandma
We cannot help nature because of climate change

Nature Knows Best / Nature will Heal
Want to discourage regrowth; time is needed to heal the land so good to keep animals away
Don't bother with re-vegetating as nature will heal
The environment is powerful; nature will heal; it will grow again
Tundra vegetation is very powerful; it is like there is something underneath that is helping
We saw nature kill 30 caribou from lightening near Mackay Lake
What happened at DDMI is not natural so we cannot leave it to Nature to heal; we need to help Nature

Regrowth Happens
Roads from the 1960s now have growth
They never replanted at the DEW lines and today they are beautiful
We learned from the DEW lines that vegetation grows again
The plants will grow
Natural revegetation is happening
I saw flowers on the rock pile; there will be more in the future
I saw that [natural] vegetation is growing again and I am happy with it
Vegetation grows very slowly (recovers very slowly)
The key to regrowth is to keep the footprint very slow
University students will help us know how to help regrow

Rock Pile
Keep the slope as it is at the test pile
The slope is good at the rock pile, it will be good
Slope at the test rock pile would be good for the side of roads too
Slope looks good at the test pile; keep it as natural as possible
There are some big rocks at the bottom that need to be covered (like on the test pile)
Big boulders should be pushed aside
Till on the rock piles means less moisture
The berms on the pile need to be made higher or sloped off
Think about the slope in the winter too; not just when it is snow free like now; it depends on the wind
Think about denning (e.g. fox) on the rock pile
Slope needs to be made for caribou at the North end as well as the South-East end
I'm worried about boulders and sharp rocks for animals
Don't make any easy passes for caribou to go to waste
Put muskeg at the bottom of the rock piles to invite wildlife
Once remediation is done, the berms will be gone
Rounding off the rock piles has to be done
The A21 pile should not be too high (okay if it is wider for now)
The East end will have a rock pile; don't make it too high; must be flat at top

Roads and Airstrip
(Consider Options 1, 2, 3 in slide)
Options 2 and 3 are okay, with a gradual slope, vegetation will grow
Prefer Option 3 for closure
Option 3 is easier for animals
The airstrip is good for animal safety; I hope other piles look like that (slope, shape, etc.)
There were caribou trails at the south side of the airstrip; it looks good

Lac de Gras / Fish / Water
Water levels at the shores change with snow levels
Fish move great distances
Fish travel by the shore during the fall when they are migrating
DDMI is on an island; it is different so I worry about water and fish
Dust moves through water and could go into the ground
Underwater vegetation is important for the fish
Watch out for streams going down to the lake

Questions and Comments to DDMI
What do the students and DDMI think about re-planting?
How long will they keep testing the plants (for contaminants)?
What is under the big rock pile?
How long will the mine operate?
Can a chemical be added to the slime to make it safe (harmless)?
How would you evaluate that water is safe before release into Lac de Gras?
Have they researched water in pits elsewhere (same ecosystem) or putting materials back in pit?
Will the water level of Lac de Gras go down when the pits are filled?
Is the rock pile going to get any bigger?
Where in the US is the pit that was filled?
What will happen to the airstrip?
What is the cost to fill the pits back again?
What is the dyke going to made of (for A21)?
If EKATI and DDMI are jointly owned by Dominion Diamonds, isn't it easier to work together on things like the TK Panel?
How come we never see real diamonds (seeing is believing)?

Thanks for looking after our land
Everything looks pretty good
I am sure DDMI will clean-up as they should; they don't want to leave a mess; they posted a bond
I believe DDMI will live up to their agreements
I commend DDMI for doing such a good job at keeping it clean
Good to see the land looks healthy
There is a huge job left to closure; it is difficult to envision; communities should be offered as much as possible
Good to see with my own eyes as photos don't tell the whole story

Questions to TK Panel
What is an 'acceptable' level of natural regrowth and how long does this take?

Cumulative Impacts of Mine
Used to be lots of caribou and fish around Lupin, but we don't go there anymore
Jericho mine was really
Diamond mines are different from metals mines (i.e. no chemicals, toxins in the process)
Mines look scary to me; I have experience and I have to be honest
EK'ATI wants to open Jay pits
Airstrip at Lupin was built too high
Remind BHP to fill in the pit at Misery

EK'ATI and DDMI are on the same Lake; same system; work together
We must remember that mines close; they operate in cycles

TK Panel Process
We need to verify all quotes / legends
We need to ask the right questions
We need to consult our Elders; I have so many questions for them now; both formally and informally
Elders are the keepers of our knowledge; we need to ask our Elders about these things
The TK Panel has a responsibility and job to present this work back to the communities
Elders 'senate' needs to review these recommendations; to guide the grassroots
University students doing a good job
Seeing it first-hand helps

PKC Area
Use Bentonie to solidify the surface of the PKC

Old Days, Spiritual and Miscellaneous
The barrens remind me of my ancestors; they were powerful people; it is sad to see this ugliness
Coming here reminds me of my ancestors who were born here; I really love coming here; it is my home
When you go outside, it makes your soul feel better
We struggled in the past; when our forefathers would come to the barrens, they would bring wood and hunt fox
Women worked hard back then with caring for children, collecting wood, preparing food
In the old days we would travel, visit, take care of one another
The traditional life was easier as we had no worries; there was no mines, no hardships in communities
Today we need the means to go out hunting
Kids are afraid of the cold nowadays; maintaining our traditional ways is difficult
We survived on ground squirrels when no caribou came our way
If there are too many lemmings, they will get rabies
Fox can eat squirrels and get rabies; there was an outbreak 5-6 years ago
It was a little scary at the edge of the pit
My grandma told me to help my fellow Inuit
Today we still rely on one another; Aboriginal and non-Aboriginal
We couldn't believe the when they told us, or anticipate the social problems that have come

Recommendations

We need to decide what to talk about next time (e.g. what about the dyke, pits, etc.)
We should use landmarks (e.g. trees from Walmart ☺) to direct caribou away from mines, well north of Lac de Gras
Steer caribou away from Lac de Gras area to avoid Ekati and DDMI
Return the East Island to the way it was, as much as possible
Cover the East Island with a dome, smooth sides
We need a schedule about how often and when to meet.
The main thing is to get the lichen growing
Study vegetation east and north of the East Island (for caribou)
Study how caribou pellets (poop) fertilizes their migration routes

Study / find-out caribou routes from long ago (review previous reports and talk w Elders)
Keep it nice on the other side of the lake for caribou to pass
We need a women only session on vegetation
Recommend a women only session in the field
Students should have been here
TK Panel wants to see the open pit and water treatment facilities
Concern about leaving airstrip: some want it left for emergencies and others want it removed

Closing comments
I learned a lot
I am grateful to DDMI for bringing us all together
Thank you for having us
Wise words shared here
Being together is part of our healing
I've been afraid to hunt since they confiscated the meat
The youth are walking in our footsteps
Thanks for being open to learning and sharing

Appendix F

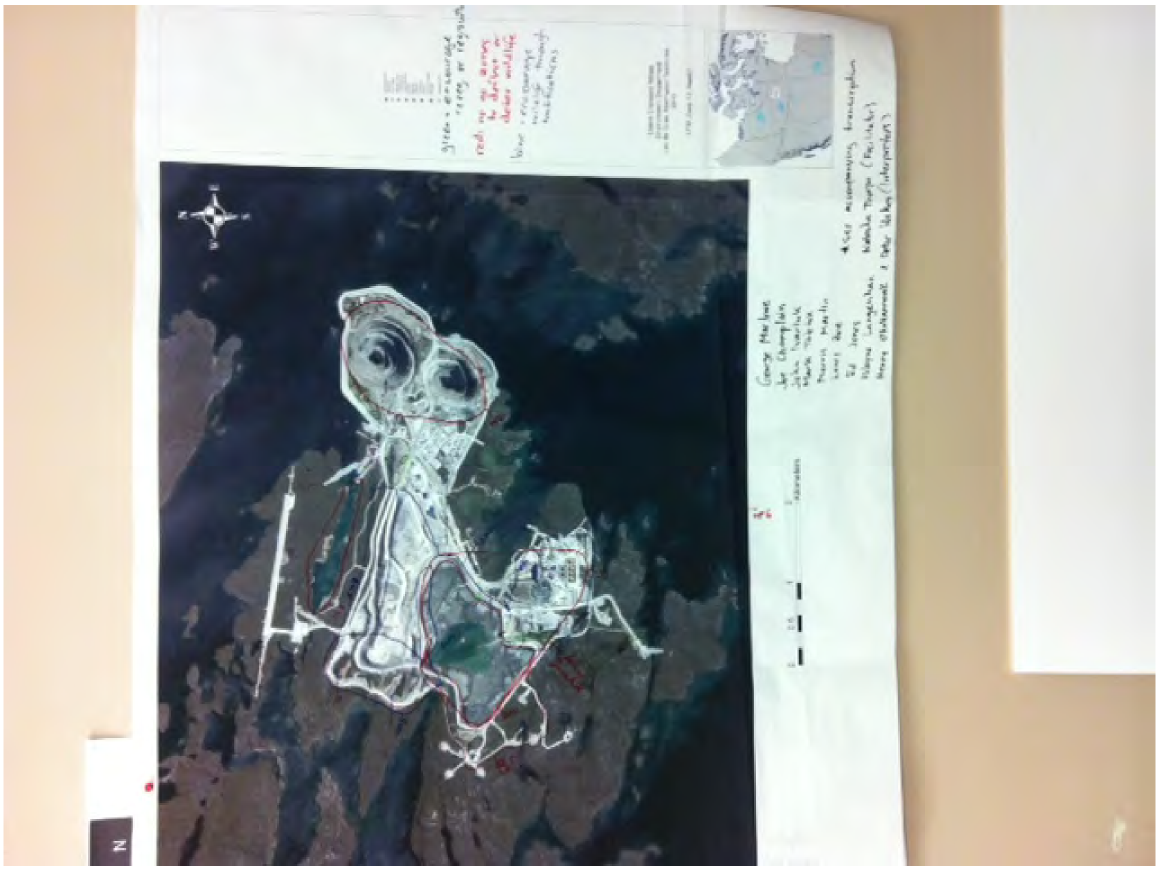
Proposed Re-Vegetation Maps

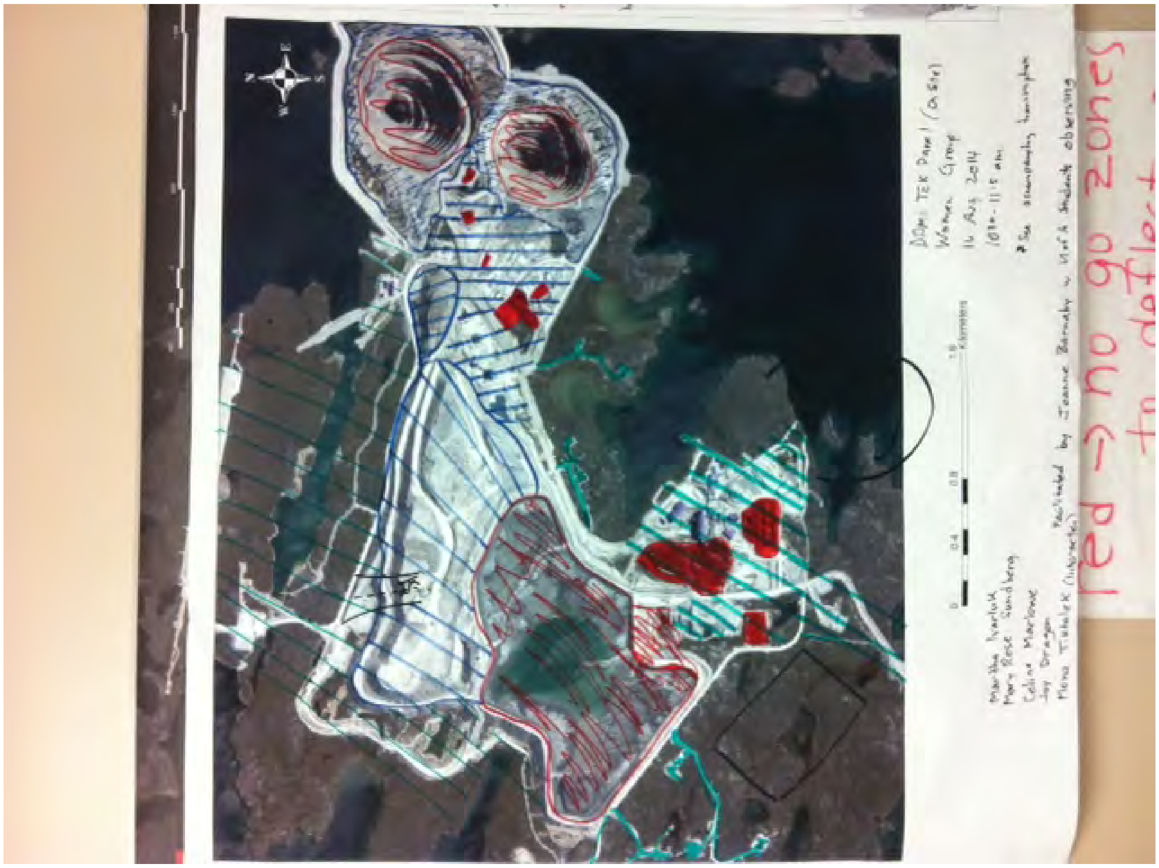
Key to Maps:

Red - You don't want wildlife to go

Green - Encourage re-vegetation or re-growth

Blue - Encourage wildlife through modifications




red -> no go zones

Appendix G

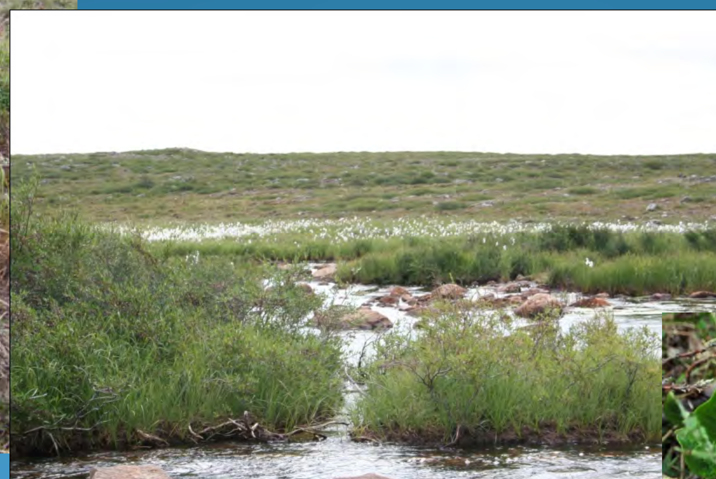
Presentation on Literature Review of TK of Plants

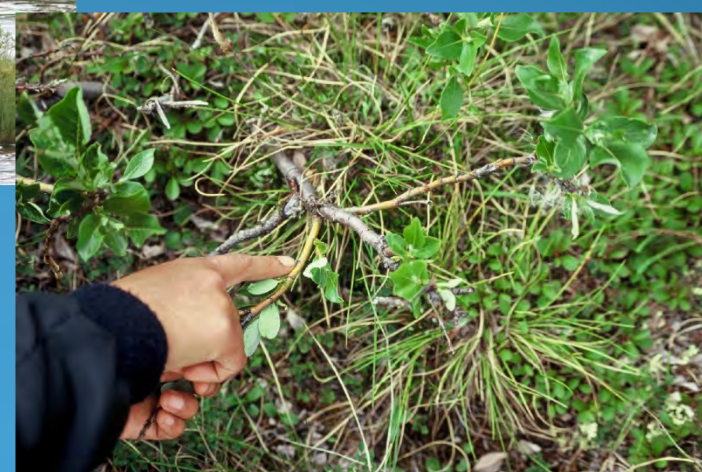
TK Panel Session #7
TK of Vegetation

Diavik Diamond Mine
August 14-18, 2014

Prepared by Natasha Thorpe, Joanne Barnaby and Mistrelle Lockhart

TK Panel Session #7
Resources: TK of Vegetation





Diavik Diamond Mine
August 14-18, 2014

Prepared by Natasha Thorpe, Joanne Barnaby and Mistrelle Lockhart

Why?

- The TK Panel
  - recommended a session on vegetation
  - expressed the need to review TK material that has already been shared
  - doesn't want to repeat themselves
  - respects the contributions of Elders from the past

What did we find?

- TK is an oral tradition: more is known than is written
- Over 100 reports reviewed: 25 reports most relevant
- People know a lot about both individual plants and their importance to the environment

What did we find?

- TK helps us understand connections between:
    - vegetation and animals
    - vegetation and people
    - vegetation and weather and climate (water, temperature)
    - vegetation and land (slope, freeze-thaw cycles)

What did we find?

- Traditional use of vegetation includes:
  - Subsistence (eating, nutrition)
  - Medicine (healing, prevention, treatment)
  - Technology (fire starter, sleeping pads)
  - Animal Food and Habitat (caribou - lichen, bears -willow)
  - Cultural Importance (cottongrass to light the *qullik*)

Questions for our Session

- How do we re-vegetate to keep wildlife safe?
- Which habitats or plants create safety for wildlife?
- Where should habitats or plants be placed?
- What should DDMI do with site roads?

Appendix H

Presentation on Closure Plan

Diavik Diamond Mines

Closure Planning for Vegetation (Plants)
TK/IQ Panel Discussion #7 – August 2014

Document #:
Template #: DCON-029-1010 R2

Closure Planning for Vegetation

Content

Re-vegetation – focus for TK Panel Session 7

- How does Diavik monitor plants right now?
- Closure plan research & development for re-vegetation
- Mine site facilities overview
- Information requests for the TK/IQ Panel

1998 Pre-feasibility

Current Site-wide Closure Objectives

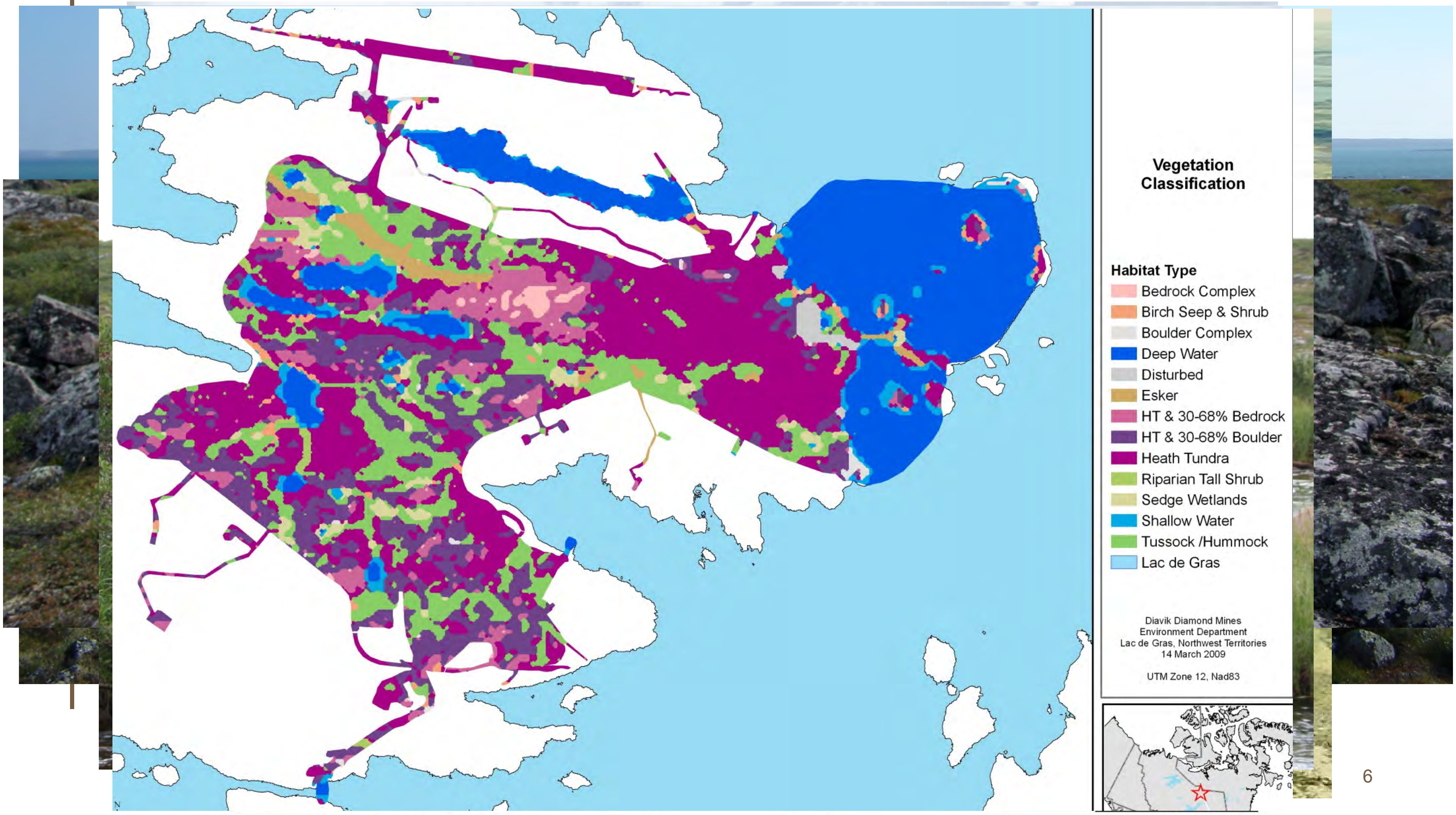
- Safe dust levels that do not affect the taste of plants for wildlife.
- Re-planting targeted to priority areas.
- Features on the land (plants) that match what is naturally found in the surrounding area.
- Safe passage and use for caribou and other wildlife.

Diavik Closure Goals

- Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life
- Land and water that allows for traditional use
- Final landscape guided by Traditional Knowledge
- Final landscape guided by pre-development conditions
- Final landscape that is neutral to wildlife – being neither a significant attractant nor deterrent relative to pre-development conditions
- Maximize northern business opportunities during operations and closure
- Develop northern capacities during operations and closure for the benefit of the north, post-closure
- Final site conditions that do not require a continuous presence of mine staff

How does Diavik monitor plants?

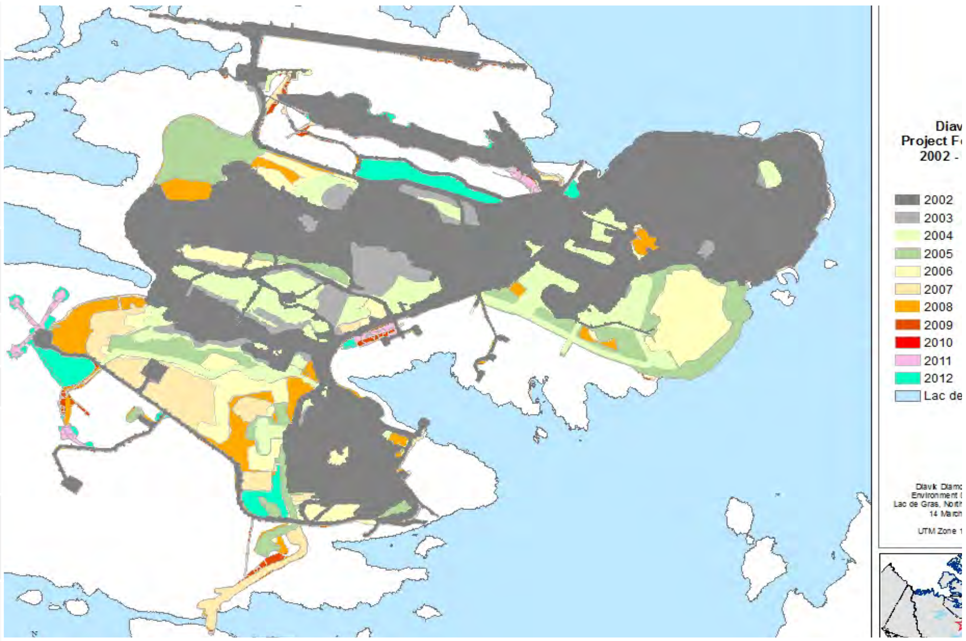
- Baseline



How does Diavik monitor plants?

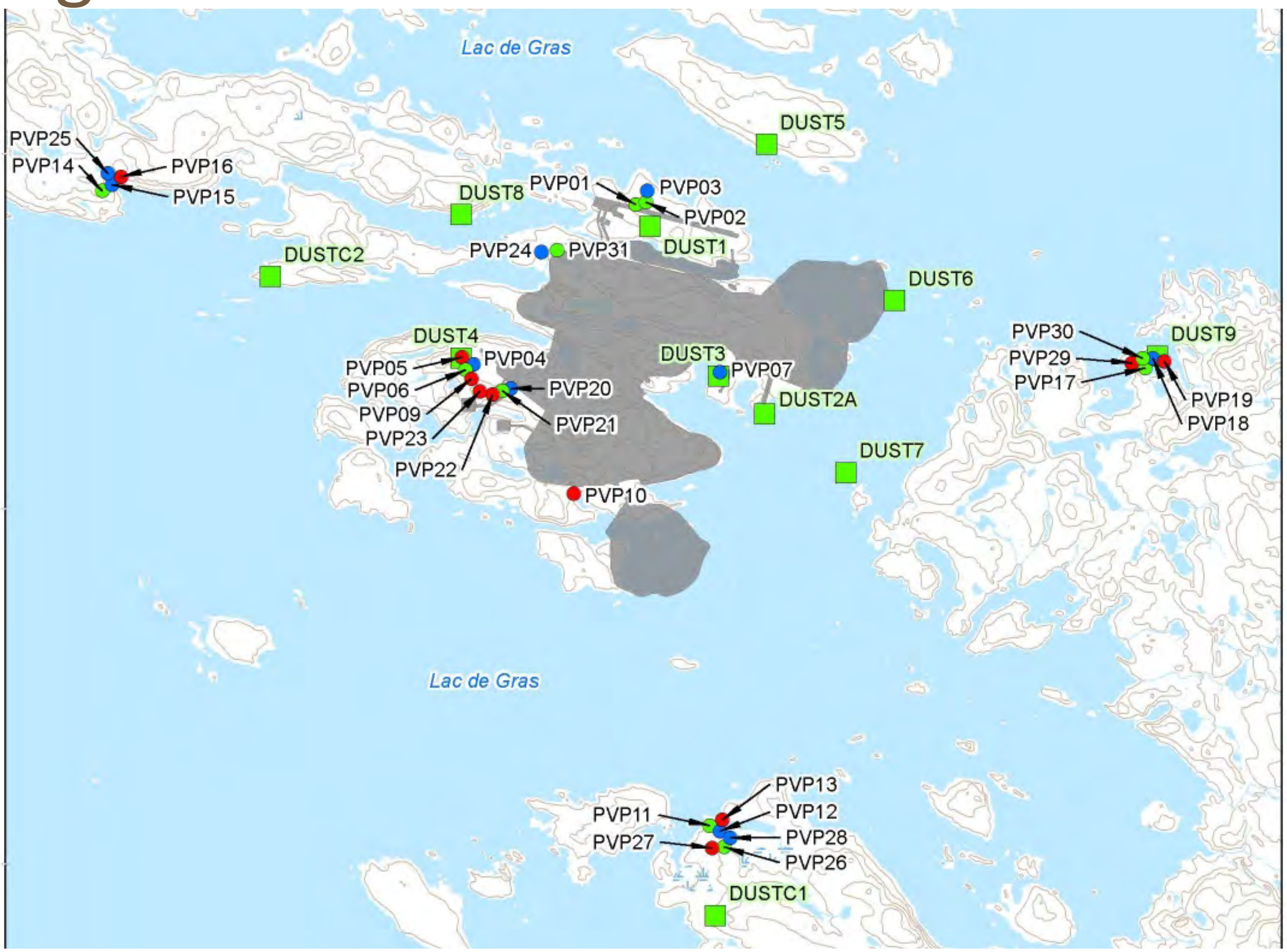
- Habitat loss to date

Habitat Classification	Total Area (/km²) to date	
	2013	Predicted
Heath Tundra	3.2	3.68
Heath Bedrock (30-68%)	0.64	0.78
Health Boulder (30-68%)	1.62	1.89
Tussock/Hummock	1.46	1.64
Sedge Wetland	0.22	0.26
Riparian Shrub	0.03	0.03
Birch Seep & Shrub	0.1	0.11
Boulder Complex	0.04	0.05
Bedrock Complex	0.07	0.07
Shallow Water	0.36	0.48
Deep Water	2.13	3.46
Disturbed***	0.06	0.06
Esker	0.17	0.16
Total (km^2)	10.12	12.67
Total (mi^2)	3.91	4.89



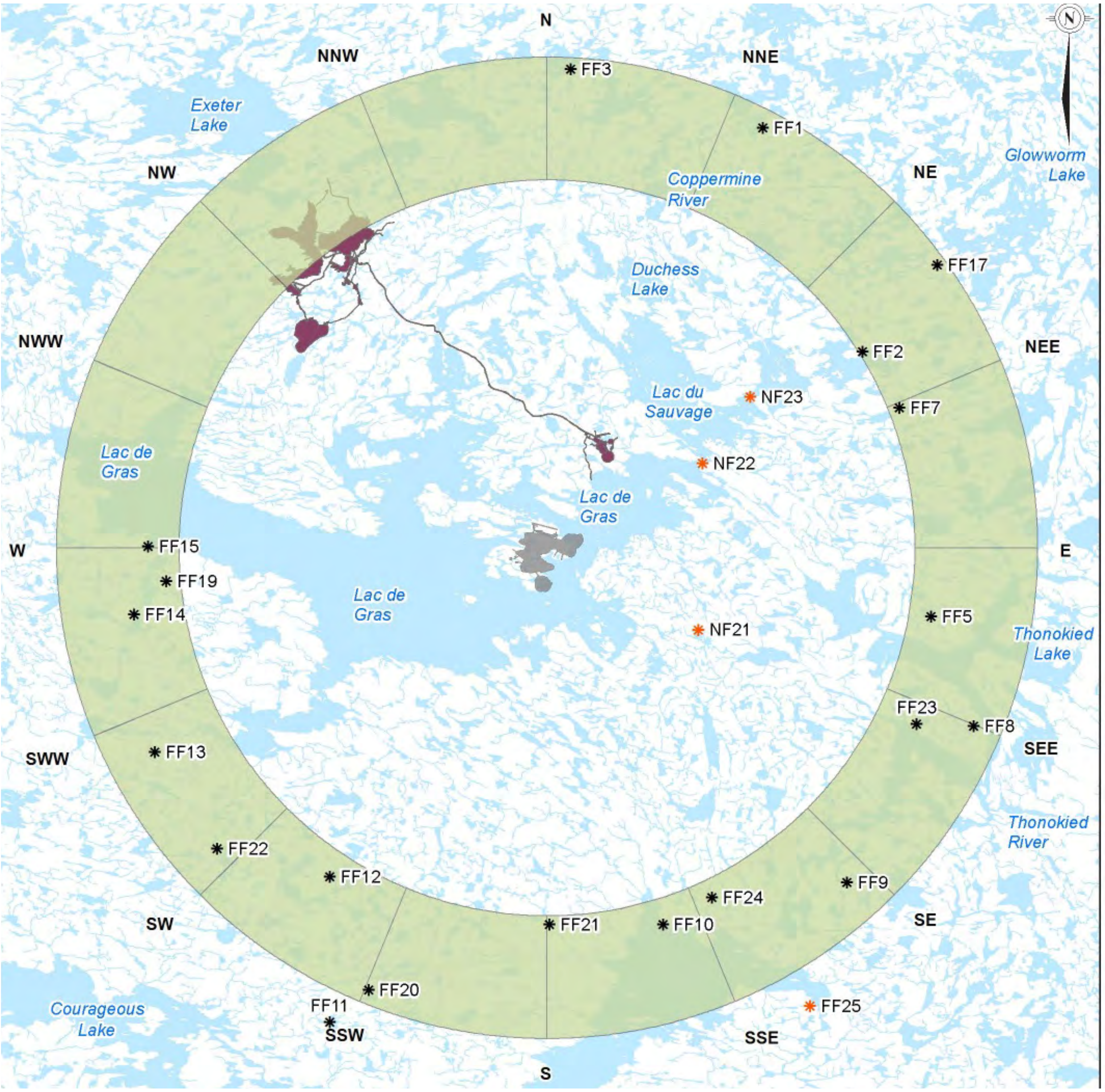
How does Diavik monitor plants?

- Permanent Vegetation Plots (PVP's) & Dust Gauges: on and off site



How does Diavik monitor plants?

- Metals in lichen & possible risks to caribou



Re-vegetation Research

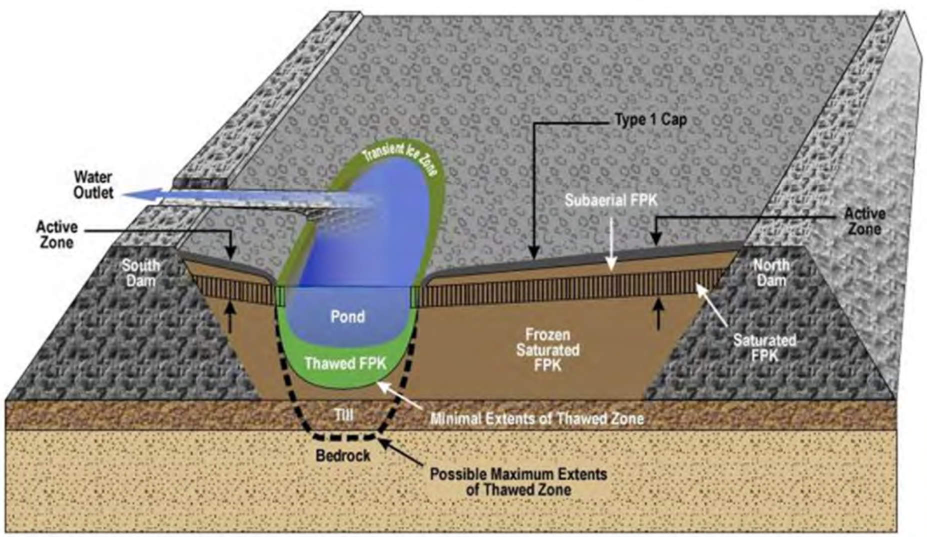
- Testing plants, methods and different materials that can act as soils for use in closure

DDMI Closure Plans – the mine site

- The footprint of the mine will remain identifiable on the land
- Most of the areas you see around site that are still in their natural state will stay that way

DDMI Closure Plans – rock pile & PKC

- The approved closure design does not include re-vegetation of the rock pile or the PKC



DDMI Closure Plans – roads

- Approach to restructuring site roads is yet to be determined

Research on Plants & Soils – What have we learned so far?

- 'Soils'

Research on Plants & Soils – What have we learned so far?

- Amendments (similar to fertilizer)

Research on Plants & Soils – What have we learned so far?

- Plant growth

What have we heard from you so far?

Experiment with possible deflection zones

Leave the airstrip intact – do not re-vegetate it

Smooth slopes on sides of roads & scarify surfaces

Leave some steep areas for denning

Re-vegetate the bottom of the rock pile with shrubs

Re-vegetate according to baseline TK

Use willow to stabilize ground

Re-vegetate to support biodiversity

Create marshy areas with moss, lichen & berries

Create wildlife habitat

Try to re-create natural conditions if possible

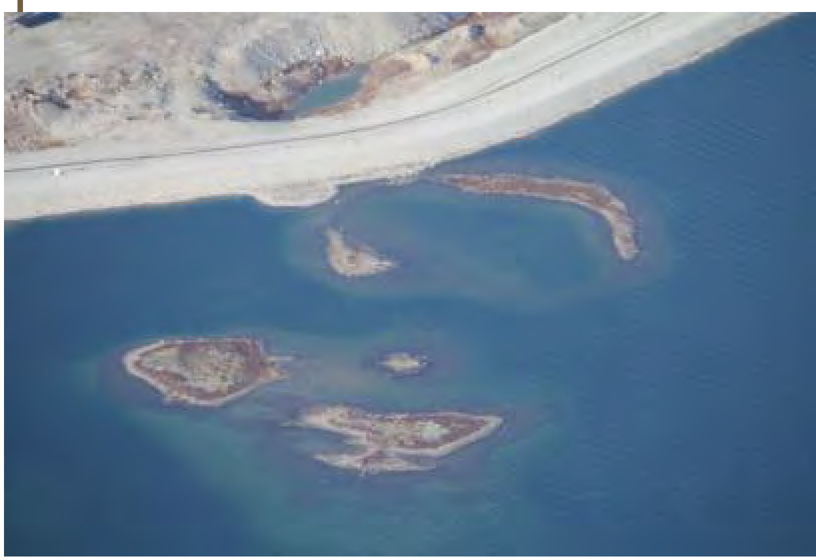
Provide travelways for caribou made of soft materials

Re-vegetation at Closure – Requested Input

1. At a side-wide level, what is the best approach to re-vegetation to help wildlife stay safe?
   a) Passageways
   b) Stay and play
   c) Keep away
2. What kinds of habitats or plants would be useful in creating that approach?
3. Where should these types of habitats or plants be placed; equal effort across the site or area-specific focus?
4. What should DDMI do with the site roads?

Overview of Closure Plan by Area

Open pits



Rock Pile

North inlet

PKC

Infrastructure

Re-vegetation at Closure – Requested Input

1. How do we re-vegetate (grow plants) to keep wildlife safe?
2. Which habitats or plants create safety for wildlife?
3. Where should habitats or plants be placed?
   a) Focus on certain areas or use the same amount of effort all over the site?
4. What should DDMI do with the site roads?

Appendix I

TK Panel Recommendations

TK Panel Session #7 Recommendations

Diavik Diamond Mine

August 14-18, 2014

Introduction

- This TK Panel Session on Vegetation was requested by the Panel
- Diavik asked for direction on four key questions related to vegetation
- The TK Panel has provided general comments, responses and recommendations

Questions posed by Diavik

- How do we re-vegetate to keep wildlife safe?
- Which habitats or plants create safety for wildlife?
- What should Diavik do with site roads?
- Where should habitats or plants be placed?

General Comments

- Nature is powerful, natural re-vegetation should be encouraged overall
- At the same time, some re-growth should be encouraged
- There are specific areas where re-vegetation should not be encouraged out of concern that any possibility of contamination going up the food chain should be avoided: there are areas where we do not want wildlife to forage

General Comments

- There is a lot of TK that has been shared in the past about specific plants and their uses by people and animals, the completion of the literature review report together with results from our session will give specific direction on some of the questions raised by Diavik
- Climate change is affecting vegetation now – this will only increase in the future – warming is introducing new species and everything is growing faster
- Wild fires south and west of the mine may force wildlife to come closer to the mine as their food source gets burned: smoke and ash from the forest fires will impact the air and vegetation

General Comments

- It is important to always get the women's perspective – they have specialized knowledge that is needed to make good recommendations
- The Panel supports the research being carried out by the University of Alberta students and wants to work together to watch that develop over time
- The work of the TK Panel should be shared with the students

General Comments

- The TK Panel needs to meet more often in order to keep the momentum going
- Diavik has said they will not remove the slime from the mine site, we must re-visit our recommendations to re-vegetate the PKC
- Since the diamond mines started, caribou are migrating further south and east

Recommendations: How do we revegetate to keep wildlife safe?

1. Do not disturb new areas, protect natural vegetation areas on the Island (except for A21 and the rock pile for A21)
2. Study vegetation east and north of the Island to understand good caribou habitat
3. Use traditional techniques (e.g. flags, trees) to keep caribou away from areas that are unsafe (both near and far from site)
4. Test both natural and seeded plot plants for toxicity

Recommendations: Which habitats or plants create safety for wildlife?

5. Create safe passage for caribou over the rock pile and through the site following their old migration routes on the north and south east sides (see map)
6. Use fine crushed rock on passage-ways to protect the feet of the caribou (like what is on the sides of the airstrip right now – August 2014)
7. Create barriers and other means between rock pile and PKC to discourage animals from to the PKC
8. Allow more time for TK Panel to talk about options for keeping animals away from certain areas (e.g. fencing)

Recommendations: What should Diavik do with site roads?

9. Create slopes on roads and on the rock pile similar to that on the test pile to support safe travel for animals using crushed rock on the surface (like airstrip)

Recommendations: Which habitats or plants create safety for wildlife?

9. Transplant a variety of natural ‘tundra mats’ and compare them to seeded test plots; this will help natural recovery by maintaining the biodiversity of the area
10. Use the natural tundra mat to guide plant selection to ensure natural balance (learn from the quilt)

Recommendations: Which habitats or plants create safety for wildlife?

12. When using fertilizers, use natural local fertilizers like droppings from local animals (the question of treated human sewage will be revisited)
13. Complete the TK literature review report so that it can be used as a guide in the vegetation program and closure plan and be available to communities

Recommendations: Where should plants and habitats be placed?

14. We need to revisit the North Inlet in terms of it being a no go zone, replanting zone or encouraging wildlife zone.
15. The maps are not yet complete and we need to spend more time discussing and finalizing them.
16. The TK Panel would like to mark maps that show TK of traditional caribou migration routes and use this "big picture" to identify areas for sloping (modification) on the East Island
17. Have a women's only session in the field next summer to address vegetation and other issues of interest to them

Recommendations: TK Panel membership and operations

18. Diavik must meet its commitments to support a minimum of two TK Panel sessions a year
19. TK panel members need to verify TK recommendations with elders back home
20. Require one male and one female member on the TK Panel (or formal alternates); where possible, members must know the LDG area (directed to Aboriginal governments)
21. Formalize our recommendations to Aboriginal governments to have youth participate
22. Celebrate our TK Panel as a model for other mining companies

Recommendations: Topics for Future Sessions

- Panel (vs. DDMI) to develop a list of questions to answer related to closure, and establish priorities to guide future sessions
- Review 'big picture' closure and reclamation plan and share literature / report review jointly with EMAB
- Develop a plan for including both traditional knowledge and western science in regional monitoring for post closure
- TK Panel to draft letter to other mining and exploration companies and governments regarding opportunities for Aboriginal peoples in closure

Recommendations: Topics for Future Sessions

- Water, fish, shoreline, muskeg, plants/filtration at closure
- Air quality
- Knowing the slime is not going to be removed, pull together what has been said about the PKC and tie this into another session
- Climate change impacts on closure
- Cultural landscapes and closure healing ceremonies to ask the spirits to return

Recommendations: Topics for Future Sessions

- Update 'Working Together' Document
- Compare non-Native and Native plants re-vegetation occurring naturally: how Nature is healing
- Seeing with Our Own Eyes
  - Want to see what is being mined (e.g. diamonds) so we can believe what is being mined
  - Pits: Panel wants to go into the pits and to the water treatment plant, some want to go underground

Recommendations: General

- DDMI should request regular meetings in each community with women during annual updates
- Provide participants with a copy of this presentation to take back to the communities

Cumulative Effects

- Support from Diavik requested by TK Panel to:
  - Acknowledge the problems created by multiple industrial activities (exploration and development) occurring at the same time along the caribou and fish migration routes
  - Encourage Regulators to limit the number of mines operating at one time to recognize that the land and animals can only handle so much especially when climate change is also happening fast. No further industrial activity on migration route should be approved until the caribou population grows.

Cumulative Effects

- Create a joint TK Panel session with other mines to address issues of concern around closure in the area (e.g. caribou migration, water and fish in Lac de Gras): work together
- Develop a map that brings together known caribou migration routes and calving grounds of the past (TK from all five groups) – Bathurst and Beverley
- Encourage the filling of the Misery Pit as it is in the middle of the caribou migration route (TK Panel to draft letter to EKATI)

Appendix I-3

Literature Review: Traditional Knowledge of Plant Life at the Diavik Diamond Mine

October 2014

LITERATURE REVIEW: TRADITIONAL KNOWLEDGE OF PLANT LIFE AT THE DIAVIK DIAMOND MINE

Prepared by Natasha Thorpe, Joanne Barnaby and Mistrelle Lockhart

Thorpe Consulting Services

Disclaimers

The document does not represent the results of community consultation. It is subject to the "No Prejudice" clauses of Article II, Section 2.1 of the *Environmental Agreement for the Diavik Diamond Project.* The document represents the work of the TK/IQ Panel only, and does not necessarily reflect the views of any Party to the *Environmental Agreement.*

The authors have attempted to review and report on traditional knowledge related to plants in the Lac de Gras area. The results of this review cannot be considered to be comprehensive nor can it be assumed that what is presented is the entire 'body of knowledge' held by traditional knowledge experts. Further, it is not clear that knowledge holders have reviewed their contributed quotes cited in the reviewed sources; as such, it is likely that some errors exist.

Executive Summary

As part of closure planning, Diavik supports a Traditional Knowledge (TK) Panel that is assembled to provide guidance and recommendations on how best to incorporate TK into the planning process. Diavik has a strong commitment to re-vegetation and has sought to meaningfully integrate TK of tundra plants as part of closure planning. In addition to supporting TK Panel discussions relating to re-vegetation onsite, Diavik has also responded to Panel recommendations and commissioned Thorpe Consulting Services (TCS) to carry out a high-level literature review of publicly available references related to TK of plant life in the Lac de Gras area. It is envisioned that this information will inform the Diavik closure plan, and be used as a reference for the TK Panel and communities when considering ecosystem needs at closure, from an Aboriginal perspective.

Through the internet search and email requests, a total of 92 reports and books were accessed to search for previously recorded, publicly available knowledge of Aboriginal use of plants in the Slave Geological Province with a focus on the Lac de Gras area. Of the 92 examined, 33 books and reports were most relevant and thus informed the bulk of the traditional knowledge summarized in this report.

Very few references found in the literature are specific to use in the Lac de Gras area, other than works carried out for the Diavik, Ekati or Snap Lake mines. Thus, plants identified to be in the Lac de Gras area and known to be important regionally for Aboriginal use became the focus for reporting relevant TK. This literature review cannot be assumed to be comprehensive; rather, it is a start in trying to assemble TK of plants in and around the Lac de Gras area. Additionally, it is not clear that the studies reviewed included full consideration of the knowledge that women possess as primary harvesters of vegetation and as meat processors.

Results from the literature review were broken into two main categories: plants and people, and plants and animals. Within both categories, plant types were broken into major groups (i.e. berries; flowering plants; lichens, mosses and mushrooms; trees and shrubs) and identified according to use; food, medicine, tools and technology (plants and people) and forage and habitat (plants and animals). Through the literature, TK demonstrates that blueberries and cloudberries were identified as prized food sources. Much of the low-lying muskeg areas around Lac de Gras likely created good berry picking habitat in the past, particularly for cloudberries. Labrador tea, in part because it can be burned even when green, is also an important plant for food and medicine. Birch and willow stand out, in large part because of their multiple technological uses and as a key species for wildlife. Pockets of spruce and willows were also very important for camping, providing fuel, animal dens and more. Several types of moss, especially peat moss and lamp moss, were traditionally very important for medicinal, ceremonial and technological uses. People have long understood that lichens are a critical food source for caribou and so must be protected.

Identified gaps in the TK literature reviewed for this report include:

- Lack of documented use of plants for food and technological use in the Lac de Gras area, particularly for the YKDFN and NSMA
- Shortage of well documented TK at a small scale, regional and landscape level analysis:

  - Integration and reporting of TK at a landscape level can be challenging given the predominance of a reductionist western scientific paradigm in most environmental assessment and reporting
  - The ways in which botanists view plant assemblages may not be parallel with the ways that Aboriginal peoples make sense of the landscape
- TK of practices for winter/early spring use of vegetation:
  - preservation methods carried out in the fall seem to be better documented
  - This type of information might be more readily available in proper ethnographies
- Detailed understanding of which types of plants animals tend to avoid:
  - While not represented in the literature, it is probable that this TK is held by Aboriginal peoples of the Lac de Gras area
- Detailed understanding of plant succession, colonization and response to disturbance
- Review of Aboriginal trail networks, place names, camps and known lifeways for references to vegetation and how plants were utilized to identify suitable resource areas

This high-level literature review, although not exhaustive, is a start in understanding the significant traditional knowledge available about the pre-development state of the environment of the Lac de Gras area. This knowledge extends to how vegetation contributes to the health and diet of wildlife in the area and how Aboriginal peoples used vegetation to meet their food, medicinal and technological needs. This knowledge provides critical information about vegetation that is required to support future use of the area by both wildlife and Aboriginal peoples.

Survival in harsh conditions necessitated that peoples become astute observers of environmental relationships (Berkes 2012). Every day brought multiple opportunities to study "indicators" of healthy land or wildlife populations. Accordingly, many indicators identified within the body of TK have helped communities understand the changes they see as a result of development. These same observations and indicators could be useful in developing closure plans and post-closure monitoring programs.

Insight into the complexity of ecological relationships, particularly at a landscape level, was identified through some of the TK references for environmental indicators. For example, tying the harvest of a particular plant to a certain moisture condition, or looking for green tundra where caribou migrations have resulted in added natural fertilizer. The documents reviewed for this report typically did not focus on the specific broader landscape questions that Diavik requires for planning reclamation. However, they do provide the building blocks required to enable TK holders to contribute to planning at this landscape level, and a place from which to start articulating their vast TK of tundra plants.

In closing, additional work is recommended to more fully understand TK of tundra vegetation in the Lac de Gras area. Ideally, Elders would also have an opportunity to verify and expand upon this report, particularly where use in the Lac de Gras area has been assumed based on reported Aboriginal use elsewhere.

Table of Contents

List of Figures

Acknowledgements

> Although we've been taught for many thousands of years with our TK and our grandmothers and grandfathers have always have taught us a lot while we were growing up . . . But we get frustrated once in a while when they start to say something a little differently or science is a little different from TK and to get the whole picture (Bobby Algona in TCS 2013b: B-15).

The authors are grateful to have worked with northern Aboriginal peoples and learned directly from their expertise of the land. This report provides a small window into the universe of traditional knowledge held by those most intimate in their relationship with their galaxy. Particular thanks go to members of the Diavik Traditional Knowledge Panel as well as all of the Elders and ceremonialists who have shared generously so that others might better understand human and wildlife use of plants in the Lac de Gras area.

Author Biographies

Natasha Thorpe specializes in integrating indigenous knowledge and western science in a resource management context. Ms. Thorpe works primarily in Arctic and western Canada in the fields of environmental assessment, environmental change, capacity-building, and engagement. Over the last few years, Thorpe Consulting Services has brought together five Aboriginal signatories to develop and implement ways to integrate traditional knowledge into mine monitoring and closure planning in both meaningful and practical ways through the TK Panel presently administered by the Diavik Diamond Mine. Ms. Thorpe holds a MRM (Resource Management) from Simon Fraser University, and has studied indigenous knowledge systems under the guidance of many Elders for over eighteen years. Ms. Thorpe has collaborated with Inuit and First Nations in multiple conference presentations and co-authored several papers, reports and books on the subjects of Inuit qaujimajatuqangit and traditional knowledge.

Joanne Barnaby has extensive experience in the development of initiatives that are designed to recognize and utilize the full benefits of traditional Indigenous knowledge enabling aboriginal communities to effectively participate in modern challenges. Ms. Barnaby was instrumental in the development and establishment of a government wide traditional knowledge policy in the Northwest Territories and in getting Indigenous knowledge on the United Nations Biodiversity Agenda. Through her work as founding CEO for the Dene Cultural Institute, Joanne established a range of traditional knowledge research and development programs. The development of effective research methodology has led to Aboriginal communities sharing their knowledge with others with confidence that it will be respected by the social science community, industry and government. These programs are recognized as leading edge initiatives that now serve as models for indigenous communities world-wide.

Mistrelle Lockhart is an Anthropologist with over 15 years' experience as an archaeologist, museum specialist, and research co-ordinator involved in community sustainability, climate change adaptation, cultural impact assessment and cultural landscape impact assessment projects in the Canadian Arctic, south-western British Columbia and the American Southwest. Mistrelle has a strong multi-disciplinary research skill set which has been integral to her work in the consulting and academic research industries. She has co-ordinated large interdisciplinary, multi-institutional and multi-stakeholder research projects which required the liaising and coordination of a diversity of stakeholders - from community groups, to academic researchers, to government representatives and those from the private sector. Mistrelle's research management experience has also involved the design of research protocols, data collection and the analysis of data. She has also designed and implemented community engagement programmes such as workshops, conferences and public events.

Abbreviations and Acronyms

DAR	Developer's Assessment Report
DDC	Dominion Diamond Corporation
DDMI	Diavik Diamond Mines (2012) Inc.
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EMAB	Environmental Monitoring Advisory Board
IEMA	Independent Environmental Monitoring Agency
KIA	Kitikmeot Inuit Association
IQ	Inuit Qaujimajatuqangit
LKDFN	Łutsel K'e Dene First Nation
NIRB	Nunavut Impact Review Board
MVEIRB	Mackenzie Valley Environmental Impact Review Board
MVLWB	Mackenzie Valley Land and Water Board
NSMA	North Slave Métis Alliance
SLEMA	Snap Lake Environmental Monitoring Agency
TK	Traditional Knowledge
TG	Tłı̨chǫ Government
YKDFN	Yellowknives Dene First Nation

1.0 Introduction

> My mother taught me these things. If she had not shown me these things, I would not know them. Sometime we would walk by ourselves and other times we had company, but I always paid attention (Aalasi Joamie in Joamie and Ziegler 2009: 10)

Aboriginal lifeways and travel routes throughout the Lac de Gras area of the Northwest Territories tell of a long history of hunting, fishing, berry-picking and other subsistence activities. It is a place important to both the Dene and Inuit and indeed was a meeting area for many, where lifelong friendships were developed between these groups. Through time, the relationship between Aboriginal peoples and the Lac de Gras area has evolved as the region now experiences significant mining activity.

Lac de Gras is renowned for abundant and quality diamonds currently mined from three active mines: the Diavik Diamond Mine, Ekati Diamond Mine and the Snap Lake Diamond Mine. The Diavik Diamond Mine (*herein*, Diavik) is located approximately 300 km northeast of Yellowknife (Figure 1) and is a joint venture between Rio Tinto and the Dominion Diamond Corporation. Recognizing Aboriginal peoples as experts of the land, water and surrounding environment in Lac de Gras, Diavik is committed to integrating Traditional Knowledge (TK) into current operations and planning for closure and reclamation.

In 2012, a TK Panel was established to assist Diavik with this commitment and to work with local communities in facilitating appropriate and meaningful accommodation of TK in the planning and review of environmental management and monitoring. The TK Panel meets regularly on topics that Diavik and the TK Panel identify as important and has membership from the five Aboriginal parties to Diavik's Environmental Agreement:

- Kitikmeot Inuit Association (KIA)
- Łutsel K'e Dene First Nation (LKDFN)
- North Slave Métis Alliance (NSMA)
- Tłı̨chǫ Government (TG)
- Yellowknives Dene First Nation (YKDFN)

During an October 2012 session, the TK Panel spoke about the importance of vegetation in closure planning and that current closure planning and re-vegetation strategies should build upon TK shared through other forums. Specifically, the TK Panel advised Diavik to *ensure that TK/IQ knowledge that has been shared in the past is incorporated into future planning, specifically in relation to caribou and vegetation* (EMAB 2012: 6).

Subsequently, Diavik then contracted Thorpe Consulting Services (TCS) to review TK literature pertaining to plant life in the Lac de Gras area. This literature review was carried out in preparation for an August 2014 TK Panel session focused on re-vegetation for closure planning. Diavik also funded a concurrent review of the scientific literature related to northern re-vegetation initiatives.

1.1 Background

> Now, young and old alike seem to be ignorant about tundra vegetation. They do not seem to realize that there is a lot of food out there. I know it must look like there is not much food, but there is. We must notice the plants and we must look after them well. There are foods out there that we can cook or eat after picking them. Plants are healthy for us (Joamie Aalasi in Aalasi and Ziegler 2009: 12).

The purpose of this work was to conduct a high-level review of publicly available TK references related to Lac de Gras area plants for use as a reference for the TK Panel and to inform current closure planning and research. The task of carrying out a TK literature review can be challenging given the nature of TK, the low number of published reports relevant to TK of plant life specifically, and a relatively small geographical area of focus, such as Lac de Gras. As this is a high-level literature review, it cannot be assumed to be comprehensive; rather, it is a start in trying to assemble TK of plants in and around the Lac de Gras area.

While a vast library of TK for the Lac de Gras area clearly exists in the memories of Elders across the North, there are many reasons why much of this has not been well documented. For example, TK is primarily shared through oral tradition rather than through the written word; many TK holders do not necessarily participate in documentation initiatives; TK reports of the past may not be in a digital or accessible format; and many Elders are passing away before their TK is documented. Even where TK has been well recorded, it is not necessarily available to the public, owing to issues around confidentiality and intellectual property rights. The work also may not have been verified, thus errors are likely. For these reasons, the challenges of finding publicly available literature pertaining to TK of plant life in the Lac de Gras area were significant and are reflected in this report.

Re-vegetation is an important consideration in closing the mine and in addition to work carried out by the TK Panel, Diavik is supporting several re-vegetation studies through the University of Alberta. Efforts began more than ten years ago and have increased significantly over the last few years. Some of the re-vegetation test plots explore various substrates as well as species for re-vegetation.

In particular, Diavik hoped that the literature review would:

- Identify the species in the area that are most important to communities and reasons why they are important (e.g. food, medicine, ceremony)
- Cross-reference such species with those that have been used to date in the re-vegetation research
- Capture Aboriginal names for common plant species (by organization)
- Clearly identify and explain any gaps that may exist in the literature
- Any other relevant themes relating to closure considerations for Diavik

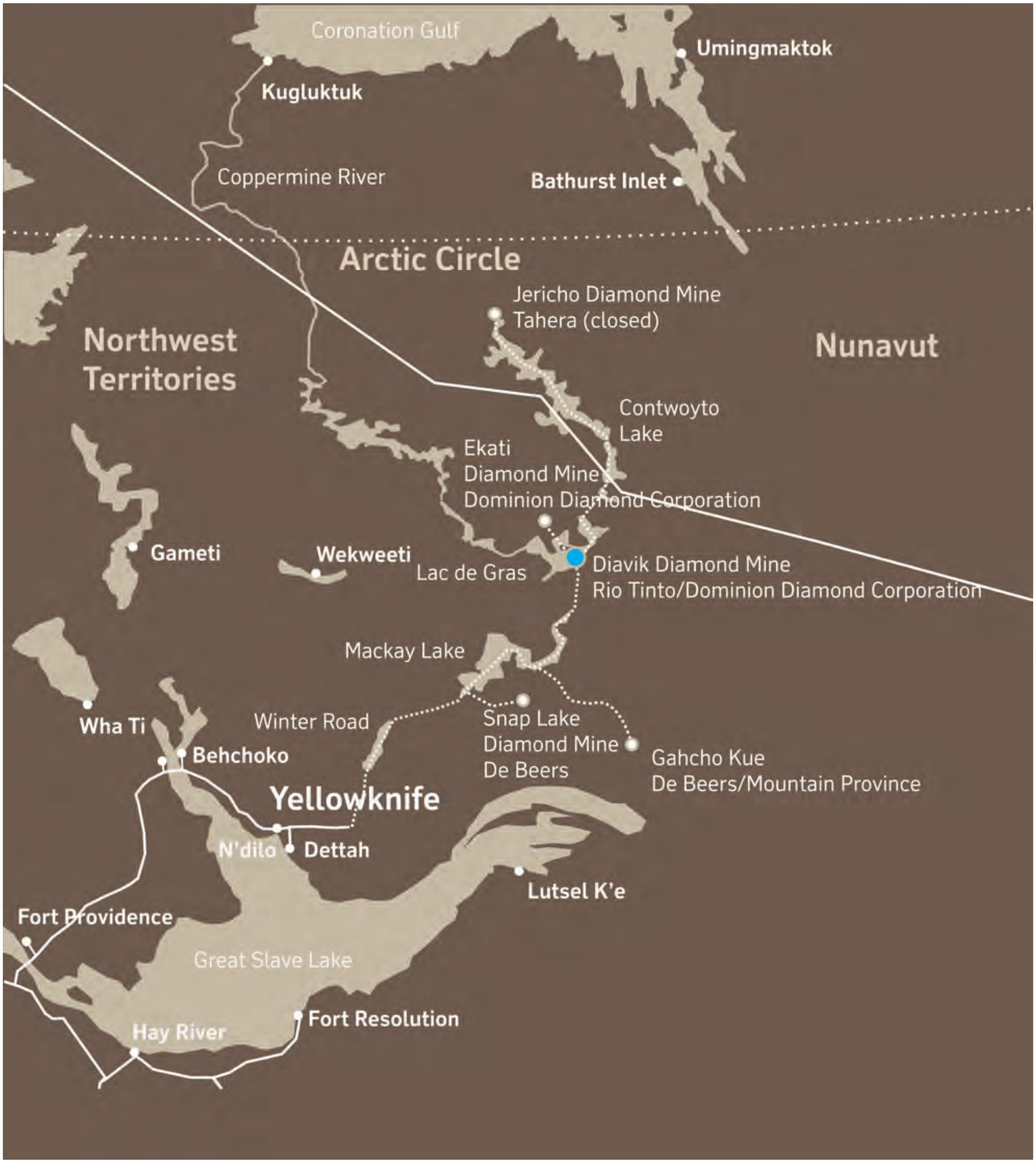


Figure 1 **Map of Diavik Diamond Mine and Aboriginal Communities**

This report consists of nine sections, including:

- Section 1.0 - Introduction
- Section 2.0 – Methods
- Section 3.0 – Results
- Section 4.0 – Plants and People
- Section 5.0 – Plants and Animals
- Section 6.0 – Risks and Impacts
- Section 7.0 – Re-Vegetation
- Section 8.0 – Gaps in the Literature
- Section 9.0 – Conclusions

2.0 Methods

Given that this review was intended to be high level, an internet search along with a small number of email requests for relevant literature were the main ways in which references were identified. Accordingly, it was not possible to be exhaustive in this search given the scope.

The review started by looking at vegetation works carried out directly for Diavik mainly to develop an understanding of vegetation in the area, including:

- Vegetation baseline studies (Burt 1997)
- Dust monitoring studies (EMAB 2006)
- Soil and lichen sampling (Tłı̨chǫ Government 2013)
- Permanent Vegetation Plot (PVP) monitoring and analysis, as reported in Diavik's Wildlife Monitoring Reports (2001-2008, alternating years)
- Comprehensive Vegetation (PVP) and Lichen Monitoring Program Reports (Golder 2011; 2014)
- University of Alberta reclamation studies report (Naeth and Wilkinson 2011)

Next, the following relevant TK works carried out under the West Kitikmeot Slave Studies (WKSS) were consulted:

- Caribou and habitat studies (Dogrib Treaty 11 Council 2001a; 2001b)
- Monitoring in Łutsel K'e traditional territory reports (LKDFN 2001a; 2002; 2003; 2005).
- Caribou, calving grounds and climate change (Thorpe and Eyegetok 1998; Thorpe et al. 2001)

Google search terms, internet database investigation and governmental agency online document repositories were consulted in order to investigate a variety of types of publicly available materials, such as academic journal articles, environmental impact statement reports and supporting documentation, and reports produced by Aboriginal communities themselves.

In terms of internet databases, the primary ones utilized were Google and Google Scholar. Specific search terms utilized were:

- Dene medicine
- Dogrib medicine
- Inuit medicine
- Tłı̨chǫ medicine
- Chipewyan medicine
- Łutselk'e Dene medicine
- Yellowknives Dene medicine
- Tłı̨chǫ vascular plants
- Yellowknives Dene vascular plants
- Inuit ethnobotany
- Dogrib ethnobotany
- Tłı̨chǫ ethnobotany
- Yellowknives ethnobotany
- Chipewyan ethnobotany
- Łutselk'e Dene ethnobotany
- Diavik baseline vegetation
- Ekati baseline vegetation
- Snap Lake baseline vegetation

Note that when using the term "Inuit" in the search engines, the majority of the results were materials discussing eastern Arctic communities. So the term was not broadly used in the Google and Google Scholar searches due to the results providing materials from outside the project area.

It was known from previous research activities that there is little publicly available material discussing NSMA traditional knowledge. To address this and ensure relevant materials were included in this study, documents were sought directly from the NSMA Research and Resources website.

In addition to the internet database search terms listed above, a snowball methodology was used during the research process whereby references from one document were used to help find others (Babbie 2001). Titles that were encountered in the references of examined reports were also searched for in Google or Google Scholar. When searching for all materials on these databases, other titles of potential interest were present in the search results, and if relevant, they also were consulted.

A number of other specialized internet databases, government and monitoring agency websites were investigated for relevant information. These included:

- ASTIS (Arctic Science and Technology Information Service) – Search terms used were: Inuit Plants and Ethnobotany
- University of Saskatchewan iPortal (Indigenous Studies Portal Research Tool) – Search term used: Ethnobotany
- MVEIRB (Mackenzie Valley Environmental Impact Review Board) Public Registry – Searched the following projects: DeBeer's GahchoKué and Snap Lake Projects; Diavik; Ekati; Thor Lake; and Seabridge Gold
- MVLWB (Mackenzie Valley Land and Water Board) Public Registry – Searched the following projects: Diavik; Ekati and Seabridge Gold
- NIRB (Nunavut Impact Review Board) Public Registry – Searched the following projects: Miramar's Hope Bay Project; Wolfden's High Lake Project; Tahera Diamond's Jericho Project; the BIPAR Project and Sabina Gold and Silver's Back River Project

- EMAB (Environmental Monitoring Advisory Board)– Searched for relevant documents on the agency's report and publication pages
- IEMA (Independent Environmental Monitoring Agency) – Examined the Ekati EIS report (Baseline Vegetation and TK sections)
- SLEMA (Snap Lake Environmental Monitoring Agency) – Searched for relevant documents on the agency's report and publication pages

Within the projects examined from the Government and Monitoring Agency databases, the Developer's Assessment Report (DAR), Draft Environmental Impact Statement (DEIS) and Environmental Impact Statement (EIS) reports were sought out to discover materials which would contain either traditional knowledge studies or vegetation baseline reports. The vegetation baseline reports were investigated not only for the plant species recorded, but also to determine if any traditional use of plants were included within those reports. In passing, baseline wildlife reports were also examined for the same reason – to identify if there was traditional knowledge shared discussing vegetation utilized (as food or preferred habitat) by any animal species.

A select number of wildlife species scientific reports were also consulted in reference to discussions of Arctic food webs. The purpose of this was to identify connections between wildlife species and vegetative species that were grazed upon. This information was then used to investigate TK discussions of these species and identify the importance (if possible) of the grazed vegetation species for those wildlife species.

Through the internet search and email requests, a total of 92 reports and books were examined to search for previously recorded, publicly available knowledge of Aboriginal use of plants in the Slave Geological Province with a focus on the Lac de Gras area. Of the 92 examined, 33 books and reports were utilized for the bulk of the traditional knowledge summarized in this report and are listed with an asterisk (*) in the references cited at the end of this report. In addition, the full list of reports and books examined which did not contain relevant data for inclusion into the report is attached in Appendix A. Sources that may be relevant but were not readily available so were not reviewed are included in Appendix B. Several references with details of Aboriginal plant use outside of the Lac de Gras area were also consulted to extrapolate possible use in the Lac de Gras area (Joamie and Ziegler 2009; Marles et al. 2002; Turner 2014). The scope of the literature review and the narrow geographic area limited a more comprehensive review of these additional references.

Knowledge of plant use within Aboriginal societies has long been shared orally with those demonstrating spiritual and healing powers or the appropriate respect and interest in learning. As with all TK, this expertise is dynamic, evolving and altered through personal experience (Berkes 2012; Legat 2012). Accordingly, what is documented through this literature review should be understood to be a living body of knowledge.

3.0 Results

The literature reviewed for this report suggests that Aboriginal peoples continue to hold a strong understanding of plant life both at a landscape and species-specific level. Throughout the seasonal round, vegetation has always been important to Aboriginal peoples, not only for food, ceremonial and medicinal purposes, but also in terms of understanding the relationships between vegetation and wildlife, water, birds, disturbance and more. Indeed, plant names in Aboriginal languages commonly reveal the role of the plant in traditional medicine or refer to a biogeographic feature (Turner 2014).

Plants can provide “clues” to what is happening in the environment or act as “indicators” of the type or overall state of health of ecosystems.

> My father also taught me how to use plants as indicators, as a compass is used. By using rocks, the positions of plants, wind and hills, you can find you way back. (Aalasi Joamie in Joamie and Ziegler 2009: 9)

For example, studying the stomach contents of a caribou can help to predict if the meat will taste more like lichen or grasses (Thorpe et al. 1998). Tufts of fur on trees, shrubs or the tundra help people know whether grizzlies have been in a specific area. From the 2012 Aquatic Effects Monitoring Program (AEMP) TK program at the Diavik mine, participants also noted that the overall health of shoreline vegetation is understood as an indicator of water quality (TCS 2013a).

Very few references found in the literature are specific to Lac de Gras other than those related to the Diavik, Ekati or Snap Lake mines. Thus, plants identified to be in the Lac de Gras area (Burt 1997) and known to be important regionally for Aboriginal use (Burt 2004; LKDFN 2002; Dogrib Treaty 11 Council 2001b) became the focus for reporting relevant TK. As discussed, known Aboriginal uses in other regions were identified as being possible uses in the Lac de Gras region, where specific geographic references were not available.

The following six sections discuss the results from the literature review according to TK of the relationship between people and vegetation (i.e. use for food, medicine, tools, technology, ceremony, culture, identity, and environmental indicators), as well as between wildlife and vegetation.

The vegetation baseline data were compared to the species list provided by the University of Alberta in their re-vegetation program and linked to Aboriginal language terms (Appendix C). The initial purpose of this investigation was to create a master list of species to work from in order to include/exclude plant species discussed in the TK literature review. Once the review findings were collated, the plant species discussed in the following sections below, and those species that were found to be listed in the Burt (1997) data, were compared; a list of the scientific names, English common names and Aboriginal language terms (where available) was then developed. The list of plants identified by Dene and Inuit communities was combined with their TK of multiple uses and is presented in Appendix D. Aboriginal names and terms within quotes have been preserved in the relevant language (i.e. an Inuit speaker uses Inuinnaqtun or Inuktitut terms), but one can refer to this Appendix D to confirm the identity of the plant discussed. Where spellings of a term differ, attempts have been made to include multiple spellings. For

Inuinnaqtun, the spelling promoted by the Government of Nunavut (i.e. the 'new' spelling) is provided throughout.

Results from the literature review are presented in the following sections that highlight TK of:

- Plants and people
- Plants and animals

Many northern Aboriginal communities have lived through mine closures and experienced the effects of mining on vegetation. As such, references to these experiences were commonly found in the literature and the information shared has been summarized within this report for consideration in closure planning. While this knowledge may be categorized more as observations or concerns, perceptions of risk and lessons learned from past experiences are valuable and have been included. Specifically, this information has been categorized into the following sections:

- Risks and Impacts
- Re-vegetation

4.0 Plants and People

Aboriginal peoples both north and south of the treeline have long used various plants and select parts of these plants including berries, flowers, leaves, sap, branches and roots. Timing was important, depending on what part of the plant was being harvested and for what purpose; people knew when to harvest plants that were rich in nutrients and taste (Burt 2003). Indeed, plants had a very important role in the seasonal round of all Aboriginal communities across the North. As in the past, food use of plants today is perhaps equally important as its ceremonial and spiritual use. For example, the Dene continue to show respect to spirits and the environment by giving a botanical offering to "feed" the land, water or fire (Legat 2012; TCS 2013a).

Whether people harvest plants for food or medicine has always necessitated a strong understanding of botany, weather, climate, and biogeography in order to know where, when, and how to best harvest and prepare the bounty. Depending on what time of year people's lifeways intersected with Lac de Gras, different plants would have been harvested for various purposes.

> The Tłı̨chǫ know where berries and traditional medicine can be found, based on certain characteristics of the soil and weather, and the specific locations they can be gathered at certain times of the year. Around ʔewaànit'iitì [Courageous Lake] particular locations are known to produce significant amounts of berries (Tsatchia et al. 2013: 26).

Carefully and systematically studying environmental conditions has enabled Aboriginal peoples to plan and harvest accordingly.

> This year there was less berries. There's more if there's a lot of water. I used my berries for jam and ate them plain with sugar (ME 10 09 04 in LKDFN 2005: 51).

> During the fall a variety of berries and plants of use to the Tłı̨chǫ grow on the barrenlands. The Tłı̨chǫ have detailed knowledge of which plants and trees can be used for various medicinal treatments, and where to find them (Tsatchia et al. 2013: 26).

Part of planning necessitated knowing where good food sources were located, especially during years when the caribou migrations and distributions shifted away from camps.

> For example during the spring migration of caribou, it was wise for people to camp near a good fishing area where birch trees were numerous. While waiting for the caribou, people sustained themselves on fish and built their summer canoes. If caribou did not arrive in the area, the people could move as soon as the water was open (Legat et al 1995; 2000 in Dogrib Treaty 11 2002: 57)

Further, knowledge of plants has always provided insight into landforms and locations. As documented in Legat (2012: 20):

> As Moise told the story, he remembered more details, urging Georgina and me to watch specifically for certain vegetation communities: *kwekàanǫ̀hkwǫ̀ǫ̀* (rocky area with moss), *ts'oo* (muskeg), *whagweè* (sandy area with particular vegetation), and *tł'ogaa* (type of grassy area). Moise repeated the part of the story that told of the burial. "It's located," he said, "between the ts'oo and the whagweè, where a little sandy hill was attached to the esker running along the shore of NàdenìʔàatÌ."
>
> Moise again repeated the parts of the story so that we would look for an odd cluster of rocks with rock tripe on them. He repeatedly stated how the rocks would be placed: they would not look like they belong because people had moved them; we would know that people had moved them because rocks with rock tripe do not exist on small sandy hills attached to eskers. By following the story, we found the burial site with little trouble, the past being validated as the relationships associated with the place remembered and re-established by our travelling there (Legat 2012: 20)

Many plants were harvested at one time of the year and used throughout the seasonal round.

> The cottony bristles of the perianth of Arctic Cotton were gathered in Autumn and stored for year-round use. This material would be rolled between the fingers and placed along a raised ledge in stone lamps (qulliq) that held rendered seal or, less commonly, caribou fat (Davis and Banack 2012: 81).

Women have long been recognized as plant experts, largely because berry-picking and food preparation was traditionally more of a female endeavour.

> Picking berries is a popular social event throughout the summer and fall months. Women congregate in the rich berry patches of the Kakinëne to gather the necessary supply of berries for the winter months (LKDFN 2002: 40).

> The Elders say that medicine plants grow everywhere on the barrenlands at ʔewaànit'iitì [Courageous Lake]. It is primarily the elderly women who have specialized knowledge about medicine plants. They know which plants are important, where they grow and how to use them (Tsatchia et al. 2013: 26).

> During the study, a pattern has emerged that suggests that types of knowledge vary between gender and age. When sharing knowledge, women talk mostly about plants and caribou, whereas men tell of caribou crossings, travel routes, and fishing and trapping sites. It is interesting to note that the women over eighty seem to have similar knowledge to the men on caribou crossings, travel routes, and fish sites, but do not have the knowledge of trapping sites; nor do most men seem to have the same in-depth understanding of plants as the women (Dogrib Treaty 11 Council 2001b: 36)

4.1 Food

Plants have always provided sustenance when fish or game was unavailable or to add variety to a protein rich diet. As explained by Elder Aalasi Joamie: “Sometimes I could get a good fill from eating plants,” (Joamie and Ziegler 2009: 9). Owing to unpredictable fluctuations in animal populations, Aboriginal peoples depended on their expertise of tundra vegetation in the Lac de Gras area and beyond.

> We also picked different plants, including swamp turnips, wild onions, and fireweed for food. We would pick berries and catch fish to can them and sell them. .... (Wayne Mercredi in NSMA 2013: 67)

> [For people], berries, Arctic cotton and roots that grow [Eskimo potatoes] are the most useful plants for eating. (Steve Anavilok in Golder 2003: 39)

> Everything is tied up together – fish, caribou, plants, and air. It’s all connected to what we eat out on the land. What we eat is who we are. (Bobby Algona in TCS 2013a: 61)

> The raw fruits were eaten, and they were mixed with fat (Davis and Banack 2012: 80)

> I know how to find drinking water, find berries, caribou and more. In the past, we only bought dried goods. Dene people lived on wildlife a long time ago. We lived to be very old. (Madelaine Drybones in TCS 2013a: 63)

The following sections outline results from the literature review relevant to: berries, flowering plants, lichens and mosses, and trees and shrubs as they relate to food. Medicinal and ceremonial uses are elaborated in Sections 4.2 and 4.4, respectively, while tools and technological uses are highlighted in Section 4.3.

4.1.1 Berries

For all Arctic groups, spring and summer berries have long been a welcome change from a winter diet consisting mainly of meat and fish. First Nation and Métis groups harvest mainly blueberries, cranberries, crowberries, cloudberries and whiskey jack berry/alpine berries while Inuit are more familiar with tundra berries such as blueberries, cranberries, bearberries, crowberries, and cloudberries. All of these berries are found in the Lac de Gras area. Of these berries, it is said that blueberries are “perhaps the most sought after berry plant,” (Joamie and Ziegler 2009: 74). Second to blueberries, cloudberries are also highly prized, perhaps in part because they are not as common in southern parts of the Arctic and because they are not as prolific as some of the other berries found on the tundra (Madelaine Drybones in TCS 2013a).

Berries have been said to taste better in the barrenlands where there is more sun (Łutsel K’e Dene First Nation, Parlee et al. 1998 in LKDFN 2002: 40). Some berries are best eaten fresh while others are preserved by mixing them with animal fats or other plants or to make tea (Joamie and Ziegler 2009). The act of berry-picking continues to be important in terms of the way it provides for time ‘on the land’ as well as with family or friends and building relationships through sharing knowledge and stories (TCS 2013a).

> I counted twelve varieties of berries. That many exist on the land, but we didn't include some, there's so many of them. There are those that are close to the ground, and then there are rosehips. There's ʔį̀hk'aį̂i - whiskey Jack berry, dahł'į̀į, gǫhjį̨ą - tamarack bud, blueberries, cloudberries, raspberries, cranberries. (Roseanne Mantla in Tsatchia et al. 2013: 26)

> There were blueberries, cranberries, crowberries, cloudberries, raspberries. They are small and red on long roots. That sits on lower ground. … They are red. We eat fish eggs with it. They also call it whiskey jack berries. Whiskey jack berries are like blueberries but they are big, very tasty. When children have canker sores in their mouth you use these berries and clean the sores. It clears the sores - even twice you use it. We collect them in jars and take them home. (Roseanne Mantla in Tsatchia et al. 2013: 26)

> To make pemmican, you mash in berries with (dried) meat and bear fat. For the meat, you use caribou, moose, or whatever was there. You pound the meat out until it is just a bit better than powdery, then mix it all up and roll it into pemmican balls that are just bigger than golf balls. It becomes firm, but not rock hard. Pemmican is made so the meat doesn’t go bad all winter (Lawrence Mercredi in NSMA 2013: 66-67).

> The berries used included blueberry or *kegotangenak* (*Vaccinium uliginosum*), lingonberry or *kingmingnak* (*Vaccinium vitis-idaea*), crowberry or *paungnak* (*Empetrum nigrum*), cloudberry or *akpik* (*Rubus chamaemorus*), bearberry or *kablak* (red and black, *Arctostaphylos alpina*, *A. rubra*), bog cranberry (*Oxycoccos microcarpus*), and probably some limited use of raspberries (*Ribes* sp.) in the southern end of the region, on summer migrations. Berries were eaten fresh, and likely saved for short periods of time. Lingonberries can be eaten when they are revealed by melting snow in the spring (Burt 2003: 6-2).

> We make dryfish on rocks. Once the fish is dried, we pound it to make powder. We also mix fish eggs with blueberries. It preserves for a long time. Takes a couple of days to dry (Fred Sangris in TCS 2013a: 39).

> If we need a fridge, we dig under the moss to the permafrost and put our berries there to keep cool and come back and get them. We can also mix up the berries with the permafrost to make ice cream or yogurt for children and old people (Fred Sangris in TCS 2013a: 61).

> Around here [Snap Lake] there are three kinds of berries and three kinds of Labrador tea (JF 17 06 01 in LKDFN 2001b: 45).

Berries were commonly harvested in August or September.

> The blueberries are usually ripe in August also. Cranberries are usually ripe at the end of August and in September. It is best to pick the berries at these times because they get ripe and juicy. It is best to store them at that time (AJ 09 01 in LKDFN 2002: 63).

> Blueberries and cloudberries are harvested in summer, and cranberries and crowberries in early fall. Berry-picking continues to be an activity undertaken primarily by women (LKDFN 2005: 50).

> The best time to collect these berries is in late August and September. Any later in the season the blueberries would start to fall (LE 03 09 02 in LKDFN 2003: 53).

> The best time of year to pick up raspberries is in July, same as strawberries. They are the first berries to ripen up. It is best to pick up blueberries in August. Cranberries are best to pick about this time of year (fall). It turns out really good now. ... It is good to go this time of year because they freeze and it is easier to pick when it is like that (MF 10 01 in LKDFN 2002: 64).

Berries were enjoyed fresh or preserved.

