DE BEERS CANADA

GAHCHO KUÉ PROJECT

Detailed Alternatives Analysis Report

June 2012

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1 INTRODUCTION

1.1 BACKGROUND

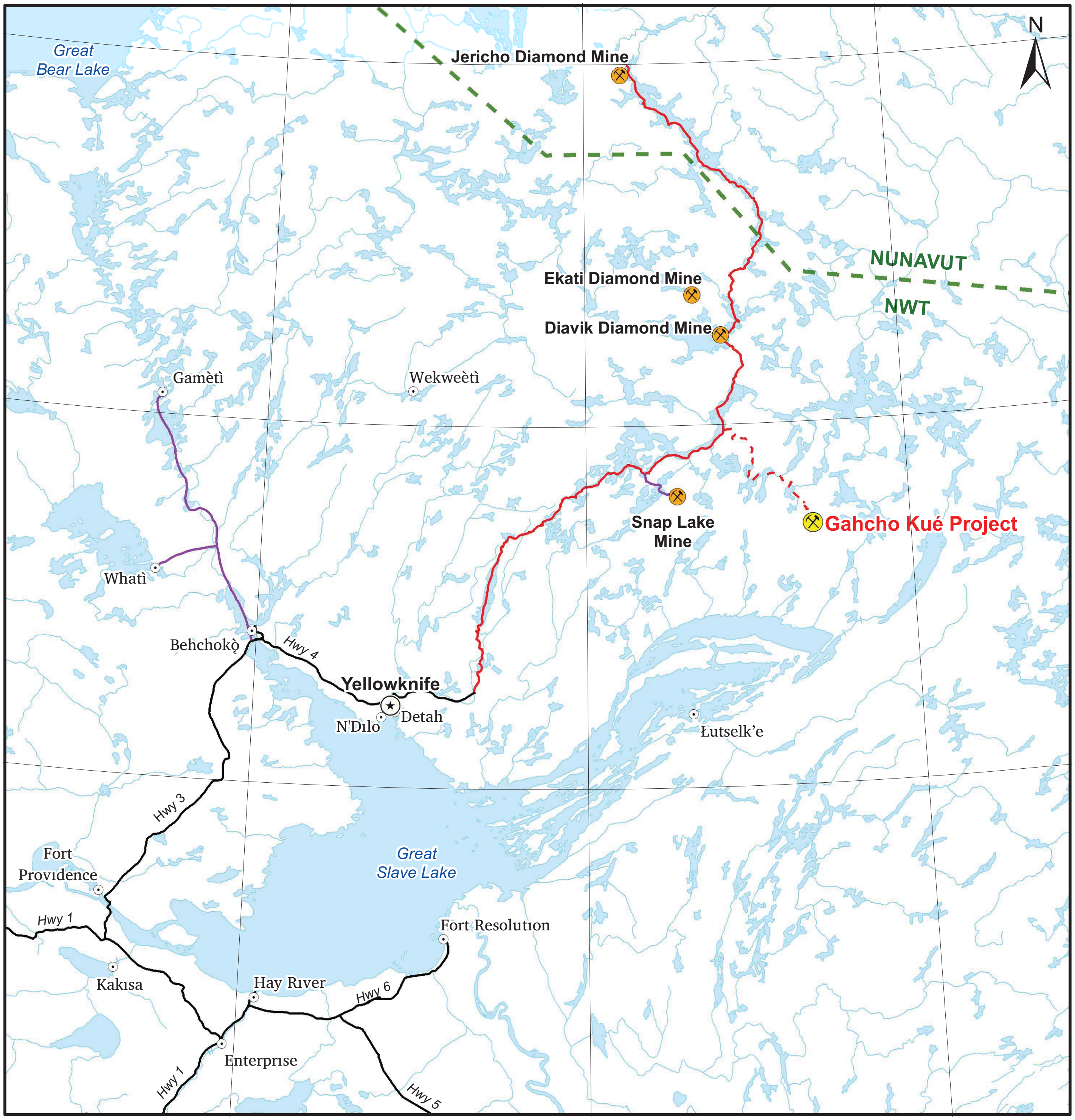
De Beers Canada Inc. (De Beers) has proposed to develop the Gahcho Kué Project (Project), a diamond mine in the Northwest Territories (NWT). Location of the Project and surrounding diamond mines is shown in Figure 1-1. The Project Environmental Impact Statement (EIS) including Project Description was submitted in December 2010 to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) and MVEIRB issued a decision in July 2011 indicating that the Project had achieved conformity with the Terms of Reference (TOR). In April 2012, De Beers submitted an EIS Supplement that describes updates to the Project description and impact assessment based on a reduction to the Fine Processed Kimberlite Containment Facility (Fine PKC Facility).

As part of the ongoing consultation process for the Project, De Beers met with Department of Fisheries and Oceans Canada (DFO) on February 22, 2012 to review the project alternatives. A letter was issued by DFO on March 29, 2012 requesting that De Beers submit a more detailed alternatives analysis including a discussion of the potential impacts to fish and fish habitat. De Beers also made a commitment during the Technical Sessions (May 22 to 25, 2012) to submit an detailed alternative analysis document to the MVEIRB Public Registry by mid June 2012.

In considering alternatives, De Beers used the *Guidelines for the Assessment of Alternatives for Mine Waste Disposa*l (Environment Canada 2011) as a general guide for assessing waste disposal alternatives including the multiple accounts analysis for determining the fine processed kimberlite (PK) disposal area (Appendix A). Although this guideline was designed for metal mines, the general principles for presenting alternatives were considered in this report.

1.2 DECISION HIERARCHY

Within this document, a hierarchal decision tree or a tiered process is used to arrive at the selected design alternatives. The decision tree consists of multiple levels, beginning with broad alternatives (e.g., mining method) and becoming more narrowly focused on alternatives through the subsequent levels. Figure 1-2 provides a summary of the key topics that were considered at each level of the decision tree. Lake dewatering, water management, and mine waste disposal aspects of the Project are interrelated and are therefore considered together when comparing the alternatives.



LEGEND

- Gahcho Kué Project
- Existing Mine
- Territorial Capital
- Populated Place
- Highway
- Existing Winter Road
- Tibbitt-to-Contwoyto Winter Road
- Winter Access Road
- Watercourse
- Waterbody
- Territorial/Provincial Boundary

NOTES
Source: Figure 1.1-1 in De Beers 2010
Base data source: The Atlas of Canada

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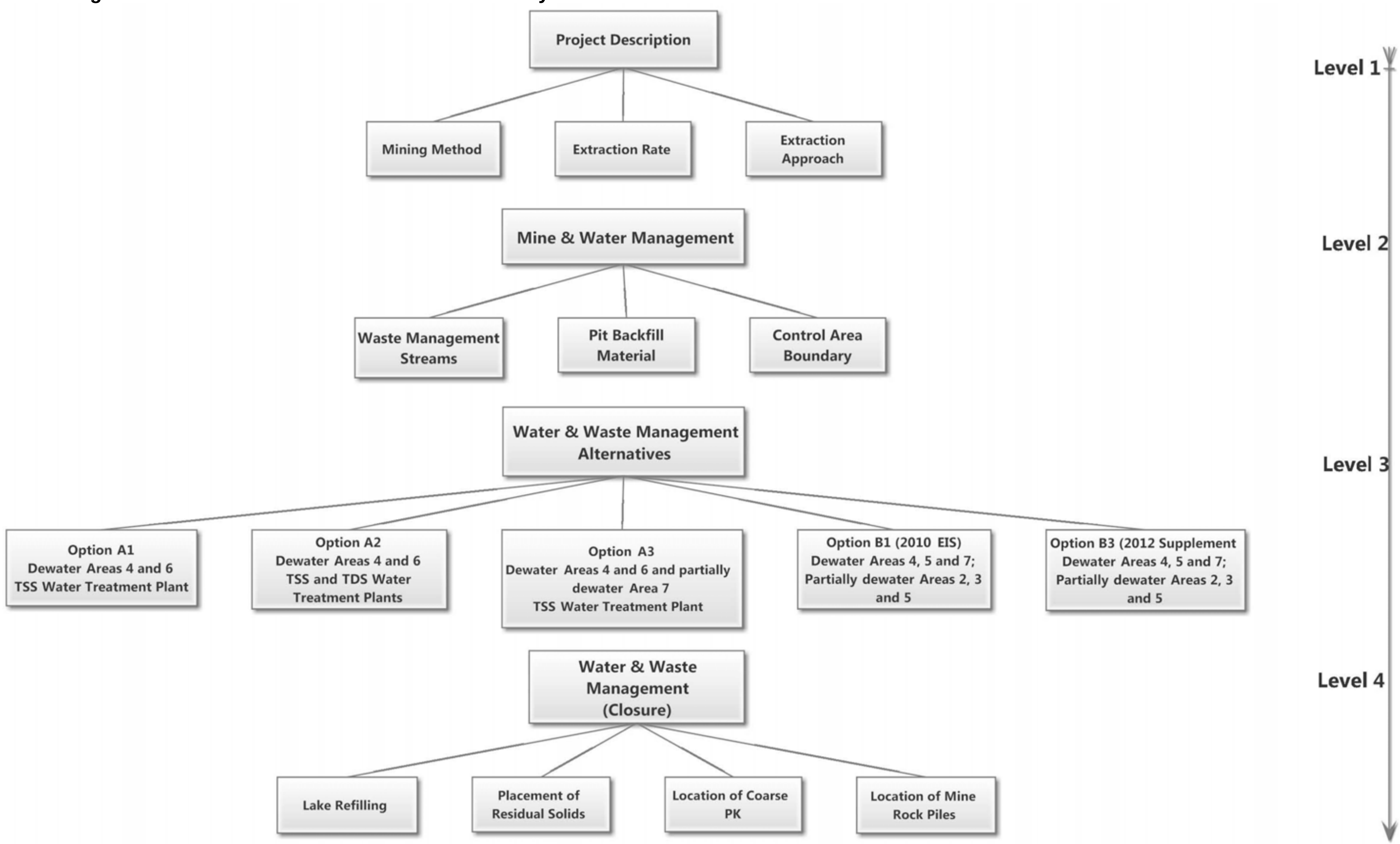
GAHCHO KUÉ PROJECT

Location of the Gahcho Kué Project

PROJECTION: Canadian Lambert Conf. Conic	DATUM: NAD83
Scale: 1:3,500,000 (50 25 0 50 Kilometres)	DE BEERS CANADA
FILE No: B2012-Heritage-001-GIS	DATE: February 7, 2012
JOB NO: 11-1365-0012	REVISION NO: 8
OFFICE: GOLD-CAL	DRAWN: JH	CHECK:

Figure 1-1

Figure 1-2 Alternatives and Decision Hierarchy



The alternatives assessment was based on the geological, physical, and economic data available when the 2010 Project Description was developed, including the extent of the known ore bodies. The goal of the Project design was to minimize the Project footprint to reduce overall environmental effects, which is consistent with Environment Canada guidance that states "*the overall objective of the alternatives assessment process is to minimize the environmental footprint of the disposal area*" (Section 1.2 of Guidelines; Environment Canada 2011).

1.3 DECISION CRITERIA

The development of the selected design proceeded in a top-down manner (Figure 1-2), in which the consequences and opportunities linked to the decisions made at one level of the decision tree influenced the alternatives considered at the next level. Selection of evaluation criteria was a critical step in the alternatives assessment. The following three broad criteria were used to assess the available alternatives:

- technical feasibility;
- economic viability; and
- environmental considerations.

Alternatives that did not meet these broad criteria on a preliminary level were eliminated in early stages of assessment.

Within these broad assessment criteria and accounting for the integrated nature of the water and waste management programs, more defined criteria were established to help guide the Project design, including:

- Technical Feasibility
  - provide a safe working environment;
  - use designs proven and demonstrated to be successful in the North;
  - learn from and improve on existing operations' practices;
  - maximize operating flexibility and minimize Project risk;
  - utilize passive containment (as available);
  - re-establish self-sustaining ecosystems that do not require site maintenance after closure; and
  - maximize capability to meet discharge criteria.

- Economic Viability
  - minimize cost;
  - reduce schedule/timetable for construction; and
  - produce a sufficient return on investment to support capital investment.

- Environmental Considerations
  - minimize Project footprint;
  - minimize loss of, degree of impact to, or risk to fish habitat (and associated compensation costs);
  - maintain the natural flow regime whenever possible;
  - restoration of the natural flow regime at closure;
  - re-establish self-sustaining ecosystems that do not require site maintenance after closure; and
  - seek Aboriginal community acceptability.

The use of these criteria in a pragmatic process assured that alternatives with favourable economics along with reasonable long-term technical and environmental risks were selected. This approach was chosen because it presented the best method for identifying a Project design that would provide for economic mining operations while minimizing negative environmental consequences.

The Project site prior to disturbance is shown in Figure 1-3 (see Figures Appendix). The alternatives considered at each level in the decision making process are discussed in more detail in the following Sections, beginning with the Level 1 alternatives in Section 2.

2 LEVEL 1 DECISIONS

2.1 MINING METHOD

2.1.1 Available Alternatives

Mining method selection is based on many factors including the ore and host rock geotechnical characteristics, as well as the ore body shape, orientation, location, and size. Generally the choice between surface and underground methods is made first, each general method having many specific variations based on safety, technical applicability and economics. Surface environment at Kennady Lake plays an important role in the method selection since the ore bodies are vertical and generally sub-crop under water. If the lake above the deposits was to be drained in either case, the alternative selection would centre on safety and economics. However, the alternatives consider that underground options would preserve Kennady Lake.

Surface methods in hard rock are generally employed on ore bodies that are large, disseminated, and close to the surface. Open pit mining is less selective, yet recovers a higher percentage of the ore within the pit limits. A large part of pit design includes wall stability because mining activity is open to the atmosphere. This method entails the use of large earth-moving equipment and is capable of relatively high production rates at low unit costs.

Underground methods are more selective, yet require close attention to opening safety, stability, and ventilation; thus, unit operating costs are relatively higher. Underground mining methods would limit the production rate and ore recovery percentage, in that ground support pillars would be left in place to provide stability to the workings. Underground methods would access the ore with a remote main ramp or vertical shaft, from which ore and mine rock would be hauled. Various schemes for backfilling mine openings are also available and common practice.

Combinations are common whereby the ore close to surface is mined by open pit methods until the cost of moving increasing amounts of mine rock per tonne of ore is balanced by the higher cost of underground mining. Then, underground mining would be employed to exploit the deeper continuation of the ore body (e.g., Ekati and Diavik Mines).

Two mining alternatives (open pit and underground) were assessed, as shown in Table 2-1. They were evaluated using the three broad criteria presented in Section 1: technical feasibility, economic viability, and environmental considerations.

Table 2-1 Comparison of Mining Method Alternatives

Evaluation Criteria	Alternatives	
	Open Pit	**Underground**
Technical feasibility	• Kimberlite pipes outcrop at or near the bottom surface of Kennady Lake, which minimizes the amount of overlying material that needs to be removed to access the ore bodies. • Once Kennady Lake is dewatered, mine operation will be comparable to other existing diamond mines; the experiences gained at those mines can be applied to this Project. • Pit water management is relatively straightforward, with measured operational risks. • Work environment is open and unconfined, which eliminates production limitations, and design issues associated with underground methods. • Clear precedence exists in the NWT for open pit mining of similar size and shape deposits. • Placement of physical structures (e.g., dykes, dams) would be required within the lake to facilitate safe mining of the ore bodies.	• Large crown pillars (50 m thick) under the lake would be required to provide a safe and stable work environment; this material would be unavailable for diamond production. • Risk of uncontrolled inflow from Kennady Lake is high, because the kimberlite pipes outcrop at or near the bottom surface of the lake. • Technical limitations exist to achieve economic production rates.
Economics	• Open pit mining allows for maximum ore body recovery and higher and more flexible mining rates. • Operating cost of near surface ore is much lower than cost with underground methods.	• An underground mine would be uneconomic. • Large proportion of the ore bodies would be unavailable because of the construction of the pillars required to maintain a stable work environment (e.g., a 50 m pillar would prevent ~20% of the ore from being mined). • The total cost per tonne of ore in underground mining would be higher than mining from the surface, and care would have to be taken at the surface interface to prevent high-consequence safety issues from occurring. • Capital and schedule risk to reach comparable production rates would be high compared to open pit mining.
Environmental Considerations	• Larger volume of mine rock must be handled and disposed of, relative to underground mining. • Dewatering requires dividing Kennady Lake into sections and isolating the lake from the downstream spawning grounds associated with outlet streams. • Greater potential for dust emissions, will be associated with larger tonnage moved and hauled. • Initial dewatering of Kennady Lake and lake re-filling could result in alteration/disruption of natural flow regime in receiving environment. • Disruption of fish habitat will occur due to the dewatering of Kennady Lake until aquatic habitat is restored during closure. • Saline groundwater entering the pits will have to be managed and disposed of. • Dewatering of Kennady Lake would provide water management capacity during operations. • Physical structures, such as roads and dykes, within the lake would alter fish habitat.	• Water levels will be maintained in Kennady Lake during the operational life of the Project, greatly reducing loss of fish habitat due to the Project. • Continual dewatering of the mine will be required; water flows to the mine could be substantial, given the vertical proximity of the kimberlite to the bottom of Kennady Lake. • Opportunity for backfilling is relatively limited, which would likely result in larger overall disturbance footprint for processed kimberlite storage. • Less mine rock storage area will be required. • The ability to maintain suitable conditions in Kennady Lake is uncertain, given the potential water losses to the underlying mine and subsequent release of mine dewatering flows. • Need to manage and dispose of saline groundwater reporting to the mine. • A water management pond for storage of saline water and water with high total suspended solids concentrations would need to be constructed and treatment may be required. • Area collection systems and storage facilities for surface facility runoff water would be required.
Alternative Selected	Yes	No

2.1.2 Selected Alternative

After a five-year review of the available alternatives (i.e., 2000 to 2005), De Beers opted to proceed with an open pit design, because revenue stream losses as well as the challenges and safety risks associated with underground mine design, which include:

- substantial safety risks and catastrophic consequences associated with an uncontrolled inflow of water from the overlying lake;
- high probability for treatment and release of large volumes of mine water;
- loss of availability of a notable portion of the existing ore resource through construction of the crown pillars required for safe working conditions; and
- unfavourable economics associated with a completely underground operation.

