HARDROCK PROJECT
Final Environmental Impact Statement / Environmental Assessment

Chapter 4.0:
Evaluation of Alternatives

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4.0 EVALUATION OF ALTERNATIVES

An assessment of alternatives is required as part of both the federal and provincial environmental assessment (EA) processes. The following sections describe the method used to identify and evaluate alternatives for the various Project components to meet the requirements of *Canadian Environmental Assessment Act, 2012* (CEAA 2012) and the *Environmental Assessment Act, 1990* (EAA), and the results of the alternatives screening and comparative evaluation.

The alternatives evaluation method has been refined through ongoing consultation since the development of the Terms of Reference (ToR; Appendix A2) and throughout the EA process. This has included incorporating input received through comments on the draft and final ToR, as well as at key milestones related to consultation on the alternatives assessment method and preliminary results of the comparative analysis, and information from ongoing or additional baseline and traditional knowledge (TK) and traditional land and resource use (TLRU) studies as available. Input at these stages has shaped the assessment process and the results of the comparative analysis, as described in Chapter 3.0 and summarized in Section 4.1.5.

4.1 ALTERNATIVES ASSESSMENT METHOD

The EAA refers to two types of alternatives: "alternatives to" and "alternative methods". "Alternatives to" a project are functionally different ways of approaching or dealing with a problem or opportunity. "Alternative methods" are different ways of carrying out the same activity, including different technologies, locations, designs and methods of operation. The EAA requires the consideration of a reasonable range of alternatives for the Project.

CEAA 2012 more generally requires an EA to consider alternative means of carrying out a project that are technically and economically feasible. For the purpose of this assessment, the CEAA 2012 definition of 'alternative means' is considered to align with the definition of 'alternative methods' in the provincial context, and a reasonable range of alternative methods has been identified in consideration of technical and economic feasibility.

In order to achieve the intended purpose of the Project and address the identified opportunity, an open pit mine must be developed. In accordance with the approved ToR (Appendix A2), the rationale and selection of open pit mining, which is the preferred "alternative to", was determined through a separate Preliminary Economic Assessment process that confirmed the approach for extraction.

Alternative methods of carrying out the Project have been identified and evaluated based on the method described below.

As a standard practice, the 'do nothing' alternative to the Project was considered in the context of a benchmark against which potential effects of the Project and alternatives to it were measured to highlight the advantages and disadvantages of proceeding with the Project. The 'do nothing' alternative was not considered explicitly as an alternative to the Project, but it is represented as the existing environmental conditions that will experience change through the implementation of the Project.

Similarly, the 'do nothing' alternative was not identified for evaluation in the assessment of alternative methods, since each Project component is needed to support Project construction, operation or closure, and the Project could not be feasibly implemented without the inclusion of the identified Project components. Further information on the purpose and rationale for each Project component is described in Section 4.2. A set of alternative methods that could potentially meet the required purpose or function of each Project component has been identified and evaluated.

4.1.1 Overview of Approach

The process to identify and evaluate a reasonable range of alternative methods for each Project component involved a three-step evaluation process. In accordance with Section 3.1.4 of the Ministry of the Environment and Climate Change (MOECC) *Code of Practice: Preparing and Reviewing Environmental Assessments in Ontario* (EA Code of Practice; 2014), the evaluation process used progressively more technical detail at each stage to narrow down the range of alternatives and ultimately select a preferred "alternative method" for each Project component subject to the process. The process included:

Step 1 - Long List of Alternative Methods (Section 4.1.2)

- Develop a "Long List" of potential alternatives by identifying potentially feasible alternative methods for each Project component.

Step 2 - Initial Screening of Alternative Methods (Section 4.1.3)

- Confirm the screening questions used to identify fatal flaws that would affect the ability to feasibly implement the Project.
- Complete an Initial Screening to remove alternatives that could not be considered further due to the potential severity of environmental effects or feasibility constraints including technical and financial constraints that would affect the ability to implement the Project (or 'fatal flaws').

Step 3 - Comparative Analysis of Alternative Methods (Section 4.1.4)

- Develop a set of criteria and indicators with which to consider the potential for effects of alternatives, accounting for the natural, social, economic, cultural and built environment.

- Define the key assumptions for each alternative at a conceptual level of detail to understand how the potential for effects vary between each alternative. This includes defining standard mitigation measures that would be applied to each alternative to avoid or limit effects.
- Assess the potential for effects based on each criterion/indicator for each Project phase, by considering how each alternative would be conceptually implemented and how it would result in changes to the indicators and criteria.
- Complete a Comparative Analysis to examine the remaining technically and economically feasible alternative methods (as identified for further consideration in Step 2) by comparing each alternative to determine which alternative demonstrates the greatest balance of advantages to disadvantages, based on the potential for environmental effects using the indicators and criteria.

An overview of the alternative evaluation process is shown in Figure 4-1. In some cases, a preferred alternative was identified after the initial screening step, where only one feasible alternative was identified for a Project component (i.e., other alternatives demonstrated fatal flaws and could not be feasibly implemented). In such a case, no comparative analysis was required. Where the initial screening identified multiple alternatives that were potentially feasible, a comparative analysis was undertaken to complete a more detailed evaluation to select a preferred alternative for that Project component, further to Step 3.

The alternatives assessment process utilizes a conceptual level of detail sufficient to distinguish one alternative from another, including an assumption that standard mitigation measures would be applied to each alternative. It is assumed that any requirements associated with effectively managing the potential for effects for each Project component would be implemented, including finalizing Project design in accordance with regulatory standards, guidelines and guidance, ongoing monitoring for effectiveness and compliance where appropriate, and developing follow-up programs to address any issues that may arise during the Project. Such requirements are not developed in detail as part of the alternatives assessment, but mitigation measures are described as they apply to each valued component (VC) in Chapters 7.0 to 19.0.

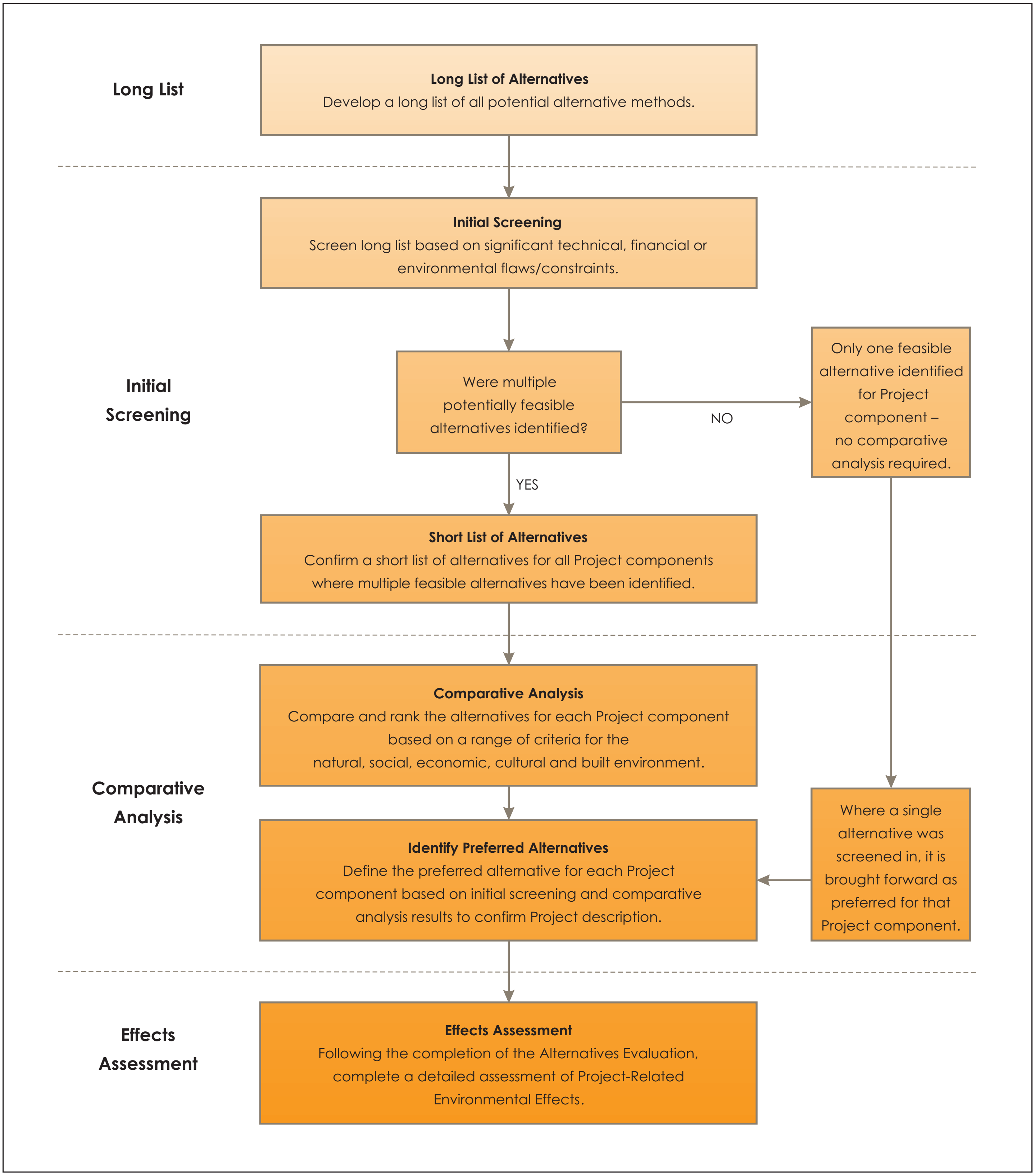
This involved developing and understanding the alternatives for each Project component to a level of detail that allowed for a clear determination of the advantages and disadvantages of each alternative method compared to the other alternative methods being considered. Once a preferred alternative was selected for each Project component, the technical details for the preferred Undertaking were refined through additional engineering and design work for the Project description (Chapter 5.0), which informed the environmental effects assessment in the subsequent stage of the EA, as described in Chapter 6.0 (EA methods). This is consistent with Section 3.1.4 of the EA Code of Practice, which indicates that decision-making should be phased, narrowing progressively to a preferred alternative, with decisions on what type or combination of alternatives are preferred being made earlier in the planning process and more detailed decisions on how to implement the preferred alternative made later.

Baseline information was used at each step of the process to consider existing conditions, Project constraints and potential effects. TK and TLRU information from Aboriginal communities was incorporated into the existing baseline conditions and the assessment of alternatives as appropriate. A conservative approach was used to consider traditional knowledge and land use information during the early stages of the assessment by assuming that effects on VCs (such as fish and fish habitat and wildlife and wildlife habitat) may be linked to traditional activities (such as hunting and fishing). The conservative approach assumed that the Aboriginal communities identified for consultation on the Project may have practiced traditional activities associated with these VCs, and that effects on the VCs could be linked to disruptions in traditional uses. Following the completion of TK and TLRU studies, site-specific information was also incorporated into the assessment to identify sites or areas of importance to Aboriginal communities that may be affected by alternatives. Where relevant, the conflicts and potential for effects on these sites or areas were specifically identified in the comparative analysis (including for Highway 11 routes, Goldfield Creek diversion options, and Hydro One Networks Inc. Longlac Transformer Station [Hydro One TS] locations). The results of the comparative have been updated based on these results where appropriate (e.g., some Highway 11 routes were reassessed to identify specific disadvantages associated with overprinting LLFN hunting cabins/sites). Both the method and results of the alternatives assessment have been refined through consultation to incorporate additional information from further baseline work and TK and TLRU studies.

The alternative methods assessment process has also been confirmed and refined in consultation with the public, stakeholders, government agencies and Aboriginal communities. Opportunities were provided to comment on components of the assessment process at key milestones, including confirmation of the range of alternatives, criteria and indicators, method and assessment results. Greenstone Gold Mines GP Inc. (GGM) has considered additional input on, and refinements to, the alternatives assessment as consultation has continued. If refinements have been made to one step in the process, those changes were brought forward through appropriate refinements to subsequent steps in the process (e.g., updates to how criteria/indicators were assessed may result in changes to the determination of advantages or disadvantages, leading to a reconsideration of the conclusions of the assessment). Section 4.1.5 describes how key input on the alternatives assessment method and results influenced the Final EIS/EA.

Each of these key steps is described in Sections 4.1.1 to 4.1.4, followed by a description of the results of the alternative methods assessment process in Section 4.2.

Following the selection of a preferred alternative for each Project component, the Project description was finalized and a more detailed assessment of overall Project effects was completed as presented in the subsequent chapters of the Final EIS/EA.



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Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
4-1

Title
Alternatives Evaluation Process Flow Chart

This method includes the consideration of TK where appropriate

4.1.2 Long List of Alternative Methods

The purpose of examining alternative methods is to identify preferred technologies, methods, designs, and siting options for the Project components taking into account environmental, economic, and technical factors. Each alternative method is evaluated based on its potential effects considering applicable management measures.

The approved ToR (Appendix A2) requires that the EIS/EA assess a reasonable range of alternative methods considering all phases of the Project for the Project components identified in Table 4-1.

The approved ToR (Appendix A2) identified key components that are anticipated to form part of the Project, and this list has been refined through ongoing studies and consultation to create the final list used in the Final EIS/EA.

The EIS Guidelines (Appendix A1) also require the identification of alternatives to carry out the Project, specifically related to:

- location of key Project components
- fuel storage and distribution
- water supply and treatment (mine and potable)
- mine waste disposal (methods, conveyance and sites considered)

Based on expected Project operational requirements, GGM developed an initial long list of potentially applicable alternatives (as identified in the Long List component of Figure 4-1). The long list identified reasonably applicable technologies and methods based on industry standards as a starting point for the evaluation process. The long list of alternative methods that were identified for each Project component are identified in Table 4-1, with more detail describing each alternative in Table 4-6. This table also identifies the Project components that were initially identified for assessment in the approved ToR (Appendx A2), and describes the updates to the list of Project components since the ToR approval.

Table 4-1: Long List of Alternatives

Project Component Identified in the Final EIS/EA	Preliminary Project Component Identified in the ToR	Rationale for Change	Long List of Methods Identified for Assessment
Waste Rock Storage Areas (WRSA)	Waste Rock Storage Areas	No change from ToR. Assessed through a separate Multiple Accounts Analysis as described in Section 4.1.4.3.	Locations: • WRSA-1 • WRSA-2 • WRSA-3 • WRSA-4 Disposal Methods • In-pit storage of non-segregated waste rock • Combined above ground and in-pit storage of non-segregated waste rock • Co-disposal of waste rock and tailings • Segregation of waste rock due to acid rock drainage/metals leaching (ARD/ML) potential
Tailings Management Facility (TMF)	Tailings Management Facility	No change from ToR. Assessed through a separate Multiple Accounts Analysis as described in Section 4.1.4.3.	Locations: • TMF-1 • TMF-2 • TMF-3A • TMF-4 • TMF-8 • TMF-9 Disposal Methods: • Cyclone separation with sand embankment and slimes impoundment storage • Co-disposal of waste rock and tailings • Dry stacking of filtered tailings • Surface disposal of paste tailings • Surface disposal of thickened tailings • Impoundment disposal of conventional tailings • Impoundment disposal of thickened tailings Dam Construction Methods: • Upstream • Downstream • Centerline

Table 4-1: Long List of Alternatives

Project Component Identified in the Final EIS/EA	Preliminary Project Component Identified in the ToR	Rationale for Change	Long List of Methods Identified for Assessment
Process Plant	Ore Milling and Processing Plant	Minor change to terminology.	Process Plant Location • onsite • offsite Ore Processing • cyanidation and gravity separation • flotation • gravity separation • thiosulphate/alpha-cyclodextrin Process Water Supply • reclaim from the tailings management facility (TMF) • dewatering historical underground workings • surface water
Ore Stockpile, Crushing Plants and Mill Feed Ore Storage Area	Mill Feed Ore Storage Area and Crushing Plant Ore Stockpile	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA.	Ore Stockpile, Crushing Plant and Mill Feed Ore Storage Area (onsite, offsite)
Goldfield Creek Diversion	Watercourse Realignments	Updated to reflect the fact that the only realignment is for Goldfield Creek, which is overprinted by the TMF.	Diversion Options (1, 2, 3, 4A, 4B, 5, 5A, 6)
Highway 11 Realignment	Highway 11 Realignment (and Potential Relocation of MTO Patrol Yard)	Highway 11 alternatives are considered separately due to the higher potential for effects and level of detail required. The Ministry of Transportation [MTO] Patrol Yard is still considered, but separately from the highway realignment as part of Provincial Infrastructure.	Highway Routes (1A, 1B, 1C, 1D, 1D optimized, 2, 3, 4, 5, 6)

Table 4-1: Long List of Alternatives

Project Component Identified in the Final EIS/EA	Preliminary Project Component Identified in the ToR	Rationale for Change	Long List of Methods Identified for Assessment
Historical Tailings and Other Contaminated Soil	Historic MacLeod Tailings and Hardrock Tailings	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA (includes consideration of historical tailings and other contaminated sites).	Historical Tailings (no removal, partial removal, complete removal within the Project development area (PDA) Contaminated Soils (manage on site or remove, leave in place)
Aggregate Sources	Aggregate Pit(s)	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA (including consideration of using mined waste rock as an aggregate source).	Aggregate Sources (existing quarries/pits, use mined waste rock, new aggregate sources)
Contact Water Collection, Treatment and Discharge	Mine Water Treatment Facility	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA.	Open Pit Contact Water (direct to historical underground workings, pump to surface treatment) WRSA and Process Plant Area Contact Water (central treatment, direct to historical underground workings, direct to TMF) Treatment Method (coagulation/filtration, reverse osmosis, ion exchange, lime precipitation, biological treatment, engineered wetland)
Sewage Treatment Plant for the Mine Site	Sewage Treatment Facility	Clarified that the focus is on the overall mine site sewage treatment (sewage treatment for temporary camp considered separately below)	Sewage Treatment (sewage treatment plant, septic tanks, lagoons, connection to the municipal system, trucking offsite)
Potable Water Supply	Water Supply and Distribution System	Minor change to terminology to focus on supply alternatives, since distribution will be confirmed during design and will be limited to the PDA.	Potable Water Supply (groundwater wells, surface water, connect to municipal system)

Table 4-1: Long List of Alternatives

Project Component Identified in the Final EIS/EA	Preliminary Project Component Identified in the ToR	Rationale for Change	Long List of Methods Identified for Assessment
Explosives Management	Explosives Storage and Manufacturing	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA.	Explosives Management (onsite management, transport from existing facilities)
Power Source and Associated Infrastructure	Power Generation Distribution System	Minor change to terminology to clarify the alternatives considered.	Primary Power (natural gas power plant, diesel or fuel generation, connection to the provincial grid, renewable energy) Temporary Power (connection to the provincial grid, diesel or natural gas generation)
Waste Management	Domestic Solid Waste Handling Facility	Minor change to terminology to better capture the scope of the Project component as assessed in the Final EIS/EA (includes consideration of hazardous and non-hazardous waste).	Non-hazardous Waste (truck offsite, establish new landfill, onsite incineration) Hazardous Waste (truck offsite, onsite disposal)
Mining Equipment Fuel Type and Source	Fuel Supply, Conversion, Storage and Distribution System	Minor change to terminology to clarify that the alternatives are focused on fuel type and source for mine equipment.	Fuel Type (full diesel, diesel/liquefied natural gas [LNG] blend, gasoline) Fuel Source (LNG trucking, LNG plant, diesel trucking)
Infrastructure and Support Facilities	Site Infrastructure and Support Facilities	Updated to also include consideration of temporary camp location and sewage treatment alternatives for the temporary camp.	Site Access (western access, eastern access, north access) Buildings and Support Facilities (onsite facilities, offsite facilities) Temporary Camp (near Old Arena Road, near open pit, outside Geraldton, no camp) Sewage Treatment for Temporary Camp (connection to the municipal system, sewage treatment plant, septic tank, lagoon, trucking offsite)

Table 4-1: Long List of Alternatives

Project Component Identified in the Final EIS/EA	Preliminary Project Component Identified in the ToR	Rationale for Change	Long List of Methods Identified for Assessment
Hydro One TS, Transmission/ Distribution Lines and Operations Centre Relocation	HONI Substation	Minor terminology change to address Hydro One's naming preference.	Transformer Station Study Areas (1, 2, 3, 4) Transformer Station Locations (1, 1A/B, 1C, 1D, 2, 2A)
MTO Patrol Yard	MTO Patrol Yard (moved from Highway 11 Realignment)	New category to assess the MTO Patrol Yard (included as part of the Highway 11 component in the ToR).	MTO Patrol Yard Location (west of Project, east of Project)
Closure	N/A	Includes consideration of conceptual closure alternatives for various Project components.	Open Pit (natural filling, enhanced filling) WRSAs (cover and vegetate, no cover) TMF (cover and vegetate, no cover) Buildings and Infrastructure (removal, reuse)
N/A	Natural Gas Pipeline	Not considered in the Draft or Final EIS/EA, as GGM confirmed that this would be undertaken by a third party as part of a separate regulatory process.	Alternatives were not considered in the Final EIS/EA

4.1.3 Initial Screening of Alternative Methods

The initial screening step (as identified in the Initial Screening component of Figure 4-1) evaluates the technical, economic or environmental constraints that eliminate alternative methods from further analysis based on the screening questions identified in the approved ToR (Appendix A2) and the EA Code of Practice.

Initial screening of long list alternative methods for each of the Project components identified in Table 4-1 was carried out based on a landscape level assessment of the existing environment, taking into account major constraints and technical limitations and the potential for effects to the environment (i.e., natural, social, economic, cultural and built environment), to a level of detail sufficient to identify 'fatal flaws'. The initial screening of alternative methods considered the following questions:

- Do they provide a viable solution to the problem or opportunity to be addressed?
- Are they proven technologies (at the scale required)?
- Are they technically feasible (at the scale required)?
- Are they consistent with other relevant planning objectives, policies and decisions?
- Are they consistent with government priorities?
- Could they affect any sensitive environmental features?
- Are they practical, financially realistic and economically viable?
- Are they within the ability of the proponent to implement?
- Can they be implemented within the defined study area?
- Are they appropriate to the proponent doing the study?
- Are they able to meet the purpose of the Environmental Assessment Act?

The results of the initial screening and the rationale for eliminating certain alternative methods are presented in Table 4-6.

The Project team brought forward into the comparative analysis those methods with substantial merit and possibility for implementation, and eliminated those with fatal flaws that would ultimately affect the overall ability to implement the Project. The identification of fatal flaws included consideration that each alternative would be implemented by applying reasonably feasible mitigation measures based on industry standards, and relevant regulatory requirements or guidelines (e.g., highway alternatives would be assumed to include appropriate stormwater management features to manage water quality and quantity; effluent treatment would be expected to meet regulatory standards for discharge).

In the initial screening, the Project team considered the design of Project components and how alterations to location, technology and mitigation measures might affect overall potential effects. Only alternatives that presented substantially different ways of approaching the design of a Project component were identified for the initial screening to avoid comparing non-differentiating alternative methods.

In some cases, alternatives were defined based on a qualitative description, but where design differences were substantial enough to alter the potential effects of a Project component, conceptual alternatives were developed using mapping to better define alternative locations and footprints. For example, different route alternatives for Highway 11, different locations for mine waste disposal, and Goldfield Creek diversion, were developed that could have substantially different effects on the environment at a landscape level (e.g., one alternative may require more vegetation removal or changes in water flow between watersheds, where another may not experience these effects).

Where multiple potentially feasible alternatives were identified as part of the initial screening, Project components were brought forward to the comparative analysis. If only a single feasible alternative method for a Project component remained based on the results of the initial screening, the comparative analysis step was not applied, and the remaining alternative was considered preferred and brought forward into the Project description (Chapter 5.0) and environmental effects assessment as presented in the subsequent chapters of the Final EIS/EA. The initial screening results are summarized in Section 4.2.1.

Note that alternatives for tailings management and WRSAs were assessed through a process prescribed by Environment and Climate Change Canada (ECCC), as discussed in Section 4.1.4.3 and detailed in "Alternative Assessment Report: Hardrock Project – Waste Rock Storage Area and Tailings Management Facility "(WRSA and TMF Alternatives Assessment Report; Appendix G1).

4.1.4 Comparative Analysis of Alternative Methods

Potential alternative methods carried forward as part of the initial screening were compared against a range of environmental criteria to select a preferred method for each Project component as part of the comparative analysis (as identified in the Comparative Analysis component of Figure 4-1).

The Project team completed the comparative analysis by selecting a set of criteria and indicators based on the EIS Guidelines, approved ToR, regulatory requirements and input obtained through consultation, as described in Section 4.1.4.1. These criteria and indicators provide the framework that was used to measure and evaluate the potential for positive and negative effects and compare the associated advantages and disadvantages of alternative methods in order to select the alternative with the greatest overall balance of advantages for each Project component as part of the comparative analysis described in Section 4.1.4.2.

4.1.4.1 VCs/Criteria and Indicators

The comparative analysis evaluates the potential for effects of each alternative method against a comprehensive set of environmental components and other technical considerations based on the EIS Guidelines, approved ToR, regulatory requirements and input obtained through consultation.

The federal and provincial EA processes vary in how the potential effects of alternatives are categorized, and the Project team has developed a framework that combines the concepts of the two processes:

- For a federal EA, potential effects are assessed based on valued components (VCs), which are are components or attributes of the environment that are important for ecological, legal, scientific, cultural, economic, or aesthetic reasons. Effects on VCs are determined by identifying measurable parameters which facilitate the measurement of potential effects. The potential effects of the preferred Project components are described in detail in the VC chapters (Chapters 7.0 through 19.0).
- Provincially, an EA typically assesses the effects of alternatives based on criteria and indicators. Criteria are tied to each component of the environment similar to VCs (including natural, social, economic, cultural and built environment), and have related indicators that identify how the potential for effects is measured.

There is overlap between the typical VCs that would be identified for a federal EA, and the criteria that would be developed for a provincial EA. For this reason, the term "VCs/criteria" is used to describe the categories that were assessed for the comparative analysis, and the term "indicators" is used to describe the considerations for measuring the potential for effects of each alternative on the VCs/criteria for the comparative analysis of alternative methods.

The VCs/criteria list includes components of the natural, social, economic, cultural and built environment, which are identified to align with the VC chapters (Chapters 7.0 to 19.0) in the Final EIS/EA. Additional criteria related to cost, feasibility and operational health and safety are also included to assess the technical characteristics of the alternatives methods.

The environmental components of the VCs/criteria considered in the alternatives assessment (i.e., those criteria not associated with Cost, Technical Feasibility, and Operational Health and Safety) align with the VCs assessed in Chapters 7.0 to 19.0 of the Final EIS/EA. Similar indicators are applied in the environmental effects assessment for each VC chapter, with an advanced technically focused level of detail based on the collection of preferred Project components identified that make up the Project Description as an outcome of the alternatives assessment.

The final list of VCs/criteria and indicators has been confirmed and refined through consultation with government agencies, Aboriginal communities and stakeholders. Table 4-2 identifies the general rationale for the selection of each indicator from the perspective of addressing the EA requirement to consider relevant components of the environment, and potentially relevant links to other environmental approvals required for the Project. The table also identifies which Aboriginal communities provided input on each VC/criterion through consultation, to further support the selection and consideration of that VC/criterion in the alternatives assessment.

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
NATURAL ENVIRONMENT			
Atmospheric Environment	Animbiigoo Zaagi'igan Anishinaabek (AZA), Aroland First Nation (AFN), Ginoogaming First Nation (GFN), Long Lake #58 First Nation (LLFN), Métis Nation of Ontario (MNO), Red Sky Métis Independent Nation (RSMIN)	Change in ambient air quality parameters	Provincial and federal regulatory objectives, guidelines and/or standards exist provincially and federally for NOx, CO, SO_2, PM, PM_{10}, $PM_{2.5}$, and others including metals and other substances (such as hydrogen cyanide, calcium oxide). These standards are based on human health, environment and nuisance effects. Regulatory Approval Links: *Environmental Protection Act* (MOECC)
		Climate change as measured by change in greenhouse gas (GHG) emissions	Incorporating climate change considerations in environmental assessment is guided by the Canadian Environmental Assessment Agency (CEA Agency; 2003). Ontario is developing GHG emissions targets. There are also federal and provincial GHG emissions reporting requirements. Regulatory Approval Links: *Environmental Protection Act* (MOECC)
Acoustic Environment	AFN, GFN, LLFN, MNO, RSMIN	Change in noise or vibration levels	Valued receptors near the Project may experience noise or vibration effects from alternative methods. Comparable to MOECC sound level limits (MOE 2013). These limits are applicable during the operation phase. The MOECC limits are not applicable to noise produced by construction. However due to the length of the construction period (approximately two years) MOECC limits will be used as a frame of reference when assessing noise due to construction. For vibration during operation, federal, provincial and municipal regulations or guidelines are not available, but the International Organization for Standardization (ISO) publication *2631 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-Body Vibration – Part 2: Vibration in Buildings* (*1 Hz to 80 Hz*) (ISO 2003), provides recommendations for quantitative limits for human exposure to vibration. Regulatory Approval Links: *Environmental Protection Act* (MOECC)

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
Groundwater	AZA, AFN, Biigtigong Nishnaabeg, Bingwi Neyaashi Anishinaabek (BNA), GFN, LLFN, MNO, Pays Plat First Nation (PPFN), RSMIN	Change in groundwater quantity or flow	A decrease in groundwater levels may result in loss of yield to dug or drilled wells, reducing their ability to meet water supply requirements, or affect source water protection objectives. A decrease in groundwater levels and changes in the natural groundwater flow could affect baseflow to nearby surface water bodies and wetlands. Potential environmental effects from changes to saturation levels within the historical MacLeod and Hardrock tailings. <u>Regulatory Approval Links:</u> *Ontario Water Resources Act* (MOECC)
		Change in groundwater quality	Alternative methods may result in changes to groundwater chemistry. Seepage associated with storage areas/stockpiles (waste rock, ore, overburden), TMF, historical tailings facilities, roads, spills, and closure conditions may affect groundwater quality or affect source water protection objectives. Changes in groundwater quality may affect surface water quality. Changes to groundwater quality may affect municipal drinking water sources protected under Source Protection Plans. <u>Regulatory Approval Links:</u> *Ontario Water Resources Act* (MOECC), *Environmental Protection Act* (MOECC)
Surface Water	AFN, BN, BNA, Constance Lake First Nation (CLFN), Eabametoong First Nation (EFN), GFN, LLFN, Marten Falls First Nation (MFFN), MNO, PPFN, Pic Mobert First Nation (PMFN), RSMIN	Change in surface water quantity or flow	Alternative methods may result in a change in groundwater levels, which may result in a change in discharge and baseflow to nearby water bodies. Alternative methods may affect runoff characteristics and subsequently change the water balance of the area. Management of contact water may affect the contributing drainage areas of local watersheds and local hydrology regimes. The Goldfield Creek diversion to facilitate construction of Project components may affect local hydrology regimes. The number of affected watercourses and lakes can be measured to assess the potential for adverse effects on surface water and the need for mitigation. <u>Regulatory Approval Links:</u> *Navigation Protection Act* (TC), *Ontario Water Resources Act* (MOECC)
		Change in surface water quality	Alternative methods may result in changes to surface water chemistry and total suspended solids (TSS) levels. Seepage from the WRSA and TMF may affect surface water quality.

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
			Discharge of treated effluent from the effluent treatment plant (ETP) and sewage treatment plant may affect receiving water quality. Changes to surface water quality may affect municipal drinking water sources protected under Source Protection Plans. <u>Regulatory Approval Links:</u> *Ontario Water Resources Act* (MOECC), *Environmental Protection Act* (MOECC)
Fish and Fish Habitat	AZA, AFN, Biigtigong Nishnaabeg, Biinjitwaabik Zaaging Anishinaabek (BZA), CLFN, GFN, LLFN, MFFN, MNO, RSMIN	Change in fish habitat	Alternative methods have the potential to affect the quality of fish habitat by altering characteristics such as water quality, sediment composition, riparian vegetation, and in-stream cover. These parameters are important for assessing the suitability of habitat for various species and evaluating productivity. The Project may also result in the loss of fish habitat for construction of Project components. Changes to fish habitat directly influence fish, which are protected by Section 35 (1) of the *Fisheries Act*. <u>Regulatory Approval Links:</u> *Fisheries Act (*Fisheries and Oceans Canada [DFO]*), Fish and Wildlife Protection Act (Ministry of Natural Resources and Forestry* [MNRF]), *Endangered Species Act* (MNRF)
		Change in fish	Both lethal and sublethal effects on fish communities may result in adverse effects on fisheries. Work in or around water can cause direct mortality of fish, which are protected by Section 35 (1) of the *Fisheries Act* and valued locally for recreational purposes and sustenance. The Project may result in increased levels of parameters of potential concern being discharged to the aquatic environment, which can potentially bioaccumulate in fish tissue, affecting fish health and fishery productivity. <u>Regulatory Approval Links:</u> *Fisheries Act* (DFO*), Fish and Wildlife Protection Act* (MNRF), *Endangered Species Act* (MNRF)
Vegetation Communities	AFN, Biigtigong Nishnaabeg, BNA, GFN, LLFN, MNO	Change in abundance of vegetation species of interest	The direct loss of plants and vegetation communities will occur through vegetation removal to accommodate for Project development, including related to plant Species at Risk. <u>Regulatory Approval Links:</u> *Endangered Species Act* (MNRF)
		Change in abundance or	Through the loss of upland vegetation communities, or effects from alternative methods, the landscape diversity,

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
		condition of upland vegetation communities	distribution and abundance of plant species common to the area may be affected.
		Change in wetland function or connectivity	Wetlands are important from hydrological, ecological and socio-economic standpoints. The effects on wetlands by the Project can be estimated to determine the extent of change within the greater landscape. The direct loss or alteration of wetland communities will occur through vegetation removal to accommodate Project development.
Wildlife and Wildlife Habitat	AZA, AFN, BNA, GFN, LLFN, MNO, PPFN, PMFN	Change in movement, health or mortality risk of wildlife	Alternative methods may result in the direct mortality of wildlife species, or create barriers across wildlife movement corridors, including related to wildlife Species at Risk. Regulatory Approval Links: *Fish and Wildlife Protection Act* (MNRF), *Endangered Species Act* (MNRF)
		Change in wildlife habitat	Alternative methods may result in the direct and indirect loss or alteration of habitat, including related to habitat type, function and availability, including related to Species at Risk. Regulatory Approval Links: *Fish and Wildlife Protection Act* (MNRF), *Endangered Species Act* (MNRF)
SOCIAL ENVIRONMENT			
Community Services and Infrastructure[1]	AZA, AFN, BNA, GFN, LLFN, MNO, RSMIN	Change in capacity of housing and accommodation	The Project may result in local population growth that may affect the capacity and availability of local housing and accommodations.
		Change in capacity of health and emergency services and infrastructure	Project-related population and business growth may exceed the capacity of existing health and emergency services and infrastructure.
		Change in the capacity of recreation and entertainment services and infrastructure	Alternative methods may result in removal of tourism and recreation infrastructure, and Project-related population and business growth may exceed the capacity of existing recreation services and infrastructure.