> Caribou fat can be used for preserving berries (LKDFN 2002: 26).

> Berries are gathered throughout the summer and fall months for a variety of uses like sweetening pound meat, for making jams and dyes, and even for medicinal purposes (for example, cranberries are known to be good for sugar diabetes). Berries are also enjoyed fresh from the bush (LKDFN 2002: 39).

> During the fall caribou hunt women gather large amounts of berries and traditional medicines in the area around each camp, and bring this back to the communities (Tsatchia et al. 2013: 26).

Blueberry

Blueberries (ts'ąłchogh) are prized for their fresh sweetness to make jams. Elders say that blueberries from the barrenlands taste better than those from below the treeline. They identify two types of blueberry – one that is purplish-black and the other that is really blue. Blacker ones are found on high bushes but there aren't so many of them (LKDFN 2002: 40).

The blueberries that I collected I make jam and eat the berries with sugar. The children really like to eat the berries with sugar. In the olden days people would prepare berries for the hunters, mixing the berries with pound meat and it is rolled into a ball then frozen for the hunters to take (LE 03 09 02 in LKDFN 2003: 53).

Bearberry

The leaves of *Arctostaphylos spp*. were used as infusions (Davis and Banack 2012: 80).

Bearberries taste mealy, but Inuit enjoy them, frequently mixing them with blueberries and crowberries (Burt 2004: 132).

Blackberry/Crowberry

Blackberries or crowberries are tremendously abundant, and are often mixed with cranberries or blueberries too as they have a relatively bland taste. They are tasty to eat but can cause constipation, and if they are not picked they won't fall from the bush. After over-wintering, this berry will lose its taste and be a different color (LKDFN 2002: 40).

Cloudberry

Cloudberries (nadláré) are found predominantly in swampy areas on the barrenlands, but they can be discovered in areas of muskeg below treeline. These berries cannot be preserved. One cannot eat too many of these berries because they are sour in taste and will upset your stomach (LKDFN 2002: 40).

Cranberry/Lingonberry

Cranberries (nitł'ër) are used in a variety of fashions including making jams or medicine. These berries can be picked and preserved all year round. They won't fall from their bushes after their first season, so in the following spring you can still pick them. However, at this point they are darker, watery and very sour. The following summer the berries from the previous season dry up and fall off to make room for the new berries (LKDFN 2002: 40).

Whisky/Whiskey Jack Eye (Alpine Berry; Red BearBerry):

> Whiskey Jack Eye (ejízé naghé) can be eaten fresh but this doesn't happen often – usually it is preserved in a jam. These berries taste better in the barrenlands as they get more sun – here they are a clear red. Those from below treeline are black, seedless and bland. Whiskey Jack Eye berries that grow below the tree line sometimes have worms and bugs in them (Parlee et al. 1998 in LKDFN 2002: 40).

4.1.2 Flowering Plants

In addition to berries, people have always harvested flowering plants including the leaves, flowers, rhizomes, and roots. Many of these plants were harvested opportunistically while hunting and traveling on the land, for example, through areas such as Lac de Gras. As with berries, some plants are eaten raw while others were often cooked or mixed with animal fat.

> Some flowers were eaten as sweet treats. This practice persisted until candy became much more readily available and overshadowed the sweetness of flowers. These included the purple mountain saxifrage (*Saxifraga oppositifolia*), several species of lousewort (*Pedicularis lanata*, *P. arctica*, at least), and the flowers of the fireweed (*Epilobium angustifolium* and *E. latifolium*). The children of Bathurst Inlet have always sucked the nectar from the base of the flowers of the woolly lousewort, and Marilyn Walker (1984) also mentions this (Burt 2003: 6-3).

Bistort

Rhizomes of the bistort are starchy and slightly astringent, and, although edible raw, they are most palatable when cooked (Marles et al. 2012). Porsild (1964 in Kuhnlein and Turner 1996: 147) reports that rhizomes from the bistort were a choice delicacy of several Inuit groups, who preserve them by freezing, or in seal oil.

> The pecan-shaped rhizomes have long been used by the Inuit, and the leaves and bulbils were often eaten (Burt 2004: 60).

Legumes

In the past, roots were important as they kept for long periods of time and some roots such as the milk-vetch were eaten in small quantities in times of starvation (Marles et al. 2012). One of the most popular edible legumes has always been the liquorice-root, otherwise known as the Eskimo potato, bear root or Alpine sweet-vetch (Burt 2004).

> The roots were boiled (Davis and Banack 2012: 80).

> A few roots were used. In our area, the roots of the liquorice root or *mahuk* (*Hedysarum alpinum*) were carefully dug up with a special antler digger, and eaten raw or boiled. These were utilized in the spring and fall, when the nutrients were lodged in the roots, not in summer when the nutrients were in the leaves and stems of the plant (Burt 2003: 6-2).

Lousewort

> Some flowers were eaten as sweet treats. This practice persisted until candy became much more readily available and overshadowed the sweetness of flowers. These included the purple mountain saxifrage (*Saxifraga oppositifolia*), several species of lousewort (*Pedicularis lanata*, *P. arctica*, at least), and the flowers of the fireweed (*Epilobium angustifolium* and *E. latifolium*). The children of Bathurst Inlet have always sucked the nectar from the base of the flowers of the woolly lousewort … (Burt 2003: 6-3).
>
> The raw nectar was used (Davis and Banack 2012: 80).

4.1.3 Lichens and Mosses

Lichens

People have long understood that lichens are important caribou food such that they must be respected (Joamie and Ziegler 2009; Dogrib Treaty 11 2001a). Some lichens were used in traditional medicines (i.e. to treat intestinal worms or cleanse the stomach) or as food (i.e. in soups) while others were eaten as part of the contents of the caribou stomach (Thorpe et al. 2001):

> The main food use of reindeer lichen was as a major component of the partially digested stomach contents of caribou and other ungulates. Often mixed together with other lichens such as *Cetraria*, mushrooms, horsetails, sedges, grasses, willow, birch, and blueberry leaves and shoots, and other plant foods, it was considered a delicacy in this form. This food was used traditionally by most Inuit peoples ... as well as by the Chipewyan and other northern Indian groups (Kuhnlein and Turner 1996: 24).
>
> Caribou stomach contents were eaten raw (Davis and Banack 2012: 80).
>
> People used to soak the contents of the caribou stomach at the end of the summer (in the early spring the contents are too green and strong). In late August the contents taste better. It's mixed with seal blubber and is a delicacy. When the stomach is still warm put the liver inside it to cook (DDEC 2013: 35). That black lichen is good for soup - you make a broth with fish and fish eggs. People used to even dig in the snow to get it (JF 17 06 01 in LKDFN 2001b: 45).
>
> Black rock lichen is used in soups and muskox eat it as well. It helps with digestion, takes the toxic out of the system, and is good for intestinal worms. Boil to get sand out, then boil it again (DDEC 2013: 31).
>
> Black flaky lichen on the rocks is used in tea (DDEC 2013: 35).

Mosses

Review of the literature did not find references to use of mosses as food although there are several practical uses documented in Section 4.3.

4.1.4 Trees and Shrubs

Lac de Gras is located in a transition zone from treeline to tundra such that, other than the odd krummholz and black spruce, larger trees are not present. However, shrubs such as willows and birch are common. Twigs of shrubs, especially willows, are known to be important in providing fuel for fires, support for drying racks and tents, drum hoops, shafts of fish spears, and more (Burt 2004).

> Another plant is called Dahgǫ̀ǫ̀tì and Tehgǫ̀ǫ̀tì, and another plant is called Ts'aekwǫ̀ǫ̀, that kind too. You see the white birch? That too, it's bud too, and the birch bark, if you cut the birch and put a tin can under the cut, it will fill with a syrup called K'itìtì, it looks just like water. When the pail gets full we just drink it (Roseanne Mantla in Tsatchia et al. 2013: 27).

Several types of Labrador tea are found in the Lac de Gras area. Aboriginal peoples have long made tea from small quantities of the leaves (Burt 2004).

> We went up the fault [McDonald fault] there, we shot some caribou. We shot some caribou up in there…. Right away we threw some ribs on the fire. Nice and fat, cow ribs, back in the spring hunt, March…. And some kidneys, of course. Split them open, put them on a stick, over the fire right away too. Then, we were having tea, and George Marlowe throws in a handful of Labrador tea. Just pulls it off a tea bush and throws it in there. Mix it in with the black tea (Adrian D'Hont in NSMA 2013: 61-62).

Berry shrubs particularly important for traditional use are presented above under their own the heading.

4.2 Medicine

Various plants have long been celebrated for the medicinal properties they can provide, particularly in the past when people lived entirely on the land. Still today, many Aboriginal peoples prefer the use of medicinal plants than modern medicine (TCS 2013a). In the same way that the land is seen as a "grocery store", so too is the tundra a "pharmacy".

> I picked a whole bunch of all these different kinds of plants, because there are medicinal uses and values to the branches as well as the roots and the berries. So, I'm going to be working this winter on using those plants for different ailments throughout the winter, and just see how effective they are. And just get used to using them, and picking them every summer (Sue Enge in NSMA 2013: 69).

> Knowledge of medicinal plants and their preparation was transmitted orally between generations and was proprietary to initiated healers; this remains the case today. The one remaining healer in Kugluktuk indicated that normally a healer would provide medical care to four or five extended families, traveling among groups as needed. Given the lack of traditional healers in Kugluktuk today, Pauline [Plamondon] treats anyone who has a need and is interested in her help (Davis and Banack 2012: 82).

The following subsections describe how people continue to use berries, flowering plants, lichens, mosses, mushrooms, trees and shrubs for medicinal purposes.

4.2.1 Berries

Berries have always been picked primarily for food, but they were also known to have several medicinal uses outlined in the following section.

> ʔįhk'adzì [whiskey jack] are just on the ground and grow only in the barrenland. You can't find any in this area [Behchokǫ̀], only in the barrenland. When we find the berries we collect them in containers so that we can treat infections like kids' mouth rash. We put the berries in small jars (Roseanne Mantla in Tsatchia et al. 2013: 26).

Blackberry/Crowberry

> Crowberries are good for constipation (DDEC 2013: 31).

Bearberry

> *Arctostaphylos spp*. was used as a tobacco substitute (Davis and Banack 2012: 80).

Blueberry

> Blueberry bush roots can be boiled to make a broth, and is good for snow blindness. Suggestion was to soak a cloth in the broth and place on the eyes (DDEC 2013: 31).

> Blueberry branches (bottom branches), were boiled and used for when you were sick (DDEC 2013: 34).

Cloudberry

> Cloudberry and bearberry leaves could be brewed for tea, and in Nunavik, people realized these would help with kidney problems, stomach-ache, and illness in general (Stevens et. al., 1984 in Burt 2003: 6-3).

Cranberry

> Nitł'ër (cranberries) that are purple or black after a winter on the bush, they are really good for sugar-diabetes (MD 19 06 01 in LKDFN 2001b: 30).

> During one of these times, Madeline's son Peter had an infection from a cut on his face. She did not have any medicine from the Yellowknife doctor at home so she was going to get some cranberries and put it on his face and it was to stop the infection and help with the healing. Later in a week or so I noticed that Peter's face was clear and noticed just a little marking but he was okay (YKDFN 2003: 2-3).

> Boil the roots of cranberries; the water is sweet, and drink it for coughs (DDEC 2013: 34).

4.2.2 Flowering Plants

In addition to berries, many types of flowering plants in the Lac de Gras area have known medicinal uses by Aboriginal peoples.

Fireweed

> The whole plant was used to treat fetal alcohol syndrome (Davis and Banack 2012: 81).
>
> Whole *Epilobium latifolium* (dwarf fireweed) plants are cooked in diluted store-bought honey until the mixture regains the viscosity of honey. A teaspoon consumed each day was reported to calm and improve mental focus (Davis and Banack 2012: 82).
>
> Leaves and flowers of the dwarf fireweed were used for tea, stomach-aches, and to relieve general illness. Leaves were chewed to help stop a nosebleed (Burt 2003: 6-3).

Horsetail

> Used as a medicine to treat urinary tract infections. Used whole in a tea or maceration (Davis and Banack: 81).

Paintbrush

> Was used as a medicine to treat contradictory thoughts (Davis and Banack 2012: 81).

Shrubby Cinquefoil

> The leaves and petals were used to treat a sore esophagus and to treat heart problems (Davis and Banack 2012: 81).

Moss Campion / Silene

> *Silene* spp. was used to treat anxiety (Davis and Banack 2012: 81).

Yarrow

Flowers of the yarrow were commonly applied to bee stings or cuts, sores, burns or placed in a nostril to stop a nosebleed. Flowers made into a tea are known to help with menstrual cramps, childbirth pain, coughs, or liver ailments. A poultice of the whole plant can be used for a sore back or other discomfort. The root is known to help with toothaches or teething. Smoke from yarrow flowers or leaves can treat a headache or clear a room where somebody is sick (Marles et al. 2012). Given the multiple uses identified in the literature review, it is likely that this was a central traditional medicine.

> The whole plant of Yarrow was used primarily for reproductive problems (Davis and Banack 2012: 81).

It is interesting to note that the Cree name for yarrow translates to ‘head medicine’ (Marles et al. 2012: 116).

4.2.3 Aquatic Plants

In parts of Nunavut, river algae was known to be used as a medicinal eye ointment for infections or irritants and could be placed on the eyeball and left overnight (Joamie and Ziegler 2009). Given the aquatic environment around Lac de Gras, this species may also have been used here in this way. Other aquatic plants observed in the Lac de Gras area are known to provide relief.

> Big leaves in ponds (floats on the water like a lily pad). Boil it and wrap around legs. It is good for sore legs (DDEC 2013: 35).

4.2.4 Lichens, Mosses and Mushrooms

> The lichen was boiled and my grandmother had put some fish into it for taste. I asked the woman Mary Adele, "What did the soup taste like?" She said it tasted terrible, probably like eating dirt! My grandmother believed that this lichen was supposed to be good for your whole system, keeps you regular and all that. At least that's what I understood then (YKDFN 2003: 2).

> Black rock lichen is used in soups and muskox eat it as well. It helps with digestion, takes the toxic out of the system, and is good for intestinal worms. Boil to get sand out, then boil it again (DDEC 2013: 31).

> The Tłįchǫ have specialized knowledge of how to prepare treatments from various plants. For example, the black lichen and white lichen that grew on rocks are used to treat canker sores on children (Tsatchia et al. 2013: 27).

> Mushrooms can sometimes be used for sore eyes. When the mushroom gets to be powdery, it can be used also on rashes (DDEC 2013: 34).

Certain mushrooms were dried and the contents mixed with fat then applied as a poultice to burns, infections or scrapes (Joamie and Ziegler 2012).

4.2.5 Trees and Shrubs

In that same way that berries and flowering plants have always provided medicinal use for Aboriginal peoples, so too have trees and shrubs.

> Not one of the standing trees do not have liquid in them. They are all medicines. All those trees have medicine in them, without exception (Roseanne Mantla, June 5th 2012, Behchokǫ̀ in Tsatchia et al. 2013: 26).

Other than the occasional black spruce, trees are not generally found in the Lac de Gras area; however, shrubs are plentiful. In the region surrounding Diavik, various parts of the birch and willow species were likely the most relevant for medicinal use.

Birch

> My father Philip Crapeau used to talk about his mother Seelee (Julie Tatsiechele) Crapeau to me. My grandmother used to make [birch] syrup from Drybones Bay when

> they travelled to that area for spring hunts. My father said it was the best syrup but that granny used to make a lighter version of the syrup which was used for helping with colds, or other maladies that hurt and ached you (YKDFN 2003: 2).
>
> One time [Rita Wetrade's] uncle (Rosanne's husband) was travelling to the barrenland by boat. He developed sores - heat rash, because they were working hard in the heat. He had sores all over his neck area, so my mother in-law said to collect birch trees. She boiled them in a big pot and for three days she applied it to his neck. It healed, and he never developed sores again until he passed away. That is good medicine for sores. And from the same birch tree there are little bits for fluff (dahghǫą) that too can be used when a child develops mouth rash. They apply it and it goes away immediately (Roseanne Mantla in Tsatchia et al 2013: 26).
>
> Green leaves on birch plants can be chewed and put on affected areas as a poultice for bites and stings (DDEC 2013: 28).
>
> The leaf buds of dwarf birch were used as a frostbite preventative (Davis and Banack 2012: 81).
>
> She [Helen Drybones] used a birch tree's inner soft layering of soft velvety pulp for boiling and it was supposed to help with inner tummy problems (YKDFN 2003: 2).

Labrador Tea

The list of medicinal uses for Labrador tea is long, suggesting the importance of this tundra plant (Turner 2014). Aboriginal use elsewhere and likely around Lac de Gras includes harvesting the leaves to treat stomach flu and diarrhea, chills, and bad breath, pneumonia, difficulty urinating, or headaches. Tea can help with arthritis in the hands, to treat colds, teething, kidney ailments, anxiety, and stress. A leaf mixture can be applied to wound or treat infections (Marles et al. 2012).

> The new leaves on [. . .] medium-sized Labrador tea are the best for tea. Drinking it is just like good medicine, when you have a cold or even a headache (LA 18 06 01 in LKDFN 2001b: 29).
>
> A couple of years ago, when my father had pneumonia, I took him to the hospital and he was given antibiotics and sent home with me. I was afraid he would have a hard time to recover. Alfred Baillargeon came to visit and upon hearing about my father's illness he went home and came back with a bunch of Labrador tea, branches and all. He instructed me to boil it in a big cooking pot with lots of water and to let my father drink the tea. With the antibiotics, deep heating medicine rubbing on the chest, back and neck and the Labrador tea, my father recovered within ten days. When I returned to the doctor's office for a check-up, the good doctor was amazed to see how the pneumonia had cleared up so well. He said that even with younger people who have pneumonia, they usually take quite a long time to get better. So he was wondering what we were doing

> to help my father get better so fast! I explained about the traditional medicines that Dene still use today (YKDFN 2003: 3).
>
> Jessie Hagialok Kapolak [of Bathurst Inlet] told her son Sam that in the old days they used to boil Labrador tea leaves and used the resulting liquid as an insect repellent (Burt 2003: 6-3). It could also be mixed with fat to make an ointment, used for aches, sore throat, and nosebleed, but this was more customary in the eastern arctic and in Nunavik (Stevens, Palliser and Oweetaltuk 1984 in Burt 2003: 6-3).

Northern Bog Laurel

> This plant with the purple flower is kuzi hala (northern bog laurel). It only grows near water. It is really good medicine. You boil the whole thing and then put it on sores (MD 17 06 01 in LKDFN 2001b: 30).

Spruce

Results from the literature review of TK sources did not find any specific references to black spruce although it is known to be in the area. Below is an assemblage of TK quotes that speak to spruce in general.

> I helped my grandmother Helen Drybones (nee Fishbone) when she was boiling spruce tree cones for helping someone who had a cold (YKDFN 2003: 2).
>
> Growing up, my mother was a big one for spruce gum, which was used as medication .... (Wayne Mercredi in NSMA 2013: 67).
>
> Spruce gum (the one you chew) is good for cuts (DDEC 2013: 35).
>
> There is the spruce cone and bud to make medicine drink called gots'ǫǫ̀hdzìitì from the pine tree (gǫǫ̀), another is the white spruce (ts'iwà), from which we collect the spruce buds, bark lining and the wood itself to make medicinal drink. The gum of white spruce and the black spruce tree is called edzǫ, black spruce gum is called edzǫdzè, the cones/bud of the tamarack tree (doowe). The wood is chopped, all the top bark removed and the tamarack inner bark (doowek'a) is collected (Roseanne Mantla in Tsatchia et al. 2013: 27).
>
> Spruce needles are also used to make dechiti (spruce needle tea) to treat colds (Robert Mackenzie in Tsatchia et al. 2013: 27).
>
> Spruce gum is used for stomach-ache and colds. Boil it and drink the juice, or chew it. Watery spruce sap is good for the gums. There are two different types of spruce (DDEC 2013: 28).
>
> Acorns off spruce trees are used for sores in the mouth, just brush on mouth (DDEC 2013: 28).

Also can use boiled acorn water. Used for thrush (in the mouth) for kids (DDEC 2013: 28).

Willow

The roots of the willow were known to relieve a toothache (Joamie and Ziegler 2009).

The inner bark was used to treat pain, headaches and toothaches (Davis and Banack 2012: 81).

In spring, the cambium layer of many species of larger willows or okpeet (*Salix* sp., especially *Salix richardsonii* and *S. alaxensis*) was called the "fat of the willow", and eaten while it was sweet, which occurred when the sap was rising in the plants in the spring. This cambium material was sought by the elders, which made perfect sense. Willows contain salicin, which is an intermediate form of acetyl-salicylic acid, the active ingredient in aspirin. It likely helped reduce the pain and inflammation of arthritis and rheumatism (Schofield 1989 in Burt 2003: 6-3).

4.3 Tools and Technology

Typically plants in the Lac de Gras area were harvested for food or medicine, but many were also collected to improve food or survival as insulation, structural support, art and more. Availability of plants for food, medicine, tools, technology, ceremony, and culture would have influenced locations of traditional campsites around Lac de Gras.

Many plants were burned while green as smudges to discourage mosquitoes (Burt 2003: 6-3).

4.3.1 Flowering Plants

Arctic White Heather

The resinous twigs of arctic white-heather (*Cassiope tetragona*) were an important source of fuel for Inuit peoples of the Arctic (Porslid 1964 in Kuhnlein and Turner 1996: 113).

[Arctic white heather} was used as tinder, fuel, and as an insect repellent (Davis and Banack 2012: 80).

It [Arctic white heather] was used as a fuel by the Inuit when travelling on the land (Burt 2004: 132).

This plant is oily and burns readily when green or wet (Burt 2004: 211).

Grasses

> Grasses can be collected, dried and put inside clothing for warmth (DDEC 2013: 27).
>
> Grass or ivik [ivgit], was used for padding and as insulation in kamiks [kamngit] (Burt 2003: 6-4).

4.3.2 Sedges

Arctic Cotton

> Was used as a wick for seal-oil lamps [qulliq] (Davis and Banack 2012: 80).
>
> Inuit people would pick cotton grass heads (also known as cotton balls) when they are full, and mix them with seal fat to use for lamp oil. Wait until the buds are easy to fall off, then easy to pick. Roll them around in oil in the lamp oil, and lift them out to the edge of the oil in the lamp, making them even along the edge and light them. Can adjust the flame to make it low or high depending on how much the bud burns. Can also use caribou fat in place of seal fat (DDEC 2013: 34).
>
> Use cotton balls to stop bleeding; place them in the nose to stop nosebleeds (DDEC 2013: 34).

4.3.3 Lichens and Mosses

Mosses were used primarily to support human subsistence rather than as sustenance. Moss is known for its absorbent properties. Peat moss was especially valued for use as diapers, menstrual pads, toilet paper, to absorb grease, to clean out pots or as a wick. In the past, it is likely that peat/sphagnum moss around the Lac de Gras area was collected in the summer to be dried and used during the winter. Other Aboriginal peoples have reported that moss was used to block drafts in a tent or for insulation in footwear, kamiks [kamngit] or bedding (Joamie and Ziegler 2009; Marles et al. 2012). When Arctic cotton or Arctic willow plants were not available, people could use lamp moss and peat moss together as a wick in an oil lamp (Joamie and Ziegler 2009; TCS 2013a). Lamp moss is more common than peat moss in the Lac de Gras area (Burt 1997).

> I gather moss (*ipiraq*) and use it to clean out the fish. I do not use water to clean the fish. I also use the [peat] moss (*ipiraq*) to add flavour to the fish during baking (Mark Taletok in TCS 2013a: 39).
>
> Sphagnum moss (*ipiraq* in Inuinnaqtun/*kwa* in Tłı̨chǫ) is used to cook fish on top of hot rocks. We used it to cook caribou heads, too. We poured water with a cup on the fire and it cooks. Bobby explained that we never needed a cooking pot, just moss. It is acidic before it is cooked, but once cooked, it loses the acid. You can also burn moss like a mosquito coil to keep away the mosquitoes (Mark Taletok in TCS 2013a: 61).
>
> We use moss as a candle with fish oil (also muskox oil) (Fred Sangris in TCS 2013a: 61).

> We also use moss as diapers for babies (Mark Taletok in TCS 2013a: 61).
>
> In some areas, especially inland areas where the plants were small and there was no driftwood, heather and lichens were scraped up in large quantities and used in small fires. Arctic heather or ikhutik and hair lichen or kagiuyat both would burn when damp, so were important as tinder for starting fires. Dry mosses were also used as tinder (Burt 2003: 6-4).

4.3.4 Trees and Shrubs

In traveling to the Lac de Gras area, the Dene would camp in wooded areas as well as bring with them wood for fires and for trade with the Inuit.

> And we would play together and dance together and the Inuit and Dene would get together (Mark Taletok in TCS 2013b: B(Day 2)-12).

Still today there are remnants of this wood occasionally found on the land.

> These small groups of trees near eskers (tsu̓dza deʔa) are very important for us. We always camp by them because there is firewood, water and a flat spot. You can tell by the axe-marks on trees that people stayed there. In the wintertime, you can see just the tips of the trees because of all the snow (EB 17 06 01 in LKDFN 2001b: 18).
>
> Certain Tsu̓dza deʔa [small pockets of trees and willows] have strong cultural and historical meaning to our community because we know our ancestors stayed in those places. You can see that they were there by the markings on the trees and the kunk̓e (tent rings) on the ground. We continue to use these areas in practicing our traditional way of life (LKDFN 2003a: 2.1).
>
> Up on the top of this highest esker here…, there was a piece of wood that either got stuck in a tornado and landed up there, or somebody actually set it up there! Probably as in hauling it along as firewood on a trip across the country... It might have fallen from their sleigh or they may have left it there as a marker or something (Adrian D'Hont in NSMA 2013: 72).
>
> One of my grandfathers did a lot of exploration when I was growing up. We would visit him in the summer time in the bush camps. We would live in a prospector tent and live off the land, including using drying racks for fish (Wayne Mercredi in NSMA 2013: 67).
>
> Just about anything was used as firewood, including any kind of driftwood, willows, dwarf birches, and more (Burt 2003: 6-4).
>
> Wood was used as construction material and fuel (Davis and Banack 2012: 80).

Black Spruce

Tsu̓dza deʔa are small pockets of black spruce which provide shelter and wood (LKDFN 2003b: 2).

Tsudaí chëné are spruce stands in the barrenlands where people in the past used to make Dëne Kų̨nk̓é (winter camps) for trapping and hunting (LKDFN 2001a: 30).

Tsu̓dza deʔa or the small pockets of black spruce (*Picea mariana*) and the thickets of willow (*Salix planifolia*) and birch (*Betula pumila* var. *glandulifera*) found in the valleys and along rivers in the barren lands are very important areas of traditional use by the Denesuline. They provide shelter and are a source of dry wood and other resources for those hunting and trapping in the barren lands (LKDFN 2003a: 2.1).

Green Alder

K’alisín (green alder) like this is good to cook fish on. You put the fish on k’ai dedlin (basket willow) and set it on top of the fire made with k’alisín - this gives it a good smoked taste. This is how we cook on the barrenlands. We don't need no grill (JM 18 06 01 in LKDFN 2001b: 30).

Birch

Louie’s father used to canoe to Kokeghotì with birch bark canoe. And to ʔek̓atì (Lac de Gras) where there is a mine today around that area there used to be lots of ʔekwǫ̀ (barrenland caribou) (Eddie Lafferty, 97/04/17 in Dogrib Treaty 11 Council 2001a: 20).

Birch bushes on the tundra are good for firewood, they give a sparkling fire, and good heat. The gum/sap helps it burn well, and the tundra green wood burns well (DDEC 2013: 27).

The [Qitirmiut] made sleeping mats to use on the sleeping benches in the snow houses, and in tents in summer. These were called “willow mats” but were made from the dwarf birch. There were two kinds, one made with thongs and branched lined up and carefully tied, and casual ones, just twigs strewn on the sleeping area. The idea was to insulate the sleeping skins from the dampness and prevent body heat from melting the snow bench (Burt 2003: 6-4).

Labrador Tea

Labrador tea was often used as firewood, [as it] burns even when green (Burt 2004: 211).

Willow and Birch

> Birch and willow branches can be cut and tied together, then put under bedding (caribou hides) to prevent dampness (DDEC 2013: 34).
>
> Willow and birch branches can also be collected and bundled together to start a fire on rainy days because they are waterproof. Ends of birch bushes can be mixed with grass seed heads to start a fire (DDEC 2013: 34).
>
> To start a fire, strike a rock (ingnak), with another rock, or metal file. Use very small branches from the end of the birch twigs. Sparks will light the brush (DDEC 2013: 35).
>
> Loon bags are used to keep things in to start the fires (waterproof). Inuit would take bones and meat out of the loon. Dry the skin and make a hole in the top (on its back). Because the bottom (under-belly) is stronger and will hold water. The bag is used to hold things that need to be kept dry (e.g. fine moss, twigs and things to make a fire) (DDEC 2013: 35).
>
> Twig mats were also used in storage caches, to insulate stored items, especially winter clothing from the damp ground. These were usually made of dwarf birch, willows, heather, or other woody vegetation (Burt 2003: 6-4).

Willow

> We use to boil ice to get water, and when there was little wood, we use to get willows and burn them slowly with green wood (MD 11 07 01 in LKDFN 2001b: 32).
>
> We lived all around - all the way east of the Thelon. We would carry dry wood with us and use it really wisely with small willow branches. How much wood you had determined how long you could stay out. (MD 19 08 01 in LKDFN 2002: 23).
>
> Willow (2 types) for fire (bundled up) put meat on it to dry. When you put canoes on land place it on land to not damage canoe (DDEC 2013: 28).
>
> Willows - creeping and standing - and heather are important for bedding and fires (Steve Anavilok in Golder 2003: 39).

4.4 Ceremony, Culture and Identity

The practice of harvesting plants for subsistence, technological, ceremonial and medicinal use has always been an important part of the cultural landscape of Aboriginal peoples in the Lac de Gras area. Harvesting, preparing and using plants provides opportunity for the intergenerational sharing of knowledge, relationship building, and passing down long understood expertise contained within the larger body of traditional knowledge (Joamie and Ziegler 2009; Legat 2012; Turner 2014). Further, the act of harvesting ensures that people go out on the land, maintain their strong connections both to one another and to the land, practice or 'operationalize' their knowledge and engage with the spiritual worlds. In short, being outside to harvest plants is good for the soul (TCS 2014).

> You know, when we were out the other day, we had a lot of fun. There was Nora, myself, and my daughter, and we were picking all kinds of Labrador tea, and we were having a lot of fun. During that whole time, all we did was talk about, you know, all kinds of things, and it just brought us together really close. It bonded us together in a way that just wouldn't happen when you're back in the city (Sue Enge in NSMA 2013: 69).

> I enjoy going and picking berries, it takes my mind off my troubles (AA 18 09 02 in LKDFN 2003: 54).

> I enjoy picking berries. They taste good and they're healthy, and you get some time out on the land (VD 01 06 04 in LKDFN 2005: 51).

> I enjoy being outdoors and enjoying the fresh air. I used the berries I picked to make jam, and just ate them (MF 01 06 04 in LKDFN 2005: 51).

> Berry picking is a family tradition, and I get to go outdoors. I ate them, and used them to make jam and for other baking (LA 01 06 04 in LKDFN 2005: 51).

Plants and plant products also provided the 'tools' for ceremonial practices.

> ...pots suspended over a qulliq would accumulate a layer of black soot that would be gathered and used as ink for tattoos. A thread of caribou sinew would be coated in soot and pulled through the skin of the face with a copper needle to create a dashed pattern. Women were traditionally the recipients of such tattoos and in this community is considered to denote status and accumulation of knowledge. One of the elders considered it an initiation to womanhood (Davis and Banack 2012: 81).

> Puffy mushrooms. A long time ago some of the puffy plants were put on the baby, so that they can become a shaman, a strong person. Puff would help things disappear – when people are really scared (DDEC 2013: 34).

4.5 Indicators and Growing Observations

Through time, TK determined whether Aboriginal peoples would perish or persevere: survival in harsh conditions necessitated that peoples become astute observers of environmental relationships (Berkes 2012). Every day brought multiple opportunities to study "indicators" of healthy land or wildlife populations, or whether the ice was safe for travel. Accordingly, many indicators identified within the body of TK have helped communities understand the changes they see as a result of development. These same observations and indicators could be useful in developing closure plans and monitoring programs. This section highlights some of the understandings of "indicators" inherent in TK related to tundra plants.

> There were less berries in the summer and fall of 2004 as compared to the previous year, and several people commented that the berries were also smaller. This was deemed to be natural change due to the weather. It was an extremely late spring in 2004 and a very early fall, so the berry growing season was very short. There was also not much rain, compared to the summer and fall of 2003 when the ground was much wetter (LKDFN 2005: 54).

> This year the berries [blueberries] are more and bigger because of the rainy season. Last year the berries were not as much as this year because it did not rain as much (MD 14 09 02 in LKDFN 2003: 53).

> It was kind of a cold summer, but there was lots of rain. That's why the berries are big and easy to pick this year (AA 18 09 02 in LKDFN 2003: 54).

Indicators of berry health or fitness identified by the Łutsel K'e Dene First Nation include:

- Type (species) and abundance of berries in traditional berry patches
- Location of berry-harvesting activities
- Levels of rain during the spring and summer months
- Temperature during the spring and summer months
- Forest fire activity in the region (LKDFN 2003: 53)

Elders and land-users discussed how berry patches arise or disappear when habitat areas undergo disturbance:

> This year I found there was much more berries than the years before. In the past there was too much forest fires and it was also the weather was too hot" (YD 10 01 in LKDFN 2002: 41).

> Pin cherries never used to grow here until they made a road and pushed the dirt around. It grows on the exposed dirt. It grows by the big hill around town. I've never seen pin cherries around here until they fixed the road. Then the berries started growing on the new dirt. The cherries started growing about two years after the road got pushed through. They don't last long though, only a week to ten days. (MD 12 01 in LKDFN 2002: 41).

Astute study of the relationships between vegetation and moisture is also a key element of TK:

> I know that mushrooms start to sprout during the spring time. When there's lack of rain, they tend to dry up. It's the same with different types of plants. The tundra shrinks and die[s] off. ... It has to be a certain condition for the plants to grow (Lena Kamoayok in Golder 2003: 39).

Tundra vegetation also has a role in understanding "indicators" for water quality (TCS 2013a).

> Because of that pristine water, berries grow around that area. They are very sweet for us. […] Not too many people in the world can drink out of the lake. We need to keep on

> doing this, not only for our generation, but for our next generation. […] Because of the quality of the water that we get up here, our animals need to be clean and pristine for the tourism. Our tourists come because of how clean and pristine our water is. […] We can have as many fishing lines from one boat as we would like and it is because of how good our water is (Bobby Algona in TCS 2013a: 50).

> My Elders told me to drink water from pools on a hill near moss (like here) (Fred Sangris in TCS 2013a: 52).

Given the importance of wildlife to Aboriginal peoples in the Lac de Gras region and beyond, there are several references in the TK literature that link peoples observations of vegetation on a very detailed scale, as well as between plants and animal behaviour.

> Changes in local weather conditions on a micro-scale can cause changes in the rate of green-up (Golder 2003: 15-16).

> People say that vegetation quality and the timing of green-up partially explains why the calving grounds shift . . . (Thorpe et al. 2001 in Golder 2003: 16).

Community members have also contributed important observations between environmental change, fire and re-growth.

> Regarding the forest fires - some scientists say it's good for new growth. But do you know what the caribou eat? If the lichen burns - it will take over 100 years for the plants to grow back. Some scientists say the forest fires are good but it's not like that for us. There never used to be so many forest fires. .... (PM 11 06 00 in LKDFN 2001a: 75).

> Winter grazing caribou avoid areas where burns are too recent for lichen cover to have become re-established, or where a lack of fire has allowed extensive canopy development (Senes Consultants 2008: 196). This is confirmed by TK research with communities including the Tłı̨chǫ in which elders discuss locations of fire and why caribou avoid these locations (Dogrib Treaty 11 Council 2001 in Senes Consultants: 2008: 196).

> ... As we see today, the tundra is becoming too dry from the lack of rain, and because of that, we seem to get more forest fires (John Akana in Golder 2003: 27).

5.0 Plants and Animals

Many Elders speak about how people move back and forth between the spiritual and animal worlds which may explain why TK of animal use is so rich. For example, it is understood that the Dene share a common language and song with the animals and the land. Elder Pierre Marlowe explains this connection:

> In the olden days, all the animals including the birds used to talk like people. This was at the same time in history when the fire was alive. If you wanted a fire, all you had to do

> was call to the trees and the wood would come running and make a fire for you. One time a piece of wood hit a man by mistake. The man got very mad and started hitting the stick. After that the wood would no longer make fires for the people (PM 03 06 99 in LKDFN 2002: 24).

Many place names similarly convey an understanding of the relationships between plants and wildlife, even when the association may not be explicit. As explained in Dogrib Treaty 11 (2002: 58):

> A number of placenames refer to caribou without mentioning them, for example by mentioning a favourite caribou food (Daàghǫǫtì [Type of Lichen] Lake) or a caribou crossing (Kwik'ìiʔedaà 'Gun Crossing'). These kinds of names are potentially more informative than names just including the word 'caribou' because they indicate descriptions of the bio-geographical surroundings that are useful for other purposes (Dogrib Treaty 11 2002: 58).

The following section presents findings from this literature review of how animals use and interact with tundra plants according to the categories of forage and habitat. Where possible, specific reference is made to the Lac de Gras area.

5.1 Forage

5.1.1 Berries

> Last year as I was picking berries and there was a black bear eating blueberries near where I was picking berries - bears really like berries (CM 03 09 02 in LKDFN 2003: 53).

> They [Willow Ptarmigan and Rock Ptarmigan] eat willows, berries, seeds and also ingest sand to aid digestion (LKDFN 2002: 37).

> The plants that grow, it seems like there is in abundance. We know the bears and ground squirrels and birds feed on berries. And so, berry plants are important to us (Philip Kadlun in Golder 2003: 39).

> As far as berries are concerned, although the grizzly feed on ground squirrels, they feed on plants and berries, they also feed on birch by peeling off the skins. It's like someone had taken a knife to take the skin off. The bears like it. And certain plants are important for caribou and certain berries too. And by feeding on certain plants the caribou fatten up and stay healthy. And it's important that we keep in mind these plants are important to wildlife (Joseph Niptanatiak in Golder 2003: 39).

> Caribou pick leaves (e.g. bearberry leaves) and keep them in their cheeks, and when they sit down (to rest) they chew on these slowly. Squirrels do the same thing (DDEC 2013: 35).

5.1.2 Flowering Plants

Plants (General Discussion)

Grizzlies also dig out certain roots. Bears have a different diet. Certain wildlife eat different types of plants (Lena Kamoayok in Golder 2003: 39).

Bistort

The bulbils of bistort also are sought by ptarmigan and small seed-eating birds (Burt 2004: 60).

Moss Campion

Caribou eat the little flowers of moss campion early in summer (they grow earlier than other flowers). The seeds can be found in the rabbit and caribou stomachs (DDEC 2013: 35).

5.1.3 Grasses

Aquatic grass is used for bird nesting and moose food (DDEC 2013: 28).

Wolverine like rough ground that is very rocky with holes, so there are a lot of wolverine in that area..., there is also shallow water in that area for them to catch fish and berries and grass for them to eat.... (Charlie Bolt, 050217; Stanley Klengenberg, 050217 in Wolfden 2006: 4-23).

Arctic Cotton

Elders and sisters, Mary Kaniak and Lena Kamoayok, made the interesting observation that cottongrass is typically the first food that calves eat (Thorpe and Eyegetok 1998).

5.1.4 Lichen, Mosses and Mushrooms

Lichen

... there is the white lichen that caribou like to eat all over the place [around Snap Lake] (JF 17 06 01 in LKDFN 2001b: 45).

Caribou eat yellow lichen and moss together, and makes what is in their stomach turn color (DDEC 2013: 35).

Caribou like to eat the yellow/white lichen in the winter, along with leafy plants. They dig these out from under the snow (DDEC 2013: 35).

Lichen is the caribou primary food source. Caribou like different types of lichen just like people like different types of food (DDEC 2013: 28).

During the spring and winter, lichens seem to be a favourite food source [for caribou] (Thorpe and Eyegetok 1998).

The most important [use of vegetation by wildlife] would be lichen. It is the main food for caribou. Grasses for muskoxen and lemmings (Steve Anavilok in Golder 2003: 39).

Lichens identified by the community assistant [Fred Sangris] as those that would be consumed by caribou ... includes the following species: *Alectoria nigricans*; *Cladina mitis* (green reindeer lichen); *Cladonia* species; *Cladina stellaris* (northern reindeer lichen); *Cetraria cucullata*; *Cetraria nivalis* (also *Flavocetraria nivalis*) (crinkled snow lichen); *Cetraria* spp.; *Nephroma arcticum*; *Peltigera* species; and *Stereocaulon tomentosum* (woolly foam lichen) (Golder 2011: 6).

The elders said that caribou would eat the lichen if they had to, because they have to eat, but the animals would most likely avoid eating lichen at this location [NS 15 at the Diavik mine]. “If [lichen] doesn’t taste good, they are not going to eat it” (Joseph Judas in TG 2013: 19).

Mushrooms

Several elders pointed to mushrooms as being an important food source for caribou. You can tell when caribou have been grazing mushrooms when the top of the mushroom is missing. Jack Alonak says that mushrooms are a "water bottle" for caribou because they contain so much moisture. He also likens mushrooms to chewing tobacco since caribou often keep them in their mouths for long periods of time (Thorpe and Eyegetok 1998).

In my own experience I've seen the caribou eat mushrooms. They also feed on grass. Certain wildlife have plants that they like to eat. And it's good that way because there's abundant plants for certain wildlife (Lena Kamoayok in Golder 2003: 39).

5.1.5 Trees and Shrubs

Birch

Caribou eat young birch leaves (DDEC 2013: 28).

Willow

The best way to tell what caribou are eating is to examine the stomach contents. In the summer, willow leaves are plentiful in the digestive tract. Caribou particularly enjoy stripping the leaves from the stalk of the plant. Willows smell and taste differently in one area compared with another. This is reflected in the taste of the caribou meat (Thorpe and Eyegetok 1998).

There is a general agreement that the island caribou move to the mainland during the winter for better food such as willow, tamarack, heather, lichen, puff balls and berries (Wolfden 2006: 4-20).

> Willows are important to moose and caribou as a source of food and fish as a place to hide from predators (Charlie Bolt, 050217; Issac Klengenberg 050217; Stanley Klengenberg 050217 in Wolfden 2006: 4-24).

5.2 Habitat

In addition to studying what wildlife consume, Aboriginal peoples in the Lac de Gras area have long observed how wildlife interact with vegetation and what defines key wildlife habitat (Thorpe et al. 2001; Dogrib Treaty 11 Council 2001a, 2001b).

> The caribou will return back to the [East] island and they always smell their feet when they are walking and we plant the vegetation again (Mark Taletok in TCS 2013b: B(Day 3) – 16).

> The ground and vegetation is also very important. NiʔelʔAze (hummocks), nikel kue (valleys with water and moss) and nikele (muskeg) provides valuable habitat for ducks and geese as well as provide[s] a rich source of plant life including birch and lichens for caribou feeding (LKDFN 2003a: 2.4).

> This landform [eskers] is also used by grizzly bears and wolves, and these are also important for vegetation and the animals to feed on. ... The eskers are where there's vegetation, streams, rivers those are important because we have to keep in mind what the wildlife feed on (Philip Kadlun in Golder 2003: 32).

> The caribou prefer to walk through valleys and lie down to rest and forage in the muskeg in the bottom of the valley (TG 2013: 15).

Indeed, many Aboriginal place names are tied to wildlife and provide insight on a landscape level (Dogrib Treaty 11 Council 2001b). For example, in a WKSS research initiative to record Tłı̨chǫ placenames, out of the over 300 placenames recorded, ten percent were related to indicators of vegetation (Dogrib Treaty 11 Council 2001b: 11). Habitat type knowledge also included an understanding of the associated plant communities. The following examples illustrate the importance of place names in understanding the land:

> Goèhʔaa - A valley characterized by with a particular predominate shrub or tree and a small stream. There are several types. Goèhʔaa are important for such resources as securing wood for fires and smoking meat and fish as well as for using willows to make fishing nets in the past (Dogrib Treaty 11 Council 2001b: 18).

> K'ògoèhʔaa - A stream valley with predominately willow shrubs; Ts'igoèhʔaa - A stream valley with predominately spruce trees; Kigoèhʔaa - A stream valley with predominately birch trees; Kw'ah - A large area of predominately moss; Kw'ia - A stand of ʔedzǫ (black spruce) on the barrenlands and important for firewood in association with a good campsite. Unlike the habitat known as goèhʔaa, the kw'ia is not in a valley (Dogrib Treaty 11 Council 2001b: 18).

Tłoga/Tł’otè - These are both grasslands on the hozìì (barrenlands) where caribou wander and feed in the fall. During their discussion of vegetation, Louis Whane (PHP-98/08/04) explained that tł’otè was a blanket of grass usually associated with ts’oo, and when the grass looks like a white blanket then that grass is call tł’oga. The soil is moist in parts and dry in others and grasses and sedges predominate.

Patterns associated with Tłı̨chǫ placenames suggest that names that contain topographic and water flow terms have the primary purpose of describing safe understandable travel routes, whereas the primary purpose of the placenames containing biological terms seem to indicate locations with various resources or biodiversity. Placenames stimulate oral narratives that contain knowledge of socio-political relationships, social behaviour, resources, ancestral use, graves and obstacles while traveling and camping in the area. Often a placename will be mentioned to stimulate the listener’s memory, hoping to encourage them to think and act in a certain way (Dogrib Treaty 11 Council 2001b: 15).

5.2.1 Grasses

The caribou come for the green grass they don't stay in areas where there is a lot of gravel.... (Marion Bolt 050217 in Wolfden 2006: 4-21).

Moses Koighok (050208) noted that caribou alter their migrations to pursue better quality food and allow plants and grass to grow back (Wolfden 2006: 4-20).

5.2.2 Roots

Overgrowing roots in water are important for birds and waterfowl (Steve Anavilok in Golder 2003: 39).

5.2.3 Lichen, Mosses and Mushrooms

Lichen

Caribou forage on lichen when it is dry, but prefer their forage to be moist (TG 2013: 13).

Caribou have a preference to lie down and rest while foraging on lichen and sedges in the flat muskeg (TG 2013: 13, 26).

The elders explained that caribou forage everywhere all the time. While walking through any kind of terrain, the animal will always look for forage at the same time. They combine their diet by eating lichen, sedges, bog birch and other plants at the same time (TG 2013: 13).

The [caribou] eat lots, they eat anywhere. They eat as soon as they see food they eat. They are always hungry. For them there’s pie, strawberries, green tea. All kinds of food everywhere, there’s mushroom soup...(laughter). (Joseph Judas, August 14th 2013 in TG 2013: 13).

Aboriginal peoples talk about caribou being very smart and knowing how to best find good habitat (Dogrib Treaty 11 Council 2001a; Thorpe et al. 2001; TCS 2014).

> Some go there on the grass and go right here. They don't go on the rocks. Well, you know the caribou. Even me, I wouldn't go there. The caribou are just the same. (Albert Boucher, August 14th 2013 in TG 2013: 14).
>
> On the occasions when caribou travel across Ek'adì [Ekati], the herds will only pass through because they recognize the low quality of the lichen and other plants they forage on. An elder describe the conditions on the island, "the whole island is dead for [caribou] now" (21.10.2013, Yellowknife in TG 2013: 14).
>
> The herds do not forage at this location [NS9 at the Diavik mine] anymore as they recognize the poor quality of lichen. At this location, the elders noticed dust on the lichen and other vegetation that caribou forage on. The caribou will taste and smell a difference in lichen quality, and thus avoid locations where the lichen is of poor quality (TG 2013: 18).
>
> The elders noticed dust on the vegetation at this site [NS 20 at the Diavik mine] and stated that caribou most likely would avoid forage in areas where a different smell or taste can be noticed (TG 2013: 20).
>
> On the barrenlands, the caribou herds travel relatively fast through ... areas with high [tall] vegetation to better forage areas with increase[d] visibility (TG 2013: 24).

5.2.4 Trees and Shrubs

> Tsuˀdza deʔa are also important areas for wildlife. They provide shelter as well as food for small animals such as: kˀasba - ptarmigan; gahcho - arctic hare; thele - ground squirrel. Other species that use these areas include: sascho - grizzly bear; nuni - wolf; naghai - wolverine; tsˀiba - white fox; nagidhe - red fox (LKDFN 2003a: 2.1).
>
> Birch bush provides shelter for birds and hare, and bears (DDEC 2013: 28).
>
> The elders say that the ʔekwǫ̀ (caribou) migrate to the boreal forest in the winter because the trees shelter them from the wind and cold. For example: ... because there's no trees in the barrenland and the ʔekwǫ̀ are not so cold in the bush, they will move into the bush [during the winter] (Jimmy Martin, 97/04/17 in Dogrib Treaty 11 Council 2001a: 31).

Willow

> Willows are important to moose and caribou as a source of food and fish as a place to hide from predators (Charlie Bolt, 050217; Issac Klengenberg 050217; Stanley Klengenberg 050217 in Wolfden 2006: 4-24).

> As well, the wetlands are important because the wildlife feed on certain plants. I've seen certain wildlife feeding in wetlands. Willows in the wetlands (Philip Kadlun, Kugluktuk in Golder 2003: 39).

6.0 Risks and Impacts

The Aboriginal way of knowing and understanding the health of the land, passed orally through generations and incorporated into personal experience, still persists today and guides Aboriginal peoples in understanding and making decisions related to the Lac de Gras area and beyond.

Perception of the land as healthy, unspoiled and uncontaminated is critical to how people engage with the land. People avoid contaminated areas and grieve for the damages done to the land. Indeed, they feel a responsibility to heal the land not only for themselves, but also for the wildlife, birds and fish that depend on healthy ecosystems. Such sentiments have been expressed multiple times throughout meetings held by the Diavik TK Panel since 2012 (EMAB 2006, 2007, 2013; TCS 2013b). Each Aboriginal organization's experience is unique; therefore, the observations of each organization have been independently summarized below.

6.1.1 Łutsel K'e Dene First Nation (LKDFN)

> The caribou around that place; I am concerned about if they caribou start eating food around the mine area; anything that spills on the ground is taken up by the plants (JB 02 14 01 in LKDFN 2001a: 74).
>
> Dust may affect plants that caribou eat (LKDFN 2003b: 9).
>
> Spills and waste may contaminate caribou's food (LKDFN 2003b: 9).

In discussing the Snap Lake project, community members commented that:

> Many plants in this wetland are dying - they have black leaves. It could be from the water being put in here, or maybe from the dust (MD 16 06 01 in LKDFN 2001b: 35).
>
> The intake pipe from the lake - do they treat the water with chlorine? Maybe it is the chlorine that is killing the plants. Maybe that [chlorinated] water, as well as laundry water, goes into the sewage, and then gets dumped into the wetland. We really have to think about it before we make any recommendations. (LE 16 06 01 in LKDFN 2001b: 35).
>
> One of my main concerns is dust and the cumulative effect on vegetation. The dust will be blowing from many different places, year after year. It will affect the vegetation. (LA 28 06 01 in LKDFN 2001b: 43).
>
> Dust from the mine and the quarry [at Snap Lake] could settle on this stuff [caribou lichen], and they would still eat it. Maybe this is why some of them are so skinny and have pus in the meat this year (JM 17 06 01 in LKDFN 2001b: 46).

Concerns about food webs and relationships between environmental components have been identified.

> All living things need water - the plants, lichens and people too. The caribou eat the lichens and it gets into the food chain that way. We should be doing tests to see if the water is contaminated or not. Especially in the springtime, there is lots of water. At the end of August, the water goes away [some streams dry up] (PC 25 05 01 in LKDFN 2001b: 39).

> Many plants in this wetland are dying - they have black leaves. It could be from the water being put in here, or maybe from the dust (MD 16 06 01 in LKDFN 2001b: 35).

> At the sewage outflow, we can't really say right now what is happening. The plants are dead, but they haven't really started to grow this year. It's still cold (JBR 16 06 01 in LKDFN 2001b: 35).

> The plants aren't growing right now in the wetland. But we cannot tell until later in the summer if this is because the land is spoiled (JBR 16 06 01 in LKDFN 2001b: 36).

> Those plants around the wetland have black leaves, like they have been flooded or dying. If these black leaves stay there later in the summer, we know that something is killing those plants (AM 16 06 01 in LKDFN 2001b: 37).

> They should watch [monitor] to see in which way the dust mostly blows, and how far from the mine site. They should make sure that this dust does not turn the plants black, or sometimes white with so much dust (JD 10 07 01 in LKDFN 2001b: 43).

6.1.2 Yellowknives Dene First Nation (YKDFN)

The YKDFN have been dealing with the effects of mining for over 60 years in relation to gold mining near Yellowknife. Due to growing concerns about the safety of plant medicines harvested by community members, in 1998-1999 the YKDFN Land and Environment committee initiated a study as part of DIAND's Northern Contaminants Program of the berries and plant medicines growing in the vicinity of the Giant Mine, Con Mine, Ptarmigan Mine, as well as Yellowknife Bay and surrounding areas for the presence and concentrations of arsenic (YKDFN 2003: 3).

Plants such as Labrador tea, shore grasses, blueberries, cranberries, birch tree bark and sap, spruce bark, needles and gum, rock tripe lichens, and willows (branches and leaves) were collected by YKDFN community members and submitted for analysis to Dr. Laurie Chan of CINE (Centre for Indigenous Nutrition and Environment) at McGill University. Results of the study indicated that the highest concentrations of arsenic were found in lichen, spruce bark, spruce branches and tamarack bark samples collected from the Giant and Con mine areas (YKDFN 2003: 4). It was recommended that community members not to drink medicinal teas from plant medicines collected in the vicinity of the mine sites, while plants collected further away from these sites demonstrated safe levels of arsenic (YKDFN 2003: 6).

6.1.3 North Slave Métis Alliance (NDMA)

There are quite a few areas that are not used any more due to mine sites being in the area, or other developments. Vegetation around mines, especially in Yellowknife does not fare well, and some fish do taste different near mines (NSMA 2012: 18).

[Caribou] eat stuff off the ground, there. Well, if it's polluted, half of them are going to be sick! Some caribou, they have disease, eh…. Inside the meat, you could see sores on it…. In the olden days, they never had that trouble (Nora McSwain in NSMA 2013: 70).

I have concerns because the water is vital to the survival of everything, and so the more protective measures that can be taken to ensure that the water is not totally contaminated – that there are steps taken to preserve the quality of the water – I think you will automatically preserve the quality of the wildlife, and every one of us that come out here to hunt and to harvest food from the land. And the berries, the berries – they wouldn't survive any contamination, and I wouldn't want to collect berries in contaminated areas. .... (Sue Enge in NSMA 2013: 78).

6.1.4 Tłı̨chǫ Government (TG)

The Lac de Gras area is known to be important habitat for caribou.

Ek'adì [Ekati] used to be an important feeding area. The caribou know that their forage is currently in poor condition at this location and choose not to use and forage on the island. The elders said that caribou avoid using this area anymore and will most likely not forage in this area for 20-30 years after the mine is closed (TG 2013: 14).

A common concern among the elders involves the potential consequences of the deteriorated forage areas around near-site sample locations [at Diavik mine]. One of the consequences is altered migration routes. The caribou know their feeding grounds are of poor quality close to the mine and as such the herds choose to travel to other areas with increased forage quality (TG 2013: 39).

Yes, back in days for healing purposes I guess a lot of people depend on the traditional medicines. It's a fear that once the development gets underway all the traditional medicines will disappear with it as well. Certainly this is the point of view directly coming from our elders. They're the ones that have great concerns about what might happen after development, mine develops…. the elders, they knew what type of plants and what type of trees are good for any illness I guess. They identified them. They depend a lot on the traditional medicines. Even the blueberries and the cranberries, a lot of animals really live on it too as well too because in the event that their land is ruined in the future and what animal will be feeding on it?" (Harry Apples in Olson and Chocolate 2012: 39).

… if the chemical's contaminating stuff and it goes out into the environment, the caribou rely on lichen. So, in the summer, the caribou will eat lichen, and some of those shrubs … the caribou will get ill, it will be unhealthy -- it won't be healthy, and so if the mining goes ahead, the caribou are sensitive to noise, then the caribou will avoid those areas (Rosa Romie in Olson and Chocolate 2012: 43).

Even though Rayrock is cleaned up, people don't go there anymore. Even after this place is used, people won't go there. That way of life in that area will be gone." (Georgina Chocolate in Olson and Chocolate 2012: 50).

Tłı̨chǫ citizen's observations include increased perceived contamination of traditional resources and foods (including plants and animals), upon which use of habitation areas rely, likely leading to lost or reduced use (Olson and Chocolate 2012: 46).

Elders found berries at the location [NS 9 at the Diavik mine] but would not eat the berries because of possibility of pollution due to the close proximity to the mine site (TG 2013: 18).

6.1.5 Kitikmeot Inuit Association (KIA)

During caribou migrations, when there is exploration going on around here, might be good to leave the area alone. Leave there or until they get through . . . (Allen Kapolak in Thorpe et al. 2001: 109).

I am worried that if there is too much mining going on up here in the North, caribou might just change their route and not come around completely. Not come around their normal migration routes, and people are going to have to move further and further for caribou. It is going to be harder for everyone up north to go hunting (Anonymous C in Thorpe et al. 2001: 109).

I started growing up in the DEW lines back when the DEW lines first started in the 1950's when construction was going on there and all those DEW lines, they closed. They didn't do any reclamation in those sites so they just left the airstrips and the roads as they were and after so many years I still go back to the one DEW line where I grew up. The runway there the grass is all grown again, it's even more beautiful, prettier than the natural landscape. You know the weather is not as hot as down south but any kind of vegetation grows on the airstrip and roads. I won't be too concerned about removing the airstrip. Maybe some parts could be taken down, but the runway I wouldn't be too concerned about it (Henry Ohokannoak in TCS 2014: D (Day 3)-4).

It's been mined the land is being destroyed and as I was growing up I knew the land and we had food from the land and we would eat together and we would play outside and we ate very well and lived very well . . . it hurts your heart that the land is destroyed and when we hear that the mines are closing it feels so much better that it kind of surprises me (Mark Taletok in TCS 2014: B (Day 2)-12).

7.0 Re-Vegetation

One of the key strengths of Aboriginal cultures everywhere is in the way that "Nature" or "Mother Earth" is at the core of everything: health, wellness, survival, and quality of life. Natural forces need to be respected and there are cultural taboos associated with interference (Dogrib Treaty 11 Council 2001a, 2001b; Legat 2012; TCS 2014). Recognizing this, there are still ways in which people have experimented with helping to heal the land through re-vegetation, healing ceremonies or cultural rules (e.g. people are taught to avoid stepping on lichen as this is the main forage for caribou). There are also stories of people applying their TK in attempts to transplant certain valued plants:

> I began to plant flowers in the mist soil. I remember I was always busy with plants (Aalasi Joamie in Joamie and Ziegler 2009: 8).

The TK Panel for Diavik is currently discussing ways in which to approach re-vegetation at Diavik as part of the closure plan. Discussions with elders at the nearby Ekati mine included several recommendations for re-vegetation that may be helpful.

> Make the tailings beaches wavy with little hills so that the plants are easier to grow (DDEC 2013: 31).
>
> Waste rock piles have large rocks and water will not collect and stay, but if you use fines in the cover they will hold moisture and plants will be able to grow in that (DDEC 2013: 31).
>
> You will need to roughen the area around willow cuttings so that progression can take off (DDEC 2013: 31).
>
> Rough and loosening the ground promotes growth, and heavy seeding outcompetes native species. It promotes growing of vegetation, by using pockets where moisture collects. Also pockets collect seed over time so that it doesn't get dispersed. Improves natural recovery, cost effective for preventing erosion, seed collection as well (DDEC 2013: 31).
>
> Should think about what will prevent natural recovery (DDEC 2013: 31).
>
> When transplanting sedges you want to only take a maximum of 10% of the material from where the plants are taken from (DDEC 2013: 31).

Important guidance from TK can directly assist Diavik and other projects in re-vegetation efforts in the future.

> As they travel across the Naaɂòok'è at NS 23 [at the Diavik mine], the animals avoid the western tip of the peninsula because of the rocky area. Instead, caribou prefer to walk on the western side, covered with lichen and sedges. This is evident by the multiple caribou trails leading into the water on the western side of the peninsula (TG 2013: 14).

In general, there didn't appear to be much available through the literature review relating to TK of re-vegetation or disturbance. However, people have long known that fireweed is common at traditional camps, along airstrips, and other areas of the land that have been disturbed are undergoing natural recovery processes. While onsite at Diavik, the TK Panel commented on the abundance of fireweed naturally growing in disturbed areas (TCS 2014).

8.0 Gaps in the Literature

Results from this high-level review of the literature pertaining to TK of plants in the Lac de Gras area show that while there is undoubtedly much TK held by Elders, much of this is not well documented for reasons discussed earlier in this report. The following is a list of gaps in the TK literature reviewed for this report:

- Lack of documented use of plants for food and technological use in the Lac de Gras area , particularly for the YKDFN and NSMA
- Shortage of well documented TK at a small scale, regional and landscape level analysis:
    - Integration and reporting of TK at a landscape level can be challenging given the predominance of a reductionist western scientific paradigm in most environmental assessment and reporting
    - The ways in which botanists view plant assemblages may not be parallel with the ways that Aboriginal peoples make sense of the landscape
- TK of practices for winter/early spring use of vegetation:
    - Preservation methods carried out in the fall seem to be better documented
    - This type of information might be more readily available in proper ethnographies
- Detailed understanding of which types of plants animals tend to avoid:
    - While not represented in the literature, it is probable that this TK is held by Aboriginal peoples of the Lac de Gras area
- Detailed understanding of plant succession, colonization and response to disturbance; and,
- Review of Aboriginal trail networks, place names, camps and known lifeways for references to vegetation and how plants were utilized to identify suitable resource areas.

While not well documented in the literature, it is probable that Aboriginal peoples possess this important understanding of the Lac de Gras area. There are likely additional gaps in the literature, but the above list is likely most relevant to Diavik. Additional review of identified sources could possibly help to reduce these gaps.

9.0 Conclusions

> I am telling the younger people now that they must be prepared for change. Do not get lost in the rapid changes in our lives. Many things come from the Qallunaat [white people] that are not in our traditional customs. We must be prepared for these changes. Be prepared, as we have been taught to be prepared (Aalasi Joamie in Joamie and Ziegler 2009:14).

As Elder Aalasi Joamie so eloquently says, it is true that change is constant. Aboriginal peoples have always had to adapt to changing weather patterns, wildlife migrations, temperatures, and socio-economic conditions and many times in ways that they never expected. With the arrival of diamond mining in the Lac de Gras area came a significant change in the relationships between people, wildlife, plants, and more. Through change comes the opportunity for learning; change has always been a foundation of TK.

This high-level literature review, although not exhaustive, is a start in understanding the significant traditional knowledge available about the pre-development state of the environment of the Lac de Gras area. This knowledge extends to how vegetation contributes to the health and diet of wildlife in the area and how Aboriginal peoples used vegetation to meet their food, medicinal and technological needs. This knowledge provides critical information about vegetation that is required to support future use of the area by both wildlife and Aboriginal peoples.

While it is not clear if the studies reviewed included full consideration of the knowledge that women possess, both as primary harvesters of vegetation and as meat processors, this review provides insight into knowledge specific to particular plants. Through the literature, blueberries and cloudberries were identified as prized food sources. Labrador tea, in part because it can be burned even when green, is also an important plant for food and medicine. Birch and willow stand out, in large part because of their multiple technological uses and as a key species for wildlife. Pockets of spruce and willows were also very important for camping, providing fuel, animal dens and more. Several types of moss, especially peat moss and lamp moss, were traditionally very important for medicinal, ceremonial and technological uses. People have long understood that lichens are a critical food source for caribou and so must be protected.

Insight into the complexity of ecological relationships, particularly at a landscape level, was identified through some of the TK references for environmental indicators. For example, tying the harvesting of a particular plant to a certain moisture condition, or looking for green tundra where caribou migrations have resulted in added natural fertilizer. The documents reviewed for this report typically did not focus on the specific higher level landscape questions of concern to DDMI in planning for reclamation. However, they do provide the building blocks required to enable TK holders to contribute to planning at this landscape level and a place from which to start articulating their vast TK of tundra plants. Results reported in this review can be used by Diavik, TK Panel Members and communities as a checklist to ensure that planning decisions are cognizant of the ecosystem needs from an Aboriginal perspective.

In closing, ongoing work is recommended to more fully understand TK of tundra vegetation in the Lac de Gras area. Ideally, Elders would also have an opportunity to verify and expand upon this report, particularly where use in the Lac de Gras area has been assumed based on reported Aboriginal use elsewhere.

10.0 List of References

Babbie, E. (2001). *The Practice of Social Research*. 9th Edition. Belmont, CA: Wadsworth Thomson.

Berkes, F. (2012). Sacred Ecology: Traditional ecological knowledge and resource management. New York: Taylor and Francis. 3rd ed.

*Burt, Page. 2004. *Barrenland Beauties: Showy Plants of the Canadian Arctic*. Revised Edition. Yellowknife, Northwest Territories: Outcrop, The Northern Publishers.

*Burt, Page M. 1997. *Diavik Diamond Project Vegetation Baseline Studies - Plant Associations and Habitat Types and Plant Species List*. Rankin Inlet and Yellowknife: Outcrop Ltd. and Bathurst Arctic Services.

*———. 2003. *Summary of Vegetation Baseline Studies Report, 2003 for the Miramar Hope Bay Ltd., Doris North Project, Kitikmeot Region, Nunavut.* Yellowknife, NWT: Outcrop Ltd. Accessed August 8, 2014 at http://ftp.nirb.ca/02-REVIEWS/COMPLETED%20REVIEWS/02MN134-DORIS%20NORTH%20GOLD%20MINE%202004/118%20Final%20EIS/118ii%20-%20Supporting%20Documents/118ii%20D%20-%20Terrestrial%20Environment/118ii-%20D1%20%28Veg.%20Baseline%20Studies%202003%29.pdf.

*Davis, Jonathan Duffy, and Sandra Anne Banack. 2012. Ethnobotany of the Kiluhikturmiut Inuinnait of Kugluktuk, Nunavut, Canada. *Ethnobiology Letters* 3: 78–90. Accessed August 8, 2014 at http://ethnobiology.org/sites/default/files/publications/ebl/pdfs/davis_banack_2012_ebl.pdf.

Dogrib Divisional Board of Education [DDBE]. 1996. *Tłı̨chǫ Yatìı̀ Enı̨htł'è: A Dogrib Dictionary*. Rae-Edzo, NWT: Dogrib Divisional Board of Education. Accessed August 8, 2014 at http://www.Tłıchǫ.ca/sites/default/files/A_Dogrib_Dictionary.pdf.

*Dogrib Treaty 11 Council. 2001a. *Caribou Migration and the State of Their Habitat. Final Report.* Final Report. Submitted to West Kitikmeot Slave Study Society (WKSS). Yellowknife, NT: West Kitikmeot Slave Study Society. Accessed August 8, 2014 at www.enr.gov.nt.ca/_live/documents/content/WKSS_Caribou_Migration_and_Habitat_2001.pdf

*———. 2001b. Habitat of Dogrib Traditional Territory: Placenames as Indicators of Biogeographical Knowledge Final Report. Submitted to West Kitikmeot Slave Study Society (WKSS). Yellowknife, NT: West Kitikmeot Slave Study Society. Accessed August 8, 2014 at www.enr.gov.nt.ca/sites/default/files/wkss_dogrib_territory_place_names_2001.pdf

*———. 2002. *Dogrib Knowledge on Placenames, Caribou and Habitat Final Report*. Submitted to West Kitikmeot Slave Study Society (WKSS). Yellowknife, NT: West Kitikmeot Slave Study Society. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/_live/documents/content/WKSS_Dogrib_Knowledge_2002.pdf.

*Dominion Diamond Ekati Corporation [DDEC]. 2013. *Appendix A: Vegetation Workshop Community Participant Information*. Yellowknife, NT: Dominion Diamond Ekati Corporation. Accessed August 8, 2014 at http://www.mvlwb.ca/Boards/WLWB/Registry/2012/W2012L2-0001/W2012L2-0001%20-%20Ekati%20-%20CRP%20-%202013%20Closure%20and%20Reclamation%20Progress%20Report%20-%20Dec%2030_13.pdf.

Environmental Monitoring Advisory Board for the Diavik Project [EMAB]. 2006. Dust Monitoring Workshop July 14-16, 2006. Community-Based Monitoring Camp Draft Report. Yellowknife, NT: Environmental Monitoring Advisory Board for the Diavik Project.

———. 2007. Annual Report 2006/2007. Yellowknife, NT: Environmental Monitoring Advisory Board for the Diavik Project.

———. 2012. A Way of Life: Bridging Science and Aboriginal Knowledge in Caribou Monitoring at Diavik Diamond Mine. Technical Report. Presented by the TK and IQ Panel. Compiled by SENES Consultants. Ltd.

———. 2013. *EMAB Annual Report 2012-2013*. Yellowknife, NT: Environmental Monitoring Advisory Board for the Diavik Project. www.emab.ca/Portals/0/Documents/Annual Reports/2012-2013 Annual Report.pdf .

*Golder Associates Ltd. 2003. *Report on Inuit Qaujimajatuqangit Literature Review, Gap Analysis and Workshop Results Related to the Doris North Project Hope Bay Belt, Nunavut*. Victoria, BC: Prepared for Miramar Hope Bay Limited. Accessed August 8, 2014 at http://ftp.nirb.ca/02-REVIEWS/COMPLETED%20REVIEWS/02MN134-DORIS%20NORTH%20GOLD%20MINE%202004/118%20Final%20EIS/118ii%20-%20Supporting%20Documents/118ii%20E%20-%20Social%20Env.,%20Heritage%20Res.,%20TK/118ii-%20E1%20%28Traditional%20Knowledge%29.pdf.

*———. 2011. *Appendix II: Risk Assessment of Caribou Exposure to Metals from Dust Deposition to Lichen*. Report Number: 10-1328-0028. Saskatoon, SK.

———. 2014 *Final Report: 2013 Comprehensive Vegetation and Lichen Monitoring Program*. Report Number 13-1328-001. Edmonton, Alberta.

Jaker, Alessandro. 2013. Dzo. In *Weledeh Reader*. Accessed August 8, 2014 at https://docs.google.com/file/d/0B8ohgYXzu0gwM3o0dnNSM0FJbkk/edit?pli=1.

*Joamie, Aalasi and Anna Ziegler. 2009. *Walking with Aalasi: An Introduction to Edible and Medicinal Arctic Plants*. Toronto and Iqaluit: Inhabit Media.

Johnson, Derek, Linda Kershaw, Andy MacKinnon, and Jim Pojar. 1995. *Plants of the Western Boreal Forest and Aspen Parkland*. Edmonton: Lone Pine Publishing.

*Kuhnlein, Harriet V., and Nancy J. Turner. 1996. Descriptions and Plant Foods by Indigenous Peoples. In *Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use*, Second Edition, pp. 16–175. Amsterdam: Gordon and Breach Publishers. Accessed August 8, 2014 at http://www.fao.org/wairdocs/other/ai215e/ai215e06.htm.

*Legat, Allice. 2012. *Walking the Land, Feeding the Fire: Knowledge and Stewardship Among the Tłı̨chǫ Dene.* Tuscon, AZ: University of Arizona Press.

*Łutsel K'e Dene First Nation [LKDFN]. 2001a. *Final Report: Traditional Ecological Knowledge in the Kaché Tué Study Region.* Submitted to the West Kitikmeot Slave Study (WKSS). Yellowknife, NT: West Kitikmeot Slave Study Society. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/_live/documents/content/WKSS_TK_Kache_Tue_Region_2001.pdf.

*———. 2001b. *Traditional Knowledge in the Nâ Yaghe Kué Region: An Assessment of the Snap Lake Project Final Assessment Report*. Submitted to De Beers Canada Mining Inc. Accessed August 8, 2014 at http://www.reviewboard.ca/upload/project_document/EA01-004_z04-App_IV_3_1313193179.PDF

*———.2002. *Traditional Knowledge in the Kaché Tué Study Region: Phase Three – Towards a Comprehensive Environmental Monitoring Program in the Kakinene Region*. Submitted to the West Kitikmeot Slave Study (WKSS). Yellowknife, NT: West Kitikmeot/Slave Study Society. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/sites/default/files/wkss_tk_kache_tue_region_2002.pdf.

*———. 2003. *Ni Hat'ni - Watching the Land: Results and Implications of 2002-2003 Monitoring Activities in the Traditional Territory of the Łutselk'e Denésôliné.* Final Report - Complete. Submitted to West Kitikmeot Slave Study Society (WKSS). Yellowknife, NT: West Kitikmeot Slave Study Society. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/_live/documents/content/WKSS_Ni_Hat_ni_2003-2005_Report.pdf.

*———.2003a. *Denesuline Perspectives and Issues About the Proposed DeBeers Mine at Na Yaghe Kue*. Yellowknife, NT. Accessed August 8, 2014 at http://www.reviewboard.ca/upload/project_document/EA01-004_866_1154541456.PDF.

*———. 2003b. Denesuline Recommendations on Na Yaghe Kue (Snap Lake). Accessed August 8, 2014 at http://www.reviewboard.ca/upload/project_document/EA01-004_865_1154541174.PDF.

*———.2005. *Ni Hat'ni - Watching the Land: Results of 2003-2005 Monitoring Activities in the Traditional Territory of the Łutselk'e Denesoline*. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/_live/documents/content/WKSS_Ni_Hat_ni_2003-2005_Report.pdf.

Mallory, Carolyn, and Susan Aiken. 2012. *Common Plants of Nunavut*. Iqaluit, NU: Inhabit Media. Accessed August 8, 2014 at http://nbes.ca/wp-content/uploads/2014/03/CommonPlants_Oct12-1.pdf.

Marles, Robin J., Christina Clavelle, Leslie Monteleone, Natalie Tays, and Donna Burns. 2012. *Aboriginal Plant Use in Canada's Northwest Boreal Forest.* Edmonton, AB: Natural Resources Canada, Canadian Forest Service, and Northern Forestry Centre.

Naeth, M. Anne, and Sarah R. Wilkinson. 2011. Reclamation at the Diavik Diamond Mine in the Northwest Territories Substrates Soil Amendments and Native Plant Community Development: Phase II Final Report. Edmonton, AB: Department of Renewable Resources, University of Alberta.

Nunavut Arctic College [NAC]. 2012. *Inuinnaqtun to English Dictionary*. Nunavut Arctic College. Accessed August 8, 2014 at http://www.nald.ca/library/learning/nac/nac_dictionary/nac_dictionary.pdf.

*North Slave Métis Alliance [NSMA]. 2012. *Traditional Land Use, Occupancy and Knowledge Report for Environmental Assessment #EA0809-004. Fortune Minerals' NICO Gold Project.* Yellowknife, NT: North Slave Métis Alliance. Accessed August 8, 2014 at http://www.nsma.net/Portals/0/TK_reports/2012_NSMA_LAND_USE_TK_FORTUNE.PDF.

*———. 2013. *Traditional Knowledge and Land Use Report 2012-2013: A Study for De Beers Canada Inc. Proposed Gahcho Kué Project*. Yellowknife, NT: North Slave Métis Alliance. Accessed August 8, 2014 at http://www.nsma.net/Portals/0/TK_reports/2013_NSMA_GKTK.pdf.

*Olson, Rachel, and Georgina Chocolate. 2012. *Asi Edee T'seda Dile: Tłįchǫ Nation Traditional Knowledge and Use Study. September 15th, 2012*. Firelight Group Research Cooperative and Tłįchǫ Government. Accessed August 8, 2014 at http://reviewboard.ca/upload/project_document/EA0809-004_Traditional_Knowledge_and_Use_Study_Tłichǫ_Government.PDF.

Piruvik Centre. 2014. Inuinnaqtun Tusaalanga. Accessed August 8, 2014 at http://www.tusaalanga.ca/.

*Senes Consultants Limited. 2008. *West Kitikmeot Slave Study State of Knowledge Report - 2007 Update*. Prepared for the West Kitikmeot Slave Study Society. Accessed August 8, 2014 at http://www.enr.gov.nt.ca/_live/documents/content/West_Kitikmeot_Slave_Study_2007_Update.pdf.

*Thorpe Consulting Services Ltd. (TCS). 2013a. At Night We Slept on Diamonds: Report of the Traditional Knowledge Camp for the Diavik Aquatic Effects Monitoring Program. Prepared for Diavik Diamond Mine.

*———. 2013b. Report on the DDMI Traditional Knowledge Panel Session #6: Focus on Processed Kimberlite Containment. October 24-18, 2013. Prepared for Diavik Diamond Mine.

*———. 2014. Report on the DDMI Traditional Knowledge Panel Session #7: Focus on Re-Vegetation. August 14-18, 2013. Prepared for Diavik Diamond Mine.

*Thorpe, Natasha, and Sandra Eyegetok. 1998. *Tuktu and Nogak Project 1998 Annual Report*. Submitted to West Kitikmeot Slave Study Society. Yellowknife, NT: West Kitikmeot/Slave Study Society. Accessed August 8, 2014 at http://www.polarnet.ca/tuktu/Reports/98Annrpt.html.

*Thorpe, Natasha, Sandra Eyegetok, Naikak Hakongak, and Tuktu and Nogak Project. 2001. *Thunder on the Tundra : Inuit Qaujimajatuqangit of the Bathurst Caribou*. Ikaluktuutiaq, NU: Tuktu and Nogak Project.

*Tłı̨chǫ Government [TG]. 2013. *Traditional Knowledge Study for Diavik Soil and Lichen Sampling Program*. Behchokǫ̀, NWT: Tłı̨chǫ Research and Training Institute.

Toolik Arctic Geobotanical Atlas. 2014. Photo Library - Plant Species Photos. Accessed August 8, 2014 at http://www.arcticatlas.org/photos/pltspecies/alphaList.php?queryID=none.

*Tsatchia, Mogoʔa, Yabe Michel, Rosanna Mantla, Booliwi Mackenzie, Dzibia Tlokka, Ari Apples, Goligoʔa Judas, T'sakwà Kodzin, and Whilii Dryneck. 2013. *Tłı̨chǫ Use and Knowledge of ʔewaànit'iitì*. Tłı̨chǫ Traditional Knowledge Reports, Research and Monitoring Program. Traditional Knowledge Research and Monitoring Program, Tłı̨chǫ Government. Accessed August 8, 2014 at http://Tłichǫ.ca/sites/default/files/ewaanitiiti%2010.03.2014.pdf.

Turner, Nancy. 2014. Ancient Pathways, Ancestral Knowledge: Ethnobotany and Ecological Wisdom of Indigenous Peoples of Northwestern North America. Montreal, PQ: McGill-Queen's University Press. Volumes 1 and 2.

UVic Linguistics Department [UVic]. n.d. Tłı̨chǫ Yatıì Multimedia Dictionary. Accessed August 8, 2014 at http://Tłichǫ.ling.uvic.ca/default.aspx.

*Wolfden Resources Inc. 2006. *High Lake Project Proposal Volume 3: Human Environment, Section 4: Inuit Qaujimajatuqangit (IQ)*. Thunder Bay, ON: Wolfden Resources Inc. Accessed August 8, 2014 at http://ftp.nirb.ca/02-REVIEWS/COMPLETED%20REVIEWS/06MN082-MMG%20HIGH%20LAKE/1-SCREENING/01-APPLICATION/061122-Project%20Proposal/Volume%203%20Human%20Environment/VOL3_SEC4_Inuit_Qaujimajatuqangit.pdf.

*Yellowknives Dene First Nation [YKDFN]. 2003. *Yellowknives Dene First Nation Land and Environment Committee's Medicinal Plants Study Report 2002-2003*. Submitted to Northern Contaminants Program. Yellowknife, NT: DIAND. Accessed August 8, 2014 at http://reviewboard.ca/upload/project_document/EA0809-001_YKDFN_Medicinal_Plant_Study_Report_1328902255.PDF.

** indicates references that were utilized for the bulk of the traditional knowledge summarized in this report.*

Appendix A – List of Additional References Reviewed

Banci, Vivian. 2012. *Back River Project Draft Environmental Impact Statement Supporting Volume 3: Public Consultation, Government Engagement, and Traditional Knowledge. Appendix V3-3A Inuit Traditional Knowledge of Sabina Gold & Silver Corp.'s Back River (Hannigayok) Project*. Banci Consulting Ltd. Accessed August 8, 2014 at: http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%201C%20to%203A-IT6E.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%202-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%203-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%204-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%205-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%206-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20to%203B-IT6M.pdf

http://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/12MN036-SABINA-BACK%20RIVER/02-REVIEW/05-DRAFT%20EIS%20%26%20CONFORMITY%20REVIEW/02-DEIS%20JAN%202014/Vol%203-Consultation/140120-12MN036-Vol%203-App%203A%20Pt%207-IT6M.pdf.

