Snap Lake Project Vegetation Monitoring Plan

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Introduction

De Beers Canada Inc. (De Beers) owns and operates the Snap Lake Project (the Project). The Project is located approximately 220 km northeast of Yellowknife, Northwest Territories (NWT), 30 km south of MacKay Lake, and 100 km south of Lac de Gras where the Diavik Diamond Mine and the Ekati Diamond Mine are located (Figure 1-1).

The Project includes the development of an underground mine, a kimberlite storage facility (the North Pile), mine facilities and infrastructure, an airstrip, a winter access road and a quarry (for occasional use) situated on an esker outside of the main development area.

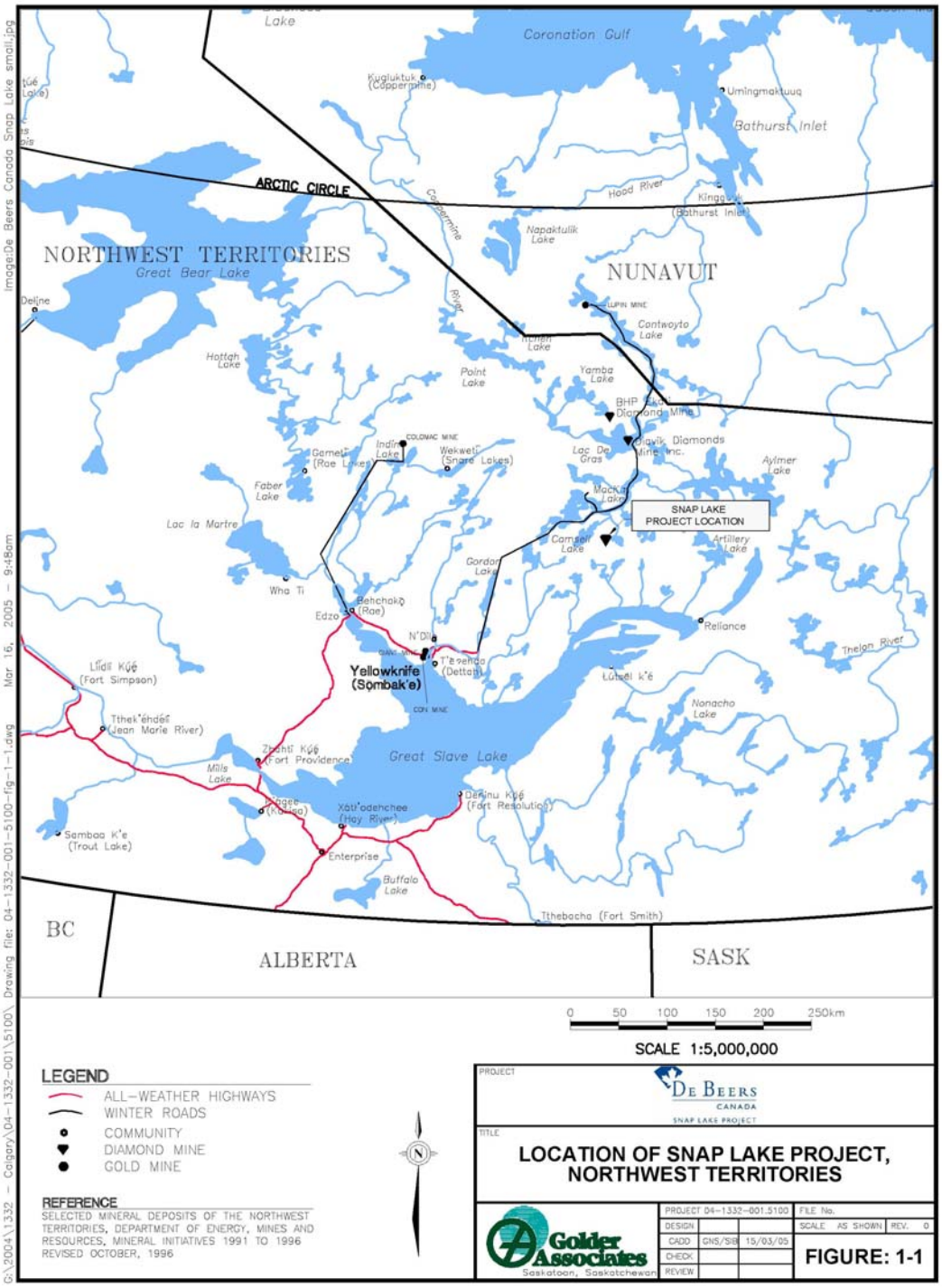
An Environmental Assessment Report (EAR) for the proposed mine (De Beers 2002a) was completed and submitted to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) in February 2002. The MVEIRB in turn completed a review, and recommended that the Project proceed subject to the implementation of measures to mitigate environmental impacts (MVEIRB 2003). The MVEIRB's report and recommendation was submitted to the Minister of Indian and Northern Affairs in July 2003 and received ministerial approval in October, 2003. In May, 2004, De Beers received the required Water License, Land Leases, Environmental Agreement, and Fisheries Authorization to begin construction and operation of the mine.

The Vegetation Monitoring Program (VMP) is a requirement of the Environmental Agreement for the Project and provides support for the closure and reclamation research and monitoring requirements of the Project's Water License (MV2001L2-0002). It also provides research and monitoring details, linked to the Closure and Reclamation Plan (AMEC 2003).

