

**APPENDIX 4B**

**JAY PIPE PROJECT**

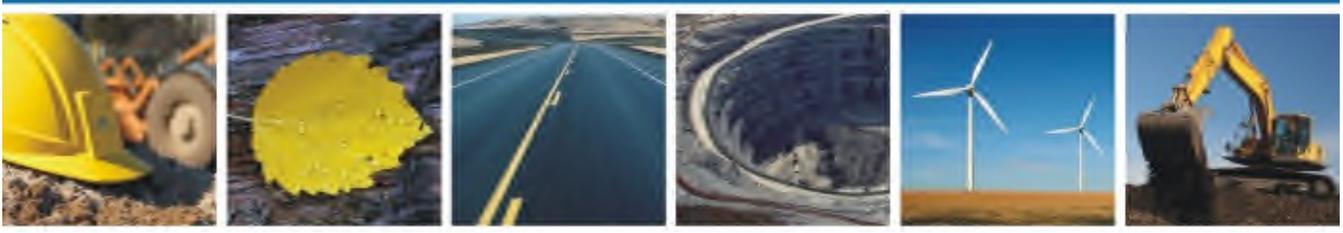
**CIVIL ENGINEERING COMPONENTS**

**SEPTEMBER 2013**

DOMINION DIAMOND EKATI CORPORATION

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# JAY PIPE DEVELOPMENT: REVISED IDENTIFICATION PHASE STUDY OF CIVIL ENGINEERING COMPONENTS EKATI DIAMOND MINE, NT



## REPORT

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SEPTEMBER 2013  
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## EXECUTIVE SUMMARY

This work updates the Jay Pipe identification phase study completed by EBA in June 2010. The primary focus has been to investigate improved mining and construction methodologies with the aim of reducing costs, increasing safe operations, and maintaining operational reliability. A secondary focus was to review and modify the haul road and dyke quarry plans based on more recent information.

The 2010 proposed causeway and dyke quarry location appears suitable based on the existing geological mapping. However, due to acid rock drainage concerns, the haul road quarry source will need to be switched from Misery waste rock pile to a potential location near the existing Misery haul road or the proposed Jay Pipe road. Air photo interpretation indicates a relatively large number of potential locations. The identification of a suitable quarry site is not expected to be a significant challenge.

The most promising development in dyke construction technology is considered to be in-situ concrete mixing for the plastic cut-off wall. EBA feels that using cutter soil mixing (CSM) technology instead of the more conventional Diavik-style approach will result in a significant cost saving.

The 2010 costs for a conventional Diavik-style cut-off wall were updated to a total of \$894 million. The comparative estimate for CSM is \$783 million (CAD). Cost changes were the result of a change in plastic concrete overconsumption estimates, an increase in the Jay Pipe haul road development costs, changes to contingency and EPCM engineering costs, and an overall reduction due to improved technology. EBA recommends that comparative prices for CSM and jet grouting be obtained on a per unit of surface area basis by soliciting formal bids from several pre-qualified contractors.

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## **LIMITATIONS OF REPORT**

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## 1.0 INTRODUCTION

EBA Engineering Consultants Ltd. operating as EBA, A Tetra Tech Company (EBA) was retained by Dominion Diamond EKATI Corporation (DDEC) to undertake a revised identification phase study of civil engineering components at the proposed EKATI Jay Pipe Development.

The initial Jay Pipe identification phase study was completed by EBA in June 2010 (EBA 2010). DDEC has requested that EBA revise the work based on potential improved mining and construction methodologies with the aim of safe operations, operational reliability, and reducing costs. In addition, a review of the haul road and dyke quarries was done in light of new information.

All costs are reported using 2013 Canadian dollars and are estimated to have an accuracy  $\pm 30\%$ .

### 1.1 Identification Phase Study Background

The Jay Pipe deposit is located beneath Lac du Sauvage and is approximately 1.2 km from the shoreline. The area and shoreline close to the Jay Pipe deposit is undeveloped, although facilities and infrastructure exist nearby at Misery Camp (approximately 7 km to the southeast) and the main EKATI mine site located approximately 30 km to the northwest.

EBA's 2010 study presented the design basis for the alignment, design, and construction approach for Jay Pipe dyke and infrastructure components to support the development (EBA 2010). The EBA report also provided, at a concept level, the proposed construction methods together with estimated costs and construction schedule. Potential geotechnical and construction risks associated with dyke construction were identified and measures were recommended to mitigate these risks. The identification study was completed by a project team with vast experience with dyke and infrastructure construction in northern environments, including the chief engineer for the Diavik A154 dyke and the consortium of contractors who built both the A154 and A418 dykes.

The 2010 IPS focused on the evaluation of a dyke with plastic cut-off walls in Lac du Sauvage large enough to permit the development of Jay Pipe by open pit mining methods. Besides the dyke, other civil engineering infrastructure and mining components identified by EBA as necessary for Jay Pipe development included:

- A quarry for dyke and road construction materials;
- An access road to connect the dyke with the existing Misery road;
- A waste rock storage area (WRSA);
- A land-based construction support site, including laydown areas and quarry access roads; and
- A causeway and bridge linking the dyke to the mainland.

### 1.2 Revised Identification Phase Study

EBA's scope of work for updating the 2010 Jay Pipe identification phase study involved the following tasks:

- Evaluating other potential dyke construction approaches with the intent of reducing costs, maintaining reliability, and contributing to safe operations.

- Re-evaluating the granular material source for the initial Jay Pipe road construction. EBA's assumption in the 2010 identification phase study was to utilize waste rock from the Misery Pit WRSA. However, granite from this source will not be available due to potential acid drainage issues and new sources have been identified. Estimated development costs have been adjusted accordingly.
- Geological review of the proposed dyke quarry location and potential geochemical conditions. The primary purpose of the dyke quarry material is for causeway and dyke construction around the Jay Pipe Development.
- Review and revision of the project costs and schedule. Specifically, costs have been broken out on a component basis.

### 1.3 Project Team

EBA selected a project team that had first-hand experience with dyke and infrastructure construction in northern environments. In addition to the EBA Arctic Group, which has been involved with development at EKATI since 1993, EBA consulted:

- Mr. John Wonnacott, P.Eng., who was Deputy Project Manager/Chief Engineer for the Diavik A154 dyke from February 1997 to August 2003, and
- BAUER Resources Canada Ltd. (BAUER). BAUER contributed through several meetings and developed recommendations addressing the improved technologies aspects of this document. BAUER supplied the cut-off wall equipment used on the A154 and A418 dykes at Diavik.

EBA would like to acknowledge and express our gratitude to Mr. John Wonnacott and BAUER for significant contributions to this document.

## 2.0 DYKE QUARRY LOCATION

The 2010 EBA-proposed dyke and causeway quarry is located within the footprint of the proposed waste rock dump approximately 3.5 km to the west of the Jay Pipe deposit. The volume of the proposed quarry is 3.8M m<sup>3</sup> of material (Figure 1).

DDEC recently raised the concern that the originally proposed dyke quarry location was located in metasediment material. Metasediments at EKATI are considered potentially acid generating (PAG) and are avoided as a construction material.

A bedrock geology map provided by DDEC appears to show the 2010 proposed quarry location entirely within the Two Mica Granite (Figure 1). As a result, the quarry location appears to be suitable at this time, although more investigative work will be required. The following section provides comments with respect to experience at other pits at the EKATI mine site and an understanding of the regional and local geology of the EKATI site.