Banci, Vivian, Chris C. Hanks, Rosemary M. Spicker, and Gerry Atatahak, eds. 2004. *Walking in the Path of the Caribou: Knowledge of the Copper Inuit Placenames Atlas, Naonayaotit Traditional Knowledge Project*. Kitikmeot Inuit Association.

Banci, Vivian, and Rescan Environmental Services Ltd. 2007. *Bathurst Inlet Port and Road Project, Nunavut, Canada: Traditional Knowledge of Wildlife, Fish and Water Quality Report. November 2007*. Bathurst Inlet Port and Road Project Draft Environmental Impact Statement, Vol. VII, Appendix F-5. Rescan Environmental Services Proj. #623-8. Vancouver, B.C.: Rescan Environmental Services Ltd. Accessed August 8, 2014 at: ftp://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/03UN114-BIPR/02-REVIEW/07-DRAFT%20EIS/01-DEIS/Volume%20VII.pdf.

BHP Billiton Canada Inc. 2009a. *ICRP Appendix 5.1-4A Reclamation Research Plan # 24 Establishment of Self-Sustaining Plant Communities – Buildings and Infrastructure*. Yellowknife, NT. Accessed August 8, 2014 at: http://www.mvlwb.ca/Boards/WLWB/Registry/2009/W2009L2-0001/W2009L2-0001%20-%20BHP%20-%20ICRP%20-%20%20Reclamation%20Research%20Plans%20and%20Oct%202009%20WLWB%20Directive%20-%20Email%20Dist%20-%20Mar%204_10.pdf.

———. 2009b. *ICRP Appendix 5.1-4A Reclamation Research Plan # 25 Vegetation Cover and Surface Stability – Buildings and Infrastructure*. Yellowknife, NT. Accessed August 8, 2014 at: http://www.mvlwb.ca/Boards/WLWB/Registry/2009/W2009L2-0001/W2009L2-0001%20-%20BHP%20-%20ICRP%20-%20%20Reclamation%20Research%20Plans%20and%20Oct%202009%20WLWB%20Directive%20-%20Email%20Dist%20-%20Mar%204_10.pdf.

———. 2009c. *ICRP Appendix 5.1-4A Reclamation Research Plan # 26 TK Incorporation in Reclamation Planning*. Yellowknife, NT. Accessed August 8, 2014 at: http://www.mvlwb.ca/Boards/WLWB/Registry/2009/W2009L2-0001/W2009L2-0001%20-%20BHP%20-%20ICRP%20-%20%20Reclamation%20Research%20Plans%20and%20Oct%202009%20WLWB%20Directive%20-%20Email%20Dist%20-%20Mar%204_10.pdf.

BHP Diamonds Inc. 1995a. *NWT Diamonds Project: Volume II - Environmental Setting (Parts 1-2)*. Yellowknife, NT. Accessed August 8, 2014 at: www.monitoringagency.net/LinkClick.aspx?fileticket=Ubmw5sUf1WQ%3d&tabid=111&mid=581.

———. 1995b. *NWT Diamonds Project: Volume II - Environmental Setting (Parts 3-4)*. Yellowknife, NT. Accessed August 8, 2014 at: www.monitoringagency.net/LinkClick.aspx?fileticket=ljXqg%2fYVRxc%3d&tabid=111&mid=581.

———. 1995c. *NWT Diamonds Project: Volume I Project Description – Appendix 1-A*. Yellowknife, NT. Accessed August 8, 2014 at: http://monitoringagency.net/LinkClick.aspx?fileticket=7Y%2ftAoCMVeg%3d&tabid=111&mid=580

Boudreau, Stéphane, and Serge Payette. 2004. “Caribou-Induced Changes in Species Dominance of Lichen Woodlands: An Analysis of Plant Remains.” *American Journal of Botany* 91 (3): 422–29.

Brodo, Irwin M., Sylvia Duran Sharnoff, and Stephen Sharnoff. 2010. “Bibliographical Database of the Human Uses of Lichens: Sorted by Type of Use.” Accessed August 8, 2014 at: http://www.lichen.com/usetype.html.

De Beers Canada Inc., and Golder Associates Ltd. 2010a. *Gahcho Kué Project, Environmental Impact Statement, Annex M: Traditional Knowledge and Traditional Land Use Baseline*. Report Number: 09-1365-1004. De Beers Canada Inc. Accessed August 8, 2014 at: ftp://199.247.52.13/Gahcho Kue/Annex M TK-TLU_Dec-FINAL.pdf.

———. 2010b. *Gahcho Kué Project, Environmental Impact Statement, Section 5: Traditional Knowledge*. Report Number 09-1365-1004. De Beers Canada Inc. Accessed August 8, 2014 at: www.reviewboard.ca/upload/project_document/EIR0607-001_EIS_Section_5__Traditional_Knowledge_1294329702.PDF.

Deninu K’ue First Nation. 2012. *Deninu K’ue Ethno-History Report*. Accessed August 8, 2014 at: www.reviewboard.ca/project_document/EIR0607-001_DKFN_Ethno-history_Report__Part_1_pgs_1-240_.pdf and www.reviewboard.ca/project_document/EIR0607-001_DKFN_Ethno-history_Report__Part_2_pgs_241-435_.pdf.

Diavik Diamond Mines Inc. 2012. *Annual Interim Closure and Reclamation Progress Report - 2012*. Document #: CLSR-001-1112R0. Yellowknife, NT: Diavik Diamond Mines Inc. Accessed August 8, 2014 at: www.mvlwb.ca/Boards/WLWB/Registry/2007/W2007L2-0003/W2007L2-0003 - Diavik - ICRP - 2012 Annual Progress Reprt - Dec 10_12.pdf.

Environmental Monitoring Advisory Board for the Diavik Project. 2006. *July 14-17 Community-Based Monitoring Camp Proposal: Dust Workshop*. Yellowknife, NT: Environmental Monitoring Advisory Board for the Diavik Project.

GeoNorth Limited. 2003. *Workshop Report: Traditional Knowledge Monitoring Workshop March 12-14, 2003*. Yellowknife, NT. Accessed August 8, 2014 at: www.emab.ca/Portals/0/Documents/TKworkshopreportMarch12-14_2003.pdf.

Golder Associates Ltd. 2013a. *Dominion Diamond Project Description: Proposed Development of the Lynx Kimberlite Pipe*. Yellowknife, NT. Accessed August 8, 2014 at: http://www.ddcorp.ca/docs/default-source/default-document-library/lynx-project-description-report-sept-2013.pdf .

———. 2013b. *Dominion Diamond Project Description: The Jay-Cardinal Project*. Yellowknife, NT. Accessed August 8, 2014 at: www.mvlwb.ca/Boards/WLWB/Registry/2013/W2013D0007?Ekati Jay Project - Project Description - Oct 18_13.pdf.

Johnson, Leslie Main. 2008. "Plants and Habitats - a Consideration of Dene Ethnoecology in Northwestern Canada." *Botany* 86 (2): 146–56.

Johnson, Leslie Main. 2009. "Reflections on Seeing a Coyote Cross the Path." *Reflections on Nature, Culture and Society*. November 26. Accessed August 8, 2014 at: http://reflectionsonnatureculureandsociety.blogspot.ca/2009/11/reflections-on-seeing-coyote-cross-path.html.

Kemper, J. Todd, and S. Ellen MacDonald. 2009. "Directional Change in Upland Tundra Plant Communities 20-30 Years after Seismic Exploration in the Canadian Low-Arctic." *Journal of Vegetation Science* 20 (3): 557–67.

Kendrick, A., P.O'B. Lyver, and Łutsël K'é Dene First Nation. 2005. "Denésǫliné (Chipewyan) Knowledge of Barren-Ground Caribou (Rangifer Tarandus Groenlandicus) Movements." *Arctic* 58 (2): 175–91. Accessed August 8, 2014 at: http://pubs.aina.ucalgary.ca/arctic/Arctic58-2-175.pdf

Land and Environment Committee. 2003. *Areas of Importance to Yellowknives Dene First Nation Potentially Affected by the Snap Lake Diamonds Project*. Dettah, NT: Yellowknives Dene First Nation. Accessed August 8, 2014 at: http://www.reviewboard.ca/upload/project_document/EA01-004_517_1153174252.PDF.

Milburn, Alexandra. 2002. *Wild and Wacky Plants of the NWT*. Yellowknife, NT: Department of Resources, Wildlife and Economic Development Government of the Northwest Territories. Accessed August 8, 2014 at: www.enr.gov.nt.ca/sites/default/files/documents/wacky_plants.pdf.

Nicholson, Heather. 2002. "Arsenic in Plants Important to Two Yukon First Nations: Impacts of Gold Mining and Reclamation Practices." M.Sc. Thesis, Department of Geography, Vancouver, B.C.: University of British Columbia. Accessed August 8, 2014 at: www.geology.gov.uk.ca/pdf/MPERG_2002_4.pdf.

North Slave Métis Alliance. 2001. *Can't Live Without Work: North Slave Métis Alliance Environmental, Social, Economic and Cultural Concerns: A Companion to the Comprehensive Study Report on the Diavik Diamonds Project*. Third Printing. Yellowknife, NT: Dargo & Associates. Accessed August 8, 2014 at: www.nsma.net/Portals/0/TK_reports/1999_NSMA_LAND_USE_TK_DIAVIK.pdf.

———. 2005. *North Slave Métis Alliance Land Use Report for the Yellowknife Gold Project.* Yellowknife, NT: North Slave Métis Alliance. Accessed August 8, 2014 at: www.nsma.net/Portals/0/TK_reports/2005_NSMA_LAND_USE_TYHEE.pdf.

———. 2012. *North Slave Métis Alliance Traditional Land Use, Occupancy Study and Knowledge of the Thor Lake Project Area.* Yellowknife, NT: North Slave Métis Alliance. Accessed August 8, 2014 at: www.nsma.net/Portals/0/TK_reports/2013_NSMA_LAND_USE_TK_AVALON.pdf.

Pielou, E.C. 1994. *A Naturalist's Guide to the Arctic*. Chicago: University of Chicago Press.

Rescan Environmental Services Ltd. 2012. *Courageous Lake Project Vegetation Baseline Report*. Prepared for Seabridge Gold Inc. Project #0868-104-03. Yellowknife, Northwest Territories: Rescan Environmental Services Ltd. Accessed August 8, 2014 at: http://www.mvlwb.ca/Boards/mv/Registry/2010/MV2010C0046/Reports/Environmental%20Baseline%20Reports/MV2010C0046%20-%20B1%20Vegetation%20Baseline%20Report%20-%20May15-12.pdf.

Rook, Earl J.S. 1999. "Cladonia Species: Reindeer Lichens." Accessed August 8, 2014 at: http://www.rook.org/earl/bwca/nature/moss/cladonia.html.

Senes Consultants Limited. 2008. *West Kitikmeot Slave Study State of Knowledge Report - 2007 Update*. Prepared for the West Kitikmeot Slave Study Society. Accessed August 8, 2014 at: http://www.enr.gov.nt.ca/_live/documents/content/West_Kitikmeot_Slave_Study_2007_Update.pdf.

Tahera Corporation. 2003. *Jericho Project Final Environmental Impact Statement*. Toronto, Ontario: Tahera Corporation. Accessed August 8, 2014 at: http://ftp.nirb.ca/02-REVIEWS/COMPLETED%20REVIEWS/00MN059-JERICHO%20DIAMOND%20MINE/2-REVIEW/09-FINAL%20EIS/030121-00MN059-Jericho%20Final%20EIS-167a-IT2E.pdf.

Tłı̨chǫ Government. 2012a. *Tłı̨chǫ Knowledge for De Beers Canada Proposed Gahcho Kué Diamond Project.* Behchokǫ̀, NWT: Tłı̨chǫ Knowledge Research and Monitoring Program, Tłı̨chǫ Government. Accessed August 8, 2014 at: www.reviewboard.ca/upload/project_document/EIR0607-001_Tłicho_Traditional_Knowledge_Study.pdf.

———. 2012b. "Adi Edee Ts'eda Dile: The Place We Go Where We Can Survive. Tłı̨chǫ Knowledge (TK) Study for the Fortune Minerals NICO Project." October 10. Accessed August 8, 2014 at: www.reviewboard.ca/upload/project_document/EA0809-004_Traditional_Knowledge_presentation_-_Tłicho_Government.pdf.

Tyhee NWT Corp. 2011a. *Yellowknife Gold Project Developer's Assessment Report: 2.0 Existing Environment and Baseline Conditions*. Tyhee NWT Corp. Accessed August 8, 2014 at: http://www.reviewboard.ca/upload/project_document/EA0809-003_02_YGP_DAR_Existing_Environment_and_Baseline_Conditions__020-096__1306362637.PDF.

———. 2011b. *Yellowknife Gold Project Developer's Assessment Report: 7.0 Human Environment Assessment*. Tyhee NWT Corp. Accessed August 8, 2014 at: http://www.reviewboard.ca/upload/project_document/EA0809-003_07_YGP_DAR_Human_Environment_Assessment__549-591__1306342835.PDF.

Uprety, Yadav, Hugo Asselin, Archana Dhakal, and Nancy Julien. 2012. "Traditional Use of Medicinal Plants in the Boreal Forest of Canada: Review and Perspectives." *Journal of Ethnobiology and Ethnomedicine* 8 (1). Accessed August 8, 2014 at: http://www.ethnobiomed.com/content/8/1/7.

Weledeh Yellowknives Dene. 1997. *Weledeh Yellowknives Dene: A History*. Dettah, NT: Yellowknives Dene First Nation Council. Accessed August 8, 2014 at: www.akaitcho.info/linked/weledeh yellowknife dene history.pdf.

"Wild Edible Plants of Northwest Territories." n.d. *Northern Bushcraft*. Accessed August 8, 2014 at: http://northernbushcraft.com/guide.php?ctgy=edible_plants&region=nt.

Appendix B– List of Additional References to Consider

Chocolate G., Legat A. 2000. A Tłı̨ chǫ Perspective on Biodiversity. Yellowknife, NWT: Dogrib Treaty 11 Council

Dene Mapping Project. 1985. Dogrib and Chipewyan Land Use in the Dene/Inuit Overlap Region. Dene Mapping Project. Edmonton, Ab.

Łutsel K'e Dene First Nation and South Slave Divisional Education Council. 2013. Łutsel K'e Chipewyan Dialect Dictionary.

Łutsel K'e Dene First Nation. 2012. Gahcho Kue Traditional Knowledge Report.

Ryan J. and Marie Rabesca. 1994. Traditional Dene medicine. Part one: Report. Lac La Martre, Northwest Territories: Dene Cultural Institute.

Sadownik L., Harris H. 1995. Dené and Inuit Traditional Knowledge: A Literature Review. Edmonton, AB: Canadian Circumpolar Institute, University of Alberta.

Yellowknives Dene First Nation (YDFN). 1999. Weledeh Yellowknives Dene: A Traditional Knowledge Study of Ek'ati. Prepared and approved by the Yellowknives Dene First Nation Elders Advisory Council.

Zoe, Therese, Philip Zoe, and Mindy Willett. 2009. Living Stories: Godi Weghàà Ets' eèda. Markham, Ont. Fifth House.

Appendix C – List of Plant Life at Diavik

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Polypodiaceae	**Ferns**				
Dryopteris fragans	Fragrant Shield Fern				
Equisetaceae	**Horsetails**				
Equisetum sp.				Food (caribou stomach contents)	
Equisetum arvense	Common Horsetail			Medicine	
E. scirpoides					
E. sylvaticum var. pauciramosum	Woodland Horsetail				
Lycopodiaceae	**Club-mosses**				
Lycopodium annotinum	Stiff Clubmoss				
L. clavatum	Running Clubmoss				
L. complantum	Ground Cedar				
L. selago	Shining Clubmoss				
Pinaceae					
Picea mariana	Black Spruce			Medicine; Technology; Cultural Importance; Animal Habitat	
Sparganiaceae	**Bur-reeds**				
Sparganium hyperboreum	Bur-reed				
S. minimum					
Graminae	**Grasses**			Food (caribou stomach contents); Technology; Animal Forage; Animal Habitat	
Argrostis borealis					
		Agropyron violaceum	Broadglumed Wheatgrass		This species was not found in Burt's 1997 baseline
Arctagrostis latifolia ssp. latifolia		*Arctagrostis latifolia*	Wideleaf Polar Grass		
Arctagrostis scabra		*Agrostis scabra*	Tickle Grass		
		Agropyron pauciflorum	Slender Wheatgrass		This species was not found in Burt's 1997 baseline
Arctophila fulva					
		Calamagrostis purpurascens	Bluejoint		Burt (1997) lists this as identified by BHP at Ekati, but was not seen during her assessment

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Calamagrostis canadensis var. langsdorfi	Blue-joint Grass				
C. Canadensis ssp. canadensis	Bluejoint/Marsh Reed Grass	*Calamagrostis canadensis*	Bluejoint		
C. lapponica					
C. stricta ssp. inexpansa					
C. stricta ssp. stricta					
Deschampsia caespitosa	Hairgrass	*Deschampsia caespitosa*	Tufted Hair Grass		
		Elymus trachycaulus	Slender Wheatgrass		This species was not found in Burt's 1997 baseline
Festuca brachyphylla	Fescue	*Festuca rubra*	Creeping Red Fescue		This species was not found in Burt's 1997 baseline
F. saximontana	Rocky Mountain Fescue	*Festuca saximontana*	Rocky Mountain Fescue		
Hierochloe alpina	Holygrass				
Poa alpina	Bluegrass	*Poa alpina*	Alpine Bluegrass		
P. arctica	Arctic Bluegrass	*Poa glauca*	Glaucous Bluegrass		
		Puccinellia nuttalliana	Nuttall's Alkali Grass		This species was not found in Burt's 1997 baseline
Trisetum spicatum		*Trisetum spicatum*	Spiked Trisetum		
Vahlodea atropurpurea					
Cyperaceae	**Sedges**				
Carex sp.				Food (caribou stomach contents); Animal Forage; Animal Habitat	
Carex aquatilis	Water Sedge				
C. aquatilis/bigelowii	hybrid				
C. bigelowii					
C. bigelowii forma anguilata					
C. brunnescens					
C. capillaris	Hair-Like Sedge				
C. lugens					
C. rariflora					
C. rotundata					
C. saxatilis					

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Eriophorum sp.				Technology; Cultural Importance; Animal Forage	Many of the TK sources consulted just state the use of 'arctic cotton' and the exact species is not identified.
Eriophorum angustifolium	Multiple Headed Cottongrass				
E. callitrix	Arctic Cotton				
E. russeolum					
E. vaginatum					
Kobresia simpliuscula					
Scirpus caespitosus ssp. austriacus					
Juncaceae	**Rushes**				
Juncus stygius ssp. americanus	Bog Rush				
Luzula confusa					
L. groenlandica					
L. nivalis					
L. wahlenbergii					
Liliaceae	**Lillies**				
Torfieldia pusilla	False Asphodel				
Orchidaceae	**Orchids**				
Corallorhiza trifida	Coralroot				
Habenaria obstutata	Small Northern Bog Orchid				
Salicaceae	**Willows**				
Salix sp.				Food (caribou stomach contents); Medicine; Technology; Cultural Importance; Animal Forage; Animal Habitat	Many of the TK sources consulted just state the use of 'willow' and the exact species is not identified.
Salix actophila					
S. arbusculoides					
S. fuscescens					
S. glauca var. glauca	Blue-green Willow	*Salix glauca*	Grey Leaved Willow		
S. herbacea	Least Willow				
S. herbacea/fuscescens	hybrid				
S. planifolia ssp. planifolia		*Salix planifolia*	Plane Leaved Willow	Technology; Cultural Importance	
S. reticulata	Net-veined Willow				
S. pulchra					

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Myricaceae					
Myrica gale	Sweet Gale				
Betulaceae	**Birches**				
Alnus crispa	Green Alder			Technology	
Betula sp.				Food; Food (caribou stomach contents); Medicine; Technology; Animal Forage; Animal Habitat	Many of the TK sources consulted just state the use of 'birch' and the exact species is not identified.
Betula glandulosa	Dwarf Birch	*Betula glandulosa*	Bog Birch	Medicine; Technology; Cultural Importance	
Betula occidentalis					
Polygonaceae	**Buckwheats**				
Polygonum viviparum	Bistort			Food; Animal Forage	
Caryophyllaceae	**Pinks**				
Minuartia rubella	Sandwort				
Silene acaulis	Moss Campion			Medicine; Animal Forage	
Stellaria calycantha	Star Chickweed				
S. monantha	Bluegreen Chickweed				
Ranunculaceae	**Buttercups**				
Anemone richardsonii	Richardson's Anemone				
Ranunculus flammula var. filiformis					
R. gmelinii	Yellow Water Crowfoot				
R. lapponicus	Lapland Buttercup				
R. pallasii	Pallas' Buttercup				
Cruciferae	**Mustards**				
Arabis arenicola	Rock Cress				
Draba lactea					
Saxifragaceae	**Saxifrages**				
Chrysosplenium tetrandrum	Golden Saxifrage				
Parnassia kotzebuei	Grass of Parnassus				
Saxifraga cernua	Bulblet Saxifrage				
S. foliolosa					
S. tricuspidata	Prickly Saxifrage				

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Rosaceae	**Rose Family**				
Potentilla fruticosa	Shrubby Cinquefoil			Medicine	
P. nivea	Snow Cinquefoil				
P. palustris	Marsh Five-Finger				
P. rubricaulis	Red-Stemmed Cinquefoil				
Rubus acaulis	Dwarf Raspberry			Food; Cultural Importance; Animal Forage	A few of TK sources consulted just state the use of 'raspberry' and the exact species is not identified.
R. arcticus	Arctic Raspberry			Food; Cultural Importance; Animal Forage	A few of TK sources consulted just state the use of 'raspberry' and the exact species is not identified.
R. chamaemorus	Cloudberry			Food; Medicine; Cultural Importance; Animal Forage	
Leguminosae	**Legumes**				
Astragalus alpinus	Alpine Milkvetch				
Hedysarum alpinum var. americanum	Liquorice Root	*Hedysarum alpinum*	Alpine Hedysarum	Food	
		Hedysarum mackenzii	Northern Hedysarum		This species was not found in Burt's 1997 baseline
		Oxytropis deflexa	Reflexed Locoweed		This species was not found in Burt's 1997 baseline
		Oxytropis campestris	Northern Yellow Locoweed		This species was not found in Burt's 1997 baseline
Oxytropis glutinosa					
O. hudsonica					
O. maydelliana ssp. maydelliana	Yellow Crazyweed				
		Oxytropis splendens	Showy Locoweed		This species was not found in Burt's 1997 baseline
O. viscida					
Callitrichaceae					
Callitriche verna	Water Starwort				
Empetraceae					
Empetrum nigrum	Crowberry	*Empetrum nigrum*	Crowberry	Food; Medicine; Cultural Importance; Animal Forage	
Violaceae	**Violets**				
Viola epipsila ssp. repens					

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Elaegnaceae					
Sherpherdia canadensis	Soapberry			Food	No TK data is included in the report about this species. Data for this species was observed during the literature review, but the vegetation baseline information was not available at the time to correlate its occurrance in the study area
Onagraceae	**Primrose Family**				
Epilobium angustifolium	Tall Fireweed			Food; Medicine	
E. latifolium	Dwarf Fireweed	*Epilobium latifolium*	Fireweed	Food; Medicine	
E. palustre	White Fireweed				
Haloragaceae					
Hippuris vulgaris	Mare's Tail				
Myriophyllum exalbescens					
Pyrolaceae					
Pyrola grandiflora	Large-Flowered Wintergreen				
Pyrola secunda	Side-Flowered Wintergreen				
Ericaceae	**Heath Family**				
Andromeda polifolia	Bog Rosemary				
Arctostaphylos sp.				Food	
Arctostaphylos alpina	Black Bearberry			Food; Cultural Importance; Animal Forage	
		Arctostophylus rubra	Arctic bearberry; Whisky Jack Berry	Food; Medicine; Cultural Importance; Animal Forage	
Cassiope tetragona	White Arctic Heather			Technology	Was listed by Burt (1997) as potential vascular species found in the area (i.e. at Ekati), but was not found during her fieldwork
Kalmia polifolia	Bog-Laurel			Medicine	
Ledum decumbens	Labrador Tea			Food; Medicine; Technology; Cultural Importance	Many of the TK sources consulted just state the use of 'labrador tea' and the exact species is not identified.
L. groenlandicum	Large Labrador Tea	*Ledum groenlandicum*	Northern Labrador tea	Food; Medicine; Technology; Cultural Importance	Many of the TK sources consulted just state the use of 'labrador tea' and the exact species is not identified.
Loiseleuria procumbens	Alpine Azalea	*Loiseleuria procumbens*	Alpine Azalea		
Oxycoccus microcarpus	Bog Cranberry			Food; Medicine; Cultural Importance; Animal Forage	Many of the TK sources consulted just state the use of 'cranberry' and the exact species is not identified.

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Phyllodoce coerulea	Mountain Heather				
Rhododendron lapponicum	Lapland Rosebay				
Vaccinium uliginosum var. alpinum	Arctic Blueberry	*Vaccinium uliginosum*	Bog Bilberry	Food; Food (caribou stomach contents - leaves); Medicine; Cultural Importance; Animal Forage	Many of the TK sources consulted just state the use of 'blueberry' and the exact species is not identified.
Vaccinium uliginosum var. uliginosum	Blueberry			Food; Food (caribou stomach contents - leaves); Medicine; Cultural Importance; Animal Forage	Many of the TK sources consulted just state the use of 'blueberry' and the exact species is not identified.
Vaccinium vitis-idaea var. minus	Lingonberry/Mountain Cranberry	*Vaccinium vitis idaea*	Lingonberry	Food; Medicine; Cultural Importance; Animal Forage	Many of the TK sources consulted just state the use of 'cranberry' and the exact species is not identified.
Plubaginaceae					
Armeria maritima ssp. labradorica	Thrift				
Scrophulariaceae	**Snapdragon Family**				
Castilleja elegans	Painted-cup / Paintbrush			Medicine	Was listed by Burt (1997) as potential vascular species found in the area (i.e. at Ekati), but was not found during her fieldwork
Pedicularis sp.				Food	Burt (2003: 6-3) states that several species of louseworts were eaten for food purposes.
Pedicularis labradorica	Labrador Lousewort				
P. lapponica	Lapland Lousewort				
P. sudetica	Sudetan Lousewort				
Lentibulariaceae					
Pinguicula villosa	Small Buterwort				
P. vulgaris	Butterwort				
Rubiaceae					
Galium trifidum	Bedstraw				
Caprifolaceae					
Linnaea borialis	Twin-Flower				

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Compositae					
Achillea nigrescens				Medicine	Was listed by Burt (1997) as potential vascular species found in the area (i.e. at Ekati), but was not found during her fieldwork
Antennaria angustata	Pussy-Toes				
A. compacta	Pussy-Toes				
A. eckmaniana					
Arnica alpina ssp. angustifolia	Alpine Arnica				
Artemesia borealis	Boreal Wormwood				
Aster sibiricus	Siberian Aster				
Saussurea angustifolia	Fireworks Flower				
Senecia congestus	Mastodon Flower				
Lichens			U of A did not have a list of lichens or mosses available for circulation	Food; Medicine; Technology; Animal Forage	Many of the TK sources consulted had descriptions of lichens (e.g. black lichen or lichen) for aboriginal use and did not identify species or common name
Alectoria sp.					
Alectoria nigricans	Witch's Hair Lichen			Animal Forage	Not listed in Burt 1997; source from Golder 2011 Diavik vegetation report
Alectoria ochroleuca	Green Witch's Hair Lichen	*Alectoria ochroleuca*			
Arctoparmelia centrifuga	Rippled Rockfrog / Ring Lichen				
Aspicilia cenerea					
		Bryocaulon divergens	Heath Foxhair Lichen		
		Bryoria nitidula	Tundra Horsehair Lichen		
Cetraria sp.		*Cetraria sp.*	Iceland Lichens	Food (caribou stomach contents); Animal Forage	U of A state they have identified 5 species to date
Cetraria cucullata		*Flavocetraria cuculata*	Curled Snow Lichen	Animal Forage	
Cetraria islandica	Icelandmoss			Animal Forage	
Cetraria nivalis	Flattened Snow Lichen / Ragged Paperdoll	*Flavocetraria nivalis*	Crinkled Snow Lichen	Animal Forage	Not listed in Burt 1997; source from Golder 2011 Diavik vegetation report
Cladina mitis	Green Reindeer Lichen			Animal Forage	Not listed in Burt 1997; source from Golder 2011 Diavik vegetation report
Cladina rangifernina	Grey Reindeer Lichen / True Reindeer Lichen			Animal Forage	
Cladina stellaris	Northern Reindeer Lichen / Star Reindeer Lichen			Animal Forage	
Cladonia sp.		*Cladonia sp.*		Animal Forage	U of A state they have identified 20 species to date

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Cladonia cenotea	Powdered Funnel Cladonia / Floury Funnel Lichen				
Cladonia chlorophaea	False Pixie Cup				
Cladonia cornuta	Horn Cladonia / Pioneer Cladonia				
Dactylina arctica	Arctic Finger Lichen	*Dactylina arctica*	Arctic Finger Lichen		
		Gowardia nigricans	Gray Witch's Hair Lichen		
Haematomma lapponicum					
Masonhalea richardsonii	Arctic Tumbleweed	*Masonhalea richardsonii*	Arctic Tumbleweed		
		Melanelia stygia	Alpine Camoflage Lichen		
Nephroma arcticum	Arctic Kidney Lichen			Animal Forage	
		Parmelia sp.	Shield Lichens		
Peltigera sp.	Pelt Lichens			Animal Forage	Not listed in Burt 1997; source from Golder 2011 Diavik vegetation report
Pseudephebe pubescens					
Rhizocarpon geminatum					
Rhizocarpon geographicum	Green Map Lichen				
		Sphaerophorus globosus	Coral Lichen		
Stereocaulon sp.		*Stereocaulon sp.*	Easter Lichens	Animal Forage	
Stereocaulon alpinum					
Stereocaulon tomentosum	Woolly Coral / Woolly Foam Lichen			Animal Forage	
Thamnolia subuliformis					
		Thamnolia vermicularis	Whiteworm Lichen		
Tremolecia atrata					
Umbilicaria sp.				Food; Medicine; Animal Forage	
Umbilicaria vellea	Frosted Rocktripe				
Xanthoria sp.					
Fungi/Mushrooms				Food (caribou stomach contents); Medicine; Cultural Importance; Animal Forage	No fungi species were listed by Burt 1997

Diavik Baseline Vegetation Species - Vascular Plants, Bryophytes and Lichens (Burt 1997)		University of Alberta Reclamation Species		Aboriginal Use	Comments
Species	**Common Name**	**Species**	**Common Name**		
Bryophytes	**Mosses**			Technology; Animal Forage	
		Aulacomnium turgidum	Turgid aulacomnium moss		
		Bartramia ithyphylla	Bartramia moss		
		Brachythecium albicans	Brachythecium moss		
		Bryum pseudotriquetrum	Common green bryum moss		
		Bryum sp.	Bryum moss		
		Calliergon richardsonii	Richardson's calliergon moss		
		Ceratodon purpureus	Ceratodon moss		
		Dicranum fulvum	Dicranum moss		
		Dicranum groenlandicum	Greenland dicranum moss		
		Dicranum scoparium	Dicranum moss		
		Fissidens sp.	Fissidens moss		
		Hylocomium splendens	Stairstep moss		
		Pleurozium schreberi	Schreber's big red stem moss		
		Rhytidiadelphus loreus	Goose neck moss		
		Rhytidiadelphus squarrosus	Square goose neck moss		
		Rhytidiadelphus triquetrus	Rough goose neck moss		
		Polytrichum commune	Polytrichum moss		
		Polytrichum piliferum	Polytrichum moss		
		Polytrichum strictum	Polytrichum moss		
		Racomitrium canescens	Racomitrium moss		
		Racomitrium fasciculare	Racomitrium moss		
		Racomitrium lanuginosum	Racomitrium moss		
		Rhytidium rugosum	Rhytidium moss		
		Sanionia uncinata	Sanionia moss		
Sphagnum spp.				Technology	
		Sphagnum capilifolium	Red bog moss	Technology	
		Sphagnum warnstorfii	Warnstorf's sphagnum		
		Tortella tortuosa	Tortured tortella moss		
		Cephalozia sp.	Pincerwort		
		Diplophyllum albicans	White earwort		
		Ptilidium ciliare	Ciliated frigewort		
		Tetralophozia setiformis	Monster pawwort		

Appendix D - Aboriginal Terms and Use of Plant Life at Diavik

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Vascular Plant Species

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
Compositae	*Achillea nigrescens*		Black-Tipped Yarrow	Medicine			
Betulaceae	*Alnus crispa*		Green Alder	Technology		Gǫǫkàa[7]	K’alisín[9]
Ericaceae	*Arctostaphylos species*			Food			
Ericaceae	*Arctostaphylos alpina*		Alpine Bearberry	Food; Cultural Importance; Animal Forage	Kablaq[1] (General term for Bearberry)	Į̀hk’adzìì, Į̀hk’ajìì[7,8] (General term for Bearberry)	Denie jie[10]; Denie[11] (General term for Bearberry)
Ericaceae	*Arctostaphylos rubra*		Red Bearberry	Food; Medicine; Cultural Importance; Animal Forage	Kablaq[1] (General term for Bearberry)	Į̀hk’adzìì, Į̀hk’ajìì[7,8] (General term for Bearberry) ʔį̀hk'aĵi, ʔį̀hk'aĵi (Term for Whiskey Jack Berry)[17]	Denie jie[9]; Denie[10] (General term for Bearberry)
Betulaceae	*Betula species*			Food; Food (caribou stomach contents); Medicine; Technology; Animal Forage; Animal Habitat	Avalakiak[2] (Refers to Alders & Birch family)	K’i[8] (General term for Birch)	
Betulaceae	*Betula glandulosa*		Glandular Birch	Medicine; Technology; Cultural Importance	Avaalaqiaq[3]		T’abath[10]
Polygonaceae	*Bistorta vivipara*	*Polygonum viviparum*	Alpine Bistort	Food; Animal Forage	Tuqtak[4]		
Cyperaceae	*Carex species*		Sedge species	Food (caribou stomach contents);	Kilirnait[6]		

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
				Animal Forage; Animal Habitat			
Ericaceae	*Cassiope tetragona*		White Arctic Heather/Four-Angled Mountain Heather	Technology	Ikhun[1]; Eghotik, Iksutit[2]		
Scrophulariaceae	*Castilleja elegans*		Painted cup/Paintbrush	Medicine			
Onagraceae	*Chamerion angustifolium*	*Epilobium angustifolium*	Tall Fireweed	Food; Medicine	Paunnaq[4]	Gǫ̀h[7] (General term for Fireweed)	
Onagraceae	*Chamerion latifolium*	*Epilobium latifolium*	Dwarf Fireweed/River Beauty	Food; Medicine	Paunnaq[4]	Gǫ̀h[7] (General term for Fireweed)	
Rosaceae	*Dasiphora fruticosa*	*Potentilla fruticosa*	Shrubby Cinquefoil	Medicine			
Empetraceae	*Empetrum nigrum*		Black Crowberry/Black Berry	Food; Medicine; Cultural Importance; Animal Forage	Paunngaq, Paun'raq, Ahiaq[1]; Paun'ngaq[5]; Baongak[2]	Tsǫht'è[7]	Ts'at'eth dhe[10]; Ts'ât'eth dhé[12]
Equisetaceae	*Equisetum species*		Horsetail	Food (caribou stomach contents)			
Equisetaceae	*Equisetum arvense*		Field Horsetail	Medicine			
Cyperaceae	*Eriophorum species*		Arctic Cotton/Cottongrass	Technology; Cultural Importance; Animal Forage	Ipirakhat[1] (Term for arctic cotton used as a lamp wick); Ipiraq[1] (General term for wick) Kanguujaq[1]; Kangguyak, Kangoyak[2] (General term for Arctic Cotton/Cottongrass)	K'alatso[8]	
Fabaceae	*Hedysarum alpinum*		Alpine Sweet-Vetch/Liquorice Root	Food	Mahok[2]; Mahuk[5]		
Ericaceae	*Kalmia polifolia*		Northern Bog	Medicine		Kuzi hala[9]	

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
			Laurel/Pale Bog Laurel				
Ericaceae	*Ledum groenlandicum*		Common Labrador Tea	Food; Medicine; Technology; Cultural Importance	Qisiqtuti[2]	Gots'agoò, Lıgaezǫǫ̀, Lìgaezǫ̀ą[8] (General term for Labrador Tea)	
Ericaceae	*Ledum palustre*	*Ledum decumbens*	Marsh Labrador Tea	Food; Medicine; Technology; Cultural Importance	Qisiqtuti[2]	Gots'agoò, Lıgaezǫǫ̀, Lìgaezǫ̀ą[8] (General term for Labrador Tea)	
Scrophulariaceae	*Pedicularis sp.*		Louseworts	Food			
Pinaceae	*Picea mariana*		Black Spruce	Medicine; Technology; Cultural Importance; Animal Habitat		Ts'i[8] (General term for Spruce)	Tsu'dza deʔa[12] (General term for stands of Spruce)
Rosaceae	*Rubus arcticus*		Arctic Raspberry	Food; Cultural Importance; Animal Forage		Dahkàà (General term for Raspberry)[8]	
Rosaceae	*Rubus chamaemorus*		Cloudberry	Food; Medicine; Cultural Importance; Animal Forage	Akpik[2]; Aqpik[5]	Nǫdlàa; Gots'ǫkà[7,8]	Nadlare[10]; Nadláré[12]
Salicaceae	*Salix species*		Willow species	Food (caribou stomach contents); Medicine; Technology; Cultural Importance; Animal Forage; Animal Habitat	Uqpik[1]; Okpeet, Ukpigait[2] (General term for Willows)	K'àa, K'òò[8] (General term for Willow)	K'àa; K'òò[13] (General term for Willow)

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
Elaegnaceae	*Shepherdia canadensis*		Soapberry	Food			
Caryophyllaceae	*Silene acaulis*		Moss Campion	Medicine; Animal Forage	Miqutiqarviitut, Nautiat[2]; Airait, Aupilattunguangujuq[6]		
Ericaceae	*Vaccinium uliginosum*		Alpine Blueberry	Food; Food (caribou stomach contents - leaves); Medicine; Cultural Importance; Animal Forage	Kiguangirnaq[1]; Kegotangenak[2]	Dzìewà; Jìewà[7,8]	Tsachogh[10]; Ts’ąłchogh[14]
Ericaceae	*Vaccinium vitis-idaea*		Mountain Cranberry	Food; Medicine; Cultural Importance; Animal Forage	Kingmignaq, Kingmingnak[1]; Kinminak[2]	Įtł’ǫ̀[8]	Nitl’er[10]; Nitł’ër[14]
Graminae			Grasses	Food (caribou stomach contents); Technology; Animal Forage; Animal Habitat	Ivik (Term for blade of grass), ivgit (pl.)[1]	Tł’o (General term for Grass)[8]	

Bryophytes Species

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
Sphagnaceae	*Sphagnum species*		Peat Moss Species	Technology	Urjuk (General term for Moss)[1]	Kw’ah (Term for Diaper Moss)[8]	
Sphagnaceae	*Sphagnum capillifolium*		Small Red Peat Moss/Acute-Leaved Peat Moss	Technology			Tth’al delgi (Term for Red Sphagnum Moss)[9]

Fungi Species

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Family	Scientific Name	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
		Mushrooms	Food (caribou stomach contents); Medicine; Cultural Importance; Animal Forage	Kaiptauyat (General term for Mushroom)[16]	Dłòodii (General term for Mushroom)[15]	

Lichen Species

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłı̨chǫ	Chipewyan
			Lichen	Food; Medicine; Technology; Animal Forage	Kagiuyat (General term for all Lichens)[2]	Adzı̨̀ı̨, Ajìı, Ajı̨̀ı̨ (General term for Lichen)[8]	
Parmeliaceae	*Alectoria species*		Witch's Hair Lichen Species	Animal Forage			
Parmeliaceae	*Alectoria nigricans*		Witch's Hair Lichen	Animal Forage			
Parmeliaceae	*Cetraria species*		Heath Lichens	Food (caribou stomach contents); Animal Forage			
Parmeliaceae	*Cetraria islandica*		Iceland Moss	Animal Forage			Ts'aju kal[10]
Parmeliaceae	*Cetraria cucullata*	*Flavocetraria cucullata*		Animal Forage		Adzìı degoo, Ajı̨̀ı̨ degoo (General term for White Lichen)[7]	
Parmeliaceae	*Cetraria nivalis*	*Flavocetraria nivalis*	Flattened Snow Lichen/Ragged Paperdoll	Animal Forage		Adzìı degoo, Ajı̨̀ı̨ degoo (General term for White Lichen)[7]	

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Family	Scientific Name	Synonym	Common Name	Aboriginal Use	Inuinnaqtun	Tłįchǫ	Chipewyan
Cladoniaceae	*Cladonia species*		Club Lichen Species	Animal Forage			
Cladoniaceae	*Cladonia mitis*	*Cladina mitis*	Green Reindeer Lichen	Animal Forage			
Cladoniaceae	*Cladonia rangiferina*	*Cladina rangiferina*	Grey Reindeer Lichen	Animal Forage			
Cladoniaceae	*Cladonia stellaris*	*Cladina stellaris*	Star-tipped Reindeer Lichen/Northern Reindeer Lichen	Animal Forage		Adzìì degoo, Ajįį degoo (General term for White Lichen)[7]	Ts'aju[10]
Nephromataceae	*Nephroma arcticum*		Arctic Kidney Lichen	Animal Forage			
Peltigeraceae	*Peltigera species*		Pelt Lichens	Animal Forage			
Stereocaulaceae	*Stereocaulon species*		Foam Lichen Species	Animal Forage			
Stereocaulaceae	*Stereocaulon tomentosum*		Woolly Foam Lichen/ Woolly Coral	Animal Forage		Adzìì degoo, Ajįį degoo (General term for White Lichen)[7]	
Umbilicariaceae	*Umbilicaria species*		Rocktripe Lichen	Food; Medicine; Animal Forage		Kwetsį (General term for Black Rock Fungus)[15]	

Plant Species Found in the Lac de Gras Area Used by Aboriginal Peoples

Sources:

[1] NAC 2012

[2] Burt 2004

[3] Thorpe et al. 2001

[4] Piruvik Centre 2014

[5] Davis and Banack 2012

[6] Mallory and Aiken 2012

[7] UVic n.d.

[8] DDBE 1996

[9] LKDFN 2001b

[10] YKDFN 2003a

[11] LKDFN 2002

[12] YKDFN 2003b

[13] Jaker 2013

[14] LKDFN 2002

[15] Dogrib Treaty 11 Council 2001b

[16] Thorpe et al. 2001

[17] Tsatchia et al. 2013

Appendix II-1

Four-Year Hydrogeochemical Field Investigation of Processed Kimberlite Weathering at Diavik Diamond Mines Inc.

Four-Year Hydrogeochemical Field Investigation of Processed Kimberlite Weathering at Diavik Diamond Mines Inc.

***Submitted To*:**
Gord Macdonald
Diavik Diamond Mines Inc.
PO Box 2498 Stn Main
5007 – 50th Avenue
Yellowknife, NT
X1A 2P8

Submitted By:

Michael Moncur, M.Sc.
Alberta Innovates – Technology Futures
3608 – 33 Street N.W.
Calgary, AB T2L 2A6
Tel: (403) 210-5368; Cell: 403-700-5077
Email: michael.moncur@aitf.ca

Lianna Smith, M.Sc.
Lianna Smith Consulting
55 Fulton Ave
Ottawa, ON K1S 4Y5
Tel : (613) 293-4046
Email(1): lianna.smith@riotinto.com
Email(2): lianna.smith@outlook.com

Alberta Innovates Technology Futures

October 2014

Table Of Contents

List of Figures

List Of Tables

1.0 INTRODUCTION

During the spring of 2008, a mass balance study of the Processed Kimberlite Containment (PKC) Pond was identified as a priority action item. Water samples collected from the PKC pond show that concentrations of total ions had increased over time. As part of the mass balance study, Alberta Innovates-Technology Futures (AITF) and Lianna Smith Consulting was retained by Diavik Diamond Mines Inc. (DDMI) to evaluate the geochemical evolution of fine processed kimberlite (FPK) over a four year period since deposition. Results from this program will help to better predict water quality within the PKC and potential effluent discharging from the PKC post-closure.

2.0 OBJECTIVES

The objective of this project is to characterize the porewater geochemistry from freshly deposited FPK in the PKC facility over a four year period to understand short and long-term weathering and the subsequent release of dissolved ions to the pore waters. Work performed by Alberta Innovates-Technology Futures includes:

- Collecting continuous cores of FPK from the PKC facility for pore-water geochemistry, geotechnical and mineralogical studies.
- Using a squeezing method extract porewater from the FPK core.
- Installing piezometers below the water table to collect groundwater samples.
- Installing piezometers off the end of the PKC Barge
- Sampling groundwater from all piezometers.
- Measuring pore-gas concentration through the unsaturated zone on the East Beach of the PKC facility to determine the depth of oxygen diffusion.
- Submitting all water and solid samples to the appropriate laboratories
- Performing geochemical modeling of the pore water and groundwater.
- Measuring water levels in all installed piezometers.
- Preparing annual progress reports detailing advancements of study.
- Preparing a final report detailing the results and conclusions of the study.

3.0 SITE BACKGROUND

The Diavik Diamond Mine Inc. (DDMI) is located in the barrens lands on East Island in Lac de Gras, 300 km northeast of Yellowknife, NT. The mean annual temperature, rainfall, snowfall and lake evaporation at Diavik is -12^{0}C, 164 mm, 187 mm and 271 mm, respectively (Golder, 2007). Winter conditions persist from September through to June with a 1.5 to 5 m deep active layer developing during the warmer months. The maximum lake evaporation rate occurs in July, corresponding to the maximum air temperature.

The DDMI property contains four economic kimberlite pipes. Currently diamonds are extracted from pipes A154N, A154S and A418 through underground mining. Kimberlite pipe A21 is not currently being mined. After diamonds are recovered from the kimberlite ore, the reject material is transported as a slurry to the PKC facility. Water from the processing plant is used in the FPK slurry which contains predominantly recycled PKC pond water and recycled mien water, and, at times, Lac de Gras water. FPK deposited in the PKC facility settles gravimetrically for permanent storage. The standing water in the PKC facility is decanted and recycled back to the processing plant. There are several small collection ponds on site and several seepage collection wells around the PKC that are used to control surface water run off and seepage from the PKC. Although the total volume of monthly discharge water removed from the ponds and seepage wells to the PKC pond is measured, there is no record that identifies which pond is being pumped. Pond waters discharged to the PKC pond make up approximately 15 % of the total input. Treated sewage waste water from mining operations is also discharged to the PKC pond. The monthly volume of treated sewage effluent discharged to the PKC pond makes up approximately 2 % of the total water volume (Moncur Groundwater, 2009).

4.0 MINERALOGY

The kimberlite pipes at DDMI are intrusions within supracrustal rocks and late Archean granitoids of the the Slave structural province (Moss et al., 2008). The pipes are composed of bedded volcaniclastic kimberlite, consisting of both kimberlite and mudstone xenoliths. Mineralogical studies of the kimberlite ore by Jambor (1997) and Baker et al. (2003) found that the dominate minerals in the kimberlite include olivine [$(Mg,Fe)_2SiO_4$ with sub-percentage amounts of Ni], enstatite [$MgSiO_3$], chromium diopside [$Cr\text{-}CaMgSi_2O_6$], and lizardite [$Mg_3Si_2O_5(OH)_4$], with accessory minerals of garnet [$(Mg,Ca)_3(Al,Cr)_2(SiO_4)_3$], phlogopite [$KMg_3AlSi_3O_{10}(OH)_2$] and ilmenite [$FeTiO_3$]. Although not appreciable, pyrite [FeS_2] was the principal sulfide, with trace amounts pyrrhotite [$Fe_{(1-x)}S$], sphalerite [$(Zn,Fe)S$], pentlandite [$(Fe,Ni)_9S_8$], chalcopyrite [$CuFeS_2$], galena [PbS], marcasite [FeS_2] and millerite [NiS] observed in the kimberlite material (Baker et al., 2003). Dominant and accessory minerals were hosted in a fine-grained, smectite-rich calcite and serpentine matrix. The mean-total sulfur value for the kimberlite was 0.52 % ± 0.24 % (Baker et al., 2003). Mean values of the neutralization potential (NP) and maximum potential acidity (MPA) for the kimberlite were 196 ± 131 $CaCO_3$ t^{-1} and 14.8 ± 6.6 $CaCO_3$ t^{-1}, respectively, indicating that the processed kimberlite is acid-consuming. The mudstone was fine-grained and composed of quartz [SiO_2], feldspar [$NaAlSi_3O_8$], muscovite [$KAl_2(AlSi_3O_{10})(F,OH)_2$], framboidal pyrite, calcite, smectite and gypsum [$CaSO_4 \cdot 2H_2O$]. The mean-total sulfur value for the mudstone is 0.70 % ± 0.86 %. Mean values of (NP) and MPA for the mudstone were 288 ± 186 $CaCO_3$ t^{-1} and 19.93 ± 25.36 $CaCO_3$ t^{-1}, respectively. Many of the mudstone samples had significantly lower NP and higher total S suggesting that the material is potentially acid generating (Baker at al., 2003). Although Jambor (1997) found wide-spread contamination of mudstone in almost all kimberlite ore samples analyzed, the high neutralizing potential of the kimberlite was expected to neutralize acid generation.

Wilson et al., (2009) studied efflorescent crusts of secondary minerals on the surface of PKC facility where the FPK was deposited sub-aerially. Calcite, gypsum and nesquehonite [$Mg(HCO_3)(OH) \cdot 2H_2O$] were the most pervasive secondary mineral phases in the PKC facility post deposition. Other secondary Ca-Mg mineral phases identified in trace amounts within the unsaturated FPK material included anhydrite [$CaSO_4$], epsomite [$MgSO_4 \cdot 7(H_2O)$], hexahydrite [$MgSO_4 \cdot 6H_2O$], syngenite [$K_2Ca(SO_4)_2 \cdot (H_2O)$], gaylussite [$Na_2Ca(CO_3)_2 \cdot 5H_2O$], natrite [$Na_2CO_3$], vaterite ($CaCO_3$) and portlandite [$Ca(OH)_2$]. Nesquehonite was the only secondary mineral identified to persist at depth within the PKC facility.

Processed kimberlite collected from the East Beach of the PKC facility in 2009 was studied by Paktunc and Thibault (2010). They found that the FPK was composed of nickeliferous olivine (Ni from 1800 to 4300 ppm), calcite, quartz, garnet, lizardite, biotite, albite, and saponite. Both framboidal and massive pyrite were observed with concentrations ranging between 0.3 to 0.7 wt.%. Pyrite grains were mostly encapsulated in fragments of serpentine and aluminosilicate clays. Maximum acid generating potential (AP) of the pyrite varied from 5 to 12 kg $CaCO_3$ eq/t, however not all of the AP would be available due to the occurrence of some pyrite as locked particles in other mineral fragments. Neutralization potentials (NP) provided by calcite were between 39 to 85 kg $CaCO_3$ eq/t. In addition to calcite, olivine also contributed to NP with values ranging from 104 to 193 kg $CaCO_3$ eq/t, similar to those reported by Baker et al. (2003). The net neutralization potential (NNP) and neutralizing potential of the FPK, based on mineralogy, was 110-196 and 12-39, respectively, far exceeding the acid generating potentials (Paktunc and Thibault, 2010). No oxidation or alteration rims were identified on any pyrite grains, however partial dissolution of olivine and calcite was observed.

Slimes collected from the Barge at depth of 6 and 12 m were characterized by Thibault and Paktunc (2012). Mineralogy was similar between the two depths with crystalline phases identified as olivine (forsterite), lizardite, quartz, calcite, biotite, K-feldspar, pyrite and saponite. Framboidal pyrite was the only sulfide mineral observed in significant amounts, typically within clay fragments, although fully liberated grains were common (Thibault and Paktunc, 2012). Mineralogical observations of the slimes were consistent with that of the coarser FPK from the East Beach of the PKC facility (Paktunc and Thibault, 2010). No sign of in-situ weathering of olivine, calcite or pyritewas observed, suggesting that the oxidation and dissolution reactions are limited by sub-aqueous disposal.

5.0 METHODS

In 2009 the East Beach of the PKC facility was instrumented with five piezometer nest and characterized for porewater geochemistry, groundwater flow, oxygen diffusion, microbial populations and mineralogy (Moncur et al., 20011). During the spring of 2011, fresh FPK was discharged as a slurry onto East Beach, submerging all piezometer locations. Shortly after discharge of the fresh FPK ended, the East Beach was re-instrumented in August 2011 with two piezometer nests at previous locations PKC 1 and PKC 2, and two new locations PKC6 and & PKC7 (Figure 1). One additional location was instrumented at the end of the PKC barge where groundwater was collected from beneath standing water of the PKC water column. The PKC Barge was previously instrumented in 2009 and 2010, but due to rising pond levels, all piezometers were submerged.

Figure 1: Aerial view of the PKC facility showing core collection and piezometer nest locations. The whitish-grey areas covering most of the brown-grey PK are secondary efflorescent minerals.

5.1 Piezometer Installation

During August 2010, a total of 15 drive point piezometers were installed into the PKC facility (Table 1). All drive-point piezometers were driven through the FPK by hand until refusal. At that point a Pionjar rock drill was used to drive the piezometer to the preferred depth or until refusal. Six piezometers were installed off the barge and nine piezometers were installed across the East Beach of the PKC facility, ranging from one to four piezometers per location. Piezometers were surveyed for x-y-z coordinates by DDMI staff.

Table 1: Piezometer details, elevations and ground elevations. Abbreviations: SS-stainless Steel; masl-meters above sea level.

Location	Piezometer Type	Installation Date	Stick Up m	Tip Depth m	Ground Elev. mbsl	TOP Elev mbsl	Tip Elev. mbsl
PKC1-1	1-¼-inch PVC	August 2011	0.61	1.00	455.69	456.33	454.72
PKC1-2	1-¼-inch PVC	August 2011	0.86	1.69	455.69	456.57	454.02
PKC1-3	¾-inch-SS	August 2011	0.42	2.65	455.69	456.11	453.05
PKC2-1	1-¼-inch PVC	August 2011	1.00	1.26	454.18	455.28	453.02
PKC6-1	1-¼-inch PVC	August 2011	0.76	1.00	456.93	457.68	455.88
PKC6-2	1-¼-inch PVC	August 2011	0.97	2.25	456.93	457.89	454.67
PKC6-4	¾-inch-SS	August 2011	0.78	3.83	456.93	457.70	453.09

PKC6-5	¾-inch-SS	August 2011	1.11	5.05	456.93	458.04	451.89
PKC7-1	1-¼-inch PVC	August 2011	0.88	1.00	454.33	455.21	453.33
Barge-10	1-¼-inch PVC	August 2011	n/a	2.74	n/a	n/a	n/a
Barge-20	1-¼-inch PVC	August 2011	n/a	6.10	n/a	n/a	n/a
Barge-30	1-¼-inch PVC	August 2011	n/a	9.14	n/a	n/a	n/a
Barge-40	1-¼-inch PVC	August 2011	n/a	12.19	n/a	n/a	n/a
Barge-55	¾-inch-PVC	August 2011	n/a	16.76	n/a	n/a	n/a
Barge-75	¾-inch-SS	August 2011	n/a	22.86	n/a	n/a	n/a

5.2 PKC Solid and Pore Gas Collection

During August 2011, 2012, 2013 and June 2014, continuous vertical cores of FPK were collected from ground surface to refusal (frost) at each piezometer nest location within the East Beach of the PKC facility. Core was collected by driving an aluminum core tube into the FPK material with a gas-powered Pionjar rock drill. Three continuous vertical cores were collected from surface to the frost layer: one 3-inch (7.6 cm) core for porewater extraction and two 2-inch (5.1 cm) cores for mineralogy and moisture content. In 2011, at locations PKC1 and PKC6, it was possible to collect deeper core from discountinuous frost layers. At the Barge location, fine FPK (slimes) were collected from depths of 6 m and 12 m for mineralogical analyses by Thibault and Paktunc (2012). Immediately following the collection of a 3-inch continuous core, the core was cut into ~0.25 m sections and transported to the DDMI environmental laboratory for porewater extraction or immediately frozen and shipped to AITF in Calgary for extraction. All 2-inch cores for mineralogy were frozen and are currently being stored at AITF in Calgary. Core for moisture content determinations were cut into 0.10 m sections, dried for 24 hours at 110°C, and weighed onsite. The depth to frost was measured at all locations during each site visit.

Samples of FPK pore gas from the unsaturated zone were collected at all four locations on the East Beach using a drive-point sampling tube. Pore gas was collected in 60 CC syringes at 0.10 m increments from ground surface to refusal or a max depth of 1.4 m. Gas-loaded syringes collected from each sampling interval were immediately injected into sterile vacuum-sealed Kendall 16x125 mm glass vials. Gas content from the vials was analyzed for O_2, CO_2, CH_4, and N_2 using a Varian CP-4900 Micro Gas Chromatograph at AITF in Calgary, AB.

5.3 Porewater Sampling

Porewater was squeezed from core collected at locations PKC1, PKC2, PKC6 and PKC7 in August 2011, 2012, 2013 and June 2014. Core was not available from PKC2 in June 2014 due submergence from recently discharged FPK. The squeezing technique, as described by Moncur et al. (2013), involved adding a viscous immiscible liquid (Paraplex) to the top of each core, then applying light pressure with a sealed plunger to displace the Paraplex and porewater down through the core. The resulting water samples were collected in 60 mL syringes and passed through 0.45 µm filters. This squeezing technique eliminates the contact between porewater samples and atmospheric O_2, limiting oxidation during sample collection. Eh and pH measurements of the extracted porewater were made one to three times during the collection of unfiltered sample to obtain representative results. The Eh was measured using an Orion platinum redox electrode (model 96-78BN), checked in Zobell's solution (Nordstrom,

1977) and Light's solution (Light, 1972). The pH was measured using an Orion Ross combination electrode (model 815600) calibrated with standard buffer solutions at pH 4, 7, and 10. Measurements of alkalinity were made on filtered samples using a Hach digital titrator and bromcresol green / methyl red indicator and with 0.16 *N* H_2SO_4. Water samples were split into two aliquots: one aliquot of water was acidified with 12 *N* trace-metal grade HNO_3 to a pH of <2 for cation analysis; and another aliquot was left unacidified to use for anion analysis. All samples were stored in pre-washed Nalgene bottles and immediately refrigerated until analysis. Water samples were analyzed using inductively coupled plasma – optical emission spectrometry for major cations, inductively coupled plasma-mass spectrometry for trace metals, and ion chromatography for anions. Dissolved NH_3 was measured using a Hach DR2800 spectrometer.

5.4 Groundwater Sampling

Porewater from the saturated zone was collected from piezometers using a peristaltic pump and ¼-inch diameter polyethylene tubing. Piezometers were bailed dry and allowed to recover prior to sampling. Measurements of Eh and pH were made in the field using a sealed flow-through cell to prevent any alterations from atmospheric O_2. Temperature, conductivity, dissolved O_2, and alkalinity was measured at each location. All water samples collected were refrigerated until they were analyzed following the same methods as for samples collected from the vadose zone. Dissolved H_2S, NH_3, Fe(II), and PO_4 were measured in the field using a Hach DR2700 spectrometer. From the Barge piezometers, samples were collected for dissolved organic carbon (DOC) and stable isotopes of $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C_{DIC}$.

5.5 Geochemical Modeling

The geochemical model PHREEQC 2.18 (Parkhurst and Appelo, 1999) using the WATEQ4F (Ball and Nordstrom, 1991) database was used to elucidate mineral phases that may be controlling the concentrations of dissolved species in porewater of the PKC facility. PHREEQC is an equilibrium/mass-transfer model that provides calculations of saturation indices (SI) for discrete mineral phases. Additional solubility data was incorporated for siderite (Ptacek, 1992).

6.0 RESULTS AND DISCUSSION

6.1 East Beach Processed Kimberlite Disposal

During initial investigations of the PKC East Beach (Moncur et al., 2011; Moncur and Smith, 2012), there was ~2.4 m rise in the PKC Pond water level between August 2009 and August 2010, which resulted in completed submergence of piezometer nests PKC3, PKC4, and PKC5, with a 0.30 m deep water column above the ground surface at PKC2 during sampling in 2010. PKC1 was the only piezometer nest not submerged. During early spring in 2011, the mine began discharging fresh FPK over the East Beach until mid-June 2011. This resulted in the accumulation of 5.65 m of fresh FPK over piezometer nest PKC2 and 5.04 m over PKC1 (Table 2). However, there was only a 1.12 m rise in the PKC pond water lever. In August 2011, piezometers were reinstalled at locations PKC1 and PKC2, with two new piezometer nests at PKC6 and PKC7 (Figure 1). PKC6 was located near the toe of the containment dam, PKC 2 and 7 were approximately 200 m away near the standing PKC pond water, and PKC1 was midway between the pond and PKC7. Fresh FPK was again discharge over the East Beach in May 2014 resulting in the complete submergence of PKC2, with 0.40 m of fresh PK at PKC1 and 0.54 m at PKC7 (Table 2). Additional FPK was deposited over the East Beach between June 18, 2014 and September 16, 2014 resulting in the complete submergence of PKC1 and PKC7. As of September 18, 2014, 0.03 m of fresh FPK had been deposited at PKC6.

Table 2: Changes in surface elevations on the East Beach between 2010 and 2014.

Location	2010 mbsl	2011 masl	Δ 2010-2011 m	June 2014 masl	Δ 2011-2014 m	Sept. 2014 masl	Δ June 2014-Sept. 2014 m
PKC1	450.65	455.69	5.04	456.09	0.40	>456.33	Submerged
PKC2	448.54	454.18	5.64	454.72	0.54	>455.28	Submerged
PKC6		456.93		456.93	0.00	456.96	0.03
PKC7		454.33		>455.00	>0.67	>455.21	submerged

6.2 East Beach Frost Depth

The installation of piezometers and core collection in August 2011 was initiated approximately two month after fresh FPK was deposited over the East Beach of the PKC facility. During piezometer installation at PKC1 and PKC6, frost was encountered at depths of 1.76 m and 2.3 m, respectively (Table 3). Below theses depths, layers and thin lenses of frost were observed. The layered characteristic of the FPK may represent times of freezing and thawing during the spring deposition. At PKC2 and PKC7 near the PKC ponded water, the frost layer was shallower and not penetrable with piezometers or coring equipment (Table 3).

Table 3: Measured depths to frost during initial piezometer installation in August 2011.

PKC6		**PKC1**		**PKC2**		**PKC7**	
0 to 2.3 m:	No Frost	0 to 1.76 m:	No Frost	0 to 1.26 m:	No Frost	0 to 1.2 m:	No Frost
2.3 to 3.2 m:	Frost	1.76 to 2.6 m:	Thin Frost Lenses	>1.26 m:	Frost	>1.2 m:	Frost
3.2 to 4.5 m:	No Frost	2.6 to >3m:	Frost				
4.5 to 4.7 m:	Frost						
4.7 to ~5 m:	No Frost						
>5 m:	Frost						

During the study, the depth to frost decreased (Table 4). From August 2011 to August 2013, the active zone in the FPK decreased in thickness by 0.85 m at PKC6, 0.55 m at PKC1, 0.21 m at PKC2 and 0.12 m at PKC7. The limited upward migration of frost at PKC2 and PKC7 was likely due to the close proximity of open water in the PKC Pond. By June 2014 the active zone at PKC6 had decreased to a 1.14 m depth. Fresh FPK had been deposited over PKC1, and PKC7. With 0.40 m of fresh FPK deposited over PKC1, only 0.36 m of the older underlying FPK remained active (0.76 total active zone), whereas 0.54 m of fresh FPK was deposited over PKC7 resulting in a total active zone of 0.42 m. As the frost migrates upwards, it matures becoming more stable. For example, at PKC6 in August 2011, a piezometer was driven to a depth of 5 m, but in 2014 coring was limited to a maximum depth of 1.76 m.

Table 4: Depth to frost from ground surface, between August 2011 and June 2014. Note that in June 2014, 0.40 and 0.54 m of fresh FPK were deposited over PKC1 and PKC7, respectively. PKC2 was completely submerged.

Location	August 2011 Depth (m)	August 2012 Depth (m)	August 2013 Depth (m)	June 2014 Depth (m)
PKC6	2.3	1.58	1.46	1.14
PKC1	1.76	1.53	1.21	0.76
PKC7	1.20	1.01	1.08	0.42
PKC2	1.26	1.04	1.05	n/a

6.3 East Beach Water Levels

On August 7, 2012, depth to the water table in the East Beach of the PKC facility was 1.24 m below the surface at PKC1, similar to the previous water level of 1.25 m measured from piezometers at the same location on October 5, 2009 (Moncur et al., 2011). Water was not available from PKC1 piezometers for years following 2011 because the wells were either dry or damaged, as was the case with PKC1-3 (Table 5).

Table 5: Water levels in East Beach PKC facility piezometers, measured from 2011 to 2014. The bold-italic values represent the measured ice level in the piezometer.

Location	Depth m	August 2012 m	August 2013 m	June 2014 m	September 2014 m
PKC1-3	2.65	1.24	n/a	n/a	n/a
PKC1-2	1.69	Dry	Dry	Dry	n/a
PKC1-1	1.01	Dry	Dry	Dry	n/a
PKC2-1	1.26	1.00	0.15	n/a	n/a
PKC6-5	5.05	***2.47***	***2.19***	***1.11***	2.45 ***(2.54)***
PKC6-4	3.83	***2.49***	***2.16***	***1.1***	2.22 ***(2.54)***
PKC6-2	2.25	*Dry*	Dry	Dry	Dry
PKC6-1	1.04	Dry	Dry	Dry	Dry
PKC7-1	1.00	0.85	0.74	***0.43***	n/a

The water level in PKC2 was 1.0 m in 2012, increasing to 0.15 m in 2013, reflecting the rise of the PKC pond level. Water levels were not available from PKC2 in 2014 due to submergence by fresh FPK.

Water levels were not available from piezometers at PKC6. Piezometers PKC6-1 and -2 remained dry for the duration of monitoring, however ice levels were observed in PKC6-4 and -5. Both piezometers showed similar ice levels with an identical increasing trend during monitoring. Ice levels increased from a depth of 2.5 m in 2012 to 1.1 m in June 2014, similar to increases observed in FPK frost levels. On September 15, 2014, both piezometers exhibited a decrease in ice levels to 2.54 m, with an overlying column of melt water in the piezometer (Table 5).

6.4 East Beach Porewater Geochemistry

In August 2011, approximately 2 months after fresh FPK was slurried over the East Beach of the PKC facility, pore water was squeezed from core and sampled from piezometers. The porewater geochemistry revealed that weathering of the FPK had occurred despite only being exposed to the atmosphere for 2 months. The highest concentration of dissolved SO_4 and major cations were observed within the upper 0.25 to 0.50 m of the FPK (Figures 2 to 5). The Eh values also showed oxidizing condition in this zone, becoming reduced with depth. The pH was circumneutral in all profiles. Oxygen profiles were consisted with the pore water geochemistry, showing atmospheric concentrations (20.9%) at the surface and becoming depleted with depth. For example, in 2011, O_2 concentrations at PKC6 were near atmospheric in the upper 0.30 m of the FPK, rapidly decreasing to 7 % at 0.50 m, then depleted to <1 % at 1.2 m (Figure 6). Porewater chemistry at PKC6 showed a similar trend with the highest concentration of dissolved ions near the surface, rapidly decreasing then showing low concentrations below 1 m. Causes for the decrease in O_2 gas concentration with depth are due to sulfide oxidation and increasing water contents with depth in the FPK material. The decreasing O_2 content with depth at PKC6 and the other piezometer nests coincides with saturation of the FPK at the same depth (Figure 6), similar to observations made in 2009 and 2010 (Moncur et al., 2011).

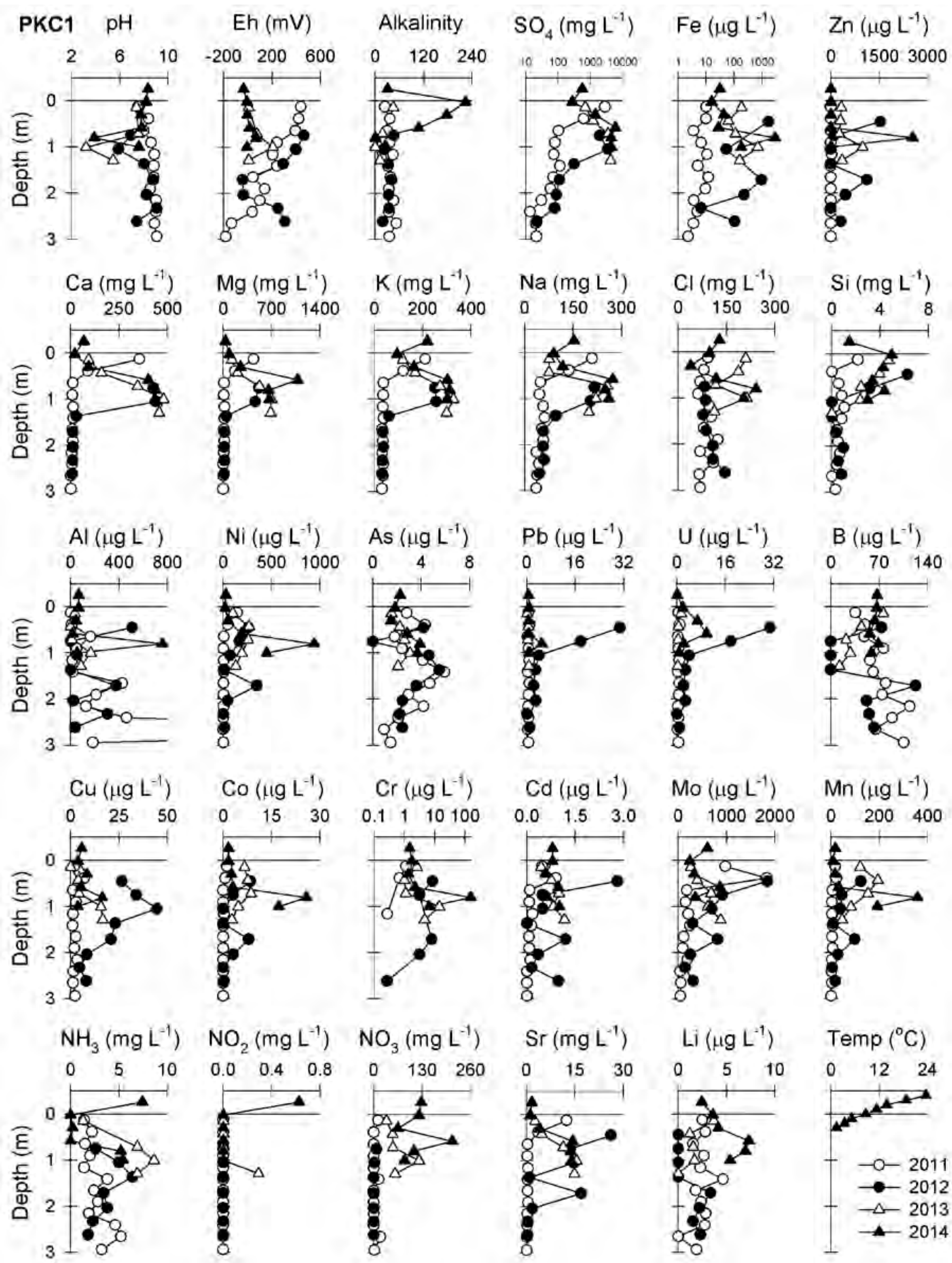


Figure 2: Depth profiles of porewater geochemistry from piezometer nest PKC1. Water samples were collected in 2011, 2012, 2013 and 2014. The horizontal line at zero refers to the interface between old FPK and FPK freshly slurried in 2014.

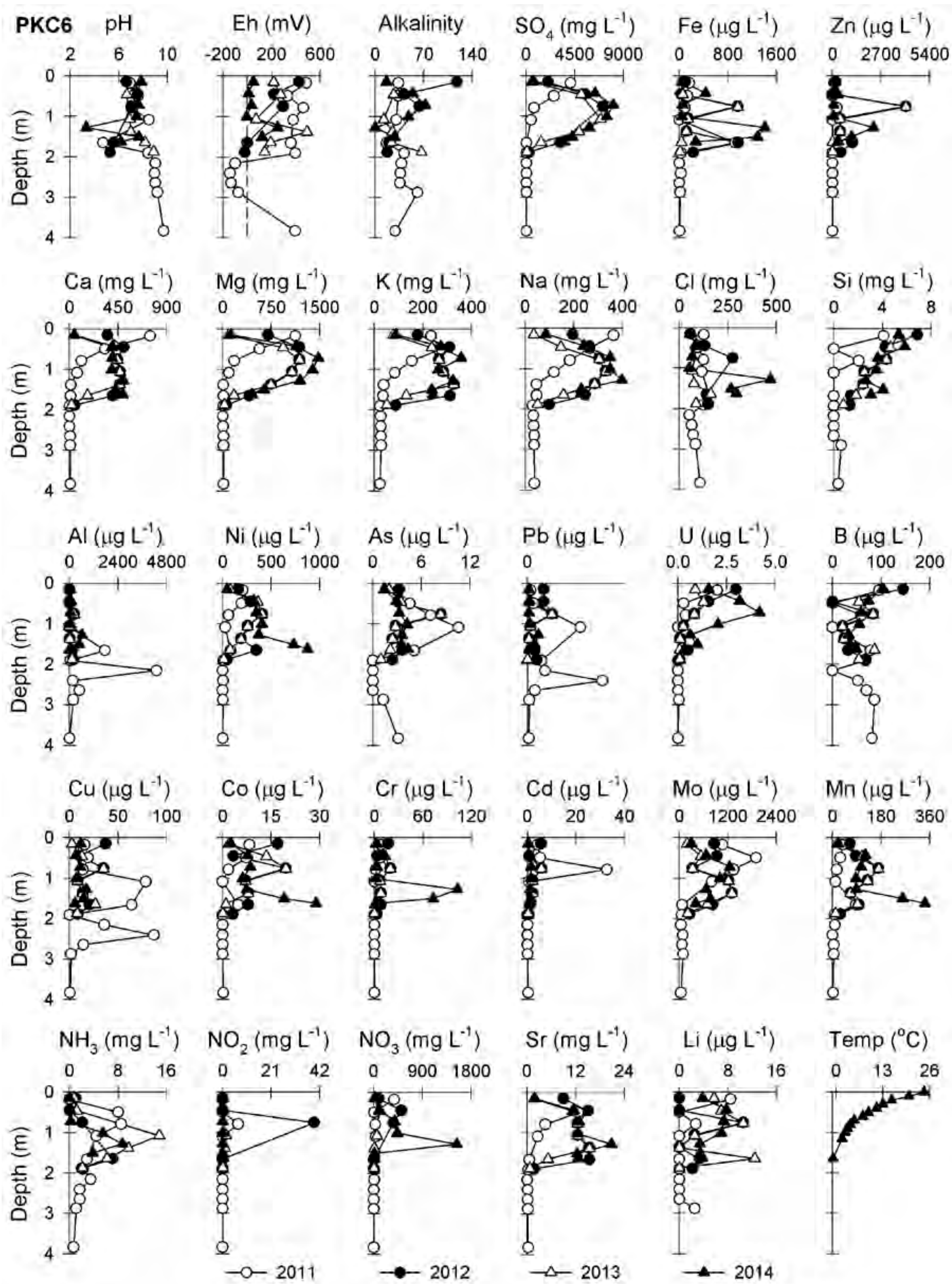


Figure 3: Depth profiles of porewater geochemistry from piezometer nest PKC6. Water samples were collected in 2011, 2012, 2013 and 2014.

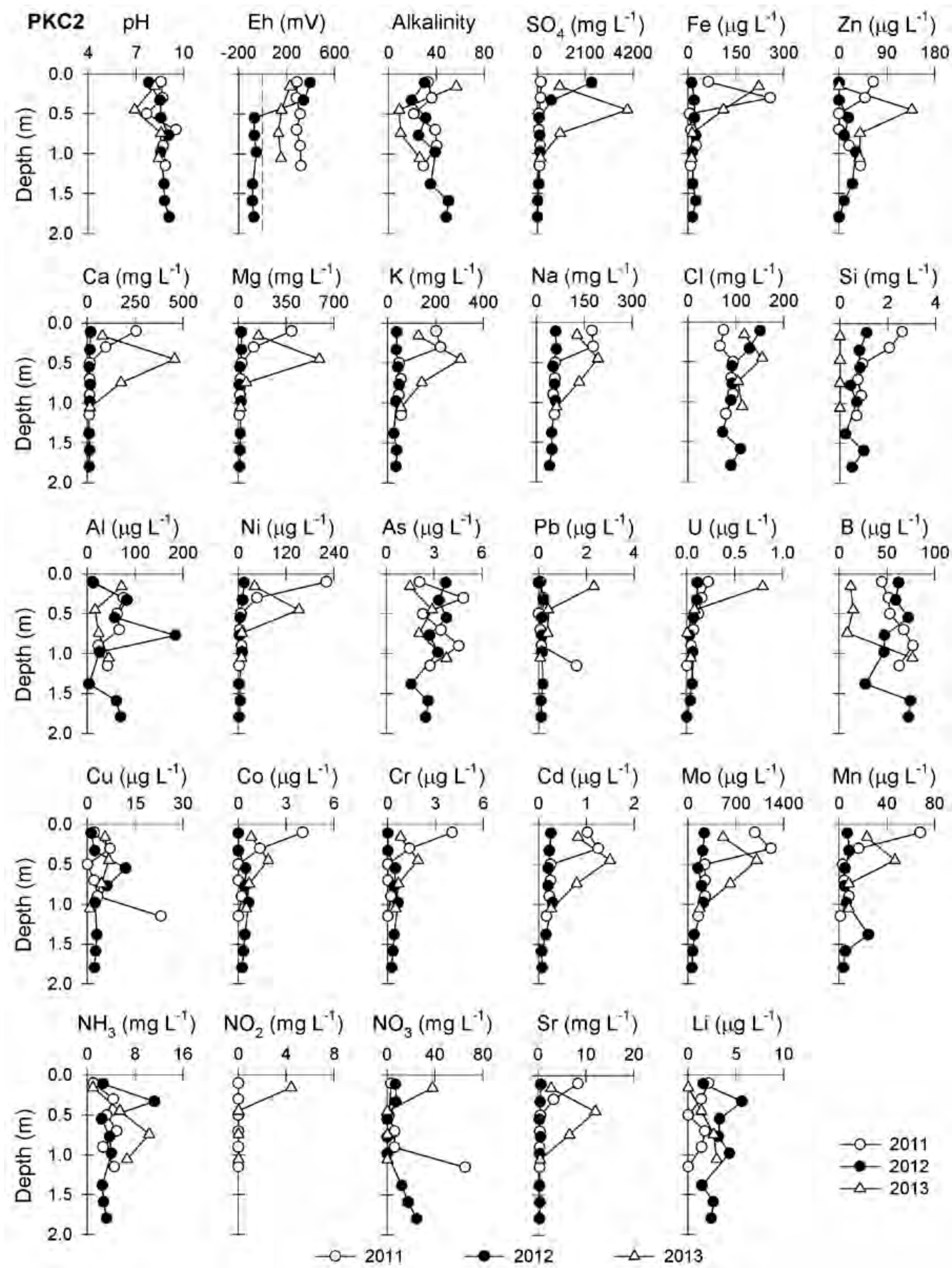


Figure 4: Depth profiles of porewater geochemistry from piezometer nest PKC2. Water samples were collected in 2011, 2012 and 2013.