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
		Change in the capacity of provincial and municipal services and infrastructure	The Project will result in the relocation of some transportation infrastructure, and may affect traffic patterns and capacity along existing roads. Alternative methods and related business growth may exceed the capacity of existing water, sewer and power services and infrastructure. During operation, workers with families may place additional demands on schools. The ability of Aboriginal communities to use provincial and municipal services or infrastructure may also be affected by Project activities.
Operational Health and Safety[2]	-	Health and safety of mine workers	The Project will be designed and operated in consideration of avoiding the potential for operational failures that could lead to injury.
		Health and safety of local residents	The Project will be designed and operated in consideration of providing a safe environment for local residents outside the PDA.
ECONOMIC ENVIRONMENT			
Cost[2]	-	Capital cost	The cost to construct Project components for the establishment of the Project is a Key Differentiating Factor in the economic viability of the Project.
		Operational / maintenance cost	The long-term operating/maintenance costs for Project components is a Key Differentiating Factor in the economic viability of the Project.
		Rehabilitation / closure cost	Closure is required by legislation, and costs associated with ensuring adequate decommissioning and rehabilitation is a Key Differentiating Factor in the economic viability of the Project.
Labour and Economy	AZA, AFN, BN, BZA, BNA, CLFN, GFN, LLFN, MNO, PMFN, RSMIN	Change in labour	The direct, indirect and induced employment effects of the Project will result in increased employment opportunities. Project demand for labour may encourage people who are not otherwise employed or who are not in the workforce to work on the Project. Project employment may result in reduced availability of skilled labour for other employers.

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
		Change in economy	The Project will result in increased business contracts for local and regional companies. Increased labour income will contribute to the local and regional economies. The Project has potential to interact with economic activities related to tourism and forestry. Taxes and royalties associated with the Project will contribute to government revenue.
Technical Feasibility[2]		Ability to implement / commonly used technology in similar applications	Construction complexity and risk are key factors in determining the industry standard technology or design methods to apply to the Project.
		Effectiveness / reliability	Using safe and proven technology will limit Project risks and enhance the long-term viability of the Project from an economic, operational, and environmental protection perspective.
CULTURAL ENVIRONMENT			
Heritage Resources	AZA, AFN, BZA, GFN, LLFN, MNO, RSMIN	Change in archaeological sites	The Project has the potential to permanently remove, disrupt, or displace archaeological resources determined to have cultural heritage value or interest. Regulatory Approval Links: *Ontario Heritage Act* (Ministry of Tourism, Culture and Sport [MTCS])
		Change in architectural or historical resources	The Project has the potential to permanently remove, disrupt, or displace architectural or historical resources determined to have cultural heritage value or interest. Regulatory Approval Links: *Ontario Heritage Act* (MTCS)
TLRU	AZA, AFN, Biigtigong Nishnaabeg, BNA, CLFN, EFN, GFN, LLFN, MFFN, MNO, PPFN, RSMIN	Change in Aboriginal communities' cultural practices	Various biophysical and socio-economic environmental conditions may affect the use of cultural or spiritual sites. Alternative methods may disrupt watercourses or trails used by Aboriginal communities to access areas used for traditional purposes.
		Change in Aboriginal communities' traditional land uses (including hunting, fishing, trapping and harvesting)	Plant harvesting, fishing and hunting depend on the health and abundance of traditionally harvested species, and the continued availability of traditional harvesting areas, which may be affected by alternative methods. Project-related employment may increase traditional land uses through increase wages used towards getting out on the land. Alternative methods may disrupt watercourse or trails used by Aboriginal communities to access areas used for traditional purposes.

Table 4-2: Final List of VCs/Criteria and Indicators

VC/ Criterion	Aboriginal Community Input	Indicators	Rationale
BUILT ENVIRONMENT			
Land and Resource Use (LRU)	AFN, GFN, LLFN, PMFN	Change in recreational LRU	The Project may affect park use (including MacLeod Provincial Park) indirectly by creating disturbance or altering the landscape. Areas used for hunting and fishing may be restricted or lost due to alternative methods. Areas used for recreational activities and recreational trails may be restricted or lost due to alternative methods.
		Change in navigation	Alternative methods may either restrict navigation on watercourses or may affect the quality of the experience of navigation. <u>Regulatory Approval Links:</u> *Navigation Protection Act* (Transport Canada [TC])
		Change in commercially-based LRU	Traplines and guide-outfitting are area based, and reduction in accessible areas or access to these areas can reduce economic potential. The Project may affect trapping, guide outfitting and bait harvesting indirectly by creating disturbance to practitioners or altering the landscape. Alternative methods may affect existing commercially-based LRU. Existing mining tenure and facility locations may be disrupted by alternative methods.

NOTES:

1 Also applies to infrastructure used by Aboriginal community members

2 Not a VC, but included as an additional non-environmental criterion to assess alternatives based on other relevant technical and operational factors.

The list of VCs/criteria and indicators developed for the alternatives assessment considered the following factors:

- addressing the potential for effects on the natural, social, cultural, economic and built environment
- linkages to the VCs identified for the environmental effects assessment
- considering the potential for effects on environmental components, based on an understanding of existing conditions from a review of baseline information
- considering the interests or mandates of regulatory authorities based on input received and an understanding of post-EA approvals required to implement the Project

- considering the interests of and the potential for adverse effects on Aboriginal communities based on input received and the results of Traditional Knowledge and Land Use studies, and information received during consultation activities with communities and leadership
- considering the interests of other stakeholders and members of the public based on input received during consultation activities

The initial list of VCs/criteria was developed early in the EA process to support consultation on the alternatives assessment method. The list was developed based on previous project experience and the expertise of the Project Team, GGM has also considered input from other parties to identify how their specific regulatory mandates, policies and interests can be addressed through the assessment. Where government agencies have provided specific direction on their regulatory roles or mandates, this information was considered by confirming that the broad list of VCs/criteria addressed the environmental components of interest, and by refining the criteria or indicators and definitions to reflect the input provided. Input from Aboriginal communities was considered and confirmed the components of the environment addressed in VCs/criteria and indicators. Information provided through Traditional Knowledge studies or other reports was also reviewed and incorporated into the assessment through updating existing conditions and the subsequent conclusions related to the potential for effects linked to TLRU (at the level of detail required to complete the alternatives assessment).

Information received through ongoing Aboriginal consultation has generally validated the comprehensive nature of the list of VCs/criteria and indicators. Where new information was brought forward during the Draft EIS/EA review process regarding a particular land use location that may be affected by the selection of a preferred alternative method, GGM reviewed methods and updated the comparative analysis to assess whether a change was warranted, and followed up with the communities to develop additional mitigation as needed (refer to TLRU VC, Chapter 18.0, for community-specific detail).

Similarly, input from stakeholders was also considered and applied to the list of criteria and indicators, assessment method and results to confirm that the components of the environment reflected the identified interest.

Further detail on how consultation with government agencies, Aboriginal communities and stakeholders has informed the development of the list of VCs/criteria and indicators is described in Section 4.1.5.

4.1.4.2 Comparative Analysis Process

The comparative analysis process was based on the VCs/criteria list identified above, and supported with baseline information obtained and studies undertaken as part of the EA process, which cover a wide range of data sources. Information from engineering studies undertaken by GGM was used to define the operational needs of the Project. This information was used to define the scope of potential alternative methods, and to predict the potential for positive and negative effects of each alternative method on the VCs/criteria.

Following completion of the preliminary comparative analysis results, ongoing baseline studies and consultation were further considered as the comparative analysis process and results were refined. This information was reviewed to identify relevant additions to key environmental constraints or features, and the results of comparative analysis were updated to determine if changes were required, including refinements to the results related to the potential for effects and overall advantages and disadvantages of alternatives. Key changes to the comparative analysis results are outlined in Section 4.1.5. This iterative approach to the assessment has strengthened the evaluation process and validated the outcomes carried forward in the Final EIS/EA.

Both quantitative and qualitative observations are used to identify the potential effects for each indicator under the alternative method being assessed, and considered for each Project phase (construction, operation, and closure). A comparative evaluation was then completed to establish the relative advantages and disadvantages of each alternative based on the following process:

- Define how each alternative would conceptually be implemented to a level of detail sufficient to distinguish each alternative from the others (including as appropriate: location, nature of disturbance to the landscape, potential for emissions/discharge assuming the application of standard mitigation measures, etc.).
- Characterize the potential for effects of each alternative based on expected potential for emissions, discharges or disturbance during each phase of the Project (construction, operation, and closure). The interactions of various VCs/criteria were considered at a conceptual level.
- Compare the potential for effects of each alternative method on each VC/criterion through the indicators to determine which alternatives represent advantages or disadvantages in relation to the others.
- Identify the Key Differentiating Factors for each Project component, by confirming which criteria identify clear advantages or disadvantages for one or more alternatives.
- Summarize the advantages and disadvantages of each alternative based on the Key Differentiating Factors identified.
- Select a preferred alternative based on measuring the greatest balance of advantages to disadvantages of each alternative (in most cases this is a simple comparison of which alternative demonstrates the most advantages, though in some cases further rationale may be applied to confirm a particular selection).

The detail required for a conceptual understanding of alternatives varies depending on the overall potential for effects. For instance, a higher level of detail regarding location and dimensions was developed for Project components with the potential for greater effects on the local landscape and overall PDA, such as the WRSAs, TMF, Goldfield Creek diversion and Highway 11 realignment. For Project components with less potential for effects or where options are limited, such as the location of the process plant, more general assumptions about potential designs were made to inform the evaluation process.

The comparative ranking of each alternative for each VC/criterion and indicator was determined as outlined below and based on the process described in the ToR:

- Major Advantage – the alternative will result in substantially more positive effects or less negative effects compared to other alternatives.
- Advantage – the alternative will result in moderately more positive effects or less negative effects compared to other alternatives.
- Neutral – the alternative does not demonstrate a measurable difference in positive or negative effects compared to other alternatives.
- Disadvantage – the alternative will result in moderately more negative effects or less positive effects compared to other alternatives.
- Major Disadvantage – the alternative will result in substantially more negative effects or less positive effects compared to other alternatives.

The Project team considered the anticipated positive and negative effects for each alternative method related to each indicator. The key advantages and disadvantages identified through the ranking of the VCs/criteria were then summarized to identify an overall ranking of Preferred or Not Preferred for each alternative method based on the Key Differentiating Factors selected for that particular Project component.

With the exception of the federally prescribed process for the TMF and WRSA alternatives assessments, a weighting approach was not required for the VCs/criteria, as the identification of Key Differentiating Factors and overall balance of advantages for each Project component was a transparent means to focus the comparative analysis to arrive at a clear conclusion for the preferred method. The preferred alternative for each component of the Project was confirmed based on this overall assessment of VCs/criteria to identify advantages and disadvantages, as illustrated in Table 4-3. The summary provided in Section 4.2 for the comparative analysis process focuses on the most relevant VCs/criteria for that particular set of alternative methods to help clarify the Key Determining Factors for the preferred methods selected.

Table 4-3: Sample Comparative Analysis

VC/Criterion	Indicators	Alternative Methods for Project Component	
		Alternative 1	Alternative 2
VC/Criterion 1	Parameter 1	Describe potential effects for all phases (construction, operation and closure)	Describe potential effects for all phases (for construction, operation and closure)
	Parameter 2	Describe potential effects for all phases	Describe potential effects for all phases
Overall VC/Criterion Ranking **Key Differentiating Factor? (YES/NO)**		Provide comparative ranking and summary rationale	Provide comparative ranking and summary rationale
VC/Criterion 2	Parameter 1	Describe potential effects for all phases	Describe potential effects for all phases
	Parameter 2	Describe potential effects for all phases	Describe potential effects for all phases
Overall VC/Criterion Ranking **Key Differentiating Factor? (YES/NO)**		Provide comparative ranking and summary rationale	Provide comparative ranking and summary rationale
Key Differentiating Factor 1		Comparative Ranking (advantage/disadvantage)	Comparative Ranking (advantage/disadvantage)
Key Differentiating Factor 2		Comparative Ranking (advantage/disadvantage)	Comparative Ranking (advantage/disadvantage)
OVERALL ALTERNATIVE RANKING		**Preferred / Not Preferred**	**Preferred / Not Preferred**

The results of the comparative analysis are provided in Appendices G2 through G11, and are summarized in Sections 4.2.3 to 4.2.19. Following the identification of a preferred alternative for each Project component, the overall description of the Project was finalized (Chapter 5.0). This Project description was then used to undertake the environmental effects assessment provided for VCs and assessment of cumulative effects. The VCs applied to the comparative analysis link directly with the VCs considered in the environmental effects assessment in Chapters 7.0 to 19.0, with the exception of Operational Health and Safety, Cost, and Technical Feasibility, which were additional non-environmental criteria specifically defined for the comparative analysis to assess alternatives based on other relevant technical and operational factors.

4.1.4.3 ECCC Alternatives Requirements

ECCC's *Guidelines for the Assessment of Alternatives for Mine Waste Disposal* (ECCC Guidelines; 2013) lay out specific requirements for the assessment of mine waste disposal alternatives, which includes a seven-step process as follows:

1. Identify Candidate Alternatives
2. Prescreening Assessment
3. Alternative Characterization

4. Multiple Accounts Ledger
5. Value-Based Decision Process
6. Sensitivity Analysis
7. Document Results

GGM completed an assessment of alternatives for the TMF and WRSAs based on the ECCC Guidelines. The process followed is also consistent with the general requirements of the EA Code of Practice, which calls for a systematic evaluation of the potential environmental effects of alternatives, including the weighing of advantages and disadvantages of proceeding with a project. The results of this assessment, along with a detailed description of the assessment method, are found in Appendix G1 (WRSA and TMF Alternatives Assessment Report), separate from the results of the comparative analysis for other Project components. The results are summarized in Section 4.2.2.

4.1.5 Influence of Consultation and Consideration of Aboriginal Information

Consultation has been ongoing prior to and throughout the EA process, and will continue with government agencies, local Aboriginal communities, and stakeholders through the life of the Project. Chapter 3.0 (community and stakeholder consultation) provides more detail on the consultation process covering open houses, targeted meetings, newsletters, questionnaires, presentations, and capacity funding for technical reviews and community-based studies among other areas. The Record of Consultation (RoC; Appendix C) includes detailed comments received during the development of the Final EIS/EA. As part of the information sharing through the consultation process, Project-related information was provided by Aboriginal communities in the form of TK and TLRU studies and other forms of information sharing and considered in the alternatives assessment as described below.

Consultation feedback related to the alternatives assessment has been addressed through direct responses (in writing and follow up meetings), updates to assessment method and results in the Final EIS/EA, as appropriate. Information received has been considered by the Project team. An overview of the key comments that influenced the alternatives assessment between the Draft and Final EIS/EA is provided below.

Development of VCs/Criteria and Indicators (and Consideration of Aboriginal Information and Traditional Knowledge)

Comments directly related to the list of VCs/criteria and indicators developed for the comparative analysis were received from ECCC, the MOECC, LLFN and the MNRF.

ECCC provided comments on the rationale for identifying VCs/criteria and indicators, requesting updates to the rationale related to air quality, noise, groundwater, surface water, fish and fish habitat, and wildlife and wildlife habitat. The MNRF provided similar comments requesting updates to the rationale related to the consideration of MacLeod Provincial Park and species at risk. The MOECC generally requested that the list of VCs/criteria and indicators be updated to include further rationale for the selection of each, and for consideration of climate change and source water protection to be included. Table 4-2 was updated to clarify the rationale for the selection of VCs/criteria and indicators based on this input.

LLFN requested clarification on how Aboriginal TK was considered as an indicator in the alternatives assessment for various Project components. A direct response was provided to clarify that TK was considered through the TLRU criterion, which included two separate indicators for consideration (change in Aboriginal communities' cultural practices, and change in Aboriginal communities' traditional land uses). In addition, the results of the alternatives assessment related to these indicators was updated based on additional TK information provided by communities. This has included consideration of specific traditional use sites and areas identified by LLFN as part of its TK study and TK studies received by other communities, and identification of where the potential for direct effects exists (including related to Highway 11 routes, Hydro One TS locations and Goldfield Creek diversion options).

LLFN also requested clarification on why the 'human and ecological health' and 'number and type of water bodies affected' indicators were removed from the assessment. This approach was clarified through direct responses, and the inclusion of a description of why these changes were implemented in Table 4-4. It was clarified that the 'human health and ecological risk' indicator was initially considered as a separate criterion to support the alternatives assessment, but after reviewing the results of the comparative analysis, it was determined that there were no key advantages related to human health and ecological risk that played a determining role in the selection of alternatives, so this was removed. However, related effects are considered in other criteria (e.g., treatment requirements for drinking water from surface water and groundwater sources). The number and type of waterbodies affected is considered under the change in surface water quantity or flow indicator. Table 4-2 was updated to indicate that the number of affected watercourses and lakes can be measured to assess the potential for adverse effects on surface water and the need for mitigation.

Along with direct comments, addressed as described above, some additional alterations have also been made to the VCs/criteria and indicators based on the evolution of Project planning and the ongoing assessment of VCs. A summary of key changes to the initial list of VCs/criteria and indicators developed and presented for consultation is provided in Table 4-4, accounting for direct comments received on the list and other refinements.

The list of VCs/criteria has also been reviewed and validated in consideration of ongoing input provided through consultation from Aboriginal communities, to confirm that the VCs/criteria adequately address the comments and input received. Table 4-5 summarizes which Aboriginal communities provided comments or input on each VC/criterion.

Detailed records of the comments provided related to the identification of criteria and indicators and the responses from GGM can be found in the RoC (Appendix C).

Table 4-4: Summary of Key Changes to the Initial VCs/Criteria List Following Consultation, Baseline Updates and Review of TK Studies

Final VC/Criterion	Key Changes to Initial List Used for Consultation
Atmospheric Environment	• Change criterion name from 'Air Quality' to Atmospheric Environment. • Inclusion of air quality parameters in indicator. • Inclusion of climate change consideration in the indicator related to GHG.
Acoustic Environment	• Inclusion of vibration along with noise. • Updated rationale to include consideration of potential effects on valued receptors near the Project.
Groundwater	• Inclusion of groundwater flow in indicator. • Updated rationale to include consideration of changes to saturation levels from historical tailings, identification of Project activities that may affect groundwater quality, and acknowledgement of the potential to affect municipal drinking water sources.
Surface Water	• Inclusion of surface water flow in indicator. • Removal of 'number and type of watercourses' as an indicator, as this measure was only relevant to a limited number of alternatives. Added this in the rationale for consideration in relevant comparative analyses. • Updated rationale to include consideration of changes to water chemistry and TSS level, and acknowledgement of the potential to affect municipal drinking water sources.
Fish and Fish Habitat	• Inclusion of change in fish in indicator.
Vegetation Communities	• Inclusion of species abundance, community condition and wetland connectivity in indicators. • Updated rationale to include consideration of how vegetation removal can result in loss or alteration to wetland communities, and the potential for effects on plant Species at Risk.
Wildlife and Wildlife Habitat	• Identification of wildlife movement, health and mortality risk as an indicator. • Updated rationale to include consideration of wildlife habitat type, function and availability, and the potential for effects on wildlife Species at Risk.
Community Services and Infrastructure	• Combined indicators for infrastructure and transportation to simplify the assessment process. • Inclusion of police, fire, medical and provincial infrastructure in indicators. • Updated rationale to include consideration of effects on traffic patterns and road capacity. • Updated rationale to clarify that Aboriginal use of community services and infrastructure may also be affected by Project activities.
Operational Health and Safety*	• No changes.
Human and Ecological Health	• Removed as an indicator, as it was determined that there were no key advantages related to Human Health and Ecological Risk that played a determining role in the selection of alternatives at the conceptual level. However, related effects are considered in other criteria (e.g., treatment

Table 4-4: Summary of Key Changes to the Initial VCs/Criteria List Following Consultation, Baseline Updates and Review of TK Studies

Final VC/Criterion	Key Changes to Initial List Used for Consultation
	requirements for drinking water from surface water and groundwater sources).
Cost*	• No changes.
Labour and Economy	• Minor changes to criteria and indicator labels to more accurately address the parameters being considered. • Updated rationale to include consideration of contributions to government revenue from taxes and royalties.
Technical Feasibility*	• No changes.
Heritage Resources	• Combined built heritage and heritage landscape indicators into a single 'architectural or historical resources' indicator to simplify the assessment process.
TLRU	• Combined indicators related to access, well-being and employment into two more general indicators related to cultural practices and traditional land uses to simplify the assessment process. • Updated rationale to include consideration of the potential to disrupt watercourses or trails used for access to areas for traditional purposes.
LRU	• Combined indicators related to trapping, hunting, fishing, parkland and other recreational activities into a single 'recreational land and resource use' indicator to simplify the assessment process. • Combined indicators related to planning, timber harvesting, tenure, mining and other land uses into a single 'commercially-based land and resource use' indicator to simplify the assessment process. • Updated rationale to include consideration of effects on MacLeod Provincial Park users, hunting and fishing restrictions, restricted access to recreational areas, mining tenure, industrial land uses, and private property.

NOTE:

* Not a VC, but included as an additional non-environmental criterion to assess alternatives based on other relevant technical and operational factors

Request for Consideration of Additional Alternatives

AFN and GFN requested additional analysis of specific alternatives as part of the assessment, including related to power supply, open pit filling and the natural gas pipeline.

AFN requested additional analysis of potentially connecting to the power grid, noting that they have an interest in regional power expansion, however this alternative was screened out due to a lack of capacity in the provincial grid. The summary results were updated to make it clear that use of an expanded power grid will be revisited if it becomes feasible in the future.

GFN requested specific consideration of water taking from Kenogamisis Lake in assessing the effects of the enhanced filling alternative for open pit closure. Section 4.2.19.1 was updated to clarify that expedited filling may include use of Kenogamisis Lake, a contribution that reduced the estimated filling time from approximately 50 years to 16 years. The comparative analysis in Appendix G11 and the summary results in Section 4.2.19.1 were updated to acknowledge this approach and address the potential for effects from water taking.

Determination of the Potential for Effects and Advantages/Disadvantages

LLFN, MNO, the MNRF and the MOECC provided comments requesting further information or clarification on the results of the comparative analysis, related to how the potential for effects was determined and advantages/disadvantages assessed.

LLFN and the MNRF requested that further quantitative analysis be completed to support the comparative analysis to clarify how the potential for effects was determined. Although the approved ToR (Appendix A2) indicated that a qualitative evaluation methodology would be applied that uses professional judgment of the Project team, further quantitative detail was provided where applicable to support the assessment of alternatives. In particular, this included updates to the Highway 11 and Goldfield Creek diversion assessments based on the latest Project information. For alternatives where quantitative information is not available, further detail on how potential effects were considered qualitatively for each Project phase is provided to enhance traceability. Sections 4.1.1 and 4.1.4.2 were updated with more detail on the alternatives assessment approach to explain that alternatives were developed to a conceptual level of detail sufficient to understand how the potential for effects vary between each alternative, using a combination of quantitative and qualitative observations as appropriate for each particular set of alternatives.

MNO and the MOECC requested clarification on how VCs/criteria and indicators were developed and applied in the alternatives assessment. In response, the comparative analysis tables in Appendices G2 to G11 were updated to include more detail on how potential effects were considered for each Project phase (construction, operation and closure) and the assumptions that were made regarding design and mitigation approaches, and this information was incorporated into the summary of results in Section 4.2. Section 4.1 was also updated to provide additional information on how the alternatives assessment was undertaken related to the development of criteria and indicators, how advantages and disadvantages were considered related to Key Differentiating Factors for each alternatives assessment, and how the application of mitigation measures was assumed to be applied to each alternative at a conceptual level.

Assessment of Project Components and the Selection of Preferred Alternatives

Comments were received from the CEA Agency, LLFN, MTO, MNO, the Ministry of Northern Development and Mines (MNDM), MOECC, RSMIN, the Municipality of Greenstone and members of the public requesting clarification on how various alternatives were assessed and the rationale for selecting preferred alternatives. Comments generally related to requests for more detail on how potential effects were characterized and considered in selecting preferred alternatives, including for aggregate sources, open pit closure, Highway 11 realignment, Goldfield Creek diversion, waste management, sewage treatment, power supply, management of historical tailings, temporary camp and the Hydro One TS.

In response to these comments, Section 4.1 was updated to provide additional clarity on how the alternatives assessment was carried out for each Project component, and the rationale for the decisions made as part of this process. The rationale for the selection of each Project component was updated in Section 4.2 and Appendix G where appropriate, based on the input received during consultation and Project planning to further justify the results.

Consideration of Aboriginal Information and Traditional Knowledge

For the purpose of the alternatives assessment, TK and TLRU information was considered at a landscape level to determine where alternatives would have the potential to affect traditional uses. For Project components that contribute to the overall extent of the PDA (including the Highway 11 realignment, Goldfield Creek diversion and Hydro One TS), mapping was used to identify specific interactions with Aboriginal sites or areas for each alternative. For Project components with a more limited extent (e.g., those components that are located within the boundary of the PDA, where offsite effects would be limited), a more general assumption was made on the potential to affect TLRU based on the potential to affect other VCs (e.g., the potential for surface water taking could have an effect on fish habitat, resulting in a localized disruption to Aboriginal fishing activity in that location).

The alternatives assessment considered the following community-specific TK information provided by Aboriginal communities:

- LLFN – TLRU information and mapping related to cabins and camps, travel routes, hunting and fishing areas, and hunting and trapping sites (from “Traditional Knowledge Assessement Related to the Premier Gold Mines Hardrock Project: prepared for Long Lake #58 First Nation” [Appendix J1] and “Long Lake #58 First Nation Traditional Land Use Survey Results Greenstone Gold Mine” [Appendix J2]).
- MNO – TLRU information and mapping related to tents or temporary structures, game kill sites, fishing areas, natural materials and plant harvesting areas, large game and small game harvesting areas, trapping areas, upland game bird harvesting areas, and cultural practice sites and routes (from “Métis Nation of Ontario - Traditional Knowledge and Land Use Study for the Hardrock Project: Lakehead/Nipigon/Michipicoten Traditional Territories” [Appendix J3]).
- AFN – information identified as confidential and not specifically identified as part of the assessment, although a summary document omitting confidential information was referenced but not appended to the Final EIS/EA.

- EFN – TK information and mapping related to environmental, habitation, transportation and subsistence activities (from "Eabametoong First Nation Knowledge and Use Scoping Study for Greenstone Gold's Proposed Hardrock Project" [Appendix J5]).
- GFN – information provided related to comments about the availability of fish, wildlife and traditional plants, reduced availability of traditional foods affecting traditions and culture and restricting rights and title, increased travel time to find traditional foods, and effects on housing prices (from "Community Needs Assessment Ginoogaming First Nation" [Appendix J7] and "Ginoogaming First Nation Social Impact Assessment" [Appendix J8].
- Pays Plat First Nation – a watershed study was completed, which identified that community members use the general area for hunting, fishing, trapping, gathering, travel and ceremonies, but otherwise focused on sampling of select lakes to confirm existing conditions (from "Pays Plat First Nation Watershed study for Greenstone Gold Mines" [Appendix J4]).

The comparative analysis tables in Appendix G describe how the potential to affect TLRU was considered for each alternative, including consideration of known Aboriginal sites or areas where relevant. Where the potential for effects on TLRU was identified as a Key Determining Factor in the assessment, a summary of the potential for effects was included in Section 4.2.

In addition to incorporating community-specific TK information in the assessment, consultation input was also considered from AFN, GFN, LLFN, MNO and RSMIN. Comments provided ranged from specific input into the assessment method and results to more general requests for more information related to Project components considered in the assessment; this input was used to refine the alternatives assessment. Comments provided by Aboriginal communities on VCs were also considered in refining the chapter, and this information was used to confirm that the VCs/criteria and indicators were scoped to effectively capture the environmental components of concern to each community. Particular comments about the environmental effects on VCs were also considered in confirming that the potential for effects of each alternative was effectively characterized in the comparative analysis.

A summary of how Aboriginal information and TK was incorporated into the three-step alternatives assessment is provided in Table 4-5.

Table 4-5: Consideration of Aboriginal Information and TK in the Alternatives Assessment

Assessment Step	Approach to Incorporating Aboriginal Information and TK
Step 1 - Long List of Alternative Methods	• Input into Project components and alternative methods considered, including refining alternatives considered and provided additional rationale for why alternatives were identified for consideration.
Step 2 - Initial Screening of Alternative Methods	• Input into the rationale for screening out alternatives resulted in adjustments to the screening rationale. • Comments related to potential effects or requests for more detail on alternatives were considered in confirming that adequate rationale was

Table 4-5: Consideration of Aboriginal Information and TK in the Alternatives Assessment

Assessment Step	Approach to Incorporating Aboriginal Information and TK
	provided to support the screening results and provide a traceable decision-making process.
Step 3 - Comparative Analysis of Alternative Methods	• Direct input on the list of VCs/criteria and indicators considered in updating the list. • Comments with specific VCs and environmental features identified in TK studies were referenced to confirm that the assessment was scoped to effectively address the areas of interest of each community • Requests for more detail on Project components and the reasons for identifying specific alternatives were considered in revising the summary of results to clarify the assumptions used in assessing alternatives. • Comments related to potential effects were considered in updating the comparative analysis with more detail on how the potential for effects was determined, and how this was applied to each Project phase (construction, operation and closure). • TK information was used to identify the potential for effects on identified Aboriginal sites and areas. • Direct input on the comparative analysis results was used to refine the assessment through additional detail and clarifications on how alternatives were assessed to provide a logical and traceable summary of the decision-making process.

The comparative analysis tables provided in Appendix G and summary of results described in Section 4.2 represent an assessment of the Aboriginal information and TK collected for the Project.

4.2 SUMMARY OF INITIAL SCREENING AND COMPARATIVE ANALYSIS RESULTS

This section provides a summary of the decision-making process to identify a preferred alternative method for each Project component. In cases where only a single feasible alternative method was screened in for a Project component, a summary of the rationale for this decision is provided. In cases where a range of alternative methods went through the comparative analysis or the Alternatives Assessment for Mine Waste Disposal to select a preferred alternative method, a summary of the key advantages and disadvantages of each alternative based on the conceptual identification of potential effects is provided.

4.2.1 Initial Screening Results

As identified in Section 4.1.3, an initial screening was completed on the long list of alternatives based on a set of screening questions, to identify fatal flaws that would affect the ability to feasibly implement the Project. Table 4-6 provides the results of the initial screening, and identifies the screening questions relevant to the elimination of alternatives and the rationale for their elimination.

Sections 4.2.2 to 4.2.19 provide further discussion on each Project component, including a summary of the decision-making process undertaken through both the initial screening and comparative analysis (where relevant) to select the preferred alternative.

Table 4-6: Summary of Initial Screening Results

Legend:			
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)	

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
PROCESS PLANT			
Process Plant Location	On site	**Selected as preferred**	Onsite locations adjacent to the open pit provides the greatest efficiency and reduces environmental effects of ore handling by reducing transport requirements and, reducing the Project footprint. The location has been adjusted based on the constraints of other Project components, geotechnical characteristics and operational needs.
	Off site	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Processing off site would be inefficient and uneconomical based on expected ore processing of up to 30,000 tonnes per day (tpd). This would also result in increased GHG emissions, dust and overall increase in Project footprint.
Ore Processing (Gold Recovery)	Cyanidation and Gravity Separation	**Selected as preferred**	Initial metallurgical testing confirmed that whole ore cyanidation would provide an effective means of gold recovery. This method is a simple industry standard approach, which provides the greatest simplicity in design, process efficiency and cost effectiveness. Gravity separation will also be used to improve the recovery performance.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Flotation	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Initial investigation indicated that very fine grinding is required to produce an economical concentrate. The amount of flotation concentrate product is too high for a smelter to accommodate and would require additional regrinding and cyanidation with higher overall energy and reagents and potential downstream issues. The costs for both capital and operating, risk and complexity of such an alternative is high relative to the previous alternative.
	Gravity separation	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Initial metallurgical testing concluded that gravity separation alone will only provide about 15 to 35% gold recovery, and is insufficient as a sole means of gold recovery. However, gravity separation will be applied to improve the recovery performance of chemical separation through cyanidation.
	Gold recovery using thiosulphate and alpha-cyclodextrin	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they proven technologies (at the scale required)? (NO)** **Are they technically feasible (at the scale required)? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Neither of these experimental technologies are proven at pilot or industrial scale, and would require extensive experimental work, scale-up, and essentially design of a process from scratch with associated technical challenges.