Study Area

The VMP covers two study areas, to allow for both a local assessment and a regional assessment. The Local Study Area (LSA) includes the Project footprint plus a 500 m buffer (Figure 1-2). The Regional Study Area (RSA) for vegetation was defined by a circle with a radius of 31 km, centred on the Project site (Figure 1-3), and is identical to the RSA used in the Project EAR (De Beers 2002a). Within the RSA the main focus of monitoring will be on the esker quarry, although additional criteria could trigger a more detailed regional assessment.

Landsat image analysis, complemented by vegetation surveys established 18 Ecological Land Classes (ELC) units in the RSA, with seven of these ELC units occurring in the LSA. ELCs are areas with similar vegetation cover and composition, reflecting relatively uniform terrain, soils, vegetation, drainage and disturbance conditions. Water is the most common land cover class and the dominant ELC unit is a heath boulder complex, followed by tussock-tundra.


Coronation Gulf
Kugluktuk (Coppermine)
Umingmaktuuq
Bathurst Inlet
ARCTIC CIRCLE
Hood River
Kingaunk (Bathurst Inlet)
Napaktulik Lake
NORTHWEST TERRITORIES
Great Bear Lake
NUNAVUT
Deline
LUPIN MINE
Contwoyto Lake
Hottah Lake
Point Lake
Yamba Lake
BHP Ekati Diamond Mine
COLOMAC MINE
Garnet (Rae Lakes)
Wekweti (Snare Lakes)
Lac De Gras
Diavik Diamonds Mine Inc.
Aylmer Lake
Faber Lake
Mackay Lake
SNAP LAKE PROJECT LOCATION
Lac la Martre
Camsell Lake
Artillery Lake
Gordon Lake
Wha Ti
Behchokǫ (Rae)
Edzo
Reliance
N'Dilǫ
Yellowknife (Sǫmbak'e)
Thelon River
Łíídlı̨ Kų́ę (Fort Simpson)
Łutsel k'e
Nonacho Lake
Tthek'ehdeli (Jean Marie River)
Zhahtì Kų́ę (Fort Providence)
Great Slave Lake
Mills Lake
Dechinu Kų́ę (Fort Resolution)
Xatı'odenchee (Hay River)
Sambaa K'e (Trout Lake)
Enterprise
Buffalo Lake
Tthebacha (Fort Smith)
BC
ALBERTA
SASK
0 50 100 150 200 250km
SCALE 1:5,000,000
LEGEND
ALL-WEATHER HIGHWAYS
WINTER ROADS
COMMUNITY
DIAMOND MINE
GOLD MINE
REFERENCE
SELECTED MINERAL DEPOSITS OF THE NORTHWEST TERRITORIES, DEPARTMENT OF ENERGY, MINES AND RESOURCES, MINERAL INITIATIVES 1991 TO 1996 REVISED OCTOBER, 1996
PROJECT
DE BEERS CANADA
SNAP LAKE PROJECT
TITLE
LOCATION OF SNAP LAKE PROJECT, NORTHWEST TERRITORIES
Golder Associates
Saskatoon, Saskatchewan
PROJECT 04-1332-001.5100
DESIGN
CADD GNS/SIB 15/03/05
CHECK
REVIEW
FILE No.
SCALE AS SHOWN REV. 0
FIGURE: 1-1
G:\2004\1332 - Calgary\04-1332-001\5100\ Drawing files: 04-1332-001-5100-fig-1-1.dwg Mar 16, 2005 - 9:48am
Image:De Beers Canada Snap Lake small.jpg

Objectives

The principal goal of the VMP for the Project is to comply with relevant articles in the Environmental Agreement (Article VII), Water License and related corporate commitments. To comply with these articles the VMP is designed to include the following objectives:

- verify the accuracy of impact predictions made in the EAR;
- establish action levels or triggers for early warning signs to implement adaptive management and mitigation measures where appropriate;
- implement, through the Environmental Management System (EMS) (De Beers 2002b), operational practices that mitigate disturbance to native vegetation;
- determine the effectiveness of mitigation measures implemented through the EMS; and
- design studies and data collection techniques that are consistent with, and will contribute to, understanding and managing vegetation effects and ensuring effective reclamation.

To respond to these objectives, the VMP includes three annual monitoring programs. Additional monitoring programs may also be triggered if specific action levels are exceeded.

The annual programs are designed to test EAR impact predictions and the success of reclamation activities. These programs will measure:

- the total area disturbed by mining activities in the LSA and in the esker quarry;
- the area of vegetation types disturbed by mining activities in the LSA and in the esker quarry; and
- the effects of reclamation methods on revegetation.

The programs that may be triggered will assess the environmental impacts and causes if EAR predictions are exceeded. These programs will identify:

- the changes to the vegetation cover, composition, plant health, soil properties and active layer depth of ELC units, if EAR predictions are exceeded; and
- the effect of fugitive dustfall on vegetation and active layer depth, if dustfall emissions exceed regulatory guidelines.

Information from the VMP may result in alterations in environmental management of the Project if the data indicate that impacts are greater than predicted, unanticipated impacts are occurring or reclamation efforts could be more effective. These changes in environmental management could, in turn, necessitate changes to the VMP (Figure 1-4).

Vegetation Monitoring study design

The VMP is divided into two main categories: annual programs and those programs that may be initiated, or triggered, if the Project exceeds specific environmental criteria (Tables 1 and 2).