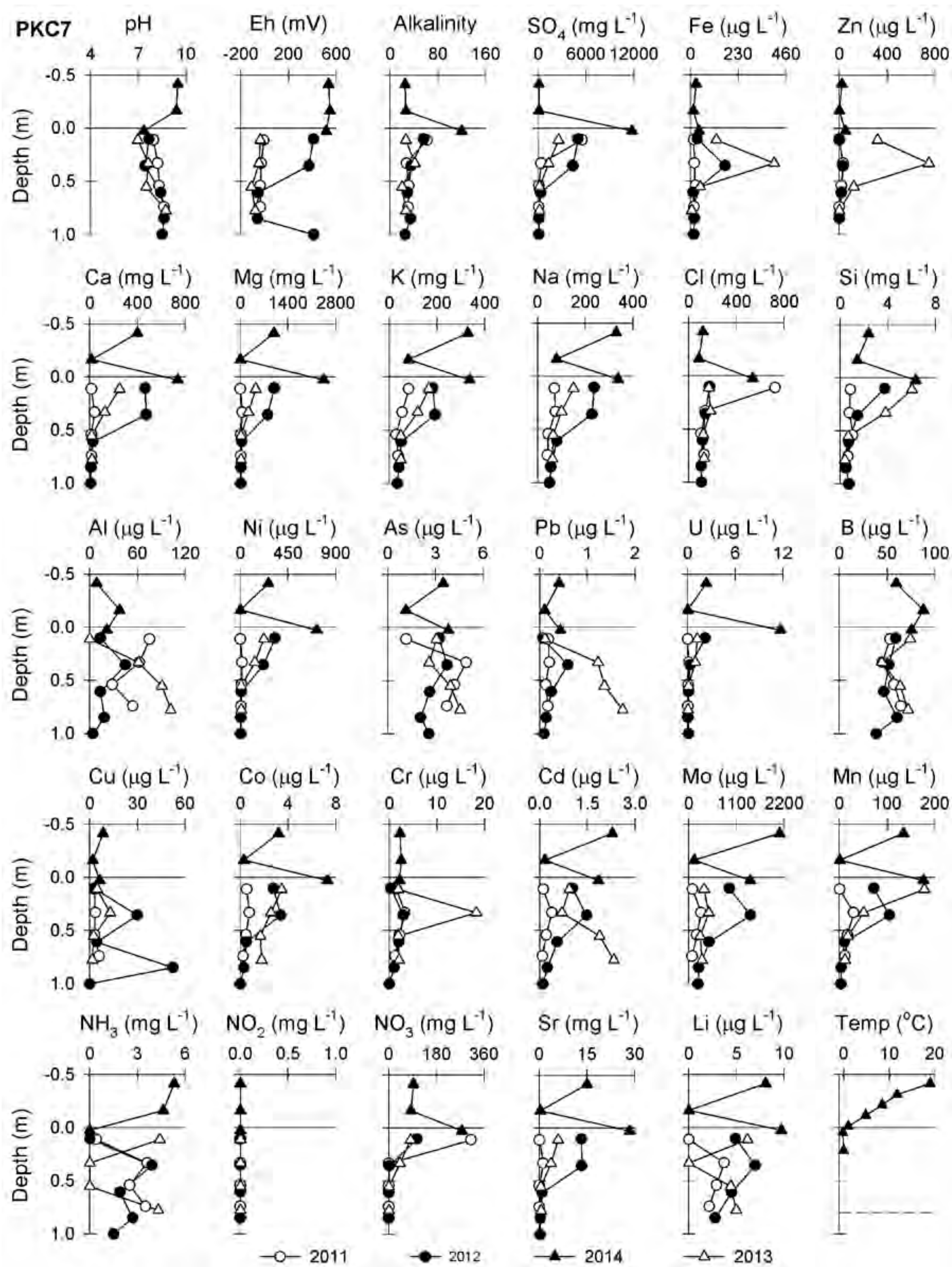


Figure 5: Depth profiles of porewater geochemistry from piezometer nest PKC2. Water samples were collected in 2011, 2012 and 2013. The horizontal line at zero refers to the interface between old FPK and FPK freshly slurried in 2014.

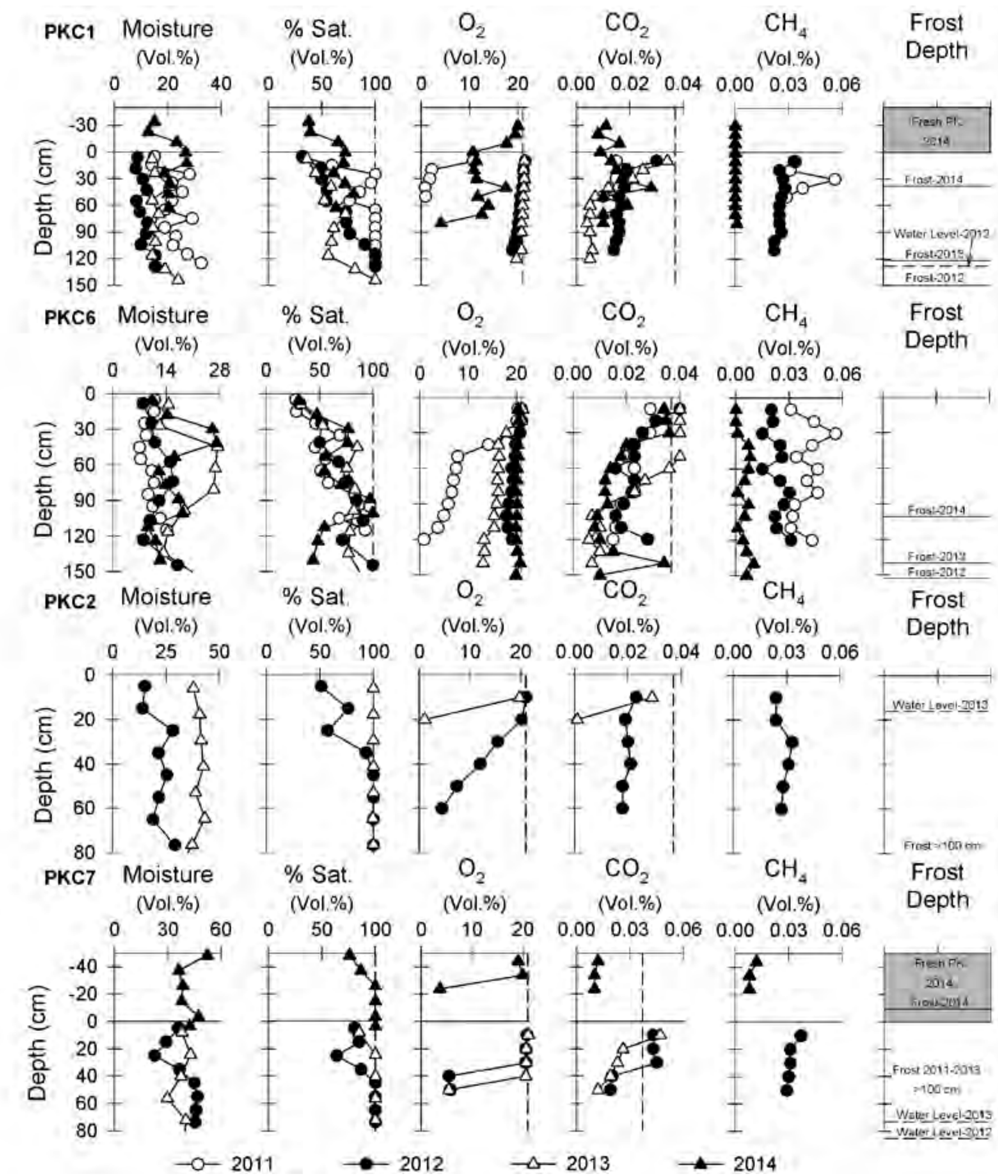


Figure 6: Depth profiles of FPK moisture and pore gas measured from locations PKC1, PKC2, PKC6 and PKC7 in 2011 to 2014.

In 2012 porewater concentrations of dissolved ions decreased in the upper 0.25 m of the FPK, and continued to decline during the study (Figures 2 to 5). For example, between 2011 and 2014, SO_4 and Ni concentrations at PKC6 decreased from 4090 to 680 mg L^{-1} and 204 to 48 $\mu g\ L^{-1}$, respectively (Table 6). This rapid decline in concentration is likely due to downward displacement by infiltrating meteoric waters and secondary mineral precipitations. During this study, crusts of efflorescent minerals were observed covering the PKC surface during dry summer months (Figure 1), also observed by Wilson et al. (2009). Porewater was at or near saturation with respect to gypsum suggesting it could be controlling Ca and SO_4 concentrations (Figure 7 and 8). The decreases of dissolved Ni may be the result of precipitation or co-precipitation/adsorption reactions with secondary mineral phases such as Ni and Fe oxyhydroxides. Speciation modeling shows that the porewater is at saturation with respect to $Ni(OH)_2$ and saturated to supersaturated with respect to Fe-oxyhydroxide minerals (Figure 7 to 10). The formation of secondary Fe-oxyhydroxide minerals may also account for the decrease of dissolved Fe in the unsaturated zone. The precipitation of Fe-oxyhydroxides at a pH above 4 leads to the co-precipitation or adsorption of metals, such as Zn, Cu, Ni, Co, and Cd (Thornber and Wildman, 1984; Bowell and Bruce, 1995; Holmström and Öhlander, 2001).

Table 6: Selected PKC6 porewater concentrations from depth intervals of 0-0.25 m and 1.75-2.00.

Location	Sample Date	Depth m	SO_4 mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	Cl mg L^{-1}	Ni µg L^{-1}
PKC6 (0-0.25 m)	15/08/2011	0.17	4093	745	1122	126	204
PKC6 (0-0.25 m)	12/08/2012	0.15	2020	352	698	57	161
PKC6 (0-0.25 m)	13/08/2013	0.15	532	42	95	54	75
PKC6 (0-0.25 m)	18/06/2014	0.14	679	46	126	61	48
PKC6 (1.75-2.00 m)	15/08/2011	1.91	19	2	16	123	9
PKC6 (1.75-2.00 m)	12/08/2012	1.89	268	48	52	148	48
PKC6 (1.75-2.00 m)	13/08/2013	1.88	69	19	28	86	9
PKC6 (1.75-2.00 m)	18/06/2014	1.62	3537	495	455	293	874

Below a depth of 0.25, concentrations of dissolved SO_4 and major cations increased rapidly to a depth of 1.2 m at PKC1 and 1.8 m at PKC6. From 2011 to 2014 at a depth interval of 1.75 to 2.00 m, dissolved SO_4 and Ni concentrations increased from 19 to 3540 mg L^{-1}, and 9 to 874 µg L^{-1}, respectively, within the active layer at PKC6. The increase of dissolved ions with depth is likely due to decreases in moisture content resulting in deeper O_2 diffusion, the downward displacement of ions, and possibly cryoconcentration due to the upward migration of frost expelling dissolved ions.

The possible effects of cryoconcentration in the FPK can be demonstration in profile PKC7 (Figure 5). In 2013, the depth to frost at PKC7 was 1.08 m. In May 2014 approximately 0.54 m of fresh PK was deposited over the surface at PKC7. By June 2014 the frost had migrated upwards to a depth of 0.42 m, completely freezing the older PK and the bottom 0.12 m of the fresh PK. Although the exposed FPK had only been weathering for about one month, porewater extracted from the upper 0.25 m of the FPK had elevated dissolved concentrations of cations and SO_4, much higher than the PKC Pond water or water from the End of Pipe (EOP - produced water from the slurried FPK) (Table 7). Oxygen had only diffused into the FPK to a depth of 0.2 m, consistent with oxidation products in the porewater (Figure 5). Water extracted from interval 0.25 to 0.50 m contained porewater in the range of EOP, indicating produced water had not been expelled and oxidation products had not infiltrated to this depth (Table 7). The bottom interval of the profile, from 0.50 to 0.63 m, was a mixture of recently deposited PK and older PK. Porewater extracted from this lower core section contained elevated concentrations of dissolved ions much higher than the dissolved concentrations previously measured in porewaters from the underlying weathered PK at PKC7 (Table 7; Figure 5). The porewater contained concentrations of SO_4 close to 12000 mg L^{-1} and Ni at 720 µg L^{-1}, whereas previous maximum concentrations of SO_4 and Ni from the weathered zone at PKC7 were 5480 mg L^{-1} and 330 µg L^{-1}. This strongly suggests that as frost migrated upwards, dissolved ions were expelled ahead of the ice front due cryoconcentration, accumulating major ions and metals near the interface between the frozen and thawed FPK.

Table 7: Selected PKC7 porewater concentrations measured in 2014 compared to the PKC Pond and End of Pipe (EOP): produced water from the slurried FPK.

Location m	Date	SO_4 mg L^{-1}	Mg mg L^{-1}	Ca mg L^{-1}	Cl mg L^{-1}	Ni µg L^{-1}	Zn µg L^{-1}
PKC Pond	2011-2014	270-380	38-51	19-34	35-71	10-29	<dl-1.8
PKC7-0-0.25	2014	51	983	399	116	266	23
EOP	2011-2014	59-329	2.2-16	1.6-21	33-86	1.4-1.6	<dl-7.3
PKC7-0.25-0.50	2014	86	4	13	83	1	<dl
PKC7-0.50-0.63	2014	11768	2441	734	536	721	52

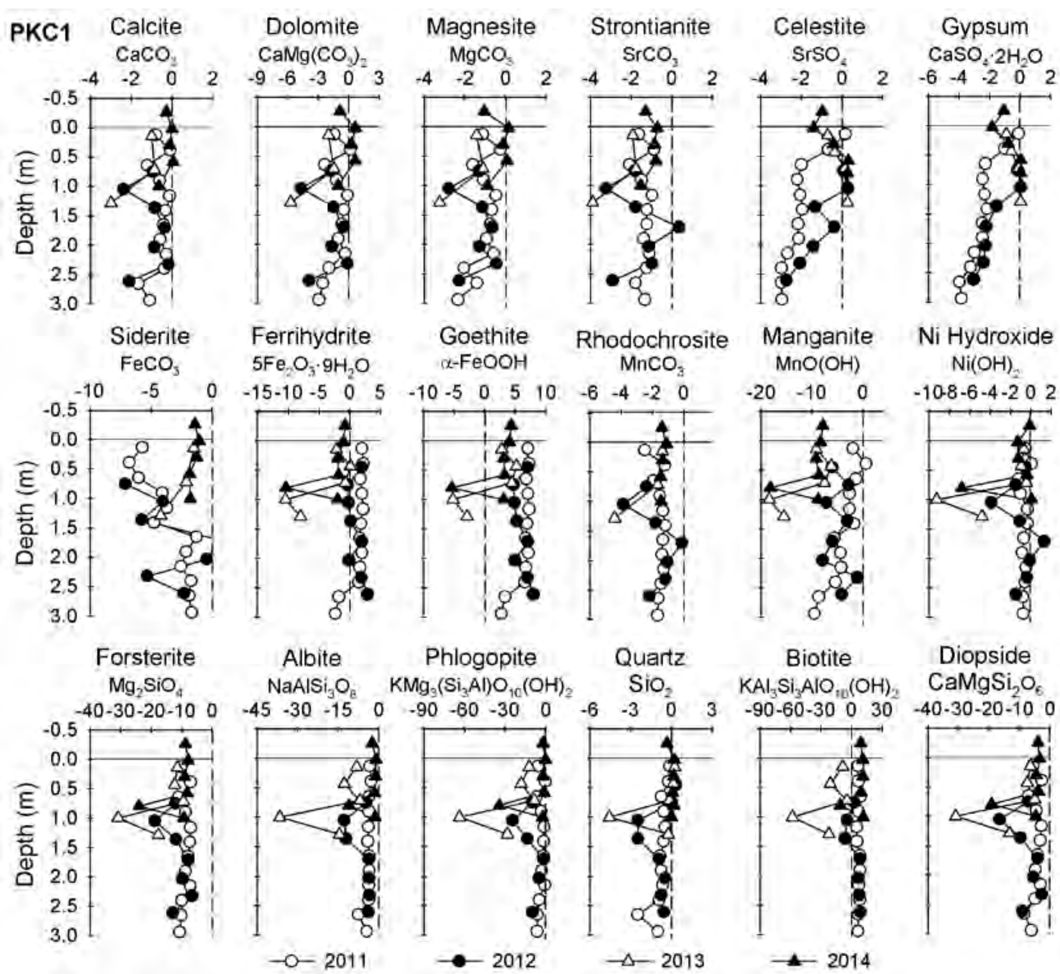


Figure 7: Depth profiles of saturation indices from PKC1 calculated using PHREEQC. The horizontal line at zero refers to the interface between old FPK and FPK freshly slurried in 2014.

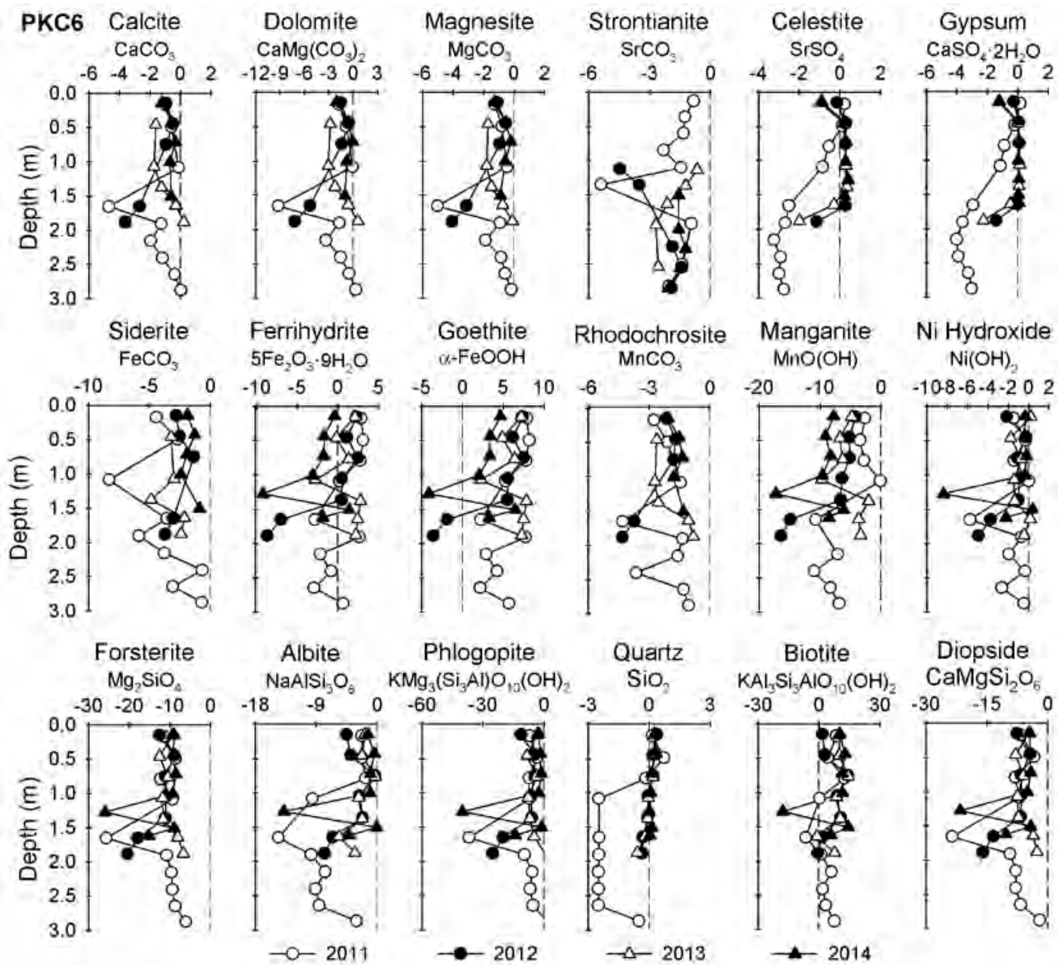


Figure 8: Depth profiles of saturation indices from PKC6 calculated using PHREEQC.

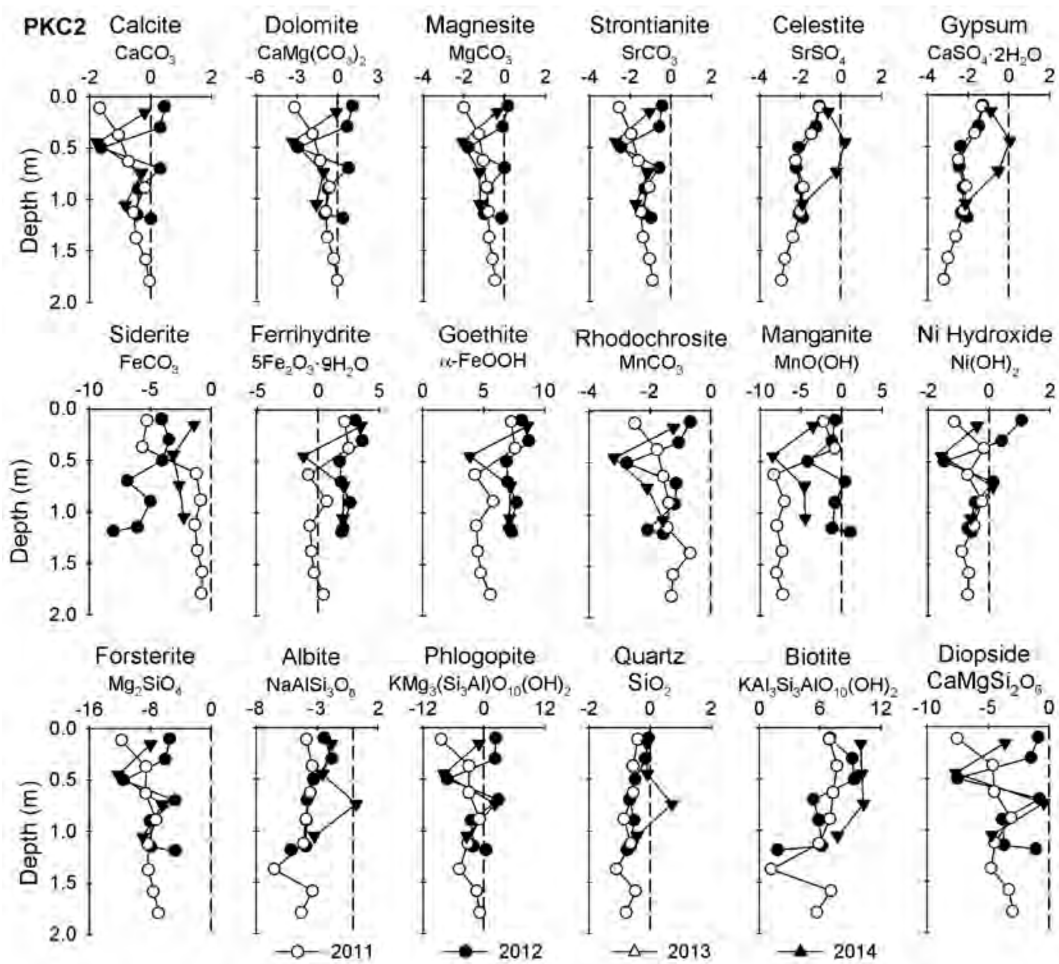


Figure 9: Depth profiles of saturation indices from PKC2 calculated using PHREEQC.

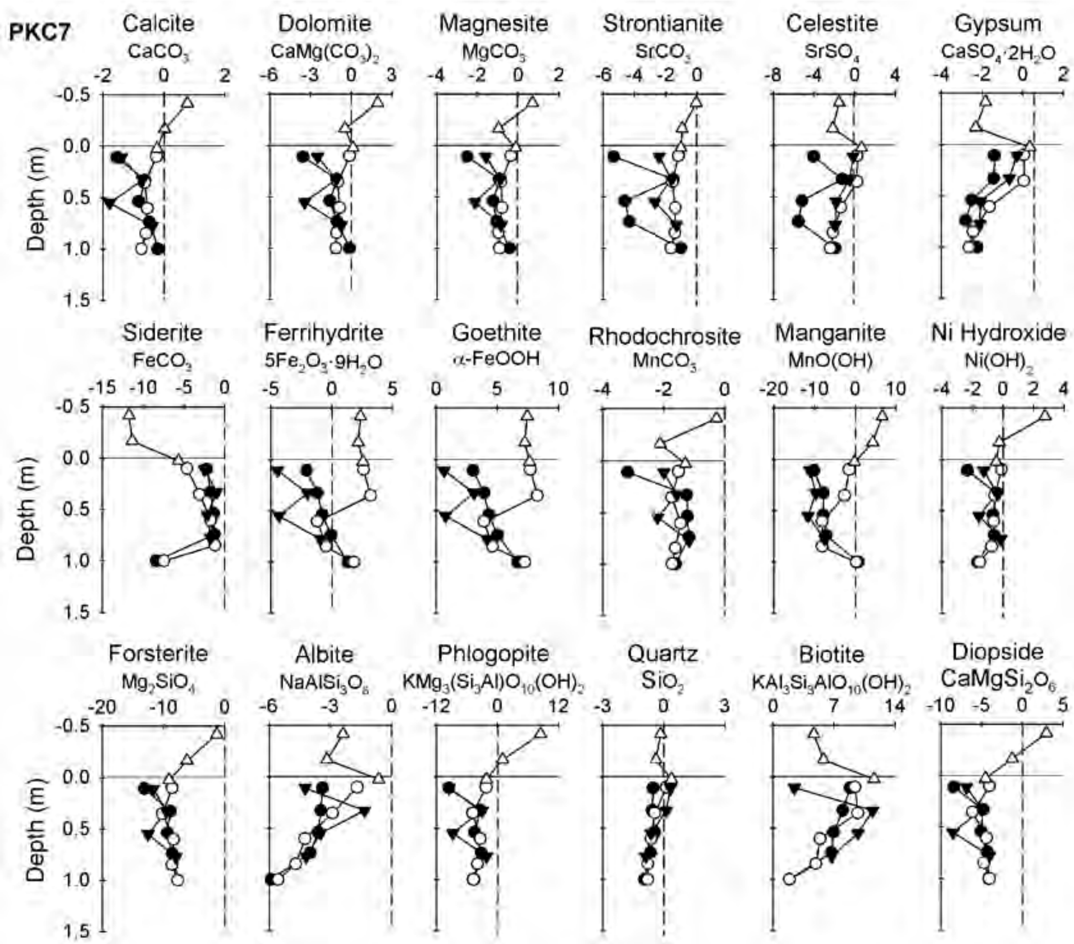


Figure 10: Depth profiles of saturation indices from PKC7 calculated using PHREEQC. The horizontal line at zero refers to the interface between old FPK and FPK freshly slurried in 2014.

Similar to the FPK study in 2009-2010 (Moncur and Smith, 2012), there were distinct differences in Eh, pH, and concentration of dissolved ions from the unsaturated zone and the frost zone. Differences in Eh measurements indicate oxidizing conditions in the unsaturated zone that became progressively more reduced with depth into the frost zone. The shift towards more reduced conditions with depth corresponds with a shift towards increasing pH values. Dissolved concentration of sulfate, silica, major cations and most metals decrease typically by an order of magnitude from the unsaturated zone to the saturated zone (e.g. at PKC2: SO_4: 3940 to 987 mg L^{-1}, Mg: 590 to 56 mg L^{-1}, Ni:152 to 9 μg L^{-1}). The concentrations of dissolved ions are significantly lower in the frost zone than in the unsaturated zone.

There were, however, a few anomalously low pH zones observed at PKC1 and PKC6. At a depth of 1 m at PKC1, the porewater pH decreases from 8.84 in 2011 to 3.88 in 2014 (Table 8). The alkalinity was consumed and there were elevated concentration of some dissolved metals (eg. Fe, Al, Zn, Ni). Oxygen has also diffused to a 1 m depth by 2012. Speciation modeling showed that the porewater in this zone was undersaturated with respect to carbonate, Al and Fe oxyhydroxide, and aluminosilicate minerals, suggesting that these phases could be dissolving (Figure 14). The low pH water is likely causing the dissolution of these minerals and subsequent release of dissolved ions to the porewater. A similar trend was observed with depth at PKC6, as were two locations during studies by Moncur et al. (2011). These low pH zones may represent areas with a higher processed mudstone content. The mudstone xenoliths found throughout the kimberlite ore is not removed before processing, therefore FPK with higher proportions of mudstone may be deposited in areas as small discontinuous lenses. Column experiments by Baker et al. (2003) found that the mudstone is highly reactive, resulting in acidic effluent (e.g. pH=3) and elevated concentrations of SO_4, Fe, Al, Co, Cu, Ni and Zn in the mg L^{-1} range, similar to our observations in the low pH zones of the FPK. Although there are small lenses of low pH water observed in the FPK, they are not expected to impact the overall water quality in the PKC facility due to the high neutralizing potential of the olivine and calcite.

Table 8: Time-series at PKC1 showing selected porewater concentrations and pH from a depth of 1 m.

PKC1 Date	pH	Alkalinity mg L^{-1} $CaCO_3$	SO_4 mg L^{-1}	Fe µg L^{-1}	Ni µg L^{-1}	Zn µg L^{-1}	Al µg L^{-1}
2011	8.84	44	75	11	15	24	8
2012	5.88	21	3540	53	73	<0.8	52
2013	3.19	<1	4330	706	194	982	167
2014	3.88	<1	4450	2963	940	2531	760

Elevated concentrations of dissolved ions within the unsaturated zone are likely the result of weathering reactions. Elevated concentrations of dissolved SO_4 and some metals may be due to microbially mediated pyrite oxidation within the FPK. The majority of pyrite observed in the FPK was framboidal which is less stable and more reactive than massive pyrite (Paktunc and Thibault, 2010). When the mineral surface of pyrite is exposed to atmospheric O_2 and water it will oxidize by the following reaction:

$$FeS_2(s) + 7/2O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad (1)$$

Reaction (1) releases one mole of Fe^{2+}, two moles of SO_4^{2-}, and generates 2 moles of acid for every mole of pyrite oxidized. To determine if the elevated SO_4 concentrations were derived from sulfide oxidation, isotope ratios of $\delta^{34}S\text{-}SO_4$ measured in porewater from the FPK in 2010 and 2011 (Moncur and Smith, 2012). $\delta^{34}S\text{-}SO_4$ values were strongly depleted (-19‰) and showed minimal fractions from the kimberlite ore (-21‰), suggesting that the source of SO_4 was most likely a product of sulfide oxidation. Trace elements that occur as impurities in pyrite also may be liberated via reaction (1). For example, pyrite is a common carrier of arsenic [As] and other trace elements such as Pb, Sb, Bi, Cu, Co, Ni, Zn, Au, Ag, Se and Te (Deditius et al., 2011). Microprobe analyses of pyrite from the East Beach FPK found that the massive pyrite was close to pure FeS_2 end-members, whereas framboidal pyrite often contained variable contents of Mn, Ni, Cu, and As (Paktunc and Thibault, 2010). When ferrous iron (Fe^{2+}) is exposed to O_2, it will oxidize and to ferric iron (Fe^{3+}) consuming on mole of acid:

$$Fe^{2+} + 1/4O_2 + H^+ \rightarrow Fe^{3+} + 1/2H_2O \qquad (2)$$

In environments where the pH is greater than 5, such as pore waters from the East Beach of the PKC facility, hydrolysis of Fe(III) will promote precipitation of an Fe oxyhydroxide mineral phase, but will also generate additional acid:

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3(s) + 6H^+ \qquad (3)$$

Speciation modeling results show that the porewaters are at saturation or supersaturated with respect to secondary Fe oxyhydroxide minerals, suggesting theses phases may be controlling dissolved Fe concentrations (Figures 7 to 10). The precipitation of a Fe oxyhydroxide mineral would explain the relatively low dissolved Fe concentrations compared dissolved SO_4 assuming both ions were mainly due to pyrite oxidation. Column experiments using the FPK identified goethite as a secondary precipitate (Baker et al., 2003).

Other sulfide minerals present in the FPK that may also oxidize releasing metals to the porewater include sphalerite, chalcopyrite, and galena, all of which have been identified in the kimberlie ore (Baker et al., 2003). The oxidation of these sulfides can be represented through the equations:

$$ZnS + 2O_2 \rightarrow Zn^{2+} + SO_4^{2-} \qquad (4)$$

$$CuFeS_2 + 4H^+ + O_2 \rightarrow Cu^{2+} + Fe^{2+} + 2S^0 + 2H_2O \qquad (5)$$

$$PbS + 2O_2 \rightarrow Pb^{2+} + SO_4^{2-} \qquad (6)$$

Reactions (4) to (6) result in the release of Zn, Cu, Pb and SO_4. Sulfide oxidation of the PK material from DDMI was investigated using long-term kinetic column test conducted by Baker et al. (2003). This study found that sulfide oxidation could lead to the release of small amounts of Co, Sr and Zn. These metals, along with others such as Pb, As, Cr and Cd, although at low concentrations, were measured in the porewater of the unsaturated zone of the PKC facility (Figure 2 to 5). The release of Cd could be due to the weathering of sphalerite; Mn, As, and Cu from framboidal pyrite; Cr from the dissolution of chromium diopside [Cr-$CaMgSi_2O_6$] or garnet [$Ca_3(Al,Cr)_2(SiO_4)_3$].

Dissolved concentrations of metals in the unsaturated zone are generally low due to the high neutralizing potential of the PK material. The pH of the porewater and groundwater remained circumneutral, limiting the solubility of most metals. Olivine was found to be a dominant mineral phase in the FPK and had a high potential to neutralize acidity. The dissolution of olivine by the release of acid from reaction (1) and (2) maintains the pH of the porewater near neutral through dissolution:

$$Mg_2SiO_4 + 2H_2SO_4 \rightarrow 2Mg^{2+} + Si(OH)_4 + 2SO_4^{2-} \qquad (7)$$

The congruent dissolution of olivine in reaction (7) results in the neutralization of 2 moles of acid and the release of Mg and SO_4. If the dissolution of olivine is incongruent:

$$Mg_2SiO_4 + 2H_2SO_4 + H_2O \rightarrow Mg_3Si_2O_5(OH)_4 + Mg^{2+} + 2SO_4^{2-} \quad (8)$$

The incongruent dissolution of olivine would lower the neutralization potential and release one mole of Mg. The dissolution of Ni-bearing olivine will also release dissolved Ni to the porewaters. Paktunc and Thibault (2010) observed partial dissolution features along grain boundaries that appeared to occur *in situ* at the East Beach of the PKC facility in 2009. In addition to olivine, calcite was another neutralizing mineral identified in the FPK, where:

$$CaCO_3 + H^+ \leftrightarrow Ca^{2+} + HCO_3^- \quad (9)$$

The dissolution of calcite results in mole of acid being consumed and one mole of Ca and HCO_3 are released to the porewater. Geochemical modeling results show that most porewaters were at saturation with respect to calcite (Figure 7 to 10). Reactions (7) through (9) may contribute to the elevated concentrations of dissolved Mg and Ca in the unsaturated zone.

Other minerals in the PKC facility, such as phlogopite, may undergo incongruent dissolution releasing dissolved K and Mg to the porewaters (Banfield and Eggelton, 1988; Murakami et al., 2003):

$$K(Mg_2Fe)(AlSi_3)O_{10}(OH)_2 + 5H^+ + 0.25O_2 + 3H_2O \rightarrow \quad (10)$$
$$0.5Al_2Si_2O_5(OH)_4 + Fe(OH)_3 + 2H_4SiO_4 + K^+ + 2Mg^{2+}$$

Dissolved concentrations of Ca and Mg were highest in the unsaturated zone of the FPK. Phlogopite was identified in the FPK material (Baker et al., 2001; Paktunc and Thibault, 2010) and the porewater in the unsaturated zone is at saturation with respect to phlogopite (Figures 7 to 10).

In acid-neutralizing carbonate-mineral dissolution reactions the depletion of O_2 concentrations in pore gas is typically accompanied by an increase in CO_2 concentrations (Blowes et al., 1998). However, CO_2 concentrations were typically at atmospheric (0.036%) near surface then decrease in concentration with depth (Figure 6), suggesting that the CO_2 was being sequestered. This is consistent with previous work has shown that dissolution of silicate minerals within the PKC facility is sequestering CO_2 through the precipitation of carbonate mineral phases (Wilson et al., 2009). The possible dissolution and consumption of CO_2 by olivine and lizardite in the PKC facility can be represented by the equations:

olivine

$$(Mg,Fe)_2SiO_4 + 5/2O_2 + CO_2 + 5H_2O \rightarrow 2MgCO_3 + 2Fe(OH)_3 + Si(OH)_4 \quad (11)$$

Lizardite

$$Mg_3Si_2O_5(OH)_4 + 3CO_2 \rightarrow MgCO_3 + 2SiO_2 + 2H_2O \quad (12)$$

The dissolution of minerals in equations (8) and (9) would result in the consumption of CO_2 and precipitation of magnesite [$MgCO_3$] and Fe hydroxide. Speciation modeling suggests that porewater is undersaturated with respect to olivine, consistent with dissolution, and at saturation with respect to magnesite and ferrihydroxide (Figure 8 and 9). Although there may be potential to sequester CO_2 using FPK to reduce the mine's carbon footprint, the subsequent weathering of FPK minerals and release of metals would offset benefits of carbon sequestration.

6.4 PKC Barge

Profiles of piezometers were installed off the PKC barge in 2009, 2010 and 2011 (Figure 1). The Barge location had to be re-instrumented each year because rising water levels in the PKC pond would submerge piezometers. The interface between the clear water column and suspended sediments at the barge was about 2 m-deep below the water surface. The FPK beneath the water column was extremely unconsolidated to the point where piezometers could be installed by hand to a depth of 10 m. Piezometers deeper than 10 m were installed using a Pionjar percussion drill. No frost was encountered during the installation of drive-point piezometers in 2009, 2010 or 2011.

Water levels in the four Barge piezometers were measured relative to the water level in the PKC pond on 2009 and 2010, but not in 2011. Water levels showed a downward gradient in piezometers above 10 m and a strong upward gradient in piezometers below 13 m. Although water levels were not measured in 2011, the two deepest piezometers at 17 m and 22 m depths were flowing, as observed in 2009 and 2010. The hydraulic conductivity from five Barge piezometers installed in 2010 was measured using rising-head response tests. Hydraulic conductivies ranged from 7.8×10^{-8} m s^{-1} to 7.2×10^{-10} m s^{-1}, with an average of 3.5×10^{-8} m s^{-1} (Moncur and Smith, 2012), consistent with the fine-grain size of the slimes.

Profiles of groundwater chemistry collected in 2009, 2010, 2011 from the Barge piezometers show that concentrations of dissolved ions, temperature and Eh are generally higher in the PKC pond water, and decrease with depth though the PK material (Figure 11). The concentration of SO_4 and major cations showed little change between 2009 and 2011. Trace metal concentrations did show some differences between 2009 and 2011, however, these concentrations were near detection limits and likely within analytical uncertainties. In 2009 the average concentration of dissolved organic carbon (DOC) measured from the Barge piezometers and the PKC pond was 9.5 mg L^{-1}, however the concentrations measured at a depth of 8 m and 11 m was 109 and 257 mg L^{-1}, respectively. Concentrations of DOC were similar in 2010. Although there was a peak in DOC at a similar depth in 2011, concentrations were much lower, between 35 and 63 mg L^{-1} (Figure 11). Normally sewage from the mining operations is treated prior to discharge to the PKC facility, but elevated DOC may indicate a period when raw sewage was discharged to the PKC facility. The stable isotopic composition of nitrogen ($\delta^{15}N$ = 10.8 ‰) and oxygen ($\delta^{18}O$-NO_3 = 15.7 ‰) in water from the high DOC zone indicated that the nitrate originated from a mixture of fertilizer (explosives) and sewage. Speciation modeling results show that carbonate minerals calcite, dolomite, magnesite and hydroxide mineral phases are at saturation and may be controlling pH and the dissolved concentration of ions in the porewater (Figure 12).

Concentrations of dissolved ions measured from Barge piezometers are much lower than concentration from porewaters measured from the PKC East Beach. Even though the Barge PK had similar mineralogy to the East Beach PK, the difference between geochemical profiles indicates that the subaqueous disposal PK material has significantly limited weathering and the subsequent release of ions to the porewaters. The ability of a water cover to reduce the ingress of O_2 into tailings and the subsequent mineral weathering is well recognized and subaqueous disposal of mine waste is a common practice (eg. Pedersen et al., 1993; Vigneault et al., 2001; Jacob and Otte, 2004; Moncur et al., 2012). The O_2 ingress into the tailings is limited by the slow diffusion of O_2 through the water cover. For example, the diffusive flux of O_2 to water covered tailings is almost 10 000 times less than uncovered tailings (Robertson et al., 1997).

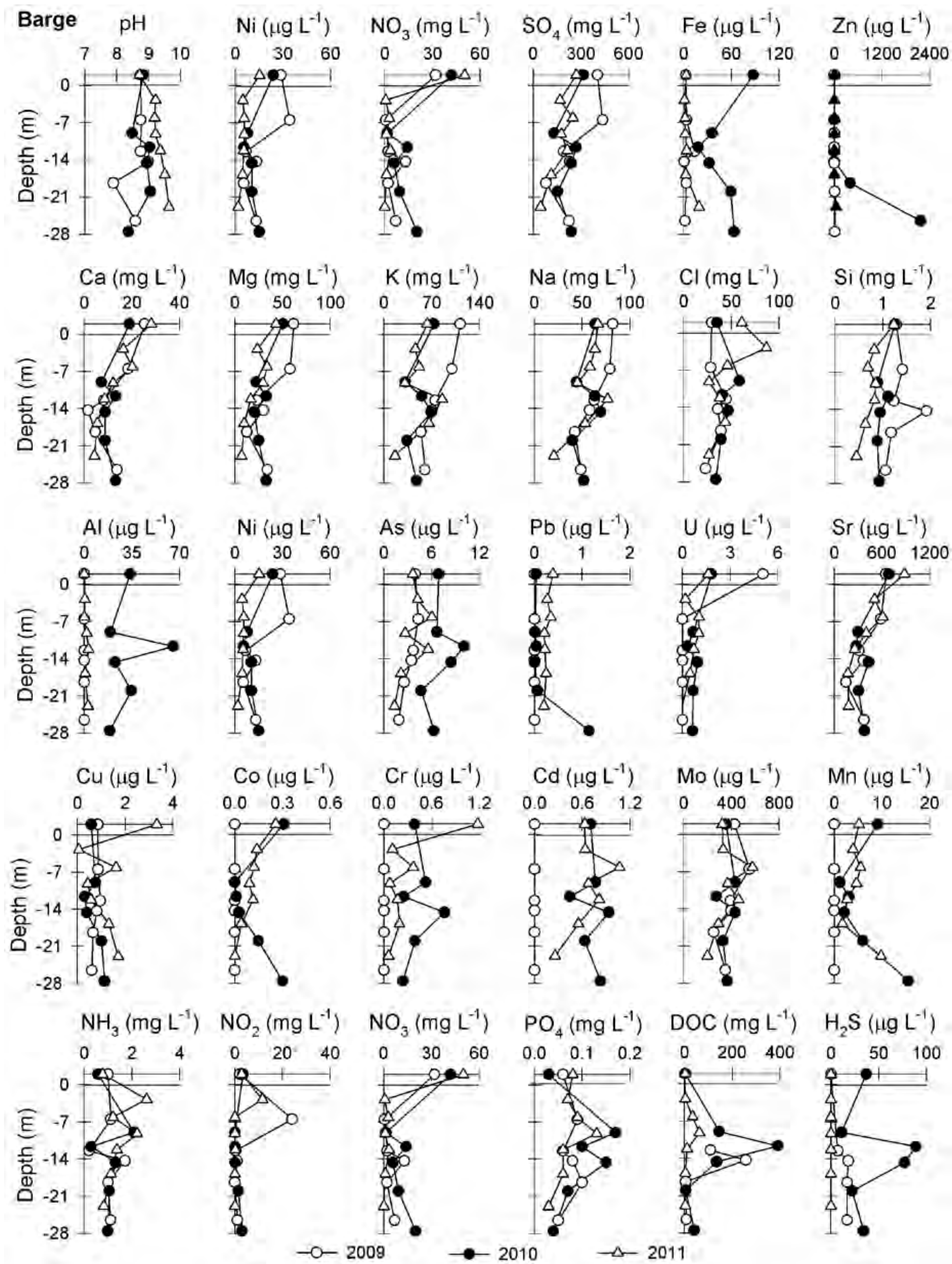


Figure 11: Depth profiles of groundwater chemistry at the Barge location measure in 2009, 2010 and 2011. The top point represents PKC pond chemistry and the horizontal solid line is the boundary between the surface water column and suspended FPK.

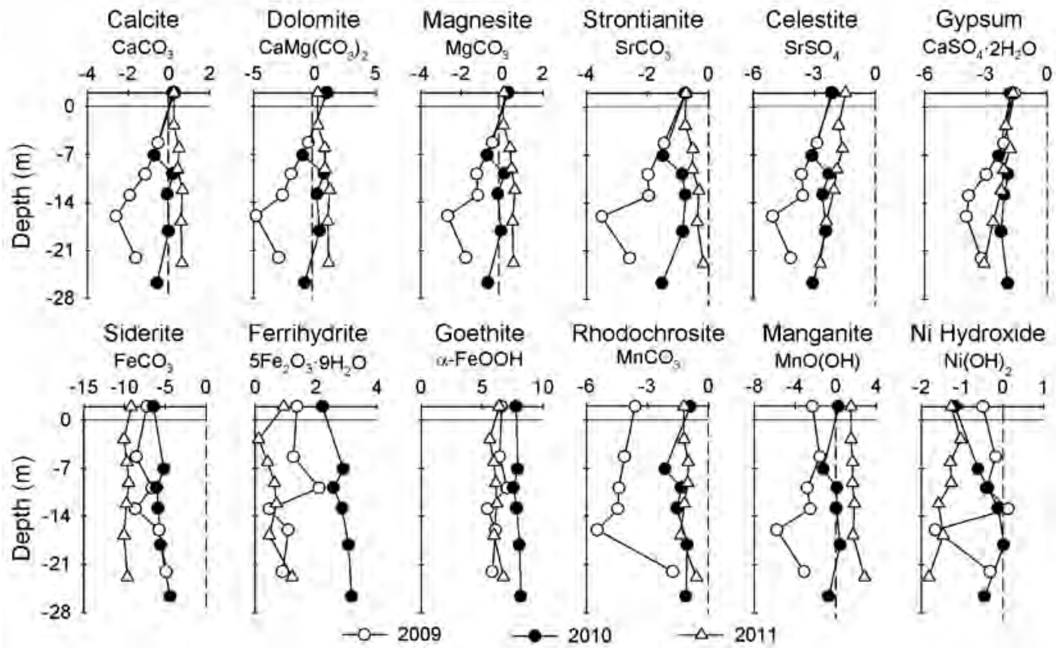


Figure 12: Depth profiles of saturation indices from the Barge piezometers calculated using PHREEQC. The upper point represents PKC pond chemistry and the horizontal solid line is the boundary between the surface water column and suspended FPK.

9.0 CONCLUSIONS

The following conclusions were made:

- Frost Zone
    - In 2011, the active, frost-free zone was at a 2.3 m depth at PKC6 near the containment dam. By 2014, frost at PKC6 had migrated upwards to a depth of 1.14 m. PKC1 had a similar decrease in active zone.
    - Minimal change in frost depth was observed from 2011 to 2013 at locations PKC2 and PKC7, adjacent to the PKC Pond.
    - Frost matured over time becoming more difficult to penetrate with sampling equipment
    - During piezometer installation at the Barge in 2011, no frost was encountered from surface to a depth of 23 m.

- Water Levels
    - In 2012 the water level in piezometer PKC1 was at a depth of 1.2 m. It was not possible to measure other water levels from piezometers at PKC1 and PKC6 during the study because they were either dry or water was frozen. Ice levels were measured in the deeper piezometers from PKC6 and were observed to fluctuate similar to frost levels in the FPK
    - At the Barge where PK material is submerged under a 1.8 m water cover, there was an upward gradient with depth

- Pore Gas
    - Pore gas profiles in 2011 showed O_2 depletion with depth of at all locations, consistent with saturated condition. In 2012 and later, moisture contents at PKC1 and PKC6 decrease which subsequently resulted in deeper O_2 diffusion into the FPK. Moisture content in the FPK material controls the depth of O_2 diffusion and is therefore an important control on the depth of weathering.
    - CO_2 concentrations were typically at atmospheric (0.036%) near surface then decreased below atmospheric concentration with depth, suggesting that the CO_2 was being sequestered due to precipitation of secondary carbonate mineral phases.

- Processed Kimberlite Groundwater Geochemistry
    - Within 1 month of fresh slurried FPK deposited over the East Beach of the PKC facility, elevated concentrations of dissolved SO_4 and major cations were observed in the upper 0.25 m of the FPK, suggesting rapid oxidation/dissolution of FPK minerals.
    - During year one, the highest concentration of dissolved ions were measured form the upper 0.25 m of the FPK, however concentration declined in succeeding years, likely due to secondary mineral precipitation and downward displacement.
    - The highest concentration of dissolved metals, major cations and sulfate were measured in the unsaturated zone of the PKC facility. The elevated ion concentrations are likely due to weathering processes. The concentrations of metals in the unsaturated zone at the PKC facility are relatively low due to the high neutralizing potential of the PK material, which neutralizes the porewater and limits the solubility of most metals. Dissolution of olivine and carbonate minerals is consistent with the elevated concentrations of dissolved Ca and Mg in porewater from the unsaturated zone
    - The upward advance of frost in the FPK appears to be concentrating dissolved ions at the frost-thawed interface through cryoconcentration.
    - Groundwater collected from Barge piezometers and frost zone had the lowest concentration of dissolved ions.
    - Speciation modeling shows that the main minerals controlling the pH and dissolved ions are secondary carbonate and (oxy)hydroxide minerals. Secondary sulfate minerals may control SO_4 and other metals at the near surface in unsaturated areas of the PKC facility.
    - The subaqueous disposal and freezing of the PK material limits the ingress of atmospheric O_2 subsequently limiting the release of dissolved concentrations of metals and SO_4 to the adjacent porewater.

11.0 CLOSURE

Alberta Innovates-Technology Futures and Lianna Smith Consulting are pleased to present the findings of this investigation into the hydrogeochemistry of the Processed Kimberlite

Containment Facility at Diavik Diamond Mines Inc. We look forward to any comments regarding this report and future investigations.

Sincerely,

Michael Moncur, M.Sc.,
Research Hydrogeologist

Lianna Smith, M.Sc., P.Geol.
Hydrogeochemist

12.0 REFERENCES

Baker, M.J., Blowes, D.W., Logsdon, M.J., Jambor, J.L., 2003. Environmental geochemistry of kimberlite materials: Diavik Diamond Project, Lac de Gras, Northwest Territories, Canada. Explor. Mining Geol. 10, 155-163.

Ball, J.W., Nordstrom, D.K., 1991. User's manual for WATEQ4F with revised thermodynamic data base and test cases for calculating speciation of major, trace and redox elements in natural waters. U.S. Geol. Surv. Open-File Rep. 91-183.

Banfield, J.F., Eggelton, R.A., 1988. Transmission electron microscope study of biotite weathering. Clays Clay Minerals 36, 47-60.

Blowes, D.W., Jambor, J.L., Hanton-Fong, C.J., Lortie, L., Gould, D., 1998. Geochemical, mineralogical and microbiological characterization of a sulphide-bearing carbonate-rich gold-mine tailings impoundment, Joutel, Québec. Appl. Geochem. 13, 687-705.

Bowell, R.J., Bruce, I., 1995. Geochemistry of iron ochres and mine waters from Levant Mine, Cornwall. Appl. Geochem. 10, 237-250.

Craig, H., 1961. Isotopic variations in meteoric waters. Science 133, 1702-1703.

Deditius, A.P., Utsunomiya, S., Reich, M., Kesler, S.E., Ewing, R.C., Hough, R., Walsh, J., 2011. Trace metal nanoparticles in pyrite. Ore Geol. Rev. 42, 32-46.

Golder Associates Ltd. 2008. 2007 Review of Baseline Climate and Surface Water Hydrology for the Diavik Diamond Mine. 07-1328-0006\6000, DCN: RPT-602 Ver. 0.

Holmström, H., Öhlander, B., 2001. Layers rich in Fe- and Mn-oxyhydroxides formed at a tailings-pond water interface, a possible trap for trace metals in flooded mine tailings. J. Geochem. Explor. 74, 189-203.

Jacob, D.J., Otte, M.L., 2004. Long-term effects of submergence and wetland vegetation on metals in a 90-year old abandoned Pb-Zn mine tailings pond. Environ. Pollut. 130, 337-345.

Light, T.S., 1972. Standard solution for redox potential measurements. Anal. Chem. 44, 1038-1039.

Moncur Groundwater, 2009. PKC mass balance study, Diavik Diamond Mines Inc., Diavik, Northwest Territories. Report prepared for DDMI.

Moncur, **M.C.,** Birks, S.J., Jasechko, S., Richardson, K., 2011. Hydrochemical investigation of the processed kimberlite facility at Diavik Diamond Mines Inc. Final technical report prepared for DDMI.

Moncur, **M.C.**, Ptacek, C.J., Blowes, D.W., Lindsay, M.B.J., 2012. Long-term storage of sulfide-rich tailings under a shallow water cover. In: W.A. Price (Ed.) 9th International Conference on Acid Rock Drainage. Ottawa, ON. May 20-26, p. 12.

Moncur, M.C., Blowes, D.W., Ptacek, C.J., 2013. Pore water extraction from the unsaturated zone. Can. J. Earth Sci. 50, pp. 1051-1058

Moss, S., Russell, J.K., Andrews, G.D.M. 2008. Progressive infilling of a kimberlite pipe at Diavik, Northwest Territories, Canada: Insights from volcanic facies architecture, textures, and granulometry. J. Volcanol. Geotherm. Res. 174, 103-116.

Murakami, T., Utsunomiya, S., Yokoyama, T., Kasama, T., 2003. Biotite dissolution processes and mechanisms in the laboratory and in nature: Early stage weathering environments and vermiculitization. Am. Mineral. 88, 377-386.

Nordstrom, D.K., 1977. Thermochemical redox equilibria in Zobell's solution. Geochim. Cosmochim. Acta 41, 1835-1841.

Paktunc, A.D., Thibault, Y., 2010. Quantitive mineralogy of processed kimberlite and waste rock samples from the Diavik Diamond Mines. CANMET-MMSL 10-019(CR).

Parkhurst, D.L., Appelo, C.A.J., 1999. User's guide to PHREEQC (version 2) - a computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. US Geol. Survey, Water-Resour. Inv. Rep. 99-4259, pp. 312.

Pedersen, T.F., Mueller, B., McNee, J.J., 1993. The early diagenesis of submerged sulphide-rich mine tailings in Anderson Lake, Manitoba. Can. J. Earth Sci. 30, 1099-1109.

Ptacek, C.J, 1992. Experimental determination of siderite solubility in high ionic-strength aqueous solutions. PhD Thesis, Univ. Waterloo, Waterloo, ON.

Robertson, J.D., Tremblay, G.A., Fraser, W.W., 1997. Subaqueous tailings disposal: A sound solution for reactive tailings. In: 4th International Conference on Acid Rock Drainage, Vancouver, May31-June 6. Vol. 3, p. 1027-1044.

Moncur, M.C., Smith, L.J.D., 2012. Processed kimberlite porewater geochemistry from Diavik Diamond Mines, Inc. In: W.A. Price (Ed.) 9th International Conference on Acid Rock Drainage. Ottawa, ON. May 20-26, p. 12.

Thibault, Y., Paktunc, D., 2012. Mineralogical characterization of nine samples from the Diavik Diamond Mines. Report CanmetMINING 12-041(CR).

Thornber M.R., Wildman, J.E., 1984. Supergene alteration of sulfides, VI. The binding of Cu, Ni, Zn, Co, and Pb with gossan (iron bearing) minerals. Chem. Geol. 44, 399-434.

Vigneault, B., Campbell, P.G., Tessier, A., De Vitre, R., 2001. Geochemical changes in sulfidic mine tailings stored under a shallow water cover. Wat. Res. 35, 1066-1076.

Wilson, S.A., Raudsepp, M., Dipple, G.M., 2009. Quantifying carbon fixation in trace minerals from processed kimberlite: A comparative study of quantitative methods using X-ray powder diffraction data with applications to the Diavik Diamond Mine, Northwest Territories, Canada. Appl. Geochem. 24, 2312-2331.

Rio Tinto

Appendix II-2

Technical Memorandum – PK Tank 2014 Progress Report.

Lianna Smith
Lianna Smith Consulting
55 Fulton Ave
Ottawa, ON K1S 4Y5
t 613.293.4046
e1 lianna.smith@riotinto.com
e2 lianna.smith@outlook.com

Mike Moncur
AITF
3608-33rd St. NW
Calgary, AB T2L 2A6
t1 403.210.5368
t2 403.700.5077
e michael.moncur@aitf.ca

Technical Memorandum

To	Gord Macdonald
cc	
From	Lianna Smith (Lianna Smith Consulting) Mike Moncur (Alberta Innovates – Technology Futures)
Reference	PK Tank 2014 Progress Update
Date	15 Oct 2014

1 Background

The processed kimberlite (PK) tank experiments are part of a complementary field and laboratory program to evaluate the geochemical evolution of fine PK (FPK) over time. The objective of the program is to more confidently predict water quality within and/or discharging from the PKC post-closure.

The field portion of the program includes *in situ* pore water sampling at stations established in 2009 and 2011, and four 5700 L tank experiments initiated in 2012. The tank configuration permits detailed instrumentation, data collection and FPK exposure to ambient conditions to provide data about the geochemical evolution without being covered by fresh slurry, as in the PKC. This technical memorandum provides a progress update on the PK tank portion of the field program.

1.1 Tank construction and instrumentation

PK was excavated in 2012 from a transect immediately adjacent to the *in situ* PKC field study area. The PK was excavated near-dam, midway between the dam and the pond, and adjacent to the pond. The three different locations permit study of coarse-, intermediate-, and finer-grained FPK caused by gravimetric segregation during perimeter slurry discharge.

Tanks are 1.7 m high and 2 m in diameter. One tank was filled with coarse FPK (CT), one with intermediate FPK (MT), and one with finer-grained FPK (FT). A fourth tank was filled with the coarser FPK and covered with 0.3 m of Type I crush (CCT) and plumbed to establish a water table 0.7 m from the bottom to evaluate the influence of a Type I cover and a water column.

Each tank was instrumented with thermistors, gas sampling lines (for O_2 and CO_2), soil water solution samplers (SWSS), moisture content and electrical conductivity sensors (ECH$_2$O probes), and tensiometers. Piezometers were installed below the water table in CCT (with the Type I cover), as was a vertical stand pipe well. Instrument distributions are presented schematically in Figure 1. A drain at the bottom of each tank directs water to a sample cell for geochemical analyses and a tipping bucket for continuous flow measurements.

Figure 1: As-built instrument distributions (depth in m). Figure on left is for the three tanks with low water tables. Figure on right is for the covered tank with a water level at 0.70 m depth. Blue line indicates the static water level.

Gas lines	ECH2O	Tensio	SWSS	Therm
0.1				0
0.2	0.25	0.25	0.25	0.25
0.3				
0.4				
0.5	0.5	0.5	0.5	0.5
0.7	0.75	0.75		0.75
0.9				
	1.0	1.0	1.0	1.0
1.1				
1.3				1.25
1.5	1.5	1.5	1.5	1.5
				1.65
1.7			1.7	1.7

1.7 m = Bottom of tank

Gas lines	ECH2O	Tensio	SWSS	Piezo	Therm
0.1					0
0.2	0.25	0.25	0.25		0.25
0.3					
0.4					
0.5	0.5	0.5	0.5		0.5
0.7	0.75	0.75			0.75
0.9					
	1.0	1.0	1.0	1.0	1.0
1.1					
1.3					1.25
1.5	1.5	1.5	1.5	1.5	1.5
					1.65
1.7			1.7	1.7	1.7

1.7 m = Bottom of tank

2 2014 Activities

2.1 Training

Sampling during the 2013 field season was conducted by the on-site, university-based Test Piles researchers. The Test Piles researchers agreed to conduct the sampling and data collection because the instrumentation and procedures are very similar to those of the Test Piles project and because the tanks were very near the Test Piles sampling locations. Because of the large research team, changing test piles schedule and that the PK tanks were not the focus of the research group, sampling, data collection and data reporting were inefficient.

For 2014 it was decided jointly with DDMI that the Environment group would become responsible for the sampling and data collection. In June 2014, Lianna Smith, Mike Moncur and members of the Test Piles research group trained on-site Environment technicians in sampling and data-downloading techniques, following standard operating procedures (SOPs). Test Piles researchers trained the remaining Environment technicians when they arrived on-site.

2.2 Sample and data collection

Geochemical sampling

Drains from the PK tanks were checked weekly and sampled when water was present in the geochemical sampling cells. SWSS sampling was conducted monthly and samples were collected when water was present. Water samples were analyzed for field parameters (pH, Eh, alkalinity, sulfide, phosphate), anions and dissolved metals.

Gas sampling

Gas sampling was conducted monthly using the Test Piles gas analyser. In September 2014, sampling using syringes and analysis by gas chromatography (GC) was conducted as a check because of suspect results from the gas analyser.

Data-logged instruments

Data loggers for thermistors (UltraLoggers), tipping buckets (Data Dolphins), ECH_2O (Em50) and tensiometers (Data Dolphins) were scheduled to be downloaded monthly.

The UltraLogger program is cumbersome and reported results are suspect, likely because of incorrect sensor allocation within the program. The cumbersome program in not intuitive and errors can easily occur during downloading and programming. It is expected the existing data can be corrected and compared to temperature data measured by the ECH_2O probes.

The Data Dolphin logger connected to the tipping buckets is performing well and producing reliable data.

The Em50 loggers connected to the ECH_2O probes are performing well, have a long battery life and are very user-friendly.

The batteries in the Data Dolphins connected to the tensiometers drained very quickly, suggesting a wiring short. The loggers were re-wired in September 2014 but the short was not corrected. Due to the charge loss in the batteries, little tensiometer data was obtained during 2014. Fixing the wiring/data loggers for the tensiometers should be a priority for the 2015 field season.

3 Results to date

3.1 Bulk geochemistry (drain)

Drainage geochemistry for available effluent quality criteria (EQC) parameters, field parameters and selected metals are provided in Appendix A. Also included are the precipitation data and cumulative flow data to illustrate the low water volume that passed through the tank and, thus, the paucity of drain samples. Anion and dissolved metals results for samples collected after July 2014 were not yet available. It should be noted that tubing from the sample cell to the tipping bucket was not in place in three of the PK tanks during an inspection in late August 2014. This misalignment may have caused flow data to be lost, and, possibly geochemical samples (due to siphoning).

The pH remained circumneutral and alkalinity remained measurable and typically >30 mg L^{-1} (as CaCO3), consistent with results from the PKC *in situ* sampling. Sulfate [SO_4] concentrations were similar and elevated (>4000 mg L^{-1}) in the MT, CT and CCT tanks, whereas SO_4 concentrations in the FT tank were lower (2500 – 3000 mg L^{-1}).

Of the EQC metals, nickel [Ni] remained elevated in all tanks, as expected based on the *in situ* PKC sampling and SNP sampling for the PKC pond. Zinc [Zn], copper [Cu] and cadmium [Cd] were elevated at times. Of the non-EQC metals, magnesium [Mg], molybdenum [Mo] and manganese [Mn] were elevated, consistent with PKC *in situ* experiments and PKC pond measurements. Uranium [U] was elevated in a single sample in the vertical stand-pipe well in the CCT tank, likely influenced by the overlying Type I crush material.

3.2 Geochemistry profiles (SWSS)

Profiles from the FT, MT and CT tanks of EQC parameters, field parameters and selected metals concentrations measured from SWSS are provided in Appendix B. It is important to note that these samples are point samples and scaling calculations are required for a full interpretation and comparison to drain geochemistry. Profiles could not be constructed for the CCT tank because the SWSS did not yield samples. Samples from below the water table were obtained in September, 2014 but results were not yet available.

Of the EQC metals, Ni was elevated in all tanks at all depths for each sample period, as expected based on the *in situ* PKC sampling and SNP sampling for the PKC pond. Zinc, Cu and Cd were elevated at times and/or shallow depths. Of the non-EQC metals, Mg, Mo and Mn were elevated, consistent with PKC *in* situ experiments and PKC pond measurements.

Ammonia [NH_3] and nitrite [NO_2] were typically low, with the exception of occasional increases at depth in the FT and MT tanks, and the 2012 sample profile in the CT tank.

3.3 Gas, moisture content and electrical conductivity profiles

Profiles of gas concentrations (O_2, CO_2 and CH_4), volumetric water content (VMC) and electrical conductivity are provided in Appendix C.

The FT and MT tanks exhibited oxygen depletion with depth for 2012, whereas in 2013 and 2014, O_2 concentrations were near-atmospheric with depth. The CT and CCT tanks had near-atmospheric concentrations at depth for O_2. All 2012 measurements for CO_2 that show 0 vol.%, measured using the Test Piles analyser, are suspect. The 2014 samples, measured by GC show slight depletions (from atmospheric concentrations) at most depths, possibly due to CO_2 sequestration by secondary mineral precipitation. Methane (CH_4) was measured as part of the GC analyses conducted in September 2014. All tanks show increases CH_4 compared to the atmospheric methane concentration of approximately 0.00022 vol. %. Methane analysis is not available using the Test Piles analyser.

VMC was typically higher in 2012 than in 2013 but varied with depth. The similar peaks and trends between sample years suggest the changes in VMC are not due to sample timing (e.g. during a particularly dry or wet time) and may suggest compositional differences by depths that affect wetting front propagation. Similarly, electrical conductivity (EC) values were higher in 2012 than in 2013 with similar trends between years.

4 Conclusions and recommendations

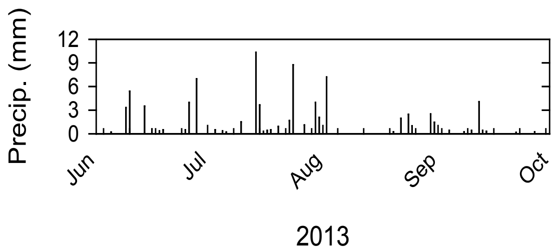
On-going monitoring and sampling from the PK tanks will provide valuable data about the geochemical evolution of FPK that cannot be obtained by only sampling the PKC *in situ*. Unlike in the PKC where ongoing slurry deposition periodically covers subaerially exposed FPK, the PK tanks will remain exposed to the atmosphere and provide an opportunity for continuous monitoring. With additional time-series and profile data, metal and anion loads can be calculated and long-term seepage quality can be predicted with greater confidence.

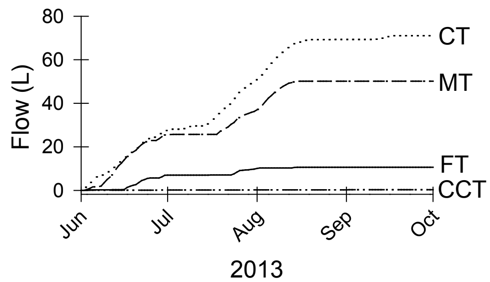
For the 2015 field season we recommend:

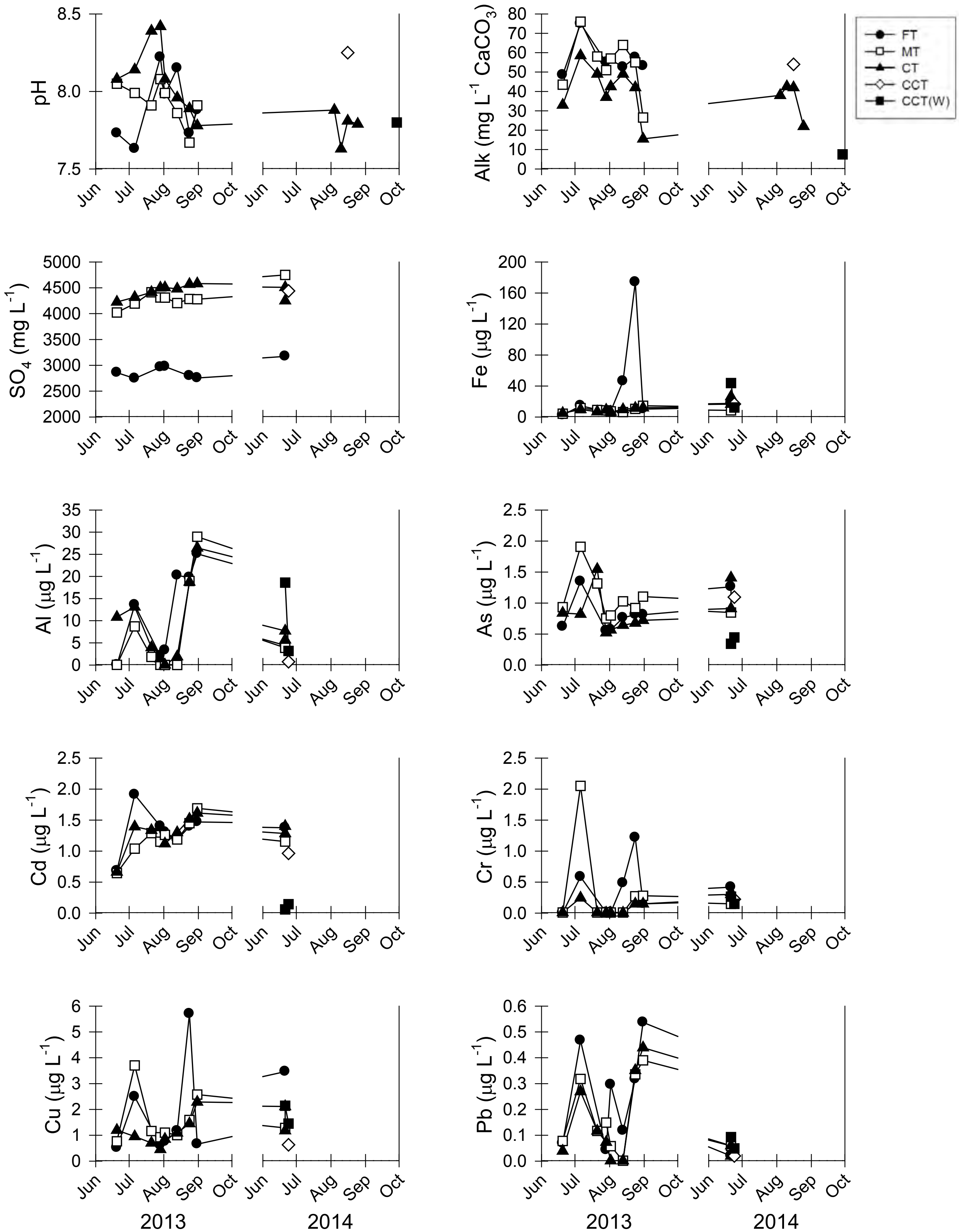
- Trouble-shoot tensiometer wiring and data storage (to permit recharge calculations);
- Determine the cost and feasibility of replacing the Ultraloggers for thermistor logging with Data Dolphins for more consistent and easier data downloading and management;
- Collect gas samples using syringes and analyze samples using Gas Chromatography (cost to be determined) rather than the Test Piles gas analyzer;
- Additional/refresher training for the Environment technicians and co-op students at the beginning of the field season (early June) for year-to-year consistency;
- Request continued on-site assistance from the Test Piles researchers for trouble-shooting;
- Speciation modeling of water geochemistry to aid in understanding the mineral phases that may be controlling dissolved metals and sulfate concentrations.

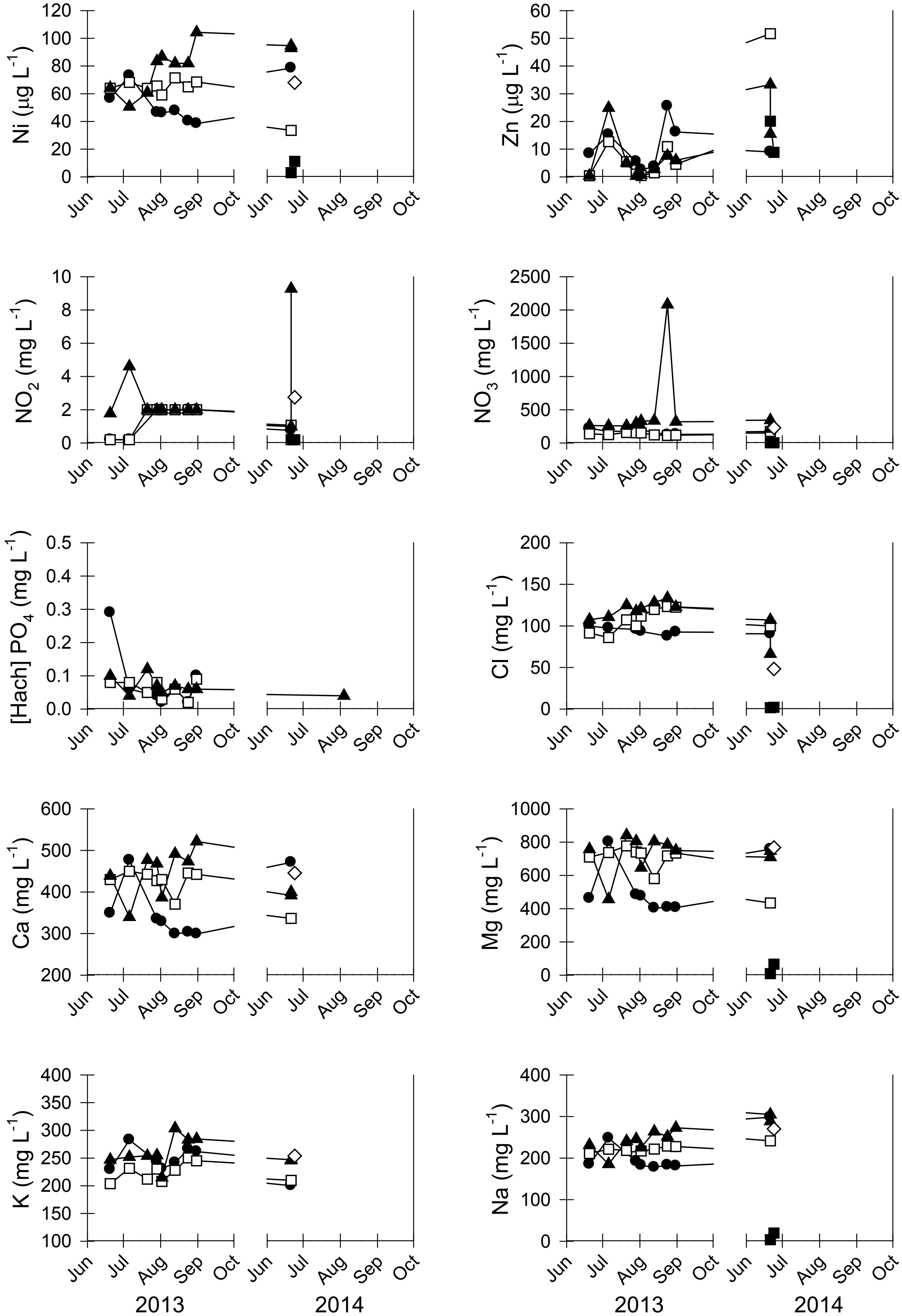
Appendix A – Drain geochemistry and flow

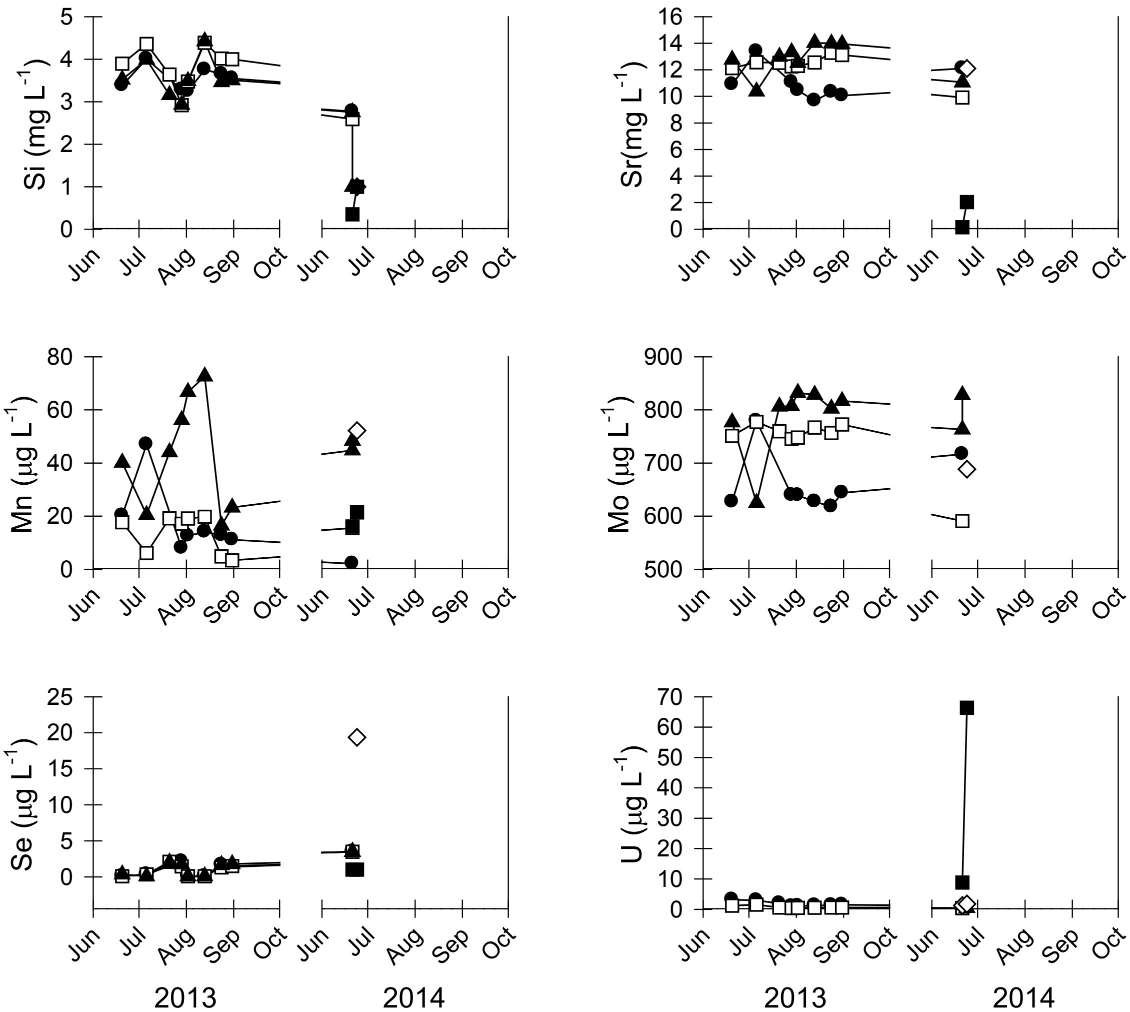
The figure on the left illustrates the precipitation at the site in mm during the 2013 field season and the figure on the left illustrates the cumulative flow in litres from the drains of each tank.