Table 4-6: Summary of Initial Screening Results

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
Legend: **Blue** - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.		**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)
Process Water Supply	Recycled water from TMF and contact water collection system	**Forwarded to comparative analysis**	Water recycled from the TMF and contact water collection ponds may provide a feasible source for the required process water to reduce the demand on freshwater sources.
	Dewatering from historical underground workings	**Forwarded to comparative analysis**	Groundwater from dewatering of historical underground workings may provide a feasible source for the required process water to reduce the demand on freshwater sources.
	Surface water takings	**Forwarded to comparative analysis**	Surface water from local lakes or rivers may provide a feasible source for the required process water. May also provide a water source for processes and maintenance that require a freshwater source.
ORE STOCKPILE, CRUSHING PLANTS AND MILL FEED ORE STORAGE AREA			
Ore Stockpile, Crushing Plants and Mill Feed Ore Storage Area	Onsite storage and crushing at the plant site	**Selected as preferred**	Onsite locations adjacent to the open pit with close proximity to the mill provides the greatest efficiency for ore handling, reduces dust and the overall Project footprint. Consider optimal location based on the constraints of other Project components and operational needs. Consider storage area capacity that meets the operational needs of the Project. Based on the proximity of process plant and open pit, will use conveyors to deliver ore to crusher, and crushed ore to mill.
	Offsite storage and crushing	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** **Can they be implemented within the defined study area? (NO)** As processing will be on site, transporting material off site for crushing would be inefficient and cost prohibitive and result in increased GHG emissions and dust, and greater Project footprint.

Table 4-6: Summary of Initial Screening Results

Legend:			
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Project Component	**Alternative Methods Identified**	**Initial Screening Result**	**Rationale**
GOLDFIELD CREEK DIVERSION			
Goldfield Creek Diversion	Option 1 (Diversion through Lake A-321 towards Lake A-322)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires draining Lake A-321 by 3 m and raising Goldfield Lake by 1 m. Alters residence time of Lake A-322, identified as important through Aboriginal consultation. Overprints an existing channel and does not provide effective opportunities to compensate for the loss of Goldfield Creek. Results in a high water column by the TMF western dam, which results in additional dam construction costs.
	Option 2 (Diversion towards Marron Lake)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires the diversion of flows across watersheds, to a different basin of Kenogamisis Lake, and alters residence time in Marron Lake. Potential issues with property access since diversion is located on lands not owned by GGM. Results in a high water column by the TMF western dam, which results in additional dam construction costs.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Option 3 (Southwest Diversion Directly to Lake A-322)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires the reversal of flows in Goldfield Lake and alters (increases) residence time in the main lake basin. Alters residence time of Lake A-322, identified as important through Aboriginal consultation. Maintains existing outlet location to Kenogamisis Lake
	Option 4A (Move West Dam further west of GFP4, diversion to Lake A-322)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires the reversal of flows in Goldfield Lake, and alters the residence time of the lake. Alters residence time of Lake A-322, identified as important through Aboriginal consultation. Largest TMF footprint, overprinting GFP4.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Option 4B (Move West Dam further west of GFP4, diversion to Marron Lake)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires the diversion of flows across watersheds, to a different basin of Kenogamisis Lake, and alters residence time in Marron Lake. Largest TMF footprint, overprinting GFP4.
	Option 5 (Stage 1 diversion to Lake A-322, Stage 2 diversion to Marron Lake)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not compatible with final TMF location. Requires the diversion of flows across watersheds. Alters residence time of Lake A-322, Marron Lake and Goldfield Lake. Potential issues with property access since diversion is located on lands not owned by GGM. Results in a high water column by the TMF western dam, which results in additional dam construction costs. Higher cost compared to most other alternatives.
	Option 5A (diversion to Lake A-322, and diversion northeast to Southwest Arm Tributary)	***Forwarded to comparative analysis***	*The alternative may provide a feasible means of managing site hydrology and aquatic habitat, which is compatible with the final TMF design.*

Table 4-6: Summary of Initial Screening Results

Legend:

Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Option 6 (diversion northeast to Southwest Arm Tributary)	***Forwarded to comparative analysis***	*The alternative may provide a feasible means of managing site hydrology and aquatic habitat, which is compatible with the final TMF design.*
HIGHWAY 11 REALIGNMENT			
Highway 11 Realignment	Route 1A (wide path north of open pit and Mosher Lake)	**Forwarded to comparative analysis**	The route may provide a feasible alternative that bypasses the Project site.
	Route 1B (wide path north of open pit)	**Forwarded to comparative analysis**	The route may provide a feasible alternative that bypasses the Project site.
	Route 1C (minor route adjustment to eastern connection of 1A and 1B to existing highway)	Screened out from further analysis	Identified as relatively minor route adjustments to 1A and 1B, and not considered as a separate alternative.
	Route 1D (wide path north of open pit with increased horizontal curve radii - identified in consultation with the MTO)	**Forwarded to comparative analysis**	The route may provide a feasible alternative that bypasses the Project site.
	Route 1D (optimized) (revised alignment based on Route 1D to address safety and improve sight distance)	**Forwarded to comparative analysis**	The route may provide a feasible alternative that bypasses the Project site.

Table 4-6: Summary of Initial Screening Results

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Routes 2, 3 and 4 (near paths north of open pit)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** The routes do not accommodate a 500 m buffer from the open pit, and are therefore not acceptable due to safety concerns.
	Route 5 (near path south of open pit)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** The route does not accommodate a 500 m buffer from the open pit, and is therefore not acceptable due to safety concerns. A route to the south of the open pit would not intersect with the existing Michael Power Boulevard affecting access to Geraldton, so additional roads would be required to provide a new connection from Highway 11 to Michael Power Boulevard to the north of the open pit.
	Route 6 (wide path south of open pit)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** There are no feasible routes that travel wide of the open pit (outside the 500 m safety buffer) on the south side due to the close proximity of Kenogamisis Lake.
HISTORICAL TAILINGS AND OTHER CONTAMINATED SOIL			
Historical Tailings within the PDA	No removal of historical tailings	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they technically feasible (at the scale required)? (NO)** Historical tailings that overlay the open pit area must be removed to allow for open pit operation.

Table 4-6: Summary of Initial Screening Results

Legend:

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Removal of historical tailings where required to facilitate construction	**Selected as preferred**	Required within open pit footprint and under a portion of the WRSA. Historical tailings could be transferred and stored in the TMF for greatest efficiency and environmental protection. Provides an opportunity to rehabilitate tailings accordance with O.Reg. 240/00 to have a have a net positive effect on Kenogamisis Lake.
	Complete removal of historical tailings within the PDA	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Total removal is not economically viable due to the volume of material to excavate and truck to the TMF and the timing of Project activities. The safe removal of historical tailings requires the construction of the TMF and approximately 2 m of fresh tailings to be deposited to act a base layer, which will only be achieved by approximately Year 2 of operation. Due to the need to realign Highway 11 prior to operation, it is not feasible or economic to remove all historical tailings. Specific design considerations for WRSAs and the Highway 11 realignment will be considered to address the long-term management of remaining historical tailings.
Contaminated Soils within the PDA	Manage on site or remove for management as required	**Selected as preferred**	Provides an effective means and flexibility for managing contaminated soils within areas of excavation. Site-specific management criteria will be developed as part of a Soil Management Plan to determine which contaminated soils require management.
	Leave in place	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they technically feasible (at the scale required)? (NO)** Material exceeding criteria requires evaluation and management consideration.

Table 4-6: Summary of Initial Screening Results

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
AGGREGATE SOURCES			
Aggregate Sources	Use existing quarries or pits	**Forwarded to comparative analysis**	May provide adequate aggregate supply for Project construction, however, the quantity of aggregates required for construction may necessitate the use of other sources.
	Use mined waste rock for crushed aggregate production	**Forwarded to comparative analysis**	May be useful where crushed rock is required for construction or road maintenance. Sampling would confirm only clean construction rock will be provided.
	Create new aggregate sources	**Forwarded to comparative analysis**	New aggregate sources may be required to provide the quantities and type of materials required for construction. Consider site selection based on material availability, proximity to the Project, water table and potential effects on groundwater.
CONTACT WATER COLLECTION, TREATMENT AND DISCHARGE			
Open Pit Contact Water	Open pit contact water directed to historical underground workings for storage and dewatering through conventional sump dewatering	**Selected as preferred**	Will facilitate the use of the historical underground workings as a source of process water and storage to reduce peak flows. May allow direct discharge to the environment, depending on water quality. Increases flexibility of overall water management approach.
	Open pit contact water pumped directly to contact water collection ponds for treatment	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Would increase the size of contact water collection pond and ditches increasing the Project footprint, complexity and costs associated with dewatering and reducing the ability to handle extreme events. No operational or environmental benefit.

Table 4-6: Summary of Initial Screening Results

Legend:

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
WRSA and Process Plant Contact Water	*Collect runoff locally and treat through central contact water collection ponds and/or treatment plant prior to discharge*	***Selected as preferred***	*Provides the most efficient and cost effective means to collect and treat surface runoff. Provides an opportunity to monitor water quality in the collection ponds for potential direct discharge. Provides an opportunity to use contact water in the process plant by drawing from collection ponds, if required. Discharge locations assessed separately as part of the Assimilative Capacity Study ("Technical Data Report: Hardrock Project - Assimilative Capacity Study of Southwest Arm of Kenogamisis Lake" [Assimilative Capacity TDR]; Appendix F6).*
	Direct surface runoff to historical underground workings	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** This would require substantial pumping to bring the water back to the surface for treatment or discharge. This would result in reduced efficiency and increased costs compared to surface treatment, with no operational or environmental benefit. Alternative may provide abilities to manage peak flows during extreme events.
	Runoff directed to TMF for storage and management	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** This would require extensive additional pumping. This would result in reduced efficiency and increased costs compared to a surface collection system, with no operational or environmental benefit.
Treatment Method	*Coagulation and filtration*	***Selected as preferred***	*Provides effective metals and total suspended solids removal, and presents a cost-effective and flexible technology to enhance arsenic removal and meet the treatment needs of the Project. This is a proven technology that is commonly used for similar mine sites with proven results.*

Table 4-6: Summary of Initial Screening Results

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Membrane technology using reverse osmosis	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Requires increased operational costs for pumping and membrane maintenance, produces additional brine waste that would need to be managed, requires specialized training and continuous monitoring and maintenance, and may require additional pre-treatment to remove metals that would foul the membranes.
	Ion exchange	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Creates a liquid waste with a high concentration of arsenic, sodium hydroxide and sodium chloride, resulting in additional waste management considerations. Treatment effectiveness is also reduced as the mine water complexity is increased.
	Chemical treatment through lime precipitation	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Arsenic concentrations are not expected to reach concentrations in raw water where lime precipitation would be effective.
	Biological treatment through sulphate reducing bacteria	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Design constraints include the need to maintain a nutrient feed and four- to eight-hour residence time, the requirement for a large holding tank, and reduced biological reaction rates over the winter months that would limit treatment effectiveness.
	Engineered wetland	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Not preferred, due to the relatively high flow rates of the Project. Difficult to site a single wetland within the limited PDA, or increased complexity in managing multiple wetlands within the PDA.

Table 4-6: Summary of Initial Screening Results

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
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SEWAGE TREATMENT FACILITY FOR THE MINE SITE			
Sewage Treatment Facility for the Mine Site	*Sewage treatment plant with surface water discharge*	***Selected as preferred***	*A sewage treatment plant will provide cost effective sewage treatment capacity for the mine site with a system that can reliably manage the potential for environmental effects to regulatory standards.* *Discharge locations would be directed to surface water and adjusted to limit effects on the environment. Discharge locations assessed separately as part of the Assimilative Capacity Study.*
	Septic tank(s) and tile field(s)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they technically feasible (at the scale required)? (NO)** Septic tanks will not provide adequate sewage treatment capacity for the mine site due to capacity restrictions and siting constraints (insufficient available area and construction challenges associated with high water table).
	Lagoons	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they technically feasible (at the scale required)? (NO)** Sewage lagoons will not provide adequate sewage treatment capacity for the mine site due to capacity restrictions and siting constraints (insufficient available area and construction challenges associated with high water table).

Table 4-6: Summary of Initial Screening Results

Legend:

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Connection to the municipal system	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** **Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Connection to the municipal system would need to link with the process plant, which is located in the southern area of the PDA. Whereas residences in the Hardrock and MacLeod townsites already have a municipal water connection, no such sewage infrastructure exists (residences rely on septic or trucked sewage). This would require carrying a sanitary sewer line along Michael Power Boulevard and through the PDA (over 2 kilometres [km] in length). Connection to the process plant would also be complicated by the need to navigate through or past Project components, avoiding conflicts with other Project infrastructure, WRSAs and the open pit, which is not technically feasible. This alternative is not technically or financially viable, when compared against the lower costs and comparable potential for environmental effects of an onsite sewage treatment plant.
	Trucking domestic sewage offsite to a licensed treatment plant	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Increased operating cost based on the expected quantities of sewage, and increased environmental effects from truck use.
POTABLE WATER SUPPLY			
Potable Water Supply	Groundwater wells	**Forwarded to comparative analysis**	Groundwater wells may be capable of meeting the potable water demands for the Project.

Table 4-6: Summary of Initial Screening Results

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Surface water	**Forwarded to comparative analysis**	Local watercourses, lakes and ponds may be capable of meeting the potable water demands for the Project.
	Geraldton municipal potable water system	**Forwarded to comparative analysis**	Connection to the Geraldton municipal system may be capable of meeting the potable water demands for the Project.
EXPLOSIVES MANAGEMENT			
Explosives Management	Manage explosives onsite	**Selected as preferred**	Provides a feasible alternative for efficient access to explosives. Raw materials transportation to the Project is safer, as raw materials are relatively inert. Bulk explosives production is the preferred alternative economically. The location of the explosives facility will be a safe distance from onsite facilities and adhere to Quantity Distance Principles User's Manual (Natural Resources Canada [NRCan] 1995)
	Transport of explosives from existing explosives manufacturing facilities.	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** **Can they be implemented within the defined study area? (NO)** More expensive to use an existing facility not owned and operated by GGM. The closest third party explosives plant is approximately 260 km away from the Project, so transportation would result in additional environmental effects over the Life of Mine (LOM). This would also result in increased safety concerns regarding the long distance transportation of explosives materials.

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Project Component	**Alternative Methods Identified**	**Initial Screening Result**	**Rationale**
POWER PLANT AND ASSOCIATED INFRASTRUCTURE			
Primary (operation) Power Source	Natural gas-fueled power plant	**Selected as preferred**	Provides a feasible alternative to secure the necessary level of power supply for the Project. Power plant would be located as close as possible to the comminution (crushing/grinding) section of the process plant, for improved efficiency of the electrical distribution system. Requires a new distribution pipeline that will be owned and operated by Union Gas Limited (Union Gas). May consider a 115 kV transmission line back to the grid in order to obtain power or sell excess power produced at the power plant.
	Onsite diesel or heavy fuel oil power generation	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Would result in higher costs and environmental effects if used to meet total operational power needs.
	Connection to existing grid (with onsite sub-station)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they within the ability of the proponent to implement? (NO)** The existing power transmission system is inadequate to provide the complete power needs for the Project. GGM will continue to evaluate opportunities for a grid connection as the Project advances if an opportunity arises in the region.

Table 4-6: Summary of Initial Screening Results

Legend:			
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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Renewable energy (hydroelectric, solar, wind)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they proven technologies (at the scale required)? (NO)** **Are they technically feasible (at the scale required)? (NO)** Not feasible, since renewable energy sources cannot provide enough output to meet electrical power requirements and/or provide consistent uninterrupted power.
Temporary (construction) / Backup (operation) Power Source	Connection to existing grid (44kV tie-in to existing transmission line)	**Forwarded to comparative analysis**	May provide a feasible alternative for temporary power prior to the establishment of the primary power supply, and backup power during operation.
	Temporary diesel or natural gas generation	**Forwarded to comparative analysis**	May provide a feasible alternative for temporary power prior to the establishment of the primary power supply, and backup power during operation.
WASTE MANAGEMENT			
Non-Hazardous Solid Waste (for material that cannot be	Truck non-hazardous waste offsite to licensed disposal facility	**Selected as preferred**	With the expected quantities of non-recyclable waste, trucking off site provides a suitable method to manage waste during operation. Consider reusing and recycling material to the extent practical to reduce overall waste generation.

Table 4-6: Summary of Initial Screening Results

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Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
recycled)	Establish a new landfill for all non-hazardous waste	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Establishing a new landfill site to manage all of the Project's non-hazardous waste is not practical. A dedicated landfill would result in a new site where environmental effects such as vegetation clearing, wildlife disruption, and groundwater and surface water contamination would need to be managed. This would also result in increased nuisance effects related to traffic, noise and odour. A new landfill site would require increased capital costs to establish and manage, with no environmental benefit. Limited inert waste may be managed on-site within WRSAs (with appropriate approvals) as a mitigation measure to limit waste generation from the Project.
	Onsite incineration	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Incineration would result in increased air emissions. The high cost of incineration is not justified based on the expected volumes of waste and other disposal options. The incineration process is difficult to manage and operate within air quality requirements.
Hazardous Waste	Truck hazardous waste offsite to licensed disposal facility	**Selected as preferred**	Provides a suitable option to manage the quantity of hazardous waste that is expected for projects of this type and size.
	Onsite disposal of hazardous waste	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** It is not economically viable to establish an onsite hazardous waste facility based on the limited quantity that will be produced.

Table 4-6: Summary of Initial Screening Results

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Project Component	**Alternative Methods Identified**	**Initial Screening Result**	**Rationale**
MINING EQUIPMENT FUEL TYPE AND SOURCE			
Fuel Type for Mining Equipment	Full diesel	**Forwarded to comparative analysis**	Full diesel may provide a feasible alternative to fuel mining trucks, and is the most conventional solution.
	A blend of LNG and Diesel	**Forwarded to comparative analysis**	Some ratio or blend of LNG and diesel may provide a feasible alternative to full diesel fuel for mining haul trucks.
	Full gasoline	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Not suitable for heavy industrial machinery.
Fuel Source for Mining Equipment	LNG through tanker truck delivery and above-ground storage tank(s)	**Forwarded to comparative analysis**	Trucking LNG for combination with diesel may provide an adequate source of fuel for operation. Will include consideration of relatively small quantities of gasoline for smaller construction and maintenance equipment.
	LNG Plant	**Forwarded to comparative analysis**	An LNG plant may provide a feasible source of LNG for operation. Will include consideration of relatively small quantities of gasoline for smaller construction and maintenance equipment.
	Diesel through tanker truck delivery and above-ground storage tank(s)	**Forwarded to comparative analysis**	Trucking diesel may provide an adequate source of fuel for operation and is the most conventional solution. Will include consideration of relatively small quantities of gasoline for smaller construction and maintenance equipment.

Table 4-6: Summary of Initial Screening Results

Legend:			
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)	
Project Component	**Alternative Methods Identified**	**Initial Screening Result**	**Rationale**
SITE INFRASTRUCTURE AND SUPPORT FACILITIES			
Site Access (Only one site access considered due to security requirements)	Permanent site access via the western leg of existing Highway 11	**Selected as preferred**	Feasible method to provide needed access to the Project. Interior road network within Project footprint will be designed based on site constraints and operational needs of the Project.
	Permanent site access via the eastern leg of existing Highway 11	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Access via Highway 11 east of the Project is not feasible due to limited space because of the proximity of Kenogamisis Lake and the location of the WRSA.
	Permanent site access via existing Michael Power Boulevard north of site.	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Access from Michael Power Boulevard will not provide access to the Project due to the location of the open pit and WRSA.

Table 4-6: Summary of Initial Screening Results

Legend:

Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
Buildings and Support Facilities	Establish facilities onsite	**Selected as preferred**	Facilities are required to support the Project. Onsite facilities will reduce cost, increase efficiency and reduce environmental effects from travel and transportation. Optimal locations are determined based on operational needs, appropriate geotechnical foundation conditions, and ensuring a safe distance from open pit and other Project components. Supporting infrastructure including water, natural gas and wastewater pipe networks will be designed based on site constraints and operational needs of the Project around the process plant area. Final determination of the specific locations of each facility and associated infrastructure within the process plant area will result in negligible environmental effects. May consider limited offsite contracting for certain facilities as appropriate (e.g., assay lab).
	Establish facilities offsite	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not operationally feasible to locate these facilities off site. Existing infrastructure not available off site.
Temporary Camp - Construction	Temporary Camp located near Old Arena Road and Michael Power Boulevard	**Selected as preferred**	Provides a feasible location for temporary workers with available servicing and proximity to the Project.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Temporary Camp located directly west of open pit	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Site is located too close to construction activities and would result in additional noise and safety issues. Also, constrained by location of WRSA and lack of services.
	Locations outside Geraldton and PDA	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Impractical due to limited access to municipal servicing and increased worker transportation time would result in increased costs with no environmental benefit.
	No temporary camp – use existing infrastructure	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Impractical, as it would require reliance on nearby communities such as Geraldton, which may not provide adequate, affordable or centralized accommodation as effectively as a dedicated camp. Using existing community infrastructure is not logistically feasible for early development labour needs that are temporary and flexible in nature during the construction period.
Sewage Treatment for the Temporary Camp	Connection to the municipal system	**Selected as preferred**	The local municipal system has capacity to manage the volume from the temporary camp. This will eliminate effects from a second discharge to Barton Bay.
	Sewage treatment plant with surface water discharge	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Use of a treatment plant to manage temporary camp sewage would require the establishment of a separate facility, most feasibly discharging to Barton Bay. The additional capital and operational cost, plus effluent discharge to the already impacted Barton Bay is not considered preferred since connection to the municipal system provides a feasible alternative.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Septic tank(s) and tile field(s)	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Septic tanks will not provide adequate sewage treatment capacity for the temporary camp due to siting constraints (insufficient available area and construction challenges associated with high water table).
	Lagoons	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** Sewage lagoons will not provide adequate sewage treatment capacity for temporary camp due to siting constraints (insufficient available area and construction challenges associated with high water table).
	Trucking domestic sewage offsite to a licensed treatment plant	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** Increased operating cost and operational complexity makes this option impractical, since connection to the municipal system provides a feasible alternative.
HYDRO ONE TRANSFORMER STATION RELOCATION			
Hydro One TS Location	Study Area 1 / Option 1 – Site west of Mosher Lake near Old Arena Road (south side)	**Forwarded to comparative analysis**	This option may provide a suitable location to meet the operational needs of Hydro One.
	Study Area 1 / Option 1A/B – Site west of Mosher Lake near Old Arena Road (west side)	**Forwarded to comparative analysis**	This option may provide a suitable location to meet the operational needs of Hydro One. Options 1A and 1B combined as a single alternative for the purpose of the comparative analysis, due to overlapping footprints.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Study Area 1 / Option 1C – Site north of the intersection of Highway 11 and Old Arena Road	Screened out from further analysis	**Are they consistent with government priorities? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Option is located in the Tombill Claim, which would require additional costs to acquire. Reduced efficiency by moving the transformer station too far from the load center, with no operational benefit.
	Study Area 1 / Option 1D – Site south of the intersection of Highway 11 and Old Arena Road	Screened out from further analysis	**Are they consistent with government priorities? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Option is located in the Tombill Claim, which would require additional costs to acquire. Reduced efficiency by moving the transformer station too far from the load center, with no operational benefit.
	Study Area 2 / Option 2 – Site north of open pit on Michael Power Boulevard	**Forwarded to comparative analysis**	This option may provide a suitable location to meet the operational needs of Hydro One.
	Study Area 2 / Option 2A – Site southwest of intersection of Michael Power Boulevard and Old Arena Road	**Forwarded to comparative analysis**	This option may provide a suitable location to meet the operational needs of Hydro One.
	Study Area 3 / Location east of Kenogamisis Lake	Screened out from further analysis	**Are they consistent with government priorities? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Would require a new 115 kV corridor across the narrow crossing of Kenogamisis Lake by Highway 11. Reduced efficiency by moving the transformer station too far from the load center. Additional effects on land use and the environment with no operational benefit.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Study Area 4 / Location further west of mine site	Screened out from further analysis	**Are they consistent with government priorities? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Reduced efficiency by moving the transformer station too far from the load center, with no operational benefit.
MTO PATROL YARD			
MTO Patrol Yard Relocation (if required)	West of PDA on Highway 11	**Selected as preferred**	This location maintains direct access to Highway 11 and is further away from MacLeod Provincial Park.
	East of PDA on Highway 11	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** This location maintains direct access to Highway 11. However, the location has technical, economic and environmental constraints. A location to the east of the PDA is constrained by the location of the WRSA and Highway 11. GGM does not own lands east of first bridge and municipal servicing is also limited. This location would bring the MTO Yard in closer proximity to MacLeod Provincial Park which may result in potential environmental effects.
CLOSURE			
Open Pit Closure	Natural filling with water	**Forwarded to comparative analysis**	May provide a feasible method to close the open pit.
	Enhanced filling with water	**Forwarded to comparative analysis**	May provide a feasible alternative to close the open pit.

Table 4-6: Summary of Initial Screening Results

Legend:		
Blue - forwarded to comparative analysis for further assessment	**Orange** - preferred alternative selected based on results of the initial screening where only one method is feasible.	**White** - screened out from further analysis based on results of the initial screening (relevant screening questions identified in bold)

Project Component	Alternative Methods Identified	Initial Screening Result	Rationale
	Backfill with waste rock	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they technically feasible (at the scale required)? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Not economically viable, since it would require double handling of waste rock. Would sterilize potential future underground mining resource. Partial backfill can be considered.
WRSAs Closure	Cover and vegetate	**Selected as preferred**	Provides a feasible method to close the WRSAs.
	No cover	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they consistent with government priorities? (NO)** Will not adequately address closure objectives.
TMF Closure	Cover and vegetate	**Selected as preferred**	Cover with soil/overburden provides a feasible method to close portions of the TMF.
	Water cover	Screened out from further analysis	**Do they provide a viable solution to the problem or opportunity to be addressed? (NO)** **Are they practical, financially realistic and economically viable? (NO)** Maintaining a water cover is typically used to manage potentially acid generating (PAG) tailings. Since tailings are anticipated to be generally non-acid generating (NAG), there is no requirement anticipated to maintain a water cover.
Mine Buildings and Infrastructure Closure	Removal and disposal	**Selected as preferred**	Provides a feasible method to achieve minimal residual footprint.
	Reuse	Screened out from further analysis	**Are they practical, financially realistic and economically viable? (NO)** No opportunities to reuse buildings and infrastructure have been identified, so removal is preferred to allow for greater rehabilitation potential.

4.2.2 Waste Rock Storage Areas and Tailings Management Facility

The alternatives assessment for WRSA and TMF alternatives was performed following the seven-step process specified in the ECCC Guidelines. Although this process is more detailed and prescriptive than provincial EA requirements, it is also consistent with the EA Code of Practice, which calls for a systematic evaluation method that uses criteria and indicators to evaluate potential effects and select a preferred alternative. As required by Section 4.2.4 of the EA Code of Practice, the process involves the identification of alternatives, data collection, and the evaluation of each alternative based on potential effects, impact management, net effects and advantages and disadvantages. This approach is also consistent with Section 5.1.5 of the approved ToR, which indicates that the TMF site selection process will generally be carried out in accordance with the Guidelines (a process that was also extended to the WRSA alternatives based on federal requirements). The process is summarized below and described in more detail in Appendix G1 (WRSA and TMF Alternatives Assessment Report).

4.2.2.1 Waste Rock Storage Area Alternatives

WRSA-4 with combined above ground and in-pit storage of non-segregated waste rock was selected as the preferred alternative for waste rock storage based on the results of the alternatives assessment, summarized below.

Step 1: Identify Candidate Alternatives

Four different locations and four different waste disposal methods were initially identified as candidate alternatives for the WRSA alternatives assessment. Candidate alternatives were selected based on the following threshold criteria:

- disposal areas with a haul distance of less than 7 km (greater haul distances would have a substantial negative effect on Project feasibility)
- disposal areas that would not require crossing or use of Highway 11 (due to public and mine safety when crossing or using the highway with mine haulage equipment)
- exclusion of areas within Geraldton[1], MacLeod Provincial Park and key lakes (as overprinting these areas with mine waste would not be allowed)
- exclusion of the open pit, process plant, and MacLeod high tailings areas (required for the identified Project components)

Candidate alternatives included those listed in Table 4-7.

[1] Geraldton is defined as the main community in the Ward of Geraldton, including the area located north of Barton Bay, and Rosedale Point.

Table 4-7: Candidate Alternatives for the WRSA Alternatives Assessment

Project Component	Alternative Method(s)
WRSAs Location	• WRSA-1: three storage areas surrounding the open pit and one area located south of the open pit, along the southern side of the Southwest Arm Tributary, consistent with the submitted to the CEA Agency in 2014) • WRSA-2: three storage areas surrounding the open pit, one area south of the open pit over the Southwest Arm Tributary, and one area on the peninsula to the southeast of the open pit) • WRSA-3: three storage areas surrounding the open pit and one area located south of the open pit over the Southwest Arm Tributary • WRSA-4: three storage areas surrounding the open pit and one area located south of the open pit, along the southern side of the Southwest Arm Tributary
WRSAs Waste Disposal Methods	• In-pit storage of non-segregated waste rock • Combined above ground and in-pit storage of non-segregated waste rock • Co-disposal of waste rock and tailings • Segregation of waste rock due to ARD/ML potential

Step 2: Pre-Screening Criteria

Following the identification of candidate alternatives, a set of pre-screening criteria were developed to exclude any alternatives that are "non-compliant with certain unique minimum specifications that have been developed for the project" (ECCC 2013). The ECCC Guidelines describe this process as a "fatal-flaw analysis" where fatal flaws are defined as any site characteristic that is "so unfavorable or severe that, if taken singly, it would eliminate that site as a candidate."

The following two criteria were used to pre-screen WRSA candidate alternatives:

1. Would the proposed waste disposal method be non-viable considering the proposed mine plan?
2. Would the alternative overlie surface rights held by others?

Following the application of these criteria, three disposal methods and one location were removed from further evaluation, as follows:

- In-pit storage of non-segregated waste rock was removed because it would require double handling of waste rock to place waste rock after the completion of open pit mining, which would substantially effect project economics, and it would affect future mine development potential.
- Co-disposal of waste rock and tailings was removed due to insufficient void space for tailings storage within the anticipated quantity of waste rock. There is also additional technical complexity associated with this method.

- Segregation of waste rock due to ARD/ML potential was removed based on geochemical characterization of the waste rock which indicates that segregated storage would not be appropriate to manage ARD/ML conditions.
- WRSA-2 was removed because it overlies a claim held by others.

Following the application of the pre-screening criteria, the following three alternatives were carried forward into Step 3 of the alternatives assessment:

- WRSA-1 with combined above ground and in-pit storage of non-segregated waste rock
- WRSA-3 with combined above ground and in-pit storage of non-segregated waste rock
- WRSA-4 with combined above ground and in-pit storage of non-segregated waste rock

Figure 4-2 presents the conceptual design of the WRSA alternatives carried through Step 2 of the assessment. Additional figures and information are included in Appendix G1 (WRSA and TMF Alternatives Assessment Report).

Step 3: Alternative Characterization

For the remaining alternatives, summary information was defined based on 44 characterization criteria to assist in considering key aspects of the alternatives in the assessment. The characterization included criteria related to environmental, technical, economic and socio-economic information that would be used to evaluate each alternative.

Step 4: Multiple Accounts Ledger

Based on the information compiled through the characterization of each alternative, a multiple accounts ledger was developed. The multiple accounts ledger is a tabular tool that uses accounts, sub-accounts, and Indicators to identify the potential effect of each alternative and place them into broad categories.

In accordance with the ECCC Guidelines, only effects that are differentiating between alternatives (i.e., an aspect that distinctly differentiates one alternative from another) were considered in the assessment. Characteristics considered to be non-differentiating were identified as a part of Step 3 and not considered further.

In accordance with the ECCC Guidelines the following four accounts were used in the assessment: Environmental, Technical, Project Economics, and Socio-Economic. Each account was divided into sub-accounts that represent the effects of each alternative. One or more indicators were then defined within each sub-account to measure effects. Table 4-8 provides a list of the accounts, sub-accounts, and indicators used in the WRSA alternatives assessment.

Table 4-8: Accounts, Sub-Accounts and Indicators used in the WRSA Alternatives Assessment

Account	Sub-Account	Indicator
Environmental	Water Management	Contact and Non-Contact Water Management
	Aquatic Life and Habitat	Loss of Watercourse Loss of Wetlands
	Terrestrial Life and Habitat	Loss of Forested Area Infrastructure Disturbance - Haul Roads
	Air Quality	Potential for Dust Generation - Haul Traffic
	Climate Change	Greenhouse Gas Emissions
Technical	Technical Risk - Stream Diversion	Length of Required Stream Diversion
	Design and Operational Complexity	Maximum Pile Height - Pile B
Project Economics	Capital Cost	CAPEX[1] - Haul Road CAPEX – Perimeter Ditch CAPEX – Collection Pond CAPEX - Stream Diversion Costs Fish Habitat Compensation
	Operating Cost	OPEX[2] – Waste Rock Hauling
	Closure Cost	Cover Construction Costs
Socio-economic	LRU	Loss of Hunting Loss of Fishing - Watercourses Loss of Bear Management Areas Loss of Trapline Areas
	TLRU	Loss of Unoccupied Crown Land Loss of Large Animal Habitat Loss of Large Game Harvesting Area Loss of Waterfowl Harvesting Area Loss of Upland Game Bird Harvesting Areas Loss of Trapping Area Loss of Plant Harvesting Area

NOTES:
[1] CAPEX: capital expenditure
[2] OPEX: operational expenditure

For each indicator, a metric was defined to allow for a consistent measurement and comparison of effects. For example, in the terrestrial life and habitat sub-account, the indicator loss of forested area was selected. This indicator uses the area of forest (in hectares) that would be lost due to construction of the alternative to measure impacts to forested land associated with that alternative.

A value scale was then developed for each indicator based on the metric selected for the indicator. In accordance with the ECCC Guidelines, the value ranges were developed using a six-point scale where the most preferred measurement is given a value of six, and the least preferred is given a value of one. In Step 5, a value between one and six is assigned to each alternative for each indicator, based on the indicator measurements.

