BHP Billiton Diamonds Inc.
Operator of the EKATI Diamond Mine

bhpbilliton
resourcing the future

BHP Billiton Diamonds Inc
#1102 4920-52nd Street
Yellowknife NT Canada X1A 3T1
Tel 867 669 9292 Fax 867 669 9293
bhpbilliton.com

Kathleen Racher
Regulatory Director, Mining
Wek'eezhii Land and Water Board
1 4905 - 48th St
Yellowknife, NT
X1A 3S3

April 14, 2009

RE: ICRP Information Request - In Preparation for the ICRP Public Hearing

Dear Ms Racher,

The Wek'eezhii Land and Water Board (WLWB) has requested BHP Billiton Diamonds Inc (BHP Billiton) provide the following information in preparation for the May 25th and 26th 2009 Interim Closure and Reclamation Plan (ICRP) Public Hearing. The information requests are referenced to the WLWB letters March 6 and April 8, 2009.

1. Reformatted Reclamation Research Plans # 14 and # 16 from Appendix 5.1-4A of the ICRP.

The above research plans have been updated to the format outlined in the WLWB letter dated February 4, 2009 and are included with this submission.

2. An investigation into the closure objectives and criteria requirements for remediation of hydrocarbon waste.

Please see attached Memorandum from Rescan Environmental Services Ltd, and BHP Billiton's Action Item # 44 in the attached Revisions Table.

3. Provide an explanation where Sections 8.2, 8.5 and 8.6 would be included in the ICRP.

Sections 8.2 Predictive Water Quality Monitoring. BHP Billiton has reviewed the information for this section and believes that a site wide model is neither practical, nor reasonably manageable. Rather than developing a site-wide water quality model, BHP Billiton has developed a set of modeling tools to address water balance and water quality at EKATI for specific sites. The nature of the water quality work undertaken for the EKATI site does not lend itself to a single unified site-wide model. Such a unified modeling approach would severely limit the applicability of the model by not

allowing the most appropriate modeling tools to be used given the nature of the question being addressed and the available data.

Sections 8.5 Other Resource Users, and 8.6 Environmental Impacts were unintentionally omitted from the ICRP. They will be included in the ICRP revision following the public hearing.

4. A list of all revisions and outstanding action items that will be included in the next revision of the ICRP following the public hearing.

BHP Billiton has included the list of revisions as requested. The attached table includes revisions to be made following the public hearing, and those revisions to be made in the next update of the ICRP, in 3 years following ICRP approval.

Data and Information Updates.

BHP Billiton has noted the WLWB's recommendation under Tracking # 8 of the February 18, 2009 Verification Table, that *'the ICRP be consistent, and maintain up to date data, tables and figures with each ICRP revision (perhaps using a cut-off date for all data and information no older than one or two years, when available)".* BHP Billiton believes that a lengthy ongoing review of a large and detailed document such as the ICRP (which entails numerous updates throughout the review period with the continuous production of reports and adjustments to the Life of Mine Plan) could unduly confuse and confound the review process. Therefore we recommend that a set of fixed cut-off dates for data and information for the next and all future ICRP revisions be established.

To that end BHP Billiton set the original cut-off date at the 2007 ICRP submission. Following this the WLWB requested BHP Billiton update a list of specified reports for the December 2008 revision. Again, and following the December 2008 revision the company was requested to update additional data and information. The company has noted confusion amongst all reviewers on appropriate cut-off dates and is also concerned about (i) the time and resource use if data and information in the document is updated with each revision, and (ii) what is reasonably achievable during revision periods to provide true "value-add" to reclamation and closure planning at this stage in the Life of Mine. A definitive and consistent cut-off date for data and information for the next and for all future ICRP revisions would alleviate such concerns.

5. Clarification on the effect(s) of not pursuing a 'definitive agreement' with DFO, BHP Billiton's current reclamation plan for Open pits, and impacts to the reclamation research.

On March 23, 2009 BHP Billiton notified DFO that it would not be continuing discussion on the Definitive Agreement with DFO and that it saw no benefit to either party in proceeding with the agreement at this time.

Although the company is disappointed that discussions on the Definitive Agreement have not provided a resolution, we believe that the effects of not having such an agreement does not compromise BHP Billiton's proposed reclamation of pit lakes. BHP Billiton still remains committed to undertaking the following reclamation activities contained within Section 5.2.8.1 of the ICRP:

- Design and construct shallow zones in the perimeters of pit lakes that will provide safe access and egress areas for people and wildlife. These shallow zones may ultimately

provide benefit for fish habitat, should it be determined after BHP Billiton has completed reclamation and closure requirements that the pit lakes can be used for this purpose.
- Place vegetation in select perimeter areas to provide stabilizing cover for bank erosion.
- Establish hydrological connections to the external watershed.
- Meet pit lake effluent water quality criteria for pit lakes.

Although BHP Billiton has already provided full compensation for the loss of fish habitat and has no legal obligation to restore lost fish habitat as noted in our prior correspondence on this point, this does not preclude DFO or other regulatory agencies from researching and creating such habitat in the future should they so desire. However, unless and until such future work is undertaken, BHP Billiton intends to construct fish barriers that will prevent fish access to the pit lakes. The Company intends to design such barriers for long term use but with a view to their possible future removal by others once the company has been released from all future reclamation liability for the site. Please refer to the attached Revisions Table # 14 and 15 for revisions in the ICRP that are associated with fish barriers and shallow zones respectively.

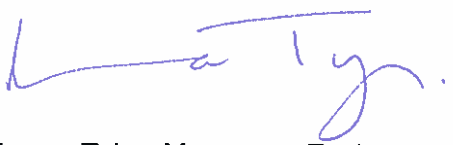
BHP Billiton has provided a comprehensive list of research plans for pit lakes in the Final ICRP Working Draft and sees no potential impact to the planned research resulting from the failure of recent negotiations with DFO. The following reclamation research and engineering study plans remain in place to assist in the pit lakes reclamation activities listed above:

- Pit Safety
- Pit Lake Water Quality
- Establishment of Self-Sustaining Plant Communities
- Vegetation Cover and Surface Stability – Open Pits
- Underground Water Quality and Quantity
- Final Pit Perimeter Stability
- Physical Topography of Final Pit Perimeters
- Fish Barriers for Pit Lakes and LLCF

We hope that the preceding information is of assistance to the WLWB and the ICRP reviewers. Please contact Helen Butler at 669-6104 if you have any questions.

Yours sincerely,

BHP Billiton Diamonds Inc.



Laura Tyler, Manager - Environment, Community, Communications and Planning
EKATI Diamond Mine

Table of Revisions and Outstanding Action Items to be Included in:
a) The Revision Following the Public Hearings, and
b) the Next Revision (in 3 Years) following ICRP Approval.

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
1	Formatting	Section 1.1 Overview General Document	Section 1.1 Overview will be reviewed and updated to ensure that the reader has a clear description of the organization and presentation of the document. Tabs will be provided for major sections for ICRP reports circulated in hard copy.	
2	Post Closure Illustrations	Chapter 5		Post closure illustrations will be developed for the next update of the ICRP. This is a large project, and to ensure the illustrations provide a realistic depiction of future landuse, it will require some field work for photography of specific mine components, as well as the development of a program to develop images of the projected landscapes at EKATI.
3	Research and Engineering Studies	Appendices 5.1-4 A&B	Appendix 5.1.4 A and B will be split over 2 Appendices.	
4	Water Quality Criteria	General Document	The document will be reviewed to ensure that: 1. Discussion and closure criteria related to water quality in receiving environments will be based on Effluent Quality Criteria. 2. Discussion on water quality in end pit lakes is based on water quality criteria. These criteria will be part of the closure water licence. Table 5.1.1D, Water 2 will be reviewed and corrected for consistency.	
5	Watershed Boundaries	Chapter 5	The document will be reviewed and watershed boundaries will be included on those figures which represent pre-disturbance, development status, and projected development.	
6	Revisions – data and information updates.	Chapter 1	The following wording will be included in the ICRP: “Currently the ICRP is based on the 2005 Life of Mine Plan (LOM Plan). However, over the course of 3 + years of ICRP update and review there have been changes to this plan. BHP Billiton has tried to keep the LOM Plan constant to avoid confusion amongst reviewers. To do this the 2005 Life of Mine Plan in the December 12, 2008 ICRP was updated to reflect changes that have already occurred to pit operations and significant changes such as the use of Beartooth for water storage.”	The ICRP will be updated to the most current LOM Plan at the time of ICRP submission.
7	Seepage Flow Clarification	Section 4.3 Figure 4.3-2	The figure and/or associated text will be edited to include reasoning for arrows and destination of seepage flow.	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
8	Beartooth Pit as Mine Water Storage	Section 4.1	A mention will be included in the document that the use of Beartooth for mine water storage and the resulting change of timing of Beartooth pit reclamation are dependent on approval of the WWPKMP by the WLWB.	
9	Beartooth Pit Mine Water Storage	Appendix 5.1-4A Research Plan 3	The research plan for pit lake water quality will be revised to incorporate concept level research (including research schedule) on the inclusion of underground or other mine water in Beartooth Pit at mine closure.	
10	Source Lakes	Appendix 5.1-4A Research Plan # 2.	The research on source lake water withdrawal will be reviewed to ensure that additional detail is provided to address the following: • The duration of existing flow monitoring time series and method of data collection for the outflow of proposed source lakes, • The duration of existing water level monitoring time series, and the method of data collection for the proposed source lakes, • The basis of the runoff coefficient value(s), • Water balance sensitivity approach to wet and dry years, • Methodology that uses field data on wetted perimeter, channel width and maximum channel depth to estimate potential effects over the entire range of pumping rates, to estimate potential effects on stream fish habitat during dry years, • The use of hydrographs to demonstrate reduction in recovery times for source lakes **and streams**, relative to average, wet and dry years. Verification Comment 38 (JW-21 in Verification Table) requested detail on how successive dry years would affect the time to pump fill pits. This question is now being addressed in Research Plan 3: Pit Lakes Water Quality, Task 4: Water Balance, rather than in Research Plan 2: Water Withdrawal from Source Lakes. Verification comment 39 (JW-22 in Verification Table) speaks to an ICRP statement (ICRP page 5-42) regarding a 15 day reduction of flow duration (a shortening of the open water season stream flow by 15 days). The 15 day reduction is conceptual and based on average conditions. More detailed analysis on the period of flow reduction in streams will be	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
			included in Research Plan 2 (as noted in the last bullet above).	
11	Misery Pit Filling Time	Table 5.2-15	The pumping duration for Misery pit should be 5 years. The value in the table will be corrected.	
12	Pit Lake Water Quality	Appendix 5.1-4A Research Plan # 3		The Reclamation Research Plan for Pit Lake Water Quality will be updated to include a field work program which will include sampling of pit water during flooding. The company noted that each pit will have differing water quality conditions and monitoring will be conducted on a pit by pit basis. The first pit to be flooded in the 2005 LOM Plan is Pigeon, so the initial monitoring program will focus on that pit.
13	Misery Pit Lake Water Quality and Quality	Appendix 5.1-4A Research Plan # 3	BHP Billiton will (if possible) provide annual estimates of the water volume in the Misery Pit during suspension of operations.	
14	Fish Barriers	Section 5.2.5.1	The section will be updated to state that fish barriers will be designed for long term performance but in contemplation that they may ultimately be subject to removal after BHP Billiton has been released from all remaining liability for the site.	
15	Shallow Zones	Section 5.2.8.1 (1st paragraph)	Section 5.2.8.1 will be updated to state "Reclamation strategies for open pits at EKATI include the construction of shallow zones at pit water edges. The purpose of the shallow zones will be to provide safe access and egress areas at the pit perimeter for people and wildlife. Rock armoring and/or establishment of riparian vegetation will also be used to stabilize potential erosional areas around the pit perimeters. The following research plans and engineering studies are in place to address how pit perimeters will be reclaimed: • Pit safety for wildlife during pit flooding, through the use of berms or other deterrent structures (Research Plan 1), Establishment of Self-Sustaining Plant Communities at Open Pits (Research Plan 4), • Vegetation Cover and Surface Stability at Open Pits (Research Plan 5), • Final Pit Perimeter Stability (Engineering Study 1), • Final Topography of Final Pit Perimeters (Engineering Study 2). *This study will be reviewed to ensure that concept shallow zones design has been included as a study task.* Fish habitat will not be constructed in pit lakes based on formalized agreements (Fisheries Act Authorizations) between DFO and BHP Billiton, which are referenced in Section 1.2 and Appendix 1.1-4 of the ICRP. Therefore barriers will be constructed to prevent fish access into pit lakes. Fish barriers	Section 5.2.8.1 will be updated to include concept designs for pit lakes that are within the Conceptual planning stages, with more detailed design plans for those pits that will be within the Pre-feasibility stage of reclamation planning for the 3 years following the next ICRP revision, as outlined in Figure 8.5-1. The above work will specify how the design will: • Provide for safe access and egress to and from the pit lake for wildlife; • Ensure the maintenance of pit perimeter stability; and • Facilitate future development of fish habitat should another party wish to do the fish habitat work in the lake once BHP Billiton had completed its reclamation and closure requirements for that pit lake and been released from any further liability in that regard.