## 2.1 Site Geology

The Geologic Survey of Canada (GSC) 1:50,000 mapping (Kjarsgaard, 1994) is the most complete geological mapping available for the area of the Jay Pipe Development (Figure 2). There is no known exploration mapping available for this area.

The footprint of the proposed quarry is located within the unit mapped as Two Mica Granite. Approximately 100 m to the west of the proposed quarry location is a unit mapped as Greywacke. There are no additional units mapped in close proximity to the proposed quarry location. The Greywacke unit is interchangeably referred to as Metasediment in various reports and maps prepared for the EKATI mine site.

The proposed Jay Pipe pit is located within an area of three mapped units, including the Two Mica Granite, Greywacke, and a Tonalite unit. The Jay Pipe kimberlite deposit is hosted within the Two Mica Granite (Figure 2).

The Misery Main deposit occupies the contact between Archean metasedimentary rocks (also known in reports as Schist, Biotite Schist and Greywacke) and the Two Mica Granite. It is not clear if the Greywacke observed at the Misery deposit can be considered analogous to that adjacent to the quarry location. Similarly, it is not clear if the Two Mica Granite unit mapped in the area of the proposed quarry would be analogous to the Two Mica Granite unit mapped in the area of the proposed pit for the Jay pipe as they are separated by a swath of Greywacke.

At the Misery Main deposit, the Two Mica Granite is noted to weather to a white to light-grey colour and contain abundant primary muscovite. Textures vary from fine to coarse-grained pegmatic and equigranular to weakly porphyritic (BHP Billiton, 2010). Compositionally, it is composed of fine to coarse-grained quartz, potassium feldspar, and plagioclase, with 3-15% biotite and muscovite. Tourmaline laths up to 0.5 cm to 3.5 cm are observed and pegmatite phases are common. Sulphide minerals are rarely observed, and if present, occur only in trace amounts (BHP Billiton, 2010).

## 2.2 Geochemistry Assumptions

There has been no analytical test work completed for rock units encountered in either of the proposed quarry or proposed pit locations for the Jay Pipe Development. Assumptions concerning the mineralogy, geochemical composition, and ultimate potential for acid generation or metal leaching of the rock units encountered at the proposed quarry location are based on experience at other pits on the EKATI mine site.

The Misery pipe is the closest operational pipe to Jay Pipe, and has an extensive database of geological information associated with it, including geochemical analyses completed on waste rock units encountered.

Geochemical test work completed for the rock units encountered at Misery indicate the Metasediment material is considered PAG and that the Two Mica Granite is considered non-acid generating (NAG). Metal leaching and whole rock elemental analyses indicate that there is not significant concern for metal leaching from either unit.

Samples of Two Mica Granite material submitted for analysis from the Misery pipe indicate very low sulphide sulphur values and low neutralization potential values. A subset of 10 samples submitted in 1997 (Norecol, Dames & Moore, 1997) all reported total sulphur values at or below the detection limit of 0.01%

sulphur. Neutralization potential values range from <1 to 4 kg CaCO<sub>3</sub>/tonne. The mean neutralization potential ratio for these samples was 100, indicating strongly NAG material.

### 2.3 Proposed Quarry Discussion and Recommendations

The 2010 proposed quarry location appears suitable based on the existing geological mapping. The following recommendations should be used to confirm the proposed location.

#### Recommendations

Detailed geological mapping and geochemical characterization of the rock units should be undertaken to ascertain potential for acid generation and metal leaching. Geological mapping of the proposed quarry location will confirm the units mapped by the GSC and determine the extents of various units in the area. Geological descriptions for each of the rock units should include a detailed focus on identifying sulphide and carbonate minerals present.

The geological descriptions should be compared to core logging or geological mapping information available from the Misery deposit to determine whether the rock units are analogous. If the rock units are the same, then the geochemical characterization for Misery rock units may be proposed as surrogate data for Jay Pipe Development.

In the case that a clear analogue of rock units encountered at Misery and Jay pipes cannot be derived, then it is recommended that confirmatory geochemical test work be completed to determine acid rock drainage (ARD) and metal leaching (ML) potential from quarried rocks. Analytical testing should be conducted according to procedures outlined in the Mine Environment Neutral Drainage (MEND) Guidelines and represent a standard suite of static tests such as:

- Acid base accounting (ABA) including paste pH, total sulphur, total carbon, total inorganic carbon, maximum potential acidity, and neutralization potential.
- Shake flask extraction tests at a 3:1 fluid to solid ratio using distilled water.
- Metal concentration for samples through inductively coupled plasma atomic emission spectroscopy (ICP-AES).
- Mineralogical evaluation in which the minerals present in a material are identified, the amounts of different materials present are quantified, and the chemistry of individual mineral grains are examined.

Based on an estimated quarried rock volume of 3.8M m<sup>3</sup> and an estimated density of 2.8 g/cm<sup>3</sup>, the material weight to characterize is 10,640,000 tonnes. The MEND guidelines suggest that the number of samples required to characterize this weight of material, when no previous information is available, is 80 samples. This number may be adjusted based on preliminary results, the homogeneity of material, and availability of information on analogous material.

Drilling investigations prior to construction will be necessary to confirm the extent of geological units at depth. It is recommended that during the excavation there is ongoing testing to confirm geochemical characterization of rock units encountered.

### **3.0 ROAD CONSTRUCTION QUARRY LOCATION**

The Jay Pipe development will require construction of a haul road to the main Misery access road. The road will initially provide construction access and will later be used as a haul road to transport ore from Jay Pipe to the EKATI process plant. The 2010 EBA report assumed the haul road would be built using rock from the existing Misery WRSA. However, this rock is not available due to PAG concerns. EBA has identified sites that can be investigated further as potential quarries for the Jay Pipe haul road.

Figure 3 shows potential quarry sites that are within the vicinity of the proposed Jay Pipe haul road. The sites were chosen based on aerial photo interpretation and accessibility to the existing Misery access road or proposed Jay Pipe haul road. The geology in Figure 2 was not consulted in these selections.

#### **3.1 Potential Locations and Material Quantity**

There are a relatively large number of potential locations and the identification of a suitable quarry site is not expected to be a significant challenge. Identification of potential quarries should follow a similar procedure to that laid out in Section 2.3 for the proposed dyke and causeway quarry.

The haul road is estimated to require approximately 1.1M m<sup>3</sup> of material. Assuming the quarry cut is 10 to 15 m deep, an area of 100,000 m<sup>3</sup> is expected to be sufficient for the quarry needs.

Initial development targets are expected to be sites identified near the proposed Jay Pipe haul road intersection.

#### **3.2 Accessibility**

The proposed quarries are closer than the Misery WRSA, so there are expected to be some haulage savings. It is assumed that potential quarries along the existing Misery road will be given priority, as otherwise equipment will need to be placed in the winter for the summer construction season.

### **4.0 IMPROVED DYKE CONSTRUCTION TECHNOLOGIES**

The most promising development in dyke construction technology is considered to be in-situ concrete mixing for the plastic cut-off wall. This method has the potential to reduce costs, increase safety, and offer an operationally reliable solution. BAUER refers to this technology as cutter soil mixing, or CSM, although the technology is not limited to them. This report uses the BAUER terminology.