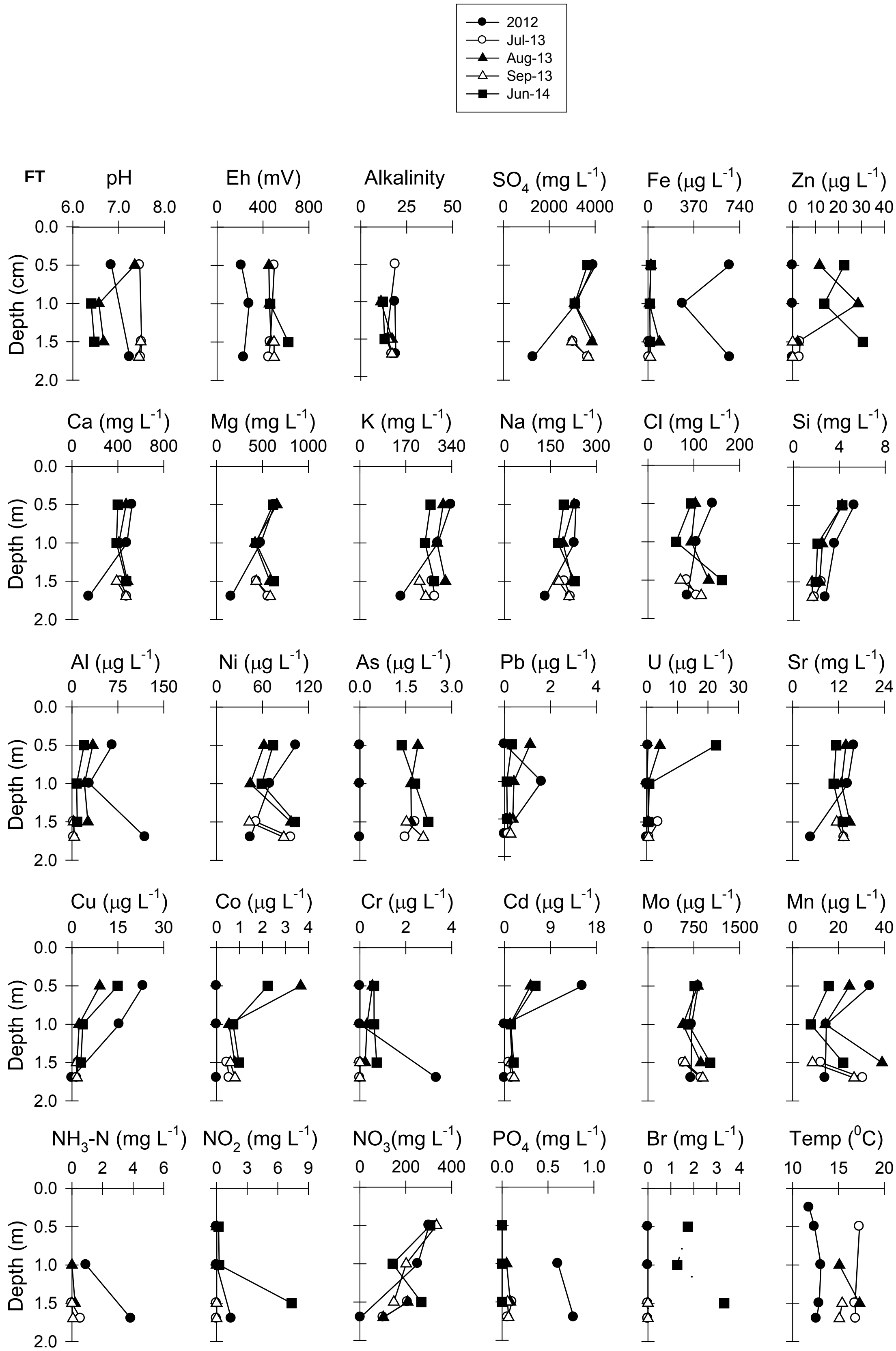


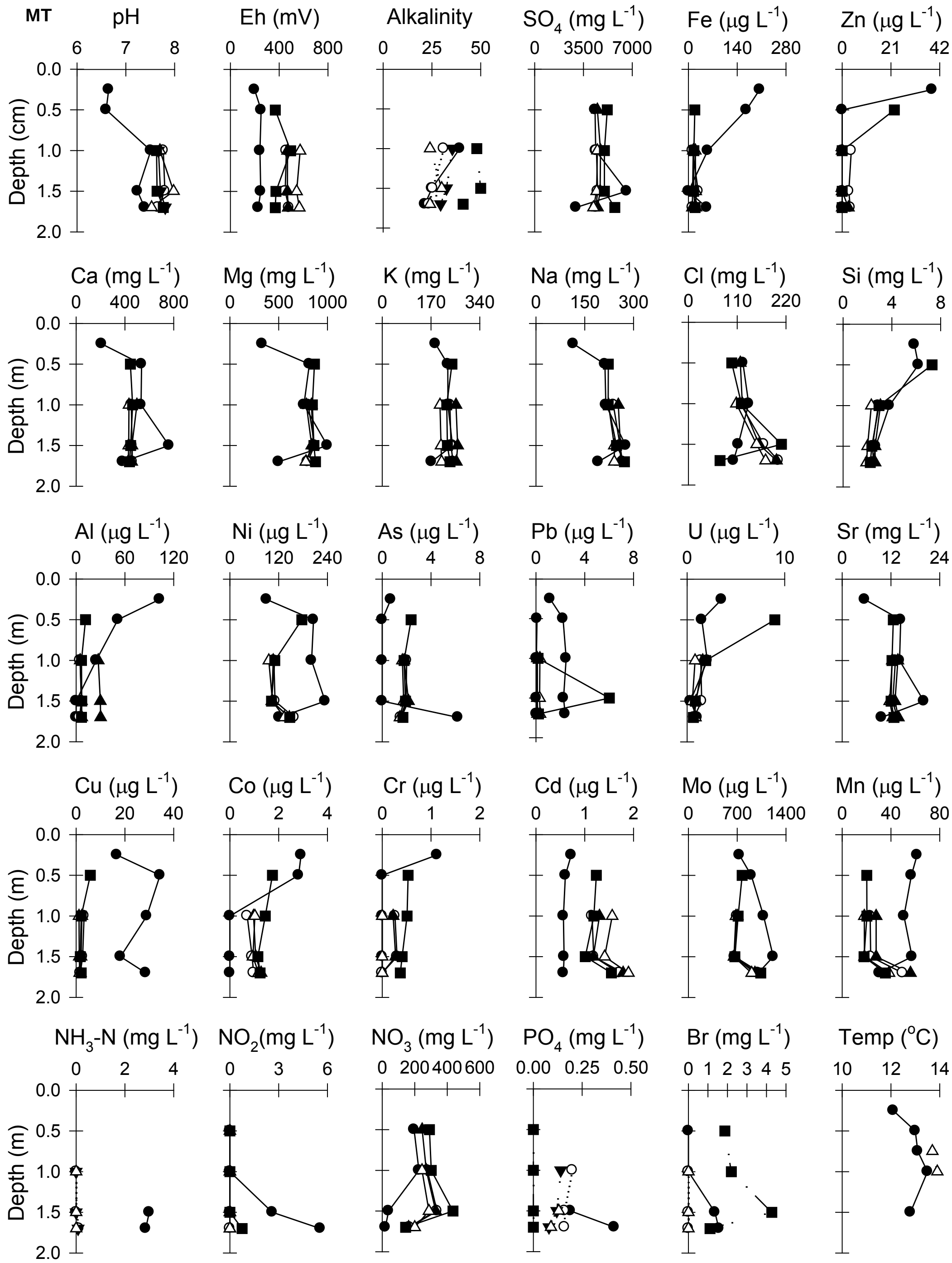

pH
Alk (mg L-1 CaCO3)
FT
MT
CT
CCT
CCT(W)
SO4 (mg L-1)
Fe (µg L-1)
Al (µg L-1)
As (µg L-1)
Cd (µg L-1)
Cr (µg L-1)
Cu (µg L-1)
Pb (µg L-1)
Jun
Jul
Aug
Sep
Oct
2013
2014

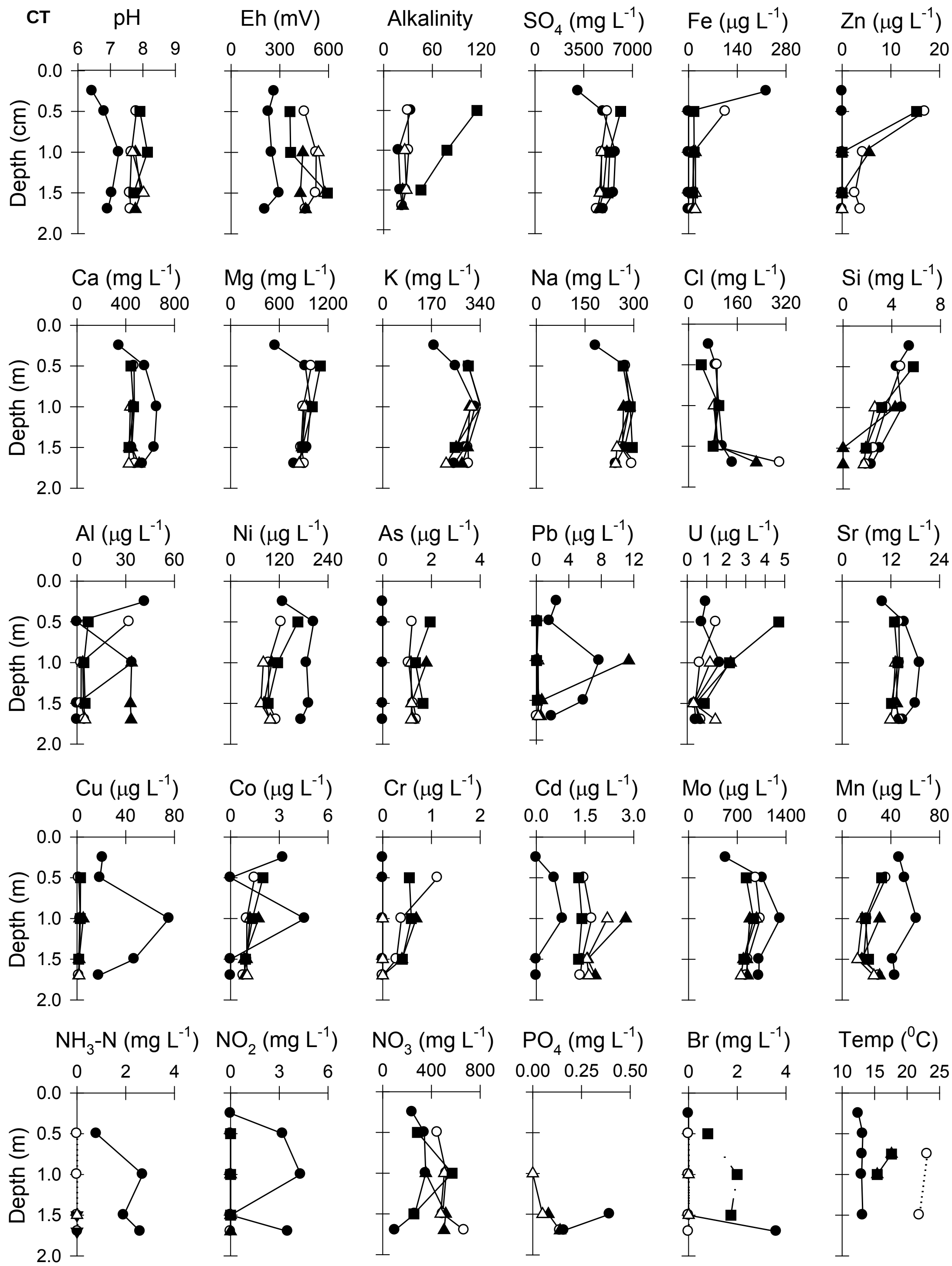

Ni (µg L^{-1})
Zn (µg L^{-1})
NO_2 (mg L^{-1})
NO_3 (mg L^{-1})
[Hach] PO_4 (mg L^{-1})
Cl (mg L^{-1})
Ca (mg L^{-1})
Mg (mg L^{-1})
K (mg L^{-1})
Na (mg L^{-1})
Jun Jul Aug Sep Oct Jun Jul Aug Sep Oct
2013
2014


Si (mg L^{-1})
Sr(mg L^{-1})
Mn (µg L^{-1})
Mo (µg L^{-1})
Se (µg L^{-1})
U (µg L^{-1})
Jun Jul Aug Sep Oct
2013
2014

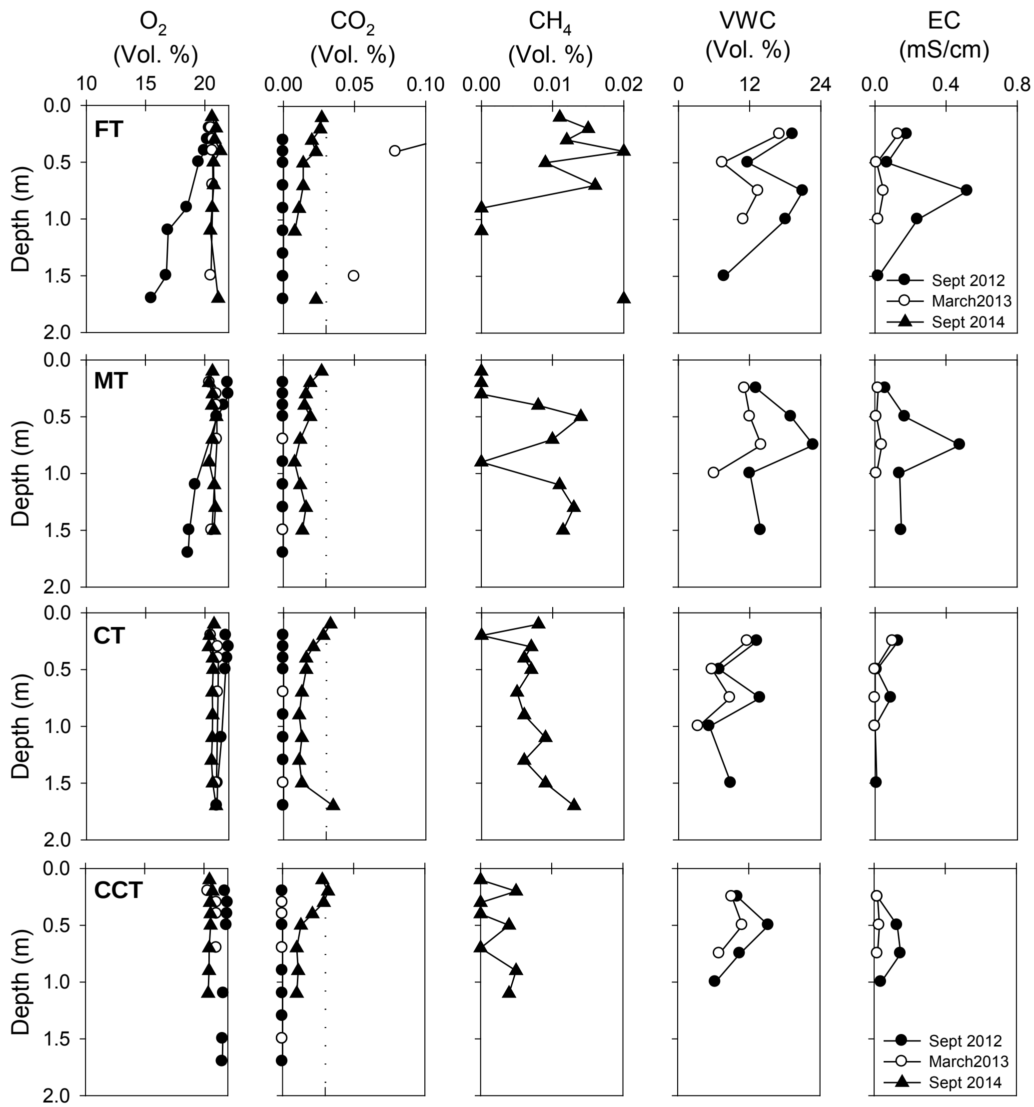
Appendix B – Geochemistry profiles




MT
pH
Eh (mV)
Alkalinity
SO4 (mg L-1)
Fe (μg L-1)
Zn (μg L-1)
Depth (cm)
Ca (mg L-1)
Mg (mg L-1)
K (mg L-1)
Na (mg L-1)
Cl (mg L-1)
Si (mg L-1)
Depth (m)
Al (μg L-1)
Ni (μg L-1)
As (μg L-1)
Pb (μg L-1)
U (μg L-1)
Sr (mg L-1)
Cu (μg L-1)
Co (μg L-1)
Cr (μg L-1)
Cd (μg L-1)
Mo (μg L-1)
Mn (μg L-1)
NH3-N (mg L-1)
NO2(mg L-1)
NO3 (mg L-1)
PO4 (mg L-1)
Br (mg L-1)
Temp (°C)


CT
pH
Eh (mV)
Alkalinity
SO4 (mg L-1)
Fe (µg L-1)
Zn (µg L-1)
Ca (mg L-1)
Mg (mg L-1)
K (mg L-1)
Na (mg L-1)
Cl (mg L-1)
Si (mg L-1)
Al (µg L-1)
Ni (µg L-1)
As (µg L-1)
Pb (µg L-1)
U (µg L-1)
Sr (mg L-1)
Cu (µg L-1)
Co (µg L-1)
Cr (µg L-1)
Cd (µg L-1)
Mo (µg L-1)
Mn (µg L-1)
NH3-N (mg L-1)
NO2 (mg L-1)
NO3 (mg L-1)
PO4 (mg L-1)
Br (mg L-1)
Temp (0C)
Depth (cm)
Depth (m)

Appendix C – Gas, moisture content and electrical conductivity profiles



Appendix II-3

Technical Memorandum – PK Static and Kinetic Tests.

Lianna Smith
Lianna Smith Consulting
55 Fulton Ave
Ottawa, ON K1S 4Y5
t 613.293.4046
e1 lianna.smith@riotinto.com
e2 lianna.smith@outlook.com

Technical Memorandum

To	Gord Macdonald
cc	
From	Lianna Smith (Lianna Smith Consulting)
Reference	PK static and kinetic tests
Date	17 Oct 2014

1 Background

The processed kimberlite (PK) PK static and kinetic tests are part of a complementary field and laboratory program to evaluate the geochemical evolution of fine PK (FPK) over time. The objective of the program is to more confidently predict water quality within and/or discharging from the PKC post-closure.

The laboratory portion of the program includes static tests and kinetic humidity cell tests that were initiated in November 2012. The static tests provide compositional and physical information about the FPK and the humidity cell experiments provide element release rates under controlled conditions. This technical memorandum provides a summary on the laboratory static and kinetic tests.

Samples for the static and kinetic tests were obtained from splits of the PK tank field experiments. For these experiments, the FPK was excavated from a transect immediately adjacent to the *in situ* PKC field study area. To obtain samples along the slurry discharge path, which causes gravimetric separation of the FPK, the FPK samples were excavated near-dam (CT), midway between the dam and the pond (MT), and adjacent to the pond (FT).

2 Static tests

Static tests included acid-base accounting (ABA) by the modified Sobek method, paste pH, sulphate-S, sulfide-S, carbonate NP, whole rock analysis, metals, X-ray diffraction (XRD) with Rietveld semi-quantitative fitting, grain size (sieve) analyses, and specific surface area by the BET method.

SGS in Burnaby, BC was contracted to perform the static testing. The XRD work and BET surface area work were sub-contracted to the University of British Columbia.

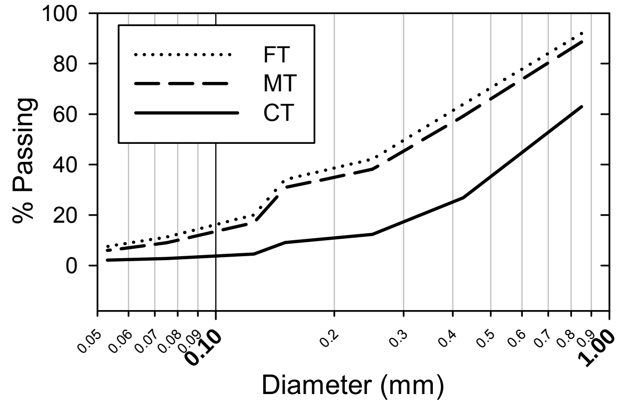
2.1 Grain size analysis

Results from grain size analyses are presented in Figure. The FT and MT fractions of FPK used for the column experiments had similar grain size distributions whereas the CT portion of the FPK was coarser (Table 1 and Figure 1).

Table 1: d10, d60 and uniformity coefficients for FT, MT and CT fractions used in the static and humidity cell tests

Tank ID	d10	d60	Uniformity Coefficient
FT	0.07	0.39	5.8
MT	0.08	0.44	5.3
CT	0.18	0.82	4.6

Figure 1: Grain size distributions for FT, MT and CT fractions used in the static and humidity cell tests.



2.2 Surface area

The surface area of each FT, MT and CT FPK were analysed using the standard BET method (nitrogen adsorption) at the University of British Columbia. The laboratory reported difficulty obtaining representative aliquots from each sample which resulted in variation between aliquots that was higher (Table 2) than is typical for more uniform samples. Repeats of a given aliquot were consistent indicating the measurement techniques was reliable and the laboratory attributed this variation to variation in the surface area of the aliquots. The laboratory observed that the measured surface areas for all samples were higher than expected compared to standard minerals. This incongruity may be due to high microporosity of some of the coarser grains, particularly in the MT samples, contributing more to surface area than the fines. The standard BET method provides total surface area and does not distinguish the surface area contribution from pores.

Table 2: Results from BET surface area analyses. A, B and C represent aliquots of the sample and run 1, 2, 3 indicate repeated runs of the same aliquot.

	FT			MT			CT		
Run	A	B	C	A	B	C	A	B	C
1	24.92	30.59	27.16	29.53	30.02	28.80	14.78	14.20	17.60
2	27.93	30.77	30.39	32.59	33.98	25.16	21.78	15.80	19.99
3	28.08	25.65	27.83	32.47	31.34	35.01	13.89	20.04	18.69

2.3 Acid-Base Accounting

Table 3 provides the results for the ABA tests. Paste pH values were alkaline, and net neutralization potential (NNP) indicate an excess of neutralization potential (NP) over acid-generating potential (AP). NP and NNP values increase with decreasing grain size (CT>MT>FT), but AP values do not. The carbonate portion of NP ($CaCO_3$ NP) represents approximately 25% of the total measured NP. The remaining NP is provided by the abundant olivine and other alumniosilicate minerals in the FPK.

Table 3: ABA test results. Under Fizz Test, "Mod." is "moderate".

Sample ID	Paste pH	TIC %	$CaCO_3$ NP	S(T) %	$S(SO_4)$ %	$S(S^{-2})$ %	AP	NP	NNP	Fizz Test
PKC-FT	8.49	0.69	57.5	0.23	0.06	0.17	5.3	218.4	213.1	Mod.
PKC-MT	8.31	0.59	49.2	0.34	0.09	0.25	7.8	203.1	195.3	Mod.
PKC-CT	8.52	0.47	39.2	0.26	0.05	0.21	6.6	165.3	158.7	Mod.
Duplicates										
PKC-FT				0.22						
PKC-MT	8.30	0.59						216.0		Mod.
PKC-CT					0.05					

2.4 Whole rock and metals analyses

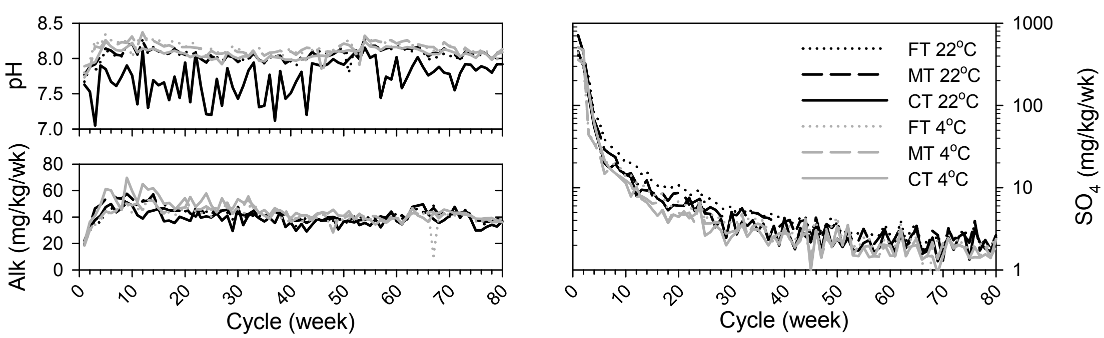
Whole rock analysis was conducted by lithium metaborate fusion with ICP finish. Metals analysis on the solid samples was conducted by aqua regia digestion with ICP-MS finish. These data were used to calculate the proportion of remaining constituents in the humidity cell experiments.

3 Humidity cell tests

Humidity cell test provide element release rates over time rather than expected concentrations. The humidity cell tests consisted of two sets of three cells each. One set consisted of FT, MT and CT FPK operated at room temperature (~22°C) and the second set consisted of the three FPK fractions operated in a cold room (~4°C). The purpose of the cold cells was to observe differences in release rates at colder temperatures more representative of the Diavik climate. The humidity cell test followed the standard ASTM5744-07, with the exceptions that samples were not crushed and one set of cells were operated in a cold room. Results from both sets of humidity cell experiments should be used in any scaling calculations.

3.1 pH, alkalinity and sulfate

Figure 2: pH, and release rates for alkalinity and sulfate [SO_4] for the 80 week humidity cell experiments.



The pH in all cells remained circumneutral to alkaline for duration of the experiment. The cells in the cold room consistently exhibited higher pH compared to the corresponding cells at room temperature. The CT cell at room temperature exhibited lower pH and erratic fluctuations (Figure 2). Alkalinity release rates remained high and relatively stable, with the exception of the first 4 weeks when products were being flushed from the cells (Figure 2).

Sulfate [SO_4] release rates were slightly higher for room temperature cells than for the cold room cells, and in descending order at both temperatures, FT, MT and CT (Figure 2). Data from the first 3-4 weeks represent flushing of accumulated reaction products. Release rates from week 4 – 24 declined rapidly, and then declined at a more moderate rate from week 24-55. Sulfate release rates become more stable after week 55 until the end of the experiment at week 80 (Figure 2). Mass balance calculations suggest 77-85% of total sulfur and 73-81% of sulfide-sulfur remained in the cells after the 80 week experiment (Table 4). However, the decreasing release rates suggest available sulfide surfaces are becoming limited by a reduction of available free grains, sulfide armoring and/or secondary mineral precipitation.

3.2 EQC parameters

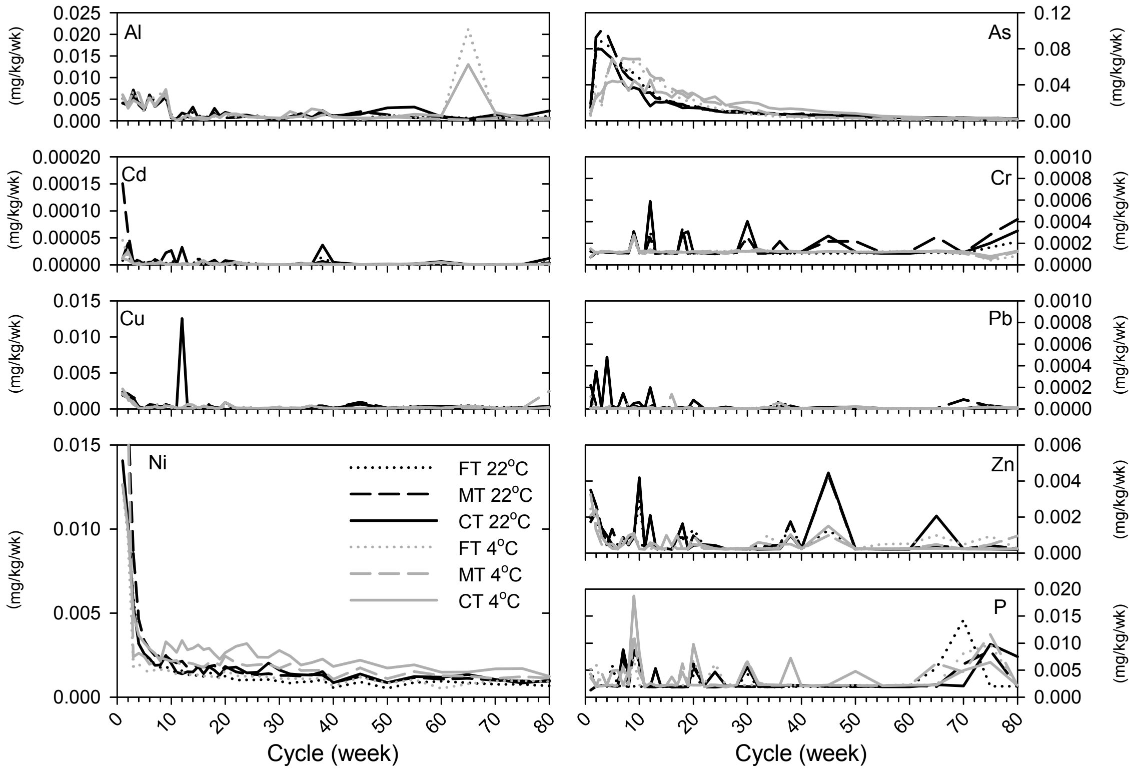
Of the effluent quality criteria (EQC) parameters in place for DDMI operations, arsenic [As], nickel [Ni] and zinc [Zn] (at early time) exhibit release rate trends (Figure 3). The concentration of other parameters in the humidity cell effluent fluctuated very near to the method detection limit, causing the "spikiness" illustrated in Figure 3. Relative release rates for Ni are opposite to those of SO_4 and somewhat counterintuitive with CT>MT>FT and cold room cells greater than room temperature cells. Ni release rates exhibit a fast decrease (flushing), followed by a more subdued release rate. Arsenic showed an initial increase release rates in all cells followed by decreasing rates and stabilization after week 55 to the end of the experiment. The As rates in the room temperature cells increase at a faster rate than the cold room cells, reaching maxima at earlier time. The As in the room temperature cells then decrease at a faster rate than the cold room cells. All cells stabilize at week 55. Zinc appears to decrease rapidly in early time (flushing) and stabilize before week 10, however after week 10 concentrations are very near the method detection limit.

Table 4 summarizes the calculated fraction remaining in the column cells after the 80 week experiment for the EQC parameters. It is important to note that sulfide armoring and/or secondary mineral precipitation likely inhibits metal releases for some elements, as evident in the reducing and stabilizing reaction rates.

Table 4: Calculated fraction of constituents remaining at 80 weeks

Sample ID	Total S	S^{2-}	CO_3 NP	Al	As	Cd	Cr	Cu	Ni	Pb	Zn	P
FT (22°C)	0.77	0.68	1.00	1.00	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MT (22°C)	0.82	0.75	1.00	1.00	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CT (22°C)	0.83	0.79	1.00	1.00	0.73	1.00	1.00	1.00	1.00	1.00	1.00	1.00
FT (4°C)	0.82	0.76	1.00	1.00	0.69	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MT (4°C)	0.82	0.78	1.00	1.00	0.65	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CT (4°C)	0.85	0.81	1.00	1.00	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Figure 3: Release rates for the aluminum [Al], arsenic [As], cadmium [Cd], chromium [Cr], copper [Cu], lead [Pb], nickel [Ni], zinc [Zn] an phosphorus [P]



3.3 Metals

Release rates for other metals of interested, including cobalt [Co], iron [Fe], manganese [Mn], selenium [Se], strontium [Sr], molybdenum [Mo] and uranium [U], are provided in Figure 4. Similar to some of the EQC metals, the "spikiness" illustrated for Fe is caused by concentrations being very near the method detection limit. The "spikiness" of Co and U trends cannot be attributed to artefacts of concentrations near the method detection limit. The greatest sudden increases for both Co and U were observed in the CT room temperature cell, the same cell that exhibited erratic pH trends. These erratic patterns may be caused by occasional preferential flow paths for oxygen and/or water that affects mineral weathering and flushing.

Selenium release rates declined rapidly during the first 4 week flush, and then more gradually decreased in before stabilizing at week 30. Both Sr and Mn exhibited rapid declines in reaction rates until week 4 and relatively stable rates thereafter. The release rates for Mo exhibited exponential decay with rates stabilizing at week 55. Release rates for Se, Mn and Mo were higher in the room temperature cells compared to the cold room cells and typically FT>MT>CT at both temperatures. Sr release rates in all cells were very similar to the Mn trends.

The calculated fraction remaining for Co, Fe, Mn, Sr, Mo and U are provided in Table 5. The fraction of remaining Se could not be calculated because metals analysis of the solid samples reported values below the detection limit.

Figure 4: Release rates for the selected metals cobalt [Co], iron [Fe], manganese [Mn], selenium [Se], strontium [Sr], molybdenum [Mo] and uranium [U].

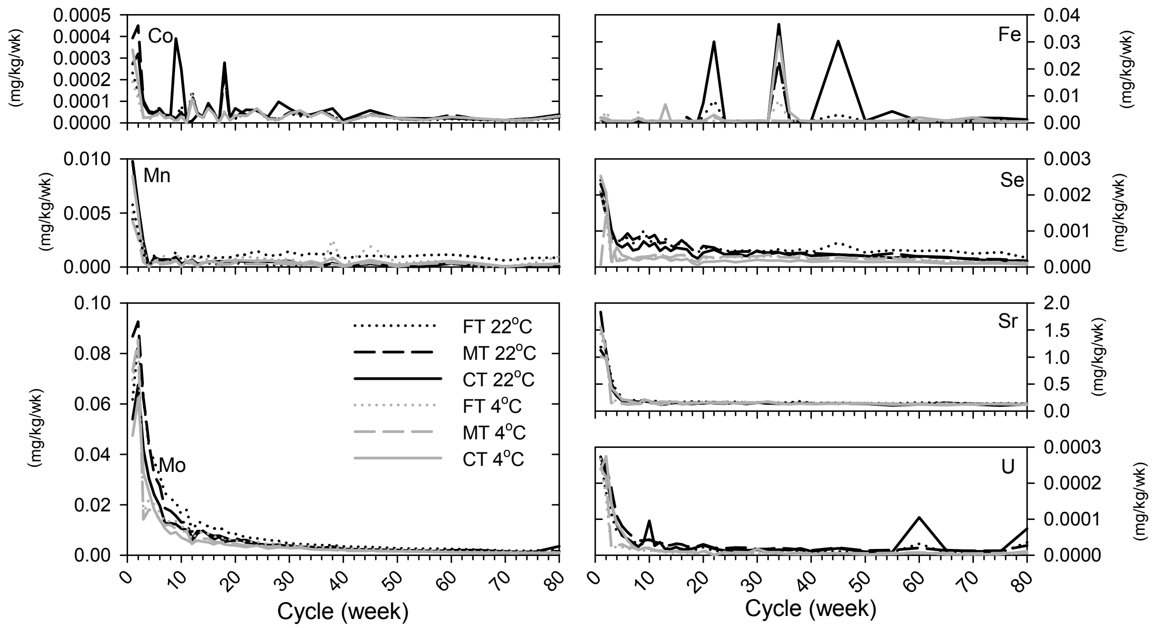


Table 5: Calculated fraction of constituents remaining at 80 weeks

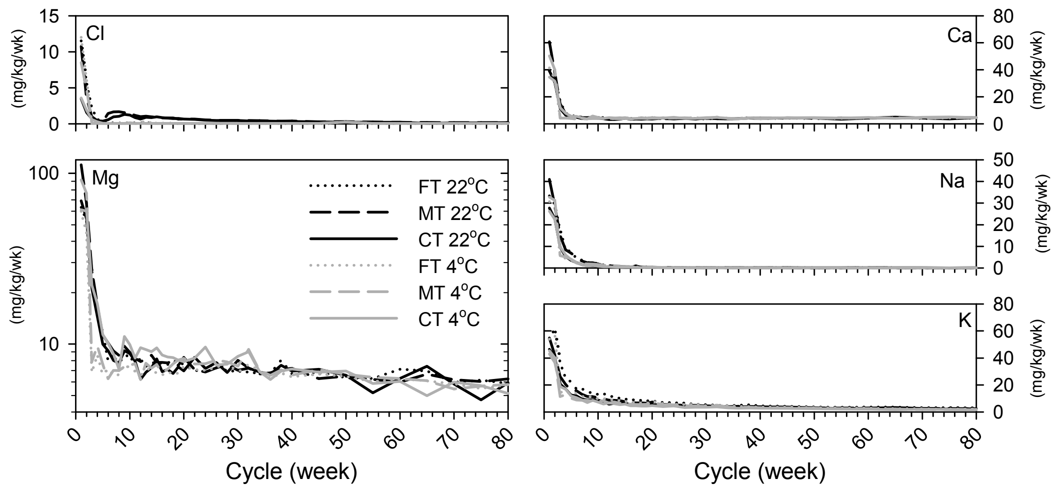
Sample ID	Co	Fe	Mn	Mo	Sr	U
FT (22°C)	1.00	0.99	1.00	0.81	0.96	1.00
MT (22°C)	1.00	0.99	1.00	0.69	0.97	1.00
CT (22°C)	1.00	0.97	1.00	0.76	0.97	1.00
FT (4°C)	1.00	0.99	1.00	0.77	0.98	1.00
MT (4°C)	1.00	0.99	1.00	0.79	0.98	1.00
CT (4°C)	1.00	0.99	1.00	0.81	0.96	1.00

3.4 Major ions

Release rates for the major ions are presented in Figure 5. The release rate trends for Cl, Ca, Na and K are similar, exhibiting a rapid decline and early-time stabilization. There is little variation between size fractions or temperatures. Release rate trends for Mg are similar to those for Ni that shows a rapid initial decrease followed by more subdued rates, and release rates from cold room cells greater than from room temperature cells. Both Mg and Ni are being released from forsterite [olivine, Mg_2SiO_4], which contains sub-percentage quantities of Ni.

Fractions of 1.00 remain for the major ions. Magnesium concentrations in the solids were above the detection limit.

Figure 5: Release rates for the major ions chloride [Cl], calcium [Ca], magnesium [Mg], sodium [Na] and potassium [K]



4 Conclusions

The results from the static and kinetic tests conducted for the FPK material provide data required for PKC seepage prediction calculations. Data from the PKC field study and PK tank experiments will allow for more rigorous scale-up calculations.

Rio Tinto

Appendix II-4

Reclamation of Disturbed Sites in the North – Implications for Diamond Mines – A Literature Review.

RECLAMATION OF DISTURBED SITES IN THE NORTH

IMPLICATIONS FOR DIAMOND MINES

A LITERATURE REVIEW

Prepared By

Dr M Anne Naeth

Ms Valerie Miller

Ms Sarah Ficko

Ms Jasmine Lamarre

Ms Sarah Wilkinson

Department of Renewable Resources

University of Alberta

Prepared For

Diavik Diamond Mine Inc

Yellowknife, Northwest Territories

October 2014

TABLE OF CONTENTS

1. INTRODUCTION

Mining in the Canadian north increased dramatically in the last two decades and is expected to double by 2020 according to the Conference Board of Canada's Centre for the North (Rhéaume and Caron-Vuotari 2013). Much growth of the industry in the past 20 years is due to the discovery of diamonds in 1991 in the Northwest Territories (Baker et al. 2001; Bryan and Donner 2003). Exploration of East Island in Lac de Gras commenced in 1992 and construction of Diavik Diamond Mine began in 2000. Today there are five active diamond mines in the Canadian north and Canada is the third largest producer of diamonds in the world. Diavik is Canada's largest diamond mine, producing over 50 million carats of rough diamonds as of 2008 (Diavik Diamond Mine 2010a). While infrastructure and skilled labour are key issues to address to support continued growth of this mining sector, greater discussion on environmental stewardship, in particular long term impacts of mining on the flora and fauna, have also been identified as essential to mining success (Rhéaume and Caron-Vuotari 2013). As a pioneer in the diamond industry in Canada, Diavik has the challenge to successfully reclaim mining disturbances to conditions resembling the pre-mine environment and the opportunity to develop innovative, cost effective and environmentally sustainable methods to achieve this goal.

Diamond mining produces physical disturbances on the landscape and large amounts of waste materials as diamonds can be economically mined at less than 1 carat (200 mg) per tonne of kimberlite ore (Baker et al. 2001; Stevens 2006; Drozdowski et al. 2012). Common disturbances at diamond mines include roads, gravel and concrete pads, processed kimberlite containment facilities, waste rock and overburden stockpiles and mine pits and underground mines (BHP Diamonds 1995a; Drozdowski et al. 2012). Waste materials include processed kimberlite, lake sediment, glacial till and rock. Kimberlites are complex and geochemically variable, hybrid, ultrabasic, intrusive, volcanic like rocks that typically contain xenocrysts and megacrysts (predominantly olivine) in a fine grained matrix of olivine, serpentine, carbonate and other minerals (Baker et al. 2001). Blasting results in waste rock, glacial till and lake sediment. The chemistry of waste rock and till is dependent on glacial history and bedrock in the region. Physical properties of processed kimberlite, waste rock and till are also dependent on the mining process. Currently these materials are stockpiled with anticipation of future use for construction or use in reclamation upon mine closure.

Reclamation depends on creation of a suitable substrate with adequate physical and chemical properties for plant establishment and growth and development of plant materials able to grow and reproduce in the challenging conditions (Kidd and Rossow 1998; Kidd and Max 2000a). Reclamation research in the north over the past 30 years has primarily focused on soil and plant community development following oil and gas and transportation corridor disturbances (e.g. Kershaw and Kershaw 1980; Johnson 1987; Jorgensen and Royce 1994; Forbes and Jefferies 1999; Forbes et al. 2001). Among industries, disturbances caused by infrastructure and transportation corridors are similar. However, each industry has its unique waste products that determine which reclamation methods are most appropriate to achieve end land use goals and relative ease of reclamation. With another 20 years of mining forecasted at Diavik, and similar disturbances across the north, development of effective reclamation practices is essential (Rausch and Kershaw 2007; Diavik Diamond Mine 2010; Natural Resources Canada 2011).

Disturbances in the arctic and subarctic (the north) tend to be long lasting and difficult to reclaim due to the harsh climate and physical environment. The growing season is short with few warm days, frequent cold temperatures and frost (BHP Diamonds 1995a; Kidd and Rossow 1998; ABR 2001; Rausch and Kershaw 2007; Diavik Diamond Mine 2010b; Ecosystem Classification Group 2012). High winds can abrade plants, desiccate soils and influence soil temperature, litter accumulation and snow cover (Crawford 1989; Anderson and Bliss 1998; Zhelezona et al. 2005). Permafrost is continuous and influences water movement, nutrient cycling, microbial activity and vegetation development (Crawford 1989; Ecosystem Classification Group 2012). Low temperatures slow decomposition from reduced microbial activity, which slows nutrient cycling and plant establishment and growth (Crawford 1989; BHP Diamonds 1995a; Kidd and Rossow 1998; ABR 2001; Deshaies et al. 2009). Precipitation in the arctic is limited due to a high pressure zone (Crawford 1989) and plant water stress causes reduced germination, seedling mortality and reduced availability of water transported nutrients (Bell and Bliss 1980; Jorgenson and Joyce 1994; Ostendorf and Reynolds 1998; Jumpponen et al. 1999; Drozdowski et al. 2012). Nitrogen tends to be the limiting nutrient and phosphorus is very low (Crawford 1989; ABR 2001; Martens 2003; Drozdowski et al. 2012). In the north, soil layers are thin with little organic matter or nutrients (BHP Diamonds 1995). Plant diversity is low, with only 1,000 vascular species (0.4 % of the global total) adapted to life above the treeline (Billings 1987). Plants tend to produce little viable seed on irregular schedules, grow through vegetative methods and have limited dispersal of plant propagules (Bliss 1962; Bishop and Chapin III 1989a; Crawford 1989; Kidd and Rossow 1998; Forbes and Jefferies 1999; ABR 2001).

Natural recovery of disturbed sites can take decades to hundreds of years due to the harsh climate and limited plant diversity, colonization and reproduction (Jorgenson and Joyce 1994;

Kidd and Rossow 1997; Densmore et al. 2000; Rausch and Kershaw 2007; Deshaies et al. 2009; Naeth and Wilkinson 2011). Forbes and Jefferies (1999) suggest that secondary succession requires 100 to 1000 years on dry tundra and 10 to 30 years on wet habitats. Secondary succession on tundra oil field pads in Alaska required 20 to 25 years (McKendrick 1997). While productivity recovers, species composition will not be similar to predisturbance for 50 to 100 years (Cargill and Chapin III 1987). There are, however, few natural recovery studies on sites greater than 5 years of age (Kershaw and Kershaw 1987).

Human disturbances introduce greater challenges through removal of shallow soil, compaction, alteration of nutrient and hydrologic cycling and differences in soil temperature (Cargill and Chapin III 1987; Forbes and Jefferies 1999). Mine substrates can resemble those exposed during glacial retreat and revegetation of gravel pads and other mine disturbances resembles primary succession which lacks any kind of plant source material (Kwiatkowski 2007). During the early stages of primary succession, plant establishment and growth are mainly controlled by abiotic conditions due to limited soil, nutrients, water and organic matter (Jumpponen et al. 1999; Mori et al. 2008). To be effective reclamation methods for human disturbances in the north must consider the harsh environmental conditions.

2. OBJECTIVES AND METHODS

The purpose of this report is to provide a review of available literature on reclamation of disturbed lands in northern regions (arctic, subarctic) and to critically asses these studies to identify what can be concluded about best methods to reclaim diamond mines in the Canadian north and where gaps in knowledge exist.

University and government library databases were searched and industry representatives contacted, where possible. Documents reviewed included peer reviewed scientific papers, conference proceedings, graduate student theses and dissertations and technical, government and industry reports. Reference lists found in procured documents were utilized to further expand the search. The primary focus was on the Canadian north and disturbances that would result in similar conditions as those found on diamond mines. However, due to the limited amount of literature in these areas, the search was expanded to northern regions of the world including Alaska, Russia and Scandinavia as they have produced more reclamation literature. Relevance of findings to the conditions found in the Canadian north and on diamond mines is clearly demonstrated.

Plant nomenclature follows Porslid and Cody (1980) and Cody (2000). Lichen nomenclature follows Brodo et al. (2001) and mosses Crum (1983). Scientific names are used throughout the document, with common names provided following the first occurrence in the document. If scientific names were not included in documents, there is low confidence in species referred to by common name.

The report is structured to address the key components of reclamation, namely soil reclamation and revegetation. A hospitable growth medium for plants is first required to facilitate plant colonization, establishment and growth. Available materials, their known benefits and challenges and the range of soil amendments to further enhance reclamation substrates are discussed. The section on revegetation addresses selection of appropriate plant and lichen species and propagation methods and timing for specific substrates. Section five provides an analysis of what is known, where the gaps are and what research would help address the gaps regarding knowledge of successful reclamation of diamond mines in the north.

3. SOIL RECLAMATION

Development of a suitable substrate is one of the most important steps in reclamation of disturbed sites in the north to support long term growth of seeded and naturally colonizing species (Johnson 1987). In most disturbances the natural soil layer has been removed, leaving a gravel or till substrate. Left unaddressed, soil may never develop as it relies on establishment of plants and a biological crust. Without soil, few plants are likely to establish and if they do so will be in low abundance and the disturbance persists (Harper and Kershaw 1996). As soil develops so does the soil microbial environment, this in turn facilitates further establishment of plant species and results in continued concomitant changes in the soil and plant communities.

Soil development is limited by low temperatures. Cryosols are most common, with some regosols and brunisols (Johnson 1987; Deshaies et al. 2009; Diavik Diamond Mine 2010b; Ecosystem Classification Group 2012). Cryosols are permafrost affected soils (Matheus and Omtzigt 2012). Turbic cryosols are mineral soils affected by frost churning which creates patterned ground; static cryosols have no frost churning; organic cryosols are found in peatlands with permafrost below. Permafrost limits trees and deep rooting species through restricted rooting depth of soil. Depth of the active layer is 30 to 40 cm in organic soils and over 2 m in coarse soils (Martens 2000).

When natural soil is lacking following disturbance, anthroposols must be created. Anthroposols are azonal soils which are highly modified or created to replace natural soil (Naeth et al. 2012). They result from human disturbance and are often formed using anthropogenic materials such as mine spoil, peat mineral soil mixes, phosphogypsum and fill. For successful soil reclamation, the anthroposol must support plants in the short and long term.

Selection of the appropriate substrates and amendments to create anthroposols in the north is based on many factors including cost and availability. Due to the remote location of diamond mines and seasonal road access, use of on site materials is a priority to reduce disposal costs. The primary by products of diamond mining are processed kimberlite, glacial till, lake sediment, gravel, waste rock, salvaged soil and sewage sludge.

In the north, most nutrients available for plants are present in organic matter (Johnson 1987). Organic matter is essential in developing self sustaining plant communities as it increases water and nutrient holding capacity and cation exchange capacity, improves soil texture, pH and electrical conductivity and is food for soil microorganisms (ABR 2001; Drozdowski et al. 2012). Similarly, increasing soil carbon, through amendment with materials such as biochar, straw and wood chips, can increase nutrients due to greater cation exchange capacity and improve soil properties such as texture, pH and electrical conductivity (Naeth and Wilkinson 2010).

3.1 Substrates

At diamond mines, substrates are the basic growth medium for plants on sites where natural soil no longer exists and comprises the largest volume of the anthroposol. The reclamation substrate must support plant establishment and development and speed the rate of recovery (ABR 2001; Reid and Naeth 2005b; Rausch and Kershaw 2007; Diavik Diamond Mine 2010b; Drozdowski et al. 2012).

3.1.1 Processed kimberlite

During separation of diamonds from kimberlite ore, large volumes of processed kimberlite are created (Baker et al. 2001; Drozdowski et al. 2012; Rio Tinto 2013). Processed kimberlite will either need to be used for reclamation or reclaimed itself. Kimberlite is primarily composed of silicon, magnesium and iron with trace elements of various metals like nickel, chromium and zinc and is high in sulphur (Baker et al. 2001; Drozdowski et al. 2012). It has coarse texture, primarily sand, no organic matter, low available nitrogen and phosphorus, basic pH and serpentine chemistry (Kidd and Max 2000a; Martens 2000; Baker et al. 2001; Reid and Naeth 2005a, 2005b; Drozdowski et al. 2012). Serpentine soils tend to be unproductive and have elevated magnesium and metal concentrations (Martens 2000; Martens 2001). The dark colour increases soil temperature and evaporation particularly in tupper surface layers (Miles and Tainton 1979; Drozdowski et al. 2012). Increased soil temperature can improve plant growth and increase temperature sensitive processes such as decomposition, soil respiration and nutrient cycling (Lloyd and Taylor 1994; Kirschbaum 1995; Davidson and Janssen 2006). Increased surface evaporation may inhibit germination.

Due to these characteristics, plant growth on processed kimberlite is restricted. Native grasses and forbs grown in unamended kimberlite have low cover and biomass (Reid and Naeth 2005a, 2005b; Stevens 2006; Drozdowski et al. 2012; Naeth and Wilkinson 2014a). After five growing seasons at Diavik mine, unamended kimberlite applied over a gravel pad had the lowest plant densities (< 10 plants m^{-2}) and plant cover (< 2 %), which declined over with time (Naeth and Wilkinson 2014a). Unamended kimberlite had significantly fewer species present than all other substrates. At Ekati mine, while plants were able to grow in kimberlite, they had lower biomass and there was evidence of metal toxicity (Kidd and Max 2000a; Martens 2001). Inclusion of peat with dewatered kimberlite improved plant response considerably in the first few years, however, by the eighth growing season, plant cover declined in amended kimberlite and cover was similar to that in unamended kimberlite (Martens 2002; Reid and Naeth 2005b; Martens 2007). The decline in cover was likely due to plant roots growing beyond the amended zone of the substrate. Plant cover ranged from 10 to 16 % and nutrients and soluble salts in the kimberlite had stabilized. The research site was part of the processed kimberlite containment area and likely had more mesic conditions relative to the Diavik site. In the greenhouse and field at Victor mine, kimberlite mixes with at least 50 % salvaged soil and a minimum amendment layer depth of 50 cm enhanced plant performance (Stevens 2006).

Differences in kimberlite's physical and chemical properties can affect their potential as a reclamation substrate (Naeth and Wilkinson 2011). Coarse processed kimberlite from Star and Orion mines was a poorer substrate for plants than fine kimberlite and fine kimberlite from the Star mine was a better substrate for plants than from the Orion mine. Differences in sodium adsorption ratio, cation exchange capacity and saturation percentage likely explained the difference between fine kimberlites as their physical structure was similar. Most native grass species had good germination (3 to 88 %) and establishment (20 to 100 %) in unamended kimberlites and with regular watering. *Agropyron trachycaulus* (Link) Malte (slender wheat grass) was one of the best performing species with high germination, establishment, density and biomass along with two non native grasses. Kidd and Max (2000) reported no difference in biomass between fine and coarse processed kimberlite for a mix of seeded native grasses, planted *Salix planifolia* Pursh (diamond leaf willow) cuttings or *Arctophila fulva* (Trin.) Rupr. (arctic pendant grass) sprigs when grown under controlled conditions. Stevens (2006) found no statistically significant difference in root or shoot biomass of three plant species grown in the greenhouse in fine and coarse kimberlites from Victor mine.

Plant uptake of metals from kimberlite is a concern as the substrate contains high concentrations of some metals. Kidd and Max (2000) found that only nickel was taken up by plants in elevated tissue concentrations. Concentrations were below 50 mg kg^{-1} and therefore not of concern for plant growth or bioaccumulation in the food chain. Martens (2004) found elevated concentrations of aluminum, barium, chromium, iron, magnesium, molybdenum and nickel in tissue of transplanted native species. These concentrations exceeded guidelines for maximum dietary intake for cattle, sheep, rabbits or wildlife (USNAS 1980; Outridge and Scheuhammer 1993). Barium, iron and magnesium exceeded these limits in native plants growing in undisturbed sites. This may be more a concern for small herbivores such as arctic hare (*Lepus arcticus*) and sik sik (*Urocitellus parryii*) who remain in a small territory throughout the year relative to caribou (*Rangifer tarandus*) who are nomadic (Martens 2005). Metal concentrations are reduced in substrate and plants when kimberlite is mixed with other substrates or amendments (Martens 2000; Drozdowski et al. 2012).

3.1.2 Gravel and crushed rock

Gravel dominated disturbances are common in the north, from gravel pads, borrow pits and mine spoil (Cargill and Chapin III 1987; Johnson 1987; Rausch and Kershaw 2007). Gravel pads are commonly created to support infrastructure and protect the underlying permafrost (Walker 1996). Gravel is difficult to revegetate due to low organic matter, nutrients and water and nutrient retention (Johnson 1987; Bishop and Chapin III 1989a; Jorgenson and Joyce 1994; Kidd and Max 1995; Forbes and Jefferies 1999; ABR 2001; Kidd et al. 2006). Added nutrients rapidly leach (Kidd and Max 2002; Naeth and Wilkinson 2010; Drozdowski et al. 2012). Gravel can have lower temperatures than other substrates as its coarse texture results in large pores that fill with air rather than water and air is a poor heat conductor (Drozdowski et al. 2012). Xeric conditions negatively affect microbial populations and activity (Kidd and Max 2000a) and the seedbank tends to be limited (Rausch and Kershaw 2007).

Bishop and Chapin III (1989a) assessed 16 gravel pads in Alaska that had mostly been fertilized and seeded with non native grasses at abandonment 8 years prior. Mean total cover was 2.7 %

and mean species richness was 4.6. Poor revegetation was attributed to lack of soil water, low nutrients and dispersal limitations. In another experiment, germination of *Salix alaxensis* (Anderss.) Cov. (felt leaf willow) was low in gravel although it was considerably increased by regular watering or addition of surface stones (up to 4 cm diameter), which provided safe sites (Bishop and Chapin III 1989b). When seedlings of *Salix alaxensis* were planted in gravel, survival rates were high (50 to 85 %) suggesting that gravel provides sufficient water and nutrients for this species once established.

Crushed waste rock from the pits is used at Diavik mine to build pads to support infrastructure and roads. Once crushed, it is similar to gravel in particle distribution. Despite the expectations that crushed rock would be unsuitable for plant growth based on its characteristics, it was effective. Drozdowski et al. (2012) found that unamended crushed rock was one of the best substrates for plant growth after two growing seasons. After five growing seasons, crushed rock still had the highest species richness relative to processed kimberlite alone or in mixes with till, however, plant cover was low (Naeth and Wilkinson 2014a). Crushed rock's coarse texture resulted in a rough surface that may provide important microsites for germination and establishment, by sheltering seed and seedlings from wind and water erosion. Surface soil water content and temperature were lowest in gravel relative to other substrates. Crushed rock does not appear to limit plant establishment but does limit plant growth.

After 5 years of natural recovery of processed placer mine spoil (gravel floodplain), native plant species established but growth was limited by the substrate (Densmore 1994). Twelve shrubs, five grasses and four forbs established but most plants were so small they did not register in plant cover assessments. Even *Salix alexansis,* which establishes readily following disturbance of riparian areas (Kershaw and Kershaw 1987), was not more than 10 cm tall and had less than 1 % cover. Others found similar results on unamended placer spoil in Alaska (Rutherford and Meyer 1981; Durst 1984; Halloran 1986).The highest plant cover was on gravel substrates that had a greater proportion of fine particles (less than sand size) and high stability.

Depth of gravel appears to play an important role in successful revegetation. Plant cover on gravel pads is inversely related to the depth of gravel as it influences uptake of ground water (Walker 1996; OASIS Environmental 2004). Thick gravel pads tend to be restricted to species that are adapted to xeric conditions (Jorgenson and Joyce 1994). Thinner layers of gravel can result in thaw of the permafrost and increased depth of the active layer (Kidd et al. 2006). A deeper active layer can result in a greater rooting zone and nutrient pool. Growth and species diversity tends to be higher on thin fill, likely due to the access to water from ground water

(Jorgenson and Joyce 1994; OASIS Environmental 2004). On gravel fill over 80 cm deep, natural revegetation is extremely limited (Kidd and Max 1995). However, removal of gravel can damage the permafrost and result in permanent flooding of the area.

Gravel pads can be compacted and due to their elevated position plants can be exposed to wind (Walker 1996). Mechanical methods to reduce compaction can disturb the underlying permafrost (Shirazi et al. 1998). Ekati mine investigated methods to reclaim gravel pads in 2010 and included assessment of deep ripping to alleviate compaction. Preliminary results indicate ripping significantly enhanced revegetation success (Martens 2012). Ekati has experimented with reclaiming gravel laydown areas by deep ripping and/or dismantling them and spreading material over the adjacent tundra. Changes in drainage were observed but higher soil water was an advantage for establishing native plants and rock and boulders provided natural microsites to shelter plants (Kidd and Max 2002). After five years native plant cover was less than 20 % with natural recovery higher where soil was exposed between the gravel and rocks (Martens 2007).

3.1.3 Glacial till and lake sediment

Glacial till (unsorted morainal material) and lake sediment are overburden materials removed prior to mining. Large amounts are excavated during construction of underground and pit mines and stockpiled (Rio Tinto 2013). These stockpiles must be used for reclamation or reclaimed themselves. Both substrates have little organic matter (Kidd and Max 2001).

Glacial till and lake sediment are often stockpiled on the same site, sometimes resulting in mixtures of the two materials. Two till-sediment stockpiles at Ekati were fertilized and seeded at a low rate with native grasses. After two years, plant establishment on the sandy silt stockpile (referred to as lake sediment) was poor due to compaction and the area was therefore rototilled and reseeded. Revegetation on the sandy gravel stockpile (referred to as glacial till) was adequate. Rocks in glacial till provided microsites for seedling establishment and areas for water to collect (Martens 2005, 2012). Plant establishment was greater at mid to lower slope positions where soil water was higher. After 9 years, vegetation cover in the glacial till stockpile seeded with native grasses was 24 to 28 % (Martens 2012). Seeded grasses and mosses dominated. The rototilled and reseeded lake sediment stockpile had less cover and patchy distribution but revegetation was good. Glacial till provided a favourable substrate for revegetation at a number of sites at Ekati mine and its physical properties may provide a substrate most similar to many natural deposits in the area (Kidd et. al. 2006; Martens 2007).

Lake sediment is fine textured with high silt and may improve water and nutrient holding capacity of coarse textured substrates (Reid and Naeth 2005a, 2005b). It has low cation exchange capacity, organic carbon and water content and neutral pH. Lack of nutrients and organic carbon may impede revegetation as nutrient cycling cannot begin and nutrients are not retained (Reid and Naeth 2005a, 2005b). Lake sediment may be too smooth and compacted due to high silt content to be an effective substrate (Kidd and Max 2001; Martens 2012). Kidd (1999) found lake sediment was a suitable substrate for revegetation in the greenhouse, however, its lack of organic matter resulted in low soil water and nutrients and which may affect sustainability of plant cover in the long term. In the field, germination and plant cover was low on lake sediment with most plants dead after 10 years (Kidd and Max 2001; Martens 2012).

A study at Diavik mine investigated use of a mixture of glacial till and lake sediment (referred to as till-sediment) as a reclamation substrate (Drozdowski et al. 2012; Naeth and Wilkinson 2014a). Texture varied widely from clay, silt and sand to large boulders. Till-sediment had high and consistent soil water content in the surface soil layer (0 to 5 cm) through five growing seasons. Others reported substrates with more clay and silt had higher water and nutrient holding capacity (Densmore et al. 2000). Till-sediment unamended had low plant cover after five years, higher than processed kimberlite but lower than gravel (Naeth and Wilkinson 2014a). Till-sediment amended with fertilizer had high plant densities after five years, over 50 plants m^{-2}, therefore meeting reclamation objectives. The pH of till-sediment was most similar to native tundra relative to other substrates and may aid plant establishment as many native tundra species are sensitive to changes in soil pH. Plant growth, however, is limited due to lack of organic matter and nutrients.

3.1.4 Combinations of substrates

A number of experiments have been conducted on mixing of substrates produced at diamond mines to create one that is more effective for revegetation (Reid 2002; Naeth and Wilkinson 2011; Drozdowski et al. 2012; Naeth and Wilkinson 2014a, 2014b). Reid (2002) combined lake sediment and processed kimberlite in greenhouse and field studies. Despite predictions, adding lake sediment to kimberlite decreased cation exchange capacity in the greenhouse and field and nutrients in the greenhouse. In the greenhouse, the combination resulted in low plant cover and root and shoot biomass, however, root biomass and plant height improved relative to processed kimberlite alone. In the field, the combination produced some of the highest vegetation cover and shoot biomass in the first two growing seasons relative to other treatments and considerably more than processed kimberlite alone. In the second year plant growth was somewhat reduced and adding lake sediment at a lower rate and in combination with amendments was suggested (Reid and Naeth 2005b).

Substrates composed of 50 % till-sediment and 50 % kimberlite had over 50 plants m^{-2} after five years (Naeth and Wilkinson 2014). Substrates of 25 % kimberlite and 75 % till-sediment were not as successful. Both combinations, however, had higher plant densities than kimberlite or till-sediment alone. Combining kimberlite with till-sediment increased nitrogen and phosphorous and diluted concentrations of some metals relative to kimberlite alone and improved structure of till-sediment by adding coarse particles (Drozdowski et al. 2012). Combinations of 25 % kimberlite and 75 % till-sediment had high and consistent soil water content over five growing seasons, similar to till-sediment alone (Drozdowski et al. 2012; Naeth and Wilkinson 2014a). Others found suitable growth substrates had mixed fine and coarse particles (Martens 2006).

3.2 Amendments

In reclamation, amendments are added to substrates to improve soil physical and chemical properties for plant establishment and growth. Amendments can be structure improving and nutrient providing. Some, like sewage, fall into both categories as it provides significant nutrients, such as nitrogen and phosphorus, and improves soil structure (Reid and Naeth 2005b). Many diamond mine substrates have poor structure, dominated by either coarse or fine particles and with little to no organic matter. The type and concentration of nutrients vary greatly and often differ from those in undisturbed tundra. Improved structure improves water hold capacity and nutrient availability by providing organic carbon to hold water and nutrients and altering texture. Amendments can be applied as a cap or layer over substrate or incorporated.

Capping can be operationally easy and buffer newly establishing plants from phytotoxic substrates. Disadvantages of capping are creation of a substrate amendment interface which may be impenetrable by plants and change drainage patterns and erosion of capping material. Incorporation blends the substrate and amendment avoiding interface issues, improving overall structure compared to either alone and maximizing benefits in rooting zone. It can be difficult to operationally apply on a large scale and result in uneven distribution of amendment.

3.2.1 Salvaged soil

Currently regulations in the north do not require mines to salvage and stockpile soil removed pre mining. This salvaged soil, however, can be an important source of organic matter and nutrients for reclamation sites. While often referred to in documents as topsoil, in many cases this includes more than just the O and A soil layers and in other cases insufficient information is provided to determine which soil layers are included. We will refer to it as salvaged soil and this may be peat, organic soil or mixes of organic and mineral soil. Use of salvaged soil increased organic matter, organic carbon, nitrogen, cation exchange capacity, water and nutrient retention and field capacity in reclamation substrates in the north (Johnson 1987; Densmore 1994; ABR 2001; Deshaies et al. 2009; Drozdowski et al. 2012; Naeth and Wilkinson 2014a).

Stevens (2006) found greater growth and health of plants when salvaged soil was incorporated into processed kimberlite in the greenhouse and field. In the field, 25 % salvaged soil mixed with 75 % kimberlite from Victor mine was not sufficient to ameliorate soil conditions but 50 and 75 % were. In the greenhouse, the effect was similar for the three plant species grown, although the magnitude for the results varied by species. Densmore (1994) found that succession on placer mine spoil (gravel) in Alaska was rapid when remnant soil was present. Sites with soil had highest number of species and greatest growth and cover.

At Ekati mine, a cap of salvaged soil over gravel considerably enhanced native grass, forb and shrub cover relative to lake sediment or esker material (Kidd and Rossow 1997; Kidd and Max 2000b; Martens 2012). While plant cover changed little after the first five years, moss cover and plant litter increased considerably during this period. When used to amend processed kimberlite, till-sediment and combinations of them at Diavik mine, it was the most consistent amendment for increasing plant density and species richness (Drozdowski et al. 2012; Naeth and Wilkinson 2014a). After five years it was one of the few treatments that contained moss. Salvaged soil is ideal for developing substrates on disturbed sites, however, due to thin layers present in the north, soil is a limited resource for reclamation (Johnson 1987; Kidd and Rossow 1997; Naeth and Wilkinson 2014a). In contrast, Deshaies et al. (2009) found salvaged soil had no effect on two native grasses and one legume and mineral fertilizer was a better option for amending disturbed substrates in northern Quebec to enhance revegetation.

Increased plant growth when salvaged soil is added to substrates may result from enhanced soil microbiology. Soil has microorganisms involved in decomposition and cycling (ABR 2001; Martens 2002). Salvaged soil had significantly higher fungal biomass than lake sediment or esker material (Kidd and Rossow 1998; Kidd and Max 2000b). Bacterial biomass was similar among substrates and to that of the undisturbed tundra (Kidd and Max 2000b). Mycorrhizal fungi are important for plant health and growth (Kidd 1996; ABR 2001). Salvaged soil added to a disturbed sand substrate in Siberia, significantly increased dehydrogenase activity, known to strongly correlate with soil fertility and hydrophysical properties (Galiulin et al. 2013).

Tundra seed banks are contained within the top 10 cm of soil with densities of hundreds of seeds per m^2 (McGraw 1980; Archibold 1983). Stratified soils have higher seed densities than unstratified soil and seeds persist in organic, but not mineral tundra soils (McGraw 1980; Ebersole 1989). Salvaged soil can therefore be a source of native plant propagules including seeds and vegetative parts for revegetation (Chapin III and Chapin 1980; Johnson 1987; ABR 2001). In the first five years following placement of salvaged soil over processed kimberlite, till-sediment and their combinations, salvaged soil was not a source of native propagules; all plant growth was from seeded species (Naeth and Wilkinson 2014a). Salvaged soil in most studies had likely been stockpiled, although details were not always provided, and in other regions this is known to affect number of viable propagules (e.g. Mackenzie and Naeth 2010). Natural recovery has been observed but likely from seed blown in from adjacent undisturbed areas.

3.2.2 Commercial peat

Similar to salvaged soil, peat can increase cation exchange capacity, water and nutrient holding capacity, organic carbon, nitrate and phosphorus (Martens 2002; Reid and Naeth 2005a, 2005b; Stevens 2006). Reid and Naeth (2005b) found high carbon nitrogen ratio may initially limit nitrogen, but it will become increasingly available with decomposition. Due to high carbon nitrogen ratios, peat can be more effective combined with a nutrient source to create a suitable ratio (Reid and Naeth 2005b; Naeth and Wilkinson 2014b). In the greenhouse, peat incorporated into fine processed kimberlite significantly increased plant cover and above and below ground biomass (Reid and Naeth 2005a). When peat was combined with other amendments plant performance was further enhanced. In the field, Reid and Naeth (2005b) found amendments which contained peat significantly increased plant cover and biomass over two growing seasons. Peat significantly increased above and below ground biomass of agronomic and native grasses when incorporated into fine and coarse processed kimberlite and till (overburden ranging from silt to cobble) from Jericho mine in the greenhouse (Naeth and Wilkinson 2014b). Incorporation of peat, at low or high rates, into processed kimberlite reduced metal concentrations in plant tissue relative to unamended kimberlite (Martens 2000).

While peat is commonly used in reclamation, the cost of commercially obtaining it and transporting to remote mine sites must be considered. Use of peat in reclamation requires that it be removed from another site, increasing the area of disturbance unless the site is already being disturbed (Price et al. 1998). Peat is slow to regenerate, which may have long term impacts on the secondary disturbance site.

3.2.3 Sewage sludge

Sewage sludge is readily available at northern mine sites. At most mine sites it is subjected to an advanced biological treatment including phosphorus removal through an alum and filtration system (Rio Tinto 2013). Sewage can provide significant nitrogen, phosphorus, potassium and sulphur (Reid 2002; Reid and Naeth 2005a, 2005b). Kwiatkowski (2007) found sewage treated substrates had a carbon to nitrogen ratio approaching the ideal 10:1 for soil respiration and decomposition. Sewage can be more effective than commercial fertilizers as it releases nutrients slowly as the sewage degrades (Bishop et al. 2000 in ABR 2001). It increased cation exchange capacity, organic matter and organic carbon, which can reduce loss of nutrients and water (Reid and Naeth 2005a, 2005b; Drozdowski et al. 2012; Naeth and Wilkinson 2014a). Cater and Jorgenson (1991), however, found the increases in organic carbon and nitrogen where short lived when applied to gravel and within two years there were no differences between plots amended with sewage and the control. Naeth et al. (2006) found treatments with sewage had highest soil water content. Sewage properties vary between mines and collection periods at a mine. Sewage collected in fall 2004 at Diavik had considerably different available nitrate and phosphorus, total carbon, electrical conductivity and soluble cations than that collected in spring 2005 (Kwiatkowski 2007).

Based on these characteristics, sewage can be an effective amendment. In the greenhouse, Reid and Naeth (2005b) found sewage significantly increased plant cover, root and shoot biomass and height in processed kimberlite and was more effective at increasing plant cover and growth than peat amended kimberlite at Ekati mine. On gravel pads at Diavik mine, initial field results found sewage resulted in poor plant growth in the first two growing seasons even though it had high soil water content, likely due to high metal and nutrient concentrations (Drozdowski et al. 2012). After five growing seasons, treatments with sewage had greatest plant densities and cover (Naeth and Wilkinson 2014a). Sewage treatments had low diversity and were dominated by a few species. Application of fertilizer at the onset may provide short term nutrients before sewage begins to decompose and increase initial plant establishment.

In the greenhouse, sewage amendment of fine and coarse processed kimberlite and till from Jericho mine significantly increased *Hordeum vulgare* L. (barley) and *Poa glauca* M. Vahl (glaucous blue grass) above and below ground biomass relative to unamended kimberlite with no to little effect on plant density (Naeth and Wilkinson 2014b). Sewage most enhanced plant performance in fine kimberlite relative to coarse kimberlite. Results were similar to peat and fertilizer treatments. Sewage was added to salvaged soil stockpiles as a method of disposal while at the same time potentially increasing soil nutrients (Martens 2006). This approach is not recommended as nitrate and ammonia concentrations were extremely high, at levels plants were not adapted to, and runoff resulted in plant mortality in adjacent tundra.

Concerns related to the use of sewage in reclamation are based on presence of bacteria and metals. Sewage is not microbiologically sterile and can represent a potential health risk (Edmonds 1976; Reid and Naeth 2005b; Drozdowski et al. 2012). Drozdowski et al. (2012) found *Salmonella* in only one sewage sample and mean fecal coliform levels of 511 g^{-1} at 0 to 10 cm and 448 g^{-1} at 20 to 30 cm. While guidelines do not exist for fecal coliforms in sewage, concentrations greater than 1000 g^{-1} in compost are considered unsuitable (CCME 2005). Cold temperatures reduce counts of fecal coliform rapidly to safe levels (Edmonds 1976; Reid and Naeth 2005b; Drozdowski et al. 2012), therefore sewage use is acceptable for reclamation.

Sewage often contains high concentrations of metals (e.g. Drozdowski et al. 2012). Chromium, cobalt, copper, molybdenum, nickel and zinc were elevated in soil treatments with sewage at Diavik mine. For metals to be a risk for plants, they must be mobile and available to move into plant roots (Foy et al. 1978; Drozdowski et al. 2012). Plant toxicities tend to only occur for copper, nickel and zinc (Foy et al. 1978). However, in soil, most metals are bound to organic matter, like that within sewage, form hydrolysis species, adsorb to clay or iron hydroxides and complex with inorganic ligands, reducing mobility (Foy et al. 1978; Weng et al. 2002; Ashworth and Alloway 2004). After five years, metal concentrations in sewage amendment plots were not above soil quality guidelines (Naeth and Wilkinson 2014a). Reductions in plant health have not been observed when applied in the field (Drozdowski et al 2012; Naeth and Wilkinson 2014a).

3.2.4 Inorganic fertilizer

Growth of established seedlings is often restricted by low nutrient concentrations (Bishop and Chapin III 1989a, 1989b). Inorganic fertilizer provides nutrients which are often in low concentrations in northern soils (Johnson 1987; ABR 2001; Deshaies et al. 2009; Drozdowski et al. 2012). Addition of nutrients is required initially to stimulate nutrient cycling which is then maintained by nutrient addition from plant decomposition (Reid and Naeth 2005b). Disturbed substrates tend to have low organic matter and cation exchange capacity and fertilizer has no effect on soils with these properties (Johnson 1987; Reid and Naeth 2005a). When nutrients are added without organic matter to ameliorate structural limitations, plant growth often does not respond. Nutrients will leach deep into the soil profile or be lost from the site (Johnson 1987; Reid and Naeth 2005b). Effectiveness of fertilizers can be influenced by summer climate as plants must be actively growing to uptake nutrients. Fertilizer increased plant growth during a warm summer, but had little effect in a cool summer (Bell and Bliss 1980).

Standard reclamation procedure in many industries is to apply fertilizer when revegetating a disturbed site. Slow release and time release fertilizers tend to be most effective as they allow the plants to develop the root system required to take up nutrients (Densmore 1994; Houle and Babeux 1994). Fast release fertilizers or large amounts can negatively affect plant growth (Houle and Babeux 1994; Deshaies et al. 2009). Seedlings in the first growing season are often too small to use large amounts of fertilizer (Densmore et al. 2000; Adams and Lamoureux 2005) and delayed application until plants are an appropriate size is more effective. Northern plants tend to be adapted to low nutrient concentrations and are unable to use high amounts (Martens 2006). Repeated application of fertilizer had favourable effects on native grass cultivar cover over multiple years (Martens 2003, 2006). Once application ceased native grass cultivars showed reduced health, emphasizing the need for maintenance applications (Martens 2012).

Fertilizer stimulated germination on gravel pads, but limited cover resulted in leaching of nutrients from the site (Jorgenson and Joyce 1994). A rapid vegetation cover is desired as it can trap more water and nutrients, facilitating development of organic matter. Fertilizer addition tends to cause plants to develop a low root to shoot ratio although once nutrients leach from the site, above ground growth slows to allow root growth to catch up (Bishop and Chapin III 1989b; Densmore et al. 2000; Adams and Lamoureux 2005). Effects of fertilizers can often be present for multiple years. In the year fertilizer was applied, N and P concentration in leaves increased, followed by increases in growth and tillering in the second year and increased flowering in the third year (Shaver and Chapin III 1995). Nitrogen was elevated only in the first year, whereas phosphorus remained elevated for 3 to 4 years (Shaver and Chapin III 1995).

Fertilizer has variable effects on seed germination, seedling growth and survival, depending on application rate, nutrient type and plant species (Stevens 2006; Deshaies et al. 2009). Densmore (1994) found adding time release 14-14-14 NPK fertilizer at 350 kg ha^{-1} significantly increased vascular and non vascular plant cover and willow (*Salix*) growth. Deshaies et al. (2009) found moderate rates (50 g m^{-2}) of slow release NPK fertilizer on a disturbed sand substrate increased cover and biomass in the field. Adding liquid fertilizer in the greenhouse at lower than field rates was detrimental to two of three species. Naeth and Wilkinson (2014) found 11-52-0 NPK fertilizer at 144 kg ha^{-1} in the first two growing seasons significantly increased native grass growth on till-sediment substrate in the first five growing seasons but the effect was not as pronounced on coarse substrates such as processed kimberlite or gravel. Stevens (2006) found *Lolium perenne* L. (perennial rye grass) with 15-30-15 NPK fertilizer at an equivalent rate of 300 kg ha^{-1} in the greenhouse grew taller and healthier in kimberlite. Bishop and Chapin III (1989b) found fertilizer (18-18-18 NPK equivalent to 555 kg ha^{-1}) reduced germination of *Salix alaxensis* on a gravel substrate although it did increase leaf and stem biomass. Based on operational practices at Ekati, fertilizer facilitated rapid establishment of plants, although it tended to be short term provision of nutrients with multiple applications required (ABR 2001).

Fertilizer is frequently applied in revegetation of tundra disturbances. High rates of fertilizer favour a dense cover of grasses, particularly non native species, while low rates result in less dense grass cover, greater invasion of native species and greater species diversity (Densmore 1992; Forbes and Jefferies 1999). Net mineralization rates were lower in fertilized plots, as a dense vegetation canopy cover and litter layer results in lower soil temperatures and greater binding of nutrients in biomass (Forbes and Jefferies 1999). Dense vegetative cover can increase herbivory (McKendrick et al. 1980). Fertilizer was necessary in early establishment (Bliss and Grulke 1988) and where organic matter is very low (Martens 1995). Magnusson (1994, 1997) found fertilizer enhanced establishment of *Betula* (birch) and *Salix* species. Cargill and Chapin III (1987) found high levels of fertilizer inhibited establishment of *Salix alaxensis*. Once basic soil properties are enhanced, at least some plant species will establish. At Ekati mine, Martens (2011) found health of grass cultivars declined as they are unable to survive without repeated nutrient additions. Fertilizers usually increases grass cover initially and at shrub cover at later stages, as grasses and forbs prefer high nutrient concentrations and shrubs prefer low (BHP Diamonds 1995; Forbes and Jefferies 1999; Martens 2006). Nutrients can become tied up in grasses due to slow decomposition in cold climates, limiting availability to other plants (Bishop and Chapin III 1989a). Based on these results, application of fertilizers may be important to support initial growth and start nutrient cycling, however long term dependence and requirements are not well understood.

3.2.5 Other amendments

Other novel materials can improve substrate structure and nutrient status although they have been less studied. Calcium sources like rock phosphate, gypsum or calcium carbonate have been added to substrates to improve calcium magnesium ratio that can be limiting for plant establishment and growth, especially in kimberlite substrates (Reid and Naeth 2005a, 2005b). Calcium sources had no effect on cation exchange capacity and did not alter calcium magnesium ratio, although gypsum increased available calcium in the greenhouse. However, none of the calcium sources had significant effects on plant growth or altered substrate properties in the greenhouse (Reid and Naeth 2005a) or over two growing seasons in the field

(Reid and Naeth 2005b). Low precipitation and climate may slow dissolution of calcium sources requiring over two years for visible effects (Schuman et al. 1994; Reid and Naeth 2005b). Schuman et al. (1994) found plant response was not evident on mine spoil amended with gypsum until the second or third growing season. Adding calcium amendments may be beneficial in the long term, however climate conditions limit their effectiveness in the short term.

Paper mill waste is sediment in waste water produced during paper pulping, composed of cellulose fibres, clay, calcium carbonate and small amounts of chemicals (Reid 2002). It can increase water and nutrient holding capacity, organic matter and organic carbon and improve texture of coarse substrates. It has low water content, high cation exchange capacity and neutral pH. Reid and Naeth (2005a) found paper mill sludge had a significant positive effect on plant cover and biomass in the greenhouse. Paper mill waste is generally available from industry at no cost, other than transportation to the mine site.

At Diavik use of water treatment plant sludge, particulate matter (ground rock, lake sediment, till, runoff water) from the water treatment plant was investigated (Drozdowski et al. 2012). Sludge had low organic carbon and high ammonium, water content and sand fraction. Metal concentrations (arsenic, barium, chromium, copper, nickel) were elevated although risk was deemed low due to dilution upon application (Kwiatkowski 2007). When sludge was applied to substrates, carbon to nitrogen ratio approached the ideal 10:1, similar to sewage, and soil water content increased. After two growing seasons, treatments with sludge applied to 25 % processed kimberlite and 75 % till-sediment had highest plant growth. Effect of sludge on plant growth was variable in the short term likely due to leaching of water and nitrogen (Drozdowski et al. 2012). After five growing seasons plant density declined and sludge had no effect on plant growth, therefore use in reclamation is not recommended (Naeth and Wilkinson 2014a).

Commercial products which add nutrients or organic matter have been used to improve substrate properties although research has been limited in northern environments. Agri-Boost® (Agri-Boost Inc, Leduc, Alberta) is a soil conditioner of dehydrated alfalfa and contains 84 % organic matter and has high water holding capacity (Reid and Naeth 2005a). In the greenhouse, it provided highest available nitrate of various amendments examined. It significantly increased plant cover and shoot biomass, although it was less successful than sewage or peat.

BlackEarth (Black Earth Humic LP, Calgary, Alberta) is a naturally weathered sub-bituminous coal high in humic substances and humified organic matter (Liem et al. 2003; Black Earth 2009a, 2009b; Liem 2010). It can improve soil quality by increasing cation exchange capacity and water and nutrient holding capacity thereby potentially increasing plant emergence, growth and survival and microbial activity. When applied to fine and coarse processed kimberlite and till in the greenhouse it was not different than the control but when applied with fertilizer it considerably increased above and below ground biomass (Naeth and Wilkinson unpublished). Further research is being conducted at the University of Alberta to determine its potential as a reclamation amendment at diamond mines (Naeth and Miller unpublished).

Starch-based polymers, polyacrylamide or gel crystals, known as hydrogels, are added to reclamation substrates to retain water. At Ekati Mine, shrubs were planted in pockets with DRiWATER® (DRiWATER, Santa Rosa, California), a hydrogel composed of cellulose gum and water. Shrub survival was too low to scientifically determine effects of the gel although most surviving plants were in pockets with the gel (Kidd and Rossow 1998). SoilMoist (JRM Chemical Inc, Cleveland, Ohio), a synthetic copolymer with a potassium salt base, was added to fine and coarse processed kimberlite and till from Jericho mine and in combination with fertilizer was beneficial to plant performance, increasing plant density and biomass relative to unamended substrates (Naeth and Wilkinson 2014b). It is currently being tested with substrate from Diavik mine (Naeth and Miller unpublished).