Kennady Lake could be dewatered in advance of underground mining to address some of the challenges with underground mining; however, this eliminates the largest potential environmental benefit of the underground mining alternative: maintaining Kennady Lake during the operational life of the Project. As a result, this approach was dismissed. It was determined that the Project was best carried out with an open-pit mining operation.

The viability of subsequent underground mining of extensions of the ore bodies is a complex decision that would ultimately depend on the resource, future market conditions and mine economics. Mining method selection for deep ore body extensions is independent of that chosen for the current resource.

2.1.3 Resulting Consequences or Opportunities

The most important environmental consequence of selecting an open-pit mining method is the need to dewater Kennady Lake to allow for physical structures to be constructed in the lake to prevent water from entering the pits, as well as associated changes in downstream water flows, which affect aquatic habitat. Being the only economic and technically sound alternative, the Project design is focused on parameters inherent in open pit mining to minimize environmental effects. Opportunities such as pit backfilling and passive containment are targeted alternatives for project development. Following from the selection of open pit mining, associated alternatives such as extraction rate and production sequencing are assessed. Although these choices are a natural outgrowth of the mining plan, the integrated nature of production parameters with the environmental, economic, and technical assessment criteria requires a detailed explanation of the design process, which is provided in Sections 2.2 and 2.3.

2.2 EXTRACTION RATE

2.2.1 Available Alternatives

Once the technical limits of ore production are determined from each ore body (i.e., mining method), the overall mining rate becomes an economic, and environmental decision. Generally larger production rates require more pre-production development and more capital for the mine equipment, infrastructure, and processing plant. Unit costs decrease with increasing production rate; however, as the production rate increases, the life of the Project and financial risks need to be a consideration. Moreover, extraction rate dictates mine life which contributes to identifying environmental conditions that would require consideration in the mine design. Three extraction rates (i.e., 3 million tonnes per year [Mt/y], 2 Mt/y, and <2 Mt/y) were evaluated as presented in Table 2-2.

Table 2-2 Comparison of Extraction Rate Alternatives

Evaluation Criteria	Alternatives		
	3 Mt/y	**2 Mt/y**	**<2 Mt/y**
Technical Feasibility	• Pits will be mined and filled faster, increasing the demands on mine planning and production scheduling within a given pit. • Larger equipment can be used to increase efficiencies and flexibility. • Pits mined at a faster rate limits miners exposure to less risk from pit wall failures.	• Slightly greater risk of deterioration of the pit walls will be present, because of slower rate of mine advancement (i.e., pit walls are exposed to the environment longer, which can result in greater levels of sloughing and other forms of deterioration).	• Risk to pit wall stability will continue due to increase in length of exposure. • Smaller equipment will be used and production flexibility will be reduced.
Economics	• This alternative provides a higher annual revenue. • Capital cost for mine equipment fleet will be higher, but generally operating costs will be lower. • Alternative will provide the rate required to generate sufficient rate of return on investment. • Robust Project economics will provide for secure employment. • This alternative will result in a shorter mine life and, therefore, a shorter period of employment.	• Alternative will provide lower level of annual revenue. • Generally capital cost for mining fleet will be lower and operating costs will increase over the 3 Mt/y alternative. • Less robust economics will subject the operation and employment to market swings. • This alternative will result in a longer mine life and longer period of employment.	• Operating costs will be higher due to smaller mining equipment. • Annual revenue is insufficient to offset operating costs and provide a reasonable return on investment.

Table 2-2 Comparison of Extraction Rate Alternatives (continued)

Evaluation Criteria	Alternatives		
	3 Mt/y	2 Mt/y	<2 Mt/y
Environmental Considerations	• Greater level of on-site activity results in higher levels of annual air emissions, but less overall emissions than mining at a lesser rate. Total time of site activity would be less but more intense and more efficient. • A reduction in the length of time the mine pit is open and the amount of groundwater that has to be managed. • Shorter mine life will allow for an earlier start to refilling Kennady Lake and to the initiation of mine site reclamation. • Size of operational water management system will likely be smaller, because of lower volumes of groundwater that would require treatment and/or active management.	• Increases the length of time the mine is active. • Longer effects on air, water, and other environmental components. • A longer Project life will result in a slower final reclamation timeline. • Annual air emission rates may be smaller, but will occur over the longer life of the Project, and total emissions will be greater.	• Similar to those outlined for the 2 Mt/a rate, delays to the initiation of final reclamation. • Length of time the mine pit is open and the amount of groundwater to be managed will increase. • Annual air emission rates may be smaller but for a longer period of time
Alternative Selected	Yes	No	No

Mt/y = million tonnes per year; <= less than.

2.2.2 Selected Alternative

Although a range of extraction rates were evaluated to determine the maximum reasonable sustainable rate, the sustained rate of 3 Mt/y was determined to be the only option that is economically viable. This mining rate is towards the upper range of the technical extraction capacity of the ore body geometries and encourages efficiencies in the mine operation. The high rate is also better from a technical perspective, as it will reduce both the time of exposure to potential pit wall failures and the amount of groundwater to be managed.

The mining rate alternative chosen dictates the schedule for material movement and drives the extraction approach to feed the plant. It also allows a large degree of flexibility in the mine plan to accommodate effective waste disposal.

2.2.3 Resulting Consequences or Opportunities

Since the selected alternative is the only economically viable alternative, it provides an opportunity for the Project to proceed and an opportunity for secure employment. The consequence is a more intensive production over a shorter period causing increased annual air emissions and site activity intensity (e.g., noise) during operations, but overall less emissions over the life of the mine, shorter duration of effects, and an earlier start to closure (e.g., refilling Kennady Lake).

2.3 EXTRACTION APPROACH

2.3.1 Available Alternatives

The mine consists of three pits: 5034, Hearne, and Tuzo. The flexibility of mining the multiple small pipes by open pit methods allows for the opportunity to optimize the production plan. The mining rate of 3 Mt/y can be met by many combinations of pipe sequencing. Alternatives were assessed by the following criteria:

- Value – In general, the highest value ore is mined first. Value takes into account the costs of mining as well as the grade of the ore.
- Size – The size of the pipe will determine its production capacity. Small pipes (e.g., Hearne ore body) must be mined concurrently with others to achieve the 3 Mt/y requirement.
- Proximity – Although included in the value equation, proximity of the pipe to the processing plant and the other ore bodies affects the economics of waste disposal and water management. Proximity forms a large part of the sequencing exercise.

The extraction approach of multiple pits versus sequential pits is based on economics. The Hearne and 5034 ore bodies are significantly higher value than the Tuzo ore body; therefore, they are planned to be mined first. However, Hearne and the bottom of 5034 ore bodies are relatively small; therefore, the effective mining capacity from these small geometric areas cannot achieve the total plant production requirement alone. Production overlaps between the pits are scheduled to provide safe mine fleet spacing and supplement production when required.

Mining the ore bodies in sequence restricts the ability of the mine to create a blended product to optimize processing efficiencies. Otherwise no real engineering or cost advantage is gained by mining all three ore bodies concurrently. Due to the conical, “carrot shape” geometry of the deposits, the largest volumes of waste rock are associated with the top layers of ore for all three ore bodies. Thus concurrent mining would require prohibitively large volumes of mine rock to be moved in the initial years.

2.3.2 Selected Alternative

The chosen production plan, included in the 2010 EIS (De Beers 2010), incorporates the selection criteria discussed in Section 2.3.1 above and allows for the following:

- Mining of 5034 ore body first, which has a portion of the pit outline above lake level, will provide a source of rock and overburden till for building roads, dykes, and dams, as well as providing aggregate for construction. This negates the need to open a separate dedicated quarry, which would have expanded the disturbance footprint. Scheduling also allows rock materials to be accessed prior to dewatering Kennady Lake.
- The 5034 ore body has the highest value and, due to its size, it will have the capacity to feed the process plant alone during the initial years of mine operations. Thus, mining of 5034 Pit will be accelerated to be completed first allowing the mined-out pit to be used as waste or water storage as required by the development plan.
- The Hearne Pit will be mined next because of its value, as well as its role as a repository for fine PK. Flexibility in the mine plan may allow earlier completion of this pit to allow additional storage of fine PK.
- The Tuzo Pit is the largest pit but has the lowest value. Its place in the mine sequence allows for short hauls of waste rock to the completed 5034 Pit. Mining Tuzo Pit later retains the option for underground mining should the resource be determined to extend in depth.

2.3.3 Resulting Consequences or Opportunities

The selected mining sequence achieves the 3 Mt/y mining rate. It allows operational flexibility and creates repositories for disposal of mine rock and processed kimberlite, as well as available volume for water storage as each pit is completed. The opportunity to use the pits to passively sequester other substances such as saline groundwater is also important. Mining the 5034 ore body first will provide an early source of mine rock and overburden till for construction, which negates the need to open a separate dedicated quarry, which would increase the overall disturbance footprint.

2.4 SUMMARY

The type and location of the kimberlite ore bodies constrains the choice of viable mining alternatives, the assessment of which showed that open pit mining was the most advantageous and the only alternative that was economically viable and technically feasible. Three alternatives were considered for the rate of mining: 3 Mt/y, 2Mt/y, and less than 2Mt/y. Only the highest rate of 3 Mt/y was economically viable; this decision constrained the alternative extraction approaches: mine the three pits sequentially or mine multiple pits. The mining sequence that would achieve the necessary mining rate was to mine multiple pits sequentially, but with overlap, specifically the 5034 Pit, Hearne Pit, and Tuzo Pit. This overlap meant that mined-out open pits would become available while mining was continuing.

The decisions made at Level 1 determined the next level of decisions that included:

- The mining sequence, which resulted in mined-out open pits being available during mining, provided an opportunity for mine waste and mine water disposal considered as Level 2 in Section 3.
- Water management and the structures associated with ore body access within the overlying and adjacent lakes is a key component of the Project because the kimberlite ore bodies are primarily located under Kennady Lake. Open pit mining meant that part of Kennady Lake had to be dewatered. Establishment of a controlled area for water and waste management in the Kennady Lake watershed emerged from these alternative assessments and partial diversion of the upper Kennady Lake watershed, which was deemed a necessary precursor of dewatering, is also considered as Level 2 in Section 3.

3 LEVEL 2 DECISIONS

3.1 MINE WASTE MANAGEMENT

3.1.1 Waste Management Streams

The open pit mining and processing operations selected for the Project determine the characteristics of the waste streams. Open pit mining creates a relatively large quantity of mine rock that must be stored. Material streams from ore processing consist of a fine and coarse processed kimberlite (PK). Rather than selecting between diamond processing alternatives, De Beers took into consideration the experience of other open pit mines in the NWT and Nunavut, as well as De Beers' Snap Lake and Victor mines. Although there are some refinements, the processing is generally similar to the proven processing systems at other mines in the NWT. By separating the processing waste into two streams, coarse PK and fine PK, De Beers was able to reduce the size of the fine PK containment required. As a consequence of the mining and processing decisions, the Project will generate three principal solid waste streams consisting of:

- Mine Rock – consists of 234 Mt of excavated bed rock, predominately granite, surrounding the kimberlite deposits. This mine rock is large sized (up to 2-3 m diameter), blasted material and is transported directly from the mine pits to the designated mine rock disposal areas. Some of the mine rock is used as the source of construction materials for dykes, dams, and roads.
- Coarse PK – consists of 23 Mt of coarse (a fine gravel material between 0.5 to 6.0 mm in particle size), processed kimberlite, produced from the diamond processing plant which is loaded into trucks and hauled to designated coarse PK storage areas.
- Fine PK – consists of 8 Mt of fine (<0.5 mm particle size) processed kimberlite produced from the diamond processing plant in the form of a slurry of approximately 30% solids by weight and transported by pipeline to the designated fine PK storage areas. (By comparison the Ekati Mine has already produced over 40 Mt of fine PK for disposal in their Long Lake storage facility).

3.1.2 Pit Backfill Material

3.1.2.1 Description

The sequential mining of the 5034, Hearne, and Tuzo ore bodies provides opportunities to place mine rock, fine PK, coarse PK, saline mine water, and other waste materials in the pits as each are mined out. The 5034 Pit is mined out after five years of operation, followed by the Hearne Pit after seven years of operations. The Tuzo Pit is not completed until the end of operations and is not available for placement of residual waste streams created during mining operations.

The plan presented in the 2012 EIS Supplement (De Beers 2012) proposes to use 5034 Pit after Year 5 as a repository for Fine PK material as well as mine rock excavated from the Tuzo Pit. Given the large quantity of mine rock from Tuzo, 5034 pit will be filled to capacity. Moreover, the plan proposes to use the Hearne Pit as a depository for coarse and fine PK after Year 7. Open volumes of the mined-out 5034 and Hearne pits during operations are also integral parts of the water management plan to control and manage water within the controlled area.

3.1.2.2 Assessment

There are clear technical, economic and environmental advantages to utilizing the capacities of the emptied pits for storing a portion of the waste streams. These advantages include:

- construction of additional containment facilities is avoided;
- allows for progressive reclamation of initial containment facilities during the operational life of the mine;
- reduces the time needed to refill Kennady Lake at closure;
- restores lake bottom bathymetry to near baseline levels for 5034 Pit; and
- provides containment for residual waste streams placed in the pits and sequesters fine PK solids, saline pit water, and other wastes at depth thereby isolating these materials from reclaimed fish habitat zones.

3.1.3 Resulting Consequences and Opportunities

Because of its importance to the Project, the decision to use the mined out pits is considered a Level 2 decision and is a reasonable extension of the sequential mine plan. The use of the mined out pits is environmentally, technically, and economically advantageous over any other feasible alternative (i.e., any other alternative that did not use the mined-out pit capacity). For this reason, no other alternatives were evaluated. However, mine waste must still be stored during the early portion of the mine life when the pits are not available, and later in the mine life when the capacity of the open pits has been exceeded. The alternatives for disposing of the residual mine waste are assessed as a Level 3 decision in Section 4.

3.2 WATER MANAGEMENT

3.2.1 Establishment of the Controlled Area

3.2.1.1 Description

The water management plan (De Beers 2010) utilizes the natural topography and headwater characteristics of Kennady Lake to establish a controlled area within which to limit disturbance (Figure 3-1; see Figures Appendix). A system of natural basins coupled with strategically placed dykes will isolate eight zones within the controlled area: Areas 1 to 7 (Figure 3-1). Area 8 is not included within the controlled area and will experience only minor physical disturbance from the Project. As part of the 2012 EIS Supplement (De Beers 2012) the water management plan was modified to exclude Area 1 (Lake A1) from the Fine PKC Facility. Natural/passive diversion of Area 1 was not possible, and therefore a mechanical (pumping and pipeline) diversion will be installed during the operations phase of the Project.

Although Kennady Lake is a headwater lake, several small tributary watersheds drain into the lake in the natural pre-disturbance flow regime. The amount of water entering the Project site from the surrounding watersheds can be reduced by diverting watercourses away from areas that will be disturbed during construction and operation of the Project. A key water management objective is to reduce the volume of water coming into contact with the mine area. To do this, a series of dykes and berms will be constructed to divert runoff from those upper watersheds adjoining Kennady Lake. These diversions will be created during mine construction, and will remain functional throughout the operating life of the mine. As part of the long term reclamation plan, these diversions will be dismantled to restore baseline watershed boundaries and flow regimes.

3.2.1.2 Assessment

Isolation of the controlled area and partial diversion of water entering the area has the following obvious technical and environmental advantages:

- reflects a philosophy of “keeping clean water clean”;
- minimizes the amount of water requiring mechanical treatment prior to discharge to downstream receptors during the initial dewatering period;
- reduces the volume of water that will have to be contained and managed on site during the operations phase;
- reduces the quantity of water coming into contact with the mine area as this water may have to be treated to remove impurities resulting from this contact before it can be discharged; and
- reduces the overall economic and technical risks related to unexpected additional treatment or additional storage capacity requirements.