The plastic cut-off wall proposed in the 2010 EBA report followed the procedure used successfully at the Diavik A154 and A418 dykes. The Diavik-style dyke is a proven method, but there appear to be significant cost, schedule, and safety advantages to the CSM construction approach. The CSM method has not been used in the far north, but CSM-style projects number in the hundreds and there appears to be general acceptance within industry. The method is under consideration for Diavik's proposed A21 dyke.

## 4.1 CSM Overview

The CSM technology aims to create a cut-off wall by using a modified trench cutter to mix cement and bentonite slurry with the in-situ material. This approach combines the excavation and placement phases into a continuous process.

The general CSM procedure is as follows:

1. The cutter head, operating as a mixing tool, is advanced into the ground at a continuous rate. The dyke core and till material is broken up and mixed thoroughly by the cutting wheels on the cutter head. Water is pumped to nozzles located between the cutter wheels, to facilitate the operation of the cutter.
2. After reaching the design depth, the cutter head is slowly extracted while a slurry of water, bentonite and cement is added. The cutting wheel rotation homogenizes the in-situ mixture with the cement slurry.

The process is repeated to create a continuous wall through the placement of overlapping primary and secondary panels, in the same manner used in the Diavik A154 and A418 dyke cut-off wall construction.

**Table 1: Comparison of Cut-off Wall Installation Approaches**

Diavik-Style Approach	CSM Approach
1. Vibrodensification	1. Vibrodensification
2. Guide Walls	2. Guide Walls
3. Excavate Cut-Off Wall Trench	3. CSM Cut-Off Wall
4. Place Cut-Off Wall	4. Jet Grouting
5. Jet Grouting	

## 4.2 Potential CSM Advantages

The combination of excavation and placement in the CSM method provides potential advantages in terms of cost, safety, and schedule.

### Potential Cost and Schedule Advantages

- Smaller guide wall installation. The Diavik-style method used large concrete guide wall sections to prevent collapse of the top of the trench excavation. The CSM approach will require guide wall sections that are approximately a third the size of previously used guide walls.
- Fewer people and less equipment on site. BAUER estimates 10 to 12 fewer people on site and equipment needs would be cut in half.

- Reduce vibrodensification. Vibrodensification was primarily needed to prevent excavated walls from collapsing before concrete placement. With CSM, the primary purpose will be to prevent settling of the dyke structure. It is estimated that the vibrodensification requirement will be halved.
- Smaller on-site footprint. The reduction in equipment and smaller footprint of the CSM rigs means that less area is needed and a narrower dyke profile can be constructed. This will result in less granular (Zone 2) material being required, which will amount to a significant cost reduction.
- Less cement and bentonite overconsumption. The CSM trench is 0.8 m wide, which is the width of the cutter wheel mixing tool. The Diavik-style excavation can experience significant sloughing, increasing the overall volume of cut-off wall material.
- Cement/bentonite transportation, not concrete. The portable cement and bentonite mix plant will be located on the dyke near the CSM rigs. It requires a supply of cement and bentonite, not concrete, which will reduce the volume of material being transported to the dyke. At Diavik, the plastic concrete mix plant was located off the dyke.
- Energy savings. BAUER expects a reduction in fuel consumption related to the additional efficiency of the CSM process and decrease in equipment.
- Cut-off wall placement is not a separate process. In the Diavik-style method, plastic concrete placement was an additional construction step that required tremie pipes, an installation crane, and a plastic concrete supply pipeline.
- Time savings.
  - Smaller guide wall eliminates the need to construct a dyke platform in two stages. The Diavik approach required placement of embankment material in two steps. The first step was to build the embankment to an initial elevation and place the guide walls. The second step was to add 1.5 m of embankment material to complete the working platform.
  - Eliminate plastic concrete placement as a separate step.
  - Eliminate the construction and operation of bentonite slurry ponds and bentonite delivery and return pipelines.
  - Eliminate the use of grabs and chisels to advance the slurry trench excavation.
  - No more sloughing of the till during excavation, thus saving time otherwise lost correcting overbreak in the till.
  - If predrilling is used (Section 4.4, Option 2), it can be done in the cold months of early spring, before the CSM cut-off wall is started.

### **Potential Safety and Environment Advantages**

- Less equipment and people on site. Traffic and congestion will be significantly reduced.

- Minimal open trench excavation and stability concerns. There will be a small open excavation done for the top of the trench, but the CSM method largely eliminates many of the safety concerns surrounding open excavations and stability from the Diavik-style method.
- With no open slurry trench, there is much less chance of having a leak of bentonite slurry into the surrounding environment.

### 4.3 CSM Mix Design

A pre-construction mix-design testing program will be established to determine a range for key parameters such as cement and bentonite content.

Mix design will be done using site materials to closely replicate the in-situ conditions. Samples of Lac du Sauvage water will be used as the water source for the testing program. Samples of cement and bentonite will be sourced from the selected suppliers.

The amount of cementitious material pumped into the panels during the CSM process will be based on the results of the pre-construction cut-off wall mix design testing program, which will determine the proportion of binders used to achieve the specified project performance criteria. As the grain-size distribution curve of the fine dyke core material can be adjusted, variations in the grain size distribution could be explored to achieve a technical and economical optimum for the CSM cut-off wall.

The parameters will be monitored and adjustments made during construction.

### 4.4 CSM Application Options

There are three options currently being considered for CSM:

#### CSM Option 1

Use the cutter to penetrate the dyke embankment core and into the glacial till, cutting through boulders to the maximum extent possible in the same manner that the cutter was used at Diavik for placement of the plastic concrete cut-off wall. When the excavation has advanced as far as possible, install a cut-off wall by mixing the in-situ material while slowly withdrawing the cutter up to the dyke surface. Then, rely on jet grouting to seal the space from the top of bedrock, up to the bottom of the cutoff wall created by the CSM. This introduces the probability of having long jet grout columns where large till boulders prevent cutter penetration.

BAUER indicates that some predrilling will be used in this method, but only in locations where significant boulders are encountered.

#### CSM Option 2

Predrill a series of closely-spaced holes along the cut-off wall alignment using an 80 cm casing that is advanced into the till. Run a suite of specialized augers, grabs and cutting tools inside the casing to penetrate or remove boulders. The resulting hole is filled with dike core material and then the CSM technique is followed as per Option 1 above.

BAUER recommends Option 2 as their preferred option because they feel it is the most economical and time efficient way to handle till boulders. However they will not be able to penetrate all the boulders, so jet grouting will still be required to seal the space between bedrock and the bottom of the cutoff wall.

The BAUER predrilling recommendation assumes that jet grouting is more expensive and more time consuming than a cut-off wall created by CSM. They also believe that predrilling and dyke core material placement in the predrilled holes will result in a cost saving compared to using CSM without predrilling.

### **CSM Option 3**

Similar to Option 1, the cutter is advanced through the dyke embankment and into the glacial. Cutting conditions are ceased when a strictly defined set of guidelines are reached. Complete the cut-off wall using CSM and jet grouting to seal the underside of the completed cut-off wall to bedrock.

This option differs from Option 1 in the amount of effort cutting through boulders before jet grouting. During the construction of the Diavik A154 dyke, cutting through boulders resulted in a large direct expense. It took significant time and caused the excavation to slough, resulting in at least a 30% increase in plastic concrete consumption.