Step 5: Value-Based Decision Process

After developing the multiple accounts ledger, values were assigned to each alternative for each indicator based on the six-point value scales defined in Step 4. For example, in an indicator measuring the area of lost wetlands, an alternative that will remove the largest area of wetlands would be assigned a value of one, while an alternative that does not remove any wetlands may be assigned a value of six.

The relative importance of: each indicator compared to the other indicators, each sub-account relative to other sub-accounts, and each account relative to other accounts was also considered in the assessment by assigning a weighting factor to each. In accordance with the ECCC Guidelines, weightings were assigned a value of one to six (where a higher weighting would put more emphasis on that particular factor in the assessment) and were developed based on the professional judgment of the Project's technical leads and consultation input. This system allows the relative importance of different impacts to be incorporated into the assessment.

Each alternative was then evaluated through the qualitative analysis which involves multiplying the assigned scores by the assigned weightings at an indicator, sub-account and account level and then calculating the overall rating for each alternative. The alternative rating is then used to compare each alternative and select the preferred alternative.

Based on the quantitative analysis, it was determined that WRSA-4 is the preferred alternative, as it scored higher than the other two alternatives. WRSA-4 is preferred by two (technical and socio-economic) of the four accounts and also scored highly in the environmental account. These three accounts together represent approximately 89% of the total account weightings.

Key findings of the evaluation include the following:

Environmental Account

- Alternative WRSA-1 is preferred in the water management sub-account as the alternative has a slightly smaller contact and non-contact water catchment area than the other two alternatives, meaning it would likely have to manage slightly less surface water than other two alternatives. WRSA-1 is also preferred in the aquatic life and habitat sub-account as it overlies a slightly lesser extent of watercourses than WRSA-4 and it overlies a smaller extent of wetlands than WRSA-3.
- WRSA-3 is scored poorly in the aquatic life and habitat sub-account as it overlies the Southwest Arm Tributary and overlies the largest extent of wetlands of any alternative. It is scored highly in the terrestrial life and habitat sub-account as it overlies slightly less forested area than the other alternatives (as a larger portion of its footprint overlies watercourses and wetlands). WRSA-3 has a slightly lower combined average haul distance than the other alternatives and, thus, has slightly lower anticipated air quality and climate change impacts.
- WRSA-4 scores highly in the aquatic life and habitat sub-account as it overlies shorter lengths of waterbodies than WRSA-3 and the least extent of wetlands of any alternative. It scores slightly lower than alternative WRSA-1 as WRSA-4 overlies a portion of ephemeral watercourse WC-O. However, there is not considered to be a notable variation in aquatic impacts between WRSA-1 and WRSA-4 as WC-O is understood to only support limited aquatic life (only a few minnows have been observed in this watercourse during field studies). WRSA-4 scores moderately in the terrestrial life and habitat sub-account as it overlies a relatively small extent of forested land (only slightly more than WRSA-3) but does require the construction of a slightly greater length of haul road, due to its greater distance from the open pit. WRSA-4 is scored lowest in the water management sub-account as it has a slightly larger contact and non-contact water catchment area than the other two alternatives. It scores lowest in the air quality and climate change sub-accounts due to slightly longer haul distances.

Technical Account

- Both WRSA-1 and WRSA-4 score highest in the length of required stream diversion indicator as only WRSA-3 requires the construction of a diversion. WRSA-3 and WRSA-4 score highest in the maximum pile height – Pile B indicator as WRSA-1B has a greater pile height than WRSA-3B and WRSA-4B, which implies increased technical complexity in design. Overall, WRSA-4 scores highest in the Technical account as it has a smaller Pile B height and does not require a stream diversion.

Project Economics Account

- WRSA-1 and WRSA-4 score relatively highly in the capital cost sub-account as neither requires the construction of a stream diversion and both require the construction of less fish habitat compensation than the WRSA-3 alternative. While WRSA-4 requires the construction of a slightly greater length of haul roads than the other two options, the cost of haul road construction is considered lower than costs associated with stormwater diversion and fish habitat compensation, and thus this indicator was given a relatively low weighting.

- Alternative WRSA-3 is preferred in the operating costs sub-account as the piles in this alternative are generally located closer to the open pit and have a shorter associated haul distance.
- Alternative WRSA-4 has the highest score in the closure cost sub-account. It is preferred in this sub-account as this alternative has a slightly smaller surface area and thus is anticipated to require placement of less cover material which would likely result in a lower closure cost.

Socio-economic Account

- In the LRU sub-account, WRSA-4 is preferred as it overlies lesser amounts of hunting, bear management, and trapline areas and only slightly more watercourses (which are assumed to be suitable for fishing) than WRSA-1. WRSA-1 is scored lowest in this sub-account as it overlies the greatest extent of hunting, bear management, and trapline areas.
- In the TLRU sub-account, WRSA-4 is preferred by all indicators except loss of large animal habitat as it overlies lesser amounts of unoccupied crown land, trapping areas, and areas of game and plant harvesting. WRSA-1 is scored lowest in this sub-account and is scored lowest by all indicators except the loss of large animal habitat indicator.

Step 6: Sensitivity Analysis

Following the completion of the valued-based decision process in Step 5, a set of sensitivity analyses were completed to test how other weighting scenarios would affect the results. Five different sensitivity scenarios were completed to compare against the base case as follows:

- **Base Case (used in Step 5) –** A weighting factor of six (the highest weighting) was applied to the Environmental account, a weighting factor of three was applied to the Technical and Socio-economic accounts, and a weighting factor of 1.5 was applied to the Project Economics account. These weightings are recommended by the ECCC Guidelines for use in the quantitative analysis.
- **Scenario 1 – Equivalent Account Weightings –** An equivalent weighting factor of one was applied to all accounts.
- **Scenario 2 – Environmental Account Bias –** A weighting factor of one was applied to the Technical, Project Economic, and Socio-economics accounts and a weighting factor of six was applied to the Environmental account. This scenario identifies the preferred alternative if non-environmental factors are largely removed from the evaluation.
- **Scenario 3 – Technical Account Bias –** A weighting factor of one was applied to the Environmental, Project Economics, and Socio-economic accounts and a weighting factor of

six was applied to the Technical account. This scenario identifies the preferred alternative if non-technical factors are largely removed from the evaluation.

- **Scenario 4 – Project Economics Account Bias –** A weighting factor of one was applied to the Environmental, Technical, and Socio-economic accounts and a weighting factor of six was applied to the Project Economics account. This scenario identifies the preferred alternative if non-project economics factors are largely removed from the evaluation.
- **Scenario 5 – Socio-Economic Account Bias –** A weighting factor of one was applied to the Environmental, Technical, and Project Economics accounts and a weighting factor of six was applied to the Socio-economic account. This scenario identifies the preferred alternative if non-socio-economic factors are largely removed from the evaluation.

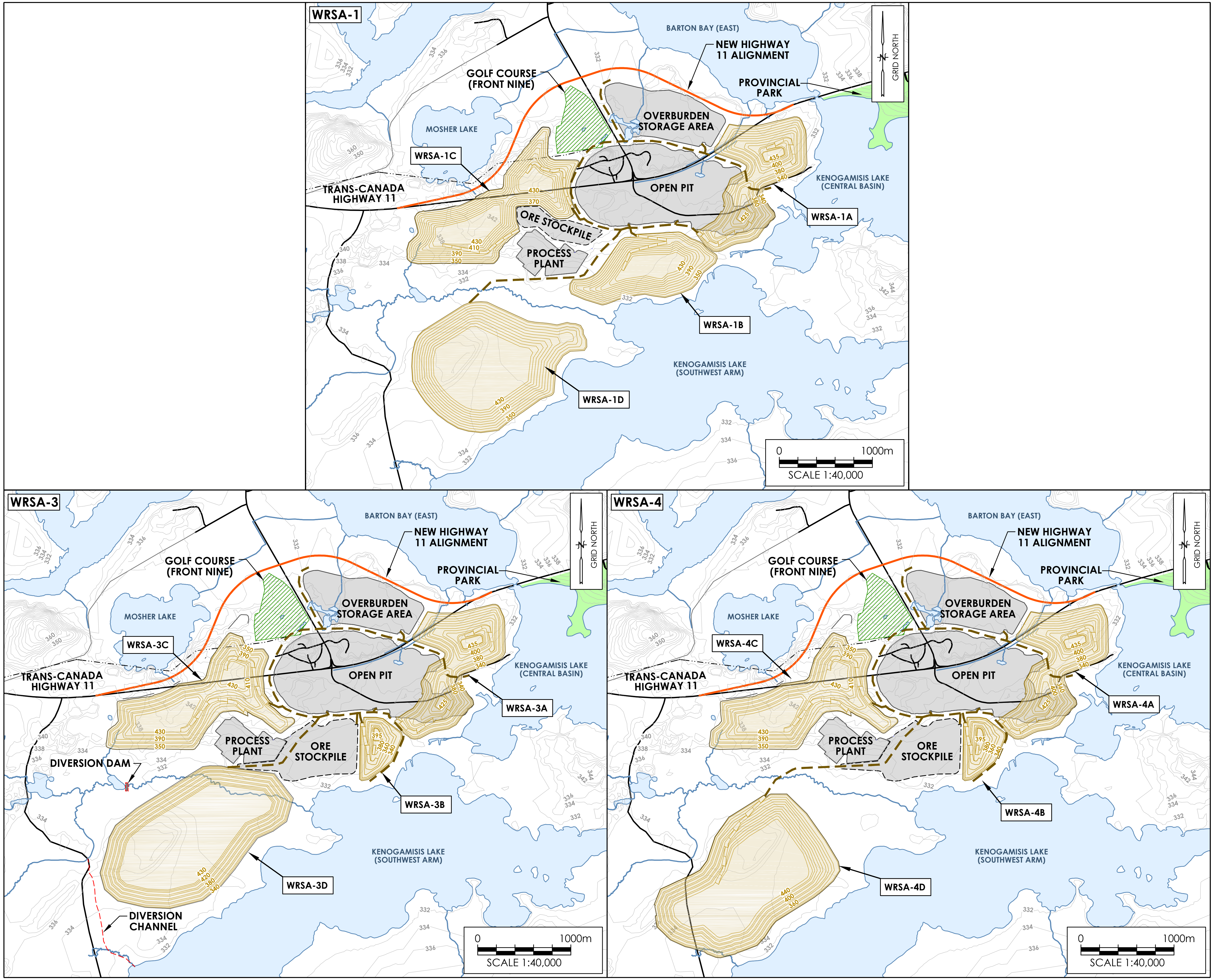
The WRSA-4 alternative remained the preferred alternative in all scenarios, regardless of which account was given preference.

Step 7: Document Results

WRSA-4 with combined above ground and in-pit storage of non-segregated waste rock was selected as the preferred alternative because it presented the following key advantages:

- it overlies shorter lengths of waterbodies than WRSA-3 and the least extent of wetlands of any alternative
- it overlies a relatively small extent of forested land
- it has a smaller Pile B height and does not require a stream diversion
- it has a slightly smaller surface area and thus is anticipated to require placement of less cover material which would likely result in a lower closure cost
- it overlies lesser amounts of hunting, bear management, and trapline areas
- it overlies lesser amounts of unoccupied crown land, trapping areas, and areas of game and plant harvesting from a TLRU perspective

The complete WRSA alternatives assessment is documented in Appendix G1 (WRSA and TMF Alternatives Assessment Report) which includes further detail on the method used, the rationale for the decisions made, the information used to score each alternative and the quantitative analysis performed to identify the preferred alternative.



Stantec

Legend

- Routinely Maintained Road
- Non-Routinely Maintained Road
- Contour (2 m Interval)
- Watercourse
- Provincial Park
- Waterbody
- Golf Course
- New Highway 11 Alignment
- Access / Haul Roads
- Waste Rock Storage Area Alternative and Contours
- Diversion Channel
- Diversion Dam

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Roads, Utility Lines, Railways & Provincial Park Boundaries produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013. Level of road maintenance is based on attribute data contained in the MNR Road Segment layer. The Non-Routinely Maintained Roads include roads where the maintenance level is classified as not maintained or unknown.
3. Watercourses based on mapping originally provided by the Ontario Ministry of Natural Resources and Forestry, Land Inventory Ontario. Watercourse mapping was later refined using a desktop based modeling approach and then field verified by Stantec between 2014-2016.
4. Contours based on Ontario Basic Mapping data.

June 2017
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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
4-2

Title

WRSA Alternatives Carried Through Pre-Screening

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4.2.2.2 Tailings Management Facility Alternatives

TMF-8 with conventional impoundment disposal and downstream dam construction was selected as the preferred alternative for tailings storage based on the results of the alternatives assessment, as summarized below and described in more detail in Appendix G1 (WRSA and TMF Alternatives Assessment Report).

Based on the relatively high rating of the TMF-8 Thickened alternative, GGM will evaluate the opportunity to transition to thickened tailings in Years 3 to 5. The thickened disposal option could potentially optimize TMF storage efficiency and is best evaluated once the mill successfully ramps up to the design throughput of 30,000 tonnes per day and additional information is available regarding the characteristics and consistency of the tailings. This approach is considered appropriate as practice has shown that the tailings slopes anticipated during design are often not achieved during operation and that the risk of such variations can be reduced though an improved understanding of site parameters such as flow rate and tailings rheology and their variability with time (Seddon and Fitton 2011, Jewell 2010).

Step 1: Identify Candidate Alternatives

Six different locations, seven different waste disposal methods and three different dam construction methods were initially identified as candidate alternatives for the TMF alternatives assessment. Candidate alternatives were selected based on the following threshold criteria:

- Areas that would not require crossing or use of Highway 11 (due to public and mine safety concerns with crossing or using the highway with mine haulage equipment).
- Exclusion of areas within Geraldton[1], MacLeod Provincial Park and key lakes (as overprinting these areas with mine waste would not be allowed).
- Exclusion of the open pit, process plant, and MacLeod high tailings areas (required for the identified Project components).

Candidate alternatives included those listed in Table 4-9. A further discussion of the identified tailings disposal methods is presented in Appendix E of Appendix G1 (WRSA and TMF Alternatives Assessment Report).

Table 4-9: Candidate Alternatives for the TMF Alternatives Assessment

Project Component	Alternative Method(s)
Tailings Management Facility Location	• TMF-1 (southwest of the open pit on a relative topographical high overlooking Goldfield Lake) • TMF-2 (west of the open pit to the southeast of Wildgoose Lake) • TMF-3A (southwest of the open pit, to the northwest of the Southwest Arm of Kenogamisis Lake) • TMF-4 (south-southwest of the open pit, to the south of the Southwest Arm of Kenogamisis Lake and immediately south of Finlayson Lake overlying a portion of a claim held by others) • TMF-8 (southwest of the open pit to the northwest of the Southwest Arm of Kenogamisis Lake) • TMF-9 (southwest of the open pit, to the southwest of the Southwest Arm of Kenogamisis Lake in an area surrounded by waterbodies and watercourses) NOTE - The naming convention reflects the optimization process used during the siting phase of the assessment. TMF-5, 6, and 7 are not listed as these alternatives were optimized and replaced with alternatives TMF-3 and TMF-8, which are located in the same general area. Additionally, note that the "A" suffix represents an optimization of an initially identified TMF-3 alternative location.
Tailings Management Facility Waste Disposal Method	• Cyclone separation with sand embankment and slimes impoundment storage • Co-disposal of waste rock and tailings • Dry stacking of filtered tailings • Surface disposal of paste tailings • Surface disposal of thickened tailings • Impoundment disposal of conventional tailings • Impoundment disposal of thickened tailings
Tailings Management Facility Dam Construction Method	• Upstream • Downstream • Centerline

Step 2: Pre-Screening Criteria

Following the identification of candidate alternatives, a set of pre-screening criteria were developed to exclude any alternatives that are "non-compliant with certain unique minimum specifications that have been developed for the project" (ECCC 2013). The ECCC Guidelines describe this process as a "fatal-flaw analysis" where fatal flaws are defined as any site characteristic that is "so unfavorable or severe that, if taken singly, it would eliminate that site as a candidate."

The following seven criteria used to pre-screen TMF candidate alternatives:

1. Would the alternative overlie surface rights held by others?
2. Would the alternative overlie the preferred WRSA alternative?
3. Would expansion of the alternative be non-viable?

4. Would the capacity of the alternative be insufficient to store the proposed quantity of tailings?
5. Is any part of the mine waste disposal system unproven technology?
6. Does the waste disposal method present a higher risk of environmental impacts without any other significant advantages?
7. Does the stability of the dam construction method rely significantly on the properties of the impounded tailings and/or consistent water and tailings management practices?

Following the application of these criteria, five waste disposal methods, two dam construction methods and three locations were removed from further evaluation, as follows:

- The co-disposal, surface paste and surface thickened disposal methods were all removed because they were considered to have insufficient capacity to store to the required quantity of tailings within a single facility.
- The dry-stacking disposal method was removed because there is no precedent for using this method at the production rate proposed at the Project, and the Project is located in a considerably less advantageous climate than those where this method has been used at relatively high throughputs, as the Project experiences significantly higher amounts of precipitation and relatively large seasonal variations in temperature.
- The cyclone disposal method was removed because this option is associated with an increased risk of seepage, and this method does not appear to have any significant advantages as waste rock is available for dam construction and would likely be stronger and more resistant to strength reduction than cycloned sand.
- The upstream and centerline dam construction methods were both removed because these methods rely on the properties of the impounded tailings for stability much more significantly than the downstream method. As the tailings properties are a function of operational practices, the stability of these two dam construction methods are more reliant on maintenance of good water management and tailings deposition practices than downstream construction.
- TMF-4 was removed because it overlies a claim held by others, and it is anticipated that obtaining ownership of this property, which is in the immediate vicinity of a proven deposit, would be: onerous, costly, have a high level of uncertainty, require lengthy negotiations, and not within the ability of GGM to implement. Due to the topography and claim location, redesign of this alternative to avoid the claim would be impractical and would result in a significant reduction in capacity.
- TMF-3A was removed because it would overlie part of the preferred WRSA alternative, and the siting of the WRSA was given precedence over TMF siting due to the higher volume of waste rock generated by the Project and the cost associated with waste rock haulage relative to tailings transport and disposal.

- The TMF-1 alternative with conventional impoundment disposal was removed as it is considered non-viable for expansion. It would require a substantially larger quantity of additional dam construction material to support future expansions than the other identified alternatives. This is due to the topography of the TMF-1 site, which consists of constructing perimeter dams along a relatively steep slope around a topographical high point and demonstrates that the TMF-1 conventional facility is poorly suited for expansion. Note that the TMF-1 location was only removed for the conventional impoundment disposal method based on this criterion. The thickened impoundment disposal method at the TMF-1 location remains under consideration in the assessment.

Following the application of the pre-screening criteria, the following seven alternatives were carried forward into Step 3 of the alternatives assessment:

- TMF-1 with thickened impoundment disposal and downstream dam construction
- TMF-2 with conventional impoundment disposal and downstream dam construction
- TMF-2 with thickened impoundment disposal and downstream dam construction
- TMF-8 with conventional impoundment disposal and downstream dam construction
- TMF-8 with thickened impoundment disposal and downstream dam construction
- TMF-9 with conventional impoundment disposal and downstream dam construction
- TMF-9 with thickened impoundment disposal and downstream dam construction

Figure 4-3 and Figure 4-4 present the conceptual design of the conventional and thickened TMF alternatives carried through Step 2 of the assessment, respectively. Additional figures and information are included in Appendix G1 (WRSA and TMF Alternatives Assessment Report).

Step 3: Alternative Characterization

For the remaining alternatives, summary information was defined based on 45 characterization criteria to assist in considering key aspects of the alternatives in the assessment. The characterization included criteria related to environmental, technical, economic and socio-economic information that would be used to evaluate each alternative.

Step 4: Multiple Accounts Ledger

Based on the information compiled for the characterization of the alternatives, a multiple accounts ledger was developed. The multiple accounts ledger is a tabular tool that uses accounts, sub-accounts, and indicators to identify the potential impact of each alternative and place them into broad categories.

In accordance with the ECCC Guidelines, only impacts that are differentiating between alternatives (i.e., an aspect that distinctly differentiates one alternative from another) were considered in the assessment. Characteristics considered to be non-differentiating were identified as a part of Step 3 and not considered further.

In accordance with the ECCC Guidelines the following four accounts were used in the assessment: Environmental, Technical, Project Economics, and Socio-Economic. Each account was divided into sub-accounts that represent the impacts of each alternative. One or more indicators were then defined within each sub-account to measure impacts. Table 4-10 provides a list of the accounts, sub-accounts, and indicators used in the WRSA alternatives assessment.

Table 4-10: Accounts, Sub-Accounts, and Indicators used in the WRSA Alternatives Assessment

Account	Sub-Account	Indicator
Environment	Water Management	Internal Water Management – Precipitation Internal Water Management – Supernatant Water External Water Management – Perimeter Ditch
	Aquatic Life and Habitat	Loss of Watercourses Loss of Waterbodies Loss of Wetlands Sensitivity of Impacted Fish habitat Impact to Spawning Areas Loss of Headwaters due to Diversion Loss of Headwaters due to TMF Surface Water Impacts from Emergency Spillway Discharge Infrastructure Disturbance – Water Crossings
	Terrestrial Life and Habitat	Loss of Forested Area Infrastructure Disturbance – Haul Roads and Pipelines Habitat Fragmentation Distance to Nearest Mapped Raptor Nest Site
	Air Quality	Potential for Dust Generation – Haul Traffic Potential for Dust Generation – Exposed Tailings Dust Impacts on Geraldton[1]
	Climate Change	Greenhouse Gas Emission
	Seepage and Leakage Risk	Facility Foundation Material - Seepage Tailings Pipeline Malfunction Water Reclaim Pipeline Malfunction
	TMF Failure Risk	Deposition Method – Failure Risk Maximum Dam Height Length of Dam Containment Failure – Watercourses

Table 4-10: Accounts, Sub-Accounts, and Indicators used in the WRSA Alternatives Assessment

Account	Sub-Account	Indicator
		Failure – Waterbodies Failure – Forested Land Failure – Wetlands Failure – Tailings and Supernatant Water Reporting to Receiving Body
Technical	Design and Operational Complexity	Stability Design – Maximum Dam Height Stability Design – Foundation Seepage Mitigation Design Discharge Complexity Operational Oversight
	Operational Flexibility	Upset Conditions
Project Economics	Capital Cost	CAPEX
	Operational Cost	OPEX – Flocculants and Pumping
	Closure Cost	Cover Construction Cost
	Economic Risks	Risk – ARD Mitigation Dam Raise
Socio-economic	LRU	Loss of Hunting Loss of Fishing – Watercourses Loss of Fishing – Waterbodies Loss of Bear Management Areas – Area Loss of Bear Management Areas – Number Loss of Trapline Areas – Area Loss of Trapline Areas – Number Loss of Routinely Maintained Access Roads Loss of Non-Routinely Maintained Access Roads
	TLRU	Loss of Unoccupied Crown Land Loss of Plant Harvesting Area Loss of Hunting Areas Loss of Proven Hunting Sites Loss of Small Game Harvesting Areas Loss of Large Game Harvesting Area Loss of Waterfowl Harvesting Area Loss of Upland Game Bird Harvesting Areas Loss of Trapping Area Loss of Large Animal Habitat Loss of Subsistence Areas Proximity to Fishing Area Loss of Travel Route

Table 4-10: Accounts, Sub-Accounts, and Indicators used in the WRSA Alternatives Assessment

Account	Sub-Account	Indicator
		Loss of Important Access Roads Proximity to Camp Site
	Aesthetics	Aesthetics – Wildgoose Lake Recreation Aesthetics – Kenogamisis Lake Recreation Aesthetics – Highway 11
	TMF Failure Risk	Failure – Highway 11 Failure – Utility Lines Failure – Pipelines Failure – Proximity to Residential and Recreational Infrastructure Failure – Anticipated Rights Held by Others Failure – Tailings and Supernatant Water Reporting to Receiving Body

For each indicator, a metric was defined to allow for a consistent measurement and comparison of effects. For example, in the terrestrial life and habitat sub-account, the indicator loss of forested area was selected. This indicator uses the area of forest (in hectares) that would be lost due to construction of the alternative to measure impacts to forested land associated with that alternative.

A value scale was then developed for each indicator based on the metric selected for the indicator. In accordance with the ECCC Guidelines, the value ranges were developed using a six-point scale where the most preferred measurement is given a value of six, and the least preferred is given a value of one. In Step 5, a value between one and six is assigned to each alternative for each indicator, based on the indicator measurements.

Step 5: Value-Based Decision Process

After developing the multiple accounts ledger, values were assigned to each alternative for each indicator based on the six-point value scales defined in Step 4. For example, in an indicator measuring the area of lost wetlands, an alternative that will remove the largest area of wetlands would be assigned a value of one, while an alternative that does not remove any wetlands may be assigned a value of six.

The relative importance of: each indicator compared to the other indicators, each sub-account relative to other sub-accounts, and each account relative to other accounts was also considered in the assessment by assigning a weighting factor to each. In accordance with the ECCC Guidelines, weightings were assigned a value of one to six (where a higher weighting would put more emphasis on that particular factor in the assessment) and were developed based on the professional judgment of the Project's technical leads and consultation input. This system allows the relative importance of different impacts to be incorporated into the assessment.

Each alternative was then evaluated through the qualitative analysis process which involves multiplying the assigned scores by the assigned weightings at an indicator, sub-account and account level and then calculating the overall rating for each alternative. The alternative rating is then used to compare each alternative and select the preferred alternative.

Based on the quantitative analysis, it was determined that TMF-8 Conventional is the preferred alternative, as it is scored higher than the other alternatives. This reflects the fact that alternative TMF-8 Conventional scores relatively high in each account whereas many of the other alternatives score relatively poorly in one or more of the accounts.

Key findings of the evaluation include the following:

Environmental Account

- In the water management sub-account, TMF-8 Thickened is preferred. This alternative has the smallest external catchment area and a slightly smaller tailings footprint. Thickened alternatives were generally preferred in this sub-account, because thickened tailings carry less water than the conventional alternatives. TMF-8 Conventional was the highest rated conventional alternative in this sub-account, and also rated higher than the TMF-2 Thickened alternative.
- In the aquatic life and habitat sub-account, TMF-1 Thickened is preferred and the two TMF-9 alternatives are rated relatively high. As with the TMF-9 Conventional and Thickened alternatives, alternative TMF-1 Thickened does not overlie any mapped watercourses, waterbodies or wetlands. In addition, it also requires the fewest (one) water crossing for access roads and pipeline alignments. The TMF-2 Conventional and Thickened alternatives rated poorly in this sub-account due to a relatively high loss of watercourses, fish habitat and headwaters and due to the fact that they require the greatest number of water crossings for access. The TMF-8 Conventional and Thickened alternatives rated lower than TMF-1 and TMF-9, but higher than TMF-2.
- In the terrestrial life and habitat sub-account, TMF-8 Conventional is preferred as it results in the loss of the least amount of forested land (as associated habitat) and results in less habitat fragmentation due to haul road and pipeline construction. The TMF-2 Conventional and Thickened and TMF-9 Conventional alternatives are rated relatively poorly in this sub-account as they would require the loss of a relatively large extent of forested area and TMF-9 is located in relatively close proximity to a mapped raptor nest.
- In the air quality sub-account, the TMF-9 Conventional and Thickened alternatives are preferred due to the relatively small amount of exposed tailings associated with them and

their relatively large distance from, and thus low anticipated dust effects on Geraldton[1]. The TMF-8 Conventional and Thickened alternatives are rated highly in this account as they have a relatively small amount of exposed tailings and are located in relatively close proximity to the open pit, thus generating less dust due to hauling. Alternative TMF-1 Thickened is rated relatively poorly in this sub-account as it is located relatively close to Geraldton[1] and has a moderate haul distance.

- In the climate change sub-account, TMF-8 Conventional and TMF-8 Thickened are preferred as these alternatives lie closer to the open pit and thus have a lower associated haul distance.
- In the seepage and leakage risk sub-account, the TMF-2 and TMF-9 Conventional and Thickened alternatives are scored poorly as both overlie areas of mapped outwash and have relatively long pipeline lengths, which represent a greater risk of seepage. Alternatives TMF-1 Thickened and the TMF-8 Conventional and Thickened alternatives are all rated relatively high in this sub-account based on their relatively short pipeline lengths and non-outwash foundation conditions.
- In the TMF failure risk sub-account, the thickened alternatives are generally preferred as thickened alternatives are associated with lower volumes of released tailings in the event of a failure and they generally have lower dam heights, which is also associated with lower failure consequences. However, TMF-8 Conventional scored substantially higher than the other conventional alternatives as the alternative uses natural topography to limit dam height and length, and the anticipated runout for this alternative is directed into Kenogamisis lake, and would not affect large areas of land or additional watercourses and waterbodies.

Technical Account

- In the design and operational complexity sub-account, TMF-8 Conventional is preferred as this alternative would require a relatively simple discharge design and the alternative overlies material that is anticipated to be relatively resistant to seepage. Additionally, this alternative is located in relatively close proximity to the open pit and the majority of the Project components, thus being less complex to access and oversee.
- In the operational flexibility sub-account, the conventional disposal alternatives are rated highly as they do not rely on deposition slopes to achieve design capacities. Alternative TMF-2 Thickened is rated the lowest in this sub-account as it would have the greatest reduction in storage capacity if design deposition slopes are not met.

Project Economics Account

- In the capital cost sub-account, TMF-2 Thickened is preferred, largely due to the relatively low volume amount of dam construction material required for this alternative. Alternative TMF-8 Conventional also scores highly in the capital cost sub-account as it is located relatively close to the process plant and open pit, thus having relatively low waste rock hauling costs and requiring relatively limited expenditures for haul road construction and piping installation. Additionally, it does not require thickener related capital expenditures.

- In the operational cost sub-account, the TMF-8 Conventional alternative is preferred as it utilizes conventional disposal (which has a lower associated operating cost) and is located in relatively close proximity to the process plant, thus requiring lower pumping costs.
- In the closure cost sub-account, TMF-8 Thickened rates the highest, but TMF-8 Conventional, TMF-1 Thickened, and TMF-9 Thickened alternatives also rate highly due to relatively small tailings surface areas that would require less cover placement at closure.
- In the economic risks sub-account, the conventional deposition alternatives all are rated highly as they are amenable to ARD/ML mitigation through tailings saturation.

Socio-economic Account

- In the LRU sub-account, the TMF-8 Conventional alternative is preferred as it is associated with a lesser loss of: hunting areas, bear management areas, trapping areas, and access roads than many of the other alternatives. The TMF-2 Conventional and Thickened alternatives generally score poorly in these sub-accounts as they would require the loss of relatively large extents of hunting areas, fishing areas (both watercourses and waterbodies), and trapline and bear management areas. These alternatives would also impact access to Goldfield Road. Alternative TMF-1 Thickened is rated relatively poorly in this sub-account as it would result in the loss of access to Goldfield Road and other access roads.
- In the TLRU sub-account, the TMF-8 Conventional alternative is preferred as it generally results in the loss of less areas used for hunting of a variety of species and less loss of unoccupied Crown land than many of the other alternatives, and does not affect Goldfield Road, which was identified as an important access road by Aboriginal communities. TMF-1 Thickened scores poorly in the TLRU sub-account as it results in the loss of relatively large extents of several types of hunting areas, is located in close proximity to a mapped camp site, and results in the loss of subsistence areas or important access roads.
- In the aesthetics sub-account, TMF-1 Thickened and the TMF-9 Conventional and Thickened alternatives are scored relatively high as TMF-1 has a low aesthetic impact on Wildgoose Lake and Kenogamisis Lake but a high aesthetic impact on Highway 11, while the TMF-9 alternatives have a low aesthetic impact on Wildgoose Lake and Highway 11 but a moderate aesthetic impact on Kenogamisis Lake). The TMF-8 and TMF-2 alternatives score equally as the TMF-8 alternatives have a high aesthetic impact on Kenogamisis Lake but a low aesthetic impact on Wildgoose Lake, while the TMF-2 alternatives have a high aesthetic impact on Wildgoose Lake and Highway 11 but a low aesthetic impact on Kenogamisis Lake.
- In the TMF failure risk sub-account, the TMF-8 and TMF-9 Conventional and Thickened alternatives are preferred as they are not estimated to impact key socio-economic infrastructure in a hypothetical failure. TMF-2 Conventional is rated poorly in this sub-account as it is estimated to impact Highway 11, utilities and pipelines, and has an estimated tailings runout in close proximity to cabins along Wildgoose Lake. Additionally, the estimated runout from this facility would overlie a relatively large extent of areas with rights that are not

anticipated to be held by GGM as a result of development of the alternatives. The hypothetical runout associated with the TMF-1 Thickened alternative would impact Highway 11, would lie in relatively close proximity to the proposed Hydro One substation, and would overlie a relatively large extent of areas with rights that are not anticipated to be held by GGM.

Step 6: Sensitivity Analysis

Following the completion of the valued-based decision process in Step 5, a set of sensitivity analyses were completed to test how other weighting scenarios would affect the results. Five different sensitivity scenarios were completed to compare against the base case as follows:

- **Base Case (used in Step 5) –** A weighting factor of six (the highest weighting) was applied to the Environmental account, a weighting factor of three was applied to the Technical and Socio-economic accounts, and a weighting factor of 1.5 was applied to the Project Economics account.
- **Scenario 1 – Equivalent Account Weightings –** An equivalent weighting factor of one was applied to all accounts.
- **Scenario 2 – Environmental Account Bias –** A weighting factor of one was applied to the Technical, Project Economic, and Socio-economics accounts and a weighting factor of six was applied to the Environmental account. This scenario identifies the preferred alternative if non-environmental factors are largely removed from the evaluation.
- **Scenario 3 – Technical Account Bias –** A weighting factor of one was applied to the Environmental, Project Economics, and Socio-economic accounts and a weighting factor of six was applied to the Technical account. This scenario identifies the preferred alternative if non-technical factors are largely removed from the evaluation.
- **Scenario 4 – Project Economics Account Bias –** A weighting factor of one was applied to the Environmental, Technical, and Socio-economic accounts and a weighting factor of six was applied to the Project Economics account. This scenario identifies the preferred alternative if non-project economics factors are largely removed from the evaluation.
- **Scenario 5 – Socio-Economic Account Bias –** A weighting factor of one was applied to the Environmental, Technical, and Project Economics accounts and a weighting factor of six was applied to the Socio-economic account. This scenario identifies the preferred alternative if non-socio-economic factors are largely removed from the evaluation.