3.2.2 Resulting Consequences and Opportunities

Because of the importance of water management to this Project, the decision to establish a controlled area to create a partial diversion of the Kennady Lake watershed is considered a Level 2 decision. The diversion of water unaffected by the Project is an environmentally, technically, and economically advantageous alternative that is a necessary consequence of preserving the integrity of the controlled area. Furthermore, the establishment of the controlled area favours the containment of all waste storage and project disturbance within a natural topographic boundary. For this reason, the concept of a controlled area and partial diversion has been included as part of all Project alternatives described in Section 4.

3.3 SUMMARY

Open pit mining of the kimberlite ore bodies located under Kennady Lake determines important aspects of both mine waste and water management. The sequential mining of the 5034, Hearne, and Tuzo ore bodies, provides a volume for permanent mine waste and mine water disposal in the mined-out open pits, thus opportunities to place waste rock, fine PK, coarse PK, saline mine water, and other waste materials in the 5034 and Hearne pits once mining is complete. However, there is still the need to dispose of mine waste in the early portion of the mine life when the pits are not available, and later in the mine life when the capacity of the open pits has been exceeded. The Level 2 decision to place as much waste in the mined-out open pits as possible applies to all the alternatives assessed in Section 4.

Similarly, the Level 2 decision to establish a controlled area integrates the waste and water management plans and favours the design of all waste management facilities to be located within this naturally isolated area. Partial diversion of tributaries to the controlled area follows from this Concept. It is a key objective of the water management plan and applies to all the alternatives assessed in Section 4.

As a result of these overarching decisions, a range of alternatives is considered at Level 3 in Section 4 that include:

- alternative locations for disposing of the residual mine waste that cannot be accommodated in the mined-out pits;
- alternative concepts related to dewatering and later refilling Kennady Lake; and
- alternative means to manage the water remaining within the controlled area during construction, operations, and closure.

4 LEVEL 3 DECISIONS

4.1 WATER AND WASTE MANAGEMENT ALTERNATIVES

4.1.1 Available Alternatives

4.1.1.1 Introduction

The open-pit mining alternative requires that portions of Kennady Lake be dewatered, the activities associated with which result in the loss of, and changes to, fish habitat during the life of the mine to access each ore body. It is expected that these changes will be considered harmful to fish habitat as defined in the federal *Fisheries Act*.

Alternatives to the combined water and waste management plans were assessed to address the question: *"To what extent would Kennady Lake need to be physically changed and still provide an economically viable Project while limiting potential environmental risks?"* These alternatives would result in varying impacts to lake surface area and volume because of the need to place physical structures in the lake to safely access the ore bodies. For the purpose of determining the amount of change to fish habitat (i.e., change to areas and volumes of habitat), the type and relative extent of predicted changes have been categorized for the alternatives analysis. The actual determination of what would be considered harmful alteration, disruption, or destruction is the responsibility of DFO, once De Beers has formally submitted an application for an authorization under Section 35(2) of the *Fisheries Act*.

Since the ore bodies are located in the middle of Kennady Lake, all of the alternatives, at a minimum, require the complete dewatering of a portion of Kennady Lake (i.e., dewatering in Areas 4 and 6) to facilitate the construction of physical structures in the lake that are necessary to safely access the kimberlite pipes by an open pit mining method. The ore deposits are situated in positions under Kennady Lake that will require a physical division of the lake and protection of the dewatered areas from flooding. Also, all alternatives change aspects of the northern portion (Areas 1, 2, 3, and 5) of Kennady Lake by severing this portion of Kennady Lake from the natural flow towards the lake outlet in Area 8. While no construction activity takes place in Area 8, the alternatives result in reduced flows through Area 8 changing the water level and annual flow volumes. This base level of activity would include changes to fish habitat, including permanent loss of habitat, physical alterations to habitat, and habitat disruption from the suspension of habitat use for the operations of the Project. Similarly, all of the alternatives include changes caused by dykes and/or dams located within Kennady Lake, some of which would be partially removed at the end of operations returning the areas to fish habitat. Likewise, each of the alternatives includes impacts to fish habitat resulting from the storage of mine waste and mine water (i.e., saline water).

Alternative means of dewatering Kennady Lake to facilitate open pit mining of the kimberlite resource that would include the placement of physical structures in the lake have been considered since conceptual planning began in 2000. Five alternatives were considered in Section 2 of the 2010 EIS (De Beers 2010).

For dewatering to occur over the ore bodies, physical structures (e.g., dykes) must be constructed in advance of mining and the water removed. The northern boundary of Areas 4 and 6 of Kennady Lake (which contain the ore bodies) can be isolated from Areas 3 and 5 to the north through a series of East-West dykes connecting the shorelines and incorporating small islands within Kennady Lake. The dykes required are common to all alternatives and labelled Dyke H, Dyke I, Dyke M and Dyke B. Likewise to segregate Areas 4 and 6 from the southern and eastern sections Area 8 (or Areas 7 and 8) of Kennady Lake, Dyke A (and/or Dyke K) is required (Figure 4-5; see Figures Appendix).

In analyzing the alternatives, economic, technical and environmental concerns were considered. Practices and precedents employed at other open pit mines in the Arctic were also examined as well as anecdotal issues associated with these other operations. Various options for the Fine PKC Facility, dyke construction, water management and waste rock management are in use at the four diamond mines constructed in the NWT/Nunavut and the alternatives considered for the Project utilize designs that are technically proven at these mine operations. For example:

- In-lake fine PK storage and water management facilities utilizing filter dykes and controlled discharge without the need for mechanical water treatment have been in place at Ekati since 1998 and also used at the Jericho Mine. On-land fine PK containment and water management facilities combined with mechanical water treatment for excess water releases are in place at the Diavik and Snap Lake Mines.
- Dewatering of lakes (or portions of lakes) above the ore bodies is common practice at the other mines, and was employed at Ekati (Panda South, Koala, Fox, Beartooth, and Misery lakes) and Diavik (a portion of Lac de Gras) mines. Furthermore, separate lakes at Ekati and Jericho were used as fine PK containment facilities. The Meadowbank Gold Mine in Nunavut required dewatering of a portion of a lake to access the ore bodies and utilizes the sectioned-off waterbody as a water management pond and tailings facility. The Diavik Mine constructed a

3,800 m long dyke in Lac de Gras connecting the shoreline to several islands to build a cofferdam dyke structure surrounding the three ore bodies. Ekati constructed a 4-km diversion channel bypassing the southern portion of Panda Lake and Koala Lake providing for a water and fish bypass channel between the upstream lakes and Kodiak Lake.

- Various types of dykes/dams were constructed at these mines including: frozen core dams; lined dykes; filter dykes; bentonite/grouted dykes; till dykes; and other designs depending on the requirements. Dykes and dams were built in wet and dry conditions, as well as seasonal summer and winter construction.

Consideration of naturally occurring landforms (islands, topography, bathymetry, soil conditions) is a critical aspect of the technical design of all earthworks structures within the controlled area. Kennady Lake is naturally configured with several narrow (and shallow) lake sections as well as one notably large island located within the lake body (Figure 1-3; see Figures Appendix). The existing topography provide low impact and low risk locations where dykes can be built to section the lake to access the ore bodies. These natural features along with planned development use form the basis for subdividing the lake into eight areas. The area and volumes of the eight areas are provided in Table 4-1. The existing lake elevation is 420.7 masl for Areas 2 through 8. Area 1 represents a separate feeder lake and has a slightly higher elevation of 421.3 masl. The Kennady Lake areas are shown on Figure 1-3.

Table 4-1 Kennady Lake Areas and Volumes

Lake Section	Area (km^2)	Volume (Mm^3)
Area 1 (A1 only)	0.38	1.02
Area 2	0.61	2.4
Areas 3 and 5	2.52	16.2
Areas 4 and 6	2.52	13.0
Area 7	0.94	3.4
Area 8	1.43	3.5
Total (2 to 8 only)	**8.02**	**38.5**

km^2 = square kilometres; Mm^3 = million cubic metres.

The ore bodies are located within Areas 4 and 6 and require complete dewatering of these areas to safely access the ore bodies. Dewatering (or partial dewatering) of Areas 1, 2, 3, 5 and 7 to facilitate the construction of physical structures to safely and economically access the ore bodies are the subject of the alternatives analysis. Under all scenarios, Area 8 is left near its original level and volume with negligible disturbance.

The alternatives were examined on the economic, technical and environmental parameters as outlined above. More specifically the parameters included:

Economics

- Capital cost impacts (dyke design and method of construction, quarry requirements, water treatment plant, fine PKC facility, lake refilling and closure costs, camp and infrastructure requirements, support services (planes, trucking, etc).
- Operating cost impacts (water transfer and pumping, increased fuel and labour costs; water treatment plant operating costs, monitoring and inspection, etc).
- Schedule impacts (extended design and construction period, seasonal construction restrictions, construction sequence issues, etc).

Technical

- Safety impacts – (must provide safe working environment)
- Simple and proven designs – (mechanical versus passive designs, requirements for specialty equipment, demonstrated at other area operations).
- Flexible and adaptable plans (minimize technical risk issues).
- Contingency planning (capacity for upset conditions).

Environmental

- Restore natural flow regime at closure.
- Incorporate progressive reclamation.
- Minimize project footprint.
- Limit impacts (or extent of impacts) to fish habitat and associated compensation costs.
- Avoid long term structures susceptible to climate change implications.

The alternatives can be grouped by two fundamental concepts. Earlier studies examined Project development scenarios that limited the area of Kennady Lake that was disturbed to the minimum area needed for mining, leaving the area north of the open pits and Area 8 undisturbed. None of these early studies resulted in development plans that were economically viable. Current plans (2012 EIS Supplement; De Beers 2012) using the isolated lake basin north of the pits resulted in an economically viable and technically feasible development plan for the Project that would also limit further the area disturbed by the overall Project footprint. Concentrating more of the necessary Project activities, placement of physical structures to safely access the ore bodies, in the lake basin would take advantage of the existing natural topography of the disturbed basin and reduce concerns related to dykes identified in the earlier alternatives. Although this alternative increases the degree of disturbance within Kennady Lake, it would result in a reduction in overall terrestrial disturbance and risks to adjacent watersheds compared to alternatives that required the construction of an on- land PK disposal facility.

Considering all of the alternatives in light of these two fundamental concepts, each of the variations can be organized into two dewatering alternatives (Alternatives A and B), each with three variations (Options A1, A2, A3 and Options B1, B2, B3). In total, six revised options for dewatering were developed for assessment as described below:

- Alternative A – To access the ore bodies and construct water retention dykes Areas 4 and 6 will be completely dewatered (Figure 4-1; see Figures Appendix). A circumferential dyke containment water management and PK facility constructed in the vicinity surrounding a portion of the dewatered Area 6 (i.e., the southwest bay of Kennady Lake) for fine PK disposal, and installing a Total Suspended Solids (TSS) water treatment plant. The following options all include these core activities:
  - Option A1: no changes or additions to Alternative A (Figure 4-1; see Figures Appendix);
  - Option A2: install a Total Dissolved Solids (TDS) water treatment plant (Figure 4-2; see Figures Appendix); and
  - Option A3: dewater Area 7 (Figure 4-3; see Figures Appendix).

- Alternative B (also Alternative 4 in Section 2 of the 2010 EIS [De Beers 2010]) consists of completely or partially dewater Areas 2 to 7 as described in the options below:
  - Option B1: completely dewater Areas 4, 6, and 7, partially dewater Areas 2, 3, and 5, and infill Areas 1 and 2 for fine PK disposal (Figure 4-4; see Figures Appendix). This was assessed in 2010 EIS;
  - Option B2: completely dewater Areas 1 to 7, and infill Areas 1 and 2 for fine PK disposal; and
  - Option B3: completely dewater Areas 4, 6, and 7, partially dewater Areas 2, 3, and 5, and infill only Area 2 for fine PK disposal

(Figure 4-5; see Figures Appendix). This was assessed in the 2012 EIS Supplement.

All options of the two alternatives were assessed using ten defined criteria, which are listed in the Introduction (Section 1) of this report.

4.1.1.2 Alternative A

4.1.1.2.1 Description

Alternative A minimizes the Project footprint in Kennady Lake by limiting dewatering to only those areas directly above the ore bodies (Areas 4 and 6). Initially lake water will be discharged to the downstream Kennady Lake environment (Area 7 and then on to Area 8) until water quality (e.g., TSS) no longer meets discharge criteria. Several options will be considered to treat the remainder of the water to be discharged. High TDS pit water along with fine PK will be stored in a constructed containment facility placed within a portion of Area 6 (i.e., the southwest bay of Kennady Lake). Figure 4-1 presents the conceptual water and mine waste management plans for Alternative A (see Figures Appendix). The major considerations and assumptions for Alternative A include:

- Areas 4 and 6 will be completely dewatered (lake surface area dewatered is 2.52 km^2, amount of water is 13.0 Mm^3).
- Ongoing pumping of excess water from the isolated north basin (Areas 1, 2, 3, and 5) to Lake N11 will be required until closure when the basin is reconnected to Areas 4, 6, and 7.
- A bridge or culvert will be constructed between Areas 7 and 8 for airstrip access.
- Dykes K, H, I, and J (Figure 4-1; see Figures Appendix) will be constructed under wet conditions of up to 8 m of water before initial lake dewatering of Area 6 in Year -2. As the upstream sides of the dykes will remain as fish habitat, sediment control measures will be required to prevent excessive flows of sediment from entering the fish habitat areas during dyke construction and thereby harmfully altering the upstream areas.
- A TSS water treatment plant is required during the initial lake dewatering and mine operation.
- Dyke B will be constructed in Year 1 and Area 4 will be dewatered in early Year 2. Area 4 will be available as a temporary water storage pond for the TSS treatment plant before mining of Tuzo Pit. Strict sediment control will be required to construct Dyke B adjacent to the fish

habitat in Area 3. Dyke B will require engineered dyke base preparation and a modified design to minimize seepage during operations.

- Runoff from Area 4 and seepage water from Dykes B, H, I, and J will be collected in the dewatered Area 4 basin. Runoff and seepage will be treated as described in the following options, and this treated water will be discharged to Area 8 during mine operation (Year 1 to mid-Year 5) before mining of Tuzo Pit.
- A ring-shaped perimeter dyke will be constructed around the west portion of Area 6 before mine production; the final dyke will have a maximum height of 35 m and a length of approximately 4,200 m.
- Site runoff and contact water, including the pit water that does not meet discharge criteria, will be stored inside the ring dyke in the west portion of Area 6 before the mined-out pits are available.
- The mined-out 5034 and Hearne pits will be partially used to store contact water.
- Additional contact water, including the pit water, will be stored inside the ring dyke in the west portion of Area 6 after the storage capacities in the mined-out 5034 and Hearne pits are reached.
- The make-up water required for ore processing will be sourced from a pond enclosed by the ring dyke in the west portion of Area 6.
- Fine PK (3.3 Mt) will be deposited in the west portion of Area 6 before the mined-out 5034 Pit is available.
- The remaining fine PK will be placed in the mined-out 5034 Pit (1.5 Mt) and Hearne pit (3.0 Mt).
- Coarse PK will be placed on land in a separate Coarse PK Pile near the Tuzo Pit, in a mined-out open pit, and in the South Mine Rock Pile.
- Mine rock will be placed in the South Mine Rock Pile, West Mine Rock Pile, and the mined-out 5034 Pit.
- Runoff seepage water collected in the dewatered Area 4 basin will be treated in the TSS water treatment plant, and this treated water will be discharged to Area 8 during mine operation (Year 1 to mid-Year 5) before mining of Tuzo Pit.
- No TDS water treatment plant will be installed.

4.1.1.2.2 Assessment

Advantages

- The advantages of Alternative A include: Areas 2, 3, 5, and 7 will not be dewatered, and could possibly be preserved as fish habitat during operations.

- All contact water that does not meet discharge criteria will be stored within the catchment areas of Areas 4 and 6.
- Fine PK will be isolated in a circumferential ring dyke and the mined out pit after closure.

The advantages of Alternative A are similar to those of Alternative 1 developed as a concept in 2000 and reported in the EIS (De Beers 2010). Alternative 1 also involved dyking only the area around the pits (Areas 4 and 6) thereby limiting the potential temporary loss of fish habitat. Alternative 1 included a fish bypass channel joining the north and south parts of Kennady Lake so that water could flow and fish could move towards the outlet in Area 8.

Disadvantages

Alternative A has many disadvantages, including:

- The plan is not economically viable due to increased capital and operating costs.
- Fish habitat will be permanently lost in that part of Area 6 (32 hectares) used as a fine PK and contaminated water storage facility.
- Areas 1, 2, 3, and 5 will be isolated from the rest of Kennady Lake to the south; this will require mechanical pumping and transfer throughout the operations and lake refilling closure period. Earlier alternatives suggested a fish passage channel could be constructed to allow water to flow to Area 8. The channel canal was considered uneconomical due to the extensive earthworks undertaking, and schedule impacts. Furthermore, with no head differential between Area 3 and Area 8, design would necessitate a deep channel and wide channel to avoid full freezing and snow blockage conditions.
- Constructing Dykes B, K, H, I, and J under wet conditions with up to 8 m of water before the initial lake dewatering will be technically challenging and construction time and material availability will be limited. The construction of Dykes B and K at the onset would add one year to schedule. The resulting additional dyke construction cost and impacts to schedule would result in a project cost increase of over $100 million.
- Silt and TSS from Dykes B, H, I, and J construction would impact isolated lake areas and fish habitat in Areas 3, 4, 5 and 6. Similarly silt and TSS from construction of Dyke K would impact Area 7.
- A TSS water treatment plant is required for initial lake dewatering and mine operation, which will increase the schedule, capital and operating costs. Direct costs to install a TSS plant and added infrastructure requirements, power, fuel storage, camp space, etc., would exceed $30M added to the Project capital requirements. Operating costs for the

TSS plant would exceed $5 million per year for the seven to eight year requirement.