## **4.5 CSM Discussion**

EBA feels that using CSM technology instead of the more conventional cutter and plastic concrete wall approach will result in a significant cost saving, and this is reflected in the projected costs presented in Section 6. However, it is not clear that predrilling and attempting to maximize the depth of the cut-off wall into bouldery till will be the most cost effective approach. It may be that planning to use jet grouting to seal almost all the glacial till will turn out to be more cost effective.

EBA recommends that comparative prices for CSM and Jet Grouting be obtained (on a per unit of surface area basis) by soliciting formal bids from several pre-qualified contractors and the final choice of which CSM option to use for construction should be based on the quoted prices.

## 5.0 COSTS

Cost estimates for the CSM-developed Jay Pipe dyke are presented here, including reasoning, comparison with previous cost projections, and detailed cost breakdowns. The alternative dyke and mining concepts presented in Section 5 are not included.

### 5.1 Cost Changes from 2010 to 2013

Most of the costs are the same as numbers presented in 2010. The mining construction industry is currently in a downturn and there is more equipment and personnel available than in 2010. The changes to most costs, when accounting for inflation, are expected to be insignificant.

#### Overconsumption Volume

The 2010 EBA report estimated 20% overconsumption of plastic concrete for the Diavik-style cut-off wall. After review, EBA no longer feels this is representative and the costs presented here assume 40% overconsumption. Forty percent was also originally proposed by the Lac de Gras Construction consortium (EBA 2010).

The overconsumption revision results in an overall increase of \$22.9 million to the 2010 costs, assuming use of a Diavik-style cut-off wall.

#### Haul Road Quarry

The Misery waste rock can no longer be used as a potential source for the Jay Pipe haul road. This will result in additional costs due to the exploitation of a new area. Drilling and blasting costs will be similar, since permafrost aggradation into Misery WRSA would have required drilling and blasting techniques as well. It is also assumed that haul distances to the Misery WRSA would have been slightly longer.

The change in location of the haul road quarry is estimated to increase the costs by \$11.1 million.

### 5.2 Improved Technology Savings

EBA feels that using CSM technology instead of the more conventional cutter and plastic concrete wall approach will result in a significant cost saving. Table 2 presents a comparison of the Diavik-style dyke with a CSM constructed dyke. BAUER estimated costs with CSM Option 2 in mind. The costs here reflect that scenario.

**Table 2: Cost Saving Comparison**

Component	Estimated Overall Costs with CSM	Estimate Overall Costs with Diavik-Style Dyke
Infrastructure	\$ 45,579,656	\$ 45,579,656
Dyke Construction	\$ 485,928,184	\$ 580,427,468
Transportation, Accommodations, and Miscellaneous Costs	\$ 169,000,000	\$ 175,500,000
Contingency	\$ 83,000,000	\$ 93,000,000
<b>TOTAL</b>	<b>\$ 783,507,840</b>	<b>\$ 894,507,124</b>

The primary savings come from the following areas:

**Increased CSM Efficiency**

There are numerous potential advantages with the CSM technology documented in detail in Section 4.2. These changes are estimated to reduce the cut-off wall construction costs by \$70 million.

**Dyke Volume Decrease**

The reduced footprint of the CSM equipment means that the dyke width can be reduced by up to 4 metres. This corresponds to a reduction of \$15 million in quarried material.

**Reduced Vibrodensification Requirement**

The need for extensive vibrodensification is reduced because there is no longer an open excavation that can potentially collapse. This corresponds to a reduction of \$8 million.

**Reduced Contingency and EPCM Engineering**

Unidentified risk contingency was kept at the rate used in the 2010 EBA report, which was 10% of site construction costs. With the decrease in construction costs, unidentified risk contingency costs were reduced from \$63 million to \$53 million.

EPCM engineering is calculated as 7% of the site construction cost. EPCM costs have been reduced from \$44 million to \$37.5 million.

**5.3 Detailed Costs**

Detailed costs in the four areas of infrastructure, dyke construction, assorted, and contingency, are broken out below. Infrastructure costs (Table 3) remain the same as in 2010. The dyke construction costs have assumed Option 2 presented in Section 4.4 (Table 4). The transportation, accommodations, and assorted costs are presented in Table 5. Contingency costs are given in Table 6. A more detailed cost summary is presented in Appendix B.

**Table 3: Infrastructure**

Item	Description	Price
1.1	Jay Pipe Haul Road*	\$ 24,017,491
1.2	Causeway*	\$ 4,602,602
1.3	Bridge	\$ 2,614,547
1.4	Quarry Access Road*	\$ 879,753
1.5	Jay Pipe Laydown Areas*	\$ 11,419,023
1.6	Quarry Laydown Areas*	\$ 449,548
1.7	Quarry Stockpile*	\$ 1,596,692
<b>Subtotal</b>		<b>\$ 45,579,656</b>
<b>Note:</b> * Indicates a change from the 2010 estimate		

**Table 4: Dyke Construction**

Item	Description	Price
2.1	Dyke*	\$ 119,691,657
2.2	Toe Berm	\$ 25,853,369
2.3	Turbidity Barrier	\$ 2,343,342
2.4	Dredging Pipeline	\$ 5,265,810
2.5	Dredging	\$ 11,836,209
2.6	Filter Blanket	\$ 30,771,381
2.7	Vibrodensification*	\$ 8,841,215
2.8	Concrete Guide Walls*	\$ 2,457,000
2.9	CSM Plastic Concrete Wall*	\$ 113,929,065
2.10	Pre-Drilled CSM to Bedrock*	\$ 23,378,706
2.10	Jet Grout*	\$ 43,231,124
2.11	Grout Curtain	\$ 47,372,692
2.12	Dewatering	\$ 21,454,121
2.13	Instrumentation	\$ 12,035,158
2.14	Thermosyphons	\$ 17,467,334
<b>Subtotal</b>		<b>\$ 485,928,184</b>
<b>Note:</b> * Indicates a change from the 2010 estimate		

**Table 5: Transportation, Accommodations, and Miscellaneous Costs**

Item	Description	Price
3.1	Mob and demob of materials and equipment (winter road)	\$ 64,000,000
3.2	Air Transport of critical materials	\$ 2,000,000
3.3	Air Transport of all personnel to/from site	\$ 3,300,000
3.4	Accommodations infrastructure at Misery site (construction and operation)	\$ 38,500,000
3.5	Site security	\$ 5,000,000
3.6	Environmental monitoring during construction	\$ 5,000,000
3.7	Geotechnical investigations and testing	\$ 8,700,000
3.8	EPCM engineering (7% of site construction cost)*	\$ 37,500,000
3.9	Minor support from EKATI mine	\$ 5,000,000
<b>Subtotal</b>		<b>\$ 169,000,000</b>
<b>Note:</b> * Indicates a change from the 2010 estimate		

**Table 6: Contingency Costs**

Item	Description	Price
4.1	Identified Risks	\$ 30,000,000
4.2	Unidentified Risks: 10% of site construction cost*	\$ 53,000,000
<b>Subtotal</b>		<b>\$ 83,000,000</b>
<b>Note:</b> * Indicates a change from the 2010 estimate		

## 6.0 SCHEDULE

There is not expected to be significant variation from the 2010 proposed schedule. The CSM approach is anticipated to be faster than the Diavik-style method, but the logistics and short summer construction season will probably mean that the same approximate schedule will be followed. However, the increased efficiency of the CSM method may mean that there is reduced risk of delays significantly impacting construction. The detailed schedule is attached in Appendix C.