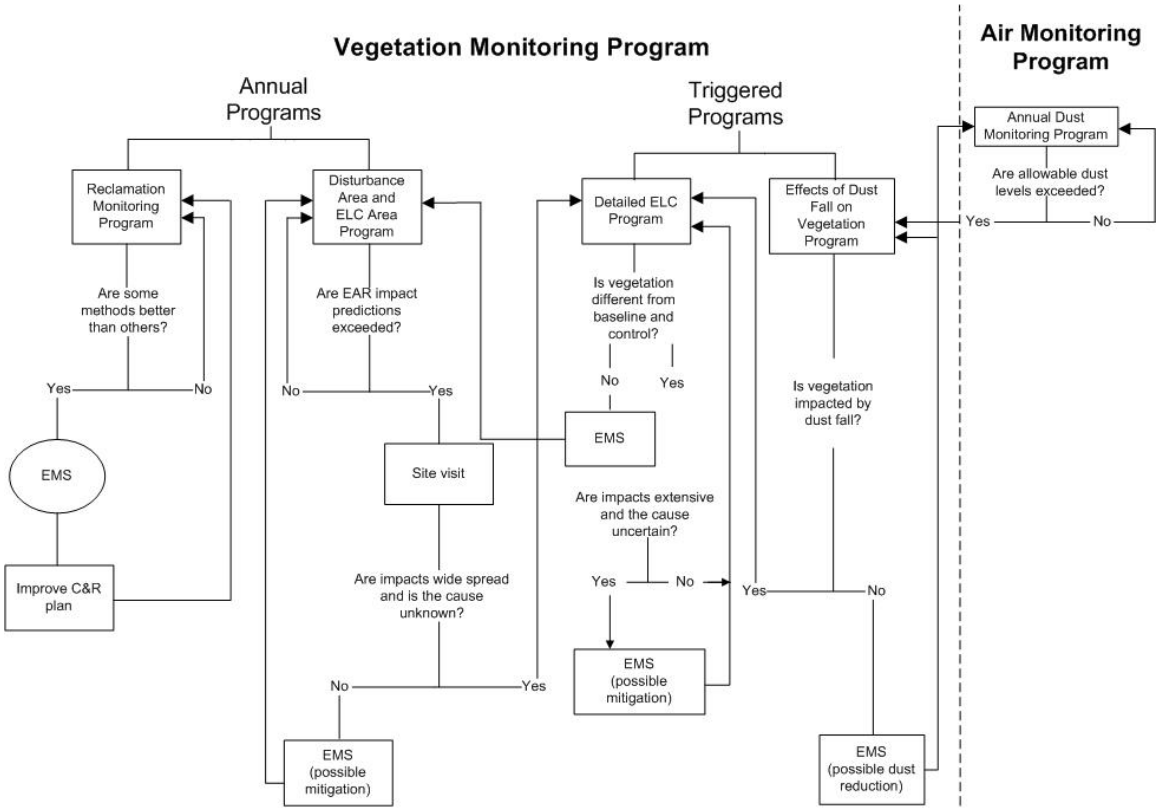


Figure 1-4 Flow Chart of Annual Vegetation Monitoring Program and Linkage to Triggered Programs and EMS

Annual Programs

Three vegetation monitoring programs will be conducted annually. These include:

- monitoring the total area of direct impact due to the Project;
- monitoring the change in ELC unit area; and
- monitoring the effects of revegetation activities.

Area of Impact Monitoring Program

This program is designed to confirm EAR predictions related to the total loss of native vegetation due to the Project. The Project will result in a change to the area of native vegetation due to the direct loss of vegetation, the disturbance or removal of soil, and re-arrangement of the terrain caused by mine construction (including the North Pile), site infrastructure, the airstrip, access roads and the esker quarry.

Monitoring the area of impact will assist in managing the direct effects of the Project. This program will also provide a mechanism by which impacts that exceed EAR predictions would be identified and the appropriate mitigation applied. Further, this program will provide a method for annually tracking the rate of area disturbance through the life of the Project and linking impacts to Project activities and to EAR predictions.

The focus of this program will be on the LSA and the esker quarry area (in the RSA) since these areas will experience most of the direct Project impacts to vegetation.

Monitoring Methods

Monitoring methods for measuring the area of impact involves a number of connected steps (Figure 1-4). These include:

- measure the total area of loss due to the Project, focusing on the mine area in the LSA and the esker quarry area and compare with impact predictions in the EAR;
- if the area impacted is consistent with or less than predictions stated in the EAR, then no further assessment will be required that year;
- if the impacted area exceeds EAR predictions by greater than 10%, a site visit will be conducted to assess the nature, extent and source of impacts that exceed EAR predictions;
- if the additional impacts are easily explained, then no further investigations will be necessary. For example, if the increase in area of impact is due to an increased area required for the North Pile, then this will be documented;
- the EMS will be used to mitigate and control, where possible, the increased impacts (Figure 1-4);
- if the additional impacts are significant and the cause is uncertain, the Detailed ELC Monitoring Program may be triggered (Figure 1-4; Section 2.2); and
- annual incremental change in impact area will be tracked to assess the rate of change due to the Project, and to identify and report significant changes and their cause; for example, in 2008 the starter cell of the North Pile will be constructed, resulting in a significant, predicted change in ELC area in the LSA.

The area of impact will be measured annually throughout operations and may continue past closure, depending on past results. Monitoring frequency after closure will depend on the monitoring results until that time.