- The environmental risk of uncontrolled water seepage will be high, both during mine operation and after closure, because the raised west Area 6 pond contained within the ring dyke has high head of water above the natural topography.
- Building a high (up to 35 m high), long (4,200 m), circumferential dyke around the west portion of Area 6 to contain both the fine PK and contact water will be technically challenging.
- The construction cost for the west Area 6 circumferential dyke with a geomembrane liner as a water containing element with an estimated fill volume of approximately 4.5 Mm^3 is expected to exceed $100 million in additional costs. Other added costs include more mining equipment, increased fuel requirements, and higher camp capacity.
- This alternative will have minimum operating flexibility and the risk to safe mine operation will be high.
- Minimum contingency storage capacity will require additional dyke height and or expansion of the footprint in case of unexpected situations (e.g., higher than expected pit inflows or higher percentage of fine PK). Examples at other mines where insufficient water storage capacity was available to meet unexpected pit and underground inflows.
- Increased operating costs will be associated with ongoing pumping of excess water from the isolated north basin (Areas 1, 2, 3, and 5) to Lake N11 or Area 8 until closure when the basin is reconnected to Areas 4, 6, and 7.
- Although not dewatered, the northern areas of Kennady Lake are affected by the Project as they will be isolated from Kennady Lake Areas 7 and 8 and outflow streams. The overall permanent loss of fish habitat for Alternative A will be similar to the loss of habitat in Alternative B.
- Additional runoff collection from the process plant and camp areas will be required to be monitored and managed (e.g., ditching and sediment ponds system) to ensure that water quality meets discharge criteria.
- There is a risk to the Project if the combined pit flows and pit seepage are higher than the design capacity of the ring dyke containment area.

4.1.1.2.3 Option A1

Option A1 is Alternative A with no changes or additions.

4.1.1.3 Option A2

4.1.1.3.1 Description

Alternative A2 is similar to Alternative A except that a TDS water treatment plant will be used to treat the high TDS pit water; this reduces the requirement to store the high TDS pit water. The incorporation of TDS treatment effectively reduces the amount of temporary storage of high-TDS pit water with treatment and discharge. This reduces the size of storage facilities designed to hold these waters. Figure 4-2 presents the conceptual plan for the water and mine waste management for Option A2 (see Figures Appendix). The major considerations and assumptions for Option A2 are similar to Alternative A. The advantages and disadvantages for all components that are similar to those described above are not repeated. The following highlights the elements that differ from Alternative A:

- Five perimeter dykes will be constructed around the west portion of Area 6 for fine PK storage and water storage; the final dykes will have a maximum height of 23 m and a total dyke length of approximately 2,940 m.
- A TDS water treatment plant will be installed.
- The contact water, including the pit water, that does not meet discharge criteria (high TDS) will be temporarily stored inside the pond in the west portion of Area 6 and pumped to the TDS treatment plant for treatment and discharge to the outside environment when water quality meets discharge criteria. The mined-out 5034 and Hearne pits can also be used to store contact water as available.

Other considerations for the TDS water treatment inherent in the treatment technology include:

- A considerable waste stream volume from the process must be stored (20% to 50% of feed volume). The quality of these waste streams is much lower because of the highly concentrated brine.
- Energy requirements will be higher.
- Skill level required for operations will be higher.
- Pre-treatment will be required for TDS, including addition of heat (20 to 30°C is recommended).
- Efficiency is variable and affected by changes in input conditions. A large mixing basin may be required to minimize variability in feed.
- The life cycle cost for TDS water treatment will be over $100 million, in addition to the cost for TSS as described for Alternative A.

4.1.1.3.2 Assessment

Advantages

The overall advantages of Alternative A2 are as follows:

- Areas 2, 3, 5, and 7 will not be dewatered.
- Contact water that does not meet discharge criteria will be stored within the catchment areas of Areas 4 and 6 or treated in the TSS or TDS treatment plant before discharge to the outside environment.
- Since contingency storage capacity in case of unexpected situations (e.g., higher than expected pit inflows) will be limited, the TDS water treatment plant will provide an opportunity to treat and discharge pit inflows.
- The construction cost for the west Area 6 ring dyke with a geo-membrane liner as a water containing element with a total estimated fill volume of approximately 0.8 Mm^3 will be less than the cost of Alternative A, which has a fill volume of approximately 4.5 Mm^3.
- This alternative will have greater operating flexibility because the TDS and TSS water treatment plants will allow more water to be discharged to the environment.

Mine waste (fine PK, coarse PK, and mine rock) disposal areas, except for West Mine Rock Pile, are located within the catchment areas of Areas 4 and 6.

Disadvantages

The disadvantages associated with Option A2 are similar to those associated with Alternative A with the added trade-off of installing a TDS treatment plant versus the required height and capacity of the Area 6 ring dyke containment facility. Only the altered or added disadvantages that are different from Alternative A are listed below:

- The Project is not economically viable due to the added capital and operating costs associated with this option.
- A TDS water treatment plant will be installed, which results in high initial capital cost and high on-going operating cost due to high energy requirements (overall cost in excess of $100 million).
- The high TDS residual brine and sludge from the TDS water treatment plant needs proper disposal.
- The TDS plant effectively reduces the height of the ring dyke from 35 m to 23 m; however, it is technically challenging to construct a relatively

high (up to 23 m), long (2,940 m) low permeability structure along the west portion of Area 6 to contain the fine PK and to provide temporary contact water storage before the water is treated in the TDS water treatment plant.

- The raised west Area 6 pond will have a high head of water above the natural ground beneath the ring dykes. There is a high risk of poor quality water seeping to areas beyond the controlled area, such as Lake N14 and the unnamed lake southwest of Lake E1, during both mine operation and after closure.

4.1.1.4 Option A3

4.1.1.4.1 Description

Option A3 requires dewatering of Areas 4 and 6, and the dewatering of Area 7. The high TDS pit water along with the fine PK is stored in a facility in Area 6 and the high TDS water will also be stored in Area 7. Figure 4-3 shows the conceptual plan for the water and mine waste management for Alternative A3 (see Figures Appendix). The major considerations and assumptions for Option A3 are summarized below:

- Areas 4, 6, and 7 will be completely dewatered.
- To access the pits, Dykes A, B, H, I, and J will be constructed under wet conditions before initial lake dewatering of Areas 6 and 7. Strict sediment control will be required to construct the dykes adjacent to the fish habitat areas. Runoff from Area 7 and the seepage water from Dykes A, B, H, I, and J will be collected in the drained Area 7 basin, treated in the TSS water treatment plant, and discharged to Area 8 during the mine operation until Year 10.
- Perimeter dykes will be constructed around the west portion of Area 6 before mine production; the final dykes will have a maximum height of 28 m and a total length of approximately 3,900 m.
- The Area 7 pond will be used to store the contact water, including the pit water that does not meet the discharge criteria, in Year 11 after the mined-out 5034 and Hearne pits are full.
- The make-up water required for ore processing will be reclaimed from the pond enclosed by the west Area 6 ring dykes.

A TDS water treatment plant is not required for this option.

4.1.1.4.2 Assessment

Advantages

Four advantages have been identified for Option A3:

- All contact water that does not meet discharge criteria will be stored within the catchment areas of Areas 4, 6, and 7.
- Since contingency storage capacity in case of unexpected situations (e.g., higher than expected pit inflows) will be limited, use of Area 7 will provide additional storage space.
- Isolation of the mining area can be accomplished quite easily with Dyke A and allows the construction of Dyke K to be completed more safely, economically and quickly in the dry.
- The simple design of Dyke K minimizes the need for specialty contractor equipment and seasonal construction constraints.

Disadvantages

The disadvantages associated with Option A3 are similar to those associated with Alternative A, with the added trade-off of utilizing Area 7 as a water storage facility, which is coupled with the TSS water treatment plant. The utilization of Area 7 allows for a reduction of the required height from 35m as required for Option A1 although because a TDS plant is not considered for Option A3 there is an increase in the ring dyke height compared to Option A2. Moreover, Option A3 requires an increase in capacity of the Area 6 ring dyke containment facility compared to Option A2.

The following disadvantages have been identified for Option A3:

- Constructing a high (up to 28 m), long (3,900 m), ring-shaped low-permeability dyke around the west portion of Area 6 to contain both the fine PK and contact water will be technically challenging.
- There is a high risk of poor quality water seeping from the raised ring dykes in west Area 6 pond, which has a high water head above the natural topography. This condition exists during both mine operation and after closure.
- Construction cost for the west Area 6 ring dyke will be increased due to the requirement for a geomembrane liner as water containing element with a total estimated fill volume of approximately 2.0 Mm^3.
- The overall permanent loss of fish habitat areas for Alternative A3 will be similar to Alternative A2.

In 2002, Alternative 2 was developed as a concept and reported in the 2010 EIS (De Beers 2010) and also involved dyking Areas 4, 6, and 7. In the 2002 Alternative 2, Area 7 could potentially be used as a clarification pond during initial lake dewatering and, subsequently, as a fine PK storage facility. However, fine PK storage was not included in current Option A3. There is no advantage to storing fine PK in the Area 7 basin due to its relatively large catchment area and associated high runoff; in addition, disposal of fine PK in the Area 7 basin may also compromise restoring baseline flow conditions from Kennady Lake to Area 7 after closure.

4.1.1.4.3 Summary

The group of "A" alternatives highlighted two critical points that drove the subsequent direction of design alternatives assessed that would take Level 1 and 2 findings into account and solve problems identified in the initial Level 3 analysis.

Dyke B and K Construction

Dykes isolate the immediate pit area from the Area 7 (Dyke K) and Area 3 (Dyke B). Each of these dykes is a critical structure that guards the mine workings from relatively high water head (Dyke K approximately 8 m and Dyke B approximately 12 m). The construction of each of these structures in the wet at the onset of the project is expensive due to the design requirements and need for specialty equipment/contractor to construct. The construction also has a negative impact on the mine development schedule as well as presenting a high risk of sedimentation during construction to the adjacent fish habitat area that they are designed to preserve.

Constructing Dyke K prior to draining the lake will require a dyke design and construction similar to that used at the Diavik mine for the A418 and A154 ring dykes. These dykes were constructed using the following methodology:

- Silt curtains were installed in the lake outside of the dyke footprint.
- Dyke footprint dredged to remove soft lakebed sediments. This involved using a cutter suction dredge.
- Large boulders removed from the lakebed. Boulders identified by divers and removed by a crane and clamshell.
- A filter blanket (56 minus granular fill) was placed under the core and downstream shell. Filter blanket placed with a crane and skip bucket.
- The main dyke materials (900 mm minus upstream shell, 56 mm minus crushed rock core, and 200 mm minus crushed downstream shell) were

pushed into the lake. The dyke was advanced from the shoreline into the lake with all three zones being advanced simultaneously.

- Vibro-densification of 56 mm minus core material.
- Installation of concrete guide walls for the concrete cut-off wall.
- Construction of the plastic (bentonite and cement) concrete cut off walls. A specialized contractor and equipment is required for the cut off wall construction.
- Jet grouting the foundation below the cut off wall.

As Area 7 is a long thin water body with a constrained outlet to Area 8, there will be little water movement at the Dyke K location. Dyke B will be adjacent to the isolated area of Areas 2, 3, and 5 with little water movement through the area. Suspended solids migrating through the silt curtain may not be diluted by the lake currents as they were at Lac de Gras/Diavik; thus it is probable that TSS water quality guidelines will be exceeded during Dyke K construction. A possible mitigation to this TSS problem could be to modify the dyke construction methodology in which the dyke is constructed in between two rock fill coffer dams. However, this mitigation would be insufficient to limit sediment issues from the coffer dam construction and dyke construction between the coffer dams.

Constructing the dyke using a “Diavik” design or a modification of it prior to dewatering and adjacent to viable fish habitat negatively affects:

- Schedule – the dykes must be constructed prior to dewatering and require specialized equipment to construct. One year will be added to the project construction stage.
- Cost – the cost of the Dykes are increased substantially to the point of affecting the viability of the entire project, due to the critical nature of the integrity of these water retaining structures and their location immediately adjacent to active mine workings.
- Environmental risk – the activities required to build these structures in the wet and the small volume of the adjacent lakes makes the environmental consequence and risk of high sediment migration and possible effects high.

Water Treatment

TDS water treatment is assessed as a management tool reduce the volume required to store and ultimately sequester high TDS waters released as a result of mining deep open pits. The assessment of the "A" alternatives has highlighted the fact that TDS treatment has some problems of its own and although it provides a powerful contingency tool for upset conditions, does not necessarily have an effect on the total storage volume required for economic, environmentally low risk operations. In general:

- TDS plants are costly, energy intensive, and not efficient.
- A considerable waste stream volume must be stored (20% to 50% of feed volume) which is a high concentrate brine.
- Energy requirements will be higher which increased diesel generation on site, for example pre-treatment of feed may be required for TDS treatment which includes addition of heat (20 to 30°C feed temperatures is recommended). These requirements increase the need for fuel transport, fuel storage, as well as other infrastructure support requirements.
- Efficiency is variable and affected by changes in input conditions. A large mixing basin may be required to minimize variability in feed.
- The life cycle cost for TDS water treatment will be over $100 million.
- Skill levels required for operations will be higher.

Alternatives assessed in the following section are designed to address issues identified with Construction of Dykes B and K and with the water treatment.

4.1.1.5 Alternative B

4.1.1.5.1 Description

Reliance on active water treatment and discharge as a primary water management tool is technically viable, albeit expensive, and risky solution for water management. However, the ability to permanently store water is more reliable and operationally preferable. The availability of deep pits for permanent storage of saline waters, and adequate volume for operational water management is central to a reliable passive water management system.

Alternative B is illustrated in Figure 4-4; see Figures Appendix. Kennady Lake Areas 2 to 7 are fully or partially dewatered. Fine PK is deposited in Areas 1 and 2.

To access the ore bodies and construct water retention dykes Areas 4, 6, and 7 will be dewatered and Areas 2, 3, and 5 will be partially dewatered.

- Dyke A will be constructed between Area 7 and Area 8.
- Dykes H, I, and J will be constructed under wet conditions with up to 1.5 m of deep water before initial lake dewatering of Area 6 and 7 in Year -2.
- Dyke K will be constructed in the drained basin in two stages; Year -1 and Year 6. This will allow Area 7 to refill prior to the end of the mine operation.
- Construction of Dyke B will be staged during initial years of operations, which allows for simpler till-fill design construction utilising mining equipment in the early stage. This minimizes costs and schedule risks.
- Water quality will be managed using large settling areas with no requirement for TSS treatment plants.
- Fine PK will be deposited in Areas 1 and 2 and the mined-out 5034 and Hearne pits when they become available (5.5 Mt fine PK in Areas 1 and 2, 2.3 Mt in Hearne Pit).
- Fine PK will be managed with the installation of a filter dyke (Dyke L) with low head water control structures around Area 1 and 2.
- High-TDS pit water will be initially stored in Areas 5. Water will be discharged from Area 5 to the environment when it meets discharge criteria.
- Coarse PK will be placed in the Coarse PK Pile, South Mine Rock Pile and/or the mined out open pits.
- Mine rock will be placed in the South Mine Rock Pile, West Mine Rock Pile, and in the mined-out 5034 pit.

4.1.1.5.2 Assessment

Advantages

The advantages of Alternative B are as follows:

- Access to the kimberlites and construction of dykes to ensure safe access.
- Alternative B provides the most flexibility for water storage; contact water that does not meet discharge criteria can be stored within the catchment areas of Areas 3, 5, 6, and 7.
- There is no requirement for TDS or TSS water treatment plants.

- All mine waste and water management is contained within one basin.
- Less dyke construction is required.
- Dykes will be constructed at shallow depths.
- Alternative B does not require ongoing dyke maintenance after closure.
- The risk of uncontrolled releases outside the controlled area is significantly less.
- Alternative B provides for the shortest construction period and least amount of power, fuel usage, and associated environmental risks.
- High capacity of on-site water storage allows for a closed system during operations.
- Overall disturbance of the site is minimized.

Disadvantages

Two disadvantages of Alternative B have been identified:

- Larger area of Kennedy Lake will be affected by dewatering or partial dewatering resulting in disruption of a greater area of fish habitat during the life of the Project (until re-filling is complete).
- Loss of fish habitat in Areas 1 and 2 due to infilling with fine PK.

Summary

Alternative B was developed through various Project assessments during the project feasibility study. It provides a viable plan for the mine, which includes contingencies for various scenarios. The water treatment is passive and mine waste containment facilities (e.g., Fine PKC Facility) do not require maintenance at closure.

