TECHNICAL MEMORANDUM

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ALTERNATIVES ANALYSIS METHODOLOGY FOR THE JAY-CARDINAL PROJECT

1.0 INTRODUCTION

Dominion Diamond (Dominion) has retained Golder Associates Ltd. (Golder) to assist with the development of a design to mine the Jay and Cardinal kimberlite pipe deposits (Jay-Cardinal Project) at its Ekati Diamond Mine in the Northwest Territories (NT). The Jay and Cardinal kimberlite pipes are located under water in Lac du Sauvage (LDS), northeast of the existing Misery Pit Operations. Dominion submitted a project description for the Jay-Cardinal Project in October 2013 (DDEC 2013).

The Mackenzie Valley Review Board (MVRB) recently issued draft Terms of Reference (TOR) for the environmental assessment process for the Jay-Cardinal Project (MVRB 2013). Included in the draft TOR was the requirement for an Analysis of Alternative means for the project as a Key Line of Inquiry.

Golder has prepared this technical memorandum to present details of the alternatives analysis methodology that will be used to evaluate options for this Project. Note that Sections 3.3, 3.4, and 4 through 8 are provided only as titles to indicate how the information from these analyses will be presented.

2.0 ALTERNATIVES ANALYSIS METHODOLOGY

The Jay-Cardinal Project needs to be technically, economically, environmentally, and socially viable to proceed. An alternatives analysis process is a transparent method of evaluating project alternatives for the Jay-Cardinal Project relative to each other to determine the most viable option. The most significant alternatives analysis required for the Jay-Cardinal Project is for the overall approach to mining the Jay and Cardinal kimberlite pipes. In addition, alternatives for other mine components, such waste rock management, roads, and power supply will be evaluated using alternatives analysis.

The alternatives analysis process that has been developed for the Jay-Cardinal Project takes into account the multiple accounts method as described by Robertson and Shaw (2004) and considers alternative analysis reports recently conducted to support project applications for the Gahcho Kué Project (DeBeers 2012) and the Meliadine Gold Project (AEM 2013).

The alternatives analysis process will include an evaluation of the mining method for the Jay-Cardinal Project in the following steps:

- Identification of alternatives for the overall project mining method;
- Definition of evaluation criteria (technical, economic, environmental, and social);
- Ranking of the mining method alternatives against the evaluation criteria; and
- Identification of the most viable mining method alternative.

Once the overall mining method has been identified, alternatives for the following components of the mine will be assessed:

- Waste Rock Management;
- Energy Sources; and
- Roads.

The assessment process will be similar for each of the mine components with a set of evaluation criteria developed for each of the mine component alternative assessments followed by relative ranking of the alternatives. The level of detail and complexity of the alternatives assessment will vary depending on the complexity of the options available for the mine component being evaluated.

The technical evaluation criteria will focus on the technical complexity of the infrastructure and schedule requirements. The economic evaluation criteria will focus on capital and operating costs associated with each mine component alternative and will also consider closure and reclamation costs where applicable.

The environmental and social evaluation criteria will focus on the Key Lines of Inquiry (KLIs) and the Valued Ecosystem Components (VECs) listed in the Jay-Cardinal Project Terms of Reference (MVRB 2014). Although it is important to assess the potential effects of the Project on all the KLIs and VECs, in some cases the potential effects of the mining component alternatives on the KLIs and VECs may not vary from one alternative to another. Only the KLIs and VECs that differentiate one mining component alternative from another will be considered in the alternatives assessments.

For the more complex components of the Project, such as the overall mining method, the alternatives will be ranked and scored against each of the evaluation criteria. A nine point scoring scale will be used and the evaluation criteria will be assigned relative weightings from 1 to 5, to introduce a value bias. Weightings will also be introduced for each of the four categories of evaluation criteria (Technical Viability, Economic Viability, Environmental Considerations, and Social Economic Considerations). Overall scores for each of the alternatives will be calculated for each of the categories by multiplying the scores and weights for each evaluation criterion and adding them together. These overall scores will then be normalized by dividing them by the sum of the weightings of the evaluation criteria in that category. This will result in four normalized category scores for each alternative, which can be added together to obtain one final overall score for each alternative. The alternative with the highest overall score is the preferred alternative.

For the less complex components of the Project, where options are limited, such as the roads or waste rock pile areas, the alternatives assessment process will be simplified. It is anticipated that, for these components, the alternatives can be ranked relative to each other in each of the four categories (Technical Viability, Economic Viability, Environmental Considerations, and Social Economic Considerations) to determine the preferred alternative. Weightings will be assigned to the four categories to allow for a value bias. Scores will be assigned to each alternative for each of the categories based on their relative ranking, and these scores will be multiplied by the category weighting. The four category scores will be added together to derive a final overall alternative score. The alternative with the highest overall score is the preferred alternative.

Table 1 and Table 2 present example formats for conducting the alternatives analyses.