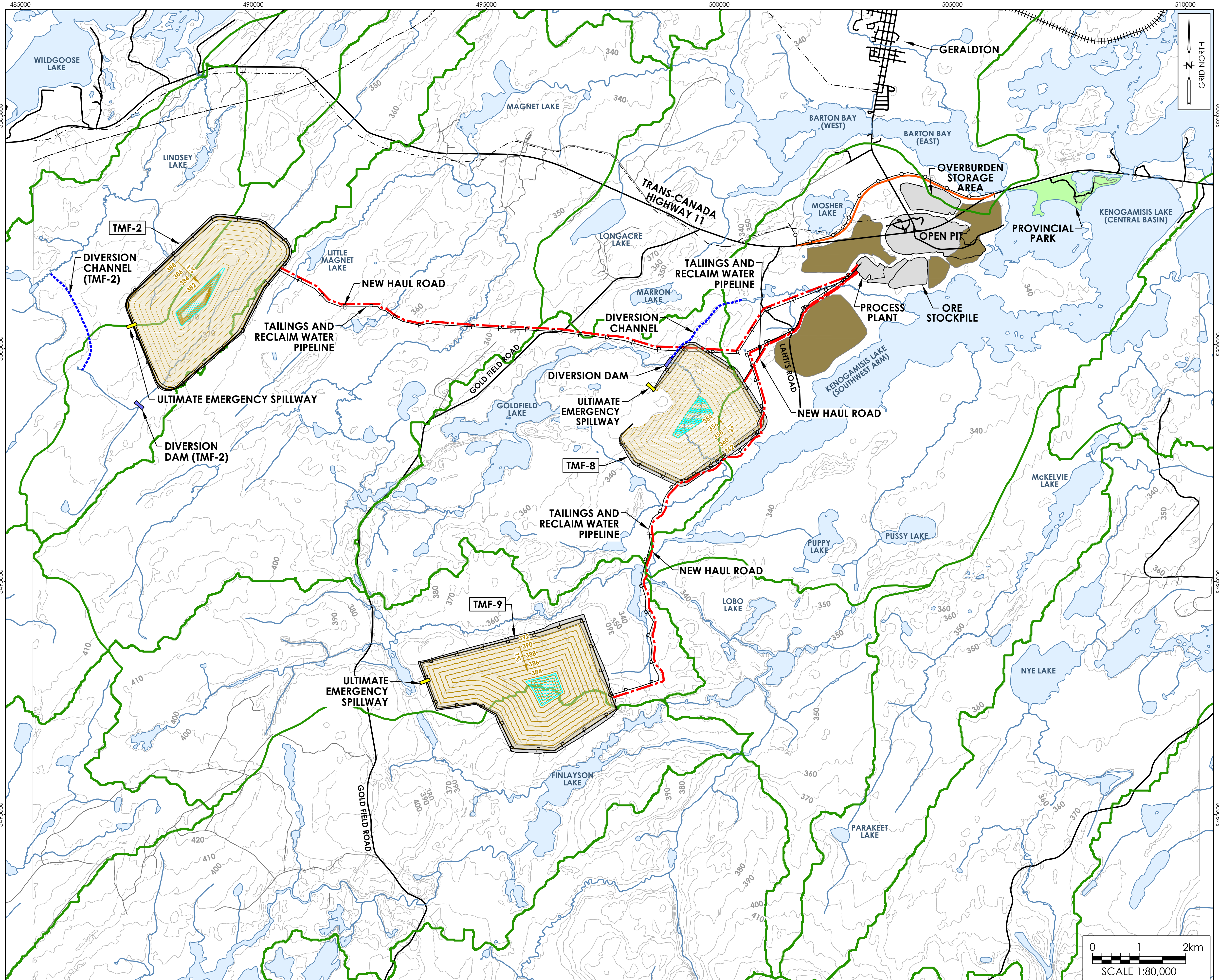
The results of the sensitivity analyses indicated that variations in account weighting did not affect the results of the evaluation. TMF-8 Conventional remained the preferred alternative in all scenarios, regardless of which account was given preference.

Step 7: Document Results

TMF-8 with conventional impoundment disposal and downstream dam construction was selected as the preferred alternative for tailings storage based on the results of the assessment. The key advantages associated with this alternative include:

- it results in the loss of the least amount of forested land (as associated habitat) and results in less habitat fragmentation due to haul road and pipeline construction
- it has a relatively small amount of exposed tailings and is located in relatively close proximity to the open pit, thus generating less dust due to hauling and wind-blown tailings
- it has a lower effect on climate change because it lies closer to the open pit, with a lower associated haul distance
- it has a lower seepage and leakage risk due to relatively short pipeline length
- it requires a relatively simple discharge design and overlies foundation material that is anticipated to be relatively resistant to seepage
- the alternative uses natural topography to limit dam height and length
- it is located in relatively close proximity to the open pit and the majority of the Project components, thus being less complex to access and oversee
- it has greater operational flexibility than thickened options, because it does not rely on deposition slopes to achieve design capacities
- it has limited construction and operation costs due to proximity to the process plant and open pit, and because it does not require thickener related expenditures
- it has a relatively small tailings surface area that would require less cover placement at closure
- it is associated with a lesser loss of: hunting areas, bear management areas, trapping areas, access roads, and unoccupied Crown land than many of the other alternatives
- it is not estimated to impact key infrastructure in a hypothetical failure

The complete TMF alternatives assessment is documented in Appendix G1 (WRSA and TMF Alternatives Assessment Report), including further detail on the method used, the rationale for the decisions made, the information used to score each alternative and the weighting calculations to confirm the preferred alternative.



Stantec

Legend

- Routinely Maintained Road
- Non-Routinely Maintained Road
- Watercourse
- Utility Line
- Railway
- 350 Contour, 10 m Interval
- Watershed Boundary
- Provincial Park
- Waterbody
- Waste Rock Storage Area (WRSA-4)
- New Highway 11 Alignment
- Power Line Realignment 44kV
- 382 Tailings Deposition Area and Contours
- Internal Tailings Reclaim Pond
- Proposed Tailings and Reclaim Water Pipeline
- New Haul Road
- Ultimate Emergency Spillway
- Diversion Dam
- Diversion Channel

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Roads, Utility Lines, Railways & Provincial Park Boundaries produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013. Level of road maintenance is based on attribute data contained in the MNR Road Segment layer. The Non-Routinely Maintained Roads include roads where the maintenance level is classified as not maintained or unknown.
3. Watercourses based on mapping originally provided by the Ontario Ministry of Natural Resources and Forestry, Land Inventory Ontario.
4. Contours based on Ontario Basic Mapping data.

June 2017
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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
4-3

Title
Conventional TMF Alternatives Carried Through Pre-Screening

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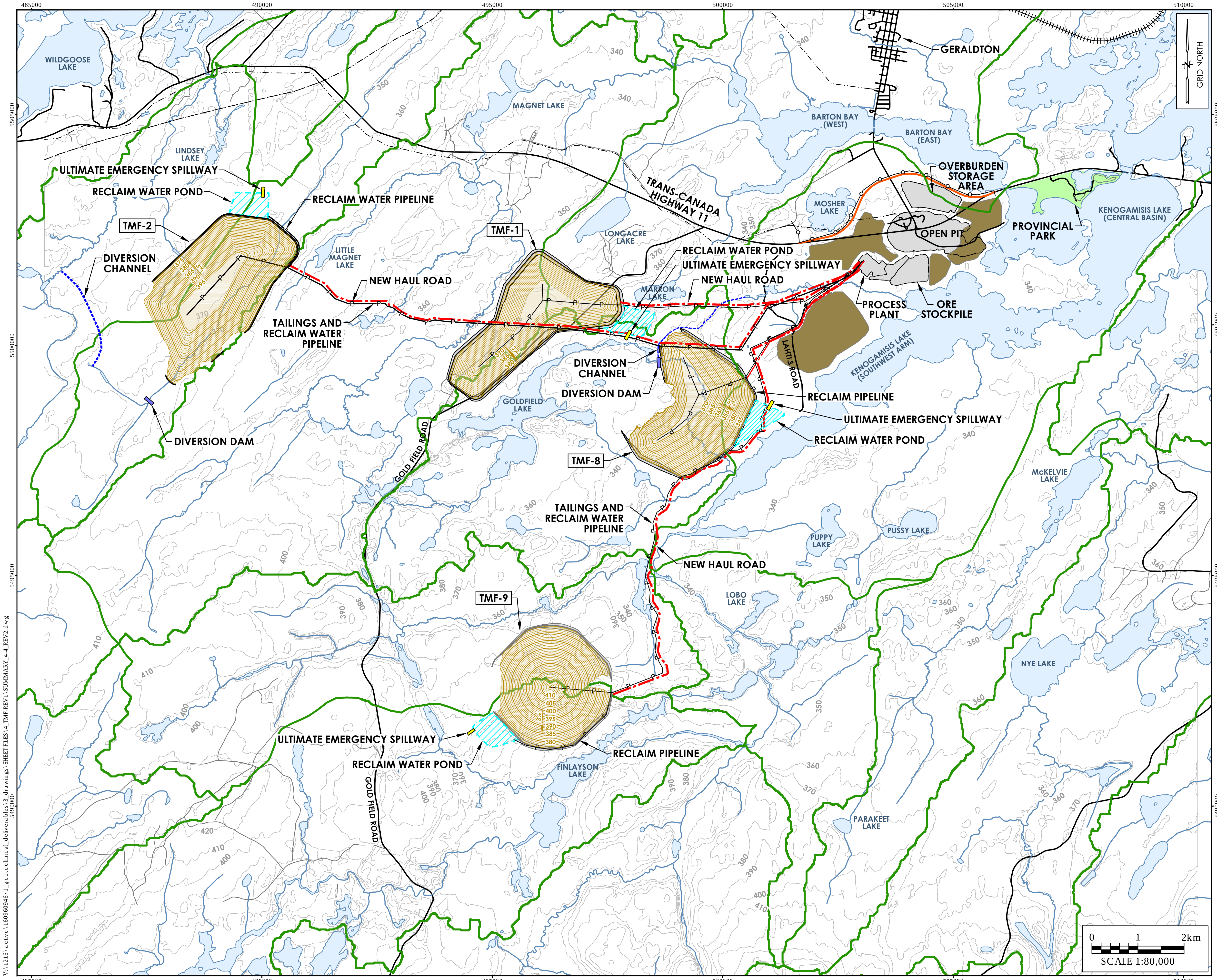

Stantec

Legend

- Routinely Maintained Road
- Non-Routinely Maintained Road
- Watercourse
- Utility Line
- Railway
- 350 Contour, 10 m Interval
- Watershed Boundary
- Provincial Park
- Waterbody
- Waste Rock Storage Area (WRSA-4)
- New Highway 11 Alignment
- Power Line Realignment 44kV
- 382 Tailings Deposition Area and Contours
- TMF Alternative External Reclaim Water Pond
- Proposed Tailings and Reclaim Water Pipeline
- New Haul Road
- Ultimate Emergency Spillway
- Diversion Dam
- Diversion Channel

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N.
2. Roads, Utility Lines, Railways & Provincial Park Boundaries produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013. Level of road maintenance is based on attribute data contained in the MNR Road Segment layer. The Non-Routinely Maintained Roads include roads where the maintenance level is classified as not maintained or unknown.
3. Watercourses based on mapping originally provided by the Ontario Ministry of Natural Resources and Forestry, Land Inventory Ontario.
4. Contours based on Ontario Basic Mapping data.

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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
4-4

Title
Thic□ened TMF Alternatives Carried Through Pre-Screening

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4.2.3 Process Plant

The following alternatives were considered for the process plant as part of the initial screening and comparative analysis:

- Process Plant Location:
  - onsite
  - offsite
- Ore Processing (Gold Recovery):
  - cyanidation
  - flotation
  - gravity separation
  - gold recovery using thiosulphate and alpha-cyclodextrin
- Process Water Supply:
  - reclaim water recycled from TMF and contact water collection system
  - dewatering from open pit and historical underground workings
  - surface water takings

The initial screening identified that the preferred alternative for the process plant location was on site, and the preferred alternative for the ore processing method was cyanidation with gravity separation. The comparative analysis confirmed that the preferred alternative for process water supply was the use of reclaim water recycled from the TMF and contact water collection system combined with dewatering from the open pit and historical underground workings. The rationale for considering alternative methods related to the process plant, and the results of the analysis are described below.

4.2.3.1 Process Plant Location

A process plant is required to recover gold from the raw ore. The required capacity of the facility is dependent on the expected daily throughput of ore. Planned ore processing is estimated at up to 30,000 tpd and it would not be feasible to move this quantity of material off site for processing. The process plant is therefore required to be located onsite, with the siting optimized for operational efficiency near the open pit and related facilities such as the crushing plants and ore stockpile.

The initial screening identified that the only feasible alternative for the process plant location was onsite, since an offsite location would be inefficient and uneconomical with increased environmental effects while reducing efficiency, with no benefits. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

The process plant will be located within the PDA immediately west of the open pit, and has been sited for operational efficiency and compatibility with other onsite facilities.

4.2.3.2 Ore Processing

The most common methods for recovering gold from a large scale mining operation include one or a combination of cyanidation, gravity concentration, and flotation concentration. Cyanide is one of the few chemicals that will dissolve gold from gold ores at a commercial scale. While cyanide requires special management, cyanide use for gold recovery is the industry standard for gold processing, and safe procedures for cyanide handling are well established. Cyanidation refers to the process of adding a dilute cyanide solution to ore that is typically crushed and ground to dissolve the gold into the liquid solution. In Canada, cyanide leaching typically occurs in large tanks, a process suited to the climate and also more easily managed from an environmental perspective. Cyanide is inherently unstable, and thus can be degraded to relatively inert compounds when exposed to sunlight and through processes referred to in this Final EIS/EA as cyanide detoxification.

Cyanidation is widely used in the industry, and effective handling processes and environmental management techniques can be applied to limit the degree of risk. This alternative also offers the most effective means of recovering gold based on the nature and grade of the mineral resource.

Flotation recovery involves crushing and grinding the ore, followed by the use of flotation chemicals and air in a sequence of water tanks, to preferentially float a gold-bearing sulphide concentrate. Cyanide is then required to leach the gold from the concentrate. Capital costs and power demands for flotation plants are generally higher than leach plants. Cyanidation of the concentrate did not show an improvement in recovery and was discarded as a possible processing option. Flotation may include similar or more cyanide in the process than cyanidation and increase process complexity and cost with reduced effectiveness.

Gravity separation relies on gold's high specific gravity compared to its host rock, which allows it to be separated by crushing and grinding the ore to liberate some of the gold particles. The ground ore is washed with water to create a slurry, which can be processed with a number of different machines in the market such as a centrifuge. This is a common gold recovery method and for the Hardrock ore achieves approximately 5 to 35% gold recovery, which is not adequate as the sole recovery method. Based on the testwork results it was determined that the most advantageous processing method was to use gravity separation for a majority of the ore and leach the remaining unprocessed ore and the materials discarded from the centrifuges into leach tanks.

Gold recovery using thiosulphate and alpha-cyclodextrin are experimental methods of gold recovery that were identified, but these are not adequately advanced to be considered as options for the Project. There are no full size thiosulphate industrial operations, except for one case specific to ore in Nevada that does not have equivalent properties to Hardrock. Alpha-cyclodextrin is also a small scale laboratory process that has no industrial application for large ore bodies such as Hardrock. Neither of these technologies are proven at pilot or industrial scale, and would require extensive experimental work, scale-up, and essentially design of a process from scratch with associated technical challenges. The anticipated capital and operating costs, and schedule are not reasonable for this Project.

A combination of gravity separation and cyanide recovery, to increase efficiency, offers the greatest advantage for effectiveness, while limiting the amount of cyanide and its potential environmental effects, and was therefore selected as the preferred alternative. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

Ore processing will be carried out using a combination of gravity separation and cyanidation for gold recovery.

4.2.3.3 Process Water Supply

Approximately 9.1 million m^3 of water per year are required on a daily basis to process 30,000 tpd of ore. Alternatives for the process water supply were considered in the comparative analysis, including a surface water source, a reclaim water source by recycling contact water including from the TMF, or using water generated from dewatering of the open pit and historical underground workings. The results of the comparative analysis are outlined in Appendix G2, and the results are described below.

The key assumptions used to compare process water supply alternatives are summarized in Table 4-11.

Table 4-11: Process Water Supply Design Assumptions

Reclaim water recycled from TMF and contact water collection system	Dewatering from Historical Underground Workings	Surface Water Takings
• The system would provide a ‘closed loop’ for reclaiming water from the TMF and contact water collection system for re-use in processing.	• The system would draw from water stored in the historical underground workings connected to the open pit. • Infrastructure would be works installed primarily above-	• The system would require the establishment of a new surface water source from Kenogamisis Lake, with surface infrastructure located within the PDA.

Table 4-11: Process Water Supply Design Assumptions

Reclaim water recycled from TMF and contact water collection system	Dewatering from Historical Underground Workings	Surface Water Takings
• Infrastructure would be installed primarily above-ground. • Standard mitigation measures would be applied to control construction effects, and address the risk of spills during operation. • Infrastructure would align with access roads within the PDA, and would not result in additional disturbance over other construction activities.	ground. • Standard mitigation measures would be applied to control construction effects, and address the risk of spills during operation. • Infrastructure location would be in close proximity to the open pit and process plant within the PDA, and would not result in additional disturbance over other construction activities.	• Infrastructure would be installed primarily above ground, and would require some shoreline footprint. • Standard mitigation measures would be applied to control construction effects, and address the risk of spills during operation. • Considered in this analysis for the primary source of process water (does not address the occasional need for additional surface water supply from the lake).

Taking surface water as the primary source for process water would have a greater environmental effect over using reclaim water based on the potential to affect surface water, fish and fish habitat, and groundwater wells under the direct influence of surface water. Surface water taking would not provide treatment efficiencies like a reclaim system would. Establishing a new surface water source at the volume required for the primary process water supply could also result in localized navigation restrictions around the intake, affecting resource use and traditional activities. Restrictions at an intake in Kenogamisis Lake would have the potential to affect LLFN and the MNO, who have identified the lake as a fishing area.

Reclaim water recycled from TMF and contact water collection system was selected as the primary source for process water. This reduces the potential for disturbance to groundwater, surface water and fish and fish habitat, reduces the demand on freshwater sources and reduces effluent discharge and loading to surface water.

Under most climate conditions, reclaim water from the TMF and contact water collection system will not fully meet the process water demands. To address this deficit, the preferred alternative also includes dewatering of the open pit and historical underground workings. Groundwater inflows to the open pit, along with precipitation and surface water runoff, can be directed to the historical underground workings as a storage reservoir and can be drawn upon to balance reclaim water demands. This use of the historical underground workings as a storage reservoir not only provides a reliable secondary source of process water, but it also provides increased storage to mitigate peak flows during high runoff periods to manage discharges to the environment.

Relatively small quantities of freshwater will also be required for processing as gland and seal water and for other process water streams where reclaim water is not adequate. General reclaim water is required for the bulk of processes, and does not need to meet the same quality standards. It is expected that dewatering from the historical underground workings, either directly or after treatment through the ETP, will be of quality to meet the intended fresh (non-potable) water demand requirement for the process plant. However, to provide flexibility as the Project advances through design stages, a surface water source from the Southwest Arm of Kenogamisis Lake will be implemented to provide a readily available freshwater supply if reclaim water is not adequate. The environmental effects associated with the limited water taking required for the freshwater supply are anticipated to be negligible.

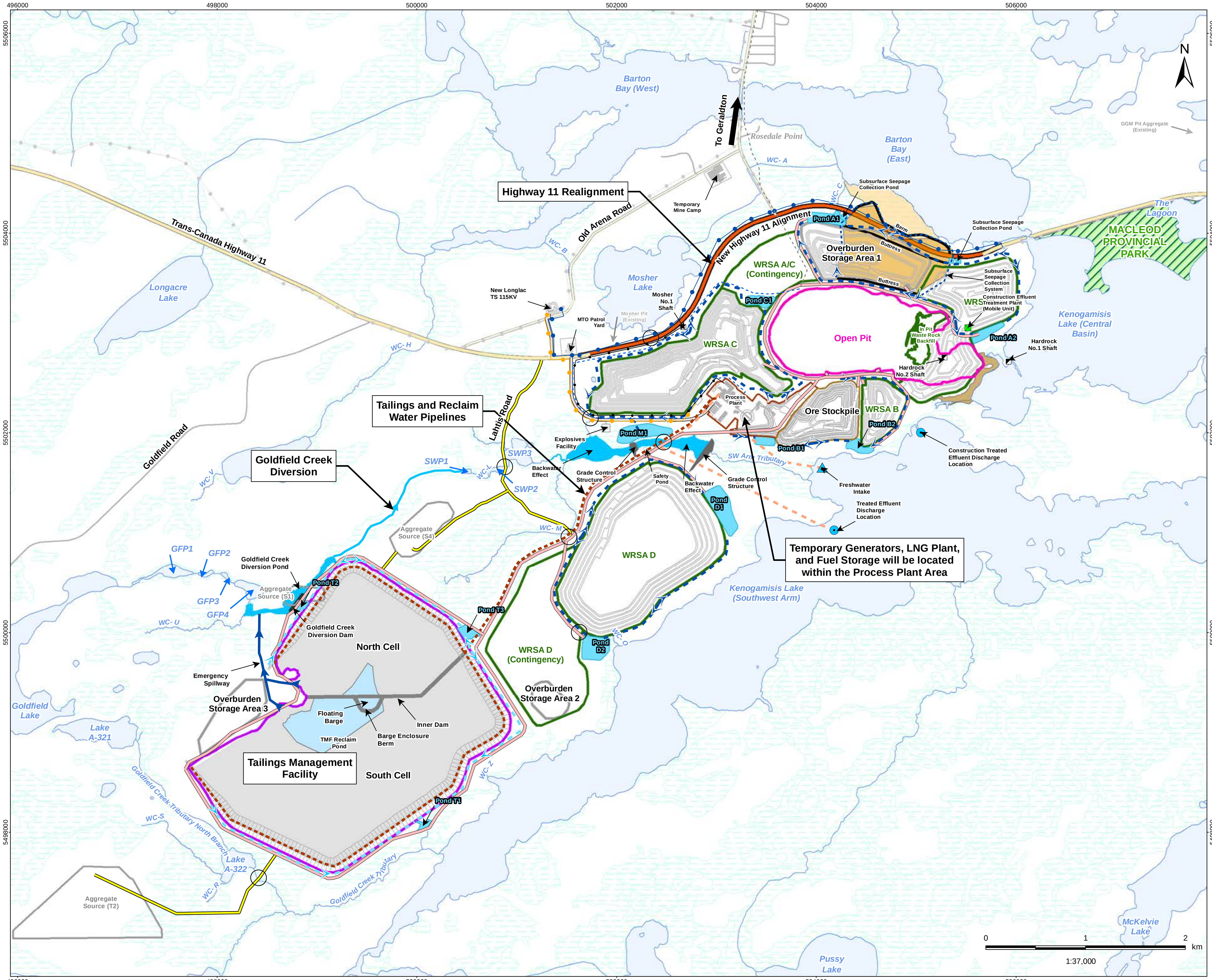
The detailed evaluation of process water supply alternatives, including consideration of components of the environment is found in Appendix G2. A summary comparison is provided in Table 4-12. The preferred location for the process plant is identified on Figure 4-5.

Table 4-12: Summary of Process Water Supply Analysis

Key Differentiating Factors	Reclaim water recycled from TMF and contact water collection system	Dewatering from Historical Underground Workings	Surface Water Takings
Groundwater	**Advantage -** No effects on groundwater anticipated because reclaim water from the TMF and contact water collection system will not require groundwater taking.	**Advantage -** No effects on groundwater anticipated because recycling water from the historical underground workings is required for open pit development.	**Disadvantage -** Potential for localized effects on Groundwater Under the Direct Influence of surface water (GUDI) well levels and quality due to the substantial water taking from Kenogamisis Lake and its potential influence on groundwater.
Surface Water	**Advantage -** The use of contact water and TMF reclaim systems will limit Project effects on surface water quality.	**Advantage -** The use of contact water and TMF reclaim systems will limit Project effects on surface water quality.	**Disadvantage -** Higher potential for effects on surface water due to increased water management requirements.
Fish and Fish Habitat	**Advantage -** No effects on fish or fish habitat are anticipated because the construction and decommissioning of the contact water collection system would not interact with fish or fish habitat. No parameters of potential concern affecting fish health are anticipated to be discharged to the aquatic environment.	**Advantage -** No effects on fish or fish habitat are anticipated because the construction and decommissioning of the dewatering system would not interact with fish or fish habitat. No parameters of potential concern affecting fish health are anticipated to be discharged to the aquatic environment.	**Disadvantage -** Higher potential for negative effects on fish habitat due to volume of water required from a fresh water source resulting in reductions in baseflows to creeks and wetlands, resulting in reduced habitat quantity and potentially quality.

Table 4-12: Summary of Process Water Supply Analysis

Key Differentiating Factors	Reclaim water recycled from TMF and contact water collection system	Dewatering from Historical Underground Workings	Surface Water Takings
Cost	**Advantage -** Reduced cost of treating effluent discharge because water from the TMF is being recycled and contact water is being reused to the extent feasible.	**Advantage -** Reduced cost of treating effluent discharge by using a reclaim system.	**Disadvantage -** No treatment efficiencies for other water management needs.
TLRU	**Advantage -** No effects on TLRU are anticipated because infrastructure will be localized to the PDA or near vicinity, and will not result in additional effects on TRLU.	**Advantage -** No effects on TLRU are anticipated because infrastructure will be localized to the PDA or near vicinity, and will not result in additional effects on TLRU.	**Disadvantage -** Navigation restrictions around surface water intake structure.
LRU	**Advantage -** No effects on LRU are anticipated because infrastructure will be localized to the PDA or near vicinity and will not result in additional LRU access or navigation restrictions.	**Advantage -** No effects on LRU are anticipated because infrastructure will be localized to the PDA or near vicinity and will not result in additional LRU access or navigation restrictions.	**Disadvantage -** Navigation restrictions around surface water intake structure
OVERALL	**PREFERRED - In Combination** (provides an effective water supply, but will not meet mill demand alone)	**PREFERRED - In Combination** (provides a viable secondary source water supply while limiting the potential for environmental effects)	**NOT PREFERRED**



Stantec

Legend

Preliminary Site Plan

- Discharge Location
- Existing Mine Shaft
- Freshwater Intake
- Construction Effluent Treatment Plant
- Watercrossing
- Access Road
- Construction Access Road
- Diversion Channel
- Emergency Spillways
- Haul Road
- Potable Water Pipeline
- Pipeline (Intake and Discharge)
- 44 kV Distribution Line
- 12.5 kV Distribution Line
- 115 kV Transmission Line
- Seepage Collection Ditch
- Subsurface Seepage Collection System
- Contact Water Collection Ditch
- Tailings Pipeline and 13.8 kV Distribution Line
- Aggregate Source
- Collection Ponds
- Open Pit- Full Extent
- Ore Stockpile
- Process Plant Area
- Tailings Management Facility
- Waste Rock Storage Area

Highway Realignment

- New Highway 11 Alignment

Existing Features*

- Highway
- Major Road
- Local Road
- Existing Power Line
- Existing Potable Water Pipeline
- Watercourse
- Provincial Park
- Waterbody
- Wetland (Eco-Site Based)

Historical Tailings Areas

- Historical Hardrock Tailings
- Historical MacLeod High Tailings
- Historical MacLeod Low Tailings

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

* Existing Features have been removed in the PDA and do not reflect current conditions.

June 2017
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Client/Project

Greenstone Gold Mines GP Inc. (GGM)
Hardrock Project

Figure No.
4-5

Title

Site Plan with Preferred Alternatives

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Revised: 2017-06-01 By: dharvey

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Acoustic Environment
- Vegetation Communities
- Wildlife and Wildlife Habitat
- Community Services and Infrastructure
- Operational Health and Safety
- Labour and Economy
- Technical Feasibility
- Heritage Resources

Preferred Alternative

Contact water will result from the open pit, WRSA runoff, and the TMF. Collection and storage components have been designed for each of these inputs. Reclaim water supplies the bulk of process water demands and will be sourced from water reclaimed from the TMF, contact water collection system, and dewatering of the open pit and historical underground workings as needed. While Kenogamisis Lake is not planned as a primary water source for the Project, there may also be a limited need for a supplemental freshwater source for specific process needs, which will be sourced from the lake if required.

4.2.4 Ore Stockpile, Crushing Plant and Mill Feed Ore Storage Area

The following alternatives were considered for the ore stockpile, crushing plant and mill feed ore storage area as part of the initial screening:

- Ore stockpile, crushing plant and mill feed ore storage area:
  - onsite near the process plant
  - offsite

The initial screening identified that the preferred alternative for the ore stockpile, crushing plant and mill feed ore storage area was on site. The rationale for considering alternative methods related to the ore stockpile, crushing plant and mill feed ore storage area, and the results of the analysis are described below.

Ore will need to be hauled from the open pit to an ore stockpile, which will require a capacity of approximately 33,600 kilotonnes with a size of approximately 37.5 hectares (ha).

Ore extracted from the open pit will need to be crushed to a size and consistency that can be processed by the process plant. Ore that is temporarily stored in the stockpile will be transferred to a crushing plant before being moved to the process plant for further processing. The crushing plant will require a storage area for crushed material that is ready to be transferred to the process plant.

Alternatives for the location of the ore stockpile and crushing plant are limited based on the need to remain close to the open pit and process plant for cost and operational efficiency considering a production rate of up to 30,000 tpd.

As final processing will be onsite, transporting material offsite for temporary storage and crushing would be inefficient and cost prohibitive and result in increased GHG emissions and fugitive dust, with no operational or environmental benefits.

The initial screening identified that the only feasible alternative for the ore stockpile, crushing plant and mill feed ore storage area was an onsite location. As a result of the initial screening, a comparative analysis was not required.

The preferred layout for the process plant area including the crushing plant is identified on Figure 4-5.

Preferred Alternative

Onsite crushing was selected as the preferred alternative. The components that will be used for ore crushing will be located east of the process plant, adjacent to the main haul road.

4.2.5 Goldfield Creek Diversion

The selected TMF location requires the diversion of Goldfield Creek, as the TMF would overprint the creek. The following alternatives were considered for the Goldfield Creek diversion as part of the initial screening and comparative analysis:

- Goldfield Creek Diversion:
  - Option 1 (diversion through Lake A-321 towards Lake A-322)
  - Option 2 (diversion towards Marron Lake)
  - Option 3 (southwest diversion directly to Lake A-322)
  - Option 4A (move west dam further west of Lake GFP4, diversion to Lake A-322)
  - Option 4B (move west dam further west of Lake GFP4, diversion to Marron Lake)
  - Option 5 (stage 1 diversion to Lake A-322, stage 2 diversion to Marron Lake)
  - Option 5A (stage 1 diversion to Lake A-322, stage 2 diversion northeast to Southwest Arm Tributary)

- Option 6 (diversion northeast to Southwest Arm Tributary)

The comparative analysis confirmed that the preferred alternative for the Goldfield Creek diversion was Option 6. The rationale for considering alternative methods related to the Goldfield Creek diversion, and the results of the analysis, are described below.

Goldfield Lake drains through Goldfield Creek to Kenogamisis Lake, and since the preferred location for tailings disposal (TMF 8) overprints Goldfield Creek, the flows from Goldfield Lake will need to be diverted.

An initial evaluation was undertaken to look at potentially feasible concepts for the diversion of Goldfield Creek. This included the initial identification of a total of eight different alternatives, which were screened down to two potentially feasible alternatives that were considered in the comparative analysis.

Creek diversion alternatives were initially developed in a process that considered different iterations of the TMF design. Initial diversion alternatives were developed for the preliminary TMF design, which included a boundary that extended further to the north and west. The first six diversion alternatives were based on this preliminary design, or a refinement to this design which moved the western dam of the TMF further west.

Following additional geotechnical work and engineering studies, the TMF design was refined and the northern extent of the TMF was reduced, which allowed for additional diversion options to the northeast. Two more diversion alternatives were identified based on this new diversion pathway, which were also compatible with the TMF design.

Based on the results of this iterative TMF design process, Options 1, 2, 3, 4A, 4B and 5 were screened out from further consideration, because the locations of the channels and dams did not align with the location and design of the TMF, and for a variety of other environmental disadvantages as outlined below.

Option 1 involved a diversion through Lake A-321 towards Lake A-322 by cutting a 70 m diversion channel between Goldfield Lake and Lake A-321. The primary environmental disadvantages of this alternative were alterations to water levels in Lake A-321 (drained by 3 m) and Goldfield Lake (raised by 1 m), and alterations to the residence time of Lake A-322 (identified as important through Aboriginal consultation).

Option 2 involved a diversion towards Marron Lake with a 930 m diversion channel from the northern bank of GFP1. The primary environmental disadvantage of this alternative was the requirement to divert flows across watersheds, and the alteration of the residence time of Marron Lake. This option also presented potential issues with property access, because the diversion would be constructed on lands not owned by the proponent. These areas may also be subject to future mining development.

Option 3 involved a 2,440 m diversion from the southern portion of Goldfield Lake directly to Lake A-322. The primary environmental disadvantages of this alternative were the alterations to residence times in the main basin of Goldfield Lake (reduction) and in Lake A-322 (increase).

Options 4A and 4B were developed by moving the TMF 8 west dam in the preliminary design to enlarge the footprint further west, which would reduce the substantial ponding required in the first three alternatives. Option 4A would divert the Goldfield Lake outflows to Lake A-322 as per Option 3, whereas Option 4B utilizes the diversion to Marron Lake as in Option 2. These alternatives were eliminated from further consideration based on the same environmental constraints as those identified for Options 2 and 3 above, and because the need to move the TMF dam further west was a deviation from the TMF design.