**Table 7: Construction Schedule**

<b>Year 1</b>	Misery site expansion to accommodate crew
	Access road to Jay Pipe site
	Quarry and Jay Pipe laydown areas
	Blasting and crushing commences for dyke construction materials
	Causeway with fish channel and bridge
	Pressure grouting of bedrock along dyke alignment
<b>Year 2</b>	Lakebed sediment dredging and excavation
	Partial filter blanket placement
	Partial dyke fill placement to 417.0 m
	Pre-drilling (option)
	CSM cut-off wall installation
	Jet grouting
<b>Year 3</b>	Filter blanket placement
	Dyke fill placement
	Vibrodensification
	Pre-drilling (option)
	CSM cut-off wall installation
	Jet grouting
	Curtain grouting
<b>Year 4</b>	Instrumentation installed
	Primary dewatering
	Toe berm construction
<b>Year 5</b>	Secondary dewatering
	Lakebed sediment removed (or optionally removed during dyke dredging)

## 7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

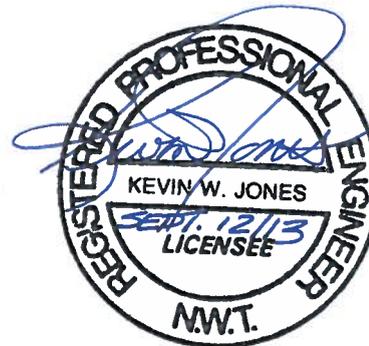
Sincerely,  
EBA Engineering Consultants Ltd.

Prepared by:



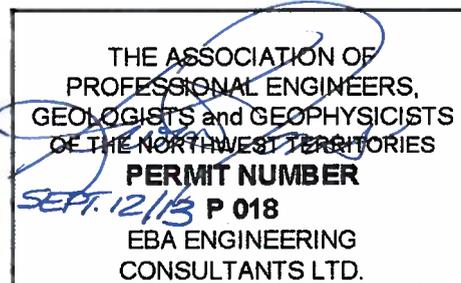
Robert Zschuppe, M.Sc., P.Eng.  
Geological Engineer - Arctic Region  
Direct Line: 780.451.2130 x341  
rzschuppe@eba.ca

Reviewed by:



Kevin Jones, P.Eng.  
Vice President, Arctic Development  
Direct Line: 780.451.2125  
kjones@eba.ca

/dlm



## REFERENCES

BHP Billiton Diamonds Ltd., Misery Definition Study, unpublished. 2010.

EBA, 2010. Identification Phase Study of Civil Engineering Components, Jay Pipe Development, EKATI Diamond Mine, NT. Prepared for BHP Billiton Diamonds Ltd. June 2010. EBA reference: E14101039.

Kjarsgaard, B.A., Spark, R.N., and Jacob, Z.J., 1994a: Preliminary Geology, Koala, 76D/10, Northwest Territories: Geological Survey of Canada Open File. Map 2966, scale 1:50,000.

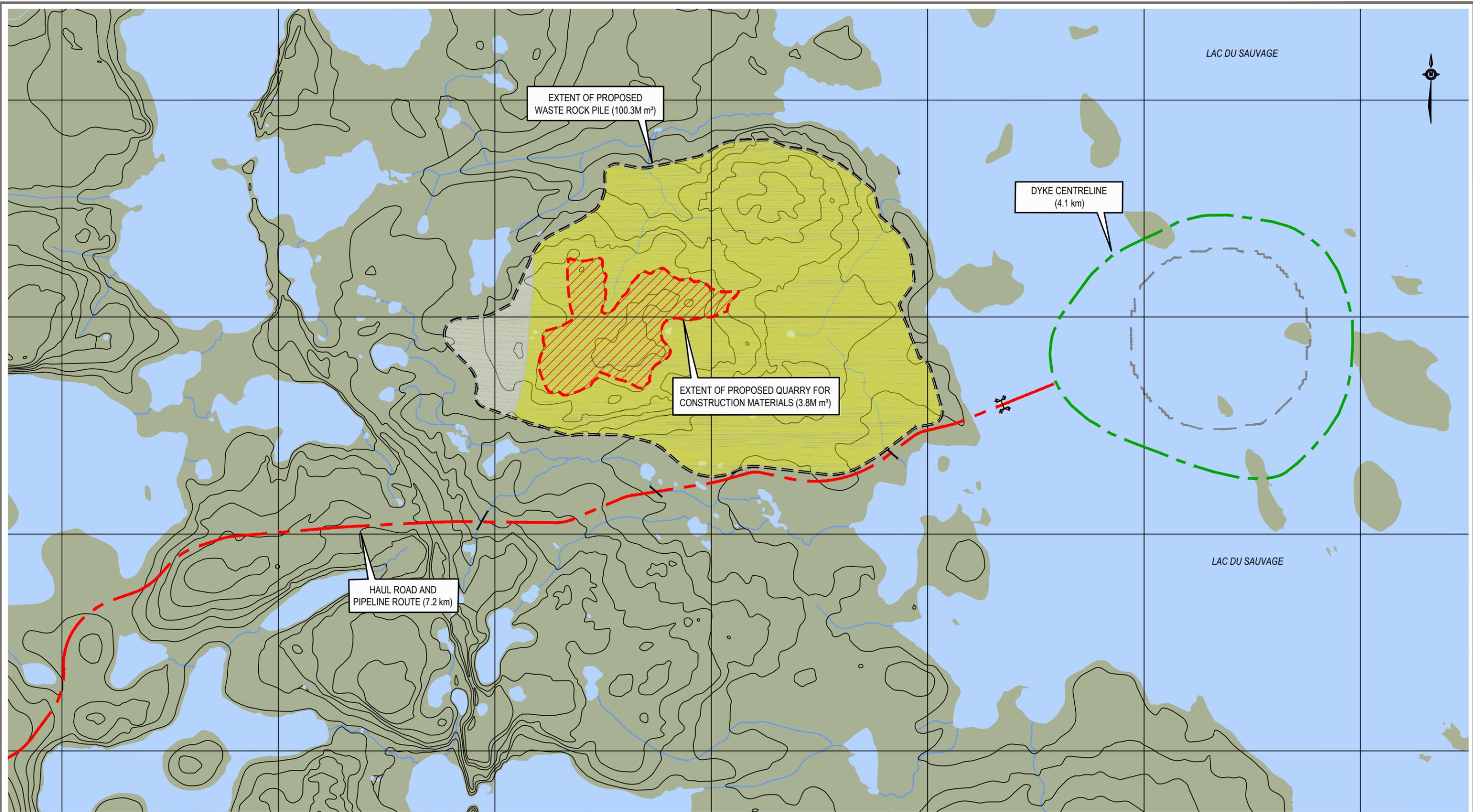
Kjarsgaard, B.A., Spark, R.N., and Jacob, Z.J., 1994b: Preliminary Geology, Ursula Lake, 76D/16, Northwest Territories: Geological Survey of Canada Open File. Map 2967, scale 1:50,000.

Norecol, Dames & Moore, 1997. Acid/Alkaline Rock Drainage (ARD) and Geochemical Characterization Program. December 31, 1997.