4.1.1.6 Option B1

Option B1 is Alternative B with no changes or additions.

4.1.1.7 Option B2

4.1.1.7.1 Description

Option B2 is similar to Alternative B with the exception that Areas 1 to 7 will be completely dewatered. Dewatering Areas 1 to 7 will require the use of a TSS water treatment plant for dewatering and discharge of high TSS water.

4.1.1.7.2 Assessment

Advantages

Two advantages have been identified for Option B2:

- Draining all the areas allows for easier construction of the dykes in the lake bed areas to access the ore bodies.
- Draining all the areas provides additional storage capacity in the water management system. It offers the most flexibility from a mining operation and its large capacity to store water throughout the mine life reduces risk of discharge of waters or wastes to the surrounding environment.

Disadvantages

The following disadvantages of Option B2 were identified:

- Installation and operation of the TSS plant will increase costs.
- A higher proportion of the fine PK will be deposited above water, which will result in a higher proportion of entrained ice in the fine PK increasing the volume of the fine PK facility.
- The fine PK filter dyke may freeze thereby restricting flow through the dyke.

4.1.1.8 Option B3

4.1.1.8.1 Description

Option B3 is primarily the same as Alternative B; however, Option B3 utilizes some of the inherent flexibility included in Alternative B to include mitigation to remove the use of Area 1 as part of the Fine PKC Facility (2012 EIS Supplement, De Beers 2012). In Option B3, the Fine PKC Facility is contained solely in Area 2 rather than Areas 1 and 2 as described in Alternative B. No fine PK will be deposited in Area 1.

A multiple accounts analysis process (Appendix A) was used to determine the optimum location for the fine PK that would have initially been placed in Area 1. The results of the multiple accounts analysis and a sensitivity analysis indicated that the best location was a combination of Area 2 and the 5034 and Hearne pits (Figure 4-5; see Figures Appendix). This location ranked highest among the five viable alternatives considered in the multiple accounts analysis (Appendix A) and is presented here as Option B3 (shown in Figure 4-5).

The following bullets highlight the elements in Option B3 that differ from Alternative B:

- Fine PK will be deposited in Area 2 and the mined-out 5034 and Hearne pits when they become available.
- Higher volume of fine PK will be directed to the 5034 pit (3.3 Mt fine PK in Area 2, 1.5 Mt in 5034 Pit, and 3.0 Mt in Hearne Pit).
- Changes in dykes around Area 2 and Area 1.
- Changes in the management of natural flows in the watershed.
- Mine rock will be placed in the South Mine Rock Pile, West Mine Rock Pile, and in the mined-out 5034 Pit, as described in Alternative B; however, the height of the West Mine Rock Pile will increase by approximately 24 m.

4.1.1.8.2 Assessment

Advantages

The advantages of Alternative B apply to Option B3; the additional advantages specific to Option B3 are as follows:

- Lakes within Area 1 (e.g., Lakes A1 and A2) will not be filled with fine PK; however, natural flows in Area 1 will be altered.
- The footprint of the Fine PKC Facility is reduced compared to Alternative B.
- Dyke C, which was a permanent dyke required to contain fine PK in Area 1 during operations and after closure will no longer be needed.
- Reversal of water flow into Lake A3 and the N watershed will not be necessary.

Disadvantages

Two disadvantages of Option B3 have been identified:

- The height of the West Mine Rock Pile will be increased.
- The contingency options available will be reduced, providing less flexibility in the disposal of fine PK, if quantities of fine PK are greater than predicted.

4.1.1.8.3 Area 7 Exclusion

Area 7 is included in the drained lake area and controlled area for Alternative B. Area 7 is temporarily removed as fish habitat during the mine operation; however, it is returned to fish habitat at mine closure when Kennady Lake is refilled. A modification was considered for Alternative B where Area 7 was not dewatered.

The advantage of excluding Area 7 is that the area of harmful alteration, disruption or disruption of fish habitat at the onset of the project would be less.

The main disadvantage of excluding Area 7 is that Dyke K must be constructed in the wet, as opposed to constructing it in the dry as in Alternative B. Dyke K is a critical structure that protects the mine workings from a relatively high head of water (approximately 8 m). The construction of the dyke in the wet requires technically challenging and expensive construction techniques as described in Section 4.1.1.4.3.

Sediment control would be critical during construction as Areas 6 and 7 would be fish habitat during the construction period in the Area 7 exclusion alternative. As Area 7 is a long, thin water body with a constrained outlet, there will be little water movement at the Dyke K location. Suspended solids migrating through the silt curtain may not be diluted by the lake currents as they were at Diavik Mine; thus, it is probable that water quality guidelines for suspended sediment would be exceeded during Dyke K construction, affecting fish and fish habitat in the vicinity.

Constructing the dyke using a “Diavik” design or a modification of it prior to dewatering and adjacent to viable fish habitat negatively affects:

- Schedule – the dykes must be constructed prior to dewatering and require specialized equipment to construct. One year will be added to the project construction stage.
- Cost – the cost of the Dykes are increased substantially to the point of affecting the viability of the entire project, due to the critical nature of the integrity of these water retaining structures and their location immediately adjacent to active mine workings.
- Environmental risk – the activities required to build these structures in the wet and the small volume of the adjacent lakes makes the risk of high sediment migration and possible effects high.

Removal of Area 7 from the controlled area reduces some of the mine flexibility of the water management plan and also may require some local water management initiatives to control the run off from the mine areas to Area 7.

4.1.2 Selected Alternative

4.1.2.1 Comparison of Alternatives

De Beers has considered many alternatives since conceptual planning began in 2000. The alternatives can be grouped by two fundamental concepts:

- Concept 1: to limit the area of Kennady Lake that was disturbed to the minimum area needed for mining, leaving the area north of the open pits and Area 8 undisturbed.
- Concept 2: to concentrate more of the necessary Project activities in the lake basin, including the area north of the open pits to improve the economic and technical feasibility, and reduce the disturbance footprint of the Project.

Using a hierarchal approach, these two fundamental concepts represented by Alternatives A and B are compared first (Table 4-2). Then each of the three options under the best alternative was considered.

Alternative A theoretically causes the least disruption of habitat areas in Kennady Lake; however, the economic costs associated with large high-head dykes, dyke construction requirements and the risk of negative impacts to isolated habitat areas remain high. Installation and operation of a TSS or TDS water treatment plant, added mine infrastructure and operating costs, and prolonging mine construction will compromise the economic viability of the Project without mitigating the primary risks. In addition, the technical and environmental risks associated with a high-head water and fine PK containment structure and the need to manage any seepage from such a long structure makes the option less feasible. Operating flexibility and contingency plans to manage variances in the environmental assumptions is also reduced. When considered as a whole, Alternative A is not an economically viable project option and furthermore carries technical and environmental risks that could lead to further economic disadvantages.

Alternative B is the preferred alternative. It is based on proven practices and precedents in the Northern environments. It relies largely on natural topography and involves fewer, shallower dykes than Alternative A. Water quality during dewatering is independent of mechanical processes. It offers the most flexibility and its large capacity to store water throughout the mine life addressed upset conditions and reduces the risk of accidental discharge of waters or wastes to the surrounding environment.

Table 4-2 Comparison of Alternatives A and B

Evaluation Criteria	Alternatives	
	Alternative A	**Alternative B**
Technical Feasibility	Contingency capacity to manage variances in the environmental assumptions is reduced. Operational complexity of the TDS water treatment plant will increase associated risk. Management of any seepage from the ring dyke will be required.	Fewer, shallower dykes are required than in Alternative A resulting in a substantial reduction in risk from a dam safety perspective. • Water discharge quality during dewatering is independent of mechanical processes. • Improvement in Project economics is substantial.
Economics	• The longer construction schedule (adding 1 to 2 years) will increase cost. • Capital cost and operating cost of the TDS water treatment plant will be high. • Installing and operating a TSS water treatment plant, and added infrastructure requirements will increase cost. • Construction of a large high-head dam severely impacts the economic viability of the Project.	• Project economics will be substantially improved.
Environmental Considerations	• Loss to fish habitat within Kennady Lake will be minimized. • Construction of a large high-head dam impacts the environmental risks to the Project. • Closure that will rely on the integrity of the engineered structure to contain the fine PK increases the long-term environmental risk.	Water currently residing in Kennady Lake will be used. • Risk of release to the outside environment is less. • Dewatering more area of Kennady Lake than other alternatives assessed will disrupt aquatic life for the life of mine
Alternative Selected	No	Yes

TDS = total dissolved solids; TSS = total suspended solids.

4.1.2.2 Description of Alternative Selected

Option B3 of Alternative B was selected because it includes the benefits identified for Alternative B above and it also includes mitigation to address DFO concerns related to using Area 1 as part of the Fine PKC Facility. In Option B3, the Fine PKC Facility is contained solely in Area 2 rather than Areas 1 and 2 as described in Option B1. The main considerations and assumptions for Alternative B, and specifically Option B3 are summarized below:

- Requirement to place physical structures in the northern portion of the lake basin.
- Areas 4, 6, and 7 will be completely dewatered.
- Areas 2, 3, and 5 will be partially dewatered.

- Dyke A will be constructed in the narrow and shallow section between Area 7 and Area 8.
- Dykes H, I, and J (Figure 4-5; see Figures Appendix) will be constructed under partially dry conditions after the initial lake dewatering of Area 6 in Year -2.
- Water quality will be managed using a water management pond with no operational requirement for TSS or TDS treatment plants.
- Fine PK will be deposited in Area 2 and the mined-out 5034 and Hearne pits when they become available (3.3 Mt fine PK in Area 2, 1.5 Mt in 5034 Pit, and 3.0 Mt in Hearne Pit).
- Fine PK will be managed with the installation of a filter dyke (Dyke L) with low head water control structures around Area 2.
- High-TDS pit water will be temporarily stored in Areas 3 and 5. Water will be discharged from Area 5 to the environment when it meets discharge criteria.
- Coarse PK will be placed on-land in the Coarse PK Pile, in a mined-out open pit, and in the South Mine Rock Pile.
- Mine rock will be placed in the South Mine Rock Pile, West Mine Rock Pile, and in the mined-out 5034 Pit.

4.1.3 Resulting Consequences or Opportunities

At the beginning of Section 4, a key question relevant to fish habitat was introduced: *"To what extent would Kennady Lake need to be physically changed and still provide an economically viable Project while limiting potential environmental risks?"* Alternative B will physically change fish habitat in Areas 2 through 7 of Kennady Lake, although permanent loss would not occur in all areas. Although alternatives affecting less of the lake area were considered, they would require water treatment and long high containment structures, which raised concerns about dam safety and dyke seepage that would result in long-term environmental risks. In contrast, Alternative B, Option B3 will provide an economically viable, less complex Project that greatly reduces the potential engineering and environmental risks.

5 LEVEL 4 DECISIONS

5.1 WATER MANAGEMENT

5.1.1 Lake Refilling at Closure

5.1.1.1 Available Alternatives

Kennady Lake will be refilled following operations. Two alternatives were considered for refilling during closure:

- restoring the natural drainage system and allowing Kennady Lake to refill from natural inflows; or
- restoring the natural drainage system to Kennady Lake, but augmenting the incoming flows by pumping water from Lake N11 to Kennady Lake.

The advantages and disadvantages of each alternative are outlined in Table 5-1.

Table 5-1 Comparison of Alternatives Considered for the Refilling of Kennady Lake

Evaluation Criteria	Alternatives	
	Refilling by Natural Runoff Augmented by Pumping from Lake N11	**Refilling by Natural Runoff**
Technical Feasibility	• Requires pipeline, pumping system, and diffusers to divert water from Lake N11 to Kennady Lake. • Requires pumping plan and monitoring of diverted flows. • Uses water from Lake N11 to supplement restored natural runoff and flow from Kennady Lake watershed. • Includes breaching of temporary diversion dykes C, F, and G to allow flooding within Kennady Lake and flow from upper watersheds.	• Uses only restored natural runoff and flow from Kennady Lake watershed streams and lakes that were diverted during construction. • Includes breaching of temporary diversion dykes E, F and G to allow flooding within Kennady Lake and flow from upper watersheds.
Economics	• Increases initial capital costs compared to the alternative, because of the requirement for pumping and pipeline infrastructure and development of a pumping plan. • Increases operating costs, because of the need for maintenance of infrastructure and monitoring of flows during pumping. • Raises overall economic risk profile compared to the alternative.	• Lowers initial capital costs compared to the alternative. • Lowers operational costs compared to the alternative. • Reduces overall economic risk profile compared to the alternative.

Table 5-1 Comparison of Alternatives Considered for the Refilling of Kennady Lake (continued)

Evaluation Criteria	Alternatives	
	Refilling by Natural Runoff Augmented by Pumping from Lake N11	**Refilling by Natural Runoff**
Environmental Considerations	• Reduces time to refill Kennady Lake (estimated time is 8 years) accelerating ecosystem recovery. • Enables flow mitigation to reduce effects on Arctic grayling downstream of Kennady Lake. • Continues flow mitigation during the refilling period.	• Increases time to refill Kennady Lake (estimated time without augmentation is 24 years) delaying ecosystem recovery. • Requires flow mitigation to be continued for longer period during refilling, rather than returning flows to near baseline sooner..
Alternative Selected	Yes	No

5.1.1.2 Selected Alternative

Although the augmentation of natural runoff by pumping water from Lake N11 is the more costly option, it was selected because it will help speed up the recovery of Kennady Lake by allowing the lake to refill earlier. Drawing water from the N watershed will not only accelerate the refill time, but it will enable augmented flows downstream of Kennady Lake as part of the flow mitigation, as required. Pumping rates from N11 will be managed so that the remaining natural flow rate exiting Lake N11 does not fall below the one-in-five-year dry condition. In years when the Lake N11 outflow is forecast to naturally fall below the one-in-five-year dry condition, no pumping will occur.

5.2 MINE WASTE MANAGEMENT

5.2.1 Placement of Mine Waste

5.2.1.1 Available Alternatives

As this alternative was technically, economically and environmentally advantageous, the option of leaving pits empty was not considered. Some waste had to be stored elsewhere before the first open pit was mined out and after the pits were backfilled to the extent technically and economically possible.

The mine waste from the mine and process plant include mine rock, coarse PK, and fine PK. The mine plan has been developed to optimize the disposal of the waste in the mined-out pits as the pits become available; however, there are timing and capacity issues. Mine waste must be disposed of early in the mine life when the pits are not available, and later in the mine life when the available capacity of the open pits has been filled. The volume of blasted or processed rock is greater than the volume of the original mine rock and ore in situ (i.e., the volume before it is mined and processed). This dictates that there will be more volume of mine waste than the space available in the mined-out open pits, even if each pit could be filled to 100% capacity. Alternate storage sites will be required for this additional volume.

On-land facilities were considered for all the solid mine waste streams; however, they would be situated in part outside of the controlled area which increases the footprint and necessitates the need for ditching and collection systems, and increases the environmental risks associated with these systems in arctic and permafrost conditions. Haulage costs are also a key factor. Storage of large volumes of waste rock at distant facilities requires longer more expensive hauls, increased fuel, more equipment, labour, and infrastructure requirements as well as subsequent increases in fugitive dust from roadways.

A comparison of the alternative to place waste on land or partially within the control basin is presented in Table 5-2.

Table 5-2 Comparison of Alternatives Considered for the Placement of Mine Waste

Evaluation Criteria	Alternatives	
	Partially in Control Basin	Distal Land Storage
Technical Feasibility	• Allows for the placement of the required mine rock piles and other disposal structures closer to the processing plant and operating mine, which reduces haul distances. • Reduces the requirements for perimeter ditching and seepage control systems, because of the natural containment the existing lake basin provides in some areas. • Smaller footprint allows for more centralized control of site-wide runoff control systems and reduced pumping demands.	• Larger disturbance footprint, which would result in: o greater haul distances, higher costs, more fuel usage and fuel storage/transport o disseminated collection, monitoring and management of runoff from the mine rock piles and other disposal facilities that would be located farther away from each other and effect adjacent subwatersheds (in comparison to the "Partially in Controlled Boundary Area basin" alternative). • More extensive seepage and runoff control systems, including impermeable dykes around the fine PKC facility (because of the absence of the natural topographical lows provided by the Controlled boundary Area basin). • Greater overall technical risk.
Economics	• Less expensive alternative, because of the following: o reduced haul distances and associated fuel consumption; and o reduces infrastructure requirements (i.e., ditches, ponds and pumps to control runoff and seepage).	• More expensive alternative, because of the following: o increased haul distances, which results in increased fuel consumption rates and a need for additional trucks; and o larger infrastructure needs in terms of fuel storage and winter road transport; camp and maintenance facilities to support larger truck fleet.