Option 5 was developed to maintain the bulk of the flow to the Southwest Arm of Kenogamisis Lake and to reduce the size of the inundated area upstream of the TMF. The primary environmental disadvantages of this alternative were the requirement to divert flows across watersheds, and alterations to the residence time of Lake A-322, Marron Lake and Goldfield Lake. This option also presented the same access issues as Option 3, as the diversion to Marron Lake would be constructed on unowned lands. This option also requires the construction of multiple channels.

Once further geotechnical investigations identified the possibility to shift the north and west dams of the TMF, an opportunity was created to modify Option 5 with a variant identified as Option 5A. This option would be similar to Option 5, but with the remnant Goldfield Creek diverted to the Southwest Arm Tributary, which discharges to the Southwest Arm of Kenogamisis Lake. This alternative was brought forward for further evaluation as part of the comparative analysis.

Considering this potential change to the TMF alignment, an Option 6 was also developed that would use the north TMF diversion in the ultimate Option 5A diversion as a single permanent solution. A relatively larger channel flow section would be required for this option as compared to Option 5A to handle the entire Goldfield Lake catchment. Although the ultimate discharge location to Kenogamisis Lake will be some distance from the current location, the outlet will remain in the Southwest Arm of the lake. The biggest environmental advantage of this option is that it avoids alteration to habitat that is otherwise unaffected by the project. For instance, there will be no alteration to habitat or residence time in Goldfield Lake or Lake A-322 with this diversion option. The overall disturbance to otherwise undisturbed areas is also more favorable with this option. For example, there is no need to construct access roads to construct a dam on Goldfield Lake or to create a diversion channel on the west side of the TMF.

Options 5A and 6 were considered for the Goldfield Creek diversion in the comparative analysis as outlined in Appendix G3, and the results are described below.

The key assumptions used to compare Goldfield Creek diversion alternatives are summarized in Table 4-13.

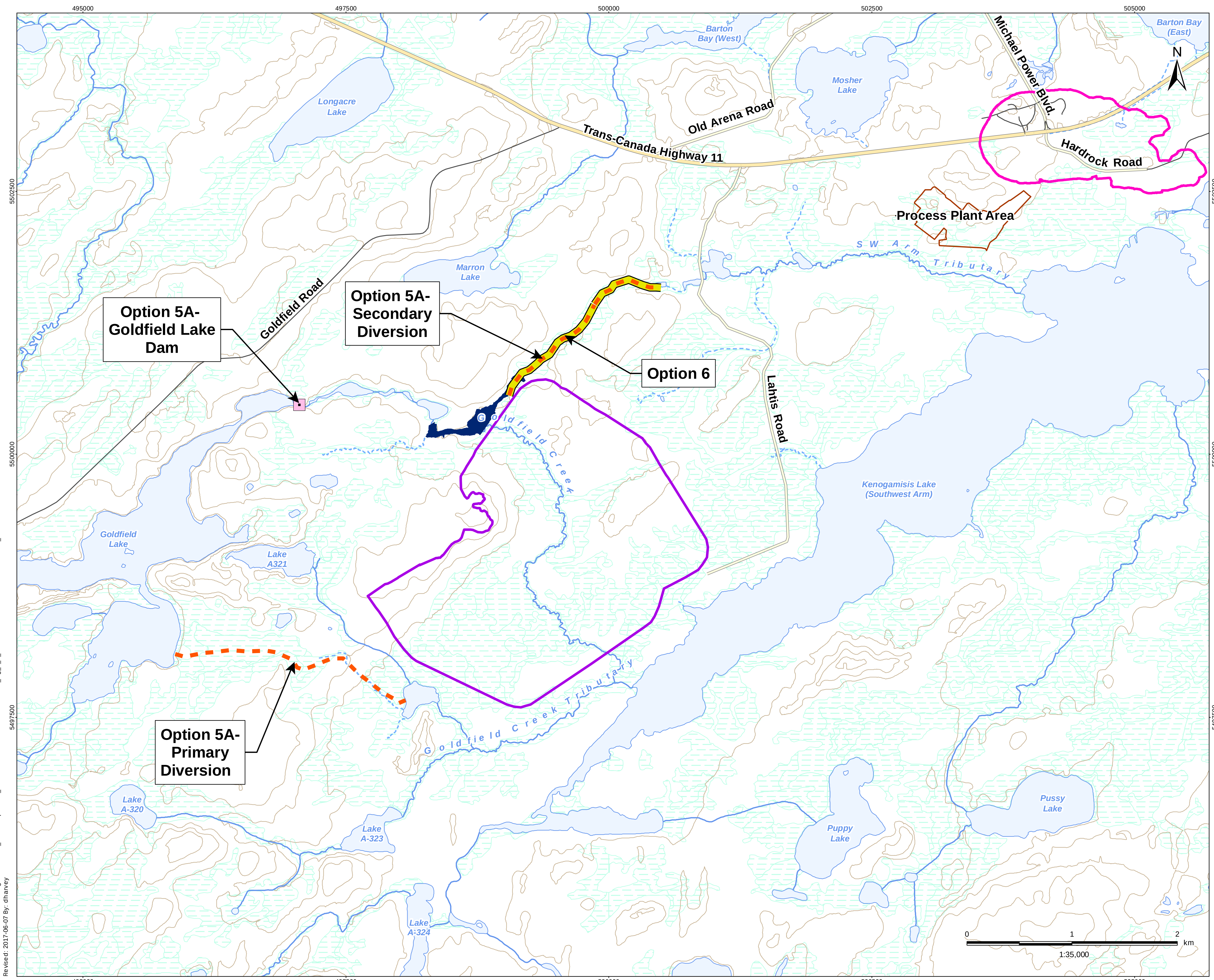
Table 4-13: Goldfield Creek Diversion Design Assumptions

Option 5A	Option 6
• Requires the excavation of two channels resulting in a total length of new channel of approximately 4.4 km. • Total footprint, including the existing and new channels and inundated area is approximately 51.7ha. • Requires the construction of a dam at the connection of Goldfield Lake and Goldfield Creek to address flow reversal. • Requires a diversion dam upstream of the TMF to create a headwater pond and separate flows from the TMF. • Standard mitigation measures would be applied to control construction effects such as sedimentation and erosion. • Final design would be restored and stabilized for natural function and would incorporate aquatic habitat features. • No anticipated effects from the channel during operation and closure, as channel will function as a natural watercourse, providing fish bearing capacity. However, flow reversal in Goldfield Creek will be a permanent alteration.	• Requires the excavation of a single channel with a total length of new channel of approximately 2.0 km. • Total footprint, including the existing and new channels and inundated area is approximately 31.8 ha. • Requires a diversion dam upstream of the TMF to create a headwater pond and separate flows from the TMF. • Standard mitigation measures would be applied to control construction effects such as sedimentation and erosion. • Final design would be restored and stabilized for natural function and would incorporate aquatic habitat features. • No anticipated effects during operation and closure, as channel will function as a natural watercourse, providing fish bearing capacity.

Option 6 was selected as the preferred alternative, because it presents advantages related to the lowest disturbance to vegetation and wildlife habitat, the lowest disturbance to existing channels and fish habitat (e.g., lowest disturbance to Goldfield Lake), and the lowest cost. This option also limits disruption to resource uses and traditional activities on the lake by avoiding a permanent reversal in the flow of Goldfield Lake. Option 6 was also preferred based on preliminary discussions with DFO. The primary disadvantage of this approach, as with Option 5A, is that the Southwest Arm Tributary may require hydraulic upgrading due to the increase in flows, which will need to be addressed with ongoing Project planning and engineering design. The upgraded Southwest Arm Tributary will be located in relatively close proximity to Project infrastructure, but this will be addressed through appropriate design. The channel will also cross areas identified by the MNO, including related to animal and bird habitat and harvesting, and plant harvesting, and the channel may have effects on an adjacent hunting area and a cabin/trapping site located downstream of the channel on the Southwest Arm Tributary identified by LLFN, but similar effects would be experienced from construction of the same channel for Option 5A.

The disadvantages of Option 5A over Option 6 included greater vegetation, wildlife habitat and wetland removal for the construction of two channels, plus higher disturbance to existing channels and fish habitat. The requirement to construct two channels will also result in a higher construction cost, while ongoing maintenance of the dam at the outlet to Goldfield Creek would increase operational costs. The second channel will also result in additional effects on traditional areas identified by LLFN and the MNO. This option also results in the highest effects on surface water, since flows would need to be permanently reversed towards the southern end of Goldfield Lake, affecting resources use and traditional activities linked to the lake such as fishing and travel. The MNO specifically identified Goldfield Creek as a fishing site, and the MNO and other communities are assumed to use the lake as a travel route.

The detailed evaluation of Goldfield Creek diversion alternatives, including consideration of the components of the environment is found in Appendix G3. A summary comparison is provided in Table 4-14. The Goldfield Creek diversion alternatives that were considered in the comparative analysis are identified on Figure 4-6.



Stantec

Legend

- Open Pit- Full Extent
- Process Plant Area
- Tailings Managment Facility
- Contour Line (10m intervals)
- Highway
- Major Road
- Local Road
- Waterbody
- Wetland (Eco-site Based)
- Watercourse- Permanent
- Watercourse- Intermittent

Goldfield Creek Diversion Alternatives

- Option 5A
- Option 6
- Goldfield Creek Diversion Pond
- Goldfield Dam (Option 5A)

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

June 2017
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Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
4-6

Title
Goldfield Creek Diversion Alternatives

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Revised: 2017-06-07 By: dharvey

Table 4-14: Summary of Goldfield Creek Diversion Analysis

Key Differentiating Factors	Option 5A	Option 6
Surface Water	**Major Disadvantage -** Higher effect on Goldfield Lake by damming the northeastern outlet and redirecting outflow through the southern end of the lake. Higher alteration to existing channels.	**Major Advantage -** Maintains flow direction in Goldfield Lake. Lower alteration to existing channels.
Fish and Fish Habitat	**Disadvantage -** This option has the potential for adverse effects on the limnology of Goldfield Lake which is an Aboriginal and recreational fishery. A greater length of Goldfield Creek and online ponds is affected through flow reduction.	**Advantage -** Avoids the potential for adverse effects on an Aboriginal and recreational fishery in Goldfield Lake and has the smaller construction footprint, while at the same time providing opportunities for offsetting the loss of Goldfield Creek.
Vegetation Communities	**Disadvantage -** Higher vegetation and wetland removal.	**Advantage -** Lower vegetation and wetland removal.
Wildlife and Wildlife Habitat	**Major Disadvantage -** Higher amount of removal of confirmed and potential wildlife habitat.	**Major Advantage -** Lower amount of removal of confirmed and potential wildlife habitat is required.
Cost	**Disadvantage -** Higher capital cost and maintenance cost.	**Advantage -** Lower capital cost and maintenance cost.
Technical Feasibility	**Disadvantage -** Higher construction complexity.	**Advantage -** Lower construction complexity.
TLRU	**Major Disadvantage -** Construction disturbance for two channels would result in increased effects, and damming and flow reversal in Goldfield Lake will affect fishing and travel activities, and access to adjacent areas.	**Major Advantage -** Effects on traditional uses will be limited by isolating work to a single channel, and maintaining flow direction in Goldfield Lake.
LRU	**Major Disadvantage -** Damming and flow reversal in Goldfield Lake will affect fishing and travel activities.	**Major Advantage -** Effects on fishing and travel will be limited by maintaining flow direction in Goldfield Lake.
OVERALL	**NOT PREFERRED**	**PREFERRED**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Acoustic Environment
- Groundwater
- Community Services and Infrastructure
- Operational Health and Safety
- Labour and Economy
- Heritage Resources

Preferred Alternative

Installation of the TMF requires the diversion of Goldfield Creek, which will include the creation of a new diversion channel to divert flow from the approximate location of GFP4 northeast around the TMF to the Southwest Arm Tributary (Option 6). Surface flow that previously entered the Southwest Arm of Kenogamisis Lake via the existing Goldfield Creek outlet will continue to discharge to the Southwest Arm of Kenogamisis Lake. The realigned channel will be designed using natural channel design principles. The channel design will be based on predicted flows for the drainage area and include habitat features for fish species common to the area. Final channel design and location details will be determined based on site-specific information to be collected during the permitting period (e.g., geotechnical data) and considering ongoing consultation.

4.2.6 Highway 11 Realignment

As the ore deposit is partially located underneath the existing Highway 11, realignment of a portion of the highway is required to accommodate the open pit and other Project components. Alternative methods for the realignment of Highway 11 were identified that will bypass the PDA, connect with Michael Power Boulevard and provide access to Geraldton.

The following alternatives were considered for the Highway 11 realignment as part of the initial screening and comparative analysis:

- Highway 11 Realignment:
  - Route 1A (wide path north of open pit and Mosher Lake)
  - Route 1B (wide path north of open pit)
  - Route 1C (minor route adjustment to eastern connection of 1A and 1B to existing Highway 11)

- Route 1D (wide path north of open pit with increased horizontal curve radii - identified in consultation with the MTO)
- Route 1D (optimized) (revised alignment based on Route 1D to address safety concerns and improve sight distance)
- Routes 2, 3 and 4 (near paths north of open pit)
- Route 5 (near path south of open pit)
- Route 6 (wide path south of open pit).

The comparative analysis confirmed that the preferred alternative for the Highway 11 realignment was Route 1D (optimized). The rationale for considering alternative methods related to the Highway 11 realignment, and the results of the analysis are described below.

Four feasible alternative routes (Routes 1A, 1B, 1D and 1D (optimized)) were initially identified for evaluation that meet the MTO's minimum design requirements for the Highway and are compatible with the local site constraints. All four alignments run north of the PDA and maintain a minimum 500 m buffer from the open pit to meet industry safety standards near blasting activities to avoid potential flyrock. Minor adjustments to the eastern connection of Routes 1A and 1B were identified as route 1C, but these were relatively minor adjustments and so 1C was not considered as a separate alternative. Routes 2, 3 and 4 to the south of the open pit were screened out because no feasible alignments were identified that could maintain the safety buffer between the open pit and Kenogamisis Lake. Routes 5 and 6 north of the open pit were also screened out because an adequate distance from this safety buffer could not be maintained.

Potential routes were initially identified through a preliminary selection study, which were then refined through a second assessment based on updated specifications, most importantly the application of the 500 m safety buffer around the open pit to eliminate potential risks that might arise if flyrock were to occur. Some routes that were initially identified as viable were then eliminated due to infringement on this safety buffer. Two routes were carried forward from the initial selection study, including Routes 1A and 1B. As part of the follow up analysis, a third option, 1D was also identified in consultation with MTO, and an optimized option 1D was identified separately to account for the MTO's preferred highway geometry.

The alternative alignments include Route 1A, a wide route that runs north of the Project and Mosher Lake, with an eastern connection near the existing MTO Patrol Yard and a western connection near the existing intersection of Highway 11 and Old Arena Road. The other alignments, Routes 1B, 1D, and 1D (optimized) follow a shortened route southwest of Mosher Lake, with an eastern connection near the existing MTO Patrol Yard, and a western connection near the southern end of Mosher Lake. The shortened routes follow different curve geometry, but follow a relatively similar path.

These four alternatives for the Highway 11 realignment were considered in the comparative analysis as outlined in Appendix G4, and the results are described below.

The key assumptions used to compare Highway 11 realignment alternatives are summarized in Table 4-15.

Table 4-15: Highway 11 Realignment Design Assumptions

Route 1A	Route 1B	Route 1D	Route 1D (optimized)
• Designed to meet MTO's minimum design requirements.	• Designed to meet MTO's minimum design requirements.	• Improved highway geometry confirmed in consultation with MTO.	• Optimized highway geometry confirmed in consultation with MTO.
• Assessment based on the construction footprint of a 110 metre (m) right-of-way (ROW). • Standard mitigation measures would be applied to control construction effects. • Although routes cross the fringes of the Kenogamisis Golf Club, removal of holes 10-18 from the golf course is required for open pit development regardless of the Highway 11 alignment, and is therefore not considered as a direct effect of highway routes. • All identified routes require a relatively similar length of highway to be constructed over top of historical MacLeod tailings. • Highway design would include standard crossing and stormwater management features to control environmental effects during operation. • Operation and closure effects are generally not considered, since the infrastructure will remain indefinitely following construction, but the permanent effect from ongoing disruption to traditional land uses is addressed.			

Route 1D was initially selected as the preliminary preferred alternative route for the Highway based on a separate trade-off study. This was based on Route 1D having the optimal highway geometry, relatively low construction costs, and relatively small environmental effects compared to other alternatives.

Once Route 1D was selected as the preliminary preferred alternative through the trade-off study, this route was then carried forward into preliminary design to examine the alignment in more detail. Minor local variations were made in the alignment through this process to address safety concerns that were encountered as additional information was gathered for preliminary design. The comparative analysis evaluates both the initial Route 1D and the final Route 1D (optimized), to confirm that Route 1D (optimized) provide the highest balance of advantages to disadvantages based on the more detailed assessment.

The alternative routes assessed in the comparative analysis are identified on Figure 4-7. A detailed description of the iterative route selection and preliminary design process can be found in the "Preliminary Design Report Highway 11 Realignment" (Appendix H2).

Overall, Route 1A was determined to have the greatest disadvantages. From a natural environment perspective, it required the crossing of six watercourses, including five watercourses with identified fish habitat. This route also required much more disturbance to existing terrestrial communities, and although it is ranked second for the amount of potential wetland removal, this route will affect three separate unevaluated wetlands. Route 1A would also affect a much greater distance of power and telecommunication lines, along with overprinting a portion of Old Arena Road. In addition, Route 1A has the highest capital cost to construct (primarily due to the number of watercourse crossings required), and the highest potential construction complexity related to rock excavation, swamp construction and the number of crossings. This route would potentially disrupt two existing hunting areas and two cabins/camps identified by LLFN, a cultural site identified by the MNO, and two subsistence areas identified by EFN. Other potential disruptions to traditional use areas would be relatively comparable across alternatives, as they follow similar routes and generally cross hunting and trapping areas identified by LLFN, and several areas identified by the MNO, including related to fishing, bird and animal habitat and harvesting, and plant harvesting.

Route 1B presented some advantages around lower construction costs and limited effects on existing infrastructure and surface water, but it would potentially disrupt two hunting areas and two cabins/camps identified by LLFN and one subsistence area identified by EFN, and it only met the minimum design requirements for the highway, which is not preferred from a technical or safety standpoint.

Routes 1D and 1D (optimized) had a relatively similar number of watercourse crossings, wetland removal and effects to existing infrastructure, and both cross one hunting area, one hunting site, and two cabins/camps identified by LLFN, and one subsistence area identified by EFN. Route 1D presented some advantages around less wetland, vegetation and wildlife habitat removal, but Route 1D (optimized) provided the optimal highway geometry, which will allow for greater design speeds, a more ideal intersection at Michael Power Boulevard, longer sightlines, and better overall road safety. Both Route 1D and Route 1D (optimized) require more wetland removal, but this will involve the removal of the southern edge of the most affected wetland, instead of fragmenting it through bisection like Routes 1A and 1B, which will maintain higher wetland function. Route 1D (optimized) will also affect a second wetland due to its proximity to Mosher Lake.

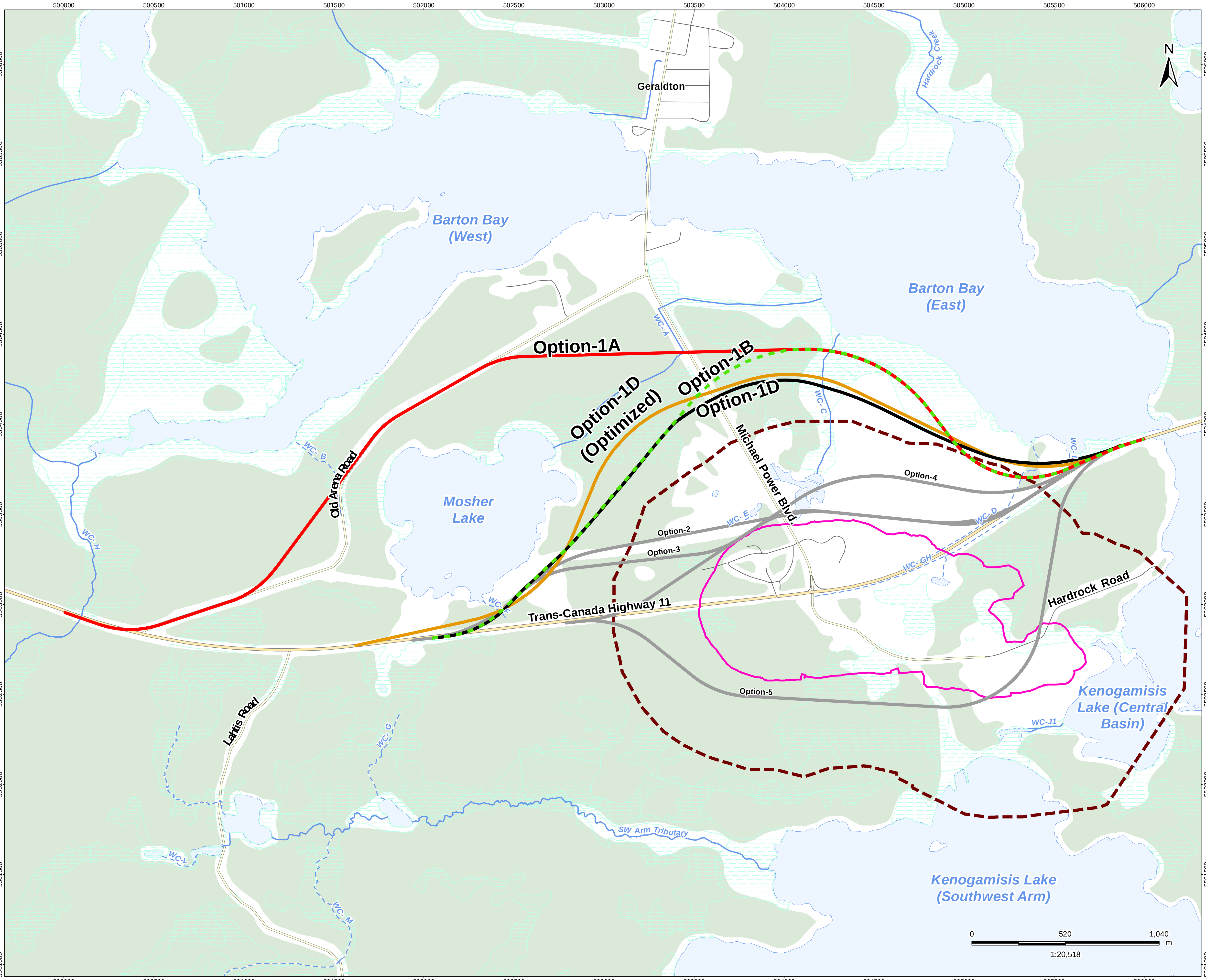
The four routes assessed in the comparative analysis were determined to be comparatively similar for other components of the environment. This includes the expectation that local receptors will not experience much increase in noise or emissions from any of the identified highway routes, and other environmental components such as cultural heritage resources, groundwater flow and quality are not expected to be greatly affected, and what effects are expected will be relatively comparable the four alternatives. The Municipality of Greenstone has also indicated a preference for routes that pass closer to Geraldton, with the assumption that this may increase travel stops in Geraldton. Since the four routes are all located over 1 km closer to Geraldton than the existing highway, this was not considered a deciding factor in the selection of a preferred route.

Since the existing highway runs through the open pit limits and must be closed prior to the majority of quarrying taking place, the realignment of Highway 11 must be complete prior to construction of the TMF. Because of this, it will not be possible to remove the historical MacLeod tailings located under the new highway route, since the TMF will not be constructed to accept the historical tailings. Specific mitigation measures will be required to construct over the historical tailings, but all routes selected for the comparative analysis require a relatively similar length of highway to be constructed over top of this historical MacLeod tailings. Although this will be a consideration in the highway design, it was not considered a deciding factor in the selection of a preferred route.

Ultimately, Route 1D (optimized) was confirmed to have the greatest advantages (including less effect on TLRU, optimal highway geometry that exceeds minimum design standards, highest road safety, relatively lowest cost, and relatively lowest effect on watercourses, fish habitat and wildlife), which outweighed the comparative disadvantages (higher removal of wetlands and vegetation). However, the higher disturbance to the existing environment was concluded to be minor as much of the realignment corridor consists of an existing disturbed environment associated with historical mining and ensuring the safest highway design is critical.

Hardrock Road is a local road that intersects with Highway 11 south of the intersection with Michael Power Boulevard. The road provides access to the small community of Hardrock, located on Kenogamisis Lake. The other local road within the PDA is Sunset Drive. The road intersects with Michael Power Boulevard just to the south of the Hydro One TS, which is the main road within the community of MacLeod to provide access to several residential properties. Since the communities of Hardrock and MacLeod will be displaced by the Project, both Hardrock Road and Sunset Drive, along with smaller roads within the existing communities, will be removed for the construction of the Project. No external access or existing connections or intersections are being considered for these roads in relation to the design of the Highway 11 realignment. Other roads in the area include Lahtis Road and Goldfield Road, and these will not be affected by the realignment.

The detailed evaluation of Highway 11 realignment alternatives, including consideration of the components of the environment is found in Appendix G4. A summary comparison is provided in Table 4-16. The Highway 11 realignment alternatives that were considered in the comparative analysis are identified on Figure 4-7.



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Revised: 2017-06-01 By: dharvey

Stantec

Legend

- Open Pit
- 500m Safety Limit
- Highway
- Major Road
- Local Road
- Watercourse- Permanent
- Watercourse- Intermittent
- Waterbody
- Wetland (Eco-site Based)
- Wooded Area

Highway Route Options

- Option-1A
- Option-1B
- Option-1D
- Option-1D (Optimized)
- Other Alternative Options

Notes

1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.

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Client/Project

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
4-7

Title

Highway 11 Alignment Alternatives

Table 4-16: Summary of Highway 11 Realignment Analysis

Key Differentiating Factors	Route 1A	Route 1B	Route 1D	Route 1D (optimized)
Acoustic Environment	**Disadvantage -** Change in acoustic environment expected from the increase in traffic and vehicle and equipment use during construction. The route is located closer to existing receptors so would be expected to have a greater effect.	**Advantage -** Change in acoustic environment expected from the increase in traffic and vehicle and equipment use during construction. The route is located comparatively further from existing receptors.	**Advantage -** Change in acoustic environment expected from the increase in traffic and vehicle and equipment use during construction. The route is located comparatively further from existing receptors.	**Advantage -** Change in acoustic environment expected from the increase in traffic and vehicle and equipment use during construction. The route is located comparatively further from existing receptors.
Surface Water	**Disadvantage -** Potential change in surface water quality in six watercourses and two lakes.	**Advantage -** Potential change in surface water quality in five watercourses and two lakes.	**Advantage -** Potential change in surface water quality in four watercourses and two lakes.	**Advantage -** Potential change in surface water quality in four watercourses and two lakes.
Fish and Fish Habitat	**Major Disadvantage -** Higher overall effect on fish habitat as up to six watercourse crossings are required.	**Advantage -** Lower effect on fish habitat as up to four watercourse crossings are required.	**Advantage -** Lower effect on fish habitat as up to four watercourse crossings are required.	**Advantage -** Lower effect on fish habitat as up to four watercourse crossings are required.
Vegetation Communities	**Major Disadvantage -** Most vegetation and wetland removal required for this route.	**Disadvantage -** More vegetation and wetland removal required for this route.	**Advantage -** The least amount of vegetation and wetland removal required for this route.	**Disadvantage -** More vegetation and wetland removal required for this route than Option 1D, but less than 1A and relatively comparable to 1B.
Wildlife and Wildlife Habitat	**Major Disadvantage -** Most habitat removal (236 ha).	**Advantage -** Less habitat removal (180 ha) required for this route than Route 1A.	**Major Advantage -** Least habitat removal (154 ha) required for this route.	**Advantage -** Less habitat removal (178 ha) required for this route than Route 1A.
Operational Health and Safety	**Disadvantage -** No effect on the health and safety of mine workers or local residents expected; however, the route	**Disadvantage -** No effect on the health and safety of mine workers or local residents expected;	**Advantage -** Improved health and safety of local residents compared to other alternatives	**Major Advantage -** Improved health and safety of local residents compared to other alternatives because although

Table 4-16: Summary of Highway 11 Realignment Analysis

Key Differentiating Factors	Route 1A	Route 1B	Route 1D	Route 1D (optimized)
	has less ideal highway geometry.	however, the route has less ideal highway geometry.	because the route provides improved highway geometry to address safety issues.	the alignment is closer to the Project, it provides optimal alignment to address traffic safety issues.
Cost	**Disadvantage -** higher capital cost to construct.	**Advantage -** Provides a comparatively lower cost to construct.	**Advantage -** Provides a comparatively lower cost to construct.	**Advantage -** Provides a comparatively lower cost to construct.
Technical Feasibility	**Major Disadvantage -** Provides an alignment that only meets MTO's minimum design standards, and has the highest construction complexity.	**Disadvantage -** Provides an alignment that only meets MTO's minimum design standards, and comparatively lower construction complexity.	**Advantage -** Provides improved alignment geometry that exceeds the minimum design requirements, and comparatively lower construction complexity.	**Major Advantage -** Provides the preferred alignment geometry for MTO that exceeds the minimum design requirements and addresses safety issues, and comparatively lower construction complexity.
TLRU	**Disadvantage -** Potential to disrupt a higher number of LLFN hunting sites/areas/cabins, MNO cultural sites, and EFN subsistence areas compared to the other routes.	**Advantage -** Less potential to disrupt LLFN hunting sites, MNO cultural sites, and EFN subsistence areas compared to Route 1A.	**Advantage -** Less potential to disrupt LLFN hunting sites, MNO cultural sites, and EFN subsistence areas compared to Route 1A.	**Advantage -** Less potential to disrupt LLFN hunting sites, MNO cultural sites, and EFN subsistence areas compared to Route 1A.
LRU	**Disadvantage -** The route has the most crossings of linear LRU features.	**Advantage -** The route has fewer crossings of linear LRU features than Route 1A.	**Advantage -** The route has fewer crossings of linear LRU features than Route 1A.	**Advantage -** The route has fewer crossings of linear LRU features than Route 1A.
OVERALL	**NOT PREFERRED**	**NOT PREFERRED**	**NOT PREFERRED**	**PREFERRED**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Groundwater
- Community Services and Infrastructure
- Labour and Economy
- Heritage Resources

Preferred Alternative

The new Highway 11 route (Route 1D [optimized]) will bypass the PDA to the north, with a new intersection with Michael Power Boulevard and therefore will continue to provide access to Geraldton. The horizontal alignment for the proposed Highway 11 realignment conforms to a 110 km/h design speed in accordance with the Geometric Design Standards for Ontario Highways. The realignment has been designed to provide a 90° intersection on tangent with Michael Power Boulevard. Due to environmental constraints, Kenogamisis Golf Club, safety limit around the open pit and highway geometric standards, approximately 600 m of Michael Power Boulevard will be realigned to achieve the 90° crossing. The section of Michael Power Boulevard being realigned will be designed using a design speed of 80 km/h.

4.2.7 Historical Tailings and Other Contaminated Soils

The following alternatives were considered for historical tailings and other contaminated soils as part of the initial screening:

- Historical Tailings within the PDA:
  - no removal of existing tailings
  - removal of existing tailings where required to facilitate construction
  - complete removal of existing tailings within the PDA
- Contaminated Soils within the PDA:
  - manage on site or remove for management as required
  - leave in place

The initial screening identified that the preferred alternative for historical tailings within the PDA was removal of existing tailings where required to facilitate construction, and the preferred alternative for contaminated soils within the PDA was management on site or removal for management as required. The rationale for considering alternative methods related to historical tailings and other contaminated soils, and the results of the analysis, are described below.

4.2.7.1 Historical Tailings

Tailings from historical mining activities are present within the PDA, and have been characterized through detailed geotechnical investigations. The historical MacLeod high tailings are located northeast of the existing intersection of Highway 11 and Michael Power Boulevard, and the historical Hardrock tailings are located south of the Hardrock Townsite. These areas may present challenges in development of the Project related to geotechnical and environmental issues from disturbance to existing tailings, and stability issues when constructing on loose tailings material. Historical tailings also contribute to elevated concentrations of metals (particularly arsenic) in Kenogamisis Lake.

Excavation of a portion of historical MacLeod and Hardrock tailings will be required for the development of the Project, thus leaving all historical tailings in place is not a viable option. Given the location of the open pit, it would not be feasible to entirely avoid removal of the existing tailings. Targeted removal of the tailings, based on geotechnical design constraints, provides the only economical alternative to manage the area that will be disturbed, and provides the opportunity to safely manage this material in the proposed TMF for the greatest efficiency and environmental protection. This option has been pursued with a focus on environmental benefits, and the option presents an opportunity to provide a net positive impact on Kenogamisis Lake by removing or rehabilitating tailings within the PDA to reduce metal loadings (primarily arsenic) from historical sources to Kenogamisis Lake.

Complete removal of all the historical MacLeod and Hardrock tailings within the PDA is not economically viable due to the volume of material to excavate and truck to the TMF and the timing of Project activities. The safe removal of historical MacLeod and Hardrock tailings requires the construction of the TMF and approximately 2 m of new tailings to be in place to act a base layer, which will only be achieved by approximately Year 2 of operation. In addition, as discussed in Section 4.2.6, since the realignment of Highway 11 must be complete prior to construction of the TMF, it will not be possible to remove the historical MacLeod tailings located under the new Highway 11 route. Due to the need to realign Highway 11 prior to operation it is not feasible or economic to remove all historical MacLeod tailings. Specific design considerations for WRSAs and highway realignment will be considered to address the long-term management of remaining historical MacLeod and Hardrock tailings.