Two action levels in the annual program may initiate additional monitoring activities (Figure 1-4):

- total impacted area in the LSA exceeds EAR predictions by greater than 10%; that is, a disturbance area greater than 616 ha in the LSA will initiate field investigations; and
- indirect impacts at the esker quarry area are observed, beyond the direct area of impact.

If these action levels are reached, the EMS would be used to review the cause of increased impacts, identify appropriate mitigation and ensure that Project activities are updated to account for the required mitigation. This in turn, may lead to modifications to the monitoring program (Figure 1-4). Further, these action levels will trigger a site visit which, in turn, may trigger the Detailed ELC Monitoring Program, if the site visits indicate that this data is needed to assess the nature and extent of impacts, identify the cause(s) and/or select the appropriate mitigation.

ELC Area Monitoring Program

The ELC area monitoring program will measure the area of ELC units in the LSA and in the esker quarry area. This value will be compared to preconstruction values and EAR predictions. This program will identify if there is significant change in ELC unit area in the LSA and the esker quarry area, compared to EAR predictions. This program will also annually track the rate of ELC change through the life of the Project and linking changes to Project activities and to EAR predictions. It will serve as a tool to assess if the Project disturbances exceed EAR predictions and, if so, will help to identify appropriate mitigation at an early stage.

The focus of this program will be on the LSA plus the esker quarry area since these areas will experience most of the Project impacts to vegetation, including indirect effects.

Methods

Monitoring methods will measure the area of ELC units in the LSA and esker quarry area, and compare these areas to pre-construction values and to EAR predictions. The following steps will be used:

- the area of individual ELC units at a recent pre-construction stage will be measured using high resolution Quickbird satellite imagery;
- during each year of operations, the ELC unit area will be measured using the same methods, and areas will be compared to EAR predictions;
- annual incremental change in ELC area will be tracked to assess the rate of change due to the Project, and to identify and report significant changes and their cause; for example, in 2008 the starter cell of the North Pile will be constructed, resulting in a significant, predicted change in ELC area in the LSA;
- if ELC unit area changes exceed EAR predictions by less than 10%, this will be documented and the EMS may be used to evaluate this change;
- if ELC unit area changes are greater than 10% from EAR predictions then an investigation and field program may be implemented;
- during the investigation the areas of significant ELC unit area change observed on the imagery will be assessed to identify the nature, extent and cause of disturbance;
- if the ELC unit area changes are widespread and the cause is unknown, then a more detailed investigation will be triggered through the EMS, which may include the Detailed ELC Monitoring Program (Section 2.2.1); and

EMS will be initiated to mitigate the cause of effects, if identified.

There are four action levels in the annual ELC Unit Area program that may initiate additional monitoring activities, site visits and the Detailed ELC Monitoring Program (Figure 1-4). Action levels include:

- impacts to the area of ELC units exceed EAR predictions by greater than 10%;
- if field investigations indicate that impacts are extensive within the LSA, then a broader, regional assessment may be triggered. This program would measure ELC unit values in the RSA and compare these to baseline values;
- ELC unit area changes at the esker quarry site are significant and occur outside of the direct quarry disturbance area; and
- impacts to ELC units at the esker quarry area indicate a significant increase from the previous year.

If these action levels are reached, the EMS would be initiated to review the cause of increased impacts and identify the appropriate mitigation. This in turn, may lead to modifications to the monitoring program (Figure 1-4).

Reclamation Monitoring

Reclamation monitoring will measure the success of various reclamation and revegetation activities. The focus of this program will be to test if revegetation activities are consistent with end land-use objectives and reclamation goals and to identify and select for the most successful methods. At this time, end land-use objectives include reclaiming the land to equivalent land capability as existed prior to mine development. However, it is recognized that over time and through on-going consultation with stakeholders, end land-use objectives may change. Reclamation and hence monitoring activities would also change to reflect these modifications. The reclamation monitoring program will provide research and information to help assess and modify the Closure and Reclamation Plan (AMEC E&C Services (AMEC) 2003).

Monitoring of reclamation programs is essential to identify and mitigate problems, to determine revegetation success and to identify and implement adaptive improvements in reclamation techniques (Elzinga et al. 1998). This program will measure the relative effectiveness of various revegetation methods.

The objective of the reclamation monitoring program is to evaluate the success of reclamation methods and adjust or modify these methods where necessary to facilitate the following:

- erosion control and landform stability;
- sustainable revegetation of disturbed areas;
- application of suitable, site-specific reclamation measures;
- optimum species performance;

- nuisance and noxious weed control; and
- re-establishment of wildlife habitat.

The results of the monitoring program may be used to direct and modify the Revegetation and Surface Materials Handling Plan (Appendix C in the Closure Plan, Golder 2003), and the Closure Plan, with regards to revegetation. Based on the success of revegetation methods and species performance, modifications would be made to ensure that the most successful methods are applied.

Methods

The study area for reclamation monitoring will be the mine footprint including the North Pile and the esker quarry area.

In addition, plots will be established during operations to monitor revegetation over time. Monitoring plots in reclaimed areas will be located according to the mine activities and progressive reclamation during operations and closure. Therefore, the focus of revegetation efforts and monitoring throughout operations will be on the North Pile. As the North Pile is progressively reclaimed, stations will be located on newly revegetated sites.