Biochar has been widely used in the agricultural industry and is currently being investigated for use in diamond mine reclamation (Naeth and Miller unpublished). Biochar is the charcoal by product produced when biological residues are combusted under low oxygen (Chan et al. 2007; Sohi et al. 2009; Major et al. 2010; Beesley et al. 2011; Fellet et al. 2011; Belyaeva and Haynes 2012; Denyes et al. 2012; Houben 2013). It is porous and high in carbon with neutral to alkaline pH. It can increase cation exchange capacity and water and nutrient holding capacity in soil, increase nutrient uptake in plants and reduce soil tensile strength. Biochar can bind with organic and inorganic contaminants reducing availability (Beesley et al. 2011; Fellet et al 2011; Belyaeva and Haynes 2012; Houben 2013). In the field and greenhouse, it can increase plant growth and microbial activity, especially with fertilizer (Chan et al. 2007; Major et al. 2010; Beesley et al. 2011; Fellet et al. 2011; Denyes et al. 2012; Jones et al. 2012; Houben 2013).

3.2.5 Combinations of amendments

Developing a suitable substrate for plant growth often requires combinations of amendments. Greenhouse and field research investigated combining structure improving amendments, such as peat moss, lake sediment and sewage sludge, with nutrient providing amendments, such as inorganic fertilizer, rock phosphate, calcium carbonate and gypsum (Naeth and Reid 2005a, 2005b). Treatment of both nutritional and structural limitations gave best results. Sewage sludge and peat moss together were most effective with highest ground cover in the second growing season in the sewage, peat, gypsum and rock phosphate combination. Sewage provided significant available nitrate and with peat, had suitable organic carbon to retain nutrients over multiple years. In the greenhouse, fertilizer with peat and hydrogel enhanced plant performance in diamond mine substrates more than either amendment alone (Naeth and Wilkinson 2014b). Field results may be different when soil water content is not ideal.

3.3 Micro Topography

Establishment of plants depends on germination and growth (Chambers et al. 1991). Safe sites (Harper 1977) or micro sites refer to sites that have conditions suitable for germination and establishment, such as soil water, nutrients, appropriate temperature and protection from seed predation, grazing and wind (Smith and Capelle 1992; Forbes and Jefferies 1999; Jumpponen et al. 1999; Mori et al. 2008). Micro sites must meet the needs of growth and germination and these needs may vary (Smith and Capelle 1992; Elmarsdottir et al. 2003), therefore variation in micro sites across a site is important for development of plant communities (Beatty 1984; Sohlberg and Bliss 1984; Jumpponen et al. 1999).

Micro sites can be considered from a biological and physical perspective. Biological micro sites include plants, litter, moss mats and lichen crusts (Sohlberg and Bliss 1984; Anderson and Bliss 1998; Forbes and Jefferies 1999). Plants, mosses and lichens can provide micro sites for seeds by protecting them, reducing evaporation and increasing soil water, increasing snow cover, stabilizing soil, reducing temperature fluctuations, reducing exposure to harsh sunlight and providing mycorrhizae necessary for seedling establishment (Sohlberg and Bliss 1984; Carlsson and Callaghan 1991; Elridge et al. 1991; Forbes and Jefferies 1999; Maher and Germino 2006; Stevens 2006). While biological micro sites are important in tundra communities, their importance on disturbed sites that have little to no vegetation cover prior to reclamation is low, at least until sustainable vegetation cover can be established.

Physical micro sites include bare soil, mounds, depressions, rocks, boulders, coarse textured substrates and cracks (Sohlberg and Bliss 1984). Physical characteristics of a micro site are important for plant germination, establishment and growth on disturbed sites (Densmore et al. 2000; Mori et al. 2006). Physical micro sites can traps seeds and provide shelter from wind and areas with increased water availability (Whitehead 1959; Bell and Bliss 1980; Carlsson and Callaghan 1991; Densmore et al. 2000; Rausch and Kershaw 2007).

Coarse substrates (gravel, glacial till) can trap seed, increasing seed soil contact and protecting seeds from wind and water erosion (Harper et al. 1965; Chambers et al. 1991; Jumpponen et al. 1999; Naeth and Wilkinson 2014a). Partial burial exposes seeds to soil water and protects it from predation and desiccation (Jumpponen et al. 1999; Elmarsdottir et al. 2003). Coarse substrates can provide greater root penetration by emerging seedlings (Jumpponen et al. 1999).

Depressions, cracks and barriers like rocks and boulders can trap seeds (Sohlberg and Bliss 1984; Chambers et al. 1991; Johnson and Fryer 1992; Densmore et al. 2000; Elmarsdottir et al. 2003). Depressions trap seeds dispersed in wind or water (Eldridge et al. 1991; Jumpponen et al. 1999; Martens 2005; Naeth and Wilkinson 2011). Greater soil water is important for germination and seedling survival as desiccation is a major risk in the north, especially at sites without vegetation cover (Jumpponen et al. 1999). Soil temperatures are reduced in depressions (Naeth and Wilkinson 2011). Plants in depressions are protected from wind (Walker 1996), where lower wind speeds reduce transpiration and increase seed and seedling survival (Sohlberg and Bliss 1984). Cracks have reduced wind speeds and exposure and provide water for plants for long periods (Bell and Bliss 1980).

Rocks and boulders can increase soil water by reducing evaporation, reducing wind, creating areas where water flows and enhancing snow capture (Cargill and Chapin III 1987; Jumpponen et al. 1999; Kidd and Max 2002; Martens 2002; Elmarsdottir et al. 2003). Shading can reduce soil temperatures around boulders relative to flat areas or mounds. Snow melts earlier near large rocks resulting in a slightly longer growing season (Jumpponen et al. 1999). Rocks can provide shelter from wind and reduce desiccation, with overhanging edges protecting seeds and seedlings (Sohlberg and Bliss 1984; Kidd and Max 2002). Boulders and rocks fit visually in the landscape providing integration of the reclaimed site (Kidd and Max 2002).

Mounds tend to be drier, have less nutrients, organic matter, cation exchange capacity, litter and snow cover and have greater temperature fluctuations seasonally relative to depressions (Beatty 1984; Price et al. 1998). Mounds can have high temperatures, resulting in higher decomposition rates and nutrient availability (Walker 1996; Bruland and Richardson 2005). Bruland and Richardson (2005) found wetland hummocks had greater nitrate and ammonium than flats and hollows and were drier. Furrows are a combination of depressions and mounds with ridges and troughs and have characteristics of both. Species diversity tends to be higher in troughs than ridges (Sterling et al. 1984).

Tundra environments are naturally micro topographically diverse, with boulders, hummocks, soil boils, stony areas, desiccation cracks, depressions, polygons and patterned ground and their role in plant distribution has been observed in undisturbed sites and naturally disturbed sites (Peterson and Billings 1980; Sohlberg and Bliss 1984; Anderson and Bliss 1998; Naeth and Wilkinson 2011). Disturbance and reclamation activities can remove natural micro topographic variation through compaction, movement of substrates, poor soil structure and removal of hydrologic connections (Forbes and Jefferies 1999; Naeth and Wilkinson 2011) and reestablishment of micro topographic variation is essential. By identifying types of micro sites that improve germination, establishment and growth, ability to reclaim degraded sites can be enhanced (Elmarsdottir et al. 2003). This can be especially important at xeric sites like gravel pads, that lose water rapidly, as micro sites improve conditions (Cargill and Chapin III 1987).

Elmarsdottir et al. (2003) found more seedlings adjacent to small rocks and in biological crusts in reclamation sites in Iceland. In the first year following reclamation at Diavik, plant density and cover and density were higher in depressions, crevices and adjacent to large rocks and substrates with surface variability had greater germination and establishment (Kwiatkowski 2007; Drozdowski et al 2012; Naeth and Wilkinson 2014a). On reclamation sites that have been scarified, germination and plant density were higher in the bottom of furrows where nutrients and water were concentrated (Kidd and Max 1995; Kidd and Rossow 1997; Martens 2007). Placing till-sediment in free dump piles or reworking a site to provide similar conditions improved plant performance, overcoming some issues from poor physical properties (Martens 2009).

Plant response on reclamation sites where micro topographic variation was created were variable and limited. Rausch and Kershaw (2007) created furrows on gravel pads in Churchill, Manitoba and found fewer seedlings in the sites with micro topographic variation, likely due to disturbance of the site which was unable to recover in the short growing season. It may bury the seedbank reducing number of seeds than can penetrate through the soil. In a northern mixed prairie, species richness and diversity was lower on artificial earthen mounds than off (Umbanhower 1992). Naeth and Wilkinson (2011) investigated shrub and forb establishment in depressions, mounds, boulders and flat micro sites on various substrates at Diavik mine. Survival was negatively influenced by erosion in depressions, however, despite high losses, rates of survival of *Vaccinium vitis idaea* L. (lingonberry), *Empetrum nigrum* L. (crowberry) and *Arctostaphylos rubra* (Rehd. & Wils.) Fern. (bog cranberry) were highest or individuals were only alive in depressions. At Ekati mine, transplant survival and seedling height were higher in ripped sites as troughs can collect water and provide shelter from wind; grass cover was higher in areas protected by rock piles and in depressions than uplands (Martens 2002, 2005, 2007, 2011, 2012). Bishop and Chapin III (1989b) found highest germination of *Salix alaxensis* on gravel pads in Alaska with stones as they created safe sites with increased shade and water.

3.4 Soil And Water Management

Substrate and amendment erosion due to wind or water is a problem on disturbed northern sites. Most field studies at Diavik and Ekati mines considered erosion detrimental to soil reclamation and revegetation. Many factors increase substrate vulnerability to erosion, mainly a lack of vegetation. Soils with low organic matter and substantial fine particles are at increased risk of erosion (Kidd and Rossow 1998; Naeth and Wilkinson 2010; Naeth and Wilkinson 2011). Flat areas are vulnerable as the surface does not slow wind speeds (Kidd and Max 2002).

Erosion can inhibit establishment of vegetation (Matheus and Omtzigt 2012). Seeds applied to the surface of a disturbed area are vulnerable to dislocation through wind and water erosion (Martens 2001; Naeth and Wilkinson 2014a). Blowing substrate and soil can smother emerging seedlings (Martens 2005). Naeth and Wilkinson (2011) found greater loss of shrub cuttings in depressions due to infilling from wind and water erosion. Lack of vegetation cover in areas surrounding reclamation sites makes both areas vulnerable to erosion and its effects (Martens 2005). Loss of amendments applied to the surface through erosion reduces their benefits to revegetation. Salvaged soil applied in patches on a Diavik reclamation site disappeared by the second growing season due to erosion (Naeth and Wilkinson 2011). Erosion control blankets were applied to reclamation plots at Ekati mine to hold amendments and seed, resulting in some of the highest initial plant cover of reclamation studies to date (Reid and Naeth 2005b).

Erosion control blankets are flexible organic or synthetic materials that can be placed on surfaces with high erosion potential and anchored into the soil (Matheus and Omtzigt 2012). Synthetic materials tend to be used for long term uses and organic form for short term uses as it decomposes. Examples of specific blankets include the Soil Saver™ jute erosion control blanket (Hy-Tex Ltd, UK) (Martens 2003; Martens 2005) and Curlex® aspen erosion control blanket (American Excelsior Co, Arlington, TX) (Kidd and Max 2000; Reid 2002; Reid and Naeth 2005b). Erosion control blankets stabilize the surface, provide organic matter, increase water and nutrient holding capacity, protect establishing seedlings and reduce evaporation and loss of soil water (Kidd and Max 2000; Martens 2001; Reid 2002). They are frequently used when reclaiming channels on mine sites. Lack of experimental assessment of the effects of erosion control blankets means at this time there is no conclusive data to support, or not support, their use. A current study is experimentally examining the effects of jute erosion control blankets and a water soluble anionic polymer called SoilLynx (Clearflow Enviro Systems Group Inc, AB) to reduce erosion and enhance revegetation success (Naeth and Miller pers. comm.).

Mulch tends to be coarse or fibrous organic material, like wood chips or straw, used to reduce erosion and improve soil conditions for plant growth (Matheus and Omtzigt 2012). Mulch can increase soil temperature, humidity, water holding capacity and nutrient availability (Houle and Babeux 1994). Price et al. (1998) used straw mulch to revegetate *Sphagnum* peat land and found it decreased water interception to the soil, and decreased evaporation resulting in greater soil water under mulch than on bare soil. Bare soil had greater net radiation and heat flux, whereas mulch kept the soil warmer at night and cooler during the day. Mulch protected *Sphagnum* diaspores and improved conditions for establishment and growth. Jorgenson and Cater (1991) reported similar results with greater cover for vascular plants when straw mulch was applied to gravel pads in Alaska. Mulch intercepted precipitation and did not increase soil water content, with increased cover likely due to reduced desiccation and increased germination. Houle and Babeux (1994) found *Alnus* species Mill. (alder) wood chips (twigs < 1 cm diameter) increased survival of *Salix planifolia* rooted cuttings. *Alnus* and *Salix* species wood chips had no effect on plant growth while transparent plastic mulch was detrimental to it.

Mulch and erosion control blankets can have negative effects. Seeds dispersed onto them have poor establishment (Densmore et al. 2000; Adams and Lamoureux 2005). Seeds dispersed under them have reduced germination due to photoinhibition and growth with seedlings having difficulty penetrating the layer (Densmore et al. 2000; Martens 2005; Matheus and Omtzigt 2012). Presence of mulch or an erosion control blanket can impede assessment of revegetation progress especially in the first year when seedlings are unable to penetrate (Kidd and Max 2000a). Mulch and erosion control blankets can accumulate blowing sediments, negatively affecting seedling establishment (Martens 2005).

Lack of adequate soil water is the primary limiting factor to reclamation on diamond mines in the north. Gravel pads block natural drainage patterns, are disconnected from the hydrologic system and alter snow drift patterns resulting in water stress (Walker 1996; Shirazi et al. 1998; ABR 2001). The dry climate exacerbates this and further limits germination and plant establishment (Bishop and Chapin III 1989a; ABR 2001). To mediate, berms and snow fencing can be used to capture drifting snow and increase soil water at snowmelt can be employed (Jorgenson and Joyce 1994). High berms of 50 and 100 cm significantly increased early summer soil water content on gravel pads at a mine and a drill site in Alaska, however, the increase was more than the substrates storage capacity and much water was lost as throughflow (Jorgenson and Cater 1991; Jorgenson et al 1992). Rauch and Kershaw (2007) found 60 cm high snow fencing had no measurable effect on plant abundance or richness even though snow pack was greater in fenced treatments. In the second year, flowering was greater in the fenced treatment and in the long term this may result in high plant densities and cover. These results differ from those of McKendrik (1996) and Jorgenson et al. (1993), who reported snow fencing increased plant abundance within the first few years.

Altering site macro and micro topography can reduce erosion and conserve soil water (See Section 3.4). Recontouring the reclamation surface and creating roughness reduces wind speed and erosion while creating troughs and pockets for water retention (Kidd and Max 2002; Martens 2005). Increasing organic matter in the substrate, through amendments like sewage sludge, increases water holding capacity and reduces erosion potential (Reid and Naeth 2005b). Incorporating amendments and seeds reduces their removal by wind and water (Reid and Naeth 2005b; Naeth and Wilkinson 2011). Establishment of a sustainable vegetation cover reduces erosion (Kidd and Max 2001; OASIS Environmental 2004; Adams and Lamoureux 2005; Matheus and Omtzigt 2012). Rapidly growing species like *Hordeum vulgare* and *Lolium multiflorum* Lam. (Italian rye grass) can be used (Matheus and Omtzigt 2012). However, the strong competitive abilities of these species can inhibit native species from establishing and growing on the site, though use of an appropriately low seeding rate can reduce these effects.

3.6 Summary

- Insufficient soil water, due to coarse textured substrates, lack of organic matter and low precipitation, is the greatest barrier to revegetation of northern disturbed sites, including diamond mines.
- A mix of coarse and fine textured particles in the reclamation substrate results in the best plant performance in short and long terms. Fine grained substrates, with more clay and silt, are more suitable for plants as they have greater water and nutrient holding capacity, which is better for germination, emergence, survival and growth. However, finer textured substrates are at more risk of erosion and compaction. Adding coarse substrates, with more sand, can increase water infiltration, root penetration and improve overall structure.
- Processed kimberlite alone is not an ideal reclamation substrate for sustainable plant growth due to elevated concentrations of some metals (nickel, chromium, cobalt) and nutrients (sulphate, potassium). Mixing with other substrate and/or amendments dilutes these concentrations.
- Capping processed kimberlite with other substrates is not feasible as most available

substrates have similar limitations to plant growth as kimberlite. Capping with organic amendments, such as salvaged soil and sewage, increases plant establishment and growth.

- Unamended gravel or crushed rock limits plant growth but not establishment.
- Gravel or crushed rock pads can be capped with organic amendments or mixes of substrates for reclamation. The pad still creates an impediment to natural hydrologic and wildlife patterns. Dismantlement of the gravel pad may be a viable option with resulting topography providing a diversity of micro sites and increased soil water.
- Glacial till is a better substrate for plants than lake sediment due to lower silt content and presence of rocks and boulders. The mixture of the two shows promise for reclamation. Lake sediment alone has not been a successful reclamation substrate.
- Amended substrates in general have better plant establishment and growth than those without amendments.
- Most field research has focused on capping with organic materials, not on incorporation.
- Combining amendments, particularly nutrient and structure improving amendments, increases their effectiveness and plant performance.
- Plant cover and biomass is greatly increased with the use of salvaged soil and/or sewage.
- Sewage sludge may be toxic to plants initially due to high metals and bound nutrients, however toxicity is reduced as nutrients are released and metal concentrations decrease.
- Native grass cultivars benefit from inorganic fertilizer application at least once and multiple applications may result in more sustainable cover.
- Micro topographic variation is important to initiate and maintain abundant and diverse native plant communities in the north regardless of the substrate being reclaimed. Operationally feasible techniques such as rough dumping materials and ripping substrates increase plant establishment and growth.
- Erosion of substrates, amendments and plant materials by wind and water and grazing and browsing by wildlife continue to impede reclamation success. Erosion control blankets appear to increase plant establishment and cover.
- There are many novel commercial amendments available that may enhance plant establishment and growth on disturbed sites at diamond mines.

5. REVEGETATION

Successful revegetation of land disturbed by mining and other anthropogenic activities in the north will require improvement of two aspects. These include the soil substrate to support and sustain plant growth and acquisition of plant material that can tolerate harsh conditions while developing an appropriate plant community.

The low arctic is characterized by shrub and graminoid communities and the high arctic by sparse vegetation and evergreen shrubs (Crawford 1989). Vegetation communities include erect dwarf shrub tundra, low shrub tundra to tussock and non tussock - dwarf shrub - moss tundra. Erect dwarf shrub tundra is dominated by *Betula glandulosa* Michx. (dwarf birch), *Vaccinium uliginosum* L. (bog bilberry), *V. vitis idaea, Ledum palustre* L. (marsh Labrador tea), *Salix glauca* L. (gray leaf willow), *Empetrum nigrum*, mosses and lichens, with 80 to 100 % cover in damp areas to little cover in dry areas. Low shrub tundra has many of the same shrub species, dominated by *Salix* and *Alnus* with thick moss. Non tussock - dwarf shrub - moss tundra cover is 50 to 100 % with extensive moss, sedges and some shrubs. Tussock tundra is dominated by *Eriophorum* species (cotton grasses), dwarf shrubs and mosses.

Desirable characteristics of species for revegetation of gravel pads and other northern disturbances include tolerance of low nutrients and soil water, low growing with large root systems, potential to improve substrates, perennials, native, commercially or locally available in sufficient quantities and provision of habitat for wildlife (Bliss 1962; Cargill and Chapin III 1987; Chapin III and Shaver 1989; Crawford 1989). Measures of successful revegetation are often based only on plant cover, although they should consider natural colonization by native plants and establishment of seedlings, increasing species diversity, reproduction by seeded and colonizing species, development of a moss layer and accumulation of litter (McKendrick 1997; Streever et al. 2003; Rausch and Kershaw 2007).

5.1 Grasses And Forbs

Natural recovery of plant communities on a disturbed site is ideal as it reduces the inputs required. However, it relies on a source of native propagules and is often unpredictable, thereby increasing the risk of soil erosion and reducing aesthetics. Particularly in the north, natural recovery is a slow process and when combined with significant alteration of soil and hydrology, through human disturbance, the process is lengthened.

Gravel disturbances are some of the most difficult to revegetate. Limitations to natural recovery on raised gravel pads in Alaska included seed dispersal, lack of soil water (resulting in low germination) and lack of nutrients (resulting in slow growth) (Cargill and Chapin III 1989). Water is responsible for the movement of nutrients in the soil and therefore affects their plant availability (Jorgenson and Joyce 1994) and is essential for germination and plant growth (Bell and Bliss 1980; Jumpponen et al. 1999; Drozdowski et al. 2012). Soil water can reduce erosion and loss of seeds by increasing cohesion between particles (Chambers et al. 1991). Ten years following gravel pad abandonment, species richness ranged from 0 to 11 species (Cargill and Chapin III 1989). Mean cover was less than 2 % across all sites. Distance from riparian seed sources explained significant variation in cover and diversity on sites. Eight years after abandonment of a gravel pad in Alaska, mean cover of native plants was 2.7 % and mean species richness was 4.6 (Bishop and Chapin III 1989a). Naturally colonizing species were primarily legumes and all species were riparian as riparian gravel bars have similar properties to some gravel pads. Jorgenson et al. (1990) found natural recolonization was limited on gravel areas even after 20 years.

Kershaw and Kershaw (1987) found mean cover was less than 5 % for most species naturally colonizing 5 to 35 year old borrow pits in the north. *Salix alaxensis* was the most successful naturally recovering species on these mineral soils. Older sites had greater species diversity and there was great regional variation in the 80 locations studied. Based on the abundance of native forbs in early establishment phases, the researchers suggest a greater emphasis needs to be put on forbs in revegetation programs. Dominance of legumes as early colonizers indicates that lack of nitrogen limits establishment and growth of other species on gravel pads (Kidd and Rossow 1997; Kidd and Max 2000a; Kwiatkowski 2007).

Species that have naturally established on gravel pads include graminoids, *Arctagrostis latifolia* (R. Br.) Griseb. (polar grass), *Deschampsia caespitosa* (L.) Beauv. (tickle grass), *Festuca rubra* L. (creeping red fescue), *Poa arctica* R. Br. (arctic blue grass), *Poa glauca*, *Puccinellia nuttalliana* (Schult.) Hitchc. (alkali grass) and *Trisetum spicatum* (L.) Richt. (spiked trisetum), *Carex bigelowii* Torr. (bigelow sedge) and *Equisetum arvense* L. (common horsetail), and forbs, *Artemisia alaskana* Rydb., *Artemisia borealis* Pall. (field sagewort), *Artemisia tilesii* Ledeb. (tilesius' wormwood), *Cochlearia officinalis* L. (scurvy grass), *Epilobium latifolium* L. (dwarf fireweed), *Epilobium angustifolium* L. (common fireweed), *Astragalus alpinus* L. (alpine milkvetch), *Hedysarum alpinum* L. (alpine sweetvetch), *Hedysarum mackenzii* Richards (licorice root), *Oxytropis glutinosa* Porslid (boreal locoweed), *Oxytropis varians* (Rydb.) K. Schum. (field locoweed), *Papaver lapponicum* (Tolm.) Nordh. (Lapland poppy), *Sagina intermedia* Fries (pearlwort), *Saxifraga cernua* L. (nodding saxifrage) and *Saxifraga oppositifolia* L. (purple mountain saxifrage) (Kershaw and Kershaw 1987; Bishop and Chapin III 1989a; Walker 1996;

Martens 2000). Despite the diversity shown here, natural revegetation is a long and slow process in the arctic (Forbes and Jefferies 1999).

Research has been conducted since the 1970s on methods to accelerate plant community development in northern environments with assisted revegetation techniques (Babb and Bliss 1974; Densmore et al. 1987; Bishop and Chapin III 1989a; Grosbois et al. 1991; Macyk and Belts 1995; Bittman 1997; Kidd and Rossow 1997; Jones et al. 1999; Withers 1999; Densmore et al. 2000; Hagen 2002; Gage and Cooper 2004; Holloway and Petersburs 2009; Naeth and Wilkinson 2011; Drozdowski et al. 2012; Naeth and Wilkinson 2014). During this period, focus shifted from using agronomic species to native species and development of native cultivars adapted to the harsh environment leading to accelerated development of self sustaining plant communities that blend with the surrounding environment (Forbes and Jefferies 1999; Kidd and Max 2000a). Early revegetation efforts generally involved seeding agronomic grasses because they are readily available and provide rapid plant cover with large fibrous root systems that can control erosion (Holloway and Zasada 1979; Densmore 1992; Kidd and Rossow 1997; Withers 1999). In some cases, annual non-native species such as *Lolium multiflorum* and *Hordeum vulgare* have been seeded to quickly establish plant cover, prevent further erosion, and act as a nurse cover for native seedlings by trapping blowing seeds, providing safe sites for germination, and by increasing the nutrient content in the top layer of the soil (Densmore et al. 2000; Cooper et al. 2004; Clark and Hutchinson 2005; Lewis, 2009). Non native grasses, however, generally do not persist without repeated fertilizer application due to low nutrient concentrations in northern soils and harsh environmental conditions (Webber and Ives 1978; Kershaw and Kershaw 1987; Klokk and Rønning 1987; Forbes and Jefferies 1999). An abundance of non native grasses, and subsequent litter, hindered colonization and establishment of native species, leaving sites in a state of suspended succession (Densmore and Holmes 1987; Younkin and Martens 1987; Bishop and Chapin III 1989; Densmore 1992; Forbes and Jefferies 1999; Withers 1999).

Seeding early successional native species on disturbed sites including grasses and legumes with the intention that later successional species will invade as soil and nutrient properties improve has been common. Rausch and Kershaw (2007) found plant densities were higher in seeded gravel pits than unseeded ones, especially in species poor areas. However, native seed mixes and seeding rates must be carefully designed as even aggressive native species, such as those that form sod, can out compete other native species for space, nutrients, sunlight and water (McTavish and Shoplik 1983; Polster 1991; Forbes and Jefferies 1999; Withers 1999).

One of the major issues for assisted revegetation is being able to acquire native species seed in sufficient quantities to reclaim large disturbances such as mine sites.

Mixes of native grass cultivars have been used widely in Alaska oil fields and mine sites (Jorgenson et al. 1990; Jorgenson and Cater 1991; Jacobs et al. 1994) and at mine sites in Yukon and Northwest Territories (Maslen and Kershaw 1989; Clark and Hutchinson 2005) with a productive cover developing rapidly. Cover was greatest on thick gravel fill where organic topsoil was applied (Jorgenson and Cater 1991) and on overburden stockpiles where soil had a high percentage of fines and permafrost under the thin active layer prevented nutrient leaching (Jorgenson et al. 1990; Jacobs et al. 1994). Growth of grasses on thick gravel fill unamended was slower, even after applying fertilizer (Jorgenson and Cater 1991).

Native cultivars have been successfully seeded on a diversity of substrates at Ekati mine include *Arctagrostis latifolia*, *Deschampsia caespitosa*, *Poa alpina* L. (alpine blue grass) and *Festuca rubra* (e.g. Kidd and Max 2000a, 2000b, 2001, 2002). In plant species research started in 2000, *Agropyron violaceum* (Hornem.) Lange (broad leaf wheat grass) and *Tristeum spicatum* (L.) K. Richt (spike trisetum) were native cultivars that had high cover in a few years; *Agropyron violaceum* had close to 70 % cover in kimberlite. Over time, cover of all species declined and stabilized with 15 and 25 % cover. This decline is likely due to nutrient depletion. At some sites little natural recovery, at least initially, was observed due to dominance by one or more native cultivars (Kidd and Max 2002; Martens 2009). Natural herbaceous colonizers on sites (salvaged soil stockpiles, till-sediment, esker, gravel) seeded with native grasses have been limited to *Calamagrostis canadensis* (Michx.) Beauv. (blue joint), *Epilobium*, *Equisetum* and *Carex* species. *Arctagrostis latifolia*, *Festuca rubra, Agrostis scabra* Willd. (hair grass) and *Deschampsia caespitosa* have not established well, while *Puccinellia nuttalliana*, *Poa glauca, Poa alpina, Agropyron violaceum* and *Festuca saximontana* Rydb. (rocky mountain fescue) have established on xeric sites at Diavik mine (Drozdowski et al. 2012; Naeth and Wilkinson 2014a). The only natural colonizer after five years, other than seeded species, has been *Epilobium angustifolium*.

Other propagation techniques investigated include collecting wild seed from native grass, legume and shrub species, growing container seedlings from seed for transplanting, and use of vegetative cuttings (Kidd 1996; Densmore et al. 2000; Matheus and Omtzigt 2012). Kidd and Max (2001) found native cultivars performed best relative to wild collected seed and shrub cuttings following five years of monitoring. However, many questions remain to be addressed regarding how to overcome dormancy factors and accelerate germination, establishment and growth of most northern plant species and encourage later successional species.

Revegetation research at Ekati mine has focused on use of native grass cultivars in conjunction with wild collected seed for native forbs. Local commercial sources of native forb seed are difficult to find and therefore the mine started collecting and establishing breeding plots for a select number of forbs (*Hedysarum mackenzii*, *Astragalus eucosumus Robins (purple peavine)*, *Oxytropis deflexa* Pall. DC. (nodding locoweed) and *Epilobium angustifolium*). Legumes are of particular interest as they may enhance nutrient status of nutrient poor substrates thereby enhancing productivity, readily germinate and establish on gravelly disturbances with low water content and organic matter and their open canopy allows for natural colonization of sites (Jefferies et al. 1981; Kidd and Max 2000a). In studies on a drainage channel, seeding a native cultivar grass mix was delayed for three years to allow forbs to first establish. Only one forb, *Hedysarum mackenzii*, was in any measurable abundance; it was not until the third year that another forb, *Oxytropis deflexa*, established. Densmore et al. (2000) and Naeth and Wilkinson (2014) also reported cover of seeded legumes and grasses was negligible until the third year.

Determining method to establish wetland species has been a priority at Ekati mine to revegetate processed kimberlite containment areas and drainage channels, with *Arctophilia fulva*, *Eriophorum* L. (cotton grass) and *Carex* species being the focus to date. Most of the *Salix* species cuttings have been planted in these areas (see Section 4.2). The most successful method for establishing *Arctophilia fulva* has been from sprigs, which avoids issues with seed dormancy and reduces seedling mortality (Streever 2001). Survival rates increased with time with 73 % in the first year and 82 % in the second year at Panda Diversion Channel and plant density increased by 300 % over three years at Kodiak Lake (Kidd and Max 2000a, 2000b, 2001). Plugs of *Carex* and *Eriophorum* had low establishment and only survived in areas that remained wet (Martens 2003).

Eriophorum species may be good candidates for sprigging or transplanting (Billings 1987). They can survive surface scraping by bulldozers. Transplanting has been done infrequently (Forbes and Jefferies 1999) and may not be feasible on a large scale (Urbanska 1997). *Arctophila fulva, Eriophorum angustifolium* Honck. (common cotton grass) and *Eriophorum russeoleum* L. (red cotton grass) have been transplanted in wet habitats (Jorgenson et al. 1990; McKendrick 1997).

Planting of container grown seedlings overcomes issues with seed dormancy and slow growth common in native tundra species and can accelerate overall vegetation cover and flowering, thereby increasing aesthetics of reclamation sites. Seedlings of *Hedysarum mackenzii*, *Oxytropis deflexa* and *Epilobium angustifolium* were grown in Spencer Lemaire root trainers and planted in spring on processed kimberlite with and without amendments (Martens 2005). Forbs survival was 14 to 50 % after the third growing season; lower survival was due burial by blowing sediment. The effect of transplanting seedlings with its potting soil growth medium was inconclusive due to compounding factors such as burial by blowing sediment and grazing.

Oxytropis deflexa and *Oxytropis hudsonica* (Greene) Fern. (boreal locoweed) seedlings were planted into a gravel esker substrate and survival was 15 and 49 % in the second year and 19 and 49 % in the third year (Martens 2003 report). The lower survival for *Oxytropis deflexa* was due to burial by blowing sediment. *Oxytropis deflexa* and *Epilobium angustifolium* seedling survival was high (20 to 35 % and 70 to 80 %, respectively) in the first year after planting in kimberlite, lake sediment, glacial till and salvaged soil, however, considerably reduced by the second year (< 4 % and 40 to 60 %, respectively) (Martens 2011, 2012). Seedlings were grown in styroblock root trainers with 340 cc root volume and outplanted as dormant stock. Seedlings were grown at a nursery in Alberta, adding to the cost of revegetation.

Timing of seeding and planting seems to have little effect on revegetation success. In the first few years there was no difference between spring and fall seeding of native grasses and forbs in processed kimberlite and till-sediment substrates (Drozdowski et al. 2012). Similar results were found for spring and fall plantings for shrub and forb plugs (Martens 2012). While after the first winter the most recent plantings had higher survival than the earliest plantings, by the second year there was no difference with forb survival,

4.2 Shrubs

Seeding graminoid species has been a staple revegetation technique despite many northern tundra ecosystems being dominated by shrub and lichen species (Holloway and Zasada 1978; Webber and Ives 1978; Chapin and Chapin III 1980). Lack of commercially available shrub species seed due to sporadic seed set, lack of understanding of propagation techniques and slow growth rates has limited shrub use in reclamation. On gravel pads in the Northwest Territories, shrubs that naturally established include *Betula glandulosa*, *Dryas integrifolia* M. Vahl (white mountain avens), *Salix alaxensis*, *Salix glauca, Salix ovalifolia* Trautv. (oval leaf willow), *Salix planifolia* and *Salix reticulata* L. (net leaved willow) (Kershaw and Kershaw 1987). *Dryas integrifolia, Betula glandulosa* and *Salix planifolia* were cited as common natural colonizers on a variety of substrates at Ekati mine 10 to 15 years after reclamation (Martens 2000, 2007, 2008, 2012). However, assisted revegetation is necessary as many shrubs are very slow growing and can take ten years or more to have significant above ground biomass

(Densmore et al. 2000; Martens 2012; Matheus and Omtzigt 2012). Techniques to propagate shrubs for revegetation include seed, container seedlings or vegetative propagules such as root and shoot cuttings (Holloway and Zasada 1979; McTavish and Shoplik 1983; Withers 1999).

Many shrub species in the north only produce good seed crops periodically rather than yearly, dependent on species and environmental conditions (Withers 1999). Collection of seeds must be carefully timed in either fall (majority of species) or spring (majority of *Salix* species) to harvest only ripe viable seed (Densmore et al. 2000). Many seeds, particularly those from non-cultivated species, undergo a period of dormancy or arrested development prior to germination where they fail to germinate even under optimal conditions (Finch-Savage and Leubner-Metzger 2006). Dormancy can be endogenous in nature (related to seed embryo), or exogenous (related to seed coat or other surrounding tissue) (McTavish and Shoplik 1983; Withers 1999; Finch-Savage and Leubner-Metzger 2006). While dormancy is not well understood, a variety of environmental conditions such as aeration, water, temperature, chemical signals and light can break or change dormancy status. Methods to overcome dormancy are species specific and can include scarification, cold or warm stratification, light, hot water treatments or chemical treatments (McTavish and Shoplik 1983; Baskin and Baskin 2003; Schwienbacher et al. 2011), although much work is still required to optimize germination for northern species.

Over time, the net effect of dormancy is accumulation of seeds on or in soil, which, along with vegetative propagules, forms the soil seed bank, generally located in the upper 5 to 10 cm of soil. Future plant population dynamics are influenced by composition of the underlying soil seed bank, particularly following natural or anthropogenic disturbances. Seed banks generally contain a biased legacy of past surface vegetation and develop over time through a combination of inputs (seed rain, dispersal), outputs (germination, predation, decay, physical damage) and continuity (dormancy, viability) (Leck et al. 1989; Tucker Carter and Ungar 2002). Salvaging and stockpiling topsoil may help preserve the seed bank for future reclamation activities. Knowledge of potential species in the seed bank and their characteristics (expected viability, longevity, abundance) can be used to accelerate revegetation at disturbed sites.

Shrub seed may require complex treatment to break physiological dormancy, resulting in very low germination rates if seed is not treated. Germination of *Empetrum nigrum* seed in the laboratory or field was less than 25 %, required six to twelve months to germinate, and was highly variable among studies (Nichols 1934; Bell and Tallis 1973; Granstrom 1982; Maslen 1989). Less than 25 % of *Betula glandulosa* seed germinated with or without scarification and cold stratification (Nichols 1934; Maslen 1989). *Vaccinium vitis idaea* and *Vaccinium uliginosum* achieved 37 to 92 % germination with cold stratification (Nichols 1934; Granstrom 1982). Both *Empetrum nigrum* and *Vaccinium vitis-idaea* germinated best under saturated soil conditions (Oberbauer and Miller 1982). *Arctostaphylos rubra* and *Salix planifolia* did not germinate in the laboratory (Maslen 1989; Maslen and Kershaw 1989). Seeding rates from *Betula glandulosa* of 243 seeds m^{-2} resulted in less than 1 % cover and low biomass after a year (Maslen and Kershaw 1989). At Diavik, *Betula glandulosa* seed had high germination in petri dishes after 1 year storage in the freezer but not in the field; seed loss and low soil water may be factors (Naeth and Wilkinson 2011). A few studies investigated *Salix* germination (Moss 1938; Bliss 1958; Bishop and Chapin 1989b) with variable results. Bishop and Chapin III (1989a) found gravel pad plots watered regularly had greater germination of *Salix alaxensis*, as germination is restricted by low soil water. The labour required to collect large quantities of seed to overcome low germination is often not available in reclamation programs, creating a limitation to use of shrub seed for large scale reclamation. Smoke water improved seed germination in some species (Bell 1999; Van Staden et al. 2000; Adkins and Peters 2001; Mackenzie 2012), but has never been investigated to improve rooting ability of cuttings.

Several species of shrubs are known to produce adventitious roots from shoot cuttings (e.g. *Salix alaxensis*, *Salix arctica* Pall. (arctic willow) and *Salix planifolia*) (Densmore et al. 2000; Naeth and Wilkinson 2011; Matheus and Omtzigt 2012; Ficko et al. in prep;). As many shrubs are slow growing, transplanting cuttings can significantly accelerate growth of these species, by overcoming sporadic seed set, uncertain viability, poor germination and low seedling establishment, although it is more time consuming and expensive than direct seeding and may have adverse effects on the donor population (McTavish and Shoplik 1983; Naeth and Wilkinson 2011; Matheus and Omtzigt 2012).

The relative success of *Salix* as cuttings, in the north and elsewhere, has made this a preferred method for establishing species of this genus. *Salix planifolia* bundles, mats and individual stem cuttings have been used in drainage channel reclamation at Ekati mine (Kidd and Max 2000b, 2002). For individual cuttings, mean survival at one site was 65, 25, 61 and 74 % over the four years. Consistent water contents were an important factor for survival during the growing season. At another site, survival was 45 % in each of the first two years and this lower than expected rate was due to late planting and a short growing season for them to establish. The mats were only used in low numbers due to the large amount of bare ground required to bury them. Specific data on *Salix* mat and bundle survival rates were not located beyond the first year. Martens (2003) concluded that *Salix* cuttings are not useful for upland areas due to lack of soil water and high over winter kill. Field research at Ekati mine showed that dormant *Salix planifolia* cuttings that are stored frozen until planting have good establishment and survival on riparian sites (Kidd and Max 2000a, 2000b, 2002).

Research has been conducted on methods to optimize collection and propagation of dormant (hardwood) shoot cuttings, growing (softwood) shoot cuttings and root cuttings for northern shrub species in the greenhouse and field (e.g. *Arctostaphylos alpina* (L.) Spreng. (alpine bearberry)*, Arctostaphylos uva ursi* (L.) Spreng. (common bearberry), *Betula glandulosa*, *Betula nana* L. (dwarf birch), *Empetrum nigrum*, *Ledum groenlandicum* Oeder (Labrador tea), *Loiseleuria procumbens* (L.) Desv. (alpine azalea), *Salix alaxensis*, *Salix bebbiana* (beaked willow), *Salix planifolia, Salix glauca* and *Vaccinium uligninosum*). Results have been inconclusive or contradictory due to differences in soil substrate properties, soil water content, weather, time of collection and planting, length of cutting and depth of planting (Holloway and Zasada 1979; McTavish and Shoplick 1983; Densmore et al. 1987; Bishop and Chapin III 1989b; Rein et al. 1991; Houle and Babeux 1993; Kidd and Rossow 1997; Houle and Babeux 1998; Densmore et al. 2000; Hagen 2002; Holloway and Peterburs 2009; Naeth and Wilkinson 2011). Factors such as soaking and rooting hormones improved rooting ability in species such as *Salix planifolia* and *Salix nigra* Marshall (black willow) (Houle and Babeux 1998; Schaff et al. 2002; Naeth and Wilkinson 2011) but require further work to determine optimal rates for a wider variety of species. Naeth and Wilkinson (2011) found rooting hormones had no effect on *Salix glauca* or *Betula glandulosa*. Much work is still required to understand species specific differences in optimal time for collection (dormant or non dormant), plant age, plant gender (for dioecious species), cutting length, planting time and depth, planting arrangement, soil water content and effect of substrate type.

For upland sites, plugs of *Betula glandulosa* and *Dryas integrifolia* were grown in Spencer Lemaire trainers and outplanted into kimberlite (Martens 2005). *Dryas integrifolia* seedlings died within two years but *Betula glandulosa* survival was 14 to 50 % after the third growing season. Effect of transplanting plug with its organic growth medium was inconclusive due to compounding factors such as burial by blowing sediment and grazing. *Betula glandulosa* and *Vaccinium uliginosum* seedlings, grown in Spencer Lemaire root trainers, were successful when transplanted into a gravel esker substrate with survival in the first three years greater than 75 % for both species and new growth observed annually (Martens 2006). When planted into ripped kimberlite, lake sediment, glacial till and salvaged soil, *Betula glandulosa* plug survival was 33 to 50 % after the first year; with the exception of salvaged soil, survival was reduced when substrates were not ripped prior to planting (Martens 2011, 2012). These seedlings were grown in styroblock root trainers with 340 cc root volume to a height of 20 to 35 cm and outplanted as dormant stock. *Salix alaxensis* performed well from containerized seedlings (87 to 100 % survival) (Densmore and Holmes 1987).

Many shrub species form associations with mycorrhizae fungi (Kidd 1996; Kidd and Rossow 1997; Withers 1999; Kidd and Max 2000). Kidd (1996) found that greater than 80 % of the *Arctostaphylos alpina*, *Vaccinium uliginosum*, *Ledum decumbens* (Ait.) Lodd. (northern Labrador tea) and *Loiseleuria procubens*. root tips tested had at least one type of mycorrhizal fungi with ectomycorrhizae being most common. Dependence of northern shrubs on these associations and how they develop over time requires further study. Use of tundra sod mats may improve shrub establishment and survival as mycorrhizae are transplanted with plants.

Tundra sod mats (25 to 30 cm diameter, 25 to 38 cm depth) were planted into pockets in salvaged soil and glacial till treatments as a source of native plant material for reclamation (Martens 2011, 2012). Based on first year results, sod mat survival was greater in salvaged soil than till and when substrates were ripped to reduce compaction relative to non ripped. There was no difference in survival of sod mats when collected in fall versus spring. In ripped salvaged soil plots, survival of tundra species, mainly shrubs, was 81 % relative to 45 % in ripped till. *Vaccinium vitis idaea* has highest survival and *Vaccinium uliginosum* lowest. A previous experiment with tundra sod mats transplanted into a gravel esker substrate resulted in good survival of species after two years (Martens 2005); no further monitoring results were found. Transplanted sod has been widely used in Denali Park in Alaska with good success although the plant composition changes with time (Densmore et al. 2000). *Betula nana* and *Salix* species remained constant but cover of ericaceous shrubs (*Ledum* and *Vaccinium*) declined and cover of grasses and forbs, in particular *Epilobium angustifolium* increased.

4.3 Bryophytes And Lichen

Cryptogamic species, mosses and lichens, are critical in northern ecosystems. Moss and lichen are important components of tundra biological crusts, regulating surface temperature and water (Van der Wal et al. 2001). Moss and lichen crusts may be most important early in succession with benefits in surface layers for seed and seedlings (Gold 1998) and may directly facilitate later communities (Bowker 2007). They act as pioneer species in ecosystem development, facilitating soil and microhabitat development (Schofield 1972; Kershaw and Kershaw 1987; Klokk and Rønning 1987; Longton 1988; Jandt et al. 2008; Rydgren et al. 2011). Mosses and lichens act as nurse species, enabling introduction of other, dependent species (Longton 1988; Forbes and Jeffries 1999; Hilty et al. 2004). They are important indicators of ecosystem health (Forbes 1994; Naeth and Wilkinson 2008) whose presence or absence can indicate level of disturbance, health, hydrologic regime, acidity and nutrient concentrations (Gignac et al. 1991). Cryptogamic species are important in erosion control, slope stability (Klokk and Rønning 1987) and landscape hydrology. They provide critical habitat and forage for northern fauna, including birds, rodents and caribou (Pakarinen and Vitt 1974; Batzli and Sobaski 1980; Longton 1980; Thompson and McCourt 1981). Mosses and lichens are of cultural importance; First Nations have been using them for thousands of years (Andre and Fehr 2002). Despite their significance, little is known about revegetation methods. Natural revegetation is not a reclamation option as recovery in the arctic is so slow.

Revegetation of non vascular species is an important but rarely considered component of many revegetation plans. Most non vascular species establish by vegetative reproduction from tissue fragments (Vitt et al. 1988; Belland 2013), so reestablishment on large disturbed areas may take many years for moss propagules such as shoot fragments, bulbils, rhizomes and gemmae or sections of lichen thalli (Brodo et al. 2001; Belland 2013) to arrive. Lichens are an integral component of most northern ecosystems, particularly reindeer lichens such as *Cladonia* (cup lichen) and *Cladina* (reindeer lichen) species which are an essential component of caribou diet in winter (Maikawa and Kershaw 1976; Klein 1987; Duncan 2011; Klein and Shulski 2011). However, very limited research has been conducted on how to collect and propagate lichen species to accelerate their growth in general or in disturbed environments.

4.3.1 Bryophytes

Several studies have been conducted on natural revegetation on the CANOL pipeline corridor through Northwest Territories and its associated disturbances (Harper and Kershaw 1996; Davis 1998). Fifty years after disturbance, bryophytes were among the richest taxonomic groups in smaller areas of disturbance, such as vehicle tracks (Harper and Kershaw 1996; Davis 1998). The pipeline, which had been recovered with original topsoil material, was in much better shape than borrow pits, which still remained in early stages of revegetation (Davis 1998). Vegetation in borrow pits was sparse, and consisted mostly of lichens and bryophytes after almost 50 years (Harper and Kershaw 1996). Bryophytes are important pioneer species, and often the first to inhabit a denuded area. Many moss species were found in a naturally revegetated borrow pit in North West Territories with *Polytrichum commune* L. (common haircap moss), *Polytrichum juniperinum* L. (robin's rye) *Polytrichum piliferum* Hedw. (bristly haircap moss) and, to a lesser extent, *Ceratodon purpureus* (Hedw.) Brid. (fire moss), *Polytrichum strictum* Brid. (strict haircap moss) and *Tomenthyphum nitens* (Hedw.) Loeske (tomentypnum moss) noted for high potential in revegetating continental tundra (Kershaw and Kershaw 1987).

Grettarsdottir et al. (2004) found sites revegetated by seeding with exotic grass species almost 25 years earlier had 0 to 2 % cover of those species, the plant cover consisting primarily of native vascular are non vascular species. After 9 years, vegetation cover in glacial till stockpiles seeded with native grasses was 24 to 28 % (Martens 2012). Seeded grasses and mosses dominated. The lake sediment stockpile had much less cover and patchy distribution. At Ekati mine, salvaged soil placed over a gravel pad had good vascular plant cover and increasing diversity (Kidd and Rossow 1997; Kidd and Max 2000b; Martens 2012). While vascular plant cover changed little after the first five years, moss cover and plant litter increased considerably during this period with moss accounting for 66 to 70 % cover. Ten years following revegetation of a drainage channel with native grass cultivars, moss accounted for the majority of vegetation cover (Martens 2012). At Diavik mine, five years following reclamation, moss cover was greatest in till-sediment amended with sewage or fertilizer, till-sediment and processed kimberlite mix (50:50) amended with salvaged soil and crushed rock with fertilizer, although cover was less than 5 % (Naeth and Wilkinson 2014a). None established in processed kimberlite.

Little research has been conducted on reintroduction of bryophytes on disturbed sites. Some studies attempted to promote growth with fertilizers (Klokk and Rønning 1987; Gretarsdottir et al. 2004), others focused on peatlands (Gorham and Rochefort 2003; Cobbaert et al. 2004; Similä et al. 2011), and some on bryophyte propagation methods (Gretarsdottir et al. 2004; Magnúsdóttir and Aradóttir 2011; Aradóttir 2012; Aradóttir and Oskarsdottir 2013). Klokk and Rønning (1987) studied effects of fertilizer on vegetative growth in Svalbard, Norway. Establishment of bryophytes and other species was stimulated by application of fertilizers. These findings could be applicable to other nutrient poor northern applications. Despite the limited scope of bryophyte revegetation research, almost any treatment will likely improve reintroduction relative to natural revegetation (Grettarsdottir et al. 2004).

Some researchers experimented with manually shredded and distributed turf materials (Magnúsdóttir and Aradóttir 2011; Aradóttir 2012). With this treatment there was an increase of moss cover with time. Increase in bryophyte cover was faster and an effective method of revegetation. Magnúsdóttir and Aradóttir (2011) tested the potential of *Racomitrium lanuginosum* (Hedwig) Bridel. Muscol. (wolly moss) for regeneration from fragments. Results from a greenhouse experiment were promising, and they postulate fragmentation of this species

Could likely accelerate its colonization on disturbed areas with little disturbance to a donor site.

Aradóttir (2012) transplanted turf blocks for reclamation at a geothermal power plant in southwestern Iceland. Turfs of different sizes (5 x 5, 10 x 10, 20 x 20, 30 x 30 cm) containing a mix of grasses, sedges, forbs, dwarf shrubs, mosses and lichens were directly transplanted. After two years, moss cover increased with all sizes of transplants, however spread of turf was low with a loss of rare species and species with low cover (< 6 %). Transplantation of live turf is an effective means of quickly establishing overall species composition of a reclaimed area, but the relative abundance of some native species in the reclaimed site may be different from that of the donor site (Aradóttir and Oskarsdottir 2013). Turf transplantation has the benefit of quickly reintroducing native plant cover, and there is a potential for salvaging industrial sites where development is planned by translocation of entire turf material to decommissioned areas. There is potential damage to donor sites, slow spread from turf and loss of rare or sensitive plant species. Determining optimal turf size and different species tolerances of transplantation is required (Aradóttir 2012).

4.3.2 Lichen

While research has been conducted on metal bioaccumulation in lichens (e.g. Kidd and Bishop 1999; Naeth and Wilkinson 2008), no projects to date have actively sought to propagate and disperse lichens for reclamation in arctic tundra habitats. Past lichen research has been conducted for conservation of endangered species and maintenance of lichen biodiversity in managed forests. Limited research for reclamation has been conducted with only two located studies, one in the oil sands and one for restoration of degraded reindeer pasture in boreal forest following clear cutting activities (Roturier 2009; Duncan 2011).

In boreal forests, lichen succession is dependent on episodic fire events to maintain an open woodland canopy, and culminates with almost complete ground cover by *Cladonia stellaris* Opiz (Pouzart and Vezda) (star tipped reindeer lichen) or *Stereocaulon paschale* (L.) Hoffm. (Easter lichen) (Kershaw 1976; Maikawa and Kershaw 1976). These lichen species are common in the north on sites with open cover and acidic, xeric sandy soils or organic substrate. As lichens rely on precipitation and atmospheric humidity for water and nutrient requirements, slow dispersion of thalli fragments from a source population likely limits natural colonization of disturbed environments rather than soil properties (Roturier et al. 2007; Roturier and Bergsten 2009; Duncan 2011). Lichens rarely grow directly on mineral soil, therefore surface substrate (moss, litter, decaying logs) and fragment size can influence their ability to establish and grow, especially in windy areas. Growth rates for reindeer lichens) average 3 to 6 mm a year (Scotter 1963; Pegau 1968; Helle et al. 1983; den Herder et al. 2003), indicating the long time frame for recovery. Much work is required to determine if methods used in boreal forest can be applied to arctic reclamation or if new methods must be developed.

Lichens naturally established on gravel pads in the north including *Cetraria cucullata* (Bellardi) Ach. (paper doll), *Cladonia cornulata* Ahti and Kashiw., *Cladonia pocillum* (Ach.) Grognot (pixie cup lichen) and *Stereocaulon alpinum* Laurer ex Funck (alpine foam lichen), and mosses such as *Ceratadon purpureus* (Hedw.) Brid. (purple horn toothed moss), *Polytrichum commune*, *Polytrichum piliferum, Polytrichum strictum* and *Tomenthyphum nitens* (Kershaw and Kershaw 1987). At Diavik mine, lichen cover was negligible five years following reclamation but was evident in till-sediment substrate amended with salvaged soil and unamended gravel (Naeth and Wilkinson 2014a). Lichens survived two winters when transplanted as part of tundra sod mats into salvaged soil and glacial till (Martens 2012).

4.4 Wildlife

While few studies have directly investigated methods to prevent or reduce herbivory, its effects on plants on reclamation sites have been well documented. Streever (2001) found native grass cultivars were extremely palatable to geese and caribou during the first three years of growth and grazing had a negative effect on stand development. At Diavik mine, grazing was more prevalent where plant cover was high but was never detrimental to revegetation success in the first five years following seeding (Naeth and Wilkinson 2014a). The occurrence of grazing steadily decreased with time and was observed in only 6 % of the quadrats assessed in the fifth year. Mortality of planted shrub and forb seedlings was high in the first few years on waste rock reclamation site due to arctic hares (Martens 2012).

Browsing of *Salix planifolia* cuttings was detrimental to their survival when planted on processed kimberlite and in drainage channels. Thus in subsequent plantings Tree Guard™(Dalen Products Inc, Knoxville, TN) and Deer Away® (Woodstream Corporation, Lititz, Pennsylvania) were applied at Ekati (Kidd and Max 2000a, 2000b). After multiple growing seasons browsing was not an issue so in 2001 plantings no herbivore deterrent was applied and plant survival remained high (Kidd and Max 2002). Legumes were targeted by herbivores, in particular by arctic hares. Marten (2001, 2002, 2004) experimentally tested the effects of Deer Away® on seedlings transplanted into kimberlite and found the deterrent was detrimental to young seedlings and did not prevent grazing.

Trampling by caribou was detrimental to establishment of *Salix planifolia* cuttings and *Arctophila fulva* sprigs planted in the processed kimberlite containment area at Ekati (Kidd and Max 2000b). Fencing was added in the third year and after five growing seasons seeded grass cover was 39 to 52 %, although legumes had poor establishment, attributed to detrimental effects of grazing in the first year, prior to fencing. *Epilobium* species were not grazed. Transplanted *Betula glandulosa* seedlings were pulled out or the stems broken by arctic hare when planted on esker material, while legumes were not affected (Martens 2006).

4.5 Summary

- Soil reclamation methods to date provide adequate plant cover within the range of cover values found on similar disturbances in the north.
- A suite of native plant species will naturally colonize gravel disturbances with sufficient time but cover remains low and key species are absent.
- Seeding agronomic grass species provides rapid vegetation cover, however, they often create monocultures preventing establishment of a diversity of species and require high amounts of nutrients to maintain their cover.
- Seeding native grass cultivars can provide good vegetation cover in one to three years, depending on substrate and site conditions. Longer term cover generally decreases but is sustained at 15 to 30 %. Dieback may be due to lack of nutrients and plant roots growing beyond the depth of substrate capping material.
- Native cultivars that have had good performance on diamond mine substrates include *Arctagrostis latifolia, Puccinellia nuttalliana, Festuca rubra, Poa alpina, Poa glauca, Tristeum spicatum* and *Agropyron violaceum*.
- Native legumes consistently establish naturally, from seed or container seedlings on disturbed sites. *Hedysarum mackenzii* in particular has high establishment and survival.
- *Salix* species and *Betula glandulosa* establish naturally on a diversity of substrates but not in the first three to five years.
- *Salix planifolia* and *Salix alexansis* establish from shoot cuttings in disturbed riparian areas but not on substrates with low soil water content. Establishment of *Betula glandulosa* from cuttings has not been successful and little to no research has been conducted on establishment of other common tundra shrub species by asexual methods.
- Container grown shrub and forb seedlings have successfully established and survived on reclamation sites including processed kimberlite, gravel and sediment substrates.

- Plants uptake metals from processed kimberlite but this does not appear to be detrimental to revegetation if the appropriate species are used.
- *Arctophila fulva* establishes readily from sprigs and is good for riparian area revegetation.
- Mosses, primarily *Polytrichum* and *Ceratadon*, naturally colonize disturbed sites within five to ten years.
- No research has been conducted on propagation methods for mosses and lichens.
- Wildlife grazing and trampling can reduce revegetation success and where predominantly legumes and shrubs are used can result in complete failure.

5. CONCLUSIONS AND KNOWLEDGE GAPS

Harsh environmental conditions and limited plant growth and reproduction introduce many unique challenges to reclamation in the north. From the reclamation research conducted to date in the north, in Canada and internationally, we can draw general conclusions to provide the basis for future reclamation and research. However, despite decades of reclamation research in the north, knowledge of the long term soil and plant community development is limited due to poor documentation of site and experiment history, sporadic monitoring and inconsistent monitoring methods. Reclamation research at diamonds mines in particular is still in its infancy due to the young age of these mines. Based on the literature to date, we know the following.

- The greater the soil disturbance and change in hydrologic regime the more difficult reclamation will be.
- Natural recovery on disturbed sites, where soil and vegetation have been completely removed, will be slow, requiring decades to obtain a vegetation cover similar to undisturbed tundra and even then soil, hydrologic and plant community characteristics will be different.
- Natural recovery of disturbed sites, where some organic soil and vegetation remain, is possible, particularly in tundra communities with mesic to hydric conditions.
- Assisted recovery is required for most disturbed sites to return them to the soil and plant communities that would naturally exist. The degree of assistance will depend on the site history and characteristics.
- Low water content of substrates is most limiting to revegetation at diamond mines.
- Processed kimberlite can be used as a reclamation substrate alone or in combination with other substrates. Like with other substrates, water and nutrient status are much more limiting than its chemical properties.

- Amendments which improve physical structure and nutrient status of substrates are required to reclaim common disturbances at diamond mines.
- Inorganic fertilizer only provides a short term nutrient supply for seeded species.
- Native vegetation cover will establish on processed kimberlite, glacial till, lake sediment and gravel with appropriate plant species, propagation methods and rates. However, plant cover and diversity will remain low without amendments.
- Seeding native grass cultivars increases plant cover, litter and organic matter. High plant cover and litter can reduce natural colonization and must be balanced with benefits of rapid establishment of a vegetation cover.
- Season of seeding or planting of container seedlings has little effect on revegetation.
- At riparian sites, dormant shoot cuttings are an appropriate method to establish some *Salix* species including *Salix planifolia* and sprigging is appropriate for *Arctophila fulva*.
- At upland sites, legumes (*Hedysarum*, *Oxytropis*) will establish from seed or as container seedlings.
- *Salix* species and *Betula glandulosa* will naturally colonize disturbed sites longer term.
- Heterogeneous surfaces including boulders, pits, troughs and pebbles increase seed germination, seedling establishment and plant growth and survival.
- Erosion by wind and water reduces revegetation success through removal or burial of amendments, seed and plant material.
- Grazing, particularly by arctic hares, reduces revegetation success of legumes and shrubs.
- Reclamation methods to date have not resulted in the same amount of vegetation cover or species composition as present in undisturbed tundra.
- Very little scientific reclamation research has been conducted on diamond mines in the north. Many of the studies to date are field trials and results are confounded by fertilizer application, lack of controls and variable monitoring intensity in time and space.
- Regular long term monitoring of a reclamation site in the north has not been conducted. Without repeated monitoring of the same site, succession on these disturbances will not be well understood and inappropriate management recommendations may result.

6. RECOMMENDATIONS FOR MANAGEMENT AND FUTURE RESEARCH

To develop suitable anthroposols for diamond mine reclamation, we provide the following recommendations for management and further research.

- Take three approaches to improve water status of reclamation substrates. Create substrates with a mix of fine and coarse particles, then add organic amendments to these substrates taking into account the need for water holding capacity and water movement in the soil profile. Add micro topographic variation to the site to facilitate snow trapping and reduce wind and water erosion, which will in turn enhance water content. Conduct more research to better understand water requirements of tundra plant species so appropriate substrate and amendments combinations can be developed.
- Consider maintenance fertilizer application to increase plant cover and growth beyond the initial establishment years and potentially accelerate establishment of moss species. Conduct more research on what type and rate of fertilizer best promote a diverse vegetation cover including grasses, forbs, shrubs and non vascular plants.
- Develop a more diverse macro and micro topography. Dump substrates to create hummocks and troughs and create pits and hummocks (boulders, pebbled surfaces) to greatly increase germination, seedling establishment, growth and survival of a diversity of plant species. Investigate sizes, shapes and locations to provide the best solutions.
- Manage or mitigate erosion through development of plans which include follow up seeding and planting over the first five years.
- Further investigate novel commercial products that are easy to transport to reduce erosion and increase substrate water and nutrient status.
- Obtain knowledge of effective amendment application rates, in particular inorganic fertilizer, for sustainable tundra communities. Determine appropriate rates for short term establishment and longer term sustainability as they may be different.
- Combinations of amendments can provide enhanced plant performance and maximize the benefits of limited organic materials such as salvaged soil and sewage. Conduct further research to determine which combinations are most effective in short and longer terms.
- Determine differential response of plants to types of microsites and erosion control methods by species and substrate and amendment type.
- Acquire a better understanding of the long term effects of substrates and amendments on soil and plant community development.

To develop suitable plant materials for diamond mine reclamation we provide the following recommendations for management and future research.

- In heath tundra, where ericaceous shrubs dominate the vascular plant cover develop reliable and consistent methods for their propagation.

- *Salix* species establish well as shoot cuttings, however, to enhance survival and growth determine the optimal time to collect shoot cuttings on a species specific basis.
- Determine suitable methods of storing large quantities of *Salix* shoot cuttings in preparation for planting in the field.
- Further investigate species specific methods to overcome seed dormancy and improve germination. Container grown seedlings have worked well for some species but are very costly and labour intensive and use of seed may be more practical for large scale reclamation.
- Compare species and their abundances in the soil propagule bank in salvaged soil and undisturbed locations to develop an understanding of how this changes when soil is removed and stockpiled and what operational practices could enhance use of salvaged soil as a propagule source.
- The biological crust is a key component of tundra communities and provides an insulative layer to regulate soil water and temperature and provide safe sites for seed and seedlings. Determine what moss and lichen species can establish on diamond mine substrates.
- Investigate methods to propagate moss and lichen species. Determine whether moss and lichens can be propagated in the laboratory to reduce impact on donor populations.
- Continue long term monitoring of reclamation sites at diamond mines to determine if natural recovery, traditional reclamation techniques (seeding with grasses and legumes) or more novel approaches such as use of sprigs and transplanting native sod or individual plants can develop self sustaining communities similar to the surrounding undisturbed environment.
- Determine if mycorrhizal fungi associations with shrubs are site or species specific.
- Investigate spatial and temporal development of mycorrhizal fungi associations over time.

5. ACKNOWLEDGEMENTS

We acknowledge Diavik Diamond Mine Inc for financial support of our research and Helen Butler at BHP Billiton for providing reclamation documents.

6. LITERATURE CITED

ABR Inc. 1995. Literature review of mine reclamation research in the arctic. Prepared for BHP Diamonds Inc. Fairbanks AK. 32 pp.

ABR Inc. 2001. Revegetation of mining disturbances in the north: literature review and identification of research opportunities for the Diavik Diamond Mine, NT, Canada. Prepared for Diavik Diamond Mine Inc. Fairbanks AK. 41 pp.

Adams, P.W. and S. Lamoureux. 2005. A literature review of the use of native northern plants for the revegetation of arctic mine tailings and mine waste. Prepared by Aboriginal Engineering Ltd. 67 pp.

Adkins, S.W. and N.C.B. Peters. 2001. Smoke derived from burnt vegetation stimulates germination of arable weeds. Seed Science Research 11:213-222.

Anderson, D.G. and L.C. Bliss. 1998. Association of plant distribution patterns and microenvironments on patterned ground in a polar desert, Devon Island, NWT, Canada. Arctic and Alpine Research 30:97-107.

Andre, A. and A. Fehr. 2002. Gwich'in Ethnobotany, Plants used by the Gwich'in for food, medicine, shelter and tools. Gwich'in Social and Cultural Institute and Aurora Research Institute. Inuvik NWT. 68 pp.

Aradottir, A.L. 2012. Turf transplants for restoration of alpine vegetation: does size matter? Journal of Applied Ecology 49:439-446.

Aradottir, A.L. and G. Oskarsdottir. 2013. The use of native turf transplants for roadside revegetation in a subarctic area. Icelandic Agricultural Sciences 26:59-67.

Archibold, O.W. 1983. A comparison of seed reserves in arctic, subarctic, and alpine soils. Canadian Field Naturalist 98:337-344.

Ashworth, D.J. and B.J. Alloway. 2004. Soil mobility of sewage sludge-derived dissolved organic matter, copper, nickel and zinc. Environmental Pollution 127:137-144.

Babb, T.A. and L.C. Bliss. 1974. Effects of Physical Disturbance on Arctic Vegetation in the Queen Elizabeth Islands. Journal of Applied Ecology 11:549-562.

Baker, M.J., D.W. Blowes, M.J. Logsdon and J.L. Jambor. 2001. Environmental geochemistry of kimberlite materials, Diavik Diamond Project, Lac de Gras, Northwest Territories, Canada. Exploration and Mining Geology 10:155-163.

Baskin, J.M. and C.C. Baskin. 2003. Classification, biogeography, and phylogenetic relationships of seed dormancy. In: R.D. Smit, J.B. Dickie, S.H. Linington, H.W. Pritchard and R.J. Probert (eds). Seed conservation: turning science into practice. The Royal Botanic Gardens, Kew. London UK. Pp. 518-544.

Batzli, G.O. and S.T. Sobaski. 1980. Distribution, abundance and foraging patterns of ground squirrels near Atkasook, Alaska. Arctic and Alpine Research 12:501-510.

Beatty, S.W. 1984. Influence of microtopography and canopy species on spatial patterns of forest understory plants. Ecology 65:1406-1419.

Beesley, L., E. Moreno-Jiménez, J.L. Gomez-Eyles, E. Harris, B. Robinson and T. Sizmur, 2011. A review of biochars' potential role in the remediation, revegetation and restoration of contaminated soils. Environmental Pollution 159:3269-3282.

Bell, J.N.B. and J.H. Tallis. 1973. *Empetrum nigrum* L. Journal of Ecology 61:289-305.

Bell, D.T. 1999. The process of germination in Australian species. Australian Journal of Botany 47:475-517.

Bell, K.L. and L.C. Bliss. 1980. Plant reproduction in a high arctic environment. Arctic and Alpine Research 12:1-10.

Belyaeva, O.N. and R.J. Haynes. 2012. Comparison of the effects of conventional organic amendments and biochar on the chemical, physical and microbial properties of coal fly ash as a plant growth medium. Environmental Earth Sciences 66:1987-1997.

BHP Diamonds Inc. 1995. Ecological mapping 1995 baseline study update. Prepared by BHP Diamonds Inc. Yellowknife NWT. 70 pp.

Billings, W.D. 1987. Constraints to plant growth, reproduction, and establishment in arctic environments. Arctic and Alpine Research 19:357-365.

Bishop, S.C. and F.S. Chapin III. 1989a. Patterns of natural revegetation on abandoned gravel pads in arctic Alaska. Journal of Applied Ecology 26:1073-1081.

Bishop, S.C. and F.S. Chapin III. 1989b. Establishment of *Salix alaxensis* on a gravel pad in arctic Alaska. Journal of Applied Ecology 26:575-583.

Bittman, K.K. 1997. High elevation native species island model for mine reclamation, Quintette Operating Corporation. In: Proceedings of the 21st annual British Columbia mine reclamation symposium. The Technical and Research Committee on Reclamation. Cranbrook BC. Pp. 12-31.

Black Earth. 2009a. Remediation - mine tailings. Black Earth Humic LP. Edmonton AB. 2 pp.

Black Earth. 2009b. Technical data. Black Earth Humic LP. Edmonton AB. 8 pp.

Bliss, L.C. 1958. Seed germination in arctic and alpine species. Arctic 11:180-188.

Bliss, L.C. 1962. Adaptations of arctic and alpine plants to environmental conditions. Arctic 15:117-144.

Bliss, L.C. and N.E. Grulke. 1988. Revegetation in the high arctic: its role in reclamation of surface disturbance. In: P. Kershaw (ed). Northern Environmental Disturbances. Occasional publication No. 24. Boreal Institute for Northern Studies, University of Alberta. Edmonton AB. Pp. 43-55.

Bowker, M.A. 2007. Biological soil crust rehabilitation in theory and practice: an underexploited opportunity. Restoration Ecology 15:15-23.

Brodo, I.M., S.D. Sharnoff and S.Sharnoff. 2001. Lichens of North America. Yale University Press. New Haven CT. 795 pp.

Bruland, G.L. and C.J. Richardson. 2005. Hydrologic, edaphic, and vegetative responses to microtopographic reestablishment in a restored wetland. Restoration Ecology 13:515-523.

Bryan, D. and R. Bonner. 2003. The Diavik Diamond Mine, Lac De Gras, Northwest Territories, Canada. In: B.A. Kjarsgaard (ed). VIII international kimberlite conference, Slave Province and Northern Alberta Field Trip Guidebook. Pp. 61-65

Cater and Jorgenson. 1991. Land rehabilitation studies in the Kuparuk Oilfield, Alaska, 1993. Prepared for ARCO Alaska Inc. and the Kuparuk River Unit. Prepared by Alaska Biological Research Inc. Fairbanks AK. 36 pp. Cited in: Jorgenson and Joyce 1994.

Cargill, S.M. and F.S. Chapin III. 1987. Application of successional theory to tundra restoration: a review. Arctic and Alpine Research 19:366-372.

Carlsson, B.A. and T.V. Callaghan. 1991. Positive plant interactions in tundra vegetation and the importance of shelter. Journal of Ecology 79:973-983.

Chambers, J.C., J.A. MacMahon and J.H. Haefner. 1991. Seed entrapment in alpine ecosystems: effects of soil particle size and diaspore morphology. Ecology 72:1668-1677.

Chan, K.Y., L. Van Zwieten, I. Meszaros, A. Downie and S. Joseph. 2007. Agronomic values of greenwaste biochar as a soil amendment. Australian Journal of Soil Research 45:629-634.

Chapin III, F.S. and G.R. Shaver. 1989. Differences in growth and nutrient use among arctic plant growth forms. Functional Ecology 3:73-80.

Chapin III, F.S. and M.C. Chapin. 1980. Revegetation of an arctic disturbed site by native tundra species. Journal of Applied Ecology 17:449-456.

Clark, A. and T. Hutchinson 2005. Enhancing natural succession on Yukon mine tailings sites: a low-input management approach. Prepared for the Mining Environment Research Group. MERG Report 2005-3. Whitehorse YK. 101 pp.

Cobbaert, D., L. Rochefort and J.S. Price. 2004. Experimental restoration of a fen plant community after peat mining. Applied Vegetation Science 7:209-220.

Cody, W.J. 2000. Flora of the Yukon Territory. Second edition. National Research Council Press. Ottawa ON. 669 pp.

Cooper, E.J., I.G. Alsos, D. Hagen, F.M. Smith, S.J. Coulson and I.D. Hodkinson. 2004. Plant recruitment in the High Arctic: seed bank and seedling emergence on Svalbard. Journal of Vegetation Science 15:115-124.

Crawford, R.M.M. 1989. Studies in Plant Survival: Ecological Case Histories of Plant Adaptation to Adversity. Blackwell Scientific Publications. Oxford UK.

Crum, H.A. 1983. Mosses of the Great Lakes Forest. Third edition. University of Michigan Herbarium. Ann Arbor MI. 417 pp.

Davidson, E.A. and I.A. Janssens. 2006. Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. Nature 440:165-173.

Davis, W.A. 1998. Responses of tundra vegetation, soil and microclimate to disturbances associated with the 1943 construction of the CANOL No. 1 pipeline, N.W.T. MSc thesis, Department of Earth and Atmospheric Sciences, University of Alberta. Edmonton AB. 146 pp.

Den Herder, M., M.-M. Kytöviita, P. Niemelä. 2003. Growth of reindeer lichens and effects of reindeer grazing on ground cover vegetation in a Scots pine forest and a subarctic heathland in Finnish Lapland. Ecography 26:3-12.

Densmore, R.V. and K.W. Holmes. 1987. Assisted revegetation in Denali national park, Alaska, USA. Arctic and Alpine Research 19:544-548.

Densmore, R.V. 1992. Succession on an Alaskan tundra disturbance with and without assisted revegetation with grass. Arctic and Alpine Research 24:238-243.

Densmore, R.V. 1994. Succession on regraded placer mine spoil in Alaska, U.S.A., in relation to initial site characteristics. Arctic and Alpine Research 26:354-363.

Densmore, R.V., B.J. Neiland, J.C. Zasada and M.A. Masters. 1987. Planting willow for moose habitat restoration on the north slope of Alaska, USA. Arctic and Alpine Research 19:537-543.

Densmore, R.V., M.E. Vander Meer and N.G. Dunkle. 2000. Native plant revegetation manual for Denali National Park and Preserve. US Department of the Interior, US Geological Survey and Biological Resources Division. Information and Technology Report USGS/BRD/JTR-2000-0006. Springfield VA. 52 pp.

Denyes, M.J., V.S. Langlois, A. Rutter and B.A. Zeeb. 2012. The use of biochar to reduce soil PCB bioavailability to *Cucurbita pepo* and *Eisenia fetida*. Science of the Total Environment 437:76-82.

Deshaies, A., S. Boudreau and K.A. Harper. 2009. Assisted revegetation in a subarctic environment: effects of fertilization on the performance of three indigenous plant species. Arctic, Antarctic and Alpine Research 41:434-441.

Diavik Diamond Mine Inc. 2010a. Diavik Diamond Mine fact book. Diavik Diamond Mine Inc. Yellowknife NT. 20 pp.

Diavik Diamond Mine Inc. 2010b. Interim closure and reclamation plan - version 3.1. Diavik Diamond Mine Inc. Yellowknife NT. 201 pp.

Drozdowski, B.L., M.A. Naeth and S.R. Wilkinson. 2012. Evaluation of substrate and amendment materials for soil reclamation at a diamond mine in the Northwest Territories, Canada. Canadian Journal of Soil Science 92:77-88.

Duncan, S. 2011. Reindeer lichen transplant feasibility for reclamation of lichen ecosites on Alberta's Athabasca oil sands mines. MSc thesis, School of Environmental Studies, University of Victoria. Victoria, BC. 143 pp.

Durst, J.D. 1984. Small mammals in relation to natural revegetation of gold dredge tailings at Nyac, Alaska. MSc thesis, University of Alaska. Fairbanks AK. 105 pp.

Ebersole, J.J. 1989. Role of the seed bank in providing colonizers on a tundra disturbance in Alaska. Canadian Journal of Botany 67:466-471.

Ecosystem Classification Group. 2012. Ecological regions of the Northwest Territories - southern arctic. Department of Environment and Natural Resources, Government of the Northwest Territories. Yellowknife NT. 183 pp.

Edmonds, R.L. 1976. Survival of coliform bacteria in sewage sludge applied to a forest clearcut and potential movement into groundwater. Applied and Environmental Microbiology 32:537-546.

Eldridge, D.J., M. Westoby and K.G. Holbrook. 1991. Soil-surface characteristics,

microtopography and proximity to mature shrubs: effects on survival of several cohorts of *Atriplex vesicaria* seedlings. Journal of Ecology 79:357-364.
Elmarsdottir, A., A.L. Aradottir and M.J. Trlica. 2003. Microsite availability and establishment of native species on degraded and reclaimed sites. Journal of Applied Ecology 40:815-823.
Fellet, G., L. Marchiol, G.D. Vedove and A. Peressotti. 2011. Application of biochar on mine tailings: effects and perspectives for land reclamation. Chemosphere 83:1262-1267.
Ficko, S.A., B. Smith and B. Zeeb. Assisted revegetation following contaminated site remediation in the Arctic: a case study of a former radar site. In prep.
Finch-Savage, W.E. and G. Leubner-Metzger. 2006. Seed dormancy and the control of germination. New Phytologist 171:501-523.
Forbes, B.C. 1994. The importance of bryophytes in the classification of human-disturbed high arctic vegetation. Journal of Vegetation Science 5:877-874.
Forbes, B.C. and R.L. Jefferies. 1999. Revegetation of disturbed arctic sites: constraints and applications. Biological Conservation 88:15-24.
Foy, C.D., R.L.T. Chaney and M.C. White. 1978. The physiology of metal toxicity in plants. Annual Review of Plant Physiology 29:511-566.
Gage, E.A. and D.J. Cooper. 2004. Controls on willow cutting survival in a montane riparian area. Rangeland Ecology and Management 57:597-600.
Galiulin, R.V., V.N. Bashkin and R.A. Galiulina. 2013. Application of peat to land reclamation ina natural gas production area. Solid Fuel Chemistry 47:249-251.
Gignac, L.D., D.H. Vitt, S.C. Zoltai and S.E. Bayley. 1991. Bryophyte response surfaces along climatic, chemical, and physical gradients in peatlands of western Canada. Nova Hedwigia 53:27-71.
Gold, W.G. 1998. The influence of cryptogamic crusts on the thermal environment and temperature relations of plants in a high arctic polar desert, Devon Island, N.W.T., Canada. Arctic and Alpine Research 30:108-120.
Gorham, E. and L. Rochefort. 2003. Peatland restoration: a brief assessment with special reference to Sphagnum bogs. Wetlands Ecology and Management 11:109-119.
Government of Canada. 2000. Environmental agreement. On line at http://www.diavik.ca/documents/DiavikEnvironmentalAgreement.pdf. Accessed April 16, 2013.
Granstrom, A. 1982. Seed viability of fourteen species during five years of storage in a forest soil. Journal of Ecology 75:321-331.
Gretarsdottir, J., A.L. Aradottir, V. Vandvik, E. Heegaard and H.J.B. Birks. 2004. Long term effects of reclamation treatments on plant succession in Iceland. Restoration Ecology 12:268-278.
Grosbois, T.D., G.P. Kershaw and J.R. Eyton. 1991. The regrowth production and allocation of Salix arbusculoides in three growing seasons following right-of-way clearing. Canadian Journal of Forest Research 21:1171-1179.
Hagen, D. 2002. Propagation of native Arctic and alpine species with a restoration potential. Polar Research 21:37-47.
Halloran, J.E. 1986. A study of the natural revegetation of placer tailings. Report, US Department of Interior, Bureau of Land Management, Alaska State Office. Anchorage AK.
Harper, J.L. 1977. Population biology of plants. Academic Press. London UK.
Harper, K.A. and G.P. Kershaw. 1996. Soil characteristics of 48-year-old borrow pits and vehicle tracks in shrub tundra along the CANOL No. 1 pipeline corridor, Northwest Territories, Canada. Arctic and Alpine Research 29:105-111.
Harper, J.L., J.T. Williams and G.R. Sagar. 1965. The behavior of seeds in soil: I. the heterogeneity of soil surfaces and its role in determining the establishment of plants from seed. Journal of Ecology 53:273-286.
Helle, T., J. Aspi and L. Tarvainen. 1983. The growth rate of *Cladonia rangiferina* and *C. mitis* in relation to forest characteristics in northeastern Finland. Rangifer 3:2-5.

Hilty, J.H., D.J. Eldridge, R. Rosentreter, M.C. Wicklow-Howard and M. Pellant. 2004. Recovery of biological soil crusts following a wildfire in Idaho. Journal of Range Management 57:89-96.

Holloway, P.S. and M.R. Petersburs. 2009. Propagation of twelve Alaska native plants by summer stem cuttings. Journal of Environmental Horticulture 27:2017-210.

Holloway, P. and J.C Zasada. 1979. Vegetative propagation of 11 common Alaska woody plants. Vol. 334. Dept. of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 pp.

Houben, D. 2013. Heavy metal mobility in contaminated soils as affected by plants, amendments and biochar: implications for phytostabilization. PhD dissertation, Department of Science, Université catholique de Louvain. Louvain-la-Neuve BE. 303 pp.

Houle, G. and P. Babeux. 1998. The effects of collection date, IBA, plant gender, nutrient availability, and rooting volume on adventitious root and lateral shoot formation by *Salix planifolia* stem cuttings from the Ungava Bay area (Quebec, Canada). Canadian Journal of Botany 76:1687-1692.