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
			will be designed for long term performance but in contemplation that they may ultimately be subject to removal after BHP Billiton has been released from all remaining liability for the site." The ICRP sections and tables will be reviewed to ensure the discussion on pit reclamation plans and activities aligns with the above.	
16	Pit Lake Final Landscape	Section 5.2.5.1	Citation will be included for completed research studies outlined on page 5-27. Citation will be included to support talik zone discussion on page 5-27.	
17	Beartooth Pit Figure	Figure 5.2.3	The figure will be expanded to include northern portions of the developed area.	
18	Pit Lake Channel Designs	Section 5.2.5.2	Reference to Appendix 5.1-4B, Research Plan 2 (Task 2) will be included.	
19	Underground Plugs	Section 5.2.5.2	Reference to Appendix 5.1-4B, Research Plan 6 will be included.	
20	Reclamation Activities Tables	Tables in Chapter 5	The end of reclamation activities and the start of monitoring will be included in the Reclamation Activities tables.	
21	Underground Facilities	Table 5.3-1	The section will be reviewed and checked to ensure that Table 5.3-1 contains the complete list of underground infrastructure.	
22	Underground Elevation Levels	Section 5.3.4	The section will be reviewed for approximate underground mine final elevations.	
23	WRSA Ground Temperature Data	Section 5.4.3.4	The relevant tables/figures in the ICRP will be updated to reflect current temperature readings.	
24	WRSA Design Edits	Table 5.4-2, and Section 5.4	The wording and number in the table will be edited. The section will be reviewed and updated to ensure that it clearly states the table is operations design criteria, but that many of these designs will be carried into closure of the WRSA.	
25	WRSA Development Status	Section 5.4.3.3 and Table 5.4-3	The section and table will be updated where possible, to ensure all text, figures and tables are referencing concurrent information/data.	
26	WRSA Hydrocarbon Site Assessment	Tables 5.4-9, 5.4-10, 5.4-12 and 5.4-13.	An assessment of the top surface of the WRSA will be completed when WRSA are no longer required for mining operations. The Reclamation Activity tables will updated to ensure this is included.	
27	Post Closure Monitoring Wording	Sections 5.2.12, 5.3.11, 5.4.11, 5.5.12, 5.6.11 and Tables in Appendix	The word 'Parameter' will be replaced with a more appropriate description of focus areas for closure monitoring.	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
		5.1-5		
28	Airstrip Lake	Figure 5.5-1	A label for Airstrip Lake will be included in the figure.	
29	Processed Kimberlite Deposition	Section 5.5.3.2	The section will be reviewed and appropriate citation included for the processed kimberlite volumes.	
30	Processed Kimberlite Deposition	Table 5.5-5		The % filled will be included, if available, in the next revision of the ICRP.
31	LLCF Watershed Boundaries	Figure 5.5-6	Watershed boundaries will be included in this figure.	
32	LLCF Vegetation	Section 5.5.5.3	Reference to fertilizer applications will be inserted.	
33	LLCF Vegetation	Section 5.5.5.3		The results from the 2008 Vegetation research will be included.
34	LLCF Dykes	Section 5.5.5.6	The section will be reviewed to ensure effects to water quality downstream of filter dykes are included.	
35	Panda Diversion Channel	Appendix 5.1-2, Figure 5.1-2E	The figure will be reviewed to ensure the transition area (cut area to non-cut areas) at the side of the channel in included. The following revision will be made to Section 5.6.4.2. Access to the channel benching would likely be provided by ramps constructed from the channel crest on either end of the stabilization zone. Site access will be finalized during design.	
36	Panda Diversion Dam Ground Temperature	Appendix 5.1-2, Figure 5.1-2F	The figure will be updated to 2007 data.	
37	Bearclaw Lake Jetty	Section 5.6.5.2	The section will be reviewed to ensure the reason for the jetty to remain in place is included.	
38	King Pond HIS Scores	Section 5.6.5.3	A reference for HIS scores for King Pond Settling Facility will be included.	
39	Panda Diversion Channel Reclamation Activities	Table 5.6-5	The table will include a date for start of Reclamation Activities.	
40	Road Reclamation	Section 5.7.9.10	The section will be reviewed to ensure information is provided on reclamation of berms, stream crossings and road treatment for closure.	Road classification, timing of reclamation and areas of significance (caribou migration areas and potentially hazardous areas) will be included in the next update of the ICRP. The section will be reviewed to ensure that explanation is provided for the berm hazardous areas. Rational will be provided around road design and decommissioning and caribou monitoring with respect to caribou migration pathways.
41	Buildings and Infrastructure Research	Section 5.7.7.1	The section will be reviewed to ensure appropriate references are included.	
42	Airport Vegetation Reclamation	Section 5.7.9.12	The section will be reviewed and an explanation of how the monitoring results inform reclamation success will be included.	
43	Open Pits Closure Objectives and Criteria	Appendix 5.1-1, Table 5.1-1A	Table 5.1-1A Water 1 and 2 will be updated to ensure references are provided to appropriate documentation on lake and stream levels, and on water quality and fish habitat in	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
			source lakes. All tables in Appendix 5.1-1 will be reviewed to ensure all appropriate research and monitoring plans are referenced.	
44	Hydrocarbon Closure Objectives and Criteria	Section 5.7.9.14, and Appendix 5.5-1	The section will be updated to state that soil remediation standards for hydrocarbons will follow the the CCME guidelines. The numerical remediation criteria will be derived for the Final Closure and Reclamation Plan based on a site assessment using the Tier 1, 2 or 3 approach as described in the CCME documentation that is in effect at that time. At this time and based on the current CCME guidelines it appears that the agricultural land use classification is the most representative surrogate for the desired future land use of "wildlands" as described in the 1995 EIS as "*productive use of land, with wildlife designated as the principal land user, in additional to limited use of cultural and natural resources of the area by Aboriginals*." BHP Billiton will continue to cleanup and report hydrocarbon spills at the minesite, followed up by INAC inspection. Please refer to the attached Memorandum on the Review of Closure Remediation Requirements for Hydrocarbon-Contaminated Soils at EKATI, completed by Rescan Environmental Services Ltd, April 14, 2009.	
45	Wildlife Closure Objectives and Criteria	Appendix 5.1-1	Tables in the appendix will be reviewed to ensure consistent wording is used for wildlife closure objectives and criteria, and that the WEMP is referenced appropriately.	
46	Reclamation Research Plan	Appendix 5.1-4	The Reclamation Research Plans will be updated to that outlined in the WLWB Feb 4, 2008 letter. The Engineering Studies will also be updated, using the same format in the Research Plan.	
47	LLCF Pilot Studies	Section 5.5.4.2	The section will be reviewed to ensure BHP Billiton states that opportunities for earlier research will be sought at the LLCF.	
48	Salinity Stability in Fox Pit Lake	Figure 7.4-1	The text associated with Figure 7.4-1 will be updated to include a definition of salinity stability.	
49	Upper Exeter Substrate Composition	Figure 7.4-5	The text associated with Figures 7.4-5 and 7.4-6 will be updated to include details of the methodology used to determine substrate percentages.	
50	Reference	Section 7.8.3	The appropriate reference for 'further work' will be included.	
51	Units of Measure	Whole Document	The document will be reviewed to ensure consistent units are used throughout the ICRP.	
52	Environmental Assessment	Chapter 7.0	Chapter 7.0 will be updated to include a summary discussion of	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
		(Section 8.2 of the June 2006 ICRP TOR)	predictive water quality modeling for specific sites at EKATI, including the LLCF at closure and pit lakes. The TOR specified the requirement for a "site-wide predictive water quality model." BHP Billiton and their consultants have reviewed this reference section and believe the development of a site wide model is neither technically appropriate or required, practical, nor reasonably manageable. Rather than developing a site-wide water quality model, BHP Billiton has developed a set of modeling tools to address water balance and water quality at EKATI. These have included published work on LLCF water balance, mass balance and water quality predictions (e.g. Rescan, 2008a,b), hydrodynamic modeling of downstream lakes (e.g. Rescan, 2007), and unpublished modeling work on water quality downstream of the LLCF. Ongoing work is in development to predict the water quality of EKATI pit lakes using a set of modeling tools. The nature of the water quality work undertaken for the EKATI site does not lend itself to a single unified site-wide model. Such a unified modeling approach would severely limit the applicability of the model by not allowing the most appropriate modeling tools to be used given the nature of the question being addressed and the available data. BHP Billiton believes its approach to water quality modeling at EKATI is technically more sound than using a single site-wide model. Rescan. 2007. EKATI Diamond Mine: Proposed Discharge Criterion for the Sable Kimberlite Pipe Development (Water License MV2001L2-0008). Prepared for BHP Billiton Diamonds Inc. by Rescan Environmental Services Ltd., January 2007. Rescan. 2008a. EKATI Diamond Mine: Long Lake Containment Facility Water Quality Prediction Model Version 1.0. Prepared for BHP Billiton Diamonds Inc. by Rescan Environmental Services Ltd., March 2008. Rescan. 2008b. EKATI Diamond Mine: Long Lake Containment Facility Water Quality Prediction Model Version 2.0. Prepared for BHP Billiton Diamonds Inc. by Rescan Environmental Services Ltd., March 2008.	
53	Environmental Assessment	Chapter 7.0	This section was omitted in the December 2008 Final Draft of	

#	Revision Topic	ICRP Section	This Revision (following the May Public Hearing)	Next Revision (3 Years following ICRP Approval)
		(Section 8.5 of the June 2006 ICRP TOR)	the ICRP. It will be included in Chapter 7.0.	
54	Environmental Assessment	Chapter 7.0 (Section 8.6 of the June 2006 ICRP TOR)	This section was omitted in the December 2008 Final Draft of the ICRP. It will be included in Chapter 7.0.	
55	LLCF Permafrost Research	Appendix 5.1-4B, Research Plan 13	In the Feb 18, 2009 Verification Table # 97 the issue has been stated as resolved. This is not yet resolved since at the Feb 3, 2009 Working Group meeting INAC had not yet produced Chris Burn's review of the research plan, and BHP Billiton had not been given an opportunity to respond. BHP Billiton will review the comments received from INAC on the LLCF permafrost research and will continue to work with INAC on discussing LLCF permafrost issues, and any agreed updates will be made to Research Plan 13.	

Memorandum

DATE: April 7, 2009

Refer to File No.: Memo, EKATI Hydrocarbon Remediation (2009 04 14).doc

TO: Helen Butler

FROM: Marc Wen

CC:

SUBJECT: Review of Closure Remediation Requirements for Hydrocarbon Contaminated Soils at EKATI

Two guidance documents exist that provide relevant information on EKATI's possible closure remediation requirements for petroleum hydrocarbons (PHCs):

1. CCME Canada-wide Standards for Petroleum Hydrocarbons in Soil (CCME, 2008a); and
2. Environmental Guideline for Contaminated Site Remediation (GNWT, 2003).

The government of NWT (GNWT) guidelines are applicable to Commissioner's Land including private land within municipalities. These lands are generally near towns and cities. The 2003 GNWT guidelines adopted the CCME guidelines of the time. The procedure described in both the NWT and CCME guidance documents for developing site-specific PHC objectives are summarized below.