Table 5-2 Comparison of Alternatives Considered for the Placement of Residual Solids (continued)

Evaluation Criteria	Alternatives	
	Partially in Control Basin	**Distal Land Storage**
Environmental Considerations	• Permanent loss of fish habitat in the areas within Kennady Lake where the disposal structures cover the lake bed. • Smaller overall Project disturbance footprint, but larger lake disturbance footprint; restricts impact to lake basins areas impacted by dewatering. • Lower rates of fuel consumption, air emissions and fugitive dust. • Provides permanent underwater storage for PAG rock.	• Greater risk of leakage and off-site release of runoff or seepage water. Effective expansion of the disturbance footprint. Expands into surrounding watersheds. • Potential for greater air emissions, fugitive dust, and fuel burn associated with increased haul distances. • Likely to result in higher and/or more expansive on-land roads and structures, with associated reclamation requirements.
Alternative Selected	Yes	No

5.2.1.2 Selected Alternative

All mine waste (fine PK, coarse PK, and mine rock) disposal areas, except for the West Mine Rock Pile, are located within the catchment areas of Areas 4 and 6. Keeping the waste facilities within the controlled area has environmental advantages including management of runoff, passive containment of operational materials and restoration of affected fish habitat.

5.2.2 Location of Coarse Process Kimberlite Pile

5.2.2.1 Available Alternatives

The coarse PK material is a fine gravel waste material created during the diamond recovery process. The Project Description (De Beers 2010) has multiple storage areas for the coarse PK waste stream over the life of the operation. Initially, the coarse PK is stored on land in the Coarse PK Pile adjacent to Area 4. The location is in close proximity to the processing facility thereby reducing hauling distances and improving operational economics. The residual runoff from the pile will flow to the Tuzo Pit during operations. The Coarse PK Pile would be progressively reclaimed during operations. The Coarse PK Pile will contain small diamonds and locating the facility on land would provide access to the material at a later time, if required. Based on area constraints, the coarse PK can also be placed within the mine rock piles and during later years of mine life disposed of in the mined-out 5034 and Hearne pits. There is also the option to utilize the coarse PK as a cover layer for the Fine PKC Facility. In this potential option, the coarse PK layer would be placed periodically during the mine operational life to allow for the progressive reclamation and closure of the Fine PKC Facility once the open pits are available. The portion initially placed on land adjacent to Area 4 would be reclaimed by having a mine rock cover placed over it during the later years of the mine operations.

5.2.2.2 Selected Alternative

The coarse PK can be stored at many locations within the Project area. Because this alternative is flexible and includes a variety of alternate locations, no other alternatives were evaluated. The advantages of this alternative include:

- Initially placing the Coarse PK Pile on land adjacent to Area 4 reduces hauling distances and improves operational economics.
- Depositing coarse PK in the mined-out pits or within the waste rock piles when available minimizes the Project footprint.
- Locating the facility on land, especially for initial production when the processing efficiency is being refined, would provide access to small diamonds in the coarse PK at a later time.
- Placing the Coarse PK Pile on land adjacent to the Tuzo Pit allows for cost-effective progressive reclamation of the pile during mine operations.
- Utilizing the coarse PK as a cover layer for the Fine PKC Facility would provide an additional option for the progressive reclamation and closure of the Fine PKC Facility.

5.2.3 Location of Mine Rock Pile(s)

5.2.3.1 Available Alternatives

Over 234 Mt of mine rock are mined throughout the life of the operation. A small portion (4 Mt) of the initial mine rock material mined is used for construction purposes to be used in dams, dykes, roads, construction aggregate, as well as operational uses (e.g., gravel for blast hole stemming and road maintenance). Use of mining waste as construction material avoids the need for quarry sites and their associated disturbance.

A large portion (approximately 35% of the total or 80 Mt) of the mine rock can be placed in the mined-out 5034 Pit. This results in the need to place and store the remaining rock material (approximately 150 Mt). Two alternatives are evaluated here (Table 5-3):

- Construction of two mine rock piles that encroach on Areas 5 and 6 (i.e., part of each pile will be submerged in water when Kennady Lake is refilled at closure).
- Construction of one mine rock pile on land on the southwest part of the Project site (slightly northwest of the Hearne Pit).

During early conceptual stages of the Project, two mine rock piles on-land were suggested. They were to be located northwest and southwest of the centre of Kennady Lake. However, a geotechnical investigation found that the land at the southwest location was more suitable for the placement of mine rock piles. This alternative was not considered further.

Table 5-3 Comparison of Alternatives Considered for the Location of the Mine Rock Piles

Evaluation Criteria	Construct Two Facilities that Encroach on Areas 5 and 6 (Alternative 1)	Construct One On-Land Facility (Alternative 2)
Technical Feasibility		
Ease of Construction	• Mine rock piles located closer to the mining areas than the other alternative. • Geotechnical foundation conditions are much more favourable in the southwest than in the northwest.	• Geotechnical foundation conditions are much more favourable in the southwest than in the northwest.
Ease of operation	• The mine rock piles positioned as close to the mining areas as possible to reduce haul distances without compromising any pit extension. • The footprints of the mine rock piles will drain directly into the Kennady Lake basin and extend partly into the basin eliminating the need for collection ditches, ponds, and pumps to control runoff.	• Placement of the mine rock pile on land will lead to increased truck haulage hours required to move the waste rock the added distance compared to Alternative 1. • Indirectly this will require greater quantities of fuel, more fuel storage capacity, higher winter road traffic, more haul trucks, and more operators compared to Alternative 1. • The mine rock pile will require collection ditches, ponds and pumps to capture runoff.
Degree of reliance on impermeable barriers or permafrost to control seepage	• None required as seepage and runoff from mine rock piles will flow directly into Kennady Lake after re-filling	• Not required as seepage will flow to Kennady Lake. Mine rock pile is within the Kennady Lake watershed.
Risk of loss of containment	• None as there is no containment.	• Potential uncontrolled seepage to other watersheds.
Overall technical risk profile	• Standard waste pile designs. Common practice in NWT, except that these piles extend into Kennady Lake and are partly submerged in lake water at closure, which is not common.	• Standard waste pile designs. Common practice in NWT.

Table 5-3 Comparison of Alternatives Considered for the Location of the Mine Rock Piles (continued)

Evaluation Criteria	Construct Two Facilities that Encroach on Areas 5 and 6 (Alternative 1)	Construct One On-Land Facility (Alternative 2)
Economics		
Influence on capital costs	• Base Case	• >$15M - Requires additional truck, Higher prestripping costs in capital phase due to longer hauls.
Influence on operating costs	• Base Case - Viable	• >$70M in increased hauling costs over life of operation.
Economic risk profile	• Base Case - Viable	• May make deeper resources uneconomic.
Overall effect on project viability	• Project viable.	• Reduces Project viability.
Environmental Considerations		
Effect to Project footprint	• Placing the mine rock containment facilities within Areas 5 and 6 of Kennady Lake minimizes the Project footprint (i.e., the physical on-land disturbance of the Project will be minimized).	• Constructing one on-land, mine rock containment facility would impact adjacent waterbodies and watersheds and increase the project footprint compared to Alternative A.
Ease of seepage control	• Any water running off the mine rock piles will passively flow to the WMP. During closure, there will be long-term seepage directly into Kennady Lake and fish habitat.	
Lakes directly affected	• Alternative A will result in the permanent loss of fish habitat in portions of Areas 5 & 6 of Kennady Lake. This alternative will also result in the permanent loss of Lake Kb1 (located under the West Rock Pile); however, Lake Kb1 is considered non fish-bearing.	• Constructing one, on-land facility would result in the permanent loss of a portion of the southwest arm of Kennady Lake, and Lakes Ka1, E2, and E3, which are considered non-fish bearing. This alternative was included in Alternative A in which the mine rock formed a cover over the Fine PKC Facility located in the southwest arm. The permanent loss was primarily due to the Fine PKC Facility.
Lakes potentially indirectly affected	• NA	• Lakes D10 and E1 are expected to receive runoff and seepage from the on-land mine rock pile. Lake E1 is a fish-bearing lake.
Haul distance and resulting effect on dust and other aerial emissions	• Placing the mine rock containment facilities within Minimizes haulage distances, fuel consumption and effects on dust and other aerial emissions (GHG emissions) because of the proximity of the facilities to operations.	• Placing one mine rock containment facility on-land Increases the haulage distances, fuel consumption and effects on dust and other aerial emissions (GHG emissions) compared to Alternative 1.
Other considerations	• Allows for a more compact disturbance footprint that includes smaller rock piles than the alternatives and more efficient use of mine rock as pit backfill.	• More fuel storage and transport. Increased fuel transport over winter road and through entire fuel transport system from Yellowknife to Edmonton area.
Overall environmental profile	• Minimizes overall Project footprint but results in permanent destruction of fish habitat in Kennady Lake Areas 4 and 5.	• Expands project foot print into neighbouring watershed and results in permanent destruction of SW arm of Area 6.
Alternative Selected	Yes	No

5.2.3.2 Selected Alternative

Alternative 1 was selected. Extending a portion of the mine rock piles into the dewatered Kennady Lake basin allows for all mine rock material to be stored and contained within the control area. Portions of the piles were designed to encroach in the Kennady lakebed effectively infilling portions of the Area 5 and Area 6. The locations provide for close proximity to the pits and natural means for controlling and capturing any runoff water. Runoff water from the waste rock piles will passively flow to the water management basin.

Alternative 1 also provides for a settling basin within the footprint of the west waste rock pile, if required, for floc-treated water pumped to Areas 3 and 5 from other areas in the controlled area (e.g., Areas 6 and 7, mined out pits). The sediments in this basin would be covered by waste rock and isolated from entering the reclaimed Kennady Lake at the end of closure.

The mine rock piles situated closer to the pits also provides economical haulage distances and minimizes disturbance area. This alternative considers the use of pit storage, where the 5034 Pit is proposed to be filled with Tuzo mine rock. Mine rock piles, through progressive reclamation practices, would be graded and reclaimed during operations.

6 RESULTING PROJECT IMPACTS ON FISH HABITAT

6.1 DIRECT PROJECT EFFECTS

The overall effects of the Project on fish and fish habitat are assessed in the 2011 EIS Update (Sections 8.10 and 9.10, De Beers 2011 for Alternative B) and in the 2012 EIS Supplement (Sections 8.2.7 and 9.2.7, De Beers 2012 for Alternative B3). Long-term effects are described in Section 10 of both the 2011 EIS Update and 2012 EIS Supplement. The direct Project effects on fish habitat are also summarized in the Conceptual Compensation Plan (CCP, Section 3, Appendix 3.II of the 2010 EIS [De Beers 2010]) in conjunction with options reviewed and recommended for habitat compensation.

The construction and operation of the Gahcho Kué mine will cause harmful alteration, disruption, or destruction (HADD) of fish habitat in the Kennady Lake watershed. The affected habitat areas include portions of Kennady Lake and adjacent lakes within the Kennady Lake watershed that will be permanently lost, portions that will be physically altered after dewatering and later submerged in the refilled Kennady Lake, and portions that will be dewatered (or partially dewatered) but not otherwise physically altered before submerged in the refilled Kennady Lake.

Changes to fish habitat will occur due to the development of the Project, e.g., excavation of the mine pits, placement of mine rock piles, the WMP, Coarse PK Pile and Fine PKC Facility, dykes, and other construction activities. The affected habitat areas related to the selected alternative (Alternative B3) include the following:

- **Habitat Destruction -** portions of Kennady Lake and adjacent lakes within the Kennady Lake watershed that will be permanently lost by infilling by mine rock, Fine PKC Facility, Coarse PK Pile, dykes, and roads.
- **Habitat Alteration -** portions of Kennady Lake that will be physically altered after dewatering and later submerged in the refilled Kennady Lake (e.g., habitat altered by the placement of dykes, pits, berms, and roads in the dewatered Kennady Lake during operations).
- **Habitat Disruption -** portions of Kennady Lake that will be dewatered (or partially dewatered), but not otherwise physically altered before being submerged in the refilled Kennady Lake (i.e., disrupted due to

dewatering, but upon refilling, the physical habitat will be similar to the pre-mine condition).

During Project construction and operations, there will also be some alterations of flows within the Kennady Lake watershed and in areas downstream from the Kennady Lake watershed. A flow mitigation plan is under development in consultation with regulators to offset downstream flow reductions, such that impacts to habitat availability will be mitigated. At closure, the flow regime will be restored to near baseline conditions, following lake refilling and dyke removals.

Based on the updated footprint of the Project related to the supplemental mitigation associated with the Fine PKC Facility, the areas of habitat losses presented in the CCP have been recalculated.

6.1.1 Permanently Lost Areas - Habitat Destruction

The area of permanent losses associated with the Project has been reduced from the 2010 EIS and CCP. As the footprint of the Fine PKC Facility will be confined to Area 2 of Kennady Lake, Lake A1 (34.5 ha), Lake A2 (3.07 ha), Lake A5 (0.14 ha), Lake A6 (0.07 ha), and Lake A7 (0.12 ha) will no longer be permanently lost due to the Project.

Based on the revised calculations, the Project will result in the permanent loss of approximately 158.9 ha of lake area (Table 6-1), due to the placement of the following:

- the Fine PKC Facility (Area 2);
- the Coarse PK Pile (edge of Area 4 and Lake Kb4);
- West Mine Rock Pile (part of Area 5 and Lake Ka1);
- South Mine Rock Pile (part of Area 6); and
- permanent dykes.

Most of the losses will occur in Kennady Lake (156.9 ha), representing about 19% of the total pre-development Kennady Lake area of 813.6 ha. The remainder of the permanently lost areas includes the complete loss of Lakes Ka1, and Kb4, and partial losses of small portions of Lakes N7, and E1 associated with roads and dykes.

Table 6-1 Areas of Habitat Loss by Loss Category

Loss Category	Area (ha)		
	Kennady Lake	Adjacent Waterbodies	Total
Permanent Losses – Habitat Destruction	156.9	2.0	**158.9**
Physically Altered and Re-submerged Areas – Habitat Alteration	84.1	0.0	**84.1**
Dewatered and Re-submerged Areas – Habitat Disruption	427.5	1.9	**429.4**
Total	**668.5**	**3.9**	**672.4**

6.1.2 Physically Altered and Re-submerged Areas – Habitat Alteration

Fish habitats that are physically altered during operations and then resubmerged in the refilled Kennady Lake at closure, include parts of Kennady Lake Areas 3, 4, 6, and 7, related to the development of mine pits, roads, dykes, and water containment ponds.

The Project will result in 84.1 ha of lake area in Kennady Lake being physically altered and re-submerged at closure (Table 6-1), representing about 10% of the total pre-mine Kennady Lake area of 813.6 ha.

6.1.3 Dewatered and Re-submerged Areas – Habitat Disruption

The areas that will be dewatered, or partially dewatered, (i.e., disrupted during operations but not otherwise altered) before being re-submerged at closure include portions of Kennady Lake Areas 3 through 7 (those parts that are not either permanently lost or physically altered), and Lake D1.

The Project will result in approximately 429.4 ha of lake area being dewatered and re-submerged at closure but will remain otherwise unaltered (Table 6-1). This area includes 427.5 ha in Kennady Lake, which represents about 53% of the total pre-mine Kennady Lake area and 1.9 ha in Lake D1.

6.1.4 Stream Habitat Losses

The Project will result in either the permanent loss of stream habitat due to project infrastructure, alteration of stream habitat due to flooding or realignment, or disruption of stream habitat due to dewatering that will be restored at closure but are otherwise unaltered. The total stream habitat area affected across all categories of loss is 0.6 ha. As the footprint of the Fine PKC Facility will be confined to Area 2 of Kennady Lake, there will no longer be permanent losses in watercourse area associated with the tributaries from the A watershed lakes.

6.1.5 Compensation Plan

Where prevention of harmful habitat alteration, disruption and destruction is not feasible, fish habitat of equivalent or higher productive capacity will be developed. The CCP describes the various options considered for providing compensation, and presents a proposed fish habitat conceptual compensation plan to achieve no net loss of fish habitat according to DFO's Fish Habitat Management Policy. The selection of the habitat compensation approach included consideration of the hierarchy of compensation preferences as outlined in the DFO Policy for Management of Fish Habitat (DFO 1986), Habitat Conservation and Protection Guidelines (DFO 1998), and Practitioner's Guide to Habitat Compensation (DFO 2006). The options presented in the CCP have also been discussed with local and regional DFO at several meetings over the past two years.

The options for providing compensation currently include the following:

- creating similar habitat near the development site;
  - construction of impounding dykes to increase lake depth and surface area in the new/expanded Lake D-E-N to immediate west of Kennady Lake; and
  - creating habitat within Kennady Lake by widening the top bench of pits to create shelf areas where they extend onto land.
- habitat enhancement structures to increase the productive capacity of existing habitat;
  - construction of finger reefs in Kennady Lake; and
  - construction of habitat structures on the decommissioned mine pits/dykes.

Estimates of the amount of habitat, in terms of surface area, gained or enhanced provided by the proposed compensation plan are summarized in Table 6-2. The area of gains does not include additional habitat enhancements with Area 6 and Area 7 of Kennady Lake, but does include the enhancement of Dyke B.

Table 6-2 Areas of Habitat Gains by Gain Category

Gain Category	Area (ha)		
	Kennady Lake	Flooded Area (429 masl)	Total
Newly Created Habitat	56.6	184.4	**241.0**
Enhanced Habitat	53.6	107.2	**160.8**
Altered Habitat	68.1	0.0	**68.1**
Habitat Disruption	427.5	1.9	**429.4**
Total	**605.8**	**293.5**	**899.3**

Quantification of habitat gains in terms of HUs, and determination of compensation ratios based on HUs, will be examined as part of the development of a detailed compensation plan, which will be developed in consultation with DFO, and with input from communities.