Table 1: Jay-Cardinal Project Detailed Alternatives Analysis Tabular Format

Account Weighting	Sub-Account	Indicator	Weighting		Alternative 1			Alternative 2			Alternative 3		
			Sub-account	Indicator	Description	Score	Weighted Score	Description	Score	Weighted Score	Description	Score	Weighted Score
Technical Viability													
	Sub-Account 1	n/a		n/a									
	Sub-Account 2	Indicator 1											
		Indicator 2											
Economic Viability													
	Sub-Account 1	n/a		n/a									
	Sub-Account 2	Indicator 1											
		Indicator 2											
Environmental Considerations													
	Sub-Account 1	n/a		n/a									
	Sub-Account 2	Indicator 1											
		Indicator 2											
Social Considerations													
	Sub-Account 1	n/a		n/a									
	Sub-Account 2	Indicator 1											
		Indicator 2											

Table 2: Jay-Cardinal Project Simplified Alternatives Analysis Tabular Format

Alternatives - Overall Project	Technical Feasibility			Economic Viability			Environmental Considerations			Social Considerations			Overall Weighted Score	
	Description	Score	Weighting	Description	Score	Weighting	Description	Score	Weighting	Description	Score	Weighting	Score	Comments
Alternative 1														
Alternative 2														
Alternative 3														

3.0 PROJECT MINING METHOD ALTERNATIVES ANALYSIS

3.1 Mining Method Alternatives

Dominion recognized that project alternatives would be required to support the proposed project development and advanced a number of conceptual design studies for the Project. These were included in the project description:

- Underground mine design for Jay Pipe (Stantec 2013);
- Ring dike design for Jay Pipe (EBA 2013); and
- Alternative lake drawdown for Jay-Cardinal Project (Golder 2013, 2014).

The mining method chosen for a project is often largely based on the characteristics of the ore body and host rock. For example, ore bodies close to surface are most often developed using open pit methods, while ore bodies at larger depths are often developed using underground methods. One of the most significant factors for the Jay-Cardinal project is that the kimberlite pipes are located below Lac du Sauvage. Different mining methods were considered for developing the Jay-Cardinal Project, as follows:

- Open Pit Mining within a Ring Dike;
- Diversion and Lake Draw Down with Open Pit and Underground Mining;
- Underground Mining;
- Wet Mining;
- Underwater Mining; and
- Lake Drawdown and Underground Mining.

A brief description of each of the above alternatives is provided below.

Open Pit Mining within a Ring Dike

It would be possible to mine the Jay kimberlite pipe by isolating an area for open pit mining behind a ring dike constructed in Lac du Sauvage. This alternative is similar in concept to the approach implemented for the Diavik Mine, although substantively more dike construction would be required to fully encircle the Jay pipe area, including a roadway connecting the ring dike to the shore of Lac du Sauvage. Dominion commissioned EBA Engineering to develop a conceptual ring dike approach for the Jay kimberlite pipe (EBA 2013). The EBA report included persons and firms that were directly involved in the design and construction of the Diavik dikes, such that opportunities for optimizations and efficiency improvements in dike construction were considered. This method would not allow for development of the Cardinal kimberlite pipe, which is smaller than the Jay pipe, because the costs to construct a ring dike around the Cardinal pipe would not be economic. Without the ability to mine the Cardinal kimberlite pipe in addition to the Jay kimberlite pipe, this approach would not be economically feasible.

Diversion and Lake Draw Down with Open Pit and Underground Mining

It would be possible to mine both the Jay and Cardinal kimberlite pipes by isolating an area in Lac du Sauvage behind dikes that divert a majority of the inflows to the north and south of that isolated area. This alternative takes advantage of the natural shape of Lac du Sauvage, which is generally a shallow lake. The shape of Lac du Sauvage is conducive to exposing the areas of the Jay and Cardinal kimberlite pipes for open pit mining by drawing down the lake water level within a diked area. In this approach, the engineering design of the dikes is less sophisticated than the "Diavik-style" ring dike because the increase in available surge capacity within the diked off areas reduces operating risks. Dominion commissioned Golder Associates Ltd. to evaluate this alternative (Golder 2013, 2014), which would be economically feasible.

Underground Mining

It would be possible to mine the Jay kimberlite pipe exclusively by underground methods. The kimberlite would be accessed from an adit located on the shore of Lac du Sauvage. Dominion commissioned Stantec Engineering to develop a conceptual underground mining approach for the Jay kimberlite pipe (Stantec 2013).

The conceptual cash flow projection is strongly negative, to the point where this alternative could not likely be made economically viable in light of current or projected costs and product pricing. This alternative also requires a significant up-front capital investment to establish underground accesses to the Jay Pipe to a much greater degree than other alternatives, contributing to additional negative economics.

Wet Mining

The concept of "wet mining" is based on using a dredge, or otherwise floating platform to raise kimberlite to the surface after underwater blasting. Water quality in Lac du Sauvage would be protected by silt curtains; however, it is not possible to design this approach using current technology to produce the necessary 12,500 tonnes per day (tpd) process plant feed. Additionally, the shape and depth of the Jay and Cardinal kimberlite pipes (i.e., vertical 'carrot' shapes) are not ideal for this approach. For these reasons, this approach is not suitable for this project.