Guidelines for petroleum hydrocarbons (PHCs) in soil are "designed to be generally protective of human and environmental health for specified uses of soil at contaminated sites" (CCMEa, 2008a). The term PHC describes a number of organic compounds found in and derived from geological substances such as oil, bitumen and coal. PHC contamination depends on the petroleum source (e.g., oil, jet fuel), soil type, the composition, extent of processing (crude, blended or refined) and the amount of weathering caused by exposure to the environment. These factors complicate the assessment of the human and environmental health risks associated with PHC contamination in soil. As such, PHC are evaluated based on four fractions (GNWT, 2003):

- F1 - equivalent carbon number (ECN) C6 to C10 (the volatile fraction);
- F2 - ECN >C10 to C16 (the semi-volatile fraction);
- F3 - ECN >C16 to C34; and
- F4 - ECN >C34 to C50+ (low mobility, volatility and solubility).

Determination of Applicable Remediation Criteria for PHCs in Soil

In order to determine which remediation criteria are applicable to a particular site, a site characterization/assessment may be required. Information is needed to determine if the site can

be adequately described by one of the four "generic" land and water use categories identified by the GNWT/CCME to identify the nature and extent of the contamination, to determine soil texture and other relevant site characteristics such as depth to groundwater, and to identify exposure pathways and receptors. CCME (2008b) defines remediation criteria in the context of four types of land and water uses:

- *Agricultural lands:* where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora. Agricultural land may also include a farm residence.

- *Residential/Parkland:* where the primary activity is residential or recreational activity. The ecologically-based approach assumes parkland is used as a buffer between areas of residency, but this does not include wild lands such as national or provincial parks, other than campground areas.

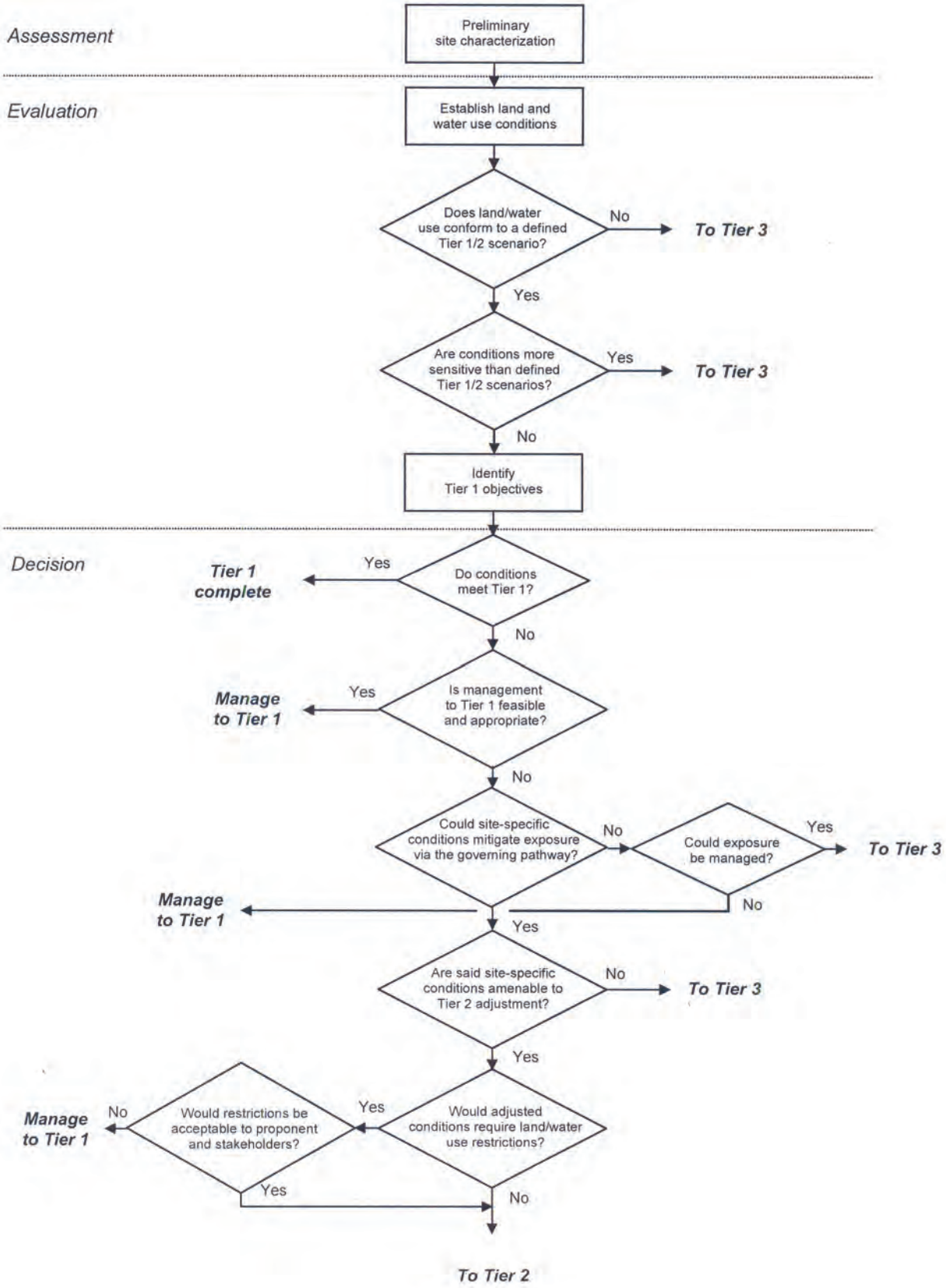
- *Commercial:* where the primary activity is commercial (e.g., shopping mall) and there is free access to all members of the public, including children. The use may include, for example, commercial day-care centres. It does not include operations where food is grown.

- *Industrial:* where the primary activity involves the production, manufacture or construction of goods. Public access is restricted and children are not permitted continuous access or occupancy.

It is the *intended* future land use that governs the choice of remediation level performed at the site (GNWT, 2003). The standards are also intended to manage the soil-to-groundwater pathway in order to prevent unacceptable transfer of contaminants from the soil, which may ultimately affect groundwater and surface water use (CCME, 2008b). Depending on the type of land use, exposure pathways and receptors vary, which alter the acceptable level of PHCs remaining in the soil at site closure.

CCME (2008b) recommends that jurisdictions may extend the Tier 1 levels for these land uses to other land uses provided that exposure pathways are similar. The guidance documentation further suggests that exposure pathways operating on agricultural lands may also operate on wild lands and natural areas, and that for this reason, jurisdictions may rule that the agricultural levels can be applied to wild land sites.

Following the site assessment, one of three possible approaches to develop site-specific remediation objectives can be followed (Tier 1, Tier 2 or Tier 3). A flow diagram outlining the decision process when choosing one of these three remediation options is provided in Figures 1 to 3 (from CCME, 2008b). These approaches are essentially the same for the GNWT and CCME evaluations.