6.2 IMPACTS ON FISH AND FISH HABITAT FROM DEWATERING IN THE PARTIALLY DEWATERED AREAS

The following provides a summary of the expected fish habitat conditions in the partially dewatered areas (primarily Areas 3 and 5), as well as the biological implications to fish and fish habitat for the selected alternative (Alternative B3). Based on our understanding of the system, the dewatering process and construction activities (i.e., dyke installation) the habitat conditions in the isolated and partially dewatered portions of Kennady Lake will no longer provide an environment suitable for the persistence of fish.

As a result of the dewatering process, the effects to fish and fish habitat would include exposed shoreline habitat, reduced littoral area and aquatic macrophyte growth which is expected to inhibit spawning habitat, reduced overwintering habitat and resuspension of lake bottom sediments for extended periods.

Cumulatively, the Project activities that are undertaken during the construction phase, would lead to degradation of habitat within the isolated and dewatered lake, which would not support an environment suitable for the persistence of fish. Details on impacts to fish and fish habitat resulting from these Project activities are described below.

6.2.1 Summary of Expected Conditions

Based on our understanding of Kennady Lake and the effects that will occur as a result of the multi-phased dewatering and construction program, it is expected that within a short period of time, the habitat will change considerably and fish will be exposed to substantially different conditions. Within several months, the water levels in Areas 2 through 7 of Kennady Lake will decrease, exposing shoreline and shallow areas. The following conditions would be expected to occur as a result:

- access to tributaries for fish species that spawn in streams would be prevented;
- shoreline habitat would be dewatered and littoral area reduced;
- shoreline spawning habitat would become exposed;
- aquatic macrophyte growth would impact spawning habitat;
- overwintering habitat would be reduced; and
- lake bottom sediments would become re-suspended for extended periods of time causing adverse effects on fish.

As stated above, cumulatively these changes would lead to degradation of habitat within the isolated and dewatered lake, which would not support an environment suitable for the persistence of fish. Additional information on expected conditions is provided below.

6.2.2 Isolation from Stream Spawning Habitat

As a result of lowering lake levels and establishing the controlled area within the Kennady Lake watershed, fish species that spawn in, or migrate through, tributary streams to spawn (i.e., Arctic grayling and northern pike) would be unable to access spawning habitat for the life of the mine.

Baseline studies indicate that Kennady Lake Arctic grayling spawn primarily in streams downstream of Kennady Lake (i.e., in the L and M watersheds). However, spawning also occurs in the upper watersheds (i.e., A, B, and D watersheds) (2010 EIS, Annex J, Section J4.4.2.4, [De Beers 2010]). Arctic grayling spawn during spring in small gravel- or rocky-bottomed streams (Scott and Crossman 1973; Richardson et al. 2001), with current velocities less than 1.4 metres per second (m/s) (Evans et al. 2002). Kennady Lake northern pike primarily spawn in lakes or streams outside of Kennady Lake, with the majority of spawning occurring in the D watershed located on the western side of Kennady

Lake due to the abundance of shoreline vegetation in Lakes D2 and D3; some spawning likely also occurs in other upper watersheds, as well as downstream in the M watershed. Northern pike generally spawn after ice break-up on the heavily flooded floodplains of rivers, marshes, and bays of larger lakes (Scott and Crossman 1973); in northern populations, spawning generally starts at the end of May through June (Richardson et al. 2001). In Kennady Lake itself, aquatic vegetation is limited, with most of the aquatic vegetation located in shallow, protected embayments in Areas 6 and 7.

Access to downstream habitats would be prevented from the installation, during construction, of Dyke A between Areas 7 and 8 to allow for the dewatering to occur. The upper watersheds will be diverted away from Kennady Lake to establish the controlled area, and as a result, fish would also be unable to access these watersheds. Therefore, spawning habitat for these fish species that use tributary streams will be unavailable for the life of mine. As there would be no, or extremely limited, suitable spawning habitat in the isolated and partially dewatered lake, the reproduction and recruitment of Arctic grayling and northern pike would be severely compromised.

6.2.3 Reduction in Littoral Area

The dewatering program will destroy shoreline habitat and littoral area, as these would be exposed during the partial dewatering. As described in the 2010 EIS Annex J, Section J4.1.1 (De Beers 2010), and shown in Figures 6-1 to 6-3 (see Figures Appendix) for Areas 2 to 7, the current habitat in Kennady Lake can be classified into three types:

- shallow, nearshore habitat within the zone of freezing and ice scour (i.e., less than 2 m deep);
- nearshore habitat deeper than the zone of ice scour but subject to wave action that prevents excessive accumulation of sediments (i.e., greater than 2 m but less than 4 m in depth); and
- deep, offshore habitat with substrate generally consisting of a uniform layer of loose, thick organic material and fine sediment (i.e., greater than 4 m in depth).

The nearshore habitat is primarily washed boulder/cobble. These types of habitat are generally found along exposed shorelines where wind and wave action keep shorelines free of silt. Calmer areas protected from prevailing winds (i.e., embayments, leeward sides of islands) have more fine sediment within the substrate. In general, substrates are increasingly embedded and covered with sediment with increasing depth (i.e., below a zone where wind and wave action keep shoreline substrates washed or free from loose fine particulates and/or not embedded in fine materials).

As a result of dewatering, littoral zone habitat will be exposed and destroyed (Table 6-3; Figure 6-4). Although De Beers may be able to further dewater the lake deeper than 3 m, a water level reduction of 3 m was assumed to provide an indication of potential effects of dewatering on littoral zone habitat. Based on the 3 m drawdown, approximately 75% of littoral zone (i.e., 0 to 4 m in depth) in Areas 2 to 5 would be lost (Table 6-3: Figure 6-4).

Table 6-3 Littoral Areas Lost in Kennady Lake as a Result of Initial 3 m Drawdown

Areas 2 through 5			
	Pre-development Area (ha)	**Area Affected by Dewatering (ha)**	**Loss from Dewatering (%)**
Shallow near-shore (0 to 2 m)	58.5	58.5	100%
Near-shore (2 to 4 m)	58.9	28.1	48%
Total Littoral (0 to 4 m)	117.4	86.6	74%
Areas 3 and 5			
Shallow near-shore (0 to 2 m)	29.1	29.1	100%
Near-shore (2 to 4 m)	31.8	15.2	48%
Total Littoral (0 to 4 m)	60.9	44.3	73%

ha = hectares;% = percent; m = metres.

Littoral areas are important for fish production, especially in northern lakes. This area provides warm water with light penetration, which is important for feeding and rearing. The destruction of approximately three-quarters of the littoral zone habitat would cause a decrease in food availability (i.e., benthic invertebrates, forage fish base), as well as a loss of rearing/feeding habitat for juvenile life stages.

6.2.4 Shoreline Spawning Habitat

Due to reduction in lake levels, most of the high quality lake trout and round whitefish spawning habitat will be exposed and unavailable. As described in Annex J (De Beers 2010), most of the high quality lake trout and round whitefish spawning habitat is in 2 to 4 m depth range, where it is kept free of silt and fine organic debris by wave-generated currents, and below the zone of ice scour. Unlike lakes such as Snap Lake and Lac de Gras, offshore shoals do not exist in Kennady Lake.

Lake trout spawn in September and October in northern areas, with most spawning taking place over cobble and large gravel substrate in shallow nearshore areas of lakes (Richardson et al. 2001). Wind and wave action is the primary mechanism keeping the spawning areas clean (Martin and Olver 1980). Wave action and currents maintain the incubating eggs free of detritus and remove metabolic wastes. Eggs remain in the substrate until hatching in early spring (i.e., March and April) (Scott and Crossman 1973; Richardson et al. 2001). Round whitefish spawn in October in northern regions, with spawning typically taking place over gravel and rubble substrates. Eggs are broadcast over the substrate and incubate until hatching some time from March to May (Scott and Crossman 1973; Richardson et al. 2001).

As the lake level is reduced, the lake bed in the remaining areas would still be subject to up to 2 m of ice scour. Beyond this new ice scour zone, the substrate is composed primarily of loose, organic sediment that would not be suitable for lake trout and round whitefish spawning, at least during the initial years until sufficient wave action clears the sediments from the substrate. Therefore, suitable spawning habitat for these fish species would be lost for the duration of the mine.

It is also expected that resuspension of lake bed sediments would occur as a result of the reduction in water levels; any remaining substrate suitable for spawning would be affected by increased sedimentation, which has the potential to infill interstices and smother embryos, and cause localized oxygen deficiencies in deeper interstitial water due to decomposition of organic material. Furthermore, in late fall/early winter, the sediment suspended in the lake would be expected to settle due to the lack of wind and wave action under ice-covered conditions. This sedimentation could affect lake trout and round whitefish egg development, adversely affecting any remaining lake trout and round whitefish spawning habitat.

As a result of the lack of spawning habitat and increased sedimentation, lake trout and round whitefish populations would be compromised due to lack of recruitment over the life of the mine.

6.2.5 Spawning Habitat - Vegetation

Due to the drawdown in lake level, the shoreline, in-lake habitat with aquatic vegetation would be destroyed and in areas with steeper drop off, it would not re-establish. As described above, aquatic vegetation in Kennady Lake is extremely limited and typically restricted to a narrow fringe of sedges in shallow, protected embayments (primarily in Areas 6 and 7) and at tributary mouths where sediments have accumulated. In Areas 2, 3 and 5, vegetation is rare (2% of nearshore habitat).

As a result of the destruction of shoreline area, no in-lake spawning habitat would be present for northern pike; this would also affect spawning for ninespine stickleback, which also requires aquatic vegetation for spawning. As described above, northern pike would be unable to access tributary streams to spawn elsewhere; therefore, there would be no spawning habitat for northern pike in the isolated and partially dewatered lake and recruitment would not occur. The northern pike population would be severely compromised due to lack of recruitment over the life of the mine.

6.2.6 Effects from Suspended Sediment

As the water level is drawn down and the shallow areas become exposed, as well as deeper areas with increased silt substrate, there would be localized areas of high total suspended solids (TSS), especially in shallow areas and along sheltered shorelines. Dewatering is expected to continue until the water quality is no longer suitable for release to the aquatic environment (i.e., release into Area 8 and Lake N11). At this point, there is a significant likelihood that habitat conditions in the partially dewatered areas of Kennady Lake would soon become unsuitable for fish due to increasingly higher turbidity and TSS levels.

Exposure to suspended sediment can affect the health of fish, with the nature and extent of adverse effects ranging from behavioural effects to mortality. The magnitude of the effect is a function of TSS concentration and duration of exposure. Newcombe and Jensen (1996) developed a dose-response model to provide an indication of the potential effects on fish that could occur from increased suspended sediment. This relationship estimates the magnitude of adverse effect expected when fish are exposed to a given concentration of sediment over a given period. Their dose-response relationship generates a severity of effect (SEV) value ranging from 0 to 14. A SEV value of zero implies no effect. SEV values of one to three indicates behavioural changes are expected, four to eight indicates sublethal effects ranging from increased respiration and coughing rates to major physiological stress. Lethal and paralethal effects are expected with SEV values of 9 to 14.

As the water level is drawn down 3 m in Kennady Lake, the TSS modelling suggests localized areas of high TSS will occur in shallow areas along the downwind shorelines (Appendix B). As described in Appendix B, drawing Kennady Lake down beyond the resuspension zone (i.e., below approximately 1.4 m), will expose new areas of the lake bed to resuspension activity.

Three linked systems were used to predict the TSS concentrations in Area 2 and Areas 3 and 5 of Kennady Lake at a water surface elevation of 420.7 m and after a 3 m drawdown to an elevation of 417.7 m (Appendix B). The first system predicted wave geometry for single wind storms on the lake by applying the classic forecasting equations for waves in shallow water, as presented in U.S. Army Corps of Engineers (1984). Second, the modelling used equations developed by Sheng and Lick (1979) to predict wave-induced resuspension of bed sediment. Finally, the modelling employed the Generalized Environmental Modelling System for Surface waters (GEMSS®) to simulate hydrodynamic dispersion and settling of TSS in the lake.

The model results predicted that a 6 hour (h) duration storm event with wind speeds of 6, 8, and 10 m/s would have little effect on TSS concentrations in Kennady Lake at a water surface elevation of 420.7 m (i.e., baseline water levels); TSS concentrations in most areas of the lake were predicted to remain within the observed background TSS range.

However, at a water surface elevation of 417.7 m (i.e., after a 3 m drawdown), the model results predicted that localized areas of high TSS would occur in shallow areas along the downwind shorelines with maximum concentrations ranging from 35 to 3,100 milligrams per litre (mg/L) within 24 h of a storm event, depending on the intensity and duration of wind (i.e., storm) events, and prior frequency of these conditions. Modelling also suggests that a single wind storm with wind speeds of 6 m/s over a 6 h period has the potential to cause elevated TSS in the order of 50 mg/L to 1,000 mg/L on the downwind shore for 2 to 30 days after the occurrence of the storm, with elevated levels of TSS lasting until the lake freezes. Wind-induced mixing would cause elevated levels of TSS throughout most of the basin for longer periods of time.

On average, 16 storms with wind speeds of at least 6 m/s and durations greater than 6 h may be expected to occur during the open-water season each year (based on weather data from Snap Lake Mine). The potential, then, is for much greater long-term TSS concentrations in Area 2 and Areas 3 and 5 of Kennady

Lake after the lake has been drawn down to 417.7 m; TSS concentrations would also be expected to be higher as a result of multiple storms than predicted by a single storm.

Initially, behavioural responses would be expected, where fish move away from the localized areas with high levels of TSS. However, with wind and wave action mixing the basin, concentrations may be elevated to levels where fish are unable to move away to escape physiological effects. Over time, mixing would cause TSS to be elevated throughout most of the partially dewatered basin for a period of time. Areas with refuge from elevated TSS would become more limited, or not available, causing stress on remaining fish within the isolated and partially dewatered lake.

Fish in the area are not well adapted to naturally high levels of TSS. For example, background TSS levels are generally low, with about 70% of water samples collected in baseline programs below detection limits in open water conditions (2010 EIS Annex I, Appendix I.II [De Beers 2010]). Based on the Newcombe and Jensen (1996) dose-response relationship, the SEV values suggest that exposure to TSS at these concentrations for extended periods will cause responses ranging from major physiological stress (i.e., long term reduction in feeding rate and feeding success, poor condition), to paralethal (i.e., reduced growth rate, delayed hatching, reduced fish density), or even lethal effects.

6.2.7 Effects from Increased Turbidity

From the resuspension of lake-bottom sediments due to the dewatering program, there would also be effects on fish from the increased turbidity (i.e., lack of water clarity and associated lack of light penetration). Recent reviews, such as Robertson et al. (2006) and Birtwell et al. (2008), looked at turbidity separate from TSS due to effects on fish related to feeding and growth.

From the increased turbidity generated from the dewatering and mixing, there is a potential for substantial effects on primary productivity. For example, studies in Alaskan lakes by Lloyd et al. (1987) found dramatic changes in light penetration and subsequent primary production caused by even small (5 to 10 NTU) increases in turbidity above naturally clear conditions. Effects on primary productivity could include decreased biomass of the phytoplankton community, or at high levels, the community may be eradicated. This would in turn affect the secondary productivity within the isolated and partially dewatered lake. This change in the lower trophic communities would reduce the food base for fish, affecting the forage fish community, as well as large-bodied species.

Decreased light penetration in water will also reduce fish foraging success, as it reduces the visual ability of fish to detect prey and predators. Even small changes in turbidity have been shown to have very dramatic effects on the feeding of clear-water fishes, and impact stream and lake productivity similarly (e.g., Lloyd 1987). Due to the reduction in food availability from effects to lower trophic levels and feeding success, the growth of fish within the isolated and partially dewatered lake would subsequently be negatively affected.

The increases in turbidity may be more related to suspension of the silt and clays than the larger particles. To provide an indication of the potential for the lake bottom sediment to remain in suspension, the results of settling tests with Kennady Lake bed sediment were reviewed. The tests were performed with segregated fine lake bed sediment, with a starting sediment mass of 50 grams per litre (g/L), and comprised of predominantly silt material (i.e., 2% sand, 95% silt, and 3% clay). Initially the silt was found to remain in suspension, but settled by around one day. The fine grained material (clays) remained in suspension after 10 days. Based on these tests, it is shown that clay material will contribute to long-term turbidity and TSS. Recent sampling in Areas 3 and 5 found sediments mainly composed of sand (~55%), with some silt (~30%) and clay (~15%), i.e., more clays than shown in this settling test. In the isolated and partially dewatered lake, it is expected that wind and wave action would keep the levels elevated over long periods of time in certain areas of the dewatered lake (as described above). De Beers will also undertake additional sediment testing to better characterize the lake bed and sediment resuspension prior to dewatering.

6.2.8 Overwintering Habitat

Under ice-covered conditions, the decrease in water levels in the isolated and partially dewatered lake would lead to a decrease in under-ice water volume and increased sediment oxygen demand from the changes to volume and lake bed sediment surface area ratio; as a result, overwintering habitat would become more limited.