The initial screening identified that the only feasible alternative to manage historical MacLeod and Hardrock tailings was site-specific management where feasible and economically viable. This presents a strong balance of realizing environmental benefits through rehabilitation activities, while maintaining technical and economic feasibility. As a result of the initial screening, a comparative analysis was not required.

4.2.7.2 Contaminated Soils

In addition to historical mine activity and tailings, some other sites within the PDA were identified as having soil potentially impacted from past activities. Historical and current activities that have or could have affected soil quality include:

- the former MacLeod Landfill Site, situated to the west of the historical MacLeod high tailings
- two properties at the intersection of Highway 11 and Michael Power Boulevard (i.e., Dan's General Store and Larry's ESSO) have been identified as being contaminated by petroleum hydrocarbons as a result of current or former use as retail gas stations
- the existing Ministry of Transportation (MTO) Patrol Yard situated between Highway 11 and Barton Bay (East) to the east of the historical MacLeod high tailings

It has been confirmed through baseline studies that contaminated soils will be disturbed and removed through Project construction, and therefore management will be required; the option of leaving the material in place is not viable. A Soil Management Plan will be developed to manage contaminated soils in accordance with applicable regulatory requirements, either onsite or offsite. A Conceptual Soil Management Plan is provided in Appendix M9.

The initial screening identified that the only alternative for managing contaminated soil was a combination of onsite or offsite management as required. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternatives – Historical Tailings and Other Contaminated Soils

Areas of soil materials exceeding management criteria defined for the Project will require removal to complete site preparation for the installation of various Project components and excavation of the open pit. These areas include removal of a portion of the historical MacLeod and Hardrock tailings, and excavation of other soils in the PDA, including soils associated with the historical MacLeod and Hardrock plant sites and other land uses such as the gas station properties.

Soil exceeding applicable criteria may be managed through a combination of onsite management or offsite disposal at an approved facility in accordance with the applicable sections of the *Environmental Protection Act* and *Ontario Regulation 347: General – Waste Management*.

4.2.8 Aggregate Sources

The following alternatives were considered for aggregate sources as part of the initial screening and comparative analysis:

- Aggregate Sources:
  - use existing quarries or pits

- use mined waste rock for crushed aggregate production
- create new aggregate sources

Aggregate will be required for the construction of numerous Project components, including construction and maintenance needs for roads, pads, TMF filter zones, and other Project facilities. Alternative aggregate sourcing methods include using existing quarries, using mined waste rock, or creating new aggregate sources.

The comparative analysis confirmed that no one option could adequately meet the various materials for the Project and therefore the preferred alternative for aggregate material was a combination of existing quarries or pits, the use of mined waste rock, and the use of new aggregate sources. These three alternatives were considered for aggregate sources in the comparative analysis as outlined in Appendix G5, and the results are described below.

The key assumptions used to compare aggregate source alternatives are summarized in Table 4-17.

Table 4-17: Aggregate Sources Design Assumptions

Use Existing Quarries and/or Pits	Use Mined Waste Rock	Create New Aggregate Sources
• Use of existing aggregate sources currently established and in operation, but increased activity may be expected to supply the Project. • Sites would be selected as close as possible to the PDA to reduce travel times. • Sites are being operated in accordance with regulatory requirements, including the application of appropriate mitigation measures to manage environmental effects.	• No facilities required, as waste rock would be handled as part of operation. • Mitigation measures will be applied for the overall Project to control environmental effects and meet regulatory standards.	• Aggregate source development would require vegetation clearing and excavation • Aggregate sources would be located in close proximity to or within the PDA to reduce haul times, improve efficiency and reduce footprint and emissions. • Sites would meet regulatory requirements and operate based on industry standard mitigation measures to manage effects on the environment.

Using waste rock presents a number of advantages, including operational efficiency, reduced cost, and the ability to limit effects outside the PDA. Only NAG waste rock would be considered for this application to avoid environmental effects. Although waste rock may be suitable for some construction needs, crushed rock is not the only aggregate required for the construction of Project components. For instance, till sources will also be required for tailings dam construction, therefore waste rock is not considered viable as a sole source of aggregate, and will need to be supplemented with additional sources.

The advantages of using existing quarries include limiting the potential for environmental effects by using existing sites (although increased extraction activity to meet Project demands may increase emissions and noise/vibration from equipment use), and providing government revenue through licensing fees. The disadvantages include the risk that the necessary amount of construction material will not be available to fulfil Project needs, and increased offsite road traffic for hauling.

By siting and establishing aggregate sources specific to the Project, the advantages include the ability to select specific material needs. This alternative will also provide government revenue through licensing fees. The disadvantages include increased potential environmental effects on vegetation, wetlands and wildlife to establish new aggregate sources and access routes, a potential for increased noise on nearby receptors depending on locations, increased traffic for hauling, potential effects on LRU and TLRU, and higher costs to establish new aggregate sources.

The preferred alternative for aggregate material is to make use of a combination of the three sources: use existing quarries and/or pits, use waste rock, and create new quarries and/or pits. The combination of these alternatives will result in the most cost-effective option that will provide the flexibility needed to supply the materials required for the Project. Existing sites and waste rock are not anticipated to provide the required amount of material, but the use of these sources will limit the need for establishing new aggregate sources. By sourcing material locally from a combination of new and existing sites and waste rock, potential effects on the environment can also be reduced by eliminating the need for hauling of material over longer distances and public roads.

The detailed evaluation of aggregate sources, including consideration of the components of the environment is found in Appendix G5. A summary comparison is provided in Table 4-18. The aggregate sources identified for the Project are identified on Figure 4-5.

Table 4-18: Summary of Aggregate Sources Analysis

Key Differentiating Factors	Use Existing Quarries and/or Pits	Use Mined Waste Rock	Create New Aggregate Sources
Atmospheric Environment	**Disadvantage -** Increased atmospheric environment effects from increased extraction activity, depending on volumes taken from existing sites. The overall effect would be comparable whether new or existing sites are used, since the aggregate quantity required does not change.	**Advantage -** Limited incremental atmospheric environment effects since extraction will occur as part of normal operation.	**Disadvantage -** Increase in emissions from the establishment and operation of new sites, depending on volumes taken from new sites. The overall effect would be comparable whether new or existing sites are used, since the aggregate quantity required does not change.

Table 4-18: Summary of Aggregate Sources Analysis

Key Differentiating Factors	Use Existing Quarries and/or Pits	Use Mined Waste Rock	Create New Aggregate Sources
Acoustic Environment	**Disadvantage -** Increased noise and vibration effects from increased extraction activity, depending on volumes taken from existing sites. The overall effect would be comparable whether new or existing sites are used, since the aggregate quantity required does not change.	**Advantage -** No net increase to the acoustic environment is expected, since waste rock removal will be required to establish the open pit and noise will be appropriately mitigated.	**Disadvantage -** Increase in noise and vibration from the establishment and operation of new sites, depending on volumes taken from new sites. The overall effect would be comparable whether new or existing sites are used, since the aggregate quantity required does not change.
Groundwater	**Advantage -** No additional effects on groundwater are expected from existing aggregate sources, since these sources are already established to operate in a manner that manages effects on groundwater to meet regulatory requirements. No excavation of aggregate sources is planned below the water table.	**Advantage –** Provided only NAG waste rock is used, no effects on groundwater are expected since waste rock would already be extracted as part of normal open pit operation.	**Disadvantage -** Potential need to manage groundwater effects if aggregate sources are located below the water table.
Vegetation Communities	**Advantage -** No effects vegetation communities expected because obtaining aggregate from existing sources will not require additional vegetation clearing.	**Advantage -** No effects on vegetation communities are expected, since activities will be limited to the PDA.	**Disadvantage -** Effects on vegetation communities expected from vegetation clearing for aggregate sources and access.
Wildlife and Wildlife Habitat	**Disadvantage -** Potential minimal increase in mortality risk from increased truck traffic. No effects on wildlife movement or wildlife habitat are expected since aggregate sources are already established.	**Advantage -** No additional effects on wildlife or wildlife habitat are expected, since activities will be limited to the PDA and will not result in additional barriers across wildlife movement corridors, mortality of wildlife or the alteration of habitat.	**Disadvantage -** Potential minimal increase in mortality risk from increased truck traffic. Potential effect on wildlife movement by creating new barriers across wildlife movement corridors and loss of habitat.

Table 4-18: Summary of Aggregate Sources Analysis

Key Differentiating Factors	Use Existing Quarries and/or Pits	Use Mined Waste Rock	Create New Aggregate Sources
Operational Health and Safety	**Disadvantage -** The use of existing aggregate sources may result in increased traffic which creates an increased safety risk for local residents.	**Advantage -** No effects on health and safety expected because the Project will be designed in consideration of avoiding health and safety risks for mine workers and in consideration of providing a safe environment for local residents outside the PDA.	**Advantage -** The use of new aggregate sources may result in increased traffic, but this would be restricted to site roads within the PDA.
Cost	**Disadvantage -** No construction cost to establish aggregate sources since sites and access are already in place, but additional cost to expand sources may be required. Potentially higher operation costs from third-party fees.	**Advantage -** No construction cost to establish aggregate sources since access is already in place. Limited operational cost. Reduces closure costs of outside sources.	**Disadvantage -** Highest construction cost to establish new aggregate sources, but lower operation costs.
Labour and Economy	**Advantage -** Potential business opportunities and increased government revenue from the annual licence/permit fees and royalties paid to the Aggregate Resources Trust.	**Disadvantage -** No effect on labour or economy as there would be no business or employment opportunities or licence/permit fees and royalties for an aggregate source paid to the government.	**Advantage -** Potential employment opportunities and increased government revenue from the annual licence/permit fees and royalties paid to the Aggregate Resources Trust.
Technical Feasibility	**Major Disadvantage -** May not meet Project needs for aggregate.	**Major Disadvantage -** May not meet Project needs for aggregate.	**Major Advantage -** Provides the greatest flexibility in having adequate aggregate sources to meet the Project needs.
TLRU	**Advantage -** No effects on TLRU are anticipated because existing aggregate sources are already established, and will not result in additional restrictions on the use of cultural or spiritual sites or traditional land use areas.	**Advantage -** No effects on TLRU are anticipated because the use of mined waste rock will be localized to the PDA, waste rock removal is already planned as part of the Project, and will not result in additional effects on TLRU.	**Disadvantage -** The establishment of new aggregate sources may affect the use of or access to cultural or spiritual sites or traditional land use areas.

Table 4-18: Summary of Aggregate Sources Analysis

Key Differentiating Factors	Use Existing Quarries and/or Pits	Use Mined Waste Rock	Create New Aggregate Sources
LRU	**Advantage -** No effects on LRU are anticipated because existing aggregate sources are already established and will not result in additional access restrictions to recreational or commercially-based LRU areas or navigation.	**Advantage -** No effects on LRU are anticipated because the use of mined waste rock will be restricted to the PDA. Waste rock removal is already planned as part of the Project, and will not result in additional access restrictions to recreational or commercially-based LRU areas or navigation.	**Disadvantage -** Potential effect on LRU because the establishment of new aggregate sources may result in access restrictions or removal of LRU areas.
OVERALL	**PREFERRED - In Combination** (provides advantages, but limited technical feasibility)	**PREFERRED - In Combination** (provides advantages, but limited technical feasibility)	**PREFERRED - In Combination** (higher potential for environmental effects, but provides the necessary technical flexibility to supplement the other options)

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Surface Water
- Fish and Fish Habitat
- Community Services and Infrastructure
- Heritage Resources

Preferred Alternative

The preferred alternative for aggregate material will be to make use of a combination of the three sources: use existing quarries and/or pits, waste rock, and create new aggregate sources. Aggregate sources will be developed to provide a local aggregate source for construction and maintenance of roads and pads, and other facilities as needed. Specific locations for new aggregate sources have been identified (refer to Figure 5-2), and these are assessed in more detail as part of the environmental effects assessment in Chapters 7.0 through 19.0 as relevant.

4.2.9 Contact Water Collection, Treatment and Discharge

The following alternatives were considered for contact water collection, treatment and discharge as part of the initial screening:

- Open Pit Contact Water:
  - open pit contact water directed to historical underground workings for storage and dewatering through conventional sump dewatering
  - open pit contact water pumped directly to surface ponds for treatment
- WRSA and Process Plant Contact Water:
  - collect runoff locally and treat through central collection ponds and ditches and/or ETP prior to discharge
  - direct surface runoff to historical underground workings
  - runoff directed to TMF for storage and management

The initial screening identified that the preferred alternative for open pit contact water was storage and dewatering through the historical underground workings, and the preferred alternative for WRSA and process plant contact water was collection through ponds and ditches and an ETP. The rationale for considering alternative methods related to the contact water collection, treatment and discharge, and the results of the analysis are described below.

4.2.9.1 Open Pit Contact Water

Water that will accumulate in the open pit due to groundwater inflow, direct precipitation, and runoff will need to be managed throughout the LOM. Standard industry practice typically involves collecting contact water in mine sumps to remove suspended solids and pumping of the water to surface where it is managed in a contact water collection pond for additional treatment as required prior to discharge.

In addition to the open pit, dewatering of the historical underground workings will also be required for the Project as the open pit will intersect the historical underground workings at various stages of open pit development. Without dewatering, uncontrolled inflows to the open pit will occur as the open pit is excavated and when the historical underground workings are encountered. The preferred alternative for dewatering is to dewater from the historical underground workings, with water that accumulates within the open pit directed to the historical underground workings through drainage shafts bored through the open pit floor. This option provides the added benefit of using the historical underground workings for temporary storage of water during periods of peak precipitation and runoff and will help to reduce peak flows requiring treatment prior to discharge.

It is expected that open pit dewatering will generate excess water volume that will not be needed for processing, so a portion will require treatment and discharge to the environment. Depending on water quality, this water may be either sent directly to the ETP, or discharged to pond M1 and then to the receiving environment.

The initial screening identified that the most effective alternative for the open pit dewatering was directing open pit inflow to the historical underground workings and dewatering through conventional sump methods from existing or new shafts connecting to the historical underground workings. As a result of the initial screening, a comparative analysis was not required.

4.2.9.2 Waste Rock Storage Area and Process Plant Contact Water

Contact water (which includes precipitation, groundwater, or surface water that comes in contact with Project components including the WRSAs, overburden storage areas, process plant and ore stockpile) will need to be managed throughout the LOM. Standard industry practice typically involves collecting contact water in mine sumps to remove suspended solids and then sending it to surface ponds for additional settling and treatment as required.

In contrast, it was determined that the volumes of water expected to accumulate from contact water could not be feasibly managed in the historical underground workings due to pumping requirements, so directing this water to locally sited surface ponds and then through an ETP, as needed, was selected. This presents the most efficient and cost effective means of treating the runoff. Directing contact water to the TMF was not considered feasible, as this option would require a complicated continuous pumping system, resulting in additional costs and reduced efficiency, with increased reliance on the TMF to manage water and no environmental benefit.

Alternative treatment approaches for the ETP were also considered, with a focus on selecting a feasible technology to remove metals (including arsenic) and total suspended solids (TSS). Coagulation and filtration was selected as the preferred treatment method, as this alternative provides effective and proven metals and TSS removal, and the alternative provides cost-effective and flexible technology to enhance arsenic removal and meet the treatment needs of the Project. This is a proven technology that is typically used for similar mine sites, and use of iron-based adsorptive media (the type of media proposed for this Project through the use of ferric sulphate) is considered the standard in arsenic removal.

A number of other technologies were also considered as described below. Membrane technology using reverse osmosis was screened out from further analysis, as it requires increased operational costs for pumping and membrane maintenance, produces additional brine waste that would need to be managed, requires specialized training and continuous monitoring and maintenance, and may require additional pre-treatment to remove metals that would foul the membranes. Ion exchange technology was screened out, as it creates a liquid waste with a high concentration of arsenic, sodium hydroxide and sodium chloride, resulting in additional waste management considerations. Chemical treatment through lime precipitation was screened out because it is considered not applicable because arsenic concentrations are not expected to reach concentrations in raw water where lime precipitation would be effective. Biological treatment through the use of sulphate reducing bacteria to precipitate arsenic and heavy metals was screened out due to a number of design constraints, including the need to maintain a nutrient feed and four- to eight-hour residence time, the requirement for a large holding tank, and reduced biological reaction rates over the winter months that would limit treatment effectiveness. An engineered wetland was also screened out, due to the relatively high flow rates of the Project. In addition, it would be difficult to site a single wetland within the limited PDA, and managing multiple smaller wetlands within the PDA would increase operational complexity.

Details on the preferred coagulation and filtration treatment process will be refined during permitting, however GGM has discussed the conceptual treatment system with the MOECC, and the MOECC confirmed that it is acceptable for the purpose of completing the Final EIS/EA.

The Assimilative Capacity TDR (Appendix F6) was prepared separately from this alternatives assessment, to consider potential discharge locations for treated effluent discharge during operation.

Multiple versus a single treated effluent discharge locations were considered to accommodate different effluent treatment processes or infrastructure and different areas of the PDA where water management and treatment may be required. Multiple discharge locations can result in increased complexity in water management, increased disturbance from additional infrastructure construction requirements and discharge to multiple receivers, and increased capital and operating expenses for construction, facility operation and compliance monitoring as well as closure costs.

To balance environmental concerns, operational functionality and economic feasibility, and to reduce potential effects on the aquatic ecosystems, treated effluent discharge locations that would allow centralized water management and a single point of discharge were given preference.

Based on the PDA and water management requirements, potential treated effluent discharge locations considered in the assessment included: Southwest Arm Tributary, Mosher Lake, Barton Bay, Southwest Arm, and Central Basin of Kenogamisis Lake. Seven criteria were identified for the evaluation of discharge locations:

- Catchment Area
- Proximity to ETP
- Mixing Potential
- Effect on Water Uses
- LRU and TLRU
- Proximity to Potable Water Supplies

- Policy 1 or 2 Receiver

A qualitative scoring system was developed to rank potential treated effluent discharge locations based on these criteria. A score of 1 to 3 was assigned to each treated effluent discharge location (i.e., receiving watercourse/ waterbody) based on its condition with regard to the evaluation criteria. A score of 3 corresponds to the best possible score (i.e., advantage) and a score of 1 corresponds to the lowest possible score (i.e., disadvantage). Scores for all the criteria for each alternative were added up and resulted in an overall score for comparison. The highest score represents the preference for treated effluent discharge location. The selection matrix which summarizes the scoring evaluation is presented in Table 4-19 below.

The highest overall score for the evaluated receivers was the Southwest Arm of Kenogamisis Lake. The Southwest Arm of Kenogamisis Lake received the highest scores for each criterion, with the exception of LRU and TRLU, where it scored as a disadvantage equally with the other locations, based on the use of the area for fishing. Based on information collected during consultation, the Southwest Arm, Central Basin, and Outlet Basin of Kenogamisis Lake, Mosher Lake, and the Southwest Arm Tributary have all been identified as areas used by Aboriginal communities for traditional uses or access. Other land and resource uses (that may also include participation by Aboriginal community members) include sport fishing, a public beach and boat launch on Barton Bay and at MacLeod Provincial Park located on the Central Basin, and recreational boating and canoeing along the waterways.

However, the LRU and TLRU criterion is representative of the sensitivity of the receiver from a LRU and TLRU perspective, but it does not specifically measure the potential for effects. A combination of highest scores in other criteria demonstrates that despite the importance of the Southwest Arm of Kenogamisis Lake from a LRU and TLRU perspective, the potential for adverse effects on Aboriginal or other resource uses is expected to be low. The high scores in the Catchment Area and Mixing Potential criteria `demonstrate that the large mixing area, higher flow/volume and lower background levels of parameters of potential concern in the Southwest Arm will result in treated effluent being readily assimilated in the water body and a low potential for exceedances of regulatory standards. The high score in the Effect on Water Uses criterion demonstrates that the treated effluent discharge can be located to avoid fish spawning or rearing areas and reduce effects on navigation and lake use. It should also be noted that based on information collected during consultation, the southern section of the Southwest Arm of Kenogamisis Lake is most often used for fishing, while the PDA is located in the northern portion of the lake (so that a discharge close to the PDA can be expected to avoid high use areas). Based on these considerations, there is limited potential for a treated effluent discharge location in the Southwest Arm to affect LRU and TLRU.

Due to centralized water management focused on pond M1 and the ETP, a single point treated effluent discharge location in the Southwest Arm of Kenogamisis Lake is preferred.

Table 4-19: Effluent Discharge Location Scoring

Water body	Criteria								Overall
	Catchment Area	Proximity to ETP	Mixing Potential	Effect on Water Users	LRU / TLRU	Proximity to Potable Water Supplies	Policy 1 or 2 Receiver	Overall Score	
Mosher Lake	1	2	1	1	1	2	1	9	Not Preferred
Southwest Arm	3	3	3	2	1	2	3	17	Preferred
Barton Bay	2	1	2	2	1	1	1	10	Not Preferred
Central Basin	3	1	2	2	1	1	1	11	Not Preferred
Southwest Arm Tributary	1	3	1	2	1	2	1	11	Not Preferred

Following the determination of the preferred receiver, the exact location of the treated effluent discharge location was determined in consideration of proximity to shore (i.e., close enough for inspection and maintenance, but far enough to limit effects on fish and conflicts with navigation or other recreational uses), water depth (preferably deeper to augment mixing and limit bottom scour/resuspension), flow pattern (because higher velocities promote mixing) and aquatic resources (i.e., avoidance of sensitive fish spawning and feeding areas). Based on these considerations, the treated effluent discharge point is proposed south of the mouth of the Southwest Arm Tributary and approximately 100 m offshore.

The preferred treated effluent discharge location for the co-discharge of treated sewage treatment plant and ETP discharge is identified on Figure 4-5. The exact location of the treated effluent discharge will be defined as design progresses, based on proximity to shore, water depth and flow pattern. Further details of this analysis can be found in the Assimilative Capacity TDR (Appendix F6).

The initial screening identified that the only feasible alternative for contact water management was to direct contact water to a series of collection ditches and ponds with water ultimately pumped or gravity fed to a central contact water management pond (pond M1). Pond M1 will be used to provide water for mill demand with excess water discharged to the Southwest Arm of Kenogamisis Lake following appropriate treatment as required. As a result of the initial screening, a comparative analysis was not required. The specific locations of collection ponds will be confirmed with ongoing Project planning and engineering design and will align with topographic low points within the PDA.

Preferred Alternative

Open pit dewatering will be directed to the historical underground workings to provide a secondary supply reservoir for mill demand, and additional sedimentation. Water from the dewatering will be used to meet deficits in reclaim water demands for the mill demand with excess water discharged to the Southwest Arm of Kenogamisis Lake following appropriate treatment as required.

Contact water, including surface runoff and seepage, will be collected in collection ditches and directed to a series of collection ponds that convey water ultimately to pond M1, the central contact water collection pond. Water from pond M1will be used to meet mill demand with excess water discharged to the Southwest Arm of Kenogamisis Lake following appropriate treatment through coagulation and filtration in the ETP.

The rationale for the selection of the treated effluent discharge location and proposed effluent discharge criteria are detailed in the Assimilative Capacity TDR (Appendix F6).

4.2.10 Sewage Treatment Facility for the Mine Site

The following alternatives were considered for the sewage treatment facility for the mine site as part of the initial screening:

- Sewage Treatment Method:
  - sewage treatment plant with surface water discharge
  - septic tank(s) and tile field(s)
  - lagoons
  - connection to the municipal system
  - trucking domestic sewage offsite to a licensed treatment plant

Note that sewage treatment for the temporary camp is considered separately under Section 4.2.16.4.

The initial screening identified that the preferred alternative for the sewage treatment facility for the mine site was a sewage treatment plant with surface water discharge. The rationale for considering alternative methods related to the sewage treatment facility, and the results of the analysis are described below.

Based on current projections, there will be a need to accommodate an average of 300 persons at the mine site, with a total estimated sewage flow of 75,000 L/d. This effluent will need to be effectively treated and discharged to meet regulatory standards.

Offsite sewage treatment methods were considered not feasible, because it has been confirmed that connection to the Geraldton municipal system is not technically or financially feasible, and trucking the sewage would result in increased costs and environmental effects from trucking.

Connection to the municipal system would need to link with the process plant, which is located in the southern area of the PDA. Whereas residences in the Hardrock and MacLeod townsites already have a municipal water connection, no such sewage infrastructure exists (residences rely on septic or trucked sewage). This would require carrying a sanitary sewer line along Michael Power Boulevard and through the PDA (over 2 km in length).

Connection to the process plant would also be complicated by the need to navigate through or past Project components, avoiding conflicts with other Project infrastructure, WRSAs and the open pit, which is not technically feasible. Since the process plant location was determined based on operational requirements of the Project (and considered in the design for the TMF), relocating the process plant for the sole purpose of facilitating a sewage connection would not be viable.

This alternative is not technically or financially feasible, when compared against the lower costs and comparable potential for environmental effects of an onsite sewage treatment plant.

Septic tanks combined with tile fields generally provide a low-cost option once installed, however they also require a larger footprint resulting in increased effects to surrounding natural features, and they must be sited to avoid watercourses and other sensitive features. Due to the constrained nature of the PDA, including the number of nearby watercourses, lakes and wetlands, and high water table conditions, siting and constructing a septic tank(s) and field(s) is not considered technically feasible.

Similarly, lagoons offer a cost-effective solution once installed, but they require large areas of land and may be subject to increased odour effects. These types of facilities are generally more effective when used in areas where temperatures do not drop below freezing, to promote biological oxidation. Like the septic alternative, lagoons present challenges related to siting given the numerous local constraints, constructability concerns due to the permeable soil conditions, and operational disadvantages related to odour management. Lagoons were therefore not considered technically feasible.

A sewage treatment plant with a surface water discharge was confirmed to be the preferred alternative to treat sewage from the mine site, as this provides a compact and reliable technology with the highest quality effluent (comparable to municipal treatment) and greatest reliability, with the smallest footprint. The sewage treatment plant will cost effectively manage the sewage volumes while limiting the potential for environmental effects.

As referenced in Section 4.2.9, an assimilative capacity study confirmed that the location for the co-discharge of treated effluent would be in the Southwest Arm of Kenogamisis Lake (Assimilative Capacity TDR, Appendix F6) as identified on Figure 4-5.

The initial screening identified that the only feasible alternative for sewage treatment was the use of a sewage treatment plant. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

A sewage treatment plant with surface water discharge will be required for the mine site. A sewage treatment plant will be constructed near the truckshop, warehouse and offices and will serve the offices and mine dry buildings as well as the process plant. The system will be sized to handle 300 persons at any given time with effluent treated to meet regulatory requirements and co-discharged with the treated ETP effluent to the Southwest Arm of Kenogamisis Lake.

4.2.11 Potable Water Supply

The following alternatives were considered for the potable water supply as part of the comparative analysis:

- Potable Water Supply:
  - groundwater wells
  - surface water
  - Geraldton municipal potable water system

A water supply that can provide approximately 75,000 litres per day for mining personnel working at the Project, for eyewash, safety shower, hand washing, toilets, and drinking water will be required during operation. A water supply and distribution system (including fresh water pumping station and potable water distribution) will need to be developed to meet these needs.

The initial screening identified that the preferred alternative for the potable water supply was connection to the municipal system. Feasible options for the water supply included groundwater wells, surface water sources, and connection to the Geraldton municipal potable water system. These alternatives were considered in the comparative analysis as outlined in Appendix G6, and the results are described below.

The key assumptions used to compare potable water supply alternatives are summarized in Table 4-20.

Table 4-20: Potable Water Supply Design Assumptions

Groundwater Wells	Surface Water	Connect to Geraldton Municipal Supply
• Would require the establishment of a new groundwater supply in the vicinity of the PDA (site not	• Would require the establishment of a new surface water supply in the vicinity of the PDA, sourced from	• Would require the establishment of a new connection to existing water supply infrastructure.

Table 4-20: Potable Water Supply Design Assumptions

Groundwater Wells	Surface Water	Connect to Geraldton Municipal Supply
determined as part of assessment). • Minor surficial disturbance to the landscape to install supply infrastructure. No watercourse crossings anticipated. • Water taking from an appropriate aquifer would lead to effects on groundwater, but would be managed based on regulatory requirements. • Would require site-specific treatment to meet drinking water quality standards. • Standard mitigation measures would limit effects from construction such as erosion and sedimentation.	Kenogamisis Lake to limit the potential for watershed effects. • Minor surficial disturbance to the landscape and shoreline to install supply infrastructure. No watercourse crossings anticipated. • Would require site-specific treatment to meet drinking water quality standards. • Standard mitigation measures would limit effects from construction such as erosion and sedimentation.	• Minor surficial disturbance along existing rights-of-way to install supply infrastructure. No watercourse crossings anticipated. • No site-specific treatment required. • Standard mitigation measures would limit effects from construction such as erosion and sedimentation.

Potable water could be sourced from local rivers or lakes, but this would require appropriate treatment, which presents effectiveness and reliability concerns due to elevated levels of some parameters. Sources would also have to be carefully considered to manage effects on fish habitat and water resources. This would require the establishment of a new water treatment and supply system, which would result in increased capital and operating costs.

Groundwater may offer a suitable supply, and other water users in the area, such as MacLeod Provincial Park, rely on wells for their water supply. However, similar to surface water sources, this alternative presents effectiveness and reliability concerns due to the potential supply capacity requirements and the needs for treatment, particularly related to potentially affected groundwater associated with the historical tailings and new Project components. There would also be increased costs related to the establishment of a new treatment and supply system, and the sourcing and establishment of wells has the potential to affect the local hydrogeology.

Overall, the alternative to connect to the Geraldton municipal supply presents the most advantages, no anticipated increase in the effects on the natural environment, the efficiency of a nearby service connection, increased reliability with no need for additional treatment, and reduced construction and operating costs. This alternative does not present technical, economic or environmental disadvantages compared to the other options.

The detailed evaluation of water supply alternatives, including consideration of the components of the environment is found in Appendix G6. A summary comparison is provided in Table 4-21. The potable water pipeline is identified on Figure 4-5.

Table 4-21: Summary of Potable Water Supply Analysis

Key Differentiating Factors	Groundwater Wells	Surface Water	Connect to Geraldton Municipal Supply
Groundwater	**Disadvantage -** Potential to decrease groundwater quantity and flow from prolonged water taking.	**Advantage -** No effects on groundwater are anticipated because a groundwater resource will not be disturbed or drawn from.	**Advantage -** No effects on groundwater are anticipated because a groundwater resource will not be disturbed or drawn from.
Surface Water	**Advantage -** No effects anticipated because the construction, use and decommissioning of groundwater wells would not interact with surface water features.	**Disadvantage -** Limited potential for localized effects on Kenogamisis Lake flow from water taking.	**Advantage -** No effects anticipated because the construction, use and decommissioning of a connection to the municipal supply would not interact with surface water features.
Fish and Fish Habitat	**Advantage -** No effects on fish or fish habitat are anticipated because the construction and decommissioning of groundwater wells would not interact with fish or fish habitat.	**Disadvantage -** Potential for fish entrainment in intake structures and effects on fish habitat.	**Advantage –** No effects on fish and fish habitat are anticipated because the connection to the municipal supply would not interact with fish or fish habitat.
Cost	**Major Disadvantage -** Higher costs associated with treatment and maintenance.	**Major Disadvantage -** Higher costs associated with treatment and maintenance.	**Major Advantage -** Lowest capital and operating costs.
Labour and Economy	**Disadvantage -** No substantial changes in labour or economy are expected because there will be no change in employment or contribution to the local economy.	**Disadvantage -** No substantial changes in labour or economy are expected because there will be no change in employment or contribution to the local economy.	**Advantage –** The Municipality of Greenstone would receive tax revenue for the use of municipal water.
Technical Feasibility	**Major Disadvantage -** Based on existing water quality and potential localized effects from Project components, it may not be technically feasible to treat groundwater to meet potable water quality requirements.	**Disadvantage** - Although technically feasible to treat surface water to meet potable water quality requirements, potential disadvantage associated with effectiveness and reliability of a treatment system to address drinking water quality exceedances in local surface water.	**Major Advantage -** No additional treatment required to address water quality issues since water will be treated municipally.
OVERALL	**NOT PREFERRED**	**NOT PREFERRED**	**PREFERRED**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Acoustic Environment
- Vegetation Communities
- Wildlife and Wildlife Habitat
- Community Services and Infrastructure
- Operational Health and Safety
- Heritage Resources
- TLRU
- LRU

Preferred Alternative

The mine site will be connected to the Geraldton municipal potable water system. The municipality has confirmed that there is adequate capacity within the existing system to service the mine site's potable water needs. A water distribution system consisting of a 102 mm diameter water pipeline network and interconnection to the municipal supply will be installed.

The historical underground workings will provide fire water to be stored in a dedicated tank on site. Automated fire detection and protection systems will be installed for critical process areas, such as the crushing, grinding and process plant buildings and interconnecting conveyor galleries and tunnels, and certain critical components such as the power plant, warehouses and fuel storage areas. A fire hydrant network will be installed around the perimeter of the Project components and process plant area, with fire hose cabinets installed in administrative buildings and the truck maintenance facility.

4.2.12 Explosives Management

The following alternatives were considered for explosives management as part of the initial screening:

- Explosives Management:
  - manage explosives onsite
  - transport of explosives from existing explosives manufacturing facilities

The initial screening identified that the preferred alternative for explosives manufacturing and storage was onsite management. The rationale for considering alternative methods related to Explosives Management, and the results of the analysis are described below.

Explosives are required for blasting during open pit operation, and potentially a limited quantity during the construction phase. Operation will require a relatively large quantity of explosives on an ongoing basis throughout the LOM.

The explosives will be managed on site, because this provides the most efficient option for producing the required explosives. This also allows relatively inert raw materials to be transported to the open pit safely, instead of transporting explosives long distances from existing facilities. Using an offsite facility to deliver explosives would result in disadvantages related to increased costs, environmental effects and safety risks from the transport of dangerous explosive material over long distances.

Specifications for the facility and the explosives storage and magazines and the locations of these facilities require a permit under the *Explosives Act* and must adhere to NRCan's Quantity-Distance criteria, which specify required distances to features such as roads and buildings.