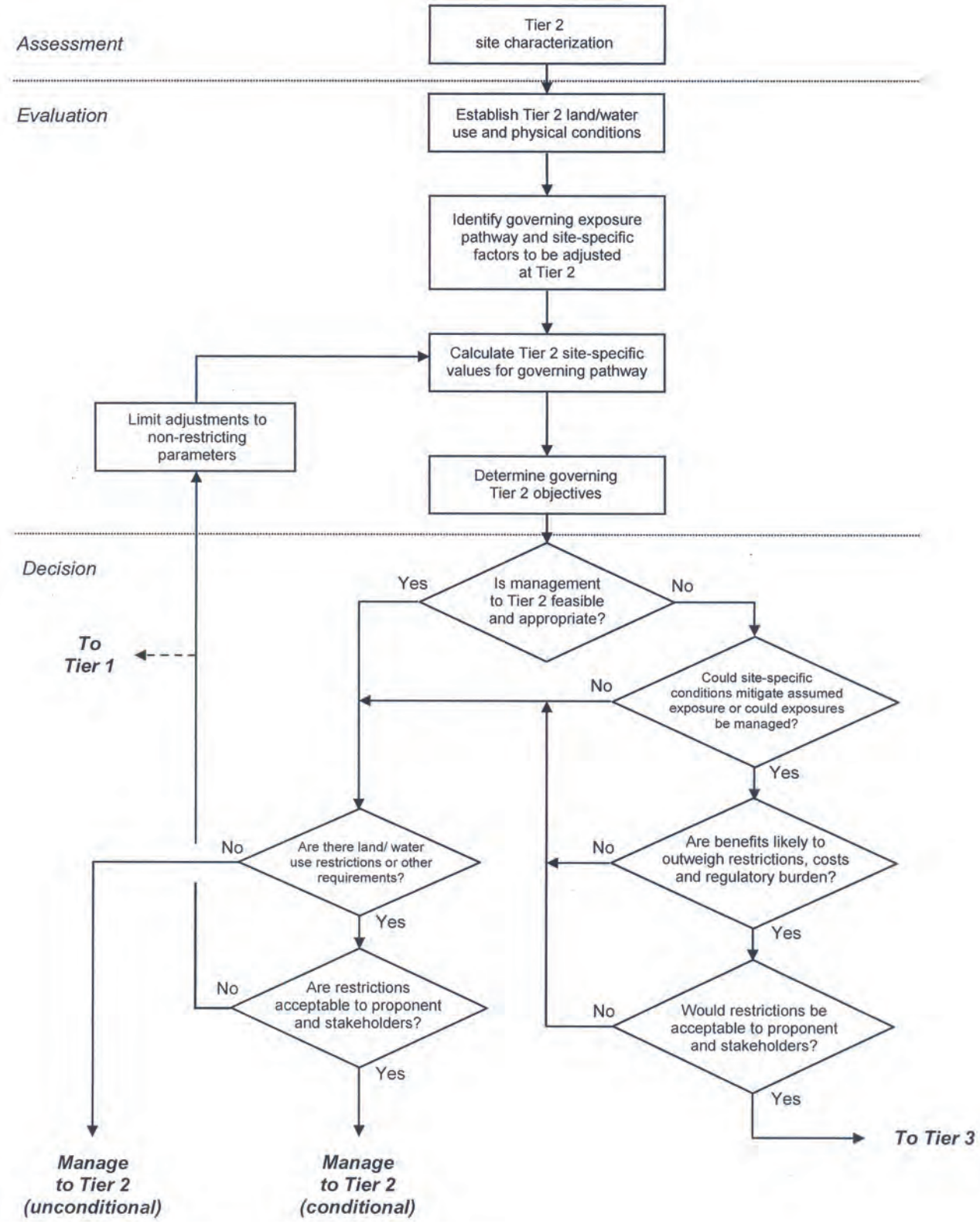
Source: CCME 2008b

FIGURE 1

Expanded Flow Diagram - Tier 1

bhpbilliton resourcing the future

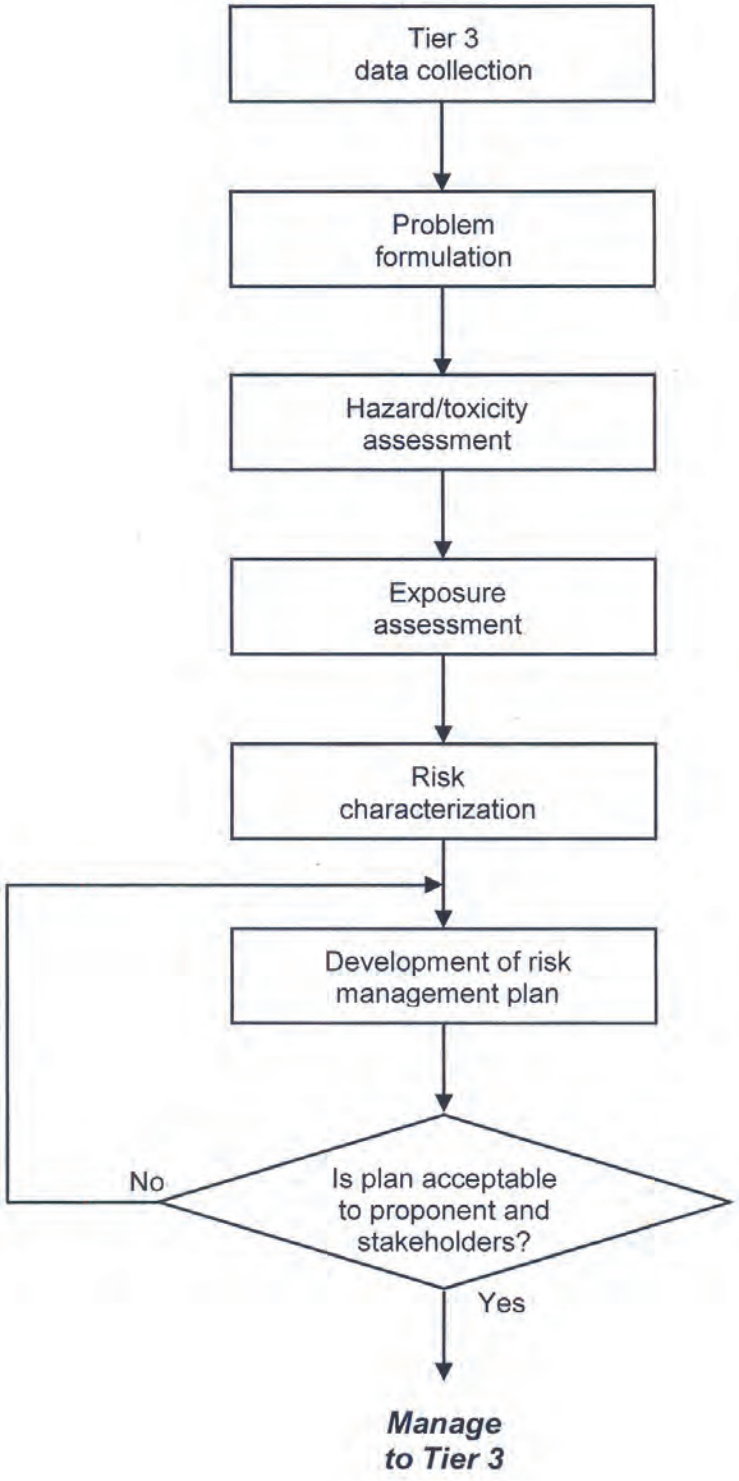
Rescan™



Source: CCME 2008b

FIGURE 2

Expanded Flow Diagram - Tier 2



Source: CCME 2008b

FIGURE 3

Expanded Flow Diagram - Tier 3

The Tier 1 approach involves the direct adoption of remediation criteria based on the four "generic" land use categories (agriculture, residential/parkland, commercial and industrial), and soil texture (coarse or fine grained soils). In order to use this approach, the generic land and water use scenarios and exposure conditions assumed in the development of the Tier 1 values must encompass those uses and exposure pathways identified for the site. The exposure conditions associated with the identified land and water use must not be more sensitive or critical than those assumed in the determination of the Tier 1 values. Examples of factors giving rise to greater sensitivity are: the presence of ecological receptors of greater sensitivity or socio-economic value (such as rare or endangered species). Examples of land uses not addressed in the development of the Tier 1 values include non-agricultural grasslands, wetlands, riparian zones and other wild lands (CCME, 2008b). In the absence of an applicable Tier 1 standard for the actual land or water use, such as at EKATI, a Tier 3 approach should be followed. However, site-specific adjustments to Tier 1 levels can be calculated to create Tier 2 levels if land uses and exposure pathways applicable to the site can be derived through a combination of Tier 1 land use categories (CCME, 2008b).

Pathway specific NWT Tier 1 levels for PHC in fine and coarse-grained surface soils are presented in Tables 1 and 2, respectively (GNWT, 2003). For comparison, CCME levels are presented in Tables 3 and 4 (CCME, 2008b).

Table 1
NWT Tier 1 Levels (mg/kg soil) for PHCs for Fine-grained Surface Soils

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15,000	8,000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	2,100	11,400	NA	NA
	Protection of Potable GW1	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Protection of GW for Livestock Watering[3]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5,600
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC
Residential	Soil Ingestion	15,000	8,000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	940	5,200	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5,600
	Produce	NC	NC	NC	NC

(continued)

Table 1
NWT Tier 1 Levels (mg/kg soil) for PHCs for Fine-grained Surface Soils (completed)

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Commercial	Soil Ingestion	RES	29,000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	4,600	25,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1,500	2,500	6,600
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (indoor)	4,600	25,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1,500	2,500	6,600
	Offsite Migration	NA	NA	12,000	RES

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.
4 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for textural factors.

Table 2
NWT Tier 1 Levels (mg/kg soil) for PHCs for Coarse-grained Surface Soils

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15,000	8,000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	200	1,100	NA	NA
	Protection of Potable GW	860	1,200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Protection of GW for Livestock Watering[2]	9,000	4,000	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2,800
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC

(continued)

Table 2
NWT Tier 1 Levels (mg/kg soil) for PHCs for Coarse-grained Surface Soils (completed)

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Residential	Soil Ingestion	15,000	8,000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, basement)	50	240	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	860	1,200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2,800
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	RES	29,000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	310	1,700	NA	NA
	Protection of Potable GW	860	1,200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1,700	3,300
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (indoor)	310	1,700	NA	NA
	Protection of Potable GW	860	1,200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1,700	3,300
	Offsite Migration	NA	NA	RES	RES

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Tier 1 values based mainly on laboratory bioassay response to fractions derived from fresh Federated Crude Oil.

Table 3
CCME Pathway-specific Tier 1 Levels (mg/kg soil) for PHC for Fine-grained Surface Soils

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Direct Contact (Ingestion + Dermal Contact)	12,000	6,800	15,000	21,000
	Vapour Inhalation (indoor, basement)	710	3,600	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	610	3,100	NA	NA
	Protection of Potable GW[1]	170	230	NA	NA
	Protection of GW for Aquatic Life[2]	RES	RES	NA	NA
	Protection of GW for Livestock Watering[3]	4,200	10,000	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	1,300	5,600
	Eco Soil Ingestion	NC	NC	NC	NC
	Produce, Meat and Milk	NC	NC	NC	NC
	Management Limit[4]	800	1,000	3,500	10,000
Residential	Direct Contact (Ingestion + Dermal Contact)	12,000	6,800	15,000	21,000
	Vapour Inhalation (indoor, basement)	710	3,600	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	610	3,100	NA	NA
	Protection of Potable GW[1]	170	230	NA	NA
	Protection of GW for Aquatic Life[2]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	1,300	5,600
	Produce	NC	NC	NC	NC
	Management Limit[4]	800	1,000	3,500	10,000
Commercial	Direct Contact (Ingestion + Dermal Contact)	19,000	10,000	23,000	RES
	Vapour Inhalation (indoor)	4,600	23,000	NA	NA
	Protection of Potable GW[1]	170	230	NA	NA
	Protection of GW for Aquatic Life[2]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	2,500	6,600
	Offsite Migration	NA	NA	19,000	RES
	Management Limit[4]	800	1,000	5,000	10,000
Industrial	Direct Contact (Ingestion + Dermal Contact)	RES	RES	RES	RES
	Vapour Inhalation (indoor)	4,600	23,000	NA	NA
	Protection of Potable GW[1]	170	230	NA	NA
	Protection of GW for Aquatic Life[2]	RES	RES	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	2,500	6,600
	Offsite Migration	NA	NA	19,000	RES
	Management Limit[4]	800	1,000	5,000	10,000

NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10-4 cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.

Table 4
CCME Pathway-specific Tier 1 Levels (mg/kg soil) for PHC for Coarse-grained Surface Soils

Land Use	Exposure Pathways	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Direct Contact (Ingestion + Dermal Contact)	12,000	6,800	15,000	21,000
	Vapour Inhalation (indoor, basement)	40	190	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[1]	970	380	NA	NA
	Protection of GW for Livestock Watering[2]	5,300	14,000	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	300	2,800
	Eco Soil Ingestion	NC	NC	NC	NC
	Produce, Meat and Milk	NC	NC	NC	NC
	Management Limit[3]	700	1,000	2,500	10,000
Residential	Direct Contact (Ingestion + Dermal Contact)	12,000	6,800	15,000	21,000
	Vapour Inhalation (indoor, basement)	40	190	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[1]	970	380	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	210	150	300	2,800
	Produce	NC	NC	NC	NC
	Management Limit[3]	700	1,000	2,500	10,000
Commercial	Direct Contact (Ingestion + Dermal Contact)	19,000	10,000	23,000	RES
	Vapour Inhalation (indoor)	320	1,700	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[1]	970	380	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	1,700	3,300
	Offsite Migration	NA	NA	4,300	RES
	Management Limit[3]	700	1,000	3,500	10,000
Industrial	Direct Contact (Ingestion + Dermal Contact)	RES	RES	RES	RES
	Vapour Inhalation (indoor)	320	1,700	NA	NA
	Protection of Potable GW	240	320	NA	NA
	Protection of GW for Aquatic Life[1]	970	380	NA	NA
	Nutrient Cycling	NC	NC	NC	NC
	Eco Soil Contact	320	260	1,700	3,300
	Offsite Migration	NA	NA	4,300	RES
	Management Limit[3]	700	1,000	3,500	10,000

NA = Not applicable
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Includes additional considerations such as free phase formation, explosive hazards, and buried infrastructure effects.

The Tier 2 approach involves the adoption of Tier 1 remediation criteria with limited modifications. The method can be used where a combination of the "generic" Tier 1 criteria can be used to accurately describe the land and water use (and exposure pathways) of a site. A Tier 2 adjustment involves a commitment to increase the accuracy of the exposure and risk estimates based on site-specific data. It may involve the elimination of exposure pathways and receptors or adjustments of Tier 1 parameters to create Tier 2 criteria (CCME, 2008b).

As summarized from the Guideline for Contaminated Site Remediaton (GNWT, 2003):

- The Tier 3 evaluation involves a risk assessment to develop site-specific remediation objectives and is the most site-specific approach. This approach is necessary if parameters and assumptions used to develop the Tier 1 or 2 criteria (e.g., pathways of exposure, receptors or other site characteristics) are different from those applicable to the site. Since the options for including site-specific information at Tier 2 are limited, the parameters and assumptions may be such that the Tier 2 exposure scenario is still conservative relative to site-specific conditions. Additional site-specific factors may exist that would mitigate exposure, leading to the development of less stringent remediation objectives. If so, these factors may be incorporated at Tier 3. Site-specific remediation objectives for soil should be developed using risk assessment when there are:
  - significant ecological concerns (e.g., critical or sensitive habitats for wildlife; rare, threatened or endangered species; parkland or ecological reserves; hunting or trapping resources);
  - unacceptable data gaps (e.g., exposure conditions are uncertain, a lack of information about receptors, a high degree of uncertainty about hazard levels);
  - special site characteristics (e.g., the site is so large, or the estimated cost of remediation is so high, that a risk assessment is needed to provide a framework for site investigation and to set remediation priorities; and/or
  - site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivation of Tier 1 and 2 criteria.

Summary of Likely Applicable Remediation Criteria for PHCs in Soil at EKATI

Based on the hydrocarbon remediation guidance documents reviewed herein, the GNWT guidelines are not readily applicable to the EKATI site. This is because the guidelines are applicable to Commissioner's Land including private land within municipalities. These lands are generally near towns and cities.

The selection of a standard for hydrocarbon remediation, whether GNWT or CCME guidelines are followed, is largely dictated by the intended future land use of the area. In the case of the EKATI site, the future land use is described in broad terms in the 1995 EIS as:

"re-establish productive use of land, with wildlife designated as the principal land use, in addition to limited use of cultural and natural resources of the area by Aboriginals."

Based on this statement and the CCME guidance documentation, the most appropriate CCME standard appears to be the agricultural standard. Nonetheless, a site assessment defining the

extent of contamination (and complexity) and localized potential receptors would be required to confirm the applicable standard and whether values can be adopted from Tier 1, modified as Tier 2 values, or derived using a Tier 3 risk-based approach.

References

CCME. 2008a. Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil. Canadian Council of Ministers of the Environment. January 2008.

CCME. 2008b. Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: User Guidance. Canadian Council of Ministers of the Environment. January 2008.

Government of Northwest Territories (GNWT). 2003. The Environmental Guideline for Contaminated Site Remediation. November 2003.

Stabilization of EFPK in the LLCF

1. UNCERTAINTY

The stabilization of extra fine processed kimberlite (EFPK) in the LLCF to ensure no negative impacts on water quality and aquatic habitat.