Underwater Mining

The underwater mining concept would use a remote-operated underwater crawler, equipped with cutting-head and suction pump, to excavate and pump kimberlite to surface. This approach would be modelled after mining techniques used in South Africa in sand deposits. While conceptually possible, the basic technology for using this concept in kimberlite containing granite inclusions has not been developed. Therefore, this approach is not possible for this project.

Lake Draw Down and Underground Mining

It would be conceptually possible to drain Lac du Sauvage to the point where underground mining could pursue a caving method similar to the methods used in the Panda and Koala underground workings at the Ekati Mine. The lake draining would be accomplished similar to the "Diversion and Drawdown" concept described above or by draining Lac du Sauvage entirely. The advantage of this approach would be that the caving methods are generally less expensive relative to other underground mining extraction techniques. However, the costs would still be higher than an open pit operation and Lac du Sauvage would be fully drained, which is environmentally less desirable than partially draining Lac du Sauvage; thus, this approach was not considered suitable for further consideration.

3.2 Multiple Accounts Ledger

A set of evaluation criteria called sub-accounts have been developed within four categories or accounts: technical feasibility; economic viability; environmental considerations; and, social-economic considerations. In some cases the sub-accounts required refinement to allow for measurement and evaluation. These sub-accounts were broken down into measurement criteria called indicators. The following sections summarize the sub-accounts and indicators for each of the four accounts.

3.2.1 Technical Feasibility

The Ekati Mine is currently scheduled to close by 2019; thus, the Jay-Cardinal project needs to be in production by 2019 to maintain continuous operation of the mine at the current production rate of 12,500 tpd. Due to the location of the Jay and Cardinal pipes below Lac du Sauvage, water management and the potential for flooding are significant issues for the development of the kimberlite pipes. In addition, the complexity of the infrastructure required for the mining method affects technical feasibility. The tabular format for the technical feasibility evaluation criteria is shown in Table 3.

Table 3: Technical Feasibility Evaluation Criteria

Sub-accounts	Indicators
Project Schedule	
Maintain Production of 12,500 tpd	
Technical Complexity of Infrastructure	
Risk of Mine Flooding	
Water Management Requirements	

3.2.2 Economic Viability

Economic viability relates to the economic benefits that can be gained from the Project considering capital costs, operation and maintenance costs, and reclamation and closure costs. Alternatives that require less capital, have a more positive cash flow, and will provide a longer mine life, are preferred. The tabular format for the economic viability evaluation criteria is shown in Table 4.

Table 4: Economic Viability Evaluation Criteria

Sub-accounts	Indicators
Capital Costs	
Operating Costs	
Closure Reclamation Costs	

3.2.3 Environmental Considerations

Alternatives for the Jay-Cardinal project can have positive, neutral, or negative effects on the environment. The focus of the evaluation is on areas of the environment identified as KLI (water quality and quantity, aquatic ecosystems, and caribou). Some negative effects can be mitigated, while others will have residual effects that cannot be fully mitigated. The latter possibility is to be avoided if at all possible, especially if the residual effects are significant and long-term. The tabular format for the environmental considerations evaluation criteria is shown in Table 5.

Table 5: Environmental Considerations Evaluation Criteria

Sub-accounts (KLI)	Indicators
Potential to effect water quality and quantity	
Potential effects on aquatic ecosystems	Effects on Lac du Sauvage
	Effects on other aquatic habitats upstream and downstream
Potential effects on caribou	

3.2.4 Social-Economic Considerations

The social-economic considerations of an alternative can be based on both positive and negative effects. Certain alternatives are more likely to have a positive social-economic impact on local communities, for example by providing employment and associated opportunities. Where possible the alternatives are developed to respect the cultural and environmental values of the local communities; however, the alternatives may rate differently with respect to their potential to affect the local communities. The tabular format for the social-economic evaluation criteria is shown in Table 6.

Table 6: Social-Economic Considerations Evaluation Criteria

Sub-accounts	Indicators
Socio-economic benefits	Northern aboriginal residents
	Northern residents
	Non-Northern residents
Potential effects on archaeological sites	
Worker health and safety	

3.3 Mining Method Alternatives Assessment Evaluation

3.4 Mining Method Alternatives Assessment Results

4.0 WASTE ROCK STORAGE ALTERNATIVE ASSESSMENT

4.1 Multiple Accounts Ledger

4.1.1 Technical Feasibility

4.1.2 Economic Viability

4.1.3 Environmental Considerations

4.1.4 Social-Economic Considerations

4.1.5 Waste Rock Storage Alternatives Assessment Evaluation

4.1.6 Waste Rock Storage Alternatives Assessment Results

8.0 CLOSURE

We trust that this document meets your needs at this time. Should you have any questions, please do not hesitate to contact the undersigned.

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