# FIGURES

- 
- |          |   |
|----------|---|
| Figure 1 | Geological Mapping of the Proposed Waste Rock Pile          |
| Figure 2 | Geological Mapping of the Jay Pipe and Misery Deposit Areas |
| Figure 3 | Potential Rock Quarry Sites Along Access Roads              |

Q:\Edmonton\Engineering\E14103069-01 (Jay Pipe)\4.0 Modeling\2.0 Working Drawings\E14103069-Figure 1\_R0.dwg [FIGURE 1] August 06, 2013 - 9:52:51 am (BY: STIRLING, JENNIFER)



**LEGEND:**  
 - TWO MICA GRANITE  
 - GREYWACKE

0  1 000 m  
 Scale: 1: 20 000 at 22"x34"

**NOTES**  
 BASED ON JAY KIMBERLITE BEDROCK GEOLOGY  
 MAP PROVIDED BY MINERAL SERVICES



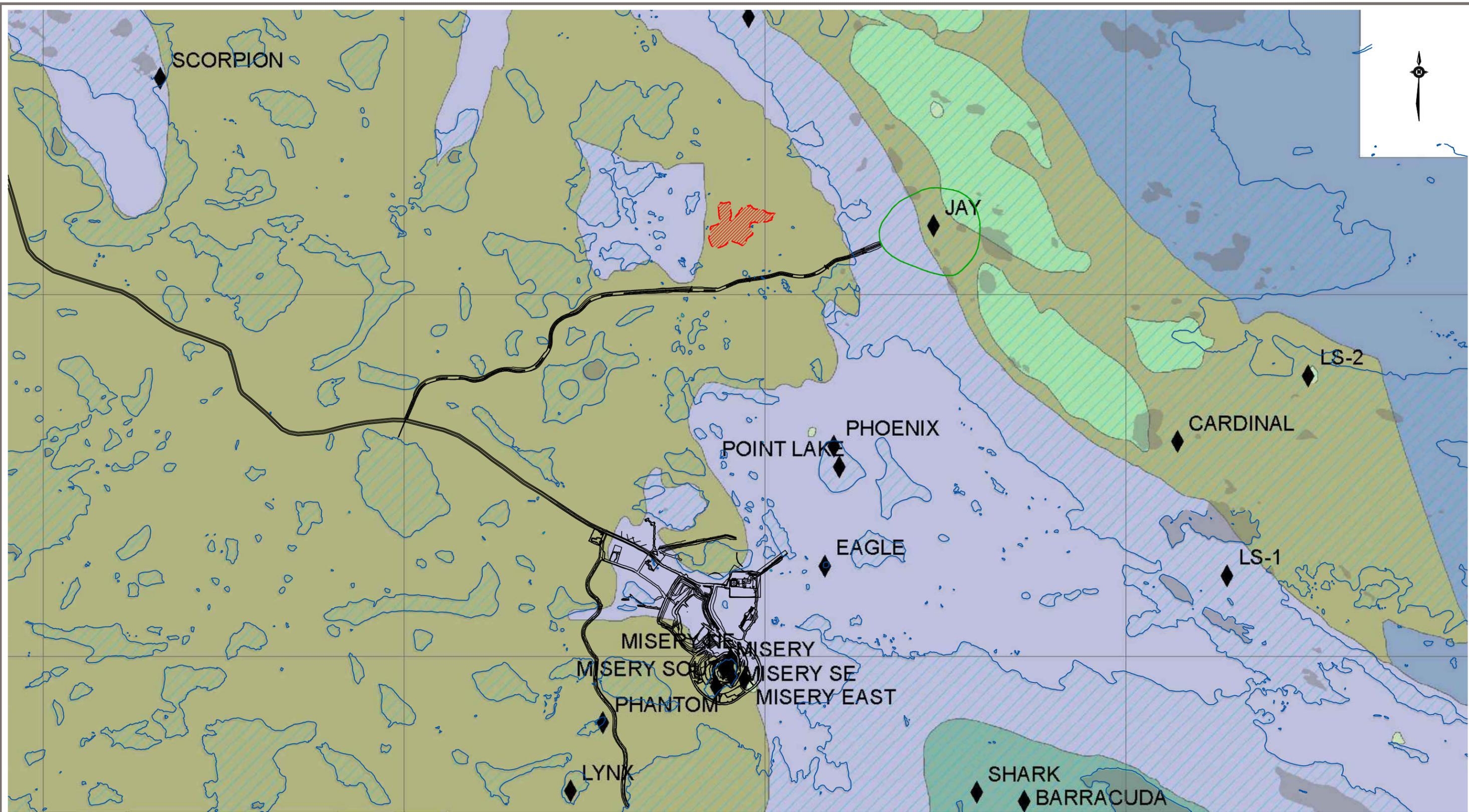
**JAY PIPE - REVISED IDENTIFICATION STUDY  
 EKATI DIAMOND MINE**

**GEOLOGICAL MAPPING OF THE PROPOSED  
 WASTE ROCK PILE**

PROJECT NO. E14103069-01	DWN JMS	CKD RZ	REV 0
OFFICE EDM	DATE July 10, 2013		

Figure 1

STATUS  
 ISSUED FOR USE



C:\Users\jennifer.stirling\Desktop\E141010309-01 - Figure 2.dwg [FIGURE 2] August 06, 2013 - 10:45:59 am (BY: STIRLING, JENNIFER)

**LITHOLOGY**

 Biotite Granite	 Magnetite Biotite Granodiorite	 Two Mica Granite
 Biotite Muscovite Monzogranite	 Migmatite	 Two Mica Leucogranite
 Greywacke	 Porphyritic Biotite Granite	 Two Mica Monzonite
 Hornblende Tonalite	 Syntectonic Granite	 UNDEFINED
 Mafic Inclusion	 Tonalite	 White Biotite Monzogranite