The reclamation monitoring program will be conducted annually, until closure. Revegetation and monitoring activities will continue until a reclamation certificate (or equivalent) is obtained from applicable regulatory agencies.

Throughout the Reclamation Monitoring Program, an annual review of reclamation methods and success will identify the most successful methods of revegetation and the appropriate monitoring programs. This will be complimented by on-going research and information exchange with other northern diamond mines, to identify new methods and technologies that can be applied to the revegetation of northern mines.

Monitoring Natural Encroachment

Preconstruction monitoring plots were established in 2004 to measure the rate and quality of natural vegetation encroachment, depth of active layer, and presence of invasive (both endemic and non-endemic) species. Monitoring of abandoned disturbances in the immediate area will provide information on natural revegetation processes, including early seral stages. It is expected that some species will prove to be more successful than others at recolonizing disturbed sites. These species may then be selected for revegetation efforts at the Project site. Monitoring of natural encroachment will be conducted throughout the construction and operations.

North Pile Reclamation Monitoring

The North Pile area will be developed in three stages: the starter cell, east cell and west cell.

Part of the starter cell will be ready for revegetation treatments by approximately 2009, followed by the east cell (approximately 2013) and then the west cell (approximately 2024). Revegetation will use a variety of methods, expected to change over time with new information and the results of monitoring. The following revegetation treatments may be applied:

1. direct placement of salvaged surface materials from the adjacent cell, (materials will include boulders, organic matter, topsoil, and plant propagules such as seeds, shoots, roots and rhizomes, that occur naturally in the surface organic matter and soil horizons);

2. transplanting vegetation plugs from the surrounding tundra;

3. transplanting native, nursery grown seedlings;

4. application of northern native seedmixes;

5. various soil amendments; and

6. natural encroachment.

Shrub, forb and grass species may be transplanted from surrounding undisturbed areas onto reclaimed areas. Progressive reclamation complements transplanting techniques, as vegetation can be removed from areas scheduled for immediate disturbance and placed on to areas prepared for vegetation, and not targeted for future disturbance. Different mixes of species and their relative proportions will be monitored to determine species success under various treatments.

Different seedmixes may be applied under varying environmental conditions to determine the most appropriate seedmix for different environmental condition (i.e., soil and moisture regime). Northern seedmixes may come from commercial sources, if available, as well as from local seeds. Information gained during the early stage of the monitoring program will help to identify the most successful seed mixtures and methods of application.

Reclaimed areas will be monitored to determine timing and rates of natural vegetation encroachment into reclaimed areas. Reclamation techniques will be considered as a treatment as certain techniques may expedite or hinder natural vegetation encroachment. In addition, environmental site conditions will be assessed to determine their influence on natural encroachment. Monitoring of invasive species will also be conducted.

Monitoring Parameters

A reconnaissance-level assessment of reclaimed areas will be conducted to assess and record the following indicators:

- use of high resolution satellite imagery (Quickbird) to measure and record rates of revegetation;

- signs of slope instability such as slumping and deep cracks in surface materials;

- signs of erosion: rilling and other alluvial erosion, indications of windblown dust, loss of surface materials, minor slumping, and collection of windblown surface materials; and

- the presence of weedy and invasive species on disturbed and reclaimed areas.

Sample plots will be established on reclaimed areas, on a variety of landforms and microsites. Plot data may include:

- plant species composition and percent cover, by strata;
- species vigour;
- rooting depth;
- area of transplanted plugs, if applicable;
- documented and standardized photo;
- soil profile description;
- soil microbial diversity (optional);
- soil texture in upper horizon (hand texture method);
- percent coarse fragments;
- soil moisture regime (xeric to hydric);
- soil nutrient regime (very rich to very poor); and
- pH and Cation Exchange Capacity at 0 to 5 cm, and deeper, depending on the depth of root penetration.

Reclamation treatments shown to be effective will be applied to other areas slated for reclamation throughout the Project phases (Figure 1-4).

Triggered Programs

Triggered programs will only be conducted if specific limits or action levels are exceeded.

Detailed ELC Monitoring Program

The Detailed ELC Monitoring Program may be conducted if triggered by one or more of the following conditions:

- the Project footprint and/or the esker quarry area exceed impact predictions by greater than 10%; and/or
- ELC unit area changes exceed impact predictions by greater than 10%.

Before the program is initiated, a site visit and reconnaissance survey would be conducted to assess the extent and nature of the change that triggered the investigation. This would include an inspection of the Project footprint, satellite image analysis, discussions with the mine operator and a site investigation, focusing on the areas of change. If this information indicates that impacts are significant and not linked to an obvious and mitigable source, then the Detailed ELC Monitoring Program may be initiated.

If triggered, the Detailed ELC Monitoring program is designed to identify the extent, nature and cause of the impacts which exceed EAR predictions. Appropriate mitigation would then be recommended.

The study area required for this monitoring program will depend on the nature of the trigger. The study area may be the LSA (e.g. if the North Pile is under investigation), the area around the esker (if the size of the esker quarry exceeded predictions), the RSA (if results indicate widespread effects), or all three areas.

Methods

Permanent sample plots (PSPs) were established in 2004 to describe baseline conditions and to provide a basis for comparison should this program be triggered (Figure 1-4). Two types of PSPs, control and treatment plots, were established using identical methods. These are located in the three dominant vegetation types, since these are widespread, often large polygons with little edge effect, comprise 97% of the land area, and support a relatively consistent vegetation cover. Plots were also designed to be transferable between the triggered programs.