Currently, the maximum depth in Areas 3 and 5 is approximately 15 m, with a mean depth of approximately 6 m. Although De Beers may be able to dewater Kennady Lake further than 3 m, a water level reduction of 3 m was assumed to provide an indication of potential effects of dewatering on overwintering habitat. Based on the 3 m drawdown, the maximum depth of the isolated and partially dewatered lake would be approximately 12 m, with a mean depth of 4.5 m. This would translate into an under-ice depth of less than 10 m, and an approximate reduction in under-ice volume of 51% (prior to dewatering, the volume of Areas 3 and 5 is approximately 11.5 million cubic metres [Mm^3], and with a 3 m drawdown, the volume is approximately 5.65 Mm^3).

To provide an indication on how overwintering habitat could be affected, two approaches were used to determine how the draw down may influence the winter oxygen depletion rate (WODR) and hence late winter DO in Areas 3 and 5:

- an empirical relationship that was referenced in the 2011 EIS Update (De Beers 2011); and
- the Generalized Environmental Modelling System for Surface waters (GEMSS®) dissolved oxygen (DO) model that was developed for the 2012 EIS Supplement (De Beers 2012).

The empirical relationship of Mathias and Barica (1980) to estimate the WODR is based on the ratio of sediment surface area and water volume for lakes following before and after the partial dewatering of Areas 3 and 5. Mathias and Barica (1980) present two relationships, one for oligotrophic lakes and one for mesotrophic lakes. Mathias and Barica (1980) developed these relationships from data from Canadian lakes that included 23 prairie lakes, 5 Arctic lakes, 26 Experimental Lake Area (ELA) lakes, and 16 Ontario lakes. For this estimation, the relationship for oligotrophic lakes was applied (Eqn 1).

WODR (mg O_2/L/day) = 0.075x + 0.012 for oligotrophic lakes (r = 0.78) *Eqn 1*

where x = ratio of surface area of sediment/lake water volume (m^2/m^3).

The WODR in Areas 3 and 5 under ice-covered condition increases by approximately 25% with the 3 m drawdown (pre-development: surface area = 2.2 km^2, volume = 11.5 Mm^3, WODR = 0.027 mg/L/d; 3 m draw down: surface area = 1.6 km^2, volume = 5.65 Mm^3, WODR = 0.033 mg/L/d). This estimate is considered conservative as the surface area of Areas 3 and 5 was calculated on a plan basis, and does not include supplemental area provided by bathymetric slope. Additionally, additional sediment oxygen demand (SOD) associated with elevated TSS (as discussed above) during periods leading into under ice conditions, which may reduce the early winter DO levels in Areas 3 and 5, is not accounted for in this estimation.

The three dimensional hydrodynamic and water quality GEMSS® model developed for the 2012 EIS Supplement (Appendix 8.V, De Beers 2012) was used to predict late winter dissolved oxygen (DO) concentrations in Areas 3 and 5 of Kennady Lake after a 3 m drawdown. Winter oxygen depletion rates were calculated by comparing predicted DO concentrations at the end of the open-water season and at the end of the ice-covered season. Model predictions at a surface water elevation with 3 m draw down (417.7 m) were compared to model predictions at the pre-development a surface water elevation (420.7 m) presented in Appendix 8.V in the 2012 EIS Supplement. The model consisted of all of the calibrated model coefficients from the calibration time period, with a baseline calibrated SOD value of -0.25 g $O_2/m^2/d$. In contrast to the Mathias and Barica (1980) empirical approach, the pre-development and 3 m drawdown scenarios for late winter indicate a similar WODR, with a similar DO decline through the water column (Figure 6-5).

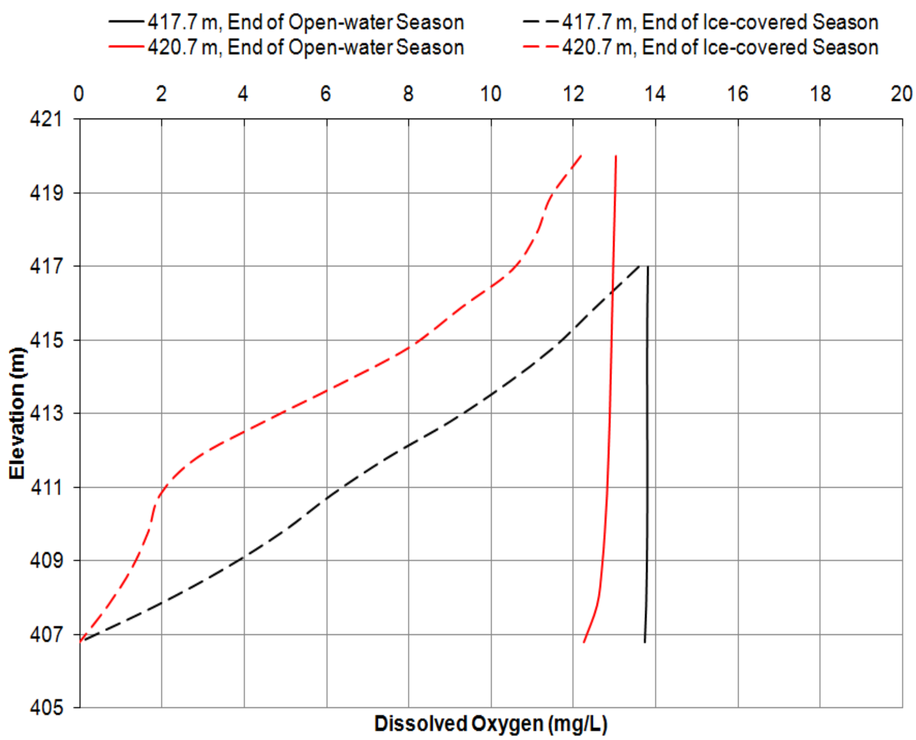
Similar to the Mathias and Barica (1980) relationship, the influence of TSS as an additional SOD source was not incorporated into the model; SOD has been shown to increase due to resuspension of bottom sediments (Doyle and Rounds 2003). The resuspension of bottom sediment and the increase in TSS concentrations in Areas 3 and 5 in the drawn down condition that were predicted to develop with a 3 m draw down, may persist for a short duration as ice-cover develops and increase DO depletion through some or all of the water column in early winter. To examine the potential for this increase in oxygen demand, the model-calibrated SOD value was increased by 50% (-0.375 g $O_2/m^2/d$) and 100% (-0.5 g $O_2/m^2/d$).

The baseline calibrated SOD rate of -0.25 g DO/m^2/d is similar to that applied to 3-D water quality model that was developed for the De Beers Snap Lake Mine (Golder 2011), and to SOD values (0.23 g DO/m^2/d) estimated for a set of eutrophic lakes within the prairie, south-eastern Ontario, Arctic, and the Experimental Lake Area regions of Canada (Mathias and Barica 1980). Whilst the calibrated baseline SOD agrees with the pre-development condition for Kennady Lake and Snap Lake to explain the observed DO late winter DO profiles, the SOD applied to the TSS scenarios may be overestimated. Lower SOD values (-0.10 g DO/m^2/d) have been reported for a small arctic gravel pit lake (i.e., 10.7 m maximum depth, and an area of 0.013 km^2) (White et al. 2008) and central Lake Erie (-0.164 g DO/m^2/d) (Matisoff and Neeson 2005).

Figure 6-6 shows DO profiles in Areas 3 and 5 with the varying SOD rates at the end of the open-water season and at the end of the ice-covered season at a surface water elevation of 417.7 m. As SOD is increased from -0.25 to -0.50 g $O_2/m^2/d$, the winter oxygen depletion rate increases (Figure 6-6), which indicates that with an increased DO demand at the onset of winter, it would be anticipated that late winter DO concentrations would be lower than modelled with pre-development SOD value.

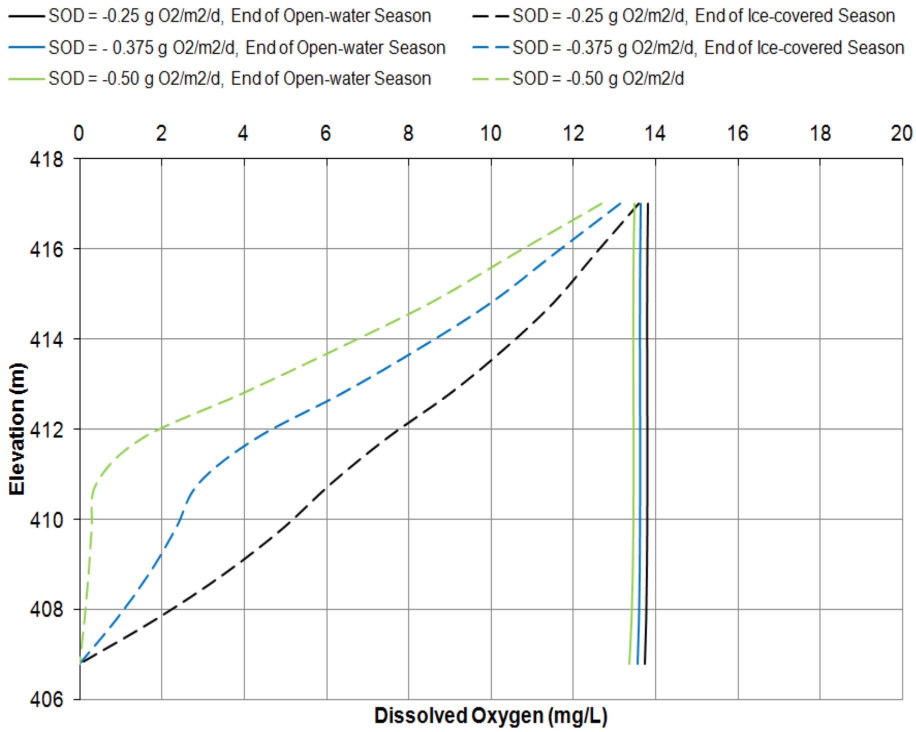
The lower volume with DO levels that are suitable for fish, associated with the potential for increased WODR and increased TSS, could lead to a reduction in overwintering habitat compared to baseline, which may be limiting for some species. Although overwintering habitat would likely be available in deeper regions of Areas 3 and 5, the habitat suitability and availability will be reduced. Furthermore, any fish remaining in the basin would congregate in these deeper areas, further increasing the oxygen demand in these areas and reducing the under-ice dissolved oxygen levels.

Figure 6-5 Dissolved Oxygen Profiles in Areas 3 and 5 with an SOD of -0.25 g $O_2/m^2/d$ at the End of the Open-water Season and at the End of the Ice-covered Season at a Surface Water Elevation of 420.7 and 417.7 m



m = metre; m² = square metre; mg = milligram; g = gram; L = litre; O_2 = oxygen; d = day.

Figure 6-6 Dissolved Oxygen Profiles in Areas 3 and 5 with an SOD of -0.25, -0.375 and -0.50 g $O_2/m^2/d$ at a Surface Water Elevation of 417.7 m



m = metre; m^2 = square metre; mg = milligram; g = gram; L = litre; O_2 = oxygen; d = day

The lower dissolved oxygen levels, combined with potentially elevated suspended sediment will cause additional physiological stress on fish through the sensitive winter period, and may inhibit survival. As a result, there may be a higher likelihood of winterkill occurring, with the potential for sensitive cold-water species to not survive. The reduction in overwintering habitat capacity would be expected to cause declines in fish populations over time, especially for sensitive fish species that are more susceptible to winterkill.

7 CONCLUSION

The alternative analysis detailed in this document outlines the decision tree process De Beers used to consider and evaluate a number of mine development options before determining the final proposed mine development plan which is described in the Project Description (Section 3, EIS Supplement; De Beers 2012).

Due the type and location of the kimberlite ore bodies, open pit mining at a production rate of 3 Mt/y was mining alternative that was the most economically viable and technically feasible. The mining plan that would achieve the selected production rate was to mine multiple pits sequentially, but with overlap, in the order of 5034 Pit, then the Hearne Pit, and finally the Tuzo Pit. This overlap allows the mined-out open pits to become available during operations for deposition of mine waste and mine water, limiting the volume of mine waste that would need to be deposited elsewhere.

Water and waste management alternatives and options can be grouped by two fundamental concepts. Alternative A with on-land disposal options that would require full dewatering Areas 4, 6 and possibly 7 with water treatment, long high containment structures and physical structures in the lake to access the ore bodies and Alternative B that requires fully dewatering Areas 4, 6 and 7 and partially dewatering Areas 2, 3 and 5, which would not rely on water treatment but would require the placement of physical structures in the lake to access the ore bodies. Using a set of criteria to evaluate each alternative and associated options advantages and disadvantages were assessed for each alternative. Overall, although Alternative A would affect less of the lake area it would increase the on-land footprint because of the need for a long high containment structure; present higher long-term risks concerning dam safety and dyke seepage; rely on water treatment plants and is economically less viable. In contrast, Alternative B would reduce the overall terrestrial footprint by containing the physical structures to the lake basin which can be either removed or breached at closure. Moreover, Alternative B is an economically viable, less complex Project that greatly reduces the potential engineering and environmental risks. As such, Alternative B was selected.

Once the operational water and waste management plan alternative was selected, the next stage in the assessment was to consider closure alternatives for lake refilling, placement of residual solids, location of coarse PK and mine rock piles were considered. It was determine that by only partially dewatering Areas 2, 3 and 5 and supplementing refilling with Lake N11 lake that refilling time would be significantly reduced.

With respect to fine PK storage locations, options were considered however the preferred option, Option B3, would reduce the overall footprint. All mine waste (fine PK, coarse PK, and mine rock) disposal areas are located in the controlled area. Keeping the waste facilities within the controlled area has environmental advantages including management of runoff, passive containment of operational materials and restoration of affected fish habitat

Water management and the construction of water retention structures associated with accessing the ore bodies within the overlying Kennady Lake led to the following key considerations for the analysis of alternatives. De Beers determined that to economically access and develop the kimberlite deposits located under Kennady Lake in a technically sound manner, that limits environmental impacts, all portions of Kennady Lake upstream of Dyke A (Areas 2 through 7) must therefore be fully or partially dewatered. Specifically, the mine plan requires that Areas 2 through 7 of Kennady Lake be fully or partially dewatered for the following reasons:

- To facilitate the construction of physical structures within the dewatered lake to safely access the ore bodies and minimize environmental risks to the receiving environment.
- To minimize overall environmental and safety risks by isolating the mine disturbance in a natural basin (i.e., controlled area).
- To allow the operational flexibility and contingency options to cope with unexpected conditions and/or variations in baseline assumptions.
- To achieve reclamation and closure objectives (i.e., self-sustaining ecosystems or habitats capable to sustain fish that do not require long-term maintenance).
- To gain acceptance by Aboriginal communities
- Reduction of the terrestrial footprint and the perception of potential risks to caribou
- Reduce the overall refilling of Kennady Lake by only partially dewatering sections of the lake and by supplementing with Lake N11.

Cumulatively, the dewatering process and associated construction activities (i.e., placement of physical structures in the lake) required to safely access the underlying kimberlite deposits are expected to render fish habitat within Areas 2 through 7 of Kennady Lake unsuitable for the operational life of the Project. The effects include:

- loss of littoral zone;

- loss of access to downstream water bodies and spawning habitat;
- reduction in lake trout, northern pike, and Arctic grayling populations to the point where it would result in a complete loss of these species over time;
- increased turbidity and TSS from the re-suspension of lake-bottom sediments and construction of dykes an dams, resulting in additive degradation of fish habitat;
- stress, or even paralethal or lethal effects to remaining fish populations; and
- reduction in the suitability and availability of overwintering habitat.

Overall, it is expected that if fish were to remain in the isolated and partially dewatered basin, there would be a significant effect on the fish community remaining due to the highly disturbed and substantially altered environment. The habitat conditions in the fully and partially dewatered portions of Kennady Lake (i.e., Areas 2 to 7) would no longer provide an environment suitable for fish following the dewatering and construction program. As a result, De Beers plans to conduct a fish salvage to remove fish from Areas 2 to 7 of Kennady Lake prior to, and during, dewatering. Moreover, De Beers will provide habitat compensation for permanent and temporary losses to fish habitat.

Although there will be some permanent losses of fish habitat within Kennady Lake due to the placement of mine rock piles, PK storage and mine pits; compensation habitats will be constructed to offset losses. Fish habitat conditions within the dewatered and partially dewatered areas are expected to be restored post closure allowing for the re-establishment of an aquatic ecosystem.

At mine closure, Kennady Lake will be refilled, and after Dyke A is removed, Kennady Lake will once again consist of five interconnected basins and be reconnected with the downstream watersheds. Water will once again flow from the upper A, B, D, and E watersheds through the refilled Kennady Lake (Areas 3 to 8), and downstream through Stream K5 into the L and M watersheds. Downstream flows will be similar to pre-disturbance conditions.

A fully functioning aquatic ecosystem will develop within Kennady Lake after refilling and reconnection of its basins. The long-term hydrology of Kennady Lake is expected to return to a state similar to current conditions and water quality in the refilled lake to return to conditions suitable to support aquatic life. The physical and chemical environment in Kennady Lake, therefore, will allow for the re-establishment of an aquatic ecosystem, including the re-establishment of the fish community within Kennady Lake.

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