NOTES  
Kjarsgaard, B.A.,  
Spark, R.N., and  
Jacob, Z.J., 1994a

STATUS  
ISSUED FOR USE



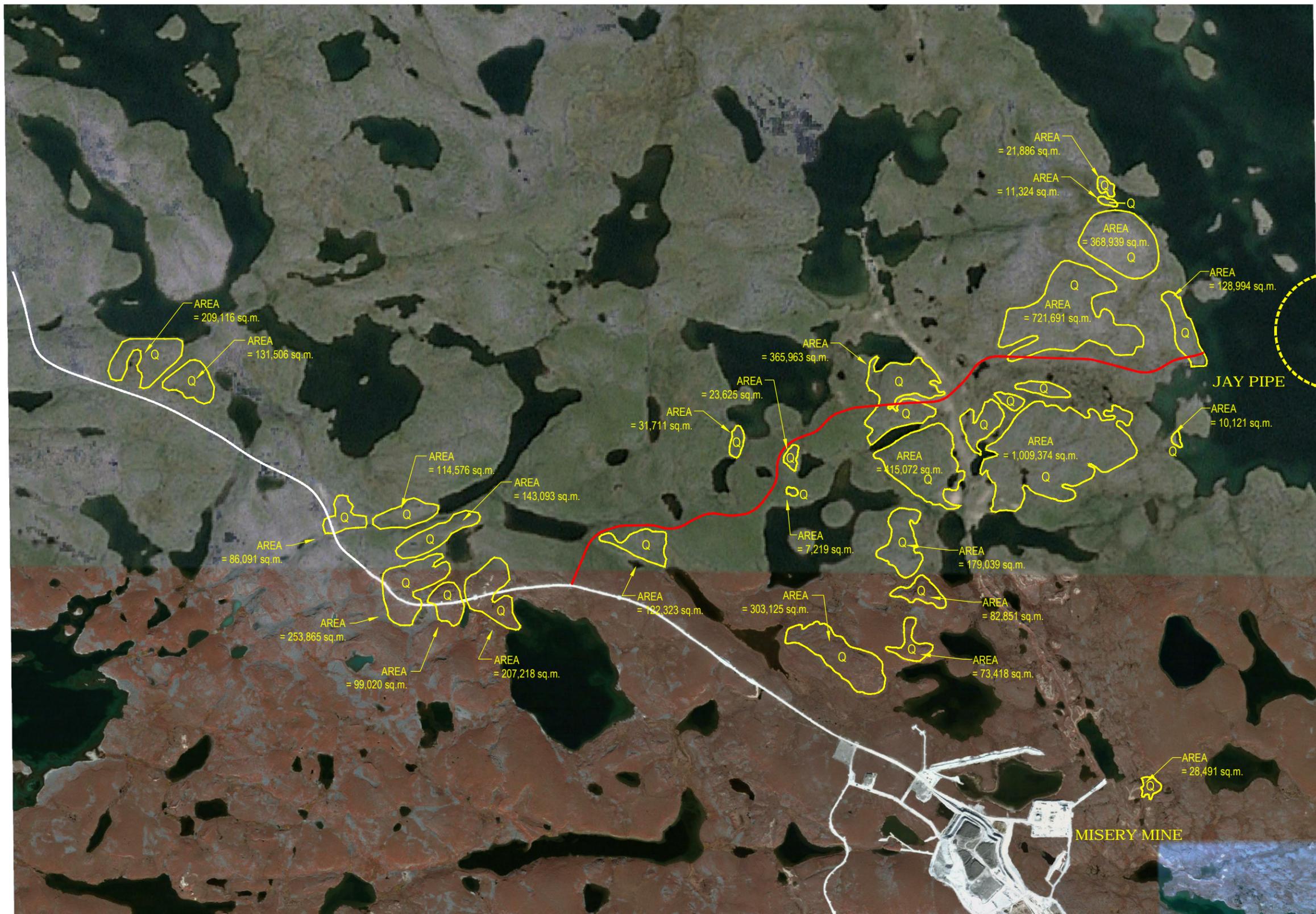
**JAY PIPE - REVISED IDENTIFICATION STUDY  
EKATI DIAMOND MINE**

**GEOLOGICAL MAPPING OF THE JAY PIPE AND MISERY  
DEPOSIT AREAS**

PROJECT NO. E14103069-01	DWN JMS	CKD RZ	REV 0
OFFICE EDM	DATE July 10, 2013		

Figure 2

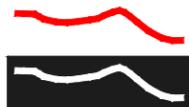
Q:\Edmonton\Engineering\E141\Projects\_EKATIE\4103069-01 (Jay Pipe)\4.0 Modeling\2.0 Working Drawings\E14103069-01\_Figure 3.dwg [FIGURE 3] August 06, 2013 - 9:02:02 am (BY: STIRLING, JENNIFER)



**LEGEND:**

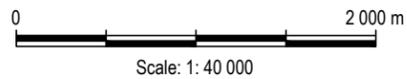


POTENTIAL QUARRY SITE (PARTIALLY EXPOSED BEDROCK WITH PATCHES OF OUTWASH MATERIAL, BOULDERS AND/OR TILL)



PROPOSED JAY PIPE ACCESS ROAD

EXISTING EKATI TO MISERY ACCESS ROAD



CLIENT



STATUS  
ISSUED FOR USE

JAY PIPE - REVISED IPS  
EKATI DIAMOND MINE

POTENTIAL ROCK QUARRY SITES ALONG  
ACCESS ROADS (WITHIN 1 km WIDE CORRIDOR)

PROJECT NO. E14103069-01	DWN DBD	CKD VER	REV 0
OFFICE EDM	DATE July 15, 2013		

Figure 3

# APPENDIX A

## EBA'S GENERAL CONDITIONS

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# GENERAL CONDITIONS

## GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

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### 1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