Treatment plots were located in or near the LSA, outside of the Project footprint. These plots are intended to be inside the zone of influence (ZOI) of mine activities (the possible sphere of Project effects) (Figure 1-2).

Control plots are further away from the LSA, outside the ZOI, but near enough to be comparable to the Treatment plots (Figure 1-2). At least 10 control plots for each of the dominant vegetation types were established, to allow for an assessment of the range of natural variability within each community type (Table 3 2-2). Control plots were established to separate natural effects from Project-related effects.

Table 3. Baseline Vegetation Permanent Sample Plots Established for the Snap Lake Project

Plot Type	Heath Boulder	Tussock-Hummock	Open Spruce Forest	Total
Treatment	21	10	10	41
Control	20	9	10	39
Total	41	19	20	80

Data on baseline vegetation and soil conditions were collected at each of the PSPs in 2004, and future data collection methods will follow the same methods.

Plots size was 5 m by 5 m, allowing for an adequate size to include trees, shrubs, boulders, and other terrain features. Each plot was marked on a map and UTM location recorded using a hand-held GPS, ensuring a high level of accuracy (Figures 1-2 and 1-3). Plots were marked by a stake

in the southwest corner of the plot, and the plot was photographed looking north from this corner, allowing for visual inspection of change if monitoring activities are triggered.

Data collected may be used to compare baseline indices with future indices from both control and treatment plots, within each ELC unit. Vegetation, site and soil parameters measured are consistent between baseline, treatment and control plots, so that data is comparable, within ELC units.

Specific vegetation parameters include the following: species composition and cover (by strata); species vigour (following standard vigour classes, AEP 1994); and percent ground cover (bare ground, water, litter, live vegetation cover by layer).

Soil parameters include: moisture regime; soil nutrients including nitrogen, phosphorus and potassium; salinity; pH; organic matter characterization (in a subset of control plots in the LSA); major ions including Ca, Fe, K, Mg, Mn, Ti and Na (in a subset of control plots located in the LSA); soil erosion; and depth of active layer.

Specific site parameters include landform, slope angle, slope aspect, elevation, plot position on slope and GPS coordinates.

Data analysis will be required to identify if the Project has had a significant effect on soils and vegetation. It will be important to separate out Project-related effects from other effects, such as climate. Therefore, comparisons between treatment plots and baseline plots will be analyzed, and compared to differences between both treatment and control plots, and baseline data. Analyses will include a statistical comparison of individual parameters between control, treatment and baseline plots using Analysis of Variance (ANOVA), within each ELC unit. Multi-variate analysis and similarity index may be conducted to establish if there is a significant difference and to identify the nature of differences.

The action level (or critical effect size) for determining a difference from reference or baseline plots and between treatment and control plots, would be two standard deviations from the mean. If Project effects appear to be significant, follow-up studies would be conducted to gather a weight of evidence for examination of cause/effect relationships between the vegetation response and alternative causes including natural factors and/or mine activities. Mitigation will depend on the specific cause of Project-related changes.

Effects of Dustfall on Vegetation

Dust will be generated from the Project by wind erosion, vehicle traffic and operation of large construction equipment. This program is designed to identify if dust from the Project has caused a significant difference in the plant species cover or composition of ELC types, in the vigour of plant species, or in the depth of the active layer.

This program may be triggered if:

- dustfall monitoring data from the Air Quality Monitoring Program show that dustfall is consistently greater than predicted in the EAR and exceeds the Alberta dustfall guideline over a three month period; or

- visual dust observations reported via the EMS show high dust conditions extending over a long enough period that visible dusting of vegetation occurs.

Impacts to vegetation associated with dustfall from the esker quarry, airstrip and mine site construction and operation can include reduced photosynthetic capability of buried or blanketed plants (Spatt and Miller 1981), altered soil pH, lower soil nutrient availability (Everett 1980; Auerbach et al. 1997), earlier snowmelt on areas affected by dust fallout, and increased seasonal permafrost thawing (Walker and Everett 1987). Changes in vegetation community species, lower biomass and decreased species diversity are also possible (Auerbach et al. 1997; Walker and Everett 1987).

Methods

Baseline data on the vegetation cover, composition, vigour and soil properties was collected from PSPs as part of the Detailed ELC Monitoring Program (Sections 2.2.1). Both control and treatment plots were selected. Treatment plots for the Dustfall effects monitoring program were located near future dust generating activities associated with the mine, including the mine footprint and next to the airstrip and esker quarry. Air monitoring stations to measure dustfall were also located in these areas.

Additional plots will be established if the dustfall monitoring program is triggered. These stations would be located according to the nature of the trigger. For example, if dustfall adjacent to the airstrip exceeds the Alberta guideline, then the study area would include representative vegetation communities near the airstrip.

If the Dustfall Monitoring Program is triggered, a reconnaissance level field survey would be initiated in the vicinity of the air monitoring station that recorded a high dustfall level. The area would be traversed to visually assess the nature and extent of dusting of vegetation. Based on the results of this assessment, a site-specific field program may be established. The number, length and alignment of transects would be based on the field indications recorded including spatial extent and severity of dusting.

Monitoring parameters and data analyses would follow those described for the Detailed ELC Monitoring program.