Houle, G. and P. Babeux. 1994. Fertilizing and mulching influence on the performance of four native woody species suitable for revegetation in subarctic Quebec. Canadian Journal of Forest Research 24:2342-2349.

Hoyle, G.L., S.E. Venn, K.J. Steadman, R.B. Good, E.J. Mcauliffe, E.R. Williams and A.B. Nicotra. 2013. Soil warming increases plant species richness but decreases germination from the alpine soil seed bank. Global Change Biology 19:1549-1561.

Hutchinson, T.C. and A.L. Kuja. 1988. The use of native and agricultural plant species to revegetate northern mine tailings. NOGAP project no. A17: Surface and subsurface disturbances induced by oil and gas activities. Environmental Studies. Canada Department of Indian Affairs and Northern Development 43 (vii). 50 pp.

Jacobs, L. J., M. T. Jorgenson, and T. C. Cater. 1994. Wetland creation and revegetation on an overburden stockpile at Mine Site D, Kuparuk Oilfield, 1993. Annual report. Prepared for ARCO Alaska, Inc. Prepared by Alaska Biological Research Inc. Fairbanks, AK. Cited in: ABR Inc 1995.

Jandt, R., K. Joly, C.R. Meyers and C. Racine. 2008. Slow recovery of lichen on burned caribou winter range in Alaska tundra: potential influences of climate warming and other disturbance factors. Arctic, Antarctic, and Alpine Research 40:89-95.

Johnson, E.A. and G.I. Fryer. 1992. Physical characterization of seed microsites - movement on the ground. Journal of Ecology 80:823-836.

Johnson, L.A. 1987. Management of northern gravel sites for successful reclamation: a review. Arctic and Alpine Research 19:530-536.

Jones, D.L., J. Rousk, G. Edwards-Jones, T.H. DeLuca and D.V. Murphy. 2012. Biochar-mediated changes in soil quality and plant growth in a three year field trial. Soil Biology and Biochemistry 46:113-124.

Jones, M.H., S.E. MacDonald and G.H.R. Henry. 1999. Sex- and habitat-specific responses of a high arctic willow, *Salix arctica* to experimental climate change. Oikos 87:129-138.

Jorgenson, M.T., T.T. Heffernan and B.K. Lance. 1990. Land rehabilitation studies in the Kuparuk Oilfield, Alaska, 1989. Annual report. Prepared for ARCO Alaska Inc. Prepared by Alaska Biological Research Inc. Fairbanks AK. 132 pp. Cited in: Jorgenson and Joyce 1994.

Jorgenson, M.T., J.G. Kidd and T.C. Cater. 1992. Rehabilitation of a thick gravel pad using snow capture and topsoil addition, Drill site 13, Prudhoe Bay Oilfield Alaska, 1991. Prepared by Alaska Biological Research Inc. Fairbanks AK. Cited in: ABR Inc 1995.

Jorgenson, M.T., T.C. Cater and M.R. Joyce. 1993. Use of snow capture for land rehabilitation in Arctic oilfields. In: Permafrost 6th international conference proceedings, July 5-9, 1993, South China University of Technology. South China University of Technology Press, Beijing

China. Pp. 316-312.
Jorgenson, M.T. and M.R. Joyce. 1994. Six strategies for rehabilitating land distributed by oil development in arctic Alaska. Arctic 47:374-390.
Jumpponen, A., H. Väre, K.G. Mattson, R. Ohtonen and J.M. Trappe. 1999. Characterization of safe sites for pioneers in primary succession on recently deglaciated terrain. Journal of Ecology 87:98-105.
Kershaw, K.A. 1976. Studies on lichen-dominated systems. An examination of some aspects of the northern boreal lichen woodlands in Canada. Canadian Journal of Botany 55:393-410.
Kershaw, P. and L.J. Kershaw. 1987. Successful plant colonizers on disturbances in tundra areas of Northwestern Canada. Arctic and Alpine Research 19:451-460.
Kidd, J.G. 1996. Natural resources inventory and pilot revegetation study, Fox Decline Mine Site, NWT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 36 pp.
Kidd, J.G. and S.C. Bishop. 1999. Air quality monitoring at the Ekati diamond mine using vegetation and lichnes as bioindicators. Prepared for BHP Diamonds Inc. Prepared by ABR Inc. Fairbanks AK. 39 pp.
Kidd, J.G. and K.N. Max. 2000a. Ekati Diamond Mine reclamation research program, 1999, NT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 67 pp.
Kidd, J.G. and K.N. Max. 2000b. Ekati Diamond Mine reclamation research program, 2000, NT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 63 pp.
Kidd, J.G. and K.N. Max. 2001. Ekati Diamond Mine reclamation research program, 2001, NT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 43 pp.
Kidd, J.G. and K.N. Max. 2002. Ekati Diamond Mine reclamation research program, 2002, NT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 34 pp.
Kidd, J.G. and L.J. Rossow. 1997. Pilot revegetation study at the Fox Portal Site, NWT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 36 pp.
Kidd, J.G. and L.J. Rossow. 1998. Pilot revegetation study at the Fox portal site, Ekati Diamond Mine, NWT, Canada. Annual Report. Prepared for BHP Billiton Canada Inc. Prepared by ABR Inc. Fairbanks AK. 42 pp.
Kidd, J.G., B. Streever and M.T. Jorgenson. 2006. Site characteristics and plant development following partial gravel removal in an arctic oilfield. Arctic, Antarctic, and Alpine Research 38:384-393.
Kirschbaum, M.U.F. 1995. The temperature dependence of soil organic matter decomposition, and the effect of global warming on soil organic C storage. Soil Biology and Biochemistry 27:753-760.
Klein, D.R. 1987. Vegetation recovery patterns following overgrazing by reindeer on St. Matthew Island. Journal of Range Management 40:336-338.
Klein, D.R. and M. Shulski. 2011. The role of lichens, reindeer, and climate in ecosystem change on a Bering Sea Island. Arctic 64:353-361.
Klokk, T. and O.I. Rønning. 1987. Revegetation experiments at Ny-Ålesund, Spitsbergen, Svalbard. Arctic and Alpine Research 19:549-553.
Kuntz, K.L. and D.W. Larson. 2006. Microtopographic control of vascular plant, bryophyte and lichen communities on cliff faces. Plant Ecology 185:239-253.
Kwiatkowski, B.L. 2007. Diamond mine reclamation in the NWT: substrates, soil amendments and native plant community development. MSc thesis, Department of Renewable Resources, University of Alberta. Edmonton AB. 126 pp.

Leck, M.A., V.T. Parker and R.L. Simpson. 1989. Ecology of soil seed banks. Academic Press, Toronto ON. 462 pp.
Lewis, R. 2009. Owner, Arctic Alpine Seed Ltd. Personal communication, March-April 2009.
Liem, L.E. 2010. Black Earth Humic LP: raw material, products, and market. Black Earth Humic LP. Edmonton AB. 2 pp.
Liem, L.E., R.M. Facey, I. Carrigan, J. Blyth, M. Fischer and A. Henderson. 2003. Enhanced bioremediation through the addition of humic substances. In: Sudbury 2003 mining and the environment III conference. Canadian Land Reclamation Association and Centre for Environmental Monitoring. Sudbury ON. 8 pp.
Lloyd, J. and J.A. Taylor. 1994. On the temperature dependence of soil respiration. Functional Ecology 315-323.
Longton, R.E. 1980. Physiological ecology of mosses. In: R.J. Taylor and A.E. Leviton (eds). The Mosses of North America. Pacific Division, American Association for the Advancement of Science. San Francisco CA. Pp. 77-113
Longton, R.E. 1988. The biology of polar bryophytes and lichens. Cambridge University Press. Avon United Kingdom. 391 pp.
Mackenzie, D.D. 2012. Oil sands mine reclamation using boreal forest surface soil (LFH) in northern Alberta. PhD dissertation, Department of Renewable Resources, University of Alberta. Edmonton AB. 240 pp.
Mackenzie, D.D. and M.A. Naeth. 2010. The role of the forest soil propagule bank in assisted natural recovery after oil sands mining. Restoration Ecology 18:418-427.
Macyk, T.M. and V.G. Belts. 1995. Establishment of trees and shrubs on mined land in the subalpine region of Alberta. In: Proceedings of the 19th annual British Columbia mine reclamation symposium. The Technical and Research Committee on Reclamation. Dawson Creek BC. Pp. 45-53.
Magnússon, S.H. 1997. Restoration of eroded areas in Iceland. Restoration Ecology and Sustainable Development 188-211.
Magnússon, S.H. 1994. Plant colonization of eroded areas in Iceland. PhD dissertation, Lund University. Lund Sweden.
Magnúsdóttir, M. and A.L. Aradóttir. 2011. Leiðir til að fjölga hraungambra og öðrum mosategundum. Náttúrufræðingurinn 81:115–122.
Maher, E.L. and M.J. Germino. 2006. Microsite differentiation among conifer species during seedling establishment at alpine treeline. Écoscience 13:334-341.
Maikawa, E. and K.A. Kershaw. 1976. Studies on lichen-dominated systems. XIX. The postfire recovery sequence of black spruce - lichen woodland in the Abitau Lake Region, N.W.T. Canadian Journal of Botany 54:2679-2687.
Major, J., M. Rondon, D. Molina, S.J. Riha and J. Lehmann. 2010. Maize yield and nutrition during 4 years after biochar application to a Columbian savanna oxisol. Plant and Soil 333:117-128.
Martens, R. 1995. Current methods for measuring microbial biomass-C in soil: Potentials and limitations. Biology and Fertility of Soils 19:87-99.
Martens, H.E. 2000. Ekati diamond mine processed kimberlite tailings reclamation research program 2000. Annual report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 44 pp.
Martens, H.E. 2001. Ekati diamond mine processed kimberlite tailings reclamation research program 2001. Annual report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 79 pp.
Martens, H.E. 2002. Ekati diamond mine processed kimberlite tailings reclamation research program 2002. Annual report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 99 pp.
Martens, H.E. 2003. Ekati diamond mine processed kimberlite tailings reclamation research

program 2003. Annual report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 62 pp.
Martens, H.E. 2005. Ekati diamond mine revegetation research projects 2004. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 127 pp.
Martens, H.E. 2006. Ekati diamond mine revegetation research projects 2005. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 52 pp.
Martens, H.E. 2007. Ekati diamond mine revegetation research projects 2006 and 2007. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 191 pp.
Martens, H.E. 2009. Ekati Diamond Mine revegetation research projects 2008. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 73 pp.
Martens, H.E. 2010. Ekati Diamond Mine revegetation research projects 2009. Final report. Prepared for BHP Billiton Canada Inc. Prepared by: Harvey Martens and Associates Inc. Calgary AB. 37 pp.
Martens, H.E. 2011. Ekati Diamond Mine revegetation research projects 2010. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 80 pp.
Martens, H.E. 2012. Ekati Diamond Mine revegetation projects – 2011. Final report. Prepared for BHP Billiton Canada Inc. Prepared by Harvey Martens and Associates Inc. Calgary AB. 108 pp.
Maslen, L. A. 1989. Revegetation trials on a simulated pipeline trench using selected native plant species, Fort Norman, NWT. MSc thesis, Department of Earth and Atmospheric Sciences, University of Alberta. Edmonton AB. 135 pp.
Maslen, L.A. and G.P. Kershaw. 1989. First year results of revegetation trials using selected native plant species on a simulated pipeline trench, Fort Norman, N.W.T., Canada. In: Proceedings of the conference reclamation, a global perspective, August 27-31 1989, Calgary AB. Alberta Land Conservation and Reclamation Council, Report No. RRTAC 89-2. Edmonton AB. Pp 81-90.
Matheus, P. and T. Omtzigt. 2012. Yukon revegetation manual. Practical approaches and methods. Mining and Petroleum Environmental Research Group. 176 pp.
McGraw, J.B. 1980. Seed bank size and distribution of seeds in cottongrass tussock tundra, Eagle Creek, Alaska. Canadian Journal of Botany 58:1607-1611.
McKendrick, J.D. 1996. Fourth through sixth year (1993-95) results from gravel revegetation tests on BP Put River No. 1 pad. Palmer, Alaska: University of Alaska Fairbanks, Alaska Agricultural and Forestry Experiment Station. Fairbanks AK. 22 pp.
McKendrick, J.D. 1997. 25 years in perspective: arctic tundra revegetation. Agroborealis 23:29-40.
McKendrick, J.D., G.O. Batzli, K.R. Everett and J.C. Swanson. 1980. Some effects of mammalian herbivores and fertilization on tundra soils and vegetation. Arctic and Alpine Research 565-578.
McTavish, B. and T. Shoplik. 1983. Propagation and use of native woody plants in northern latitudes. In: Proceedings of the 7th annual British Columbia mine reclamation symposium. The Technical and Research Committee on Reclamation. Victoria BC. Pp. 159-181.
Miles, N. and N.M. Tainton.1979. Establishing vegetation on kimberlite mine tailings: 2. field trials. In: Proceedings of the annual congresses of the Grassland Society of Southern Africa 14:43-48.
Mitchell, W.W. 1972. Red fescue and bluegrass rank high in frequent-cut test. Agroborealis 4:30-31.

Mori, A.S., T. Osono, M. Uchida and H. Kanda. 2008. Changes in the structure and heterogeneity of vegetation and microsite environments with the chronosequence of primary succession on a glacier foreland in Ellesmere Island, high arctic Canada. Ecological Restoration 23:363-370.

Mori, A.S., T. Osono, S. Iwasaki, M. Uchida and H. Kanda. 2006. Initial recruitment and establishment of vascular plants in relation to topographical variation in microsite conditions on a recently-deglaciated moraine on Ellesmere Island, high arctic Canada. Polar Bioscience 19:85-95.

Naeth M.A. and S.R. Wilkinson. 2008. Lichens as biomonitors of air quality around a diamond mine, Northwest Territories, Canada. Journal of Environmental Quality 37-1675-1684.

Naeth, M.A. and S.R. Wilkinson. 2010. Diamond Mine Reclamation in the Northwest Territories substrates, soil amendments and native plant community development phase I final report. Prepared for Diavik Diamond Mine Inc. Edmonton AB. 39 pp.

Naeth, M.A. and S.R. Wilkinson. 2011. Reclamation at the Diavik Diamond Mine in the Northwest Territories substrates, soil amendments and native plant community development phase II final report. Prepared for Diavik Diamond Mine Inc. Edmonton AB. 31 pp.

Naeth, M.A. and S.R. Wilkinson. 2014a. Establishment of restoration trajectories for upland tundra communities on diamond mine wastes in the Canadian arctic. Restoration Ecology 22:534-543.

Naeth, M.A. and S.R. Wilkinson 2014b. Reclamation of disturbed sites as Jericho diamond mine, Nunavut. Final report. Prepared for Shear Diamonds Ltd.

Natural Resources Canada. 2011. Canadian minerals yearbook (CMY) - 2008. On line at http://www.nrcan.gc.ca/minerals-metals/business-market/canadian-minerals-yearbook/2008-review/3181. Accessed May 10 2013.

Nichols, G.E. 1934. The influence of exposure to winter temperatures upon seed germination in various native american plants. Ecology 15:364-373.

OASIS Environmental Inc. 2004. North Slope plant establishment guidelines table. Prepared for BP Exploration (Alaska), ConocoPhillips Alaska, ABR Inc and Lazy Mountain Research.

Oberbauer, S. and P.C. Miller. 1982. Growth of Alaskan tundra plants in relation to water potential. Ecography 5:194-199.

Ostendorf, B. and J.F. Reynolds. 1998. A model of arctic tundra vegetation derived from topographic gradients. Landscape Ecology 13:187-201.

Outridge, P.M. and A.M. Scheuhammer. 1993. Bioaccumulation and toxicology of chromium: implications for wildlife. Reviews of Environmental Contamination and Toxicology, volume 30. Springer-Verlag. New York NY.

Pakarinen, P and D.H. Vitt. 1974. The major organic components and caloric contents of high arctic bryophytes. Canadian Journal of Botany 52:1151-1161.

Pegau, R.E. 1968. Growth rates of important reindeer forage lichens on the Seward Peninsula, Alaska. Arctic Institute of North America 21:255-259.

Peterson, K.M. and W.D. Billings. 1980. Tundra vegetational patterns and succession in relation to microtopography near Atkasook, Alaska. Arctic and Alpine Research 12:473-482.

Polster, D.F. 1991. Natural vegetation succession and sustainable reclamation. In: Proceedings of the 15th annual British Columbia mine reclamation symposium. The Technical and Research Committee on Reclamation. Kamloops BC. Pp. 59-69.

Porsild, A.E. and W.J. Cody. 1981. Vascular plants of the continental Northwest Territories, Canada. National Museums of Canada. Ottawa ON. 667 pp.

Price, J., L. Rochefort and F. Quinty. 1998. Energy and moisture considerations on cutover peatlands: surface microtopography, mulch cover and *Sphagnum* regeneration. Ecological Engineering 10:293-312.

Rausch, J. and G.P. Kershaw. 2007. Short-term revegetation performance on gravel-dominated,

human-induced disturbances, Churchill, Manitoba, Canada. Arctic, Antarctic and Alpine Research 39:16-24.
Reid, N.B. 2002. Establishment of a vegetation cover on kimberlite mine tailings. MSc thesis. Department of Renewable Resources, University of Alberta. Edmonton AB. 124 pp.
Reid, N.B. and M.A. Naeth. 2002. Ekati Diamond Mine processed kimberlite reclamation. In: Proceedings of the 26th annual British Columbia mine reclamation symposium. The Technical and Research Committee on Reclamation. Dawson Creek BC. Pp. 71-75.
Reid, N.B. and M.A. Naeth. 2005a. Establishment of a vegetation cover on tundra kimberlite mine tailings: 1. a greenhouse study. Restoration Ecology 13:594-601.
Reid, N.B. and M.A. Naeth. 2005b. Establishment of a vegetation cover on tundra kimberlite mine tailings: 1. a field study. Restoration Ecology 13:602-608.
Rein, W.H., R.D. Wright and J.R. Seiler. 1991. Propagation medium moisture level influences adventitious rooting of woody stem cuttings. Journal of the American Society for Horticultural Science 116:632-636.
Rio Tinto. 2013. Diavik Diamond Mine visitor information booklet. On line at http://www.diavik.ca/documents/Diavik_visitor_information_booklet.pdf. Accessed April 30 2013.
Rhéaume, G. and M. Caron-Vuotari. 2013. The future of mining in Canada's north. Centre for the North, The Conference Board of Canada. Ottawa ON. 92 pp.
Roturier, S. 2009. Managing reindeer lichen during forest regeneration procedures: linking Sámi herders' knowledge and forestry. PhD dissertation. Department of Forest Ecology and Management, Swedish University of Agricultural Sciences. Umeå. French National Museum of Natural History, Department of Ethnobiology and Eco-anthropology. Paris FR. 71 pp.
Roturier, S. and U. Bergsten. 2009. Establishment of *Cladonia stellaris* after artificial dispersal in an unfenced forest in northern Sweden. Rangifer 29:39-49.
Roturier, S., S. Bäcklund, M. Sundén and U. Bergsten. 2007. Influence of ground substrate on establishment of reindeer lichen after artificial dispersal. Silva Fennica 41:269-280.
Rutherford, C. and K. Meyer. 1981. Revegetation on gold dredge tailings, Nyac Alaska. US Bureau of Land Management, Anchorage District. Anchorage AK. 51 pp.
Rydgren, K., R. Halvorsen, A. Odland and G. Skjerdal. 2011. Restoration of alpine spoil heaps: successional rates predict vegetation recovery in 50 years. Ecological Engineering 37:294-301.
Rykaart, M. and D. Hockley. 2010. Cold regions cover research - phase 2. Prepared for Indian and Northern Affairs Canada and Mine Environment Neutral Drainage. Prepared by SRK Consulting. Vancouver BC. 72 pp.
Schaff, S.D., S.R. Pezeshki and F.D. Shields Jr. 2002. Effects of pre-planting soaking on growth and survival of black willow cuttings. Restoration Ecology 10:267-274.
Schofield, W.B. 1972. Bryology in arctic and boreal North America and Greenland. Canadian Journal of Botany 50:1111-1133.
Schuman, G.E., E.J. Depuit and K.M. Roadifer. 1994. Plant responses to gypsum of sodic bentonite mine spoil. Journal of Range Management 47:206-209.
Schwienbacher, E., J.A. Navarro-Cano, G. Neuner and B. Erschbamer. 2011. Seed dormancy in alpine species. Flora 206:845-856.
Scotter, G.W. 1963. Growth rates of *Cladonia alpestris, C. mitis*, and *C. rangiferina* in the Taltson River Region, N.W.T. Canadian Journal of Botany 41:1199-1202.
Shaver, G.R. and F.S. Chapin III. 1995. Long-term responses to factorial, NPK fertilizer treatment by Alaskan wet and moist tundra sedge species. Ecography 18:259-275.
Shirazi, M.A., P.K. Haggerty, C.W. Hendricks and M. Reporter. 1998. The role of thermal regime in tundra plant community restoration. Restoration Ecology 6:111-117.
Similä, M., K. Aapala, J. Penttinen and T. Haapalehto. 2011. Monitoring the ecological effects of peatland restoration in Finland. In: G. Halldórsson (ed). Book of abstracts. Restoring the

north – challenges and opportunities. International Restoration Conference, 20-22 October 2011, Iceland. Soil Conservation Service of Iceland and Agricultural University of Iceland. Pp. 47.

Slaymaker, O. 2009. Proglacial, periglacial or paraglacial? In: J. Knight and S. Harrison (eds). Periglacial and Paraglacial Processes and Environments. Geological Society. London UK. Pp. 71-84.

Smith, M. and J. Capelle. 1992. Effects of soil surface microtopography and litter cover on germination, growth and biomass production of Chicory (*Cichorium intybus* L.). American Midland Naturalist 128:246-253.

Sohi, S., E. Lopez-Capel, E. Krull and R. Bol. 2009. Biochar, climate change and soil: a review to guide future research. CSIRO Land and Water Science Report. Glen Osmond AU. 65 pp.

Sohlberg, E.H. and L.C. Bliss. 1984. Microscale pattern of vascular plant distribution in two high arctic plant communities. Canadian Journal of Botany 62:2033-2042.

Sterling, A., B. Peco, M.A. Casado, E.F. Galiano and F.D. Pineda. 1984. Influence of microtopography on floristic variation in the ecological succession in grassland. Oikos 42:334-342.

Stevens, C.J. 2006. Primary revegetation on processed kimberlite at De Beer's Victor Diamond Project near Attawapiskat, Ontario. MSc thesis. Department of Biology, Laurentian University. Sudbury ON. 139 pp.

Streever, B. 2001. Tundra revegetation in Alaska's arctic. Technical brief: Alaska's North Slope Oilfields. Prepared for BP Exploration (Alaska) Inc. Anchorage AK. 6 pp.

Streever, W.J., J. McKendrick, L. Fanter, S.C. Anderson, J. Kidd and K.M. Portier. 2003. Evaluation of percent cover requirements for revegetation of disturbed sites on Alaska's north slope. Arctic 56:234-248.

Thompson, D.C. and K.H. McCourt. 1981. Seasonal diets of the Porcupine caribou herd. American Midland Naturalist 105:70-76.

Tucker Carter, C. and I.A. Ungar. 2002. Aboveground vegetation, seed bank and soil analysis of a 31-year-old forest restoration on coal mine spoil in Southeastern Ohio. The American Midland Naturalist 147:44-59.

Umbanhower Jr., C.E. 1992. Early patterns of revegetation of artificial earthern mounds in a northern mixed prairie. Canadian Journal of Botany 70:145-150.

Urbanska, K. M. 1997. Restoration ecology research above the timberline: colonization of safety islands on a machine-graded alpine ski run. Biodiversity and Conservation 6:1655-1670.

van der Wal, R., S.M.J. van Lieshout and M.J.J.E. Loonen. 2001. Herbivore impact on moss depth, soil temperature and arctic plant growth. Polar Biology 1:29-32.

Van Staden, J., N.A.C. Brown, A.K. Jäger and T.A. Johnson. 2000. Smoke as a germination cue. Plant Species Biology 15:167-178.

Vavrek, M.C., N. Fetcher, J.B. McGraw, G.R. Shaver, F.S. Chapin III and B. Bovard. 1999. Recovery of productivity and species diversity in tussock tundra following disturbance. Arctic, Antarctic, and Alpine Research 31:254-258.

Vitt, D.H., J.E. Marsh and R.B. Bovey. 1988. Mosses, Lichens & Ferns of Northwest North America. Lone Pine Publishing. Edmonton AB. 296 pp.

Walker, D.A. 1996. Disturbance and recovery of arctic Alaskan vegetation. In: J.F. Reynolds and J.D. Tenhunen (eds). Landscape Function and Disturbance in Arctic Tundra. Ecological Studies Series 120. Springer-Verlag. Berlin DE. Pp. 35-70.

Webber, P.J. and J.D. Ives. 1978. Damage and recovery of tundra vegetation. Environmental Conservation 5:171-182.

Weng, L., E.J. Temminghoff, S. Lofts, E. Tipping and W. H. Van Riemsdijk. 2002. Complexation with dissolved organic matter and solubility control of heavy metals in a sandy soil. Environmental Science and Technology 36:4804-4810.

Whitehead, F.H. 1959. Vegetational changes in response to alterations of surface roughness on M. Maiella, Italy. Journal of Ecology 47:603-606.

Withers, S.P. 1999. Natural vegetation succession and sustainable reclamation at Yukon mine and mineral exploration sites. Prepared for Mining Environment Research Group. Whitehorse YT. 66 pp.

Younkin, W.E. and H.E. Martens. 1987. Abandoned rig site A-01 Caribou Hills, N.W.T., Canada. Arctic and Alpine Research 19:566-571.

Zhelezona, G.V., E.G. Kuznetsova, T.V. Evdoklmova and L.P. Turubanova. 2005. Monitoring of vegetation development in technogenically disturbed areas of the Usinskoe oil field. Russian Journal of Ecology 36:243-248.

Appendix II-5

Reclamation of Disturbed Sites at Diavik Diamond Mine – 2014 Annual Report.

RECLAMATION OF DISTURBED SITES AT DIAVIK DIAMOND MINE

2014 ANNUAL REPORT

Prepared By
Dr. M. Anne Naeth
Ms. Valerie S. Miller
Ms. Sarah A. Ficko
Ms. Jasmine Lamarre
Ms. Sarah R. Wilkinson
Department of Renewable Resources
University of Alberta

Submitted To
Mr. Gord Macdonald
Diavik Diamond Mines Inc.

October 2014

1. BACKGROUND

Exploration and mining for metals and minerals has been increasing at a rapid rate in Canada and around the world. Industrial development is often occurring at a faster pace than reclamation techniques, especially in the arctic. Following their discovery in the mid 1990s, diamonds have been mined in the Canadian north which has led to various disturbances, including removal of soil, road construction, infrastructure development and creation of waste rock piles. These activities leave areas partially or completely devoid of soil and vegetation, making them unstable, visually unappealing, vulnerable to wind and water erosion and unable to provide food or habitat for fauna.

Concerns over mining impacts on wildlife, human health and the environment have prompted government agencies to require reclamation of mining disturbances to viable and sustainable ecosystems to protect resource function and integrity. Without reclamation, these areas could take hundreds to thousands of years to recover naturally due to the harsh environmental conditions (e.g. short growing season, high winds, low temperature, low rainfall) (Billings 1987, Forbes and Jefferies 1999). Despite decades of research, knowledge of effective reclamation strategies for severely disturbed sites is poor. Development of innovative, cost effective and sustainable methods to reclaim disturbed land is imperative.

From 2004 to 2009, research was conducted at Diavik Diamond Mine, examining effectiveness of amendments and substrates for improving soil and native plant community development (Drozdowski et al. 2012, Naeth and Wilkinson 2014). In northern environments with limited access, reclamation must maximize use of onsite waste materials and minimize use of external materials. Anthroposols are soils that have been altered or created by human activity, often during land reclamation (Naeth et al. 2012). Several materials and amendments showed promise for soil building, others were less successful. Organic matter or fertilizer enhanced revegetation on some substrates. Planting native propagules was essential as native species are slow growing with low colonization rates (Drozdowski et al. 2012, Naeth and Wilkinson 2014). Micro topographic variability was observed to enhance reclamation but little quantitative research has addressed mechanisms by which it affects germination, establishment, recruitment and plant community development. Processed kimberlite contained high levels of metals including cadmium, chromium and nickel and it is not known if native plants, potential forage for wildlife, growing in this substrate uptake metals into their tissue. Research is needed to better understand the mechanisms associated with these successes and failures as they relate to ecological process development in the naturally harsh conditions and substrates of the north. Whether these changes are sustainable beyond the first few years after reclamation must be addressed, particularly whether management is required.

Assisted revegetation is a common reclamation technique to accelerate plant establishment and growth on disturbed sites. However, effective methods for arctic environments have yet to be developed, as revegetation in the north is often complicated by limited access to equipment and lack of available resources. Only a few suppliers carry native seeds for arctic and alpine species, and they are often of too small quantities and/or consist of grasses and legumes which lack the diversity necessary for large scale revegetation projects (Forbes and Jefferies 1999, Matheus and Omtzigt 2012). To develop self sustaining communities that are structurally and functionally integrated with surrounding heath-lichen tundra, new revegetation techniques are required for shrub, moss and lichen species.

Shrubs, both erect and dwarf, provide most of the vegetation cover in many tundra communites. Shrub cuttings have potential to provide a more consistent source of plant material than seed for reclaiming large areas in a timely manner. Methods, however, are required to reliably root large quantities of cuttings under arctic conditions. Few comprehensive studies have rigourously tested a variety of factors for multiple shrub species to determine the most practical methods to induce root development on a species specific basis (e.g. Houle and Babeux 1998, Holloway and Peterburs 2009). Improved method development for shrub cuttings could be used to inform and improve current reclamation and revegetation guidelines in the north as use of shrubs is currently limited by high costs and lack of understanding of their requirements.

Cryptogamic species, mosses and lichens, are critical in northern ecosystems. Moss and lichen are important components of tundra biological crusts, regulating surface temperature and water and providing erosion control and slope stability (Gold 1998, Van der Wal et al. 2001). Moss and lichen crusts may be most important early in succession with benefits in surface layers for seed and seedlings and may act as nurse species, directly facilitating later communities (Gold 1998, Forbes and Jeffries 1999, Bowker 2007). They are important indicators of ecosystem health whose presence or absence can indicate level of disturbance, hydrologic regime, acidity and nutrient concentrations (Gignac et al. 1991, Forbes 1994). They provide critical habitat and forage for northern fauna, including birds, rodents and caribou (Batzli and Sobaski 1980, Thompson and McCourt 1981). Mosses and lichens are of cultural importance; First Nations have been using them for thousands of years (Andre and Fehr 2002). Despite their significance, little is known about revegetation methods.

2. RESEARCH GOAL AND OBJECTIVES

The goal of this research program is to build on past research to develop methods to reclaim disturbed sites at Diavik Diamond Mine in the Canadian subarctic. The program has three focus areas: patch revegetation to maximize limited resources such as micro sites and organic matter, native shrub, moss and lichen propagation to build diverse plant communities that provide food and habitat for wildlife, and long term monitoring for continued evaluation of reclamation success. Results from reclamation research over the past decade, at Diavik Diamond Mine and other severely disturbed sites including oil sands and limestone quarries, will add to the collective findings and expedite results at Diavik.

2.1 Development Of Anthroposols For Revegetation

The objective of this component of the research program is to develop suitable reclamation substrates for sustainable soil and plant community development on disturbed sites at Diavik Diamond Mine. Soil like substrates are the foundation for successful initial plant establishment and growth and long term soil and plant community development. Research is being conducted by PhD student Valerie Miller in the field and greenhouse. Specific objectives are as follows.

- Evaluate substrate-amendment combinations for anthroposols and sustainable development.
- Evaluate micro topographic influences on revegetation.
- Evaluate short term management options for erosion.
- Evaluate amendments for potential to enhance soil water content and retention.
- Evaluate plant uptake of metals from processed kimberlite used as a reclamation substrate.
- Elucidate mechanisms by which ecosystem development triggers and trajectories are influenced by reclamation choices of substrate, management and plant species selection.

2.2 Development Of Plant Material For Revegetation

The objective of this component of the research program is to develop and improve methods for collection, propagation and dispersion of native shrub, moss and lichen species for revegetation of disturbances in harsh environments such as those at Diavik Diamond Mine. Two graduate students are currently conducting the research, Sarah Ficko (PhD student) and Jasmine Lamarre (MSc student). Research is being conducted in growth chambers and in the field.
Specific objectives are as follow for shrubs

- Evaluate time of collection on cutting shoot and root development.

- Evaluate common horticulture practices such as soaking length and rooting hormones on shoot and root development.
- Evaluate alternative practices such as different cutting lengths, planting depths and smoke water on shoot and root development.
- Evaluate the ability of shrub cuttings to develop and survive in reclamation substrates and at various soil water contents.
- Develop recommendations for reclamation methods to improve shrub establishment.

Specific objectives are as follows for biological crust (lichen and moss).

- Evaluate growth media for common lichen and bryophyte species.
- Evaluate propogation techniques for lichen and bryophyte establishment and growth.
- Evaluate erosion control material promotion of lichen and bryophyte propagation, establishment and growth.
- Develop recommendations for collection and propagation of lichens and mosses for use in reclamation.

2.3 Long Term Development of Reclaimed Communities

In 2014, ten years have passed since reclamation plots were established at Diavik Diamond Mine as part of a long term research program. The research site has not been monitored since 2009 and sufficient time has passed for potentially significant changes in soil and plant community development. In the first five years following reclamation, major changes in soil properties and plant abundance and diversity occurred depending on the reclamation substrate and amendment used. At the last monitoring, many reclamation treatments appeared to be on a trajectory to a self sustaining tundra community, while others were clearly in arrested successional stages and the likelihood of further significant changes was low (Drozdowski et al. 2012, Naeth and Wilkinson 2014).

Assessing and quantifying long term trajectories for ecosystem development will add considerably to the knowledge base for northern reclamation and will facilitate assessment of long term sustainability of reclamation treatments. Specific objectives of this research program are to determine if the best performing treatments at 5 years after reclamation are still the best performing at ten years after reclamation, if plant abundance and diversity are increasing, if phytotoxic soil properties are being ameliorated, and if a soil biological crust is developing and evolving.

3. RESEARCH ACTIVITIES IN 2014 AND PRELIMINARY RESULTS

3.1 Development Of Anthroposols For Revegetation

3.1.1 Greenhouse

The first greenhouse experiment assessed effectiveness of substrates and substrate-amendment combinations for plant establishment and growth and was completed in December 2013. The experiment consisted of 6 substrates x 7 organic amendments and a control x 2 nutrient treatments for 96 treatment combinations. The treatments were seeded with three grass species, *Elymus trachycaulus* ssp. *trachycaulus* var. Adanac (slender wheat grass), *Festuca saximontana* var. *saximontana* (rocky mountain fescue) and *Poa glauca* var. Tundra (glaucous blue grass). The six substrates were processed kimberlite, a mixture of glacial till and lake sediment (till-sediment), crushed rock and three combinations of processed kimberlite and till-sediment. The organic amendments used were sewage, salvaged soil (soil), sewage and soil, peat, peat and soil, Black Earth (commercial product) and biochar. All combinations were assessed with and without addition of nitrogen and phosphorus fertilizer.

General observations were that all species grew and survived in most of the treatments. Only *Elymus trachycaulus* produced seed and only in pots with sewage as the amendment. Plant emergence was successful in unamended crushed rock. Plant height was greater and health was better when the amendment was soil, sewage or peat. Based on initial descriptive statistics addressing the effects of substrates, amendments and fertilizer application separately (Table 1), crushed rock had the greatest number of plants and above and below ground biomass in the final week of the study. Substrates amended with peat and peat and soil combined had the greatest number of plants; substrates amended with sewage and sewage and soil had the greatest above ground biomass; and substrates amended with peat and soil had the greatest below ground biomass. Fertilizer did not have an observable effect on plant density or biomass. Detailed statistical analyses will provide a better understanding of the effects of substrates and amendments and an exploration of interactions.

Two additional greenhouse experiments were established in fall 2014 to assess effects of amendments on water holding capacity, and water stress on germination and vegetation growth. Diavik Diamond Mine has limited precipitation and a suitable anthroposol must be able to support vegetation in these harsh conditions. Processed kimberlite, till-sediment and crushed rock were combined with sewage, soil, peat and hydrogel (Photo 1). Hydrogel is polyacrylamide crystals that absorb water. Although these materials could improve hydrologic properties of soils, they could also impact plant access to that water and may pose toxicity issues for sensitive northern species.

The second greenhouse experiment was composed of a set of three small scale water holding capacity experiments. Hydrogel was added to substrates alone and wetted to the point of saturation. The amount of water (by weight) present was measured over time (5 to 10 days depending on whether it was still decreasing) to better understand maximum water holding capacity and water retention. These mixtures of substrate and hydrogel were then rewetted and amount of water measured over time. In the final experiment, substrates and amendments, including hydrogel, were combined and amount of water present was measured over time to compare effectiveness of hydrogel to increase soil water content and retention to that of organic amendments. Experiments have been completed and data are ready to be analyzed.

The third greenhouse experiment, composed of two parts, is currently in progress assessing vegetation response under water stressed conditions. The first part focuses on the effect of water stress on vegetation growth and will be monitored over an eight week period (Photo 2). The second part focuses on the effect of water stress on germination and will be monitored over a four week period. The experiments consist of 3 substrates x 5 amendments x 3 rates (5, 10, 20 % by volume) plus 3 controls for 48 treatment combinations. Pots were seeded with *Elymus trachycaulus*. Plants are being monitored weekly for density, height, health, physiological stage of development, number of leaves, and at the end of the experiment, above ground and below ground biomass. Emergence (density) is being monitored every 3 to 4 days in the experiment investigating the effects of treatment on germination. In early December, the experiments will be completed and data will be analyzed.

3.1.2 Field

The field experiment examines the role of micro topographic variability, erosion control and amendments in developing substrates to enhance and sustain native plant species. Each micro topography, amendment and erosion control treatment was combined on each substrate, with 8 micro topography types x 3 organic amendments x 2 erosion control methods = 48 combinations x 3 substrates = 144 treatment combinations x 6 replicates = 864 plots.

Establishment of the field experiment began in summer 2013. The research was established on the old magazine storage site at Diavik Diamond Mine. Three blocks were constructed in 2008 for a previous research project. Each block is divided into three approximately equal sized plots with processed kimberlite, till-sediment or crushed rock (Photo 3). In 2013, 1 by 1 m sub plots were delineated in each substrate in each block. Eight micro topographic treatments were established: small and large mounds, small and large depressions, small and large boulder piles, furrows and flats.

In 2014, organic amendments and erosion control treatments were applied and plots were seeded. The three organic matter treatments were no organic matter, added sewage and added salvaged soil. Approximately 2.4 L of soil or sewage were added, creating a thin layer of amendment 0.5 to 1.0 cm deep (Photo 4). The amendment was mixed into the top 5 to 10 cm of substrate to reduce erosion loss. The two erosion control treatments were added Soil Lynx™ or no addition. Soil Lynx™ is a commercial product (ClearFlow Solutions Inc.). It is a powder that binds with soil to create a stable and porous surface, and binds to fertilizer and seeds reducing loss from the site. Approximately 1.73 g of Soil Lynx™ was applied evenly over the surface of each 1 by 1 m plot. HOBO data loggers and sensors were installed at a depth of 5 cm to monitor soil temperature and soil water throughout the experiment (Photo 5).

Seeds of 12 native grasses and forbs, wild collected in the Northwest Territories by researchers at the Aurora Research Institute, were sown in late June in each plot (Table 2, Photo 6). Plant establishment and growth will be assessed for at least three years (2014 to 2016) for seeded and naturally recruiting species.

Plots were monitored in August of the first growing season by assessing density of grasses and forbs in 0.75 x 0.75 m quadrats (Photo 7). Plants could not yet be identified to species. Data are being analyzed. Initial results show that plant density in the first growing season was greatest in crushed rock, followed by till-sediment, then processed kimberlite.

A small scale experiment was established to examine erosion control methods. Five treatments were assessed: Soil Lynx™, jute treated with Soil Lynx™, Soil Lynx™ and treated jute, coconut erosion control blanket and an untreated control. Plots were 1 by 1 m on each of the three substrates. Approximately 1.73 g of Soil Lynx™ was applied evenly over the surface. Jute and erosion control blankets were cut larger than the plots and edges buried or secured with rocks. For Soil Lynx™ and treated jute, 1.73 g of Soil Lynx™ was applied evenly over the soil surface followed by jute then another Soil Lynx™ application. Plots were seeded with six native grass species (Table 2) and monitored using the same methods as in the primary experiment.

On disturbances created by mining activity in the north one of the reclamation goals is to reestablish a native vegetation cover as quickly as possible to provide habitat for wildlife.

Wildlife including snowshoe hares, arctic ground squirrels and barren ground caribou rely on tundra vegetation as a food source. Species such as caribou remain a staple of the diet for many local aboriginal communities. Processed kimberlite is a by product of diamond processing and is a desirable reclamation material. It has a sandy loam texture which can improve structure of gravel substrates, commonly requiring reclamation, and its use in reclamation would reduce costs required to transport it off site for disposal.

A 2 x 2 m area of fresh fine processed kimberlite was established at the former ammonium nitrate storage site next to Block 1. Depth of material is approximately 30 cm. The area was divided into twenty 50 x 50 cm plots. One of four native plant species was randomly assigned to each of the plots for a total of five replicate plots per species. The four species sown are *Elymus trachycaulus, Poa glauca, Festuca saximontana* and *Oxytropis campestris*. The species are common for reclamation in the NWT and performed better in processed kimberlite than most species in previous research conducted at Diavik. A mix of growth forms has been included in the study as this may affect plant uptake of metals.

Seeds of each species were sown in late June at high rates to ensure sufficient establishment, survival and overall biomass for harvest. Seeding rates were based on number of seeds required to obtain 50 plants per plot. Germination tests were conducted on seed lots and establishment and first year survival was estimated as 30 %. Plots were roughened prior to seeding and seed was hand broadcast on the surface then lightly covered with processed kimberlite to improve soil-seed contact. Observations in plots in August indicate there was good emergence of all species.

3.2 Development Of Plant Material For Revegetation

3.2.1 Growth Chamber

Shrub cuttings were collected from Diavik Diamond Mine in mid June and late September 2014. Five species, *Empetrum nigrum* (crowberry), *Ledum* decumbens ssp. *decumbens* (marsh labrador tea), *Loiseleuria procumbens* (alpine azalea), *Vaccinium uliginosum* (bog bilberry) and *Vaccinium vitis-idaea* (bog cranberry) were collected for summer experiments based on results of 2013 summer and fall experiments. Three additional species, *Arctostaphylos rubra* (red bearberry), *Betula glandulosa* (bog birch) and *Salix* sp. (willow), were collected for a total of eight species for fall experiments. All species were selected due to their common occurrence in plant communities at Diavik and hence their desirability in the revegetated plant community.

A shrub cutting experiment was established in October 2014 to investigate common (indole-3-butyric acid (IBA)) and unconventional (*Salix* water) hormone application and alternative methods (smoke water) to promote root initiation and enhance root development of summer and fall collected cuttings over 60 days in a growth chamber. Different concentrations of powder IBA are a conventional horticulture treatment for propagating shrub cuttings. *Salix* species naturally release hormones that promote root development. Different concentrations of *Salix* water were prepared by cutting up varying quantities of *Salix* shoots into 1 to 3 cm pieces and soaking them in water overnight. Some tundra species respond favourably to fire and many have increased germination. Smoke water dilutions are being tested to determine if they can promote root initiation by soaking cuttings in smoke water. Cuttings from each species were treated with no treatment, or one of four concentrations of powder IBA (0.0, 0.1, 0.4, 0.8 %), or one of three concentrations of *Salix* water (0.5x, 1x, 2x) or one of three concentrations of smoke water (1:1, 1:10, 1:20). Ten cuttings per treatment per shrub species were planted in summer and fall experiments for a total of 500 and 800 cuttings, respectively. Cutting shoot development is monitored weekly and root assessments are conducted at the end of each experiment.

The summer cutting experiment is completed, the fall one is in progress. Preliminary results for cuttings collected in summer and fall experiments in 2013 indicate that all species have the capacity to produce roots, with rooting ranging from 1 % for fall *Arctostaphylos rubra* cuttings to 83 % for fall *Salix* cuttings (Table 3). Time of year of collection appeared to have a species specific effect, influencing rooting behaviour for two species. *Vaccinium vitis-idaea* had more root development on summer collected than fall collected cuttings (53 and 8 %, respectively) (Photo 8a), while *Salix* species had better root development on fall collected cuttings than summer collected cuttings (83 and 30 %, respectively) (Photo 8b). Three species showed limited rooting at only one time period, summer (*Empetrum nigrum*) or fall (*Arctostaphylos rubra, Betula glandulosa*). While only 5 % of fall *Betula glandulosa* cuttings produced roots, this is promising as this species is not known to root from cuttings (Photo 8c). The other three species did not show preferential rooting behaviour for either time. Spring dormant and non dormant collection is required to determine if any species will have more consistent root development in spring than summer or fall collection. Future growth chamber experiments are expected to decipher treatment factors to enhance rooting for cuttings collected at optimal times of year.

3.2.2 Field

In June 2014, a field experiment to investigate methods to propagate biological crust was established. Five blocks of twenty-four 100 x 100 cm plots were set up on each of three substrates, processed kimberlite, till-sediment and crushed rock. Within each block, plots were randomly assigned a placement and containment treatment. Three placement treatments were no biological crust material, slurry placement or dry placement. Eight containment treatments were nothing, jute, erosion control blanket, erosion control blanket and jute, woody debris, woody debris and jute, tundra soil, tundra soil and jute. Five replicates of each placement-containment combination were established for a total of 360 plots. Within each 100 x 100 cm plot, treatments were applied to a 50 x 50 cm quadrat which was marked in each corner with spray painted rocks and isolated with a border of stones.

Biological soil crust samples were collected from three areas on the A21 pipe. Samples were collected by removing 1 to 2 cm deep patches with macro lichens where the crust naturally split when disturbed with a trowel (Photo 9). Crust material was air dried and sieved on a 1 cm grid. Samples were refrigerated in paper bags at 4 ^{o}C until placement. Sieved material was mixed and 100 g weighed out for dispersal on each treated plot for a total of 27,000 g of material. Dry material was dispersed by evenly scattering a thin layer across the surface of each plot. Slurries were prepared by mixing the 100 g of sieved biological soil crust material with 1 L of water. After 5 min the slurry was evenly poured across the plot. When material was in large clumps an upside down rake was used to gently spread the material more evenly across the plot surface. Biological soil crust material was spread on top tundra soil, erosion control blankets and woody debris. Jute was placed on top applicable treatment plots to measure lichen growth.

Biological soil crust plots were assessed from 22 to 27 August 2014. As lichens are the main visible component in these crusts, monitoring will focus on presence or absence of mosses and 12 species or genus of lichens including *Cetraria* species (Iceland lichens), *Cladonia* species (cladonia lichens), *Cladonia* ssp. *cladina* (reindeer lichen), *Dactylina arctica* (arctic finger lichen), *Flavocetraria cuculata* (curled snow lichen), *Flavocetraria nivalis* (crinkled snow lichen), *Masonhalea richardsonii* (arctic tumbleweed), *Sphaerophorus globulus* (coral lichen), *Stereocaulon* species (easter lichens), *Thamnolia vermicularis* (whiteworm lichen), foliose lichens, brown and yellow hair lichens. Observations were recorded for each treatment such as if jute was intact; debris such as leaf litter, *Epilobium latifolium* (common fireweed) seeds and pieces of siliques or woody debris was noted. General observations across plots were recorded. Photos were taken of individual plots and groups of plots on different substrates with a high resolution camera to help monitor changes over time (Photo 10).

Plots with jute appeared to have a more even distribution of lichens. Lichens from most species had blown onto control plots (small quantities) where lichens were not placed initially. Micro topography is likely an important factor in retention of lichens and biological soil crust material on all substrates, especially ones with less micro topographic variability such as processed kimberlite. Plots with erosion control blanket alone had lichens mostly in dips and not on any bumps. Lichens were associated with tundra soil when present on plots even if some had blown away and were often observed around the rock borders of the plots.

In November 2014 a growth chamber study will be established to investigate effects of propagation and dispersal techniques on composition and function of biological soil crusts collected from Diavik and grown in a growth chamber on different substrates. Specific objectives are to compare tundra soil, a natural substrate for biological soil crusts, to crushed rock, till-sediment and processed kimberlite which are common by products of mining to determine their suitability as substrates for biological soil crust material; to evaluate propagation (fragment size), dispersal (dry, slurry) and containment (mesh type) treatments under controlled conditions for suitability in field application; to evaluate species composition changes over time under controlled conditions to determine if biological soil crusts are likely to recover ecological function and/or if growth chamber studies are suitable to represent field conditions; and to assess if methods that indicate growth and survival of lichens under controlled conditions can represent total biological soil crust growth and recovery. Temperature and light patterns will be determined from data collected by the on site meteorological station at Diavik. An undergraduate student working on her fourth year thesis project will be assisting with this component of the research.

A field experiment to investigate bryophyte propagation methods was established at two research sites in 2014, Diavik Diamond Mine and Heiðmörk recreational area, near Reykjavik, Iceland. The experimental design is the same as each site. Bryophytes collected near respective field sites were identified and quantified prior to treatment application. Three different sizes of propagation materials are being tested in the field including small, dust sized moss fragments; medium, leaf or stem sized moss fragments; and large, individual moss strands. All three sizes will be tested with and without erosion control material on three different substrates including crushed rock, till-sediment and processed kimberlite. Plots were established in June. Percent cover and density were assessed twice, once when material was planted and at the end of the growing season (August). Photographs were taken of each plot with a high resolution camera to help monitor changes over time. Cover of mosses will be digitally quantified using SamplePoint, an image analysis program (Booth et al. 2006).

Effect of wind erosion on unamended treatments was severe, with a large amount of propagation material lost. Preliminary results from the first growing season show increased cover of remaining propagation material in all size treatments on all substrates with erosion control material (Table 4). Survival of material varied and further analysis with SamplePoint is required to more accurately compare effectiveness of size treatments during the first growing season. Preliminary laboratory screening results show a slight increase in effectiveness of small and medium size fragments. Statistical analyses is currently in progress.

3.3 Long Term Development of Reclaimed Communities

Long term plots established in 2004 were evaluated in early August 2014. There were three blocks and each block was divided into 5 substrate plots (processed kimberlite, till-sediment, crushed rock, 50:50 and 25:75 mixes of processed kimberlite and till-sediment). Each substrate plot was divided into 4 amendment strips (salvaged soil, inorganic fertilizer, water treatment plant sludge or sewage sludge, unamended). Each amendment strip was divided in half, for spring and fall seeding.

Five 0.25 m^2 quadrats were assessed in each spring and fall seeded section of each substrate-amendment plot. This captured most plant species. Quadrats were systematically placed along a transect traversing plot length. In each quadrat, total vegetation canopy cover and canopy cover by species were ocularly estimated. Density of each species was counted. Species in flower and/or seed and evidence of browsing were noted. A time bounded walk through was conducted in spring and fall plot to record species not found in quadrats.

In each quadrat, ground cover (moss, lichen, vegetation, scat, rock, litter, bare ground) was assessed. Lichen and moss were identified to species in the field if possible. Samples of species were collected for later identification in the laboratory. In salvaged soil, sewage and sludge plots, bare ground was divided into soil, sewage, sludge and substrate to determine the amount of amendment erosion since applied.

Three soil samples were collected from 0 to 15 cm of each spring and fall plot. Sampling from 16 to 30 cm was attempted but substrates were too compacted. Samples were kept cool and will be submitted to a commercial laboratory for analyses. Data will be analyzed in 2015.

4. RESEARCH PLANS FOR 2015

An annual report including activities and preliminary results from all components of the research program will be provided to Diavik by December 31 2015.

4.1 Development Of Anthroposols For Revegetation

In January 2015, below ground biomass from the greenhouse experiment assessing effects of water stress on vegetation growth will be collected and weighed. Data from fall 2014 greenhouse experiments will be analyzed in 2015 and manuscripts prepared for publication in peer reviewed scientific journals. The fourth greenhouse experiment will commence in spring or summer 2015 and will use combinations of most effective treatments from previous experiments and determine effective and practical amendment rates for application in the field.

In summer 2015, field experiments assessing micro topographic variability, erosion control and amendments and different methods of erosion control will be monitored. Vegetation will be assessed during peak plant production using 0.75 x 0.75 m size quadrats located in the center of each plot. Species density, health, physiological stage, height (mean, minimum, maximum) and cover will be assessed. Cover will be visually assessed for each vascular plant species, and for moss, lichen, litter, bare ground and rocks. Evidence of wildlife use, such as feces, tracks and chewed plant parts, will be recorded. Soil samples will be collected and analyzed for pH, electrical conductivity, cation exchange capacity, texture and total and organic carbon.

In 2015 biomass of the four plant species will be collected for analysis of tissue for metals of concern. Timeline and number of species will depend on availability of sufficient plant biomass for analyses. A minimum of 1 g of tissue is required and if there is not sufficient biomass in 2015 it will be collected in 2016. For each species, an above ground biomass sample will be collected from each of the five plots when plants are actively growing. Samples of each species will be combined and three composite samples submitted to a commercial laboratory for determination of aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, sodium, sulfur, thallium, tin, titanium, uranium, vanadium and zinc concentrations by inductively coupled plasma mass spectrometry and inductively coupled plasma optical emission spectrometry. Soil samples will be collected from the same treatments at 0 to 20 cm (rooting zone) and submitted to the laboratory for determination of the same metals. Soil concentrations are required to determine the source of any metals in plant tissue.

Based on results of these analyses, plant tissue may be collected from the same species in the plots established in 2004 and/or 2014 on weathered fine processed kimberlite. Once known that there is uptake, these samples will provide an understanding of over what period of time metal uptake from processed kimberlite may remain an issue.

4.2 Development Of Plant Material For Revegetation

Shrub cuttings will be collected in spring 2015 following snow melt to complete the last two parts (spring dormant and spring non dormant cuttings) of the experiment initiated in 2013. Results will be compiled and assessed for all four parts of the experiment to determine patterns in root initiation and development on a plant species specific basis. Results will inform collection time for future growth chamber experiments (September 2015) to investigate cutting survival and root development in different mixes of substrates at Diavik, such as processed kimberlite, crushed rock, till-sediment, and use of hydrogel and effect of wounding. Field plots will be prepared in fall 2015 for spring cutting planting if time and space permits at Diavik.

Biological soil crust plots set up in summer 2014 will be monitored in June and August 2015 to determine treatments effects on species composition, growth and cover after one year. Plots will be monitored visually and with photos at both time periods. A biological soil crust wind dispersion experiment will be established in June 2015 to determine effects of wind displacement on biological soil crust fragments on different substrates.

Digital photos from the bryophyte propagation plots will be analyzed with SamplePoint during winter 2015 and preliminary statistical analysis conducted. In summer, cover and plant density will be assessed in the field and compared to 2014 results. SamplePoint assessments will be conducted throughout the summer and analyzes completed in the fall before full statistical analysis of results.

4.3 Long Term Development of Reclaimed Sites

Data will be analyzed. A manuscript will be prepared for publication in a peer reviewed scientific journal.

4.4 Potential for Natural Recovery of Disturbed Sites

Natural recovery of plant communities on a disturbed site is ideal, relative to active reclamation, as it reducesinputs required to reestablish a vegetation cover. However, natural recovery relies on availability of a source of native propagules (seed and vegetative parts) and is often unpredictable, thereby increasing soil erosion risk and reducing aesthetics, at least in the short term. In the north, natural recovery is a long and slow process and when combined with significant alteration of soil and hydrologic factors through human disturbance, the process may be lengthened or prevented. These changes in site conditions may result in development of a different community than that present prior to disturbance. The purpose of this research is to identify and better understand soil, hydrologic and plant conditions on disturbed sites at Diavik Diamond Mine that promote successful natural recovery of native tundra plant communities to better emulate these conditions on future disturbed sites.

We submitted a proposal for this new research in 2015. If approved and funding secured, natural recovery sites will be selected and detailed assessment of soil and/or vegetation communities on these sites conducted in July and August. Preliminary data analyses would be conducted in fall 2015.

5. LITERATURE CITED

Andre, A. and A. Fehr. 2002. Gwich'in Ethnobotany, plants used by the Gwich'in for food, medicine, shelter and tools. Gwich'in Social and Cultural Institute and Aurora Research Institute. Inuvik NWT. 68 pp.

Batzli, G.O. and S.T. Sobaski. 1980. Distribution, abundance and foraging patterns of ground squirrels near Atkasook, Alaska. Arctic and Alpine Research 12:501-510.

Billings, W.D. 1987. Constraints to plant growth, reproduction, and establishment in arctic environments. Arctic and Alpine Research 19:357-365.

Booth, D.T., S.E. Cox and R.D. Berryman. 2006. Point sampling digital imagery using SamplePoint. Environmental Monitoring and Asssessment 123:97-108.

Bowker, M.A. 2007. Biological soil crust rehabilitation in theory and practice: an underexploited opportunity. Restoration Ecology 15:15-23.

Drozdowski, B.L., M.A. Naeth and S.R. Wilkinson. 2012. Evaluation of substrate and amendment materials for soil reclamation at a diamond mine in the Northwest Territories, Canada. Canadian Journal of Soil Science 92:77-88.

Forbes, B.C. 1994. The importance of bryophytes in the classification of human-disturbed high arctic vegetation. Journal of Vegetation Science 5:877-874.

Forbes, B.C. and R.L. Jefferies. 1999. Revegetation of disturbed arctic sites: constraints and applications. Biological Conservation 88:15-24.

Gignac, L.D., D.H. Vitt, S.C. Zoltai and S.E. Bayley. 1991. Bryophyte response surfaces along climatic, chemical, and physical gradients in peatlands of western Canada. Nova Hedwigia 53:27-71.

Gold, W.G. 1998. The influence of cryptogamic crusts on the thermal environment and temperature relations of plants in a high arctic polar desert, Devon Island, NWT, Canada. Arctic and Alpine Research 30:108-120.

Holloway, P.S. and M.R. Peterburs. 2009. Propagation of twelve Alaska native plants by summer stem cuttings. Journal of Environmental Horticulture 274:207-210.

Houle, G. and P. Babeux. 1998. The effects of collection date, IBA, plant gender, nutrient availability, and rooting volume on adventitious root and lateral shoot formation by *Salix planifolia* stem cuttings from the Ungava Bay area (Quebec, Canada). Canadian Journal of

Botany 76:1687-1692.
Kershaw, P. and L.J. Kershaw. 1987. Successful plant colonizers on disturbances in tundra areas of Northwestern Canada. Arctic and Alpine Research 19:451-460.
Matheus, P. and T. Omtzigt. 2012. Yukon revegetation manual. Practical approaches and methods. Mining and Petroleum Environmental Research Group. 176 pp.
Naeth, M.A. and S.R. Wilkinson. 2014. Establishment of restoration trajectories for upland tundra communities on diamond mine wastes in the Canadian arctic. Restoration Ecology 22:534-543.
Naeth, M.A. H.A. Archibald, C.L. Nemirsky, L.A. Leskiw, J.A. Brierley, M.D. Bock, A.J. VandenBygaart and D.S. Chanasyk. 2012. Proposed classification for human modified soils in Canada: anthroposolic order. Canadian Journal of Soil Science 92:7-18.
Rydgren, K., R. Halvorsen, A. Odland and G. Skjerdal. 2011. Restoration of alpine spoil heaps: successional rates predict vegetation recovery in 50 years. Ecological Engineering 37:294-301.
Thompson, D.C. and K.H. McCourt. 1981. Seasonal diets of the Porcupine caribou herd. American Midland Naturalist 105:70-76.
van der Wal, R., S.M.J. van Lieshout and M.J.J.E. Loonen. 2001. Herbivore impact on moss depth, soil temperature and arctic plant growth. Polar Biology 1:29-32.

Table 1. Mean plant density and biomass based on substrates, amendments and fertilizer application.

Treatment	Number of Alive Plants		Above Ground Biomass (g)		Below Ground Biomass (g)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Substrates						
Processed Kimberlite (PK)	9.5	2.7	1.1	0.9	0.3	0.2
Till-sediment (TS)	9.5	3.1	1.5	1.2	0.4	0.3
25% PK, 75% TS	9.4	2.8	1.7	1.4	0.4	0.3
50% PK, 50% TS	8.2	3.2	1.1	0.9	0.3	0.2
75% PK, 25% TS	8.0	3.3	1.1	1.0	0.3	0.2
Crushed Rock	11.3	3.5	1.8	1.1	0.6	0.3
Reference	13.6	1.0	1.8	0.3	1.6	0.1
Amendments						
No Amendment	9.0	2.7	0.5	0.4	0.2	0.2
Biochar	9.2	2.5	0.5	0.4	0.2	0.2
BlackEarth	7.4	2.3	0.6	0.5	0.2	0.2
Peat	11.8	3.1	1.0	0.5	0.5	0.3
Peat/Soil	11.6	2.8	1.6	0.5	0.6	0.3
Sewage/Soil	8.0	2.5	2.9	0.8	0.5	0.2
Sewage	7.3	3.9	2.7	1.4	0.4	0.2
Soil	10.1	2.7	1.4	0.5	0.5	0.3
Reference	13.6	1.0	1.8	0.3	1.6	0.1
Nutrient Addition						
Fertilizer	9.2	3.4	1.5	1.1	0.4	0.3
No Fertilizer	9.4	3.2	1.2	1.2	0.3	0.3
Reference	13.6	1.0	1.8	0.3	1.6	0.1

Table 2. Species planted in anthroposol field experiment.

Species	Common Name
Agrostis scabra	Rough bent grass
Arctagrostis latifolia [1]	Wideleaf polargrass
Calamagrostis purpurascens [1]	Purple reedgrass
Deschampsia caespitosa [1]	Tufted hair grass
Elymus trachycaulus [1]	Slender wheatgrass
Festuca saximontana	Rocky mountain fescue
Hedysarum alpinum	Alpine sweetvetch
Oxytropis campestris	Field locoweed
Oxytropis deflexa	Nodding locoweed
Poa alpine [1]	Alpine bluegrass
Poa glauca	Glaucous bluegrass
Trisetum spicatum [1]	Spike trisetum

[1] Species used in field experiment comparing erosion control methods.

Table 3. Percent rooting on summer and fall cuttings for each shrub species in 2013 growth chamber experiments.

Species	Total Percent Rooting	
	Summer Cuttings	Fall Cuttings
Arctostaphylos rubra	0	1
Betula glandulosa	0	5
Empetrum nigrum	6	0
Ledum decumbens	2	3
Loiseleuria procumbens	13	6
Salix sp.	30	83
Vaccinium uliginosum	2	4
Vaccinium vitis-idaea	53	8

Table 4. Bryophyte cover and survival in propagation treatments (all substrates pooled).

Treatment	Percent Cover				Percent Survival	
	June 2014		August 2014		2014	
	Present	Green	Present	Green	Present	Green
Large Fragments	85.5	14.2	46.6	3.4	53.8	24.5
Large Fragments + Cloth	90.8	13.0	84.0	3.8	92.1	44.2
Medium Fragments	82.1	5.4	22.2	1.5	27.2	22.2
Medium Fragments + Cloth	85.0	8.7	68.1	2.9	49.0	21.8
Small Fragments	83.7	5.0	12.6	1.0	14.6	14.6
Small Fragments + Cloth	89.6	7.6	69.1	2.2	77.3	33.0

Photo 1. Mixing amendments and substrates (soil and till-sediment) at three rates for effects of water stress on vegetation growth and germination.

Photo 2. One of five blocks in the experiment assessing effect of water stress on vegetation growth.

Photo 3. Aerial photograph of Blocks 2 and 3 for the micro topography, amendment and erosion control experiment.

Photo 4. Addition of organic amendments (soil) to plots.

Photo 5. Installation of HOBO sensors to monitor soil water content and temperature.

Photo 6. Seeding plots with native cultivars and applying Soil Lynx™ (erosion control material).

Photo 7. Quadrat used to assess vegetation density.

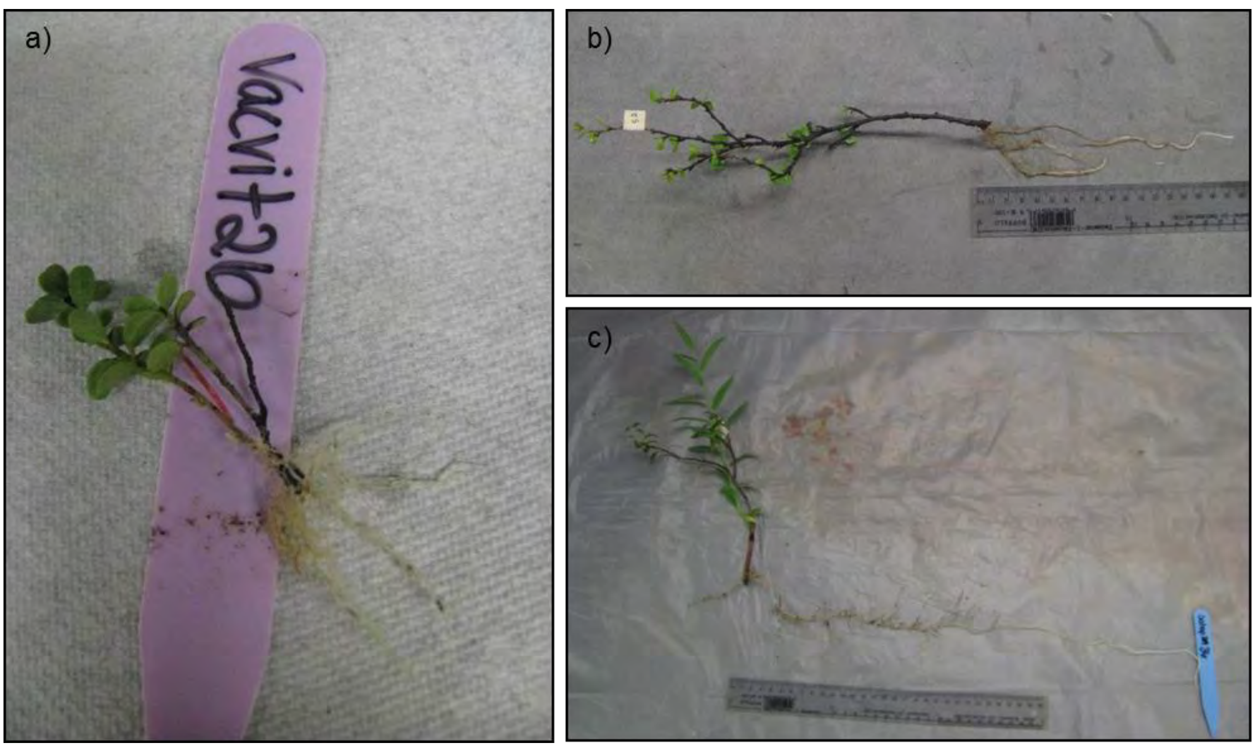


Photo 8. Root growth after 60 days for summer 2013 cuttings of *Vaccinium vitis-idaea* a) and fall 2013 cuttings of *Betula glandulosa* b) and *Salix* species c).

Photo 9. Collecting biological soil crust material from A21 pipe site.

Photo 10. Biological soil crust plots during experiment set up on till-sediment.

Appendix VI-1

Backhaul Items

Quantity	Description
1	MUT
1	2004 F-350 C/C
1	2004 F-350 C/C
1	Genie - Model Z60 - 34 Manlift
1	Airation Tanks (Various sizes)
1	60x60 Foldable Building
1	60x60 Foldable Building
1	60x60 Foldable Building
1	90 Ton Mobile Crane
1	Counter weight for 90 Ton Mobile Crane
1	50 Ton Mobile Crane
4	Blade & Miss Parts for 2001 Komatsu WD600 Wheel Dozer
1	2001 Komatsu WD600 Wheel Dozer
8	WD600 Wheel Dozer PARTS 7 plts, 14H Grader- 1 plt parts
1	2000 Caterpillar IT28G Int
1	2000 Ford F-550 4x2 R/C Flat Deck
1	2004 Ford F-550 4x2 R/C Flat Deck
1	Genie - Model Z60 - Manlift
1	2008 Toyota - HD P/U
1	2006 Toyota - HD P/U
1	2005 Toyota - HD P/U
1	2000 Ingersoll Rand - Light Tower
1	2000 Ingersoll Rand - Light Tower
1	2000 Ingersoll Rand Light Tower
1	2003 Ingersoll Rand Light Tower
1	Cable Reeler- Attachment
2	Cable Reeler Drums (x2)
1	7,900 Vertical Fuel Tank
1	13,600 L Fuel Vault
1	50,000 L Fuel Vault
1	2001 Caterpillar 14H Grader
5	45R57 3H 2 piece tread
1	2007 Ford F-350 C/C 4x4 XLT
1	2008 Toyota - HD P/U
1	2008 Toyota - HD CARRIER SIBS
1	2008 Toyota - HD VB-7 P/C
1	2000 PWR GEN 3412 CAT 500KW PORTABLE
1	2000 PWR GEN 3412 CAT 500KW PORTABLE
1	2000 PWR GEN 3512 CAT 500KW PORTABLE
1	2000 Finning Custome Control Switch Gear
1	2000 PWR GEN 3512 CAT 500KW PORTABLE
2	2 - BOOSTER PUMPS
2	1- BOOSTER PUMP, 1 HYDRAULIC POWER UNIT
2	1- BOOSTER PUMP, 1 HYDRAULIC POWER UNIT
1	2000 Caterpillar IT28G Int

Appendix VIII-1

WLWB Approved RECLAIM Estimate – August 2014

SUMMARY OF COSTS

CAPITAL COSTS	COMPONENT NAME	COST	LAND LIABILITY	WATER LIABILITY
OPEN PIT	A514,A418	$1,835,472	$64,881	$1,770,591
UNDERGROUND MINE		$1,402,419	$1,365,476	$36,943
TAILINGS FACILITY		$25,177,261	$43,969	$25,133,292
ROCK PILE	NCRP	$24,735,165	$745,853	$23,989,313
BUILDINGS AND EQUIPMENT		$17,113,932	$16,025,602	$1,088,330
CHEMICALS AND CONTAMINATED SOIL MANAGEMEI		$3,557,553	$1,758,777	$1,798,777
SURFACE AND GROUNDWATER MANAGEMENT		$1,280,539	-	$1,280,539
INTERIM CARE AND MAINTENANCE		$0	-	$0
	SUBTOTAL: Capital Costs	**$75,102,341**	**$20,004,557**	**$55,097,784**
	PERCENT OF SUBTOTAL		**27%**	**73%**

INDIRECT COSTS		COST	LAND LIABILITY	WATER LIABILITY
MOBILIZATION/DEMOBILIZATION		$9,111,200	$2,426,895	$6,684,305
POST-CLOSURE MONITORING AND MAINTENANCE		$19,508,597	$5,196,387	$14,312,210
ENGINEERING	5%	$3,755,117	$1,000,228	$2,754,889
PROJECT MANAGEMENT	5%	$3,755,117	$1,000,228	$2,754,889
HEALTH AND SAFETY PLANS/MONITORING & QA/QC	0.5%	$375,512	$100,023	$275,489
BONDING/INSURANCE	0.5%	$375,512	$100,023	$275,489
CONTINGENCY				
- Open Pit	20%	$367,094.41	$97,781	$269,314
- Underground Mine	20%	$280,483.82	$74,711	$205,773
- Tailings	30%	$7,553,178.19	$2,011,894	$5,541,284
- Rock Pile	15%	$3,710,274.75	$988,283	$2,721,991
- Buildings and Equipment	20%	$3,422,786	$911,707	$2,511,079
- Chemicals and Soil Management	20%	$711,510.60	$189,521	$521,990
- Water Management	20%	$256,107.80	$68,218	$187,890
MARKET PRICE FACTOR ADJUSTMENT	0%	$0	$0	$0
	SUBTOTAL: Indirect Costs	**$53,182,490**	**$14,165,899**	**$39,016,592**
TOTAL COSTS		**$128,284,831**	**$34,170,455**	**$94,114,376**

Comlpete document can be found at:

http://www.mvlwb.ca/Boards/WLWB/Registry/2007/W2007L2-0003/W2007L2-0003%20-%20Diavik%20-%20Security%20Review%20-%20RECLAIM%20Estimate%20-%20Revised%20-%20Aug%2019_14.zip

Appendix VIII-2

A21 Dike-Pit Closure Cost Estimate

Open Pit Name: **A514,A418** **Pit #** **1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m	450	FNCH	$203.00	$91,350	100%	$91,350	$0
Signs		each	4.5	#N/A	$37.08	$167	100%	$167	$0
Ditch, mat'l A		m3		#N/A	$0.00	$0		$0	$0
, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Berm		m3		#N/A	$0.00	$0		$0	$0
Block roads		m3	1350	SB1L	$4.30	$5,805	100%	$5,805	$0
Other				#N/A	$0.00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0.00	$0		$0	$0
STABILIZE SLOPES									
A154									
excavate 4 breaches in dike		m3	48114	SC1H	$9.30	$447,460		$0	$447,460
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat		m3		#N/A	$0.00	$0		$0	$0
A418									
excavate 3 breaches in dike		m3	36086	SC1H	$9.30	$335,600		$0	$335,600
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat		m3		#N/A	$0.00	$0		$0	$0
A21									
excavate 4 breaches in dike		m3	48114	SC1H	$9.30	$447,460		$0	$447,460
break concrete guides & wall		m3	1288	SC1H	$9.30	$11,978		$0	$11,978
construct fish habitat				#N/A	$0.00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, mat'l A		m3		#N/A	$0.00	$0		$0	$0
Place fill, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Rip rap		m3		#N/A	$0.00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0.00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0.00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0.00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0.00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0.00	$0		$0	$0
Concrete		m3		#N/A	$0.00	$0		$0	$0
Rip rap		m3		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0.00	$0		$0	$0
Place overburden		m3		#N/A	$0.00	$0		$0	$0
Vegetate		m3		#N/A	$0.00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each	4	#N/A	$5,618.00	$22,472		$0	$22,472
Remove dewatering pipeline		m	14385	PSRL	$1.00	$14,385		$0	$14,385
Remove power lines		m	8328	POWRL	$25.50	$212,364		$0	$212,364
Construct diversion ditches		m3		#N/A	$0.00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0.00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0.00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0.00	$0		$0	$0
siphon installation/operation		each	9	#N/A	$119,925.00	$1,079,325		$0	$1,079,325
silt curtains		each	9	#N/A	$11,731.00	$105,579		$0	$105,579
Remove pump post-closure		each		#N/A	$0.00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0.00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0.00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0.00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0.00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0.00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0.00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0.00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0.00	$0		$0	$0
Other				#N/A	$0.00	$0		$0	$0
					Annual pumping costs	$0			
Number of years of pump flooding		years							
					Total pumping costs	$0		$0	$0
					Total	$2,797,902		$97,322	$2,700,580
					% of Total			3%	97%

Appendix IX- Remaining Research Scopes of Work

IX-1 Development of Landscape Visualization Model (Task 1.3.1)
IX-2 PK Ultrafine Independent Characterization (Task 1.5)
IX-3 PK Geochemical Investigations (Task 4.2)
IX-4 Closure Risk Assessment Framework and Reference Condition (Tasks 4.2.5 and 6.3)
IX-5 Re-Vegetation and Metals Levels in Plant Tissue Research (Task 6.1and 6.4)
IX-6 NI Sediment Characterization Update (Task 5.6)

Appendix IX-1

Development of Landscape Visualization Model (Task 1.3.1)

IX-1 Development of Landscape Visualization Model (Task 1.3.1)

1 Objective

Visualization of the final post-closure landscape is an important consideration in finalizing the closure plan. The intent is to bring forward the specific closure concepts for each closure area so that it can be reviewed holistically.

DDMI has considered both physical (scale) models and computer generated images and has concluded that with advancements in computer imaging, air-born survey methods and the advantage of being able to link images to engineering drawings; that computer generated visualization is the preferred approach.

2 Software - Consultant Selection

DDMI has initiated the process of reviewing software and consultant options to assist with developing and applying the visualization model. The intent is to be able to link the visualization software with standard engineering software (e.g. autocad, Vulcan) so that any manipulations considered from a visualization perspective can be translated into volumes, slopes etc. for engineering and constructability analysis and eventually into for construction drawings. Similarly the selected software/consultant must be able to take existing engineering drawings and load them into the visualization model.

An important criterion in selecting the visualization software/consultant will also be the ability to readily make changes to the landscape interactively with a reviewer.

3 Model Development

Existing engineering and site survey drawings will be loaded into the visualization software and appropriate textures/colours applied to be representative of the existing landscape for both summer and winter conditions. The current closure concepts will then be applied to provide an initial visualization of a post-closure landscape.

4 Schedule

The model is expected to be fully developed and ready to use interactively with reviewers by end of Q2 2016 (see Section 3.3 of 2014 ICRP Progress Report V1.1).

Appendix IX-2

PK Ultrafine Independent Characterization (Task 1.5)

IX-2 PK Ultrafine Independent Characterization (Task 1.5)

1 Objective

The Traditional Knowledge Panel recommended, and DDMI accepted, conducting an independent characterization of the ultra-fine PK or "slimes" using the Panel's terminology. The purpose is to provide information that could help the Panel to understand the properties of this material as it relates to a closure landscape.

2 Expert Advisor

DDMI has engaged with the Director of a University Toxicology Center to:

- confirm interest and availability to take on the work;
- develop a proposal; and
- detail sampling, testing and reporting.

3 Scope

From discussions with the TK Panel and knowledge of the closure concept for the PKC the general scope DDMI has suggested is to include, but not be limited to:

- toxicological characterization using multiple aquatic and terrestrial species;
- chemical characterization – solid phase and pore-water
- mineralogy
- physical characterization – including "would caribou get stuck in this material?"

DDMI has provided relevant background material on characterization work done to date that will be reviewed by the Toxicology Center what additional testing would be most beneficial. Where specific test cannot be done by the Toxicology Center directly (e.g. some physical/mineralogical tests) the Center is to identify and coordinate this work with other University Departments or commercial laboratories.

4 Schedule

DDMI and the Toxicology Center expect to have confirmed a scope of work by May 1, 2015 with sampling and testing to proceed immediately. A written documentation of the findings will be available by the end of 2015 with a possibility of preliminary results being presented to an October 2015 TK Panel.

Appendix IX-3

PK Geochemical Investigations (Task 4.2)

IX-3 PK Geochemical Investigations (Task 4.2)

1 Ongoing Field and Laboratory Program

The ongoing complementary field and laboratory program to evaluate the geochemical evolution of fine processed kimberlite (FPK) consists of humidity cell testing, large tank experiments and *in situ* field measurements. The objective of the program is to more confidently predict water quality within and/or discharging from the PKC post-closure.

The field portion of the program includes *in situ* pore water sampling at stations established in 2009 and 2011, and four 5700 L tank experiments initiated in 2012. The *in situ* sampling will lead to a better understanding of short- and long-term weathering within operationally-deposited FPK, the subsequent release of dissolved ions, and any other controlling physicochemical processes that affect the pore water. The tank configuration permits detailed instrumentation, data collection and long-term FPK exposure to ambient conditions to provide data about the geochemical evolution without being covered by fresh slurry, as in the PKC. Instruments installed within the tanks include gas sampling ports, soil water suction samplers (SWSS), thermistors, moisture content probes (ECH$_2$O probes), tensiometers, and a tipping bucket to measure bulk flow out the bottom of the tank.

The laboratory portion of the program included static tests and kinetic humidity cell tests that were initiated in November 2012 and are now complete. The static tests provide compositional and physical information about the FPK and the humidity cell experiments provide element release rates under controlled conditions.

Samples for PK tanks and the static and kinetic tests were obtained from the FPK deposited within the PKC. The FPK was excavated from a transect immediately adjacent to the *in situ* PKC field study area. To obtain samples along the slurry discharge path, which causes gravimetric separation of the FPK, the FPK samples were excavated near-dam (CT), midway between the dam and the pond (MT), and adjacent to the pond (FT).

To date the geochemical characterization has focused on the fine fraction of the PK produced during processing. During processing a coarse fraction (coarse PK, CPK) is also produced. Fewer characterization studies have been conducted on the CPK.

The PK geochemistry research has been directed by Lianna Smith, formerly of DDMI, and now of Lianna Smith Consulting. Lianna Smith has worked closely with Michael Moncur of Alberta Innovates –Technology Futures (AITF) for the field studies.

1.1 Scope of Work for 2015

1.1.1 PK tanks

The PK tanks were constructed at the end of the 2012 field season and were operational during the 2013-2014 field season. Limited water has reported from the tanks due to “wetting up” required and low precipitation at the site. Continued monitoring and sampling during the field season in 2015 will provide data for a multi-year record that is required to monitor, evaluate and predict the geochemical evolution over time.

Specific tasks for 2015 include:

- On-going data-downloading from dataloggers (moisture content, thermistors, tensiometers, tipping buckets);

- Tank maintenance prior to freshet, including tipping bucket calibration, re-wiring of dataloggers as necessary; pipe/tubing/valve adjustments as necessary;
- Weekly sampling of bulk drainage (when present);
- Monthly sampling and analysis of gas composition and porewater from SWSS;
- Monthly downloading of all dataloggers;
- Review/train Environment Technicians/Summer students on PK tank sampling procedures;
- Analysis of field parameters for water samples will be conducted on-site by the Environment Technicans;
- Analysis of water samples for metals and anions at the University of Waterloo (commercial laboratory);
- Analysis of gas samples for O_2, CO_2, H_2S and CH_4, and selected water samples for selected stable isotopes through AITF.

To improve CPK characterization, two tanks to measure the geochemical evolution of CPK will be constructed. To date, no porewater/drainage geochemistry studies have been conducted on operational CPK. The instrumentation would be the same as for the current FPK tanks.

Specific tasks for 2015 CPK tanks include:

- Procure all required instrumentation and supplies;
- Coordinate with the Operations group to construct a bench; load and haul CPK; place CPK in tanks in lifts, per instructions;
- Install instruments at designated depths within the tanks;
- Plumb and fit drain lines, tipping bucket, bulk drainage sampling apparatus;
- Monitor tanks and sample at the same frequency of the FPK tanks;
- Conduct analyses as described under FPK tanks.

1.1.2 PK *in situ* program

Continued sampling of the accessible, established sampling points within the PKC is planned for 2015, assuming access continues to be safe. Two sample points are expected to be accessible during 2015, and an additional (3) sample locations will be established.

Specific tasks for 2015 *in situ* program include:

- Collect FPK cores in duplicate or triplicate;
- Measure gas composition at 10 cm intervals at each sample location;
- Squeeze porewater at AITF facilities in Calgary;
- Analyse water samples as per description for FPK tank analyses;
- Conduct grain size analysis on cores from new sample locations;
- Archive and consider mineralogical analyses on core from new sample locations;
- Complete PKC mass balance report.

1.1.3 Laboratory tests

Various laboratory test provide essential information for interpreting tank and *in situ* geochemical results and for predicting long-term geochemical behaviour.

Specific 2015 laboratory tests include:

- Mineralogical investigation of spent FPK humidity cell charges. Techniques would include optical, XRD, and possibly µXRD/SEM/microprobe and would be conducted by Lianna Smith and Dogan Paktunc of CANMET.
- Static and kinetic testing of CPK, including ABA, grain size, whole rock analysis, BET surface area, and humidity cells. SGS (Burnaby) is the recommended lab. Kinetic testing is recommended for 80 weeks.
- Mineralogical investigation of CPK to be used in humidity cells. Techniques would include optical, XRD, and possibly µXRD/SEM/microprobe and would be conducted by Lianna Smith and Dogan Paktunc of CANMET.
- Cryoconcentration testing, to be conducted at AITF in Calgary by Mike Moncur and Lianna Smith (3 days). Samples to be obtained from the PKC pond and from pore water squeezing (if sufficient water obtainable).

2 Predictive Modelling – PK Pore Water

Modelling processed kimberlite (PK) pore water based on pore water chemistry trends and laboratory experiments and/or small-scale field experiments that may include predictive/reactive transport modelling has been proposed as a method of integrating results of the field and laboratory testing results (see Section 1).

2.1 Scope for predicting/modelling PK pore water

2.1.1 Laboratory and field experiments

Predicting/modelling PK pore water requires integrating data sets from laboratory and field experiments

Specific tasks include:

- Calculating release rates from humidity cell experiments;
- Obtaining/calculating any cryoconcentration effects based on laboratory experiments and any applicable field results;
- Obtaining/calculating from tank experiments: release rates, pore water compositions, wetting front velocity, moisture content/saturation, infiltration, grain size/surface area, bulk composition and key mineral phases, saturation indices of secondary mineral phases, temperature, gas phase composition;

- Obtaining/calculating from in situ sampling: pore water compositions, active zone thickness, hydraulic conductivity, grain size/surface area, bulk composition and key mineral phases, saturation indices of secondary mineral phases, temperature profiles, gas phase composition;
- Developing, applying and testing scale-up approach(es).

2.1.2 Reactive transport modelling

Reactive transport modelling integrates water movement and geochemical reactions. Reactive transport modelling using MIN3P, PHREEQCi, or another appropriate model, may be considered during or after predictive modelling based on scale-up calculations.

2.2 Schedule

A proposed schedule for the required tasks is provided in Table 1. The schedule will be reviewed annually and revised as necessary.

2.3 Deliverables

Progress updates will be provided annually and will include recommendations for changes or additions to the scope and schedule. A final report that includes the pore water quality predictions and the calculation approach will also be provided.

Table 1 – Schedule of activities

	2014	2015				2016				2017				2018				2019				2020
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Static tests (FPK)	✓																					
Humidty cell experiments (FPK)	✓																					
Static tests (CPK)																						
Humidity cell experiments (CPK)																						
FPK tank experiments	✓																					
In situ experiments	✓																					
Mineralogical investigations																						
FPK column experiments (spent material)																						
CPK column experiments (starting material)																						
CPK column experiments (spent material)																						
Cryoconcentration experiment																						
Scale-up calculations																						
Reactive transport modelling - TBD																						

Appendix IX-4

Closure Risk Assessment Framework and Closure Criteria (Tasks 4.2.5 and 6.3)

IX-4 Closure Risk Assessment Framework and Closure Criteria (Tasks 4.2.5 and 6.3)

1 Objective

One of the goals of the Diavik Closure Plan is land and water that is chemically safe for wildlife and aquatic life. This goal is further defined into more specific objectives for each closure area however the overarching goal of being chemically safe applies site wide. The objective for this work scope is to develop a risk-based framework for evaluating if the planned post-closure conditions achieve the goal of being chemically safe. The final deliverable will be specific chemical closure criteria (reference conditions) for land and water that is safe for wildlife and aquatic life.

2 Risk Assessment Workshop

The WLWB hosted a Risk Assessment Workshop on December 6-7 2011 to provide communities and regulators with an overview of ecological risk assessment. DDMI was both a participant and a presenter at the workshop (see Appendix V-1 2012 ICRP Progress Report). DDMI presented a working example of how risk assessment can be used to develop closure criteria. It is this approach that is to be executed in this work scope.

3 Risk Assessment Framework

DDMI will retain a consultant with specific expertise in ecological risk assessment to apply the information and approach developed by Mucklow and Swanson (1998) (or equivalent) updated with the most recent toxicity reference values, chemicals of potential concern and receptors of concern. The deliverable from this task will be a risk assessment framework, specific for the Diavik site can be used to explicitly and transparently quantify risks to wildlife and aquatic life from land and water chemical concentrations. This framework will then be available for review, evaluation and modification if justified.

4 Closure Criteria

DDMI anticipated that regulators would have a significant role in the development of closure criteria. Specifically, DDMI understood the WLWB intended to hold a workshop specifically so that all parties could be clear on the role of regulators. With this information, DDMI's intention was to provide information or propose criteria following this regulatory guidance. As explained in the WLWB Reasons for Decision (March 16, 2015) only preliminary discussions have been held with regulators and DDMI is to continue its planned work without additional regulatory guidance.

The risk assessment framework developed in 3 above will be applied to derive closure criteria. The estimating equations that will generally be applied to calculate the risk-based closure criteria is likely similar to that described in Mucklow and Swanson (1998) as:

Water: $$\text{RBCC (mg/L)} = \frac{0.2 * bw * NOAEL}{IR_w * EFR}$$

Prey: $$\text{RBCC (mg/kg)} = \underline{0.2 * bw * NOAEL}$$

$$IR_{pr} * EFR$$

Plant: $$RBCC\ (mg/kg) = \frac{0.2 * bw * NOAEL}{IR_{pl} * EFR}$$

Soil: $$RBCC\ (mg/kg) = \frac{0.2 * bw * NOAEL}{IR_{s} * EFR}$$

Dust: $$RBCC\ (\mu g/m^3) = \frac{0.2 * bw * NOAEL * BAoral * CF}{LV * EFR * BAinhal}$$

RBCC	= risk-based closure criteria (in units specified)
bw	= body weight (kg)
NOAEL	= No-Observable-Adverse-Effect Level (mg/kg/d)
IR	= ingestion rate (L/d) (kg dry weight/d)
LV	= lung ventilation rate (m^3/d)
EFR	= exposure frequency ratio; fraction of time spent on East Island (e.g., 20/365 d)
CF	= conversion factor (1000 μg/mg)
BAoral	= oral bioavailability; fraction of chemical absorbed via ingestion (chemical-specific)
BAinhal	= inhalation bioavailability; fraction of chemical absorbed via inhalation (chemical-specific)

The deliverable from this task will be a table of closure criteria for review, evaluation and modification if justified.

5 Schedule

The risk assessment framework and closure criteria are expected to be fully developed by Q4 2015 and ready for review and discussion (see Section 3.3 of 2014 ICRP Progress Report V1.1).

Appendix IX-5

Re-Vegetation and Metals Levels in Plant Tissue Research (Task 6.1and 6.4)

IX-5 Re-Vegetation and Metals Levels in Plant Tissue Research (Task 6.1and 6.4)

RECLAMATION OF DISTURBED SITES AT DIAVIK DIAMOND MINE A RESEARCH PROPOSAL

Dr M Anne Naeth Department of Renewable Resources University of Alberta

1 Background of Previous Research

Diamond mining in the Canadian north has intensified since the discovery of diamonds in the Northwest Territories in 1991. Diamondiferous kimberlite can be mined economically at B1 carat (200 mg) of diamonds per tonne of ore; therefore, diamond mining involves processing and disposal of large quantities of rock and tailings wastes. Concerns over mining impacts on wildlife, human health and the environment have prompted government agencies to require reclamation of mining disturbances to viable and sustainable ecosystems to protect resource function and integrity.

From 2004 to 2009, we conducted research at Diavik Diamond Mine on soil and plant community development on potential reclamation substrates composed of waste materials from the mine site. This research is documented in one Master of Science thesis (Kwiatkowski 2006) two refereed journal research papers (Drozdowski et al. 2012, Naeth and Wilkinson 2012) and two final reports (Naeth and Wilkinson 2010, 2011).

From five years of research we learned the following.

- Processed kimberlite is not a good substrate for plant establishment or growth due to elevated metal concentrations, pH and available potassium and sulphate. When mixed with glacial till in a 50:50 volume ratio, these concentrations are diluted; however, plant performance is still less than optimum. At a 25:75 volume ratio, improvements are seen. Amending processed kimberlite with salvaged topsoil improved soil quality and plant performance in the short term, but with time plant survival was poor relative to other reclamation substrates.
- Glacial till was the best reclamation substrate of those assessed. Initially, glacial till was an adequate medium for plant establishment but by year three it surpassed most other reclamation treatments in plant cover, density, species richness and diversity. Inorganic fertilizer further enhanced revegetation of till substrates.
- Sewage sludge amendment to till and 50:50 processed kimberlite and till, resulted in high plant cover, but plant species richness and diversity were low. In the first few years, this treatment had low plant establishment and growth which did not increase until year three.
- Gravel substrate had high plant establishment from year one but its performance as a reclamation substrate declined with time. The rough surface is thought to have increased

microsites which sheltered seed and seedlings from the wind, increasing establishment. Over time, the substrate lacked nutrients, as even those added could not be retained due to substrate physical properties (no organic matter, large pore space, no fine mineral content). These properties also limited soil water holding capacity.

- Addition of native plant propagules is necessary to facilitate succession. Native species colonization can occur, but at a slow rate. Germination rates of seeded species were low but once germinated and established, many seeded species provided good ground cover and readily spread to adjacent plots.
- Initial plant cover increased litter which in turn will add nutrients to the substrate and increase water holding capacity. Moss and lichen were found in a few plots, signs of establishment of a biological crust which is important for soil and plant development in tundra. In the long term, litter and biological crust development should further ameliorate soil conditions and enhance plant establishment and growth.

Given the inhospitable climate and substrate conditions, results of reclamation research to date are very promising. Many reclamation treatments are on a trajectory towards development of a self sustaining tundra community. To build on our past research and advance the collective knowledge of how to successfully reclaim disturbed sites such as diamond mines in Canada's north, we would like to embark on the research program detailed in this proposal. We have results from reclamation research over the past decade at other severely disturbed sites including the oil sands and limestone quarries that support our proposed approach and building on the collective findings will expedite results at Diavik. This is an opportune time to move forward with reclamation research at Diavik as the experimental sites are established and further results can be obtained in a relatively short period of time with little additional financial support. We currently can leverage funds for this research, since we have a number of graduate students with scholarships so funds would only be required for research expenses.

The research approach incorporates three areas of focus: patch revegetation to maximize limited resources, native shrub propagation to build diverse plant communities and long term monitoring for continued evaluation of reclamation success. We consider this one research program, but have provided separate objectives, methods and budgets as they could be implemented in a phased approach if required.

2 Patch Revegetation To Maximize Limited Resources And Restore Tundra Communities

2.1 Research Purpose and Objectives

Patch revegetation refers to the application of various techniques to reestablish native vegetation on a reclamation site on a patch by patch basis. The patches together synergistically return the site to its desired plant community. This approach is ideal when the disturbance area is large or resources required to restore native plant communities are limited.

Patches include microsites, topsoil and other organic matter sources, erosion control blankets and their combinations followed by seeding. Microsites provide a unique suite of environmental conditions favourable to seed germination and plant establishment. The most common benefit they provide is increased shelter from the elements and increased soil nutrients and soil water. Organic matter can have the same effect as microsites by increasing soil available nutrients and soil water. Shallow salvaged topsoil may also be a source of native propagules, including shrubs, as found in the oil sands (Mackenzie and Naeth 2010). When placed in microsites, there may provide cumulative benefits and the shelter provided by the microsite may reduce erosion of organic material. Woody debris, even of very small size, may also provide these cumulative benefits and woody propagules (Brown and Naeth 2012). Erosion of organic matter is the greatest issue based on our previous research and straw erosion control blankets would hold organic matter and seed in place to allow successful plant establishment. Straw can add further nutrients to the reclamation substrate. Erosion control blankets have been successful in revegetation of exposed slopes at limestone quarries (Cohen and Naeth in press).

Objectives of this research are to assess the following.

- Effects of depressions, mounds and boulders on establishment of native grasses and forbs.
- Effects of organic matter amendment on establishment of native grasses and forbs.
- Effects of erosion control blankets on establishment of native grasses and forbs.
- Effectiveness of patch revegetation on establishment of a diverse native tundra community.

2.2 Materials and Methods

Research will be conducted on the second experimental site established for our previous research program. The sites consist of three blocks, each with three main reclamation plots, gravel, glacial till and processed kimberlite. Each main plot has been subdivided into four subplots for depressions, mounds, boulders and control (flat). Within each subplot, 26 microsites have been randomly created. Half of the microsites will receive organic amendment. As the site is already established, establishment will require little work. Plots will be restaked. Microsites such as depressions may require additional digging out and mounds may need material added due to erosion. Plants did not establish in the initial study but any found will be removed prior to seeding. Patches of salvaged topsoil and/or commercial peat will be randomly placed in each main plot. Patches will be approximately 1 m^2. Half of the organic matter patches will be covered with biodegradable straw erosion control blankets. An equal number of patches will have erosion control blankets without organic matter. Best performing grass and forb species from the first research program will be selected for seeding in this study. Each patch will receive the same number of seeds per species, which will be determined following germination tests. Patches will be hand broadcast seeded as early as possible in 2013, ideally late June.

Plant establishment will be assessed at regular intervals during the growing season, mid June to end of August. Density of seeded and naturally colonizing species will be recorded in each patch annually at the end of the growing season. In 2015, plant density and cover will be determined in ten to fifteen randomly located quadrats in each main plot to assess overall effectiveness of patch revegetation. All species found within main plots will be recorded to calculate beta species diversity.

HOBO Microstations (Onset Corporation) with SmartSensors have been installed on one of the three blocks to monitor surface (0-5 cm) soil temperature and water throughout the growing season. HOBOs will be installed in organic matter and erosion control blanket patches in the block. Data collected every hour will be downloaded at every monitoring period. Five soil samples will be randomly collected in each of the main plots at 0-15 and 15-30 cm. We have much substrate data from the previous research program so these samples are only required to characterize the site and determine if there are changes with time. Soil penetration resistance and bulk density will be measured in ten random locations in each main plot. Penetrometer readings will taken at 0, 5, 10, 15, 20 and 30 cm. Bulk density samples will be collected using 7.5 cm diameter and 7.5 cm deep uhland cores. These soil physical properties will be used to assess rooting environment of each substrate and influence of compaction on revegetation.

Under controlled conditions at the University of Alberta greenhouse, effectiveness of amendments to improve soil quality and subsequently plant establishment will be investigated. Salvaged topsoil and commercial peat, capped and incorporated, with or without a hydrogel will be assessed. The base substrates will be glacial till, gravel, 50:50 processed kimberlite and till, and 25:75 processed kimberlite and till. Substrates will be capped or incorporated with 5 cm of topsoil or peat. Hydrogels increase soil water holding capacity, a limiting factor in reclamation substrates researched to date, and have been successful in improving plant establishment when added to processed kimberlite and till from other diamond mines (Naeth and Wilkinson, unpublished). Two watering regimes will be evaluated, watering to maintain field capacity and half of field capacity. Each treatment will be replicated five times. Two grasses and one forb will be sown in each 15 cm diameter plot at a rate of 10 seeds per species per pot. Greenhouse conditions will be 20 ^{O}C during the day and 15 ^{O}C at night with a 16 h photoperiod.

Plant density will be measured every 3 days for the first two weeks and then once a week for the next 10 weeks. At each monitoring date, plant health will be assessed on a scale of 0 to 5, with 0 being dead and 5 green, robust and vigorously growing. At 4, 8 and 12 weeks, mean plant height and mean number of leaves per plant will be measured. At week 12, above ground biomass will be clipped in three random pots of each treatment, oven dried at 80 ^{O}C for 48 hour, and weighed. Root biomass will be hand separated from soil in these three pots, lightly washed to remove substrate particles, then oven dried at 80 ^{O}C for 48 hours prior to weighing.

3 Propagation of Native Shrubs for Revegetation of Disturbed Sites

3.1 Research Purpose and Objectives

Shrubs comprise up to 80% of the native tundra vegetation cover on and surrounding the Diavik mine site. Native grasses and forbs are a component of the native vegetation and are often the focus in reclamation because their seed is more readily available and germination and establishment rates are higher than those of shrubs. This may partially be due to the paucity of research on germination and establishment of shrub species common in the area. Research has shown that some *Salix* species can establish from stem cuttings but this is dependent on species and collection method. *Salix* species are most abundant in wet tundra and have done well under ideal hydrologic conditions but not in the field where soil water is limiting (Naeth and Wilkinson, unpublished).

While wet tundra is common around the mine site, the aim of reclamation at most disturbed sites will be establishment of heath and esker type communities due to the highly altered soil profile and hydrology. Ericaceous shrubs dominate mesic to xeric sites including *Empetrum nigrum*, *Arctostaphylos rubra*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, *Ledum decumbens* and *Loiseleuria procumbens*. *Betula glandulosa* is a common component of heath. Presence of this functional group on reclaimed sites may enhance establishment of other species through changes in soil properties and shelter. Shallow salvage of topsoil on sites to be disturbed may be a good amendment to improve soil quality and be a source of propagules (seed, vegetative parts) for native species, specifically shrubs. Research in the oil sands found significant increases in native species, specifically trees and shrubs, with amendment of topsoil salvaged from 0-20 cm depth on sites to be disturbed (Mackenzie and Naeth 2010, Mackenzie 2012).

Objectives of this research are as follows.

- To determine the ideal time for collection of seed of ericaceous shrubs and *Betula glandulosa* to facilitate germination.
- To determine ideal conditions for germination of the above species including light and temperature regime and water requirements.
- To determine if pre treatments including cold stratification, chemical and mechanical scarification are required to break seed dormancy and enhance germination of the above species.
- To quantify the propagule bank of shallow salvaged topsoil from sites to be disturbed and compare plant establishment between direct placement and stockpiling for one year.
- To develop recommendations for reclamation methods which will improve shrub establishment.

3.2 Materials and Methods

Seed of each target species will be hand collected throughout 2013 from undisturbed areas on East Island. Collection periods will depend on plant physiology to coincide with maturation of seed. For some species, this period of maturation falls early in spring, just after thaw, and for others it is end of summer. Seed will be kept dry and cool until experiments begin.

In each experiment 25 seeds of a given species will be placed on filter paper in 10 x 12 cm clear plastic germination containers and replicated three to five times. We have two incubators in our lab with temperature ranges from -10 to 60 ^{o}C to investigate effects of temperature on seed germination. Light in germination containers can be decreased by wrapping containers in paper towel or tin foil depending on requirements. Light measurements will be taken with a quantum light meter. Water potential ranges best for seed germination will be tested through use of solutions of polyethylene-glycol and distilled water at rates of -0.3, -0.8, -1 and -1.5 MPa. If under standard germination procedures, germination is not evident or very low, pre treatments will be evaluated. Common pre treatments include cold-moist stratification, chemical scarification with sulphuric acid or hydrogen peroxide and mechanical scarification with sandpaper or power sander. Each experiment will run for 4 to 6 weeks. Germinating seeds will be counted every day for the first two weeks and then every other day for the next two weeks. Seeds in dark treatments will be counted in a dark room with green light.

Species specific experiments will be developed following a detailed review of published literature. We currently have a post doctoral fellow working with our team, who specializes in seed physiology and he will provide expert advice on design and methods.

In spring and fall 2013, ten soil samples will be collected from heath, shrub and wet tundra communities on East Island at two depths, 0-5 and 6-10 cm. Soil samples will be directly placed in the growth chamber at the University of Alberta. Samples will be spread to approximately 2 cm depth in 10 x 12 cm plastic containers lined with 2 cm of Terra-Lite® Metromix and placed randomly in the growth chamber. Soils will be watered with distilled water as needed to prevent surface drying. Growth chamber conditions will be kept at 21 ^{O}C during the day for 16 hours and 15 ^{O}C at night for 8 hours. Emerged plants will be identified and counted every two weeks for the first two months and at monthly intervals thereafter for six months. Identified plants will be removed, including the root. Unidentifiable plants will be left until the next monitoring. Samples will be mixed at two and four months to promote emergence by bringing up buried seeds.

4 Long Term Monitoring To Evaluate Reclamation Success

4.1 Research Purpose and Objectives

Reclamation of disturbed sites to predisturbed landscapes requires time. Besides the physical appearance of the site, less obvious ecosystem functions must be reestablished including nutrient cycling, hydrologic regimes and plant reproduction. A self sustaining system may require years or decades depending on the ecosystem. In the arctic, a longer time period is expected due to harsh climatic conditions.

In 2014, ten years will have passed since reclamation was implemented at Diavik Diamond Mine. The research site has not been monitored since 2009 and sufficient time has passed for potentially significant changes in soil and plant community development. In the first five years following reclamation, major changes in soil properties and plant abundance and diversity occurred depending on the reclamation substrate and amendment. At the last monitoring, many reclamation treatments appeared to be on a trajectory towards a self sustaining tundra community, while others were clearly in arrested successional stages and the likelihood of further changes was low (Naeth and Wilkinson 2012). There are very few opportunities to obtain long term data on reclamation sites in Canada, particularly in the north, where detailed information on reclamation methods is also available. The opportunity to monitor the research plots in 2014 would allow us to quantitatively determine if our projections after five years were correct or if different restoration trajectories have established. These data are important to ensure that methods recommended to Diavik in the early stages of soil and plant community development are consistent with results at ten years. If changes are observed, we can assess which mechanisms may be responsible for those changes and then determine how to improve reclamation in treatments if required.

Objectives of this research are to determine the following.

- If native plant richness, evenness and abundance increases in reclamation treatments.

- If litter, lichen and moss ground cover increases and how this affects soil quality and plant abundance and biomass.
- If potentially detrimental soil properties in processed kimberlite treatments are ameliorated with time.
- If glacial till with or without fertilizer continue to be the best performing reclamation treatments for establishment of a diverse and abundant vegetation cover.

4.2 Materials and Methods

In 2004, a randomized incomplete block design was established on the research site. The site was divided into three blocks on previous storage pads or work areas. Nineteen substrate amendment treatments and 6 seed mix treatments were applied to each block. Blocks were irregular shapes and plots were established to use all available space. Each block was divided into 5 substrate plots of equal area; plots were 300 m^2 plots in Blocks 1 and 3 and 150 m^2 in Block 2. Each substrate plot was divided into 4 amendment plots of equal size. Each amendment plot was oriented north-south and divided in half for season of seeding treatments, spring or fall. Each season of seeding plot was divided into 6 to 10 approximately 3 m^2 plots for individual seed mixes. All treatments were randomly assigned. A reference area was located on the north west portion of East Island, in an area where no land disturbance had occurred.

Substrates and amendments were selected based on availability, previous reclamation research at northern diamond mines (ABR Inc 2001, Reid and Naeth 2005a, 2005b) and Diavik's reclamation research plan (2002). Substrates were glacial till (till), fine processed kimberlite from the containment facility (PK), 50 % PK and 50 % till mix (5050), 25 % PK and 75 % till mix (2575) and no substrate added (Gravel). Soil amendments were salvaged topsoil (topsoil), inorganic nitrogen phosphorus fertilizer (11-52-0) (fertilizer), sewage sludge (sewage), sludge from the North Inlet Pond water treatment plant (sludge) and no amendment.

In all years of monitoring, season of seeding had no effect on plant establishment or diversity. Seed mix significantly affected plant community development in the first two years, but beyond this did not have an effect. Therefore, in 2014, seed mix and season of seeding will not be included in monitoring and analyses. In late July 2014, vegetation will be assessed in each main plot with five to ten randomly located 20 x 50 cm quadrats. Plot edges will not be sampled to avoid neighbour effects. In each quadrat, species will be identified and individual plants counted. Cover by vegetation layer and species will be measured. The proportion of plants of each species with seed and/or flowers will be recorded. Grazing and overall plant health will be assessed. In three random quadrats, above ground biomass will be clipped at ground level, and sorted by species into paper bags. In the laboratory, biomass with be oven dried at 80 ^{o}C for 48 hours then weighed.

Three randomly located soil samples will be collected from each main plot. At each location, samples will be taken at 0-10 and 20-30 cm. Samples will be kept cool until delivered to a commercial laboratory for analyses. Samples will be analyzed using standard methods for pH, electrical conductivity, sodium adsorption ratio, total organic carbon and inorganic carbon, cation exchange capacity and available nitrogen, phosphorus, potassium and sulfur. Samples from treatments with processed kimberlite or sewage sludge will also be analyzed for metals of concern including barium, beryllium, cadmium, cobalt, chromium, copper, molybdenum, nickel, lead and selenium.

5 Literature Cited

Brown, R.L. and M.A. Naeth. 2012. Woody debris amendment enhances reclamation after oil sands mining in Alberta, Canada. Restoration Ecology. In revision.

Cohen-Fernandez, A.C.2011. Reclamation of a limestone quarry to a natural plant community. PhD Dissertation, Department of Renewable Resources, University of Alberta. 224 pp.

Cohen-Fernandez, A.C. and M.A. Naeth. 2012. Erosion control blankets, organic amendments and site variability influenced the initial plant community at a limestone quarry in the Canadian Rocky Mountains. Biogeosciences. In press.

Drozdowski, B.L., M.A. Naeth and S.R. Wilkinson. 2012. Evaluation of substrate and amendment materials for soil reclamation at a diamond mine in the Northwest Territories, Canada. Canadian Journal of Soil Science 92(1):77-88.

Kwaitkowski, B.L. 2006. Diamond mine reclamation in the NWT: substrates, soil amendments and native plant community development. MSc Thesis, Department of Renewable Resources, University of Alberta. 113 pp.

Mackenzie, D.D. 2012. Oil sands mine reclamation using boreal forest surface soil (LFH) in northern Alberta. PhD Dissertation, Department of Renewable Resources, University of Alberta. 232 pp.

Mackenzie D.D. and M.A. Naeth. 2009. The role of the forest soil propagule bank in assisted natural recovery after oil sands mining. Restoration Ecology. 17:1061-2971.

Naeth, M.A. and S.R. Wilkinson. 2012. Establishment of restoration trajectories for upland tundra communities on diamond mine wastes, Northwest Territories, Canada. Restoration Ecology. In prep.

Naeth, MA and SR Wilkinson. 2011. Diamond mine reclamation in the NWT: substrates, sol amendments and native plant community development. Final Report Phase II for Diavik Diamond Mines Inc. 45 pp.

Naeth, M.A. and S.R. Wilkinson. 2010. Diamond mine reclamation in the NWT: substrates, soil amendments and native plant community development. Final report Phase I for Diavik Diamond Mines Inc. 38 pp.

Appendix IX-6

NI Sediment Characterization Update (Task 5.6)

IX-6 NI Sediment Characterization Update (Task 5.6)

1.0 GENERAL

This work plan provides a scope for supplemental environmental investigations of the North Inlet site. The described work is a follow-up to work completed in 2010.

2.0 BACKGROUND

Golder Associates Ltd. (Golder) has been undertaking investigations of North Inlet sediment quality at the request of Diavik Diamond Mines (2012) Inc. (DDMI). The purpose of the ongoing investigations is to determine whether, at mine closure, the dike separating North Inlet from Lac de Gras could be opened (i.e., physical obstructions removed) such that North Inlet could naturally return to fish habitat.

Investigations in 2010 and 2011 included a suite of chemistry and toxicity studies, which collectively yielded uncertain conclusions regarding potential toxicants and/or habitat effects in North Inlet sediments. However, in 2012, a porewater toxicity identification evaluation (TIE) provided evidence that petroleum hydrocarbons (PHCs), in particular CCME-F3[1], could be the cause of North Inlet porewater toxicity (and by extension, the inferred cause of sediment toxicity) to the amphipod *Hyalella azteca* (Golder 2013a). A follow-up study that investigated the source and fate of PHCs and related contaminants confirmed that these organic contaminants originate from the underground mine water, which discharges to North Inlet. Once in North Inlet the PHCs associate with sediments and also pass through North Inlet water column to the NIWTP, where they are “concentrated” in the sludge (Golder 2013b). Moreover, the main fraction of PHCs detected in sediment porewater and mine water samples is CCME-F3, a finding that is consistent with the porewater and sediment chemistry results reported in the TIE study. One viable hypothesis as described in Golder (2013a) is that the source of these organic compounds is hydraulic or lubricating oils from the Mine. These recent findings (Golder 2013a,b) suggest that the presence of PHCs in North Inlet sediments is an important consideration for closure planning, and may be of equal or greater concern relative to presence of other mine-related constituents identified in water, sediment, and sludge.

The Wek’èezhìi Land and Water Board has requested that the North Inlet sediment study be repeated in 2015 to further inform closure decisions and actions. The planned approach is to provide updated information on sediment, sludge, and benthic invertebrate community conditions, while also building on recent advances in the understanding of site conditions.

3.0 SCOPE OF WORK

3.1 Update to Conceptual Site Model

The conceptual site model (CSM) for the North Inlet integrates the available operations, contaminant and ecological information. The CSM is similar to that presented in 2010 (Golder 2010), with updates based on more recent North Inlet investigations. The key features of the CSM for North Inlet includes:

---

[1] The Canada-Wide Standards for Petroleum Hydrocarbons (CCME 2008) divide PHCs into four representative fractions F1 (C6 to C10), F2 (C10 to C16), F3 (C16 to C34) and F4
(C34 to C50)

- **Sources of Contamination to North Inlet Sediments:** North Inlet is currently separated (via dike) from Lac de Gras and is used as a final settling pond for site runoff and mine water. The collected mine water is pumped directly to the western end of North Inlet. The intake to the North Inlet Water Treatment Plant (NIWTP) is located at the eastern end of North Inlet. North Inlet water is treated at the NIWTP prior to discharge to Lac de Gras, and NIWTP sludge is returned to the western end of North Inlet. The 2010 sediment investigation conducted by Golder suggested that sludge and mine water inputs may have been influencing chemical conditions and a resulting potential for biological effects in North Inlet with the influence decreasing from the west (where sludge and mine water discharge to the inlet) to the east where the NIWTP is located. Sediments from four of the five North Inlet stations (NI-1 to NI-4) were classified as toxic based on the results of standardized laboratory toxicity tests, contained varying amounts of a viscous unconsolidated algal material on the sediment surface, and exhibited an impoverished benthic community relative to reference conditions in Lac de Gras (Golder 2011a). Both the mine water and sludge are potential sources of contaminants to North Inlet sediments.
- **Contaminants of Potential Concern (COPCs):** For the mine water and sludge inputs to North Inlet, associated contaminants could include phosphorous, ammonia and sulphide, metals (including metalloids), and hydrocarbons (both petroleum hydrocarbon [PHC] fractions and polycyclic aromatic hydrocarbons [PAHs]). Investigations from 2010-2012 identified metals concentrations in exceedance of CCME ISQGs in North Inlet sediments, but the linkage between elevated metals concentrations and resulting toxicity in sediments and sediment porewater was uncertain. In contrast, a sediment porewater TIE demonstrated that PHCs, particularly CCME-F3 were the likely cause of observed porewater toxicity to Hyallela azteca. Previous toxicity tests indicate that neither ammonia, (Golder 2011a), nor sulphide, (Golder 2012), has contributed to the observed toxicity, but these will be measured in future toxicity tests to reconfirm. Phosphorous and reagents were also monitored in sediments in 2010 but were not implicated in the observed toxicity. The above-listed substances are considered COPCs for North Inlet sediments and will be assessed as part of the 2015 investigation with the purpose of updating the current understanding of contaminant conditions in the Inlet.

- **Receptors of Concern (ROCs):** The receptors of concern (ROCs) for potential contaminant issues in North Inlet sediments are:
    - Lake productivity (phytoplankton, periphyton, and zooplankton communities).
    - Benthic invertebrate community.
    - Demersal fish.
    - Pelagic fish.

The 2015 North Inlet study will focus on direct effects to the benthic invertebrate community and indirect effects to fish, via food supply to fish. Additional discussion of these pathways is provided below.

- **Pathways:** The pathways for North Inlet COPCs to affect ROCs that have been assessed since 2010 include direct sediment toxicity, indirect toxicity via leaching of toxicants from sediment or sludge to the water column, and indirect effects via degradation of food supply:

  - The benthic invertebrate community is in direct contact with sediments and may be exposed to sediment contaminants. Investigations since 2010 indicate toxicity to benthic invertebrates at some stations in North Inlet with the likely cause being petroleum hydrocarbons. This pathway is included in the 2015 study to update the current understanding of conditions in the inlet.

  - The benthic invertebrate community provides a key food supply for demersal and pelagic fish. Degradation of the benthic invertebrate community through loss of abundance, biomass, or diversity of food items could have an indirect effect on the fish community. This pathway is retained for indirect assessment in the 2015 study (similar to the 2010 study).

  - Phytoplankton and zooplankton (collectively considered as measures of “lake productivity”) are in direct contact with the water column and may be exposed to contaminants that leach into the water column. However, evidence to date does not indicate impairment of these receptors from aqueous exposures. The sediment core leaching study (Golder 2011b) confirmed that North Inlet sediments were not leaching metals at concentrations of toxicological concern, and overlying water from the cores was not toxic to the epibenthic amphipod *Hyalella azteca*. Ongoing monitoring (Golder 2013b) of the influent to the NIWTP indicates that PHC and PAH concentrations in the water column of North Inlet are below analytical detection limits. These findings indicate that contaminants are unlikely to be leaching into the water column at concentrations that would adversely affect phytoplankton or zooplankton; therefore, this pathway was not retained for the 2015 study.

  - Zooplankton provides a food supply for pelagic fish particularly younger life stages and, therefore, any degradation of the zooplankton community could have a potential indirect effect on the fish community. This indirect pathway was also not retained for the 2015 study because the lack of direct effects to zooplankton precludes any cascading responses to higher trophic levels.

  - Demersal and pelagic fish are in direct contact with the water column and exposed to contaminants that leach into the water column. Previous studies of water chemistry and aquatic toxicity indicate that contaminants are unlikely to be leaching into the water column at concentrations that would adversely affect fish; therefore, this pathway was not retained for the 2015 study.

- **Protection Goal and Endpoints:** The protection goal for North Inlet is the maintenance of habitat and conditions in the Inlet that will not adversely affect the health and ecological integrity of Lac de Gras in terms of functional lake productivity, infaunal benthic invertebrate communities and fish populations. Health and ecological integrity for fish, invertebrates, aquatic plants and algae depend on the importance of their role in the ecosystem and the degree of resilience and redundancy in the aquatic community. For example, there is typically a high degree of redundancy in zooplankton communities meaning that a decline in one species may result in compensatory responses in other species with the net results that the functional integrity of populations of fish food organisms is maintained. Conversely, there may be less redundancy in top predator fish populations meaning that a decline in top predators could have implications at the ecosystem level (i.e., via trophic cascade). This protection goal for North Inlet is elaborated in the endpoints and risk hypotheses in Table 1. These endpoints and risk hypotheses have been updated from 2010 (Golder 2010) to the current study, based on the updated understanding gained from investigations from 2010 to 2013.

Table 1: Assessment Endpoints, Risk Hypotheses and Measurement Endpoints for Receptors of Concern

Assessment Endpoints	Risk Hypotheses/Previous Conclusions	Measurement Endpoints
Benthic Invertebrate Community Maintenance of the health and ecological integrity of the infaunal benthic invertebrate community	**Null hypothesis:** Substances in North Inlet sediments that are related to mine water and sludge inputs do not result in adverse effects to the benthic invertebrate community. **Previous findings:** Potential for impairment exists based on observed laboratory toxicity, with the likely cause being petroleum hydrocarbons.	Determine the magnitude and bioavailability of sediment contaminant concentrations through the measurement of sediment chemistry and SEM:AVS molar ratios. Compare sediment chemistry results to CCME guidelines. Measure the potential lethal and sub-lethal effects of sediments to representative benthic invertebrate species (14-d *Hyalella azteca* and 10-d *Chironomus* sp. toxicity tests). Measure and evaluate in situ changes to the benthic invertebrate community in North Inlet and compare to 2010 conditions in North Inlet and current conditions in Lac de Gras (from AEMP monitoring).
Lake Productivity Maintenance of the health and ecological integrity of phytoplankton and zooplankton communities	**Null hypothesis:** Substances leaching from North Inlet sediments to the water column that are related to mine water and sludge inputs do not result in an adverse impact on lake productivity. **Previous findings:** Studies in 2011 and 2013 indicate that contaminants are unlikely to be leaching into the water column at concentrations that would adversely affect phytoplankton or zooplankton.	Not included in the 2015 study.
Demersal and Pelagic Fish Maintenance of the health and ecological integrity of fish populations.	**Null hypothesis:** Substances leaching from North Inlet sediments to the water column that are related to mine water and sludge inputs do not result in a direct adverse impact on fish. **Previous findings:** Studies in 2011 and 2013 indicate that contaminants are unlikely to be leaching into the water column at concentrations that would adversely affect phytoplankton or zooplankton at each the individual or population level.	Not included in the 2015 study.
Maintenance of the functional integrity of populations of fish food organisms.	**Null hypothesis:** The food supply for fish populations is not impaired. **Previous findings:** Uncertain study results, due to evidence for toxicity in sediment-associated invertebrates, but lack of harm for organisms in the water-column.	Not assessed directly – relies on inference from the endpoint results for benthic invertebrate community and lake productivity.

3.2 Study Design Considerations

3.2.1 Lines of Evidence

The sampling and analysis plan (SAP) for the 2015 study addresses the endpoints presented in Table 1. Three broad lines of evidence have been included:

1) **Surface Sediment Chemistry Measurements** – to determine the magnitude and spatial extent of chemical contamination from mine water and sludge inputs to North Inlet. Sediment chemistry will be integrated with sediment toxicity and benthic community structure using a weight of evidence approach. In previous sampling events (Golder 2011a, 2011b), biomagnifying substances (mercury and selenium) were not identified to be of concern in North Inlet sediments, relative to Lac de Gras sediments, but this will be reconfirmed in 2015. Specific analyses are discussed in Section 3.3.

2) **Sediment and Sludge Toxicity (acute and chronic) Determinations** – synoptic with sediment chemistry (i.e., subsamples from the same sample), to determine the direct toxicity of North Inlet sediments to benthic invertebrates. Testing of NIWTP sludge will also be repeated to investigate if conditions have changed. Specific tests are discussed in Sections 3.3 and 3.4.

3) **Infaunal Community Structure** – coincident with sediment chemistry and toxicity testing (i.e., not same samples but collected from the same sampling locations and same collection date), to evaluate in situ impacts to benthic invertebrates, if any, in North Inlet. These analyses are discussed in Section 3.5.

Indirect effects to demersal and pelagic fish populations from degradation of food supply will not be measured explicitly as part of this study. Instead, it is assumed that indirect adverse effects would be linked to alterations in the food supply; as such, the measurements of the benthic invertebrate community will be used to make inferences regarding the potential for biological consequences to fish.

The activities associated with these lines of evidence are described in the following subsections.

3.2.2 Sampling Stations

The focus of the 2015 investigation will be on North Inlet with the three lines of evidence described above being investigated in North Inlet sediments, and chemistry and toxicity investigated in NIWTP sludge. Figure 1 illustrates the 2010 sediment sampling locations in North Inlet that will be the focus on the 2015 investigation.

Reference stations in Lac de Gras were also investigated in 2010 but these stations have not been included for the 2015 investigation. The objective of the 2010 investigation was to determine if the potential adverse impacts on the aquatic ecosystem in North Inlet, and comparison to Lac de Gras reference conditions, provided important context for the chemistry, toxicity and benthic community structure findings. For 2015, the objective focusses more on monitoring the changes to conditions in North Inlet since 2010 with a focus on long-term closure planning. Thus, the 2010 findings will provide context for the 2015 test results in North Inlet (i.e., comparison to 2010 will update the current understanding of conditions and impacts in North Inlet).

LEGEND

● PROPOSED 2015 SAMPLING STATION

300 0 300

SCALE 1:15,000 METRES

STATION	EASTING	NORTHING
NI-1	533797	7153657
NI-2	533923	7153618
NI-3	534295	7153541
NI-4	534761	7153408
NI-5	535093	7153329

REFERENCE

IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, 2015.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT

DIAVIK DIAMOND MINES INC.

TITLE

SAMPLING LOCATIONS FOR NORTH INLET STATIONS

Golder Associates

PROJECT		05-1328-008	FILE No.	
DESIGN	RS	06 Apr. 2015	SCALE AS SHOWN	REV. 0
GIS	CDB	06 Apr. 2015	**FIGURE 1**	
CHECK	RS	14 Apr. 2015		
REVIEW	GL	14 Apr. 2015		

3.3 Task 1: Chemistry and Toxicity Assessment of North Inlet Sediments

The objective of this task is to update understanding of the chemistry and toxicity of North Inlet surficial sediments, and compare to the toxicity test results obtained in 2010 and 2011. It will involve:

- grab sampling of near-surface sediments from North Inlet, with sampling to a depth of sediment determined by the 2010 and 2011 findings;
- analyses of a subsample (aliquot of composited sediment) from each station for sediment chemistry; and
- laboratory analyses of sediment toxicity for each station.

North Inlet sediment chemistry will also be compared to results from samples collected at Lac de Gras reference locations in 2010.

3.3.1 Sediment Chemistry

Sediment grab samples will be collected from the five sampling stations that were previously sampled in North Inlet in 2010, specifically Stations NI-1 to NI-5. The 2010 stations will be specifically targeted so that the results of the 2015 investigation will be directly comparable to the results observed in 2010, and in subsequent investigations that have been conducted since then for a subset of the 2010 stations (NI-1, NI-3 and NI-5).

A minimum of five grabs will be collected at each station and composited prior to distribution to storage containers. It may be necessary to deploy the grab more than five times to collect a sufficient volume of sediment. Only those grab samples that meet the following acceptability criteria will be retained for analyses:

- the sampler is fully closed and does not contain large rocks or other debris;
- there is adequate penetration depth (i.e., at least 10 cm);
- the sample is not overfilled or disturbed, and sampler was not deployed on an angle (sediment surface does not touch the top of the sampler, and is relatively flat); and
- disturbance of the sediment surface is minimal.

If the grab is classified as acceptable, then processing will proceed as described below. Any remaining overlying water in the grab will be removed using a siphon and a description of the sediment with respect to colour, particle size, odour, and presence of non-sediment materials (e.g., debris, biota) will be recorded. The five grab samples will be processed to generate one composite sediment sample for chemistry analyses and five field replicate samples for sediment toxicity testing.

The sampling design for sediment quality assessment entails separate procedures for processing chemistry samples (i.e., compositing of multiple grabs) versus toxicity samples (i.e., maintenance of physically distinct replicate samples). This approach has been adopted in consideration of observations from the 2010 study, in which North Inlet sediments were observed to have varying amounts of a dark black-green viscous unconsolidated material containing large amounts of algae present on their surface.

For toxicity testing, it is desirable to evaluate the individual grabs separately, in case the viscous material causes physical effects to the test organisms that would otherwise be obscured by compositing. Accordingly, two sets of pre-cleaned bowls and utensils will be used for subsampling and compositing sediments at each location: 1) a “replicate” bowl to provide field replicates for toxicity testing, and 2) a “composite” bowl to provide a single composite sample for chemical analyses.

The surface sediment from the first grab will be removed and placed in the “replicate” bowl. Field personnel should follow these guidelines for depth of sediment collection:

- If there is no unconsolidated layer (i.e., similar to what was previously observed at NI-5), then collect surface sediment from each grab to a depth of 5 cm.
- If there is an unconsolidated layer (i.e., similar to what was previously observed at NI-1 to NI-4), then collect surface sediment from each grab up to a depth of 10 cm. The goal in this case is to attempt to obtain a combined sample of the unconsolidated material and the underlying sediments, in approximate equal amounts. This is consistent with decisions made during field sampling in 2010 and 2011.

Sediments will be thoroughly mixed in the “replicate” bowl until the sediment is homogeneous in colour and texture; one labelled 500 mL glass jar will be filled with a subsample of this homogenized sediment (Toxicity Tests Rep 1) and the remainder will be transferred to the “composite” bowl. The empty “replicate” bowl will then be washed with site water, and then the process repeated with the remaining four grabs, resulting in five 500 mL jars of sediment (Toxicity Test Reps 1 to 5) and the “composite” bowl containing the remaining sediment from the five grabs. Once all the replicate samples have been collected, the contents of the “composite” bowl will be thoroughly mixed until they are homogeneous in colour and texture, and then distributed to the labelled sample containers (two 250 mL glass jars, one 500 mL glass jar[2], and one 1 L Whirl-pak or Ziploc plastic bag) for chemistry analyses. Each sample container will be filled completely, sealed immediately, and placed in a cooler with ice packs.

The samples collected for sediment chemistry will be submitted for analyses of the following parameters:

- moisture content, sediment pH (performed on an 2:1 deionized water extract), particle size composition, total organic carbon (TOC);
- acid volatile sulphides (AVS) and simultaneously extractable metals (SEM);
- total metals[3];
- total and available phosphorus;
- polycyclic aromatic hydrocarbons (PAHs);

[2] The 500-mL glass jar of sediment from the composite sample will be submitted to the toxicity testing laboratory, for measurement of interstitial ammonia concentration (which needs to be measured at each station but not on each field replicate). This jar should be labelled “Toxicity Tests Ammonia Composite”.

[3] In this document, “metals” refers to metals as well as metalloids (such as arsenic and selenium) and other elements included in the ICPMS scan.

- petroleum hydrocarbons (PHCs; CCME F1-F4); and
- volatiles (benzene, toluene, ethylbenzene, and xylene [BTEX]) and methyl tert-butyl ether (MTBE).

One duplicate "split" sediment sample (i.e., from the same composite sample) will be collected from one of the North Inlet stations (determined at the discretion of field personnel during field sampling)

3.3.2 Sediment Toxicity

The toxicity replicates from each station will also be submitted to conduct standard whole-sediment toxicity tests similar to those that were performed in 2010, using two freshwater aquatic species: amphipods (*Hyalella azteca*) and chironomids (*Chironomus dilutus*). The laboratory will be instructed to set up the tests with field replicates maintained as distinct exposure units rather than composited in the laboratory. The toxicity tests are described in detail below.

*14-d Amphipod (*Hyalella azteca*) Toxicity Test*

Hyalella azteca is a freshwater crustacean commonly found in lakes and streams throughout temperate North America. This amphipod is an epibenthic detrivore (animal that feeds on decomposing matter near the sediment-water interface) that typically burrows into the surface of the sediment layer to feed. It has been selected by US EPA as a standard toxicity test organism because it has a short generation time, a widespread and abundant distribution, is ecologically important, has a wide tolerance of different sediment grain sizes, and easily cultured (US EPA 2000).

The 14-day *Hyalella* survival and growth test will be conducted according to procedures described in Environment Canada (1997a). Test organisms will be 2 to 9 days old at test initiation. For each test sediment sample, five replicate test containers will be prepared (each representing a single field replicate) for the toxicity test, plus one replicate test container consisting of composited sediment[4] for measuring porewater ammonia on Day 0. The negative control sediment will be clean sand.
The control/dilution water will be the standard laboratory water used by the facility for freshwater sediment toxicity tests, rather than water prepared to mimic Lac de Gras characteristics. Standard laboratory water will be used so as to avoid potential problems with laboratory-reared test organism health associated with acclimation to Lac de Gras water. Temperature, pH, conductivity and dissolved oxygen (DO) will be monitored daily; hardness, alkalinity, and total ammonia will be measured in composite samples of overlying water on Days 0 and 14. Final counts of amphipod survival will be made on Day 14, and average individual dry weight will be determined for surviving amphipods from each replicate. The test will be considered valid if mean control survival is ≥80% and mean control individual dry weight is ≥0.1 mg/amphipod. A 96-hour water-only reference toxicant test will be tested concurrently.

---

[4] Similar to 2010, the sediment sample for porewater ammonia testing will be collected from the sediment composite described in the sampling methods, above. Porewater ammonia analysis will not be conducted on each individual field replicate.

10-d Midge (Chironomus dilutus[5]) Toxicity Test

Chironomus spp. are freshwater midges whose larvae are common in depositional lentic environments such as ponds, lakes and sloughs. The larvae are benthic filter-feeders that consume organic matter and detritus, and in turn, they are important food sources for higher trophic levels such as fish and waterfowl. Chironomid larvae inhabit the first few centimetres of sediment, and then pupate and emerge as non-feeding adults (Environment Canada 1997b). *Chironomus* is a good candidate for long-term toxicity testing because it normally completes its life cycle in a relatively short period of time (25 to 30 days at 23°C), and a variety of developmental (growth, survivorship) and reproductive (fecundity) endpoints can be monitored (US EPA 2000).

The 10-day *Chironomus* survival and growth test will be conducted according to procedures described in Environment Canada (1997b). Test organisms will be third instar at test initiation. For each test sediment sample, five replicate test containers will be prepared (each representing a single field replicate) for the toxicity test. The negative control sediment will be clean sand. The control/dilution water will be the standard laboratory water used by the facility for freshwater sediment toxicity tests, rather than water prepared to mimic Lac de Gras characteristics. Standard laboratory water will be used so as to avoid potential problems with laboratory-reared test organism health associated with acclimation to Lac de Gras water. Temperature, pH, conductivity and dissolved oxygen (DO) will be monitored daily; hardness, alkalinity, and total ammonia will be measured in composite samples of overlying water on Days 0 and 10.

Final counts of chironomid survival will be made on Day 10, and average individual dry weight will be determined for surviving chironomids from each replicate. The test will be considered valid if mean control survival is ≥70% and mean control individual dry weight is ≥0.6 mg/chironomid. A 96-hour water-only reference toxicant test will be tested concurrently.

3.3.3 Data Analysis

Following analysis and quality assurance/quality control screening, the sediment chemistry and toxicity results will be compiled and analyzed to further inform our understanding of potential toxicants in North Inlet sediments. Sediment chemistry will be screened against the sediment quality guidelines (SQGs) that were used in the 2010 study and compared to sediment chemistry from the 2011-2013 investigations. Toxicity results will be compared to the 2010 and 2011 sediment toxicity results for North Inlet stations.

3.4 Task 2: Chemistry and Toxicity Assessment of NIWTP Sludge

This task involves characterization of the NIWTP sludge to supplement the analyses performed previously. It will consist of:

- monthly sampling of whole sludge and analyses of sludge chemistry over a period of three months; and

[5] Formerly known as *Chironomus tentans*

- during one of the sampling events, and following initial assessment of sludge chemistry, additional laboratory analyses of sludge toxicity.

Monthly samples of whole sludge will be collected and submited for chemistry analyses. One duplicate "split" sludge sample (i.e., from the same composite sample) will be collected during one of the monthly sampling events. The whole sludge should be analysed for moisture content, particle size, TOC, total phosphorus, total metals, PAHs, PHCs and volatiles.

Coincident with a monthly sampling event, an additional volume of whole sludge will be submitted to provide additional whole-sediment toxicity data using *Hyalella azteca* and *Chironomus dilutus*, as described in Section 3.3.2. The negative control sediment will be clean sand. The sludge sample for toxicity testing will be held at Diavik in the dark at 4°C for a period of one week to allow it to settle (i.e., solids settled to the bottom with decanting of overlying water). If necessary, the sample may be settled for an additional amount of time, and/or centrifuged at the laboratory to provide sludge that is sufficiently consolidated for use in sediment testing. The laboratory will be consulted to determine whether the sludge sample can be settled sufficiently for testing as sediment or if it would need to be tested as a water sample.

If the sludge sample cannot be settled sufficiently for the whole-sediment toxicity tests, a water-only 10-day LC50 toxicity test using *Hyalella azteca* will be conducted, using procedures based on Borgmann et al. (2005). The toxicity test will be conducted using a dilution series to allow for determination of an LC50 concentration on a volumetric (vol/vol) basis.

The static, 10-day water only *Hyalella azteca* test would be conducted using the following experimental design:

- Five-salt standard artificial medium (SAM-5S) moderately-hard reconstituted water will be the standard laboratory water used by the facility as the negative control and the diluent for Hyalella Azteca toxicity tests as per Borgmann (1996). Laboratory dilution water will be used rather than one prepared to mimic Lac de Gras characteristics in order to avoid potential problems with test organism health associated with acclimation to Lac de Gras water.
- Test containers will be 600 mL glass beakers, each containing 400 mL of leachate water.
- Two replicates will be prepared per treatment, and each replicate will contain 20 juvenile amphipods (7 to 9 days old at test initiation).
- The tests will be conducted for 10 days at 23 ± 1 °C under a 16:8 light:dark photoperiod.
- Overlying water will not be renewed during the test; gentle aeration (1 bubbles/sec for each litre of water) will be provided throughout the exposure period, and each test container of amphipods will be fed daily 5 mL of a mixture of yeast, Cerophyll (alfalfa powder), and fermented trout chow (YCT) and 5 mL of Tetramin slurry, as needed.
- Temperature and pH will be measured daily in each treatment; whereas conductivity and dissolved oxygen will be measured in the control and 100% sludge sample, at the start and end of the tests. Hardness, alkalinity, and dissolved organic carbon, as well as multiple

additional water quality parameters, will be determined for 100% sludge sample at the start of the tests.

- Final counts of survival will be made on Day 10. The *Hyalella azteca* test will be considered valid if mean control survival is ≥80%.
- A static, 96-hour water-only reference toxicant test with copper sulphate will be tested concurrently.

Sludge chemistry and toxicity results will be compiled and analyzed to further inform understanding of potential toxicants in North Inlet sediments. Considerations may include screening with sediment and water quality guidelines as well as comparison with sediment and toxicity findings for North Inlet sediments.

3.5 Task 3: Benthic Community Monitoring in North Inlet

The objective of this task is to monitor the benthic community in North Inlet. Five replicate grab samples will be collected from each of the five sediment sampling stations in North Inlet. Samples will be sieved (500 µm mesh) and preserved in the field for benthic community analysis, and then shipped to Dr. Jack Zloty for taxonomic analysis. Samples will be processed according to standard procedures based on recommendations in Environment Canada (2002) and Gibbons et al. (1993).

Samples will be washed through a 500 µm sieve to remove the preservative and fine sediments remaining after field sieving. Lighter organic material will be separated from heavier inorganic material by elutriation; the inorganic material will be checked for any remaining shelled or cased invertebrates, which will be removed and added to the organic material component. The organic material will be split into coarse and fine fractions using nested sieves (1 mm and 500 µm mesh size). Depending on the number of benthic invertebrates present in each replicate sample, subsampling may be required. Invertebrates will be counted and identified to the lower practical taxonomic level (typically genus or species) using recognized taxonomic keys. The biomass of each replicate sample will be estimated as total wet weight of the preserved organisms.

The following endpoints will be assessed for benthic community structure:

- taxa richness;
- total abundance;
- abundance of species for all major taxa (e.g., Chironomidae, Pisidiidae) and selected indicator species; and
- other benthic community indices (e.g., diversity, dominance, evenness).

The following QA/QC procedures will be used for both sorting and taxonomy:

- Sorting — sorting efficiency will be verified by the taxonomist by performing spot-checks on residual debris from 10% of the samples. If the number of the organisms found in the re-sort is greater than 10% of the total number, or if an entire taxonomic group was omitted by the sorter, then all samples will be re-sorted.

- Reference Collection — a reference collection will be prepared consisting of specimens' representative of each species (or lowest taxonomic unit of classification).

4.0 DELIVERABLE AND SCHEDULE

The deliverable for this study will consist of an interpretive report summarizing the methods and results of the three tasks described in Section 3.0, including comparison to the findings of previous investigations to provide an update on current conditions in North Inlet.

Sample collection will commence in June (Task 2) with all sampling complete by August 2015. It is important that the NI sediment sampling (Task 1 and Task 3) be concurrent and be done in August. August is the most appropriate time for the benthic invertebrate sampling to coincide with the timing of past AEMP benthic invertebrate sampling which will be referenced. August is also when the 2010 sampling was done and maintaining similar time periods will improve comparability. The laboratory work is expected to take 2 months followed by 2 months to compile, analyze the results and prepare the interpretive report. This work scope is therefore anticipated to be complete by December 2015.

Appendix X

Record of Engagement

Comments and Responses 2013 ICRP Progress Report

GENERAL INSTRUCTIONS FOR EXCEL TEMPLATE:
1. Do not leave blank rows above or between comments.
2. Do not modify the instructions or the column headings (i.e. the top three rows).
3. Each comment must have a response.
4. All formatting will be lost when this file is uploaded to the Online Comment Table.
5. If necessary, adjust the cell width and height in order to view all text.

ID	Reviewer	Topic	Comment	Recommendation	Proponent Response
					Responses should be as specific as possible, referring directly to the Comment/Recommendation.
1	Environmental Monitoring Advisory Board: Brenda McDonald	Seepage quality from Waste Rock Piles. There does not appear to be any rational basis presented by DDMI for consideration of the closure of the waste rock piles without the till and Type I waste rock cover as was originally proposed in the 2001 plan.	(Submitted after Due Date) DDMI has presented a wealth of data on the potential quality of seepage from the waste rock piles. This includes monitoring data from the test piles and extensive predictive modelling (Appendix II-5). These data clearly show that metals levels (e.g., Copper and Nickel) will exceed EQC levels and will require treatment. The modelled data also show the benefits of cover in reducing the active zone and in reducing metal levels to below EQC levels. DDMI has stated that because minimal seepage has occurred to date, they propose to defer any application of cover to the future even though all R&D work completed clearly predicts significant leaching will occur once the piles become saturated and seepage is released. DDMI should clearly explain: 1) What reason other than reduced costs do they have for delaying the application of covers? 2) What is the purpose of completing test piles and seepage quality modelling if the work is ignored when it comes to the design of the Closure and Reclamation Plan?	DDMI should respond to Questions 1 and 2 in the "Comment" cell. The Board should retain the cover concept (till plus Type I waste rock) as described in the 2001 closure plan.	In the 2013 ICRP Progress Report (pg 27) DDMI provided the following reasons for not advancing a cover over Type II waste rock at this time: a) there is no immediate need (i.e. there is no measureable seepgae) b) a decision on A21 has not been made and if it proceeds a cover could be placed at a substantially lower cost, c) no identified impacts of delaying were identified, and d) delay allows more Type III to be reused for undergound fill. There are many purposes for the test pile reseach including improved understanding of thermal, geochemical, biological, hydrological processes iin a northern waste rock pile. A specific purpose for DDMI is to inform closure planning and decision making. To that end DDMI is using the test piles research responsibly and purposefully. The preferred closure activities currently remain as described in ICRP V3.2 (i.e. cover on Type III waste). DDMI has not requested a change.
2	Environmental Monitoring Advisory Board: Brenda McDonald	Proposed modifications to the PKF closure concept. Have all practical options been considered?	(Submitted after Due Date) A workshop and options analysis (AMEC, 2013) was held to review options for closure of the PKF. The preferred option was to proceed with the original concept of having a concave cover and no pond. The analysis also confirmed that the revised convex option with shallow pond would also be feasible. There are a number of concerns with DDMI's proposal to revise the closure concept for the PKF. Firstly, there are several potential options that were either not considered or dismissed. These include: dewatering of the fine PK in place (e.g., densification methods, wick drains, chemical modification, displacement with waste, etc.). Furthermore there are potential in-plant changes that could be made. These include: thickening and dewatering methods (raised but eliminated as likely being too costly) and chemical modification to inhibit clay mineral dispersion. The latter could possiblly be achieved through pH modification, CO2 addition, coagulant/flocculant addition. DDMI should: 1) Explain why in-plant dewatering methods were not considered and 2) if any testing was completed on chemical modification of the PK to inhibit/control the dispersion of the clay minerals responsible for the separation of the coarse and fine tailings and production of the semi-solid fine tailings.	DDMI should be required to do the following: 1) Assess the potential for in-situ dewatering of the fine PK to allow for cover; 2) Assess in-plant dewatering methods which would eliminate the fine/coarse PK separation and allow for rapid consolidation and cover application; 3) Complete testing on potential chemical modification of the PK to inhibit/control the dispersion of the clay minerals responsible for the separation of the coarse and fine tailings and production of the semi-solid fine tailings; 4) Confirm if reduced cost is the only rationale for the proposed changes to the reclamation concept. The Board should not approve the revised concept at this time.	AMEC (2013) describes the 22 closure options that were evaluated. This included "in-situ dewatering of the the fine PK to allow for cover" (AMEC Options #3,8,9 and 14) and "in-plant dewatering methods" (AMEC Option #10). All of the options were evaluated based on relevant technical, environmental and economic aspects captured into five general categories: 1) effecctiveness of the closure method, 2) implementation of the closure method, 3) acceptability (by stakeholders), 4) risk and 5) economics. The results narrowed the options from 22 to 3 (with sub-options) which were further evaluted in more detail. No additional field tests were conducted. The analysis completed was sufficient to support a selected path forward. That path includes WLWB approval of the selected concept to enable further engineering studies to advance the closure design. EMAB has not provided evidence that the selected closure concept is incapable of achieving the approved closure goals for the facility nor have they specified a preferred alternative design. DDMI respectfully suggests that the WLWB has the necessary information to support approval of the design concept proposed by DDMI as a basis to move forward with closure planning. Note: The EMAB comment "*The preferred option was to proceed with the original concept of having a concave cover and no pond..*" is not correct. The original closure concept (AMEC Option#1) ranked 13th (out of 16).
3	Environmental Monitoring Advisory Board: Brenda McDonald	Spillway-Long term Stability	(Submitted after Due Date) The long term stability of the spillway remains a potential long term concern. The spillway will be prone to glaciation and ice plugging that could result in potential overtopping or rapid release of impounded water which could erode the spillay and cause the loss of PK to the environment.	If this plan is approved, DDMI should investigate alternatives to control or mitigate issues with glaciation and ice plugging of the discharge.	This issue has been identified and mitigation concepts discussed. With WLWB approval of the design concept these engineering design studies will be advanced.

4	Environmental Monitoring Advisory Board: Brenda McDonald	Revised Security Estimate. Include a provision for relocation or management of the Fine PK such that the original closure concept can be retained.	(Submitted after Due Date) The consensus from the options workshop was that the concave cover was the preferred option but DDMI has selected the more cost effective convex option leaving a pool of water in the PKF at closure. Data on the costs for relocation of the fine tailings was not presented. Furthermore no data on other in place consolidation methods or in plant dewatering/chemical alteration were discussed or presented. these options have not been addressed.	Further to the previous recommendations, DDMI should be required to present information on the costs for fine PK relocation and data on the costs for in-place and in-plant modifications that would permit the application of the concave cover. Furthermore, these costs should be added to the costs for application of the concave cover. Based upon the results, the Board should reassess the costs for the security estimate using the concave cover.	The EMAB comment "*The consensus from the options workshop was that the concave cover was the preferred option ….*" is not correct. The original "concave" closure concept (AMEC Option#1) ranked 13th (out of 16). All options were evaluated based on relevant technical, environmental and economic aspects captured into five general categories: 1) effectiveness of the closure method, 2) implementation of the closure method, 3) acceptability (by stakeholders), 4) risk and 5) economics. Economics were scored (1-5 with 1 being most expensive) in three sub-categories: pre-closure costs, closure construction costs, post-closure operating and maintenance costs. Respectively: "PK relocation" and dry cover scored 5-3-4. "In-place" treatment and dry cover scored 3-4-4 "In-plant" modification and dry cover scored 2-3-4 The closure cost estimate provided by DDMI with th 2013 ICRP Progress Report is based on WLWB approving the closure design proposed by DDMI in the 2013 ICRP Update.
5	Environmental Monitoring Advisory Board: Brenda McDonald	Revised Security Estimate. Provision for Long Term Treatment.	(Submitted after Due Date) DDMI continue to support the case for no cover on the Type III waste while all test pile and modelling data support the need for the cover. It is clear that if the piles are not covered, then contaminated seepage will be discharged to the environment. The provision for perpetual treatment seems to be almost a certainty for uncovered piles. As such, should this concept be considered, the security estimate must include provisions for perpetual treatment. DDMI should present the costs for perpetual treatment of the waste rock seepage.	It is our opinion that perpetual treatment should only be considered when all other options are exhausted. Given the cover option appears to allow for discharge without treatment, we again reiterate that the security estimate must include the cover option (as it does in the revised RECLAIM budget estimate).	EMAB's comment that "*DDMI continue to support the case for no cover on the Type III waste …*" is not correct. The preferred closure activities currently remain as described in ICRP V3.2 (i.e. cover on Type III waste). Seepage water quality estimates demonstrate the likely benefit that can be obtained with a till/rock cover design, if required. While the benefits of a cover have been demonstrated, the actual need has not. Continued site surveys have not indicated measureable seepage. Waste rock area instrumentation shows that the area is permanently frozen with seasonal surface thawing (active zone). DDMI will continue to wait until a need for a cover has been determined and/or materials are made available through advancement of the A21 kimberlite pipe development. DDMI has demonstrated that a cover could be employed to mitigate any poor quality seepage if seepage is identified. Currently there does not appear to be any significant negative aspects of waiting for a demonstrated need for construction of a cover. In the interim period Type III rock can continue to be re-mined for safe disposal underground and construction costs for a cover deferred and possibly substantially reduced if A21 proceeds. As noted by EMAB the closure cost estimate is based on cover over Type III waste rather than perpetual treatment.
1	GNWT - Environment and Natural Resources: Central Email GNWT	DDMI ICRP Progress Report - Dec. 31st 2013 General Comment	(Submitted after Due Date) DDMI has provided an ICRP Progress Report and within the report has requested a change to the Process Kimberlite Containment (PKC) facility. DDMI previously requested a change as part of an ICRP review phase. At that time, the Board ruled that insufficient rationale and design for the new closure strategy had been completed to prove the proposed closure concept for the PKC. ENR retained Mr. John Brodie of Brodie Consulting Limited to review the requested change. Mr. Brodie was involved in DDMI's original ICRP and security estimate for the mine back in 1999/2000. Mr. Brodie's review of the request is attached.	See attached review by Brodie Consulting Limited.	DDMI has considered BCL's review. No response required.
2	GNWT - Environment and Natural Resources: Central Email GNWT	PKC Cover	(Submitted after Due Date) ENR - Water Resources Division agrees with Mr. Brodie's assessment. ENR believes that the new PKC closure strategy is acceptable. If the WLWB approves the new closure strategy for the PKC facility, a revised security estimate will be prepared by ENR.	If the WLWB approves the proposed PKC closure strategy, ENR - Water Resources Division will endeavor to prepare a revised estimate for the PKC facility based on DDMI's submission.	No response required.
3	GNWT - Environment and Natural Resources: Central Email GNWT	Closure Contingency	(Submitted after Due Date) ENR - Water Resources Division agrees with Mr. Brodie's assessment that a contingency would be required for short term water treatment following closure of the PKC facility. This contingency would be in addition to the any existing water treatment requirements for the North Inlet (NI). Note contingencies to address areas of uncertainty regarding closure components are included in reclaim estimates as per the Mine Site Reclamation Policy. The Policy emphasizes the use of a precautionary approach. Note if operational monitoring and additional reclamation research identified that water quality within the PKC at closure is acceptable for release, then at that time, this contingency amount could be assessed/removed.	In the event the WLWB accepts the new closure strategy for the PKC, the Board should consider a water treatment contingency amount for the PKC. ENR - Water Resources Division will endeavor to prepare a revised estimate for the Board related to this component. Note this contingency requirement would be assessed towards the end of mining operations.	Treatment of PKC water is included in the submitted closure cost estimate. The estimate is based on removal and treatment of the initial pool volume (449,5000 m^3) plus 5 years of annual post-closure water volumes (268,300 m^3/y). Additionally a contingency amount of $2,592,113 has been included for the PKC facility.

4	GNWT - Environment and Natural Resources: Central Email GNWT	Waste Rock Pile Cover	(Submitted after Due Date) At this time, ENR - Water Resources Division does not support any change to the Waste Rock Pile cover. It has been demonstrated at other mine sites that seepage can take up to many decades to surface from large waste rock facilities and this facility will exist in perpetuity. Note towards the end of mine life, if operational monitoring and reclamation research identifies that Waste Rock Pile conditions post-closure will be acceptable, then at that time, security for the Waste Rock Pile could be reassessed.	At this time ENR - Water Resources Division does not support any change to the Waste Rock Pile cover.	There are no changes to the design of the waste rock pile cover. The updated closure costs reflect a)improved estimates of material quantities based on more developed closure engineering and b) inclusion of a cost for initial water collection and treatment. DDMI respectfully disagrees with the GNWT. It is precicely these types of changes in the cost estimate that require DDMI to review and resubmit the estimate annually. It is both necessary and appropriate that the WLWB review the security amount and revise if applicable.
5	GNWT - Environment and Natural Resources: Central Email GNWT	Regulatory Security vs. EA Security	(Submitted after Due Date) Due to potential linkages in securities under different instruments, once a decision is made by the WLWB on the above changes to the closure strategies, ENR - Water Resources Division will prepare a revised security estimate for the above components and conduct an assessment of any changes to the EA security provisions.	Pending approval from the WLWB, ENR - Water Resources Division will conduct a security review for the specific mine components and an assessment of any changes to the existing EA security provisions.	As required by the WLWB the closure cost estimate submitted with the 2013 ICRP update is a total cost estimate for the scope of work defined by the ICRP, regardless of the instrument that would require the security. DDMI has driven engagement with GNWT (then AANDC) and WLWB Staff for several years now on this process. The updated cost estimate submitted with the 2013 ICRP Progress Report includes changes resulting from these engagements. The extended time provided by WLWB for this progress report review was in part to allow opportunity to consider the updated cost estimate. The WLWB specifically requested review of the revised cost estimate when it distributed the progress report for review on January 27, 2014. DDMI requests that GNWT proceed in a timely manner with their integrated review of the cost estimate. DDMI will contact GNWT directly to understand if further engagement with the company would be helpfull in this regard.
1	GNWT - Lands: Tracy Covey	Appendix IV-1. p 12-13. Section 3.2. "Under the original design for the PKC the PK…was envisioned to have a split (by dry weight) of 2 to1 fine to coarse fractions. However, it appears that the actual split is closer to a 7:1split (fine to coarse PK)".	I realize that Fine PK is easier/more economical to transport than Coarse PK (largely because it's a slurry-like liquid & can be pumped via pipeline, whereas coarse PK can't be pumped & must be trucked). 1. Why is the material stored in the PKC so much wetter than originally envisioned? Was more water deposited than was originally envisioned (i.e., more fine pk than coarse)?	Answer question 1.	The fine:coarse processed kimberlite ratio is different than what was assumed as a basis for the 2001 PKC design. This has not resulted in more water being deposited in the PKC but has likely increased the fraction of the this total water volume that remains tighly associated with the FPK rather than existing as clarified pond water.
2	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 21. "the water currently within the PKC pond…is generally of suitable quality to discharge to Lac de Gras". The paragraph above, however, notes that "the source of major cations, metals, and sulphate is considered likely the result of weathering of the PK within the unsaturated	1. Would the proposed revised PKC design (with a pond in the PKC) increase the unsaturated zone vs. the original "capped PKC" design (thereby increasing the amount/degree of weathering of PK in the PKC)?	Answer question 1.	The theory behind the original design is that most of the PK would be unsaturated. The current design with a pond would mean that all of the PK below the pond elevation would be saturated. Based on this, the current design would be expected to have less unsaturated PK than the original design.
3	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 23. "Thermal modelling of the PK facility is a highly...uncertain undertaking".	Given that high degree of uncertainty, & the fact that you later note (p. 39) that the original dome-shaped coverover the unconsolidated semi-fluid FPK will prove "extremely difficult & is not recommended from a safety perspective" …1. can you quantify + compare how difficult & unsafe the original "capped" PKC would be vs. the proposed PKC-with-a-pond option?	Answer question 1 [Quantify & compare the do-ablility and safety of constructing the two PKC options (the original dome-shaped cover vs. PKC with a pond)].	During the March 2012 facilitated options workshop the multi-discipline team scored (on a scale of 1 - 5 with 5 being preferred) the "original dome shaped cover" a 1 and the "PKC with a pond" a 3 under constuction safety (AMEC 2013).
4	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 39. "A dome-shaped cover as presented in the permitted 2001 closure concept would require a very large volume of rock and till".	1. Would there be enough rock without the development of the A-21 pipe to accomplish the permitted cover type? 2. Has the volume of rock needed for the original (dome-cover) changed from the original closure concept design?	Answer questions 1 & 2.	Yes there would be enough rock. The volume of rock required has not been re-estimated and so remains as per 2001.
5	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 48. "The rock cover…minimum thickness would be approximately 1 m (ranging up to 2 m), depending on the size of rock used. The performance specification relates only to wind and water erosion protection".	If the performance spec's only "cover" (pardon the pun) wind and water erosion outcomes… 1. are things like pingo formation adequately protected against? i.e., will a 1-2 m cover be adequate to prevent pingo formation? 2. How might cryoconcentration changes with the revised closure concept vs. the original concept?	Answer questions 1-2.	It is anticipated that the presence of a pond would reduce the liklihood of pingo formation. Cryoconcentration has not yet been explicitly evaluated with regard to water chemistry but again the larger water body in the PKC would be expected to better mitigate effects of cryoconcentration.
6	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 48. "The rock cover…minimum thickness would be approximately 1 m (ranging up to 2 m), depending on the size of rock used. The performance specification relates only to wind and water erosion protection".	3. Will a 1 to 2 m cover be able to safely accommodate the machinery needed to monitor (and install/maintain monitoring sampling devices) inside the PKC?	Answer question 3.	The final design will ensure safe access to required areas of the facility for all future uses, including monitoring.
7	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 58-59. "Post-closure it will be preferable, for a number of wate quality reasons, that water exits the facility predominantly via the spillway rather than as seepage".	1. Will the presence of water (relatively warm) in the revised closure concept result in more projected seepage from the Perimeter dams of the PKC?	Answer question 1.	The amount of seepage through the perimeter PKC dams will depend on the volume of water within the PKC, the pond geometry (depth/width), as well as the rate and extent of freeze-back in the PKC beaches (AMEC 2013).

8	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 63. "The modelling results indicate that application of a water cover is preferred over a dry cover to reduce the loading from the PKC to the receiving environment."	I couldn't tell if the modelling was (a) comparing the original "capped" PKC vs the revised, bowl-shaped PKC with a pond design, or if (b) it focused on variations of the latter with a dry cover (with seepage) vs wet cover (with mostly pond overflow). If it's (a), then this is a significant predicted outcome in favour of the revised ("new, with pond") PKC closure design. If it's (b), then modelling simply shows that the preferred new design would probably be the wet cover option (vs. dry cover).	Clarify whether the modelling makes the comparison identified in "(a)" or "(b).	The modelling compares variations of the bowl-shaped PKC - so b)
9	GNWT - Lands: Tracy Covey	Appendix IV-1. p. 69. "this revised closure concept design…minimizes the need for additional materials".	I believe this means the revised design needs less rock to make a cover. 1. Where is the rock to be used for constructing the cover going to be quarried from? 2. How much quarried rock would the two options (revised vs. original/approved design) require?	Answer questions 1 & 2. 	The rock will come either from re-mining the North Country Rock pile or if A21 proceeds a combination of direct haul and remine. The original design required 4.3 Mm^3 of rock and 1.4 Mm^3 till. The revised design requires 2.8 Mm^3 of rock to construct the cover as described.
10	GNWT - Lands: Tracy Covey	Revised security estimate information.	The Inspector will not be commenting on security deposits (for two reasons). First, this avoids any potential or perceived conflict of interest issues. And second, I acknowledge that the determination of reclamation costs is a task outside my area of expertise.	Not applicable.	No response required
1	WLWB: Ryan Fequet	Prediction Methodology and Results	The prediction methodology is straightforward and detailed. The method was calibrated by comparison with data from the test piles and the sensitivity to infiltration assumptions were made. The results show that placement of a Type I cover over the Type III waste will significantly reduce the metals and sulfate and increase the pH of any seepage generated. The results are not given any other context. For example, the loading or concentration of constituents in potential waste rock seepage is not compared to water license limits. In other words, it is not clear if any seepage generated could be handled by existing water management practices or within the context of the post-closure water and mass balance. Copper is over-predicted by a factor of 10X compared to the test pile data and uranium and zinc are over-predicted by factors between 5 and 10x. This suggests that there is a flaw in the conceptual model on which the calculations are based. However, as pointed out by the authors, since the model results in worse water quality than is observed in the test piles, the results are conservative. 	1) Provide context to the results by comparison with water license limits and management of any seepage within the existing water management practices. 2) Evaluate if any seepage generated from the waste rock piles could provide a mass loading that is significant enough to cause a water quality impact in the post-closure condition (which would help to decide if a cover with Type I material is warranted). 3) Further evaluate the geochemical conceptual model with regard to copper, uranium and zinc to refine the seepage modeling (as recommended by the authors).	1) Context is included in Appendix B of Smith (2013) using both operating EQC and currently proposed closure EQC. Shading in the results table indicate results that exceed either. It is acknowledged that it would have been helpful to take a similar approach in Tables 5-7. 2) DDMI agrees that this evaluation is necessary and must form part of the finalization of closure perfromance criteria. This is however a seperate task from the current development of seepage estimates. 3) Acknowledged
2	WLWB: Ryan Fequet	Assumptions for Model Inputs	The assumptions used as inputs to the model are reasonable to the extent that they are documented in the report. There appear to be many other aspects to this project which the authors are very familiar with and which may be "common knowledge" to the engineering and scientific community working at Diavik (e.g., the water quality and flows from the test piles and AZLs, current on-site conditions with regard to seepage quantity and quality at the NCRP, and existing water quality issues related to water management at the mine). This may provide the Board with comfort with Diavik's conclusions.	None	No response required.
3	WLWB: Ryan Fequet	Predictions are Conservative	The model had several conservative elements incorporated. Notably, the selected thickness of the active zone (7m) is much thicker than present, chosen as representative of a warmed-climate state, and maximized contact of rock with mineral, so appears conservative. Also, as mentioned above, predicted copper, uranium and zinc concentrations are significantly higher than what was measured in the test piles; in addition, most other predicted concentrations are higher than observed in the test piles.	None	No response required.
4	WLWB: Ryan Fequet	Basis for Closure Design	The methodology and results provide a sound basis for closure design.	None.	No response required.
5	WLWB: Ryan Fequet	High-level Comments	The information provided contained only narrative (as opposed to numeric) water quality objectives. However, from experience, the concentrations of copper and nickel, even with the cover of Type I material, are significantly elevated. As indicated in comments and recommendations above, DDMI should provide context to the results by evaluating if any seepage from the waste rock piles could cause a water management issue or exceed a water license limits, and determine if seepage from the waste rock piles could cause water quality impacts in the post-closure condition.	See the recommendations above.	Numeric water quality objectives are included in Appendix B to Smith (2013). They are included for both the existing operational limits and proposed closure criteria. (see also response to recommendation #9)