### 2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

### 3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

### 4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

### 5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

### 6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

## 7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

## 8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

## 9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

## 10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

## 11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

## 12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

## 13.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

## 14.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

# APPENDIX B

## DETAILED COST SUMMARY

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**Detailed Cost Summary**

Item	Description	Bid Qty	Unit	Total Unit Rate	Price
<b>1</b>	<b>Infrastructure</b>				
<b>1.1</b>	<b>Access/Haul Road</b>				\$ 24,017,491
1.1.1	900 mm	1,058,317	m <sup>3</sup>	\$ 16.37	
1.1.2	200 mm	144,288	m <sup>3</sup>	\$ 33.63	
1.1.3	56 mm	41,288	m <sup>3</sup>	\$ 40.21	
1.1.4	Culvert	185	m	\$ 974.30	
<b>1.2</b>	<b>Causeway</b>				\$ 7,217,149
1.2.1	900 mm	256,731	m <sup>3</sup>	\$ 16.37	
1.2.2	200 mm	8,814	m <sup>3</sup>	\$ 33.63	
1.2.3	56 mm	2,574	m <sup>3</sup>	\$ 40.21	
1.2.1	40 m Bridge	1		\$ 2,614,547.10	
<b>1.3</b>	<b>Quarry Access Road</b>				\$ 879,753
1.3.1	900 mm	29,900	m <sup>3</sup>	\$ 16.37	
1.3.2	200 mm	7,475	m <sup>3</sup>	\$ 33.63	
1.3.3	56 mm	2,243	m <sup>3</sup>	\$ 40.21	
1.3.4	Culvert	50	m	\$ 974.30	
<b>1.4</b>	<b>Jay Pipe Laydown Areas</b>				\$ 11,419,023
1.4.1	Admin Laydown 900 mm	72,980	m <sup>3</sup>	\$ 16.37	
1.4.2	Admin Laydown 200 mm	18,245	m <sup>3</sup>	\$ 33.63	
1.4.3	Admin Laydown 56 mm	5,474	m <sup>3</sup>	\$ 40.21	
1.4.4	Dredge/Marine Laydown 900 mm	337,874	m <sup>3</sup>	\$ 16.37	
1.4.5	Dredge/Marine Laydown 200 mm	84,469	m <sup>3</sup>	\$ 33.63	
1.4.6	Dredge/Marine Laydown 56 mm	25,341	m <sup>3</sup>	\$ 40.21	
<b>1.5</b>	<b>Quarry Laydown Areas</b>				\$ 449,548
1.5.1	Quarry Crusher Pad 900 mm	19,762	m <sup>3</sup>	\$ 16.37	
1.5.2	Quarry Crusher Pad 200 mm	1,976	m <sup>3</sup>	\$ 33.63	
1.5.3	Quarry Crusher Pad 56 mm	1,482	m <sup>3</sup>	\$ 40.21	
<b>1.6</b>	<b>Quarry Stockpile</b>				\$ 1,596,692
1.6.1	Quarry Stockpile 900 mm	70,188	m <sup>3</sup>	\$ 16.37	
1.6.2	Quarry Stockpile 200 mm	7,019	m <sup>3</sup>	\$ 33.63	
1.6.3	Quarry Stockpile 56 mm	5,264	m <sup>3</sup>	\$ 40.21	
	<b>Subtotal Infrastructure</b>				\$ 45,579,656
<b>2</b>	<b>Dyke Construction</b>				
<b>2.1</b>	<b>Dyke</b>				\$ 119,691,657
2.1.1	900 mm	659,396	m <sup>3</sup>	\$ 16.37	
2.1.2	200 mm	622,843	m <sup>3</sup>	\$ 35.89	
2.1.3	56 mm	824,016	m <sup>3</sup>	\$ 62.35	
2.1.4	Course 20 mm	45,000	m <sup>3</sup>	\$ 48.10	
2.1.5	Washed Sand	40,000	m <sup>3</sup>	\$ 48.10	
2.1.6	Drill and Blast - dyke Material only	3,381,677	m <sup>3</sup>	\$ 9.19	
<b>2.2</b>	<b>Toe Berm</b>				\$ 25,853,369
2.2.1	Toe Berm Access Road (Zone 3), perforated pipe	1	LS	\$ 4,974,585.68	
2.2.2	900 mm	382,063	m <sup>3</sup>	\$ 31.76	
2.2.3	200 mm	75,736	m <sup>3</sup>	\$ 38.06	
2.2.4	56 mm	79,312	m <sup>3</sup>	\$ 73.91	
<b>2.3</b>	<b>Turbidity Barrier</b>				\$ 2,343,342
2.3.1	Causeway	10,366	m <sup>2</sup>	\$ 73.17	
2.3.2	Other	21,660	m <sup>2</sup>	\$ 73.17	
<b>2.4</b>	<b>Dredging Pipeline</b>				\$ 5,265,810
2.4.1	Dredging Pipeline	13,365	m	\$ 394.00	
<b>2.5</b>	<b>Dredging</b>	<b>518,839</b>	<b>m<sup>3</sup></b>		\$ 11,836,209
2.5.1	Deep (>5 m)	403,736	m <sup>3</sup>		
2.5.2	Intermediate (4-5 m)	68,239	m <sup>3</sup>		
2.5.3	Shallow (<4 m)	46,864	m <sup>3</sup>		
<b>2.6</b>	<b>Filter Blanket</b>				\$ 30,771,381
2.6.1	Filter Blanket	240,627	m <sup>3</sup>	\$ 127.88	
<b>2.7</b>	<b>Vibrodensification</b>				\$ 8,841,215
2.7.1	Vibrodensification	394,345	m <sup>3</sup>	\$ 44.84	
<b>2.8</b>	<b>Concrete Guide Walls</b>				\$ 2,457,000
2.8.1	Concrete Guide Walls	4,200	m	\$ 585.00	
<b>2.9</b>	<b>CSM Dyke Wall</b>				\$ 113,929,065
2.9.1	CSM Dyke Wall	47,769	m <sup>3</sup>	\$ 2,385.00	
<b>2.10</b>	<b>Pre-Drilled CSM to bedrock</b>				\$ 23,378,706
2.10.1	Pre-Drilled CSM to bedrock	8,815.50	m <sup>3</sup>	\$ 2,652.00	
<b>2.11</b>	<b>Jet Grout</b>				\$ 43,231,124
2.11.1	Jet Grout	8,815.50	m <sup>2</sup>	\$ 4,903.99	
<b>2.12</b>	<b>Grout Curtain</b>				\$ 47,372,692
2.12.1	Grout Curtain	62,932	m <sup>2</sup>	\$ 752.76	
<b>2.13</b>	<b>Dewatering</b>				\$ 21,454,121
2.13.1	Initial Dewatering	1	LS	\$ 13,742,743.50	
2.13.2	Permanent dewatering	1	LS	\$ 7,711,377.64	
<b>2.14</b>	<b>Instrumentation</b>				\$ 12,035,158
2.14.1	Piezometers	1	LS	\$ 1,941,357.24	
2.14.2	Inclinometers	1	LS	\$ 1,028,617.01	
2.14.3	Survey Markers/Pins/Monuments	1	LS	\$ 265,118.06	
2.14.4	Thermistor Cables	1	LS	\$ 3,421,591.12	
2.14.5	Automated Data Acquisition System	1	LS	\$ 2,187,677.42	
2.14.6	Relief Wells	1	LS	\$ 3,190,797.29	
<b>2.15</b>	<b>Thermosyphons</b>	<b>1</b>	<b>LS</b>	<b>\$ 17,467,334.33</b>	\$ 17,467,334
	<b>Subtotal Dyke</b>				\$ 485,928,184
<b>3</b>	<b>Transportation, Accommodations, and Miscellaneous Costs</b>				
3.1	Mob and demob of materials and equipment (winter road)	1		\$ 64,000,000	\$ 64,000,000
3.2	Air Transport of critical materials	1		\$ 2,000,000	\$ 2,000,000
3.3	Air Transport of all personnel to/from site	1		\$ 3,300,000	\$ 3,300,000
3.4	Accommodations infrastructure at Misery site (construction and operation)	1		\$ 38,500,000	\$ 38,500,000
3.5	Site security	1		\$ 5,000,000	\$ 5,000,000
3.6	Environmental monitoring during construction	1		\$ 5,000,000	\$ 5,000,000
3.7	Geotechnical investigations and testing	1		\$ 8,700,000	\$ 8,700,000
3.8	EPCM engineering (7% of site construction cost)	1		\$ 37,500,000	\$ 37,500,000
3.9	Minor support from EKATI mine	1		\$ 5,000,000	\$ 5,000,000
	<b>Subtotal</b>				\$ 169,000,000
<b>4</b>	<b>Contingency:</b>				
4.1	Identified Risks	1		\$ 30,000,000	\$ 30,000,000
4.2	Unidentified Risks: 10% of site construction cost	1		\$ 53,000,000	\$ 53,000,000
	<b>Subtotal</b>				\$ 83,000,000
<b>Jay Pipe Project Total</b>					<b>\$ 783,507,839</b>

# APPENDIX C

## PROJECT SCHEDULE

---

Activity	Year 1												Year 2												Year 3												Year 4												Year 5											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mobilization/Demobilization																																																												
Access/Haul Road																																																												
Jay Pipe Infrastructure																																																												
Construction of Dredge/ Marine Laydown Area																																																												
Quarry (Road Construction, Clearing, Crusher Pad, MSE Wall, Stockpile Pad)																																																												
Dyke Material Production																																																												
In Water Dyke Construction (Turbidity Barrier, Causeway, Fish Channel, Bridge)																																																												
Dyke Construction (Turbidity Barrier, Lake Bed Sediment Dredging)																																																												
Dyke Construction - Filter Blanket and Boulder Removal																																																												
Dyke Construction - Fill to El. 417m																																																												
Dyke Construction - Vibrodensification																																																												
Dyke Construction - Fab/Install Guide Walls																																																												
Dyke Construction - Infill to 418.8m																																																												
Dyke Construction - Pre-Drilling																																																												
Dyke Construction - CSM Cut-off Wall Installation																																																												
Dyke Construction - Jet Grout																																																												
Dyke Construction - Grout Curtain																																																												
Dyke Construction - Fill to El. 420.6m																																																												
Install Instrumentation																																																												
Dyke Construction - Dewatering																																																												
Dyke Construction - Toe Construction																																																												
Mainline Dyke Construction and Permanent Dewatering																																																												