A dustfall “trigger” would produce a response from the Project EMS that would include enhanced dust suppression. Given the nature of the Project (i.e., an underground mine with wet conditions and an active dust suppression program on the surface), it is unlikely that follow-up studies of the effects of dustfall would be required. However, if follow-up studies show evidence that dustfall is the cause of significant changes in vegetation community or active layer characteristics, then the appropriate changes during operations and/or at closure would be applied via the Project EMS.

Conclusions

The VMP is in the early stages of development and implementation, since De Beers has not yet started mine operations. The VMP will assist De Beers with managing and monitoring disturbance and selecting the most successful methods of reclamation and revegetation

throughout the life of the project. In addition, the program is designed to meet environmental agreements and project requirements.

The greatest level of effort will be directed towards reclamation monitoring throughout operations, as the North Pile is progressively built-up and reclaimed, and when the infrastructure areas are reclaimed at closure. Monitoring will identify and select for the most successful methods and will also provide a method for early detection of problems. The VMP will also measure the nature and extent of vegetation disturbance annually, and compare these values to EAR predictions, to assist with monitoring, controlling and mitigating surface disturbance.

The VMP is also designed to measure environmental effects that may trigger the Detailed ELC Monitoring Program or the Dust Effects Program. If triggered, the VMP will assess the need for further analysis, and the nature and extent of effects. This, in turn, may be used to select the most appropriate mitigation.

The VMP can be expected to evolve over the life of the mine as reclamation monitoring and research identified the most suitable methods to meet the objectives of the program.

REFERENCES

Alberta Environmental Protection (AEP). 1994. Ecological Land Survey Site Description Manual. Alberta Environmental Protection. Resource Information Branch, Finance, Land Information and Program Support Services. Edmonton, AB.

AMEC E&C Services (AMEC). 2003. Preliminary Mine Closure and Reclamation Plan for the Snap Lake Diamond Project. Submitted to De Beers Canada Inc. February 2003.

American Public Health Association (APHA), American Water Works Association, and Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater (17th Edition). Edited by L.S. Clesceri, A.E. Greenberg, R.R. Trussell.

Auerbach, N.A., M.D. Walker, and D. A. Walker. 1997. Effects of Roadside Disturbance on Substrate and Vegetation Properties in Arctic Tundra. Ecological Applications 7:218-235.

De Beers Canada Inc. (De Beers). 2002a. Snap Lake Diamond Project Environmental Management System.

De Beers. 2002b. Snap Lake Diamond Project: Environmental Assessment Report. Submitted to the Mackenzie Valley Environmental Impact Review Board. February 2002.

De Beers. 2004. Quality Assurance and Quality Control (QA/QC) Plan. Submitted to the Mackenzie Valley Land and Water Board as required by the Water License MV2001L2-0002. July 2004.

Elzinga, C.L., D.W. Salzer and J.W. Willoughby. 1998. Measuring and Monitoring Plant Populations. BLM Technical Reference 1730-1. Prepared by Alderspring Ecological Consulting, The Nature Conservancy of Oregon and the California State Office of the United states Department of the Interior, Bureau of Land Management, Denver. 492 pp.

Epp. H. and S. Matthews. 1998. Habitat/vegetation Classification for the West Kitikmeot/Slave Study Region. Annual report submitted to the West Kitikmeot/Slave Study Society.

Everett, K. R. 1980. Distribution and Properties of Road Dust along the Northern Portion of the Haul Road. Chapter 3 in Environmental Engineering and Ecological Investigations along the Yukon River-Prudoe Bay Haul Road, J. Brown and R.L. Berg, eds. CRREL report 80-19. U.S. Army Cold Regions Research Engineering Laboratory, Hanover, New Hampshire 203 pp.

Golder Associates Ltd. (Golder). 2002. Draft Report on Snap Lake Diamond Project Recommended Environmental Monitoring and Environmental Monitoring Consultation Process. November 2002.

Golder. 2003. Report on Revegetation and Surface Materials Handling Plan for the Snap Lake Diamond Project. Submitted to De Beers Canada Inc. February 2003.

Mackenzie Valley Environmental Impact Review Board (MVEIRB). 2003. Report on Environmental Assessment and Reasons for Decision on the De Beers Canada Mining Inc. Snap Lake Diamond Project. July 23, 2003.

Spatt, P.D. and M.C. Miller. 1981. Growth Conditions and Vitality of Sphagnum along the Alaska Pipeline Haul Road. Arctic 34: 48-51.

Walker, D. A., and K.R. Everett. 1987. Road Dust and its Environmental Impact on Arctic Taiga and Tundra. Arctic and Alpine Research 19: 479-489.

Table 1 Summary of the Vegetation Monitoring Program

Primary Theme	Linkage to Project Activity	Type of Monitoring and Project Phase	Study Area	Parameters	Frequency	Action Levels
Annual Programs						
Disturbance Area Monitoring Program	Measures full area of disturbance due to Project footprint and compares value to EAR predictions	Operational Pre-Construction, Construction, Operations, Closure	Local Study Area, Regional Study Area (Esker quarry area)	Area of Disturbance (ha) in study areas using QuickBird	Annually from Pre-construction through Closure	10% change in total disturbance area above EAR predictions
ELC Area Monitoring Program	Direct loss of ELC units due to Project footprint and operations including mine, infrastructure, airstrip and esker quarry; gains in ELC units from reclamation	Operational Pre-Construction, Construction, Operations, Closure	Local Study Area, Regional Study Area (Esker quarry area)	Area of ELC units in study areas using QuickBird	Annually from Pre-construction through Closure	10% change in area of ELC units above disturbance stated in the EAR.