The initial screening identified that the only feasible alternative for explosives storage and manufacturing was onsite management. As a result of the initial screening, a comparative analysis was not required.

The preferred location for the explosives facility is identified on Figure 4-5.

Preferred Alternative

A new onsite explosives facility for the Project will be required. The explosives facility will store bulk ingredients for producing the emulsion explosives used in blasting activities for the Project. It will also house the required pumps and tanks, truck wash bay, blasting personnel offices, and change rooms. The explosives facility will be equipped to deal with spills of hazardous materials.

Specifications for the explosives facility and the explosives storage magazines and the locations of these facilities must adhere to the *Explosives Act* and regulations as published by the Explosives Regulatory Division of NRCan. The location of the explosives facility is determined by NRCan's Quantity-Distance criteria, which specifies required distances to features such as roads and buildings.

4.2.13 Power Source and Associated Infrastructure

The following alternatives were considered for the power source and associated infrastructure as part of the initial screening and comparative analysis:

- Primary (operation) Power Source:
  - natural gas-fuelled power plant
  - onsite diesel or heavy fuel oil power generation
  - connection to existing grid (with onsite substation)

  - renewable energy (hydroelectric, solar, wind)
- Temporary (construction) / Backup (operation) Power Source:
  - connection to existing grid (44 kV tie-in to existing transmission line)
  - temporary diesel generators

The initial screening identified that the preferred alternative for the primary power source was a natural gas-fuelled power plant. The comparative analysis confirmed that the preferred alternative for the temporary/backup power source was a combination of connection to the existing grid and diesel generators. The rationale for considering alternative methods related to the power source and associated infrastructure, and the results of the analysis are described below.

4.2.13.1 Primary Power Source

Electrical power will be required to operate the Project. At maximum production, approximately 48.5 megawatts of power generation capacity is anticipated to be required for the Project.

The establishment of a natural gas-fuelled power plant was identified as the only feasible alternative to provide power to the Project. Although a distribution line currently runs through the PDA, the existing transmission system does not have the capacity to provide power required for the Project, whereas natural gas can be brought to the PDA via a short new distribution pipeline operated by Union Gas. Connection to the provincial grid would not be possible without provincial action to increase regional capacity. In the event that use of the provincial energy grid becomes feasible in the future, a new substation and 115 kV transmission line may be considered at that time to connect to the provincial electricity grid to obtain or sell power. A natural gas-fuelled power plant also offers greater advantages over diesel generation including reduced emissions, reduced costs, and a less complex fuel distribution system (diesel would need to be trucked in regularly).

The primary disadvantages of a natural gas-fuelled power plant include higher capital and operating costs, but these are offset by the greater advantages of reduced environmental effects. The selection of natural gas power plant for the Project's operational energy requirements provides an efficient low emissions energy source and an advantage with respect to GHG mitigation. There is also increased reliability, reduced health and safety risks by limiting truck traffic and fuel transport, and an economical and readily available fuel source. The plant will also increase efficiency by using heat recovered from power generation in process plant processes.

Through discussions with local Aboriginal communities, it was noted that the preference was for the Project be powered from the grid, and GGM agrees that if enough reliable power were present on the grid at a competitive price that this would likely be the preferred approach for the Project. While an operational grid connection is not considered feasible at this time GGM will consider opportunities to coordinate with energy regulators and other interested parties on future initiatives to enhance the provincial electricity supply. The initial screening identified that the only feasible alternative for the primary power source was a natural gas-fuelled power plant. As a result of the initial screening, a comparative analysis was not required.

4.2.13.2 Temporary/Backup Power Source

Options were also considered to provide temporary and backup power to the Project, before the natural gas-fuelled power plant is online and as backup during operation. Alternatives that were considered in the comparative analysis include a tie-in to the existing transmission line and temporary generation through diesel or natural gas generators.

The key assumptions used to compare temporary and backup power alternatives are summarized in Table 4-22.

Table 4-22: Temporary/Backup Power Source Design Assumptions

Temporary 44 kV Tie-in to existing Transmission Line	Temporary Diesel or Natural Gas Generation
• Connection would be installed within the PDA or existing rights-of-way. • Limited surficial disturbance required for transmission line installation.	• Generators would be located within PDA. • Standard mitigation and **emergency response measures would be in place to manage the potential for fuel spills.** • Standard health and safety practices would be implemented to meet regulatory requirements.

A tie-in to the existing transmission line presents advantages related to reduced costs and limited environmental effects. Since there is an existing transmission line running through the open pit that will need to be realigned, connection to this line is readily available and will not require additional vegetation clearing or effects to environmental features. Although the system does not have the capacity to provide power required for Project operation, it does have enough capacity for initial construction activities. The primary disadvantage of this alternative is reliance on the existing power system, which may be susceptible to outages through severe weather events.

Temporary generators, on the other hand, provide a more localized and reliable power supply onsite, with added flexibility for location since there is no need to connect to existing infrastructure. The primary disadvantages of temporary generators include increased environmental effects through emissions and increased costs for construction and for the fuel supply.

It was determined that both alternatives may provide a feasible solution to provide temporary and backup power for the Project with manageable environmental effects, and a combination of the two sources will be considered for increased reliability.

The detailed evaluation of temporary power alternatives for construction, including consideration of the components of the environment is found in Appendix G7. A summary comparison is provided in Table 4-23. The preferred location for the LNG plant (discussed below) and temporary generators are identified on Figure 4-5.

Table 4-23: Summary of Temporary and Backup Power Supply Analysis

Key Differentiating Factors	Temporary 44 kV Tie-in to existing Transmission Line	Temporary Diesel or Natural Gas Generation
Atmospheric Environment	**Advantage -** No substantial effects on the atmospheric environment are expected because emissions from the installation, operation and removal of the transmission line are anticipated to be minor.	**Disadvantage -** Effect on the atmospheric environment expected from the combustion of diesel or natural gas resulting in emissions.
Cost	**Advantage -** Relatively low capital cost based on available tie-in at the Project, and lower operational and maintenance costs.	**Disadvantage -** Higher cost to construct and operational costs for fuel supply.
Technical Feasibility	**Disadvantage -** Storm events could cause unplanned power outages.	**Advantage -** Generators are commonly used at mine sites and have proven to be very reliable.
OVERALL	**PREFERRED - In Combination** (presents the more reliable option for temporary power supply)	**PREFERRED - In Combination** (presents the most reliable option for backup power supply)

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Acoustic Environment
- Groundwater
- Surface Water
- Fish and Fish Habitat
- Vegetation Communities
- Wildlife and Wildlife Habitat
- Community Services and Infrastructure
- Operational Health and Safety
- Labour and Economy
- Heritage Resources
- TLRU
- LRU

Preferred Alternative

Power for the operation phase will be generated onsite by a natural gas-fuelled power plant.

Prior to commissioning of the power plant and during operation for backup power, a grid connection via the local distribution system that currently services the Geraldton area combined with temporary generators will be used.

4.2.14 Waste Management

The following alternatives were considered for waste management as part of the initial screening:

- Non-Hazardous Solid Waste (for material that cannot be recycled):
  - truck non-hazardous waste offsite to licensed disposal facility
  - establish a new landfill for all non-hazardous waste generated by the Project
  - onsite incineration
- Hazardous Waste:
  - truck hazardous waste offsite to licensed disposal facility
  - onsite disposal of hazardous waste

The initial screening identified that the preferred alternatives for non-hazardous solid waste management and hazardous waste management were trucking to an offsite facility. The rationale for considering alternative methods related to waste management, and the results of the analysis are described below.

4.2.14.1 Non-Hazardous Solid Waste

Non-hazardous domestic solid waste will be generated during the construction and operation phases.

The preferred alternative to manage non-hazardous waste is to temporarily store it onsite and regularly transport it by trucks to an offsite licensed facility. This has the advantage of transferring the responsibility for final management of the waste to a separate operator with a facility already designed to manage the potential effects. This alternative will also reduce the environmental issues that need to be managed onsite, such as leachate management and odour control. The primary disadvantages of this alternative include costs for transport and tipping fees, increased traffic along local roads and the resulting emissions.

Although a new landfill dedicated to the Project could be established at a separate site to manage the waste, the disadvantages of this option include increased capital costs, and higher operational complexity and costs associated with safely managing a landfill to provide worker safety and the control of environmental effects. Establishing a new landfill site will result in the need to manage environmental effects such as vegetation clearing, wildlife disruption, and groundwater and surface water contamination. This would also result in increased nuisance effects related to traffic, noise and odour. However, as a mitigation measure to limit waste generation from the Project, opportunities exist to place limited quantities of inert waste material (such as wood waste and concrete) within the WRSAs, subject to necessary environmental approvals.

Use of an incinerator was rejected as being too costly, having operational challenges particularly during winter, resulting in increased air emissions, and difficult to obtain environmental approvals, and therefore not considered further.

The initial screening identified that the only feasible alternative for non-hazardous waste management was trucking wastes to an offsite licensed facility. As a result of the initial screening, a comparative analysis was not required.

4.2.14.2 Hazardous Waste

Fuels, oils and other hazardous wastes associated with the Project will also need to be managed to protect human health, safety and the environment.

Hazardous waste requires specialized facilities for final handling and disposal. This type of waste can be sorted and stored securely onsite temporarily and removed from the PDA to a licensed facility designed to effectively manage hazardous materials.

The initial screening identified that the only feasible alternative for hazardous waste management was removing wastes to an offsite licensed facility. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

Non-hazardous domestic solid waste will be deposited in a suitable offsite landfill with capacity. The Municipality of Greenstone confirmed that the Longlac landfill has capacity to accept anticipated waste volumes from the Project, thus avoiding the need for a dedicated landfill within the PDA. Inert materials may be stored in the WRSAs subject to necessary approvals, including up to 15,000 m^3 of demolition, wood waste, concrete and other inert materials during construction, and 10,000 m^3 of inert waste during closure. Non-hazardous liquid wastes will also be trucked to appropriately licensed disposal facilities.

Hazardous waste will be collected by a licensed contractor and transported by truck for disposal at an approved facility.

4.2.15 Mining Equipment Fuel Type and Source

The following alternatives were considered for the fuel supply, conversion, storage and distribution system as part of the initial screening and comparative analysis:

- Fuel Type for Mining Equipment:
  - full diesel
  - a blend of LNG and diesel
  - full gasoline
- Fuel Source for Mining Equipment:
  - LNG through tanker truck delivery and above-ground storage tank(s)
  - LNG plant
  - diesel through tanker truck delivery and above-ground storage tank(s)

The comparative analysis confirmed that the preferred alternative for fuel type was a blend of LNG and diesel, and the preferred alternative for fuel source was a combination of truck delivery for the short term and use of a LNG plant for the long term. The rationale for considering alternative methods related to mining equipment fuel type and source, and the results of the analysis, are described below.

4.2.15.1 Fuel Type

Fuel will be required for use by heavy equipment and vehicles for the construction and operation of the Project. A readily available and reliable source of fuel will be required to allow for the continuity of Project operation.

Options for both full diesel and a combination of diesel and LNG were considered for fuel type. Small amounts of gasoline will be kept onsite for smaller construction and maintenance equipment, but gasoline is not suitable for heavy industrial machinery, which will make up the bulk of the Project fleet.

The key assumptions used to compare fuel type alternatives are summarized in Table 4-24.

Table 4-24: Fuel Type Design Assumptions

Diesel Fuel	Blended LNG / Diesel Fuel
• Standard mining equipment using diesel as a fuel source would be used for the Project. • No effects on the landscape anticipated, since this relates to equipment type.	• Conversion kits for standard diesel equipment would be used (not currently available for the truck size required for the Project). • No effects on the landscape anticipated, since this relates to equipment type.

Diesel presents a widely used and readily available fuel type for heavy industrial machinery, and has the benefit of lower capital costs to establish the necessary fuelling infrastructure. Diesel could also be sourced relatively locally, providing an economic contribution to the region and the potential to improve community services and infrastructure through local contract sourcing. The primary disadvantage of using full diesel as the fuel supply is related to the higher emissions from diesel combustion over LNG, particularly related to NOx and particulate matter. Also, although the initial capital cost for a diesel supply is lower than LNG, the price of diesel is higher than LNG, and more sensitive to market fluctuations, which increases economic uncertainty.

In general, LNG use in heavy vehicles in combination with diesel results in reduced emissions over full diesel, including related to NOx and particulate matter. The initial capital cost of establishing the necessary infrastructure and acquiring or upgrading vehicles for a combination of diesel and LNG would be higher, but based on the lower price of LNG over diesel, this approach may result in cost reductions over the LOM. The economic benefits of using LNG would be dependent on establishing a LNG plant onsite as a fuel source, since long-term trucking of LNG would not be economically viable, as discussed further in Section 4.2.15.2. The effect of the cost savings for LNG is somewhat reduced since diesel has a higher energy density to LNG (i.e., it would take 1.65 m^3 of LNG to equal the energy output of 1 m^3 of diesel). Technology for blended LNG / diesel use has been trialed successfully for the size class of trucks required for the Project, but conversion kits are not currently commercially available. It is expected that development of the technology will continue and may be commercially available in the future.

A potential secondary opportunity for sourcing LNG for the Project is that it could increase LNG access for local residents and Aboriginal communities, increasing availability and reducing costs to acquire LNG in the region, which currently does not have LNG delivery service. Although not explicitly considered as a component of the project, this may present a secondary benefit in the area should the use of LNG for the Project become feasible in the future.

It was determined that a mix of diesel and LNG could become a viable alternative for fuelling the heavy industrial machinery over the long term. This option reduces the environmental effects of diesel combustion and may offset some of the high capital costs associated with the Project with lower LNG fuel costs. However, the higher capital costs for this alternative may be restrictive and full diesel is proposed until production ramps up and the feasibility of this alternative can be confirmed along with required advancements in technology for the Project fleet.

The detailed evaluation of fuel type alternatives, including consideration of the components of the environment is found in Appendix G8. A summary comparison is provided in Table 4-25.

Table 4-25: Summary of Fuel Type for Mining Equipment Analysis

Key Differentiating Factors	Diesel Fuel Supply	Blended Diesel/LNG Fuel Supply
Atmospheric Environment	**Disadvantage -** Effect on the atmospheric environment expected from the combustion of diesel resulting in emissions.	**Advantage -** Effect on the atmospheric environment expected from the combustion of LNG and diesel resulting in emissions; however, the effect would be substantially lower than the use of full diesel as LNG results in lower emissions.
Community Services and Infrastructure	**Disadvantage -** Potential opportunity to enhance CSI through local contract sourcing of diesel fuel, but no opportunity to enhance LNG availability for local residents and Aboriginal communities in the region.	**Advantage -** Sourcing LNG for the Project may provide an opportunity to increase the availability of LNG for local residents and Aboriginal communities, potentially reducing costs to acquire LNG in the region.
Cost	**Advantage -** Lower capital costs, with higher fuel costs spread over the LOM.	**Disadvantage -** Higher capital costs but lower fuel costs over the LOM. The substantial investment early in development required may be cost prohibitive until production ramps up. Consideration of truck delivery of LNG before plant commissioning will be made depending on the economics.
Technical Feasibility	**Advantage -** Provides a commonly used, reliable fuel supply.	**Disadvantage -** Provides a successfully tried technology, when commercially available, however conversion kits are not currently commercially available for the specific truck size required.
OVERALL	**PREFERRED (required regardless of the application of LNG technology)**	**PREFERRED - for Long-term Consideration (higher complexity and initial cost, but increased environmental and potential economic benefits over the LOM)**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Acoustic Environment
- Groundwater
- Surface Water
- Fish and Fish Habitat
- Vegetation Communities
- Wildlife and Wildlife Habitat
- Operational Health and Safety
- Labour and Economy
- Heritage Resources
- TLRU
- LRU

Preferred Alternative

The principal fuel for mobile mining equipment will be diesel fuel. Opportunities to partially fuel the Project fleet with LNG will be monitored during operation for feasibility.

4.2.15.2 Fuel Source

Trucking both diesel and LNG to the Project provides a viable option for fuel source which can be stored in approved above-ground storage tanks. The establishment of an LNG plant was also considered as a viable source for LNG in the case where a combination of diesel and LNG is selected as the preferred fuel source.

The key assumptions used to compare fuel source alternatives are summarized in Table 4-26.

Table 4-26: Fuel Source Design Assumptions

Diesel Truck Delivery and Tank Storage	LNG Truck Delivery and Tank Storage	LNG Plant
• Diesel would be attained from relatively local sources. • Tanks would be designed and operated based on regulatory requirements for safety and to control environmental effects.	• LNG would be obtained from Union Gas's Hagar LNG Plant in Hagar, Ontario. • Tanks would be designed and operated based on regulatory requirements for safety and to control environmental effects.	• Union Gas would be responsible for constructing a new pipeline, to supply the Project. • The LNG Plant would have a limited footprint that can be accommodated in the existing PDA without additional landscape level effects. • Refuelling practices would adhere to regulatory requirements for safety and to control environmental effects.

Options for supplying the required diesel and LNG were considered in the comparative analysis as outlined in Appendix G9, and the results are described below.

Trucking the fuel to the Project provides a simple, reliable and well-established option for diesel supply, and would be feasible for LNG as well. Trucking will limit the capital costs for needed infrastructure onsite, but will result in increased operating costs and higher air emissions for trucking.

Despite higher capital costs for the construction of the LNG plant, this option would reduce the cost of LNG by over half, resulting in further increased cost savings over the LOM. This option would also reduce the environmental effects of transporting LNG, since the closest facility is in Hagar, Ontario, approximately 900 km away. Construction of an LNG plant is preferred for the long term, but it would require greater investment early in development which may be cost prohibitive until production ramps up. Truck delivery of LNG will be considered for the short term depending on economics.

A potential secondary opportunity for sourcing LNG for the Project is that it could increase LNG access for local residents and Aboriginal communities, increasing availability and reducing costs to acquire LNG in the region, which currently does not have LNG delivery service. Although not explicitly considered as a component of the project, this may present a secondary benefit in the area should the use of LNG for the Project become feasible in the future.

A 90% LNG -10% diesel ratio would provide optimal results related to emissions reductions and cost savings over time, however this technology is not currently commercially available. As an alternative, machinery that uses a 50% LNG-50% diesel ratio is in use in the United States, and presents a more reliable option.

The detailed evaluation of fuel source alternatives, including consideration of the components of the environment is found in Appendix G9. A summary comparison is provided in Table 4-27. The preferred location for fuel storage is identified on Figure 4-5.

Table 4-27: Summary of Fuel Source for Mining Equipment Analysis

Key Differentiating Factors	Diesel Truck Delivery and Tank Storage	LNG Truck Delivery and Tank Storage	LNG Plant
Atmospheric Environment	**Disadvantage -** Change in the atmospheric environment expected because although the tank installation, storage or decommissioning will not result in substantial emissions, trucking fuel approximately 275 km will result in higher atmospheric environment emissions.	**Major Disadvantage -** Change in the atmospheric environment expected because although the tank installation, storage or decommissioning will not result in substantial emissions, the long-distance trucking (approximately 900 km) will result in substantially higher atmospheric environment emissions.	**Advantage -** Change in the atmospheric environment expected from emissions from the construction, operation, and decommissioning of a LNG plant, but overall lower air quality effects compared to trucking fuel long distances.
Community Services and Infrastructure	**Disadvantage -** Potential opportunity to enhance CSI through local contract sourcing of diesel fuel, but no opportunity to enhance LNG availability for local residents and Aboriginal communities in the region.	**Advantage -** Sourcing LNG for the Project will provide an opportunity to enhance LNG availability for local residents and Aboriginal communities in the region.	**Advantage -** Developing a local LNG plant will provide an opportunity to enhance LNG availability for local residents and Aboriginal communities in the region.
Cost	**Advantage -** The storage tank will have a lower capital cost but higher operating costs than the LNG plant.	**Advantage -** The storage tank will have a lower capital cost but higher operating costs than the LNG plant.	**Disadvantage -** Higher capital cost may affect feasibility of implementation.
Labour and Economy	**Disadvantage -** Minor change in economy expected from the increased income to business owners from haulage fees and to the company selected to	**Advantage -** Minor change in economy expected from the increased income to business owners from haulage fees and to Union Gas for the LNG supply. Opportunity to lower LNG costs for local residents	**Advantage -** Minor change in economy expected from the increased income to Union Gas for the LNG supply. Opportunity to lower LNG costs for local residents and Aboriginal

Table 4-27: Summary of Fuel Source for Mining Equipment Analysis

Key Differentiating Factors	Diesel Truck Delivery and Tank Storage	LNG Truck Delivery and Tank Storage	LNG Plant
	supply diesel for the Project. No opportunity to lower LNG costs for local residents and Aboriginal communities.	and Aboriginal communities.	communities.
Technical Feasibility	**Disadvantage -** Diesel is commonly used and typically reliable, however a third party would be required to implement and storm events could affect delivery.	**Disadvantage** - LNG is commonly used and typically reliable, however a third party would be required to implement and storm events could affect delivery.	**Advantage -** LNG is commonly used and typically reliable, however a third party would be required to initially implement. The LNG plant provides the highest reliability due to a direct connection to the existing pipeline.
OVERALL	**PREFERRED - Long-term (ongoing diesel delivery will be required even if the combination diesel/LNG fuel supply is implemented)**	**PREFERRED - Short-term (required to supply LNG during the establishment of the LNG Plant)**	**PREFERRED - Long-term (presents the most economical option over the long-term, despite potential implementation challenges)**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Acoustic Environment
- Groundwater
- Surface Water
- Fish and Fish Habitat
- Vegetation Communities
- Wildlife and Wildlife Habitat
- Operational Health and Safety
- Heritage Resources
- TLRU
- LRU

Preferred Alternative

Diesel will be trucked to the Project on an as-needed basis and stored in approved above-ground storage tanks equipped with secondary containment in accordance with regulations. If a diesel-

LNG blend is pursued, LNG will be trucked during operation until a LNG plant is constructed onsite. The LNG plant will be located close to the power plant for ease of connection to the natural gas distribution line that will supply both facilities. Although not part of the current Project, there may be the potential to expand this facility in the future which could provide local secondary benefits. Prior to commissioning the plant, LNG would be trucked to the Project on an as-needed basis from the closest commercial source which is Hagar, Ontario.

4.2.16 Site Infrastructure and Support Facilities

The following alternatives were considered for the site infrastructure and support facilities as part of the initial screening:

- Site Access:
  - permanent site access via the western leg of existing Highway 11
  - permanent site access via the eastern leg of existing Highway 11
  - permanent site access via existing Michael Power Boulevard north of site.
- Buildings and Support Facilities (e.g. mine dry and administration building, truckshop, warehouse and offices, and recycling and sort facility):
  - establish facilities onsite
  - establish facilities offsite
- Temporary Camp - Construction:
  - camp located near Old Arena Road and Michael Power Boulevard
  - camp located directly west of the open pit
  - locations outside Geraldton and PDA
  - no camp – use existing infrastructure

The initial screening identified that the preferred alternative for access to the PDA was via the west, the preferred alternative for the buildings and support facilities was onsite, and the preferred alternative for the temporary camp was near Old Arena Road. The rationale for considering alternative methods related to Site Infrastructure and Support Facilities, and the results of the analysis are described below.

4.2.16.1 Site Access

Road access to the Project will be required for vehicles, including personnel, material deliveries and haulage trucks. Based on the location of the open pit and associated facilities, the main access to the Project will be via the western leg of the existing Highway 11 as the only operationally feasible alternative. Main access was also considered via the eastern leg of

Highway 11 and Michael Power Boulevard to the north, but access from these directions is not feasible because it would create too many conflicts with planned facilities and operation (e.g., by crossing haul/access routes, pipelines and other infrastructure) to be efficient or safe.

Along with the primary access road, GGM will also develop a network of internal site roads within the PDA, which will link the main Project components. Since these roads will be within the PDA, no effects are anticipated from their construction or use. The location of internal roads will be based on the final layout of the other Project components to provide adequate connectivity, so no specific alternatives were considered for the onsite road network.

The initial screening identified that the only feasible alternative for site access was a permanent access via the western leg of Highway 11. As a result of the initial screening, a comparative analysis was not required.

4.2.16.2 Buildings and Support Facilities

Buildings and support facilities, including parking areas, mine dry and administration building, truckshop, warehouse and offices, and recycling and sort facility will also be located within the PDA, since it would not be operationally feasible to locate these facilities offsite. Onsite facilities will reduce cost, increase efficiency and reduce environmental effects from travel and transportation.

Optimal locations for buildings and support facilities will be determined based on operational needs, appropriate geotechnical conditions, and ensuring a safe distance from open pit and other onsite facilities. Supporting infrastructure including water, natural gas and wastewater pipe networks will be designed based on site constraints and operational needs of the Project around the process plant area. These facilities will be sited within the existing PDA, so final determination of the specific locations of each facility is not anticipated to have substantive environmental effects.

The initial screening identified that the only feasible alternative for buildings and support facilities was onsite facilities. As a result of the initial screening, a comparative analysis was not required.

4.2.16.3 Temporary Camp

A temporary camp will also be required to accommodate mine staff during the initial phases of construction. The camp will need to accommodate occupancy of an average of 450 beds to a maximum of 600 beds during peak construction, so non-local construction workers can be housed during their on-site rotation. The temporary camp will include: mine dry, canteen, kitchen, dining room, dormitories, and camp administration office.

The preferred alternative for the temporary camp is located on Old Arena Road near the intersection with Michael Power Boulevard. The advantages of the preferred alternative include ready access to municipal servicing, limited effects on existing vegetation for clearing and site preparation, and efficient access to the mine site for workers. The primary disadvantage of this location is the requirement to manage greywater and sewage waste separate from the mine site due to distance from the site. Another location was identified near the open pit, but presented a number of disadvantages, including health and safety issues related to the proximity to the open pit and servicing difficulties. Other locations further away from the Project were not considered feasible, as they would result in limited access to servicing and increased time for worker travel to the mine site compared to the preferred alternative. Consideration was also given to not having a camp, but this would require reliance on nearby communities for accommodating a large number of temporary workers, which would increase costs, is difficult to manage resources, and increases worker travel time.

Sewage treatment options were considered for the temporary camp as outlined in Section 4.2.16.4.

The initial screening identified that the only feasible alternative for the temporary camp was a location near Old Arena Road and Michael Power Boulevard. As a result of the initial screening, a comparative analysis was not required.

The preferred location for the temporary camp is identified on Figure 4-5.

Preferred Alternative

Main access to the Project will be via an access road connected to the western leg of the existing Highway 11. This access point will be used by personnel, material deliveries, and haulage trucks transporting material to the process plant.

Support facilities will be located within the PDA, optimally located for ease of access and compatibility with other Project components. Support facilities will include necessary setbacks from the open pit and process plant to provide worker safety.

The temporary camp will be located on Old Arena Road, close to the intersection with Michael Power Boulevard.

4.2.16.4 Sewage Treatment for the Temporary Camp

The following alternatives were considered for the sewage treatment facility for the temporary camp as part of the initial screening:

- Sewage Treatment for the Temporary Camp:
  - connection to the municipal system
  - sewage treatment plant with surface water discharge
  - septic tank(s) and tile field(s)
  - lagoons
  - trucking domestic sewage offsite to a licensed treatment plant

The initial screening identified that the preferred alternative for sewage treatment for the temporary camp was connection to the municipal system. The rationale for considering alternative methods and the results of the analysis are described below.

Effluent from the temporary camp will need to be effectively treated and discharged to meet regulatory standards.

Connection to the municipal system provides benefits over onsite treatment options, including reduced operating costs, avoiding a localized treated effluent discharge point, and simplified implementation that would be limited to a servicing connection along previously disturbed rights-of-way. This alternative presents the least complex approach with the lowest potential for environmental effects.

Septic tanks and tile fields generally provide a low-cost option once installed, however they also require a larger footprint resulting in increased effects to surrounding natural features, and they must be sited to avoid watercourses and other sensitive features. Due to the constrained nature of the temporary camp site, including the number of nearby watercourses, lakes and wetlands, and high water table conditions, siting and constructing a septic tank and field is not considered technically feasible.

Similarly, lagoons offer a cost-effective solution once installed, but they require large areas of land and may be subject to increased odour effects. These types of facilities are generally more effective when used in areas where temperatures do not drop below freezing, to promote biological oxidation. Like the septic alternative, lagoons present challenges related to siting given the numerous local constraints, constructability concerns due to the permeable soil conditions, and operational disadvantages related to odour management. Use of lagoons for the temporary camp is therefore not considered technically feasible.

A sewage treatment plant with a surface water discharge provides improved reliability over other onsite alternatives, but the primary disadvantages of a sewage treatment plant include increased costs for construction and operation, and the requirement for effluent discharge. Based on the location of the temporary camp, effluent discharge would likely be directed to Barton Bay as the most feasible option, a water body experiencing elevated levels of parameters of potential concern from historical mining and industrial activity. Despite the availability of compact and reliable technology, and effective mitigation of environmental effects, most specifically related to effluent discharge and odour, this alternative still presents increased costs and environmental risk over the preferred municipal connection alternative.

Trucking the sewage to a more distant treatment plant would result in increased costs and environmental effects from trucking, with no benefits over the municipal connection.

The initial screening identified that the only feasible alternative for sewage treatment for the temporary camp was a connection to the municipal system. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

Through discussions with the Municipality of Greenstone, GGM has confirmed there is capacity to connect the temporary camp to the Municipality of Greenstone's sanitary sewer system. Works associated with connecting the temporary camp to the municipal sanitary sewer system will be undertaken by the Municipality of Greenstone and are not considered to be part of the Project.

4.2.17 Hydro One Transformer Station Relocation

The following alternatives were considered for the Hydro One TS relocation as part of the initial screening and comparative analysis:

- Hydro One TS Location:
  - Study Area 1 / Option 1 – Site west of Mosher Lake near Old Arena Road (south side)
  - Study Area 1 / Option 1A/B – Site west of Mosher Lake near Old Arena Road (west side)
  - Study Area 1 / Option 1C – Site north of the intersection of Highway 11 and Old Arena Road
  - Study Area 1 / Option 1D – Site south of the intersection of Highway 11 and Old Arena Road
  - Study Area 2 / Option 2 – Site north of open pit on Michael Power Boulevard
  - Study Area 2 / Option 2A – Site southwest of intersection of Michael Power Boulevard and Old Arena Road
  - Study Area 3 / Location east of Kenogamisis Lake
  - Study Area 4 / Location further west of mine site

An existing Hydro One TS and portions of the existing distribution and transmission lines must be relocated as they are currently located within or proximate to the open pit. Since the existing Hydro One TS, transmission line and some of distribution lines will need to be removed to facilitate Project development, leaving this infrastructure in place is not feasible.

The comparative analysis confirmed that the preferred alternative for the Hydro One TS relocation was Option 1A/B. A range of alternative methods for the Hydro One TS location were considered in the comparative analysis as outlined in Appendix G10, and the results are described below.

Based on the route for the relocated distribution line and following initial discussions with Hydro One, two study areas were identified for the Hydro One TS location for further assessment. The purpose of the study areas was to identify general boundaries for the potential site of the Hydro

One TS and the general extent of potential effects. Study Area 1 was identified west of Mosher Lake near Old Arena Road, and Study Area 2 was identified north of the open pit on Michael Power Boulevard. These study areas were identified to meet the operational needs and design requirements of Hydro One, which include:

- locating the Hydro One TS as close as possible to the existing transformer station's load center
- avoiding locating the Hydro One TS on historical tailing sites
- applying a basic design layout for the TS provided by Hydro One.

More generally, study areas were identified that would also:

- be located near existing access points, and in close proximity to the 115kV transmission line and 44 kV distribution line
- remain in close proximity to the existing Hydro One TS and load center to reduce line loss and increase efficiency
- enable easy access to existing roads for maintenance
- limit disturbance to natural areas by being located close to existing infrastructure and disturbed areas.

In addition to reviewing the two study areas, a desktop investigation was undertaken to consider additional potentially feasible study areas. Study Area 3 was identified east of Kenogamisis Lake along Highway 11. However, this would have required the extension of the existing 115 kV transmission line across Kenogamisis Lake at the narrow choke point at the Highway 11 crossing in order to feed the new Hydro One TS. This would have resulted in a new 115 kV corridor, which would have had greater effects on existing land use, the local population and natural areas with limited operational benefits. The operational benefits would have included shorter 44 kV distribution lines and Hydro One TS being located in close proximity to the load center. Study Area 3 was, so it was not considered further. Study Area 4 was identified further west along the existing 115 kV transmission line, but this would have brought the Hydro One TS too far from the load center, so this was not investigated further, since closer locations were available. Multiple alternatives were identified in Study Areas 1 and 2 for further analysis.

It was determined through initial investigations and desktop research that Study Area 1 was preferred, since sites in Study Area 2 would require extensive construction in wetlands, and would require extension of the 115 kV transmission line around the perimeter of the PDA at a higher cost. However, alternatives at this location were carried forward into the comparative analysis to validate these initial results, and to compare the alternatives against a broader range of environmental and technical criteria.

Four conceptual sites were identified in Study Area 1, and two conceptual sites were identified in Study Area 2 as noted above. In Study Area 1, Option 1 is sited south of Old Arena Road, and Option 1A is sited north and west of Old Arena Road. An Option 1B was also identified as an alternate footprint to Option 1A, but for the purpose of this comparative analysis, these options are considered relatively equal due to the overlap in site footprint. Options 1C and 1D are located further west in Study Area 1, near the intersection of Highway 11 and Old Arena Road.

Option 1 was the initially identified site in Study Area 1, but following geotechnical studies, concerns with water levels and drainage led to the identification of Options 1A and 1B as alternatives. Both of these options encroached on claims that are held by GGM, but this was considered manageable. Options 1C and 1D were also identified as alternatives that would avoid the wetlands and wildlife habitat concerns related to Options 1 and 1A/B. However, despite the benefit of reduced effects on wildlife habitat and wetlands, Options 1C and 1D are less favorable because they are further from the original transformer station and require a longer distribution line to connect the new Hydro One TS. In addition, both of