2. RESEARCH OBJECTIVE

The purpose of this research plan is to develop an understanding of the expected behaviour of the EFPK in the LLCF and evaluate how to maintain EFPK containment within the LLCF post closure. This will include the following:

- Physical characterization of the EFPK (e.g., particle size distribution, clay types, solids content, consolidation characteristics, permeability and strength characteristics); and

- Spatial extent of EFPK (e.g., volume, thickness, density profile, location and area).

The above will be used together with the Life of Mine (LOM) plan to estimate closure distribution of EFPK. In addition, research projects will be undertaken to:

- Evaluate possible practical and economic methods to increase the settling rate of the EFPK solids, and

- Evaluate both sub-aerial and sub-aqueous EFPK stabilization measures to maintain containment of the EFPK within the LLCF.

This research is linked to operational management of the LLCF. Results from the operations reporting and monitoring as well as updates to the Waste Water and Processed Kimberlite Management Plan will be used as a resource for the EFPK research.

3. RESEARCH PLAN

3.1 Tasks Completed or Initiated

See Section 4.0 for more detailed description of the research.

1. Evaluation of kimberlite characteristics.

Characterization study for Panda and Fox kimberlite pipes included clay types, settling characteristics, particle size and geochemistry. This work was completed by EBA in 1998.

2. Plumb line surveys.

Plumb line surveys were undertaken during the summers of 2005 and 2008 to assess the profile of EFPK within the LLCF. The 2005 survey was completed in Cell B and Cell C. The 2008 survey was completed in Cell C.

3 LiDAR survey.

A LiDAR topographic survey of the LLCF was completed in 2008. This survey will be used as a base line for ongoing processed kimberlite deposition management and also for long-term closure planning.

3.2 Short Term Tasks (to be started/continued in the next three years)

See Section 5.1 for more detailed description of the research tasks.

Short-term research tasks identified as part of this research are primarily related to assessing the in situ properties of the EFPK in the LLCF and the time-dependent behaviour of the material. This data will be used for operational management plans and closure planning.

1. Plumb Line Surveys

Complete plumb line surveys as needed to evaluate the EFPK settled density profile and compare successive surveys to quantify the EFPK volume change.

2. Evaluate EFPK Sampling Methods

Review, research and evaluate potential improvements in the sampling methods for the EFPK. Currently, it is difficult to obtain a full depth representative sample of the low-density EFPK deposit with minimal disturbance, and to sample this material while the facility is in active operations.

3. Consolidation and Settling Tests

Complete a sampling program of the EFPK in Cells A and C, and submit these samples for laboratory testing to evaluate the physical and consolidation characteristics of the material.

Initiate a column sedimentation test to further evaluate free settling and consolidation behaviour of the EFPK. This test will enable the time-dependent behaviour of the EFPK to be evaluated and will provide a baseline controlled test against which field measurements can be compared.

4. Evaluate Accelerated EFPK Settling Methods

Evaluate practical and economic methods to increase the settling rate of the EFPK solids.

5. Estimate Closure Distribution of EFPK

Estimate the final locations, volumes, and properties of EFPK within each of the LLCF containment cells.

6. Evaluate EFPK Stabilization Measures

Evaluate measures required to stabilize the EFPK. These may include a water cap, sand or rip-rap cover. This task will consist of a desktop evaluation and literature review, which will be used to determine the need for and, if necessary, design future field trials (Task 8). It will incorporate the LLCF water balance from the Reclamation Research Plan on LLCF water quality and quantity at closure (Appendix 5.1-4A), and other related studies.

3.3 Long Term Tasks (2012 and following)

See Section 5.2 for more detailed description of the research.

7. Model long-term EFPK distribution.

Update long-term solids modeling to estimate EFPK distribution over time.

8. Field Trials to Evaluate EFPK Stabilization Measures.

If it is determined under Task 6 to be needed, a field trial program will be implemented to evaluate the EFPK stabilization measures developed in Task 6.

4. Findings of Research Completed

4.1 Research Summary Results

The mass of processed kimberlite that comes from each kimberlite pipe is recorded as part of Process Plant operations. This data allows for the processed kimberlite source within various portions of the LLCF to be roughly identified.

The total volume of processed kimberlite pumped to the LLCF since operations startup is also recorded as part of the Process Plant operations. This includes total solids and treated sewage effluent, and mine water (reported in the Environmental Agreement and Water Licenses Annual Reports).

Settling tests were completed on Fox ore (BHP Billiton, 2006). Initial investigation results indicated that processing of this ore may result in an increased EFPK percentage with an increased percentage of smectite clays and therefore require different reagent and flocculent additions, including chloride to achieve desirable settling characteristics for processing.

A plumb line survey was completed in 2005. The survey was conducted by measuring the depth of penetration of a lead plumb ball (SG of 11.4) and a glycol plumb bottle (SG of 1.1) to estimate the distribution of the EFPK in Cells B and C. The survey demonstrated that the majority of EFPK has very low shear strength and behaves essentially like a 'heavy' liquid flowing to fill the lower pond zone. EFPK was found to exist in very low solids content (less than 10% solids by weight) above the elevation of the glycol plumb depth. The maximum glycol plumb depths ranged from 6 to 13 m.

A second plumb line survey was completed in 2008. The data from this survey is currently in review.

In 2008, a LiDAR topographic survey of the LLCF was completed. This provided a high resolution topographic survey of the current LLCF conditions and will form the basis of ongoing processed kimberlite deposition planning.

4.2 Application of Lessons Learned

Operational data and studies were used to estimate the quantity of EFPK in the LLCF at closure and develop an operational plan for processed kimberlite deposition in the LLCF.

During deposition, processed kimberlite is naturally separated into coarser-grained fine processed kimberlite (FPK) and EFPK in the LLCF. The FPK (mainly sand-sized) settles first to form well defined sub-aerial and sub-aqueous beaches. This material accounts for 88% by mass of the processed kimberlite discharged into the LLCF. The EFPK (mainly silt and clay-sized) that does not settle on beaches is carried into the ponds and settles as an undulating, low-density mass. EFPK constitutes an estimated 12% by mass and 35% by volume of the processed kimberlite discharged into the LLCF. The EFPK is expected to accumulate and ultimately restrict flow through the dykes.

A 2004/2005 operations assessment of the LLCF outlined Option 3aM as the preferred operational outline for the LLCF. The objectives of this option, including a drawing of the final LLCF deposition model, are found in the 2007 Waste Water Processed Kimberlite Management Plan (WPKMP) and discussed in Section 5.5.

Option 3aM describes the use of permanent ponds in the containment cells at mine close. Spillway structures in dykes will act as water level control structures for the upstream ponds.

Water cap depths were estimated for the LLCF in the 2007 WPKMP. The final EFPK surface elevation in Cell C assumed for volume calculations is 456 m based on a final dyke crest elevation of 459 m with an allowance for freshet rise and freeboard. This would allow for an approximate 1 to 1.5 m seasonal rise. In Cell D the EFPK final elevation is predicted at 437 m, with the final pond elevation at 454 m.

4.3 Data and Information Gaps

The following data gaps were identified in evaluating the EFPK in the LLCF.

- Updated EFPK volumes from Plumb Line surveys. Periodic field sampling will be required to ensure alignment with the Deposition Plan and to provide update for closure planning.
- Understanding of EFPK performance with time observed in Cell C, and the difference between the EFPK deposit properties for previous ores (in Cell C) with that for Fox dominated ore in Cell A.
- Updated deposition model based on actual deposition performance.
- Understanding of ability to place physical covers to augment water covers in zones where water covers alone could be inadequate.
- Water balance modeling and verification of final water surface elevations in containment cells post closure.

5. Remaining Scope to be Completed

5.1 Detailed Work Scopes (next three years)

Table 1 provides an outline and schedule of tasks to be undertaken during the next three years.

Task 1. Plumb Line Surveys

Conduct periodic plumb line surveys as needed to estimate the settled deposit density profile. This information will provide a snapshot of the processed kimberlite and EFPK settling profiles on the beach areas and within the ponded areas, and will assist with modeling of future EFPK settlement.

Surveys will be completed in cells that have EFPK deposits (Cells A, B and C). Similar to previous surveys, the penetration depth of plumb bobs with known specific gravities will be measured at various locations in the LLCF. The coordinates of each survey location will be recorded to enable future measurements to be taken at the same location. Surveys will be completed in summer when the cells can be accessed by boat. Survey frequency will be dictated by the findings.

Data obtained from the survey will enable the density of the EFPK to be monitored and allow the change in density over time to be evaluated.

Task 2. Evaluate EFPK Sampling Methods

Various sampling methods and current industry practice will be reviewed to assess a safe and suitable method of sampling EFPK in the LLCF. The selected method will become a standard and will be employed in the sampling program discussed in Section 5.1.3.

This task will be completed early in the research program.

Task 3. Consolidation and Settling Tests

Sample the EFPK column in both old EFPK deposit areas in Cell C and in new EFPK deposit areas in Cell A to gain an understanding of settling and consolidation characteristics. The sampling program will be developed based on the results of the Task 2 research.

Recovered samples will be tested to evaluate their physical properties and variability between different locations in the LLCF. Testing may include particle size analysis, x-ray diffraction, specific gravity and Atterberg limits.

Once the testing is complete, the data will be compared against previously completed work.

Column sedimentation testing of processed kimberlite will also be completed as part of this task. This testing will evaluate time-dependent behaviour on a bulk processed kimberlite sample. Testing of a larger sample is intended to reduce scaling errors associated with extrapolating small bench scale tests to a macro environment such as the LLCF.

The proposed testing will estimate settling rates, density and shear strength gain with time. This will provide a benchmark to compare the results of plumb line surveys to and provide input into evaluating the potential for physical covers to stabilize the EFPK at closure.

Task 4. Evaluate Accelerated EFPK Settling Methods

Review and evaluate practical and economic methods to increase the settling rate of the EFPK in the LLCF (i.e., adding flocculants and/or coagulants). The first stage of this task will be a review of current and previous process plant practices and their relative effectiveness. This work will also include research into alternate methods or industry practice that may provide improved settling rates. This work will be completed ahead of laboratory testing (Task 3).

The second stage of this task will be an evaluation of processing methods through laboratory testing likely completed jointly with Task 3. The precise nature of the testing will be determined at the time.

Task 5. Estimate Closure Distribution of EFPK

Data from the 2008 LiDAR and plumb line surveys is being used to update the short-term sequencing of processed kimberlite deposition in accordance with the approved WPKMP.

This task of the reclamation research plan will use the updated deposition plan to refine the anticipated processed kimberlite profile in each containment cell at the end of mining operations. It will provide an estimation of final locations and volumes of EFPK in the LLCF.

Task 6. Evaluate EFPK Stabilization Measures

Conduct a literature review and desktop evaluation to assess the minimum water cap needed to safely contain EFPK and minimize the risk of re-suspension and transport into the lower watershed. This task will also consider physical covers such as sand or sand/rip-rap. Use the LLCF water balance from the Reclamation Research Plan on LLCF water quality and quantity at closure (Appendix 5.1-4A), and other related studies. The results of this research task will be used to assess the need for and, if necessary, design a field trial program (Task 8).

5.2 Conceptual Work Scopes (2012 and following)

Table 1 provides an outline and schedule of conceptual tasks to be undertaken in 2012 and following.

Task 7. Model EFPK Distribution at Closure

Update the model for post closure performance of the LLCF to evaluate distribution and movement of EFPK in the LLCF.

Task 8. Field Trials to Evaluate EFPK Stabilization Measures

If it is determined under Task 6 to be needed, a field trial program will be implemented to evaluate the EFPK stabilization measures developed in Task 6. The timing and location of the field trials will depend on the processed kimberlite deposition plan for the LLCF.

6. LINKAGES TO OTHER RESEARCH AND LOM PLAN

Research on the stabilization of EFPK in the LLCF to ensure no negative impacts on water quality and aquatic habitat is linked to:

- Engineering studies on the expected behaviour of processed kimberlite and/or EFPK stored in open pits.
- Research on the long-term water quality and water balance of the LLCF and its discharge after closure.

EFPK research is conducted as part of the ongoing operations of the LLCF and updates to the Wastewater and Processed Kimberlite Management Plan. Results from the operations work will be incorporated into the EFPK Research Plan for mine closure. Results from EFPK behaviour will also assist with research on processed kimberlite backfill of open pits, if an open pit becomes available in future updates of the LOM Plan.

7. PROJECT TRACKING AND SCHEDULE

Table 1. Stabilization of EFPK in the LLCF - PKCA

		Project Tracking[1]		
Research Task #	**Task**	**(*Reporting, Modeling, Field Work, Engineering Designs*)**	**Research Start**	**Research Finish**
Short Term Research Tasks (within next 3 years)				
1	Plum Line Surveys	Field work and reporting	2009	2012
2	Evaluate EFPK Sampling Methods	Field work and literature review	2009	2009
3	Consolidation and Settling Tests	Field work and laboratory testing,	2010	2010
		Construction of settling column and ongoing monitoring	2011	On going
4	Evaluate Accelerated EFPK Settling Methods	Literature review, laboratory testing	2010	2011
5	Estimate Closure Distribution of EFPK	LiDAR and Plumb Line Survey data review, update Deposition Plan	2009	2012
6	Evaluate EFPK Stabilization Measures	Literature review and desktop evaluation	2010	2011
Long Term Tasks (2012 and following)				
7	Model EFPK Distribution at Closure	Modeling	2014	2016
8	Field Trials to Evaluate EFPK Stabilization Measures	Field work	2014	On going

8. COST

Total expected costs are $1,000,000 to $1,500,000

9. REFERENCES

BHP Billiton, 2006. Waste Water and Processed Kimberlite Management Plan. Prepared by BHP Billiton Diamonds Inc. February 2006.

BHP Billiton. 2006b. *EKATI Fox Ore Trial Water Quality Assessment.* Prepared for BHP Billiton Diamonds Inc. by Rescan™ Environmental Services Ltd., January 2006.

Rescan, 2006. Fox Ore Trial Water Quality Assessment. Prepared by Rescan Environmental Services Ltd. January 2006.

Rescan, 2008. Long Lake Containment Facility Water Quality Prediction Model Version 2.0. Prepared by Rescan Environmental Services March 2008.

Robertson and Hayley, 2004. EKATI Mine Processed Kimberlite Containment Facility Summary of Key Lessons Learned from 5 Year Performance Review. Prepared by A.MacG. Robertson of Robertson GeoConsultants Inc. and Don Hayley of EBA Engineering Consultants Ltd. October 2004.

EBA, 1998. BHP Tailings Characterization Study. Prepared by EBA Engineering Consultants Ltd., June 1998.

Establishment of Self-Sustaining Plant Communities in the LLCF

1. UNCERTAINTY

The development of self-sustaining plant communities within the Processed Kimberlite Containment Areas (PKCA) mine component (*i.e.*, on the Long Lake Containment Facility [LLCF]) that are compatible with the surrounding tundra environment.

2. RESEARCH OBJECTIVE

To determine what self-sustaining plant community type(s) can be established on the LLCF. This research will be used to develop methods for using native vegetation, both planted and naturally colonizing, to enhance surface stability within the PKCA mine component.

3. RESEARCH PLAN

Early research on processed kimberlite began with greenhouse studies in 1999. These were followed by field studies within fenced research plots on Cell B of the LLCF. After the operations review of the LLCF and a new deposition plan in 2005, the research plots were covered by processed kimberlite in 2008. The updated deposition plan shows that processed kimberlite deposition will be active in all cells (B, A and C) until approximately 2013, when a section of the north end of Cell B will no longer require processed kimberlite.

A revegetation pilot study at the north end of Cell B will commence in approximately 2013 and will address a combination of operational and research questions, including vegetation establishment without fenced enclosures. Pilot studies on vegetation will continue at the north end of Cell B through 2019, when kimberlite deposition will be completed in the LLCF. The findings from the pilot study will be applied to the remainder of the facility at that time.

3.1 Tasks Completed or Initiated

See Section 4.1 through 4.6 for more detailed description of the research.

1. ***Assessment of the suitability of processed kimberlite as a revegetation substrate***.

This task was used as the initial assessment of whether vegetation could be grown directly in kimberlite, and what types of soil amendments and fertilizers would be necessary to assist with maintenance and sustainability.

2. Identification of locations within the LLCF suitable for revegetation.

Field studies have indicated that vegetation can be used to enhance surface stability in the Water Interface Zone and the Central Zone of the LLCF.

3. Survey of tundra plant species with potential for revegetating the LLCF.

BHP Billiton has committed to using native regional plants for revegetation work at EKATI. Native plant research on the LLCF includes identifying plants that would grow and sustain on processed kimberlite (serpentine soil), as well as finding sufficient quantities of native plants (including native cultivars) which could be propagated to reclaim the LLCF surface. The survey of established and disturbed tundra communities within the EKATI mine area and the surrounding region has identified tundra species with potential for revegetating selected areas of the LLCF. Additional species need to be tested.

4. Seed collection, storage and propagation.

A Standard Operating Procedure (SOP) has been developed that identifies seed sources and provides guidelines for collecting and processing seeds for use in revegetation. The SOP will be expanded as needed, to include updated species lists and related information.

5. ***Assessment of natural colonization and successional trends.***

Natural colonization of the LLCF has been documented in the course of revegetation research. Successional trends were investigated at other mine sites in the NWT. Additional studies will focus on natural colonization and succession on tailings impoundments in the NWT and methods to encourage and assist plant establishment.

6. Assessment of weeds at EKATI.

The presence of weeds at EKATI and at abandoned mines in NWT has been assessed in the course of monitoring revegetation and rehabilitation. This practice will continue.

3.2 Short Term Tasks (to be started/continued in the next three years)

See Section 5.1 for more detailed description of the research.

1. Assess revegetation suitability of additional tundra species.

This research will build on previous work.

2. ***Seed collection, storage and propagation.***

   This research will build on previous work.

3. ***Natural colonization and plant succession on the LLCF.***

   This research will build on previous work and will also consider plant community development in response to site factors including weathering of processed kimberlite.

4. ***Weeds Monitoring***

   This research will build on previous work.

5. ***Pilot Vegetation Study Planning.***

   Information acquired from the above tasks will provide basic information for the planning and design of the Pilot Revegetation Study, to be established in Cell B of the LLCF in 2013.

3.3 Long Term Tasks (2012 and following)

See Section 5.2 for more detailed description of the research.

1. ***Pilot Revegetation Study***

Learnings from the establishment of the Pilot Revegetation Study, using operational equipment, and the assessment of results will be key in identifying the practices and procedures for the successful reclamation of the LLCF.

4. Findings of Research Completed

4.1 Assessment of the Suitability of Processed Kimberlite as a Revegetation Substrate

4.1.1 Research Summary Results

Greenhouse Trials

A greenhouse trial of plant growth and establishment on kimberlite was conducted in 1999 (Kidd and Max, 2000b). Plant materials tested included cuttings of *Salix planifolia* (diamond leaf willow), sprigs of *Arctophila fulva* (pendant grass), a seed mix of native-grass cultivars and seed of *Hedysarum mackenzii* (liquorice root).

All the plants tested were able to survive in kimberlite for a limited period, but the study concluded that long-term survival was less likely, due to low levels of nutrients and

organic matter, the potential for compaction, and possible moisture stress due to limited water holding capacity.

Additional research on methods for establishing vegetation cover on kimberlite was conducted as part of a Master of Science research project at the University of Alberta (Reid and Naeth, 2001, 2002). This study focused on the use of various soil amendments to improve the ability of kimberlite to sustain plant growth.

Field Trials

The establishment and persistence of native-grass cultivars were assessed in field test plots on processed kimberlite, located within the Central deposition zone of Cell B of the LLCF (Martens, 2000, 2001, 2003, 2005). Seedlings of five native tundra species were, in 2002-2003, transplanted into kimberlite in test plots stabilized with native-grass cultivars (Martens, 2005). The species tested included *Betula glandulosa* (dwarf birch), *Dryas integrifolia* (white dryad), *Epilobium angustifolium* (fireweed), *O.deflexa* (reflexed locoweed) and *H. mackenzii* (liquorice root). Revegetation studies initiated in the Water Interface zone in 2002 had to be abandoned when the water level in Cell B was permanently raised.

In 2003, a study was initiated to test the effectiveness of revegetation treatments for stabilizing a channel that had developed in Cell B, within the LLCF (Martens, 2003). Treatments applied included seeding native-grass cultivars, planting seedlings of native sedges and willow cuttings.

Research results indicated that:

- Vegetation can be successfully established and plant cover maintained when planted directly into processed kimberlite (Martens, 2005, 2007).

- The native-grass cultivars tested are capable of maintaining a plant cover in the Central Zone of the LLCF without the use of soil amendments.

- Vegetation established readily in the Water Interface Zone. Prior to the permanent elevation of the water level in Cell B (and the forced abandonment of the study), seeded native-grass cultivars were well established, transplanted sods of *Calamagrostis canadensis* (bluejoint reedgrass) and *Carex aquatilis* (water sedge) thrived, and willow cuttings had sprouted leaves and branches (Martens 2002).

- Amendment of processed kimberlite with peat or lake sediment improved plant growth during the second and third gr owing seasons but showed no effect in subsequent years (Martens, 2005, 2007).

- Survival of tundra plant seedlings transplanted onto kimberlite was poor. Mortality was attributed primarily to burial of seedlings by windblown kimberlite, which was trapped by the grass canopy in the test plots (Martens, 2005).

- The presence of a diverse soil microflora and nodulation of legume roots growing in processed kimberlite are positive indicators of soil development, and important

factors in the development of a self-sustaining plant cover on processed kimberlite (Martens, 2005).

- The concentration of soil salts varied somewhat from year to year, but remained at moderate levels (EC 4.5 dS/m 6.3 dS/m), without an apparent affect on growth of the native grass cultivars or the natural colonization of dwarf birch (Martens, 2005, 2007).

- Soil organic carbon and available nutrients (NPK) remained relatively stable during the eight years of the study.

- Serpentine soils that typically develop on kimberlite deposits are usually deficient in plant available calcium. The addition of several forms of calcium in the greenhouse and field studies produced no growth response, at the outset or after five years of study, suggesting that plant uptake of calcium is not a concern in the long-term revegetation of the LLCF, and requires no further study.

- Grass cover in vegetated treatment plots, high in the years following initial establishment, declined to levels that averaged between 10 % and 15 %. Dead (litter) plant cover increased steadily over the years with the annual additions from aboveground plant production.

- Native-grass cultivars rooted to a maximum depth of 90 cm, where soil moisture was readily available. Root density was greatest in the upper 25 cm.

- Establishment of native plants from seed (other than native-grass cultivars) proved unsuccessful due to unfavourable site conditions (dry surface soil and wind erosion) and lead to the testing of containerized stock, i.e., seedling plugs, and the identification of this as the most reliable method of establishing native plants in processed kimberlite.

- The accumulation of litter created favourable site conditions for colonization by dwarf birch in the sixth growing season.

- Research plots, fenced to prevent grazing by primary graziers (caribou and arctic hare), did not attract primary grazers when the fence was removed during the final season before the plots were covered with processed kimberlite. Native-grass cultivar plots, not protected from grazing from the time of seeding, persisted despite four years of grazing. The plants, however, were short and provided little cover or protection from wind erosion.

4.1.2 Application of Lessons Learned

Application of lessons learned during eight years of revegetation research in processed kimberlite:

- The surface of the LLCF should be roto-tilled to provide a homogeneous (physically and chemically) soil material, and a good seedbed.

- Drill seeding, as opposed to broadcast seeding, is preferred in the Central zone to enhance seedling establishment. Broadcast seeding is advised in the Water Interface zone because of poor trafficability and the presence of favourable moisture conditions.

- The tailings surface should be revegetated as soon as possible after final elevation is reached to control salt accumulation at the surface.

- When revegetating the LLCF under operational conditions, entire expanses of the LLCF, e.g., the area from one jetty to the next jetty, should be revegetated at the same time, to reduce the potential of wind erosion and deposition in the revegetated area. If this in not possible, the areas adjacent should be stabilized temporarily, using physical control measures such as spray on erosion control material or “snow” fences, or by the seeding of annual species, until permanent revegetation is possible.

- The use of erosion control netting to assist the establishment of seed that is broadcast seeded is not recommended because the netting accumulated windblown kimberlite and restricted the establishment of seedlings.

- Maintenance fertilizer will be required for a period of time, to develop a self-sustaining plant cover.

- Sewage sludge could be used as a source of soil nutrients, if a practical method of application can be developed.

- Tundra seedlings were planted into established grass cover in spring; all suffered transplanting shock to variable degrees despite being hardened off.

- The use of conventional erosion control blankets, such as “Jute Soil Saver” in conjunction with the application of seed and fertilizer and rooted seedlings, does not provide adequate protection from water erosion in areas of concentrated flow.

4.1.3 Data and Information Gaps

- Operational equipment, methods and procedures to successfully establish a primary erosion-controlling cover of native-grass cultivars on the LLCF.

- The effect of primary grazers on revegetation success without permanent fencing.

- Temporary measures that may be required to protect the primary vegetation cover from grazing during the establishment phase.

- Long-term fertilizer requirement to maintain a stable vegetated surface.

- Methods and procedures to successfully establish native species in an erosion-controlling grass cover, by means of direct seeding or planting, and by natural colonization.

- Successional trends and characteristics of plant community that will develop on processed kimberlite in the long-term.

4.1.4 Recommendations for Future Work

- Establishment of a Pilot Revegetation Study on the LLCF designed to provide missing information.

4.2 Identification of Locations within the LLCF Suitable for Revegetation

4.2.1 Research Results

Field studies indicated that vegetation could be used to enhance surface stability in the Water Interface Zone and the Central Zone of the LLCF (Section 5.5.5.2).

Natural colonization of the LLCF by *Puccinellia borealis* (alkali grass) began approximately in 2002, and by 2007 it occupied much of the Central Zone of Cell B (Martens 2007). The upper limit of colonization in 2007 roughly outlined the lower limit of the Upper Zone of processed kimberlite deposition. The largest processed kimberlite particles are deposited in this zone at the point of processed kimberlite discharge, resulting in a coarse-textured, rapidly drained substrate with low moisture holding capacity. These upper slopes of the LLCF are to be reclaimed with a rock cover, as outlined in Sections 5.5.5.2 and 5.5.5.3 because it is unlikely that plant cover can be sustained given the characteristics of the processed kimberlite in this area.

4.2.2 Application of Lessons Learned

The pattern of colonization of Cell B suggests that rock cover should extend approximately 100 to 300 m from the point of discharge with the lower limit taking on an undulating outline as it follows the semi-circular pattern created by successive discharge points located along the edge of the cell.

No vegetation is planned for the Upper Zone, where conditions are not expected to be conducive to sustained plant growth.

4.2.3 Data and Information Gaps

- Identification of the location of the upper and lower boundary of Central Zone.

4.2.4 Recommendations for Future Work

- Develop methodology, based upon physical characteristics of processed kimberlite, to determine the location of the upper and lower boundary of the Central Zone.

4.3 Survey of Tundra Plant Species With Potential for Revegetating the LLCF

4.3.1 Research Results

Ecological mapping and vegetation inventories for EKATI were completed early in project development (BHP Billiton, 1995), followed by an inventory of soils and vegetation for the Misery Esker (Kidd, 1999). A Traditional Knowledge perspective on biodiversity in the mine area was provided by the Dogrib Treaty 11 (Dogrib, 2000). Ongoing revegetation studies at EKATI have identified potentially useful native species (Kidd, 1996; Kidd and Rossow, 1997, 1998; Kidd and Max, 2000a, Martens, 2005).

In 1999, seed of several legume species was sown in a field plot at EKATI, along the Old Camp Road, and along the banks of the Panda Diversion Channel, with the intention of establishing collection areas. Species included were *Hedysarum mackenzii* (liquorice root), *Oxytropis deflexa* (deflexed oxytrope) and *Astragalus eucosmus* (elegant milkvetch) (Kidd and Max 2000a). Seed of several graminoid species was collected from wetland stands for testing of viability and germination (Kidd and Max, 2000a). Species tested were *Eriophorum angustifolium* (tall cottongrass), *Carex aquatilis* (water sedge), *Arctagrostis latifolia* (polargrass), *Calamagrostis purpurascens* (bluejoint) and *Arctophila fulva* (pendant grass).

Native plant species (other than native-grass cultivars) with proven ability to establish within the Central Zone of the LLCF include *Epilobium angustifolium* & *E. latifolium* (fireweed), *Betula glandulosa* (dwarf birch), *Dryas integrifolia* (white dryad) and the legumes *Hedysarum mackenzii*, *Oxytropis deflexa*, *O. maydelliana* (Maydell's oxytrope) and *O. hudsonica*. Species adapted to the Water Interface Zone include *Salix planifolia* (diamond leaf willow), *Eriophorum* spp. (cotton grass), *Carex aquatilis* (water sedge).

The grass *Puccinellia borealis* (alkaligrass) naturally colonized the study plots on the LLCF, and appeared well adapted to growth on processed kimberlite within the Central deposition zone (Martens, 2005).

Festuca rubra (Arctared fescue), *Deschampsia ceaspitosa* (Nortran tufted hairgrass), *Poa alpina* (Gruening and Glacier alpine bluegrass), *Agropyron violaceum* (Violet wheatgrass) and *Festuca ovina* (sheep fescue) are the best suited of the native grass cultivars tested to maintain a grass cover on processed kimberlite. Norcoast Bering hairgrass, also successful, will not be utilized as it accumulates trace metals and is not native to the area (Martens, 2005)

4.3.2 Application of Lessons Learned

- Species tested to date appear indifferent to growth in processed kimberlite, i.e., none exhibited symptoms of stress when growing in processed kimberlite. Seedling mortality was related primarily to burial by wind-blown kimberlite.

4.3.3 Data and Information Gaps

- Identify additional tundra species adapted to growth in processed kimberlite.
- Cultural methods and practices to enhance establishment of tundra species by means of direct seeding or planting into an existing grass cover.

4.3.4 Recommendations for Future Work

- Research into additional species suited to growth in processed kimberlite.
- Research cultural methods and practices that promote establishment of tundra species by means of containerized stock or direct seeding.

4.4 Seed Collection, Storage and Propagation

4.4.1 Research Results

A Standard Operating Procedure (SOP) has been developed to identify seed sources and provide guidelines for collecting and processing seeds for use in reclamation (BHP Billiton, 2004; Martens, 2003, 2005).

The SOP provides information on locations, collection techniques and recommended harvesting dates for seed of several shrub, forb and graminoid species that have been found to be useful for reclamation at EKATI. Species listed include:

- *Arctostaphylos rubra, A. alpina* (bearberry)
- **Betula glandulosa* (dwarf birch),
- **Carex aquatilis* (water sedge)
- **Dryas integrifolia* (white dryad)
- **Empetrum nigrum* (crowberry)
- **Epilobium angustifolium, E. latifolium* (fireweed)
- **Eriophorum vaginatum* (cotton grass)
- **Hedysarum mackenzii* (Liquorice root)
- *Oxytropis deflexa (reflexed locoweed), *O. maydelliana* (Maydell's oxytrope), **O. hudsonica* (Hudsons locoweed)
- **Vaccinium uliginosum* (bilberry)

Seed of tundra plants used in the LLCF research was collected between 2000 and 2004, cleaned and stored in a deep freeze at the EKATI Minesite. Germination tests conducted in 2008 indicated that the viability of all three *Oxytropis* spp. remained high (in excess of 90%, with scarification) after 4 to 8 years of storage. Viability of dwarf birch and fireweed seed, collected in 2004, remained at 55% and 69%, respectively.

Establishment of tundra plants by direct seeding produced poor results, leading to the production of rooted seedlings for out planting as one- to two-year old stock. Because little information on commercial production of native tundra seedling plugs is available, ecological profiles of potential revegetation species, including available information on propagation was prepared for potential revegetation species, and provided to the nursery undertaking seedling production.

The small quantities of seedlings required for the LLCF revegetation research were produced by specialty nurseries in Calgary and shipped to EKATI by airfreight. Coast to Coast Reforestation Inc, located in Smokey Lake, AB, began work on producing seedlings for out-planting in the Rock Pad Revegetation Study established at EKATI in 2008. The species marked with an asterisk have, or are currently being grown as seedling plugs (i.e., containerized stock).

4.4.2 Application of Lessons Learned

- Seed production within any one species varies from year to year and between sites within the same year. Not every year is a good seed year.
- Additional species need to be tested for suitability for growth in processed kimberlite.
- Storage conditions optimum for legume seed may not be optimum for seeds with a thin seed coat, such as those from dwarf birch and fireweed.
- A commercial nursery was retained to develop methods and procedures for the large-scale production of containerized seedling stock that will be required for LLCF revegetation.

4.4.3 Data and Information Gaps

- Location of collection sites of tundra species to be added to the revegetation research study.
- Additional collection sites of existing SOP species.
- Optimum time when seed should be collected.
- Collection methods:
    - by hand or machine assisted.
    - specialized methods for certain species.

- Estimated volumes of seed required by species
- Storage conditions for each species to retain seed viability.
- Out-planting regime to minimize mortality.

4.4.4 Recommedations for Future Work

- Build on and expand the existing Seed Collection SOP and address missing information.
- Work closely with Coast to Coast Nursery in the development of methods and practices that will minimize out-planting mortality, including practices such as forced senescence and planting dormant stock.

4.5 Assessment of Natural Colonization and Successional Trends

4.5.1 Research Results

Natural colonization on the LLCF has been observed in the course of conducting other fieldwork. The grass *Puccinellia borealis* (alkaligrass) naturally colonized the study plots on the LLCF, and appeared well adapted to growth on processed kimberlite within the Central deposition zone (Martens, 2005). Several kilograms of seed were collected and discussions with commercial seed producers are currently underway.

Betula glandulosa (dwarf birch) naturally colonized the LLCF reclamation research plots seven years after establishment (Martens, 2007). The accumulated grass litter provided site conditions suitable for establishment of seedlings. Dwarf birch is a prolific seed producer (when seed is produced), the seed is small, light in weight, and with its winged appendage, well designed for transport by wind across large distances, especially during winter when surfaces are covered with snow.

Natural colonization was also investigated at several other mine sites in NWT, but results were not reported for specific mine components (Kidd and Max, 2001; Martens, 2007).

4.5.2 Application of Lessons Learned

- Tundra species will colonize the LLCF when the particular conditions required by the species are provided. For a primary colonizer such as *Puccinellia borealis*, a bare surface is suitable; for dwarf birch, a primary colonizer given the right site conditions, appears to require a well-developed litter cover to establish on the LLCF.
- Species that are prolific producers of light weight, highly mobile seed, are likely to be among the first to colonize the LLCF.
- Natural colonization will likely be accelerated by assisting in the establishment of species that produce seed of lower mobility.

4.5.3 Data and Information Gaps

- LLCF site conditions that enhance conditions for colonization by tundra species.
- Methods to accelerate natural colonization.
- Changes in the plant community composition and structure with time.

4.5.4 Recommendation for Future Work

- Research site conditions requirements for the target tundra species.
- Research methods to assist establishment of tundra species, especially those with lower seed mobility, including the construction of islands of planted species and direct seeding in the Water-Interface Zone.
- Research successional trends in low arctic ecosystems and disturbed sites with similar characteristics to processed kimberlite.
- Assess natural colonization of abandoned tailings impoundments and similar sites in the NWT and YT.

4.6 Assessment of Weeds at EKATI

4.6.1 Research Results

The presence of weeds at EKATI has been assessed periodically in the course of conducting rehabilitation monitoring. As of 2007, the only invasive weed recorded at EKATI is *Hordeum jubatum* (foxtail barley), which is limited to the area around the airport.

At the Giant Mine, near Yellowknife, extensive colonization by *H. jubatum* was noted in 2001 (Kidd and Max, 2001). The only other non-native species present was *Equisetum pratense* (meadow horsetail). Non-native weed species recorded at the Rae Mine included *H. jubatum*, *Phalaris arundinacea* (reed canarygrass), *Taraxacum* spp. (dandelion) and *Polygonum* spp. (knotweed). At the Discovery Mine, weed species recorded included *H. jubatum*, *E. pratense*, and *Erigeron* sp. (fleabane). Martens (2007) assessed natural colonization at several disturbed sites in the region, but did not report the presence of any weedy species.

4.6.2 Application of Lessons Learned

- Although the EKATI mine is remote, opportunity still exits for weeds to establish at the mine site – through natural vectors, via the winter road, or as contaminants in seed of native grasses grown on agricultural lands.

4.6.3 Data and Information Gaps

- None

4.6.4 Recommendations for Future Work

- Continue to watch for weeds when monitoring revegetation success and moving about on the mine site.

- Take appropriate action if weeds are found

- Request Certificate of Analysis for every seed lot prior to purchase to ensure that no problem weeds are included. Refuse contaminated seed lots or request that they be cleaned again and sampled again for weeds. Note: many weeds common in agricultural fields will be killed by the harsh winters at EKATI (Hardy BBT 1986).

5. Remaining Scope to be Completed

5.1 Detailed Work Scopes (next three years)

Table 7-1 provides an outline and schedule of tasks to be undertaken during the next three years.

Task 1. Assess revegetation suitability of additional tundra species

Research to date has identified a limited number of tundra species that are adapted to processed kimberlite. Additional potential species will be identified and tested, based upon their presence in local plant communities, their ecological profiles (site preference and tolerances), and available information of growth in kimberlitic soils. Serpentine And Its Vegetation, A Multidisciplinary Approach by R.R. Brooks, Ph.D., will be a key source of information.

Potential species include, but are not limited to: *Empetrum nigrum* (crowberry), *Arctostaphylos alpina* (bearberry), *Vaccinium uliginosum* (bilberry), *Arctophila fulva*, *Carex bigelowii*. Field (if a suitable location can be found on the LLCF) and/or greenhouse trials of plant establishment and growth on processed kimberlite will be established and monitored. See also Task 3, Section 5.1.2, below.

Task 2. Seed Collection, Storage and Propagation

The immediate purpose of this program is to provide seed and suitable stock for the Pilot Revegetation Study, expected to begin in 2013. The ultimate purpose is to develop a program that will provide suitable native stock for revegetation of the remainder of the LLCF. Because native seed production is generally low and infrequent, seed collection and development of suitable methods and procedures must start early in the research program. In 2009-2012 the research will build on previous studies, by including seed collection, storage and propagation work specific to those plants already identified as candidates for the establishment of an early protective cover, and for a long term succession cover.

Sub-Tasks to be undertaken:

a) Select Species

This will include species known to do well plus others identified in the assessment trials outlined above in Section 5.1.1 .

b) Seed Collection

I. **Seed Needs**. Determine estimated quantity of seed of the target species required for LLCF revegetation research and the Pilot Revegetation Study. Seed requirements and storage viability will determine species collection priorities and quantities collected for future use.

II. **Collection Sites**. Identify accessible stands of selected species, where seed or other plant materials can be collected. Several locations (3 or 4) for each species will be selected to avoid intensive collection from the same area year after year. This may require the addition of two or three sites for those species already addressed in the SOP. Sites will be GPS referenced and marked on a collection site map.

III. **Seed Harvesting**. Research the use of handheld equipment to increase efficiency of seed collection.

IV. **Collection Schedule**. Through germination testing, determine the phenology of seed ripening and visual cues to identify mature seed.

V. **Seed Storage**. Test various storage methods to maximize seed survival and germination. Research to date has shown that legume viability is maintained at a high level, after eight years of storage in a deep freeze. Small seeds with a thin seed coat, such as fireweed and dwarf birch may require different conditions to maintained viability.

c) Plant Propagation

Research into direct seeding and growing containerized seedling stock in the greenhouse for later planting will be continued. Research into the large-scale propagation of tundra species as containerized stock began in 2008. Coast to Coast nurseries, in Smokey Lake Alberta, are currently rearing six tundra species [*Betula glandulosa (*dwarf birch*), Vaccinium uliginosum (*bog bilberry*), Oxytropis deflexa (*reflexed locoweed*), Epilobium angustifolium & E. latifolia* (fireweed), *Empetrum nigrum* (crowberry) and *Hedysarum mackenzii* (Liquorice root)] for out-planting in the Rock Pad Reclamation Study in 2009 and 2010 (Martens 2009). Research into the rearing of seedlings and development of practices to increase survival of out-planted seedlings will be directly applicable to revegetation of the LLCF. Other species with potential for processed kimberlite revegetation will be added to the Coast to Coast seedling propagation program and the on-site field testing program.

Direct seeding will, because of poor trafficability, be the preferred method of plant establishment in the Water Interface Zone. Direct seeding trials with species likely to be adapted to site conditions found in this zone, such as *Salix planifolia, Carex bigelowii, Eriophorum vaginatum,* will be initiated on site.

Task 3. Natural Colonization and Plant Succession on the LLCF

Natural colonization of *Betula glandulosa* and *Puccinellia borealis* was recorded during monitoring of revegetation studies on the LLCF. (Martens, 2005). Research during the next three years will include, but not be limited to:

- Review of literature on plant colonization community succession on disturbed lands, including information available from local mines (i.e., NWT and YT).
- Field assessment of natural colonization of abandoned tailings containments in the NWT and YT. Operations with tailings of comparable chemical and physical properties will be targeted.
- The utilization of *Puccinellia borealis* in the primary revegetation regime in an efficient and useful manner.
- The effectiveness of islands of planted tundra vegetation as centres of seed dispersion.

Integral to this research will be the characterization, to the extent possible, of the expected plant community and the successional changes that might occur over time. The effects of the anticipated changes in chemical and physical properties of processed kimberlite resulting from long-term weathering (see Appendix 5.1-4B, Plan 11) will also be considered.

Task 4. Weeds Monitoring

Continue to monitor reclamation sites within the EKATI mine area for the presence of introduced weeds. Determine whether weed control is needed, and develop a plan if appropriate.

Task 5. Pilot Vegetation Study Planning

The vegetation pilot study is planned to commence in 2013. Prior to this research will include the outline of specific equipment and material needs, types and volumes (E.gs, site preparation and seeding equipment, plants/seeds amendment materials). Vegetation study planning will also incorporate and work in conjunction with planning of other LLCF pilot studies which will be completed in the same location (north end of Cell B) at the same time as the vegetation studies.

5.2 Conceptual Work Scopes (2012 and following)

Task 6. Pilot Vegetation Study

The Pilot Vegetation Study will involve field studies of plant establishment, growth and persistence on the LLCF, established with operational equipment at the north end of the containment area. The study will incorporate the use of waste rock in the Upper Zone, and revegetation of the Central and Water Interface zones of the LLCF.

Studies will be monitored periodically to assess plant community development over the long term. The research will assess:

- Equipment and methods for site preparation, seeding and planting.
- Influence of grazing on vegetation establishment and erosion control.
- Construction and effectiveness of islands of planted tundra species.
- Vegetation establishment on the LLCF under the influence of assisted and natural colonization.
- Maintenance fertilizer requirements.
- Changes to the geochemical makeup of the processed kimberlite from weathering and wildlife grazing (see Appendix 5.1-4A Research Plan 18 and Appendix 5.1-4B Research Plan 11).
- Changes in soil organic carbon and plant nutrients.
- Drainage and erosion control.
- Location of the upper and lower limit of the Central Zone.

For research into design of internal drainage channels, see Appendix 5.1-4B Research Plan 9.

Findings from the Pilot Revegetation Study will be used in the development of final reclamation plans for the LLCF.

6. LINKAGES TO OTHER RESEARCH AND LOM PLAN

Research on the use of native plants and establishment of self-sustaining plant communities in the PKCA mine component is linked to:

- Research on the establishment of self-sustaining plant communities in other mine components. In many cases site conditions, plant species present, and other community characteristics will be similar across mine components.
- Research on vegetation percent (%) cover and surface stability for the PKCA mine component and other mine components.
- Research on Traditional Knowledge inclusion in reclamation planning for the EKATI mine components.
- Research on the weathering of processed kimberlite.
- Research on the bioaccumulation of metals in grazers using the LLCF.
- Research on the design of internal drainage channels.

Reclamation field research on the LLCF will continue until approximately 2013 when a pilot vegetation study is planned for the northern end of Cell B. BHP Billiton will continue to seek opportunities to continue field work and initiate the pilot study if the Deposition Plan for the LLCF allows the opportunity for an area to be available for research and the site is safe for field work activities.

7. PROJECT TRACKING AND SCHEDULE

Table 1. Stabilization of EFPK in the LLCF - PKCA

		Project Tracking[1]		
Research Task #	**Task**	**(*Reporting, Modeling, Field Work, Engineering Designs*)**	**Research Start**	**Research Finish**
Short Term Research Tasks (within next 3 years)				
1	Assess Revegetation Suitability of Additional Tundra Species	Field work, nursery studies, monitoring	2009	2012
2	Seed Collection, Storage and	Field work, nursery research	2009	2012

	Propagation	(germination tests), monitoring.		
3	Natural Colonization and Plant Succession on the LLCF	Literature review, field assessments, pilot study.	2009	2012
4	Weeds Monitoring	Ongoing monitoring, adaptive management (if required)	2009	On going
5	Pilot Revegetation Study Planning	Planning and Design	2010	2012
		Long Term Tasks (2012 and following)		
6	Pilot Revegetation Study	Field work, monitoring.	2013	2020

8. COST

Total expected costs, for the period 2009 to 2012, are $300,000 - $350,000.

9. REFERENCES

BHP Billiton. 1995. Ecological Mapping, 1995 Baseline Study Update. Prepared by Rescan Environmental Services Ltd., December 1995.

Brooks, R.R. 1987. Serpentine And Its Vegetation, A Multidisciplinary Approach. Dioscorides Press, Ecology, Phytogeography & Physiology Series, Volume 1. ISBN 0-931146-04-6. 454 pp.

Dogrib. 2000. A Tlicho perspective on biodiversity. Prepared by the Dogrib Treaty 11 Council.

Hardy BBT. 1986. 1986 Revegetation Monitoring of the INTERPROVINCIAL PIPE LINE (NW) LTD. Norman Wells to Zama Pipeline. 32pp + App.

Kidd, J. G. 1996. Pilot revegetation studies at the Fox portal site, EKATI Diamond Mine, NWT, Canada. Final report prepared for BHP, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Kidd, J. G. 1999. Inventory of vegetation and soils on the Misery esker, EKATI™ Diamond Mine, NWT, Canada. Final report prepared for BHP Diamonds, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Kidd, J. G., and K. N. Max. 2000a. EKATI™ Diamond Mine reclamation research program, 1999, NT, Canada. Final report prepared for BHP Diamonds, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Kidd, J. G., and K. N. Max. 2000b. EKATI™ Diamond Mine reclamation research program, 2000, NT, Canada. Final report prepared for BHP Diamonds, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Kidd, J. G., and L. J. Rossow. 1997. Resource inventory and pilot revegetation study, Fox Decline Mine Site, NWT, Canada. Second annual report prepared for BHP, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Kidd, J. G., and L. J. Rossow. 1998. Pilot revegetation studies at the Fox portal site, EKATI Diamond Mine, NWT, Canada. Third annual report prepared for BHP, Inc., Yellowknife, NWT, Canada, by ABR, Inc., Fairbanks, AK, USA.

Martens, H. E. 2000. EKATI Diamond Mine processed kimberlite tailings reclamation research program, 2000. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Martens, H. E. 2001. EKATI Diamond Mine processed kimberlite tailings reclamation research program, 2001. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Martens, H. E. 2002. EKATI Diamond Mine processed kimberlite tailings reclamation research program, 2002. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Martens, H. E. 2003. EKATI Diamond Mine processed kimberlite tailings reclamation research program, 2003. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Martens, H. E. 2005. EKATI Diamond Mine revegetation research projects, 2004. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Martens, H. E. 2009. EKATI Diamond Mine revegetation research projects, 2008. Final report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Harvey Martens and Associates, Calgary, AB, Canada.

Reid, N. and M. A. Naeth. 2001. EKATI Diamond Mine Processed Kimberlite Tailings Reclamation. Report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Department of Renewable Resources, University of Alberta, Edmonton, AB, Canada.

Reid, N. and M. A. Naeth. 2002. Establishment of a Vegetation Cover on Kimberlite Mine Tailings. Report prepared for BHP Billiton Diamonds Inc., Yellowknife, NT, Canada by Department of Renewable Resources, University of Alberta, Edmonton, AB, Canada.