Primary Theme	Linkage to Project Activity	Type of Monitoring and Project Phase	Study Area	Parameters	Frequency	Action Levels
Reclamation Monitoring Program	Reclamation methods will affect the rate and quality of revegetation.	Operationala Pre-Construction/ Construction, Operations, Closure, Post-Closure	Local Study Area and Esker	Plant species richness and diversity Plant species composition and cover Depth of active layer Erosion indicators Soil/parent material measurements including texture, organic matter content, rooting depth Physical site parameters including slope, aspect, slope position	Varies according to sequence of reclamation activities	Variance of reclamation treatment plots from non-treatment plots; Selection of treatments with the greatest variance.
Triggered Programs						
Dust Effects on Vegetation Monitoring	Dust deposition on vegetation adjacent to the source may impact species health, composition and cover	Operational Triggered by dust fall in excess of EAR predictions and Alberta guideline for three months	Study area determined by location of triggers	Plant species richness and diversity Plant species vigour, composition and cover Active layer depth Soil parameters	Study conducted only if triggered	Variance of study plots from control plots by two standard deviations from the mean.

Primary Theme	Linkage to Project Activity	Type of Monitoring and Project Phase	Study Area	Parameters	Frequency	Action Levels
Detailed ELC Monitoring Program	Changes in plant communities due to: construction, site infrastructure, the airstrip, access roads, esker quarry, reclamation	Operational Pre-Construction (baseline data). Operations only if triggered by action levels for ELC unit area change.	LSA and Esker Quarry Areas – specific study area determined by location of triggers.	Plant species richness and diversity Plant species composition and cover Active layer depth Plant vigour Soil parameters	One-time baseline during pre-construction phase Study conducted only if triggered	Variance of study plots from BL control plots by two standard deviations from the mean.

(a) Reclamation certificates are currently not issued in the NWT, although certification occurs in nearby jurisdictions (e.g., Alberta). The operational monitoring program could be adapted to also include certification monitoring, if this is required in the future.

Table 2 Detailed Summary of the Vegetation Monitoring Program Locations and Frequency

Theme and Location	Estimated Number of Plots	Frequency
Control, Treatment and Reclamation Plots		
LSA and RSA	89 Control Plots(a)	Pre-construction year to provide baseline data for all monitoring programs
ELC Unit Area		
LSA and RSA	Original training sites from EAR 249 ELC Plots for Landsat image analysis only	Pre-construction, post-construction, then every five years Preconstruction
Effects on Vegetation Cover, Composition and Vigour		
In LSA and RSA – outside of mine footprint(b)	80 Control Plots(a)	Preconstruction and 2008 Initiated if the ELC area monitoring program indicated a loss of total area 10% greater than predictions stated in the EAR and there is no obvious explanation for the loss or alteration
Along Airstrip(b)	23 Control Plots(a) 5 Triggered Plots	See above
At Esker Quarry(b)	4 Control Plots(a) 5 Triggered Plots	See above
In RSA(b)	80 Control Plots(a) 20 Triggered Plots	See above
Effects of Dust		

Table 2 Detailed Summary of the Vegetation Monitoring Program Locations and Frequency

Theme and Location	Estimated Number of Plots	Frequency
Effects of Dust	80 Control Plots(a)	Preconstruction and 2008 Program only initiated if triggered by: dust levels that exceed impact predictions and the Alberta guideline; or ELC unit area change that exceeds impact predictions, as indicated by the ELC Unit Area monitoring program
Air strip(b)	23 Control Plots(a) 6 Triggered transects	One time only in response to dustfall trigger
North Pile(b)	10 Control Plots(a) 3 Triggered transects	One time only in response to dustfall trigger
Esker Quarry(b)	4 Control Plots(a) 3 Triggered transects	One time only, if visual observation of dust during quarry operation triggers evaluation and decision to monitor via the EMS
Reclamation Monitoring		
Old Base Camp	4 Control Plots(a)	Preconstruction and 2008
Abandoned lay-down area north of Old Base Camp	1 Control Plot(a)	Preconstruction and 2008
Starter cell of north pile	12 Post-reclamation	Annually from 2008 until closure; every 5 years after until approved
East cell of north pile	12 Post-reclamation	Annually from 2015 to closure; every 5 years after, until approved

Table 2 Detailed Summary of the Vegetation Monitoring Program Locations and Frequency

Theme and Location	Estimated Number of Plots	Frequency
West cell of north pile	12 Post-reclamation	Annually for five years after closure, then every 5 years after, until approved
Airstrip	1 Control Plot(a) 4 Post-reclamation	Annually for five years after closure, then every 5 years after, until approved
Esker	4 Control Plots(a) 4 Post-reclamation	Annually for 5 years after each disturbance/reclamation period; every 5 years after, until approved
Mine site area	12 Post-reclamation	Annually from closure for five years; every 5 years after, until approved

(a) The term "Control Plots" here refers to the control, treatment and reclamation plots established in the pre-construction/construction phase. The number of plots is a subset of the 89 plots established, depending on location of the footprint component in question (e.g., 23 control plots are in the vicinity of the airstrip).

(b) One or more of these monitoring areas may be the actual study location, depending upon the particular location of the "trigger" (e.g., where dustfall exceedance occurred, or which ELC unit area change exceeded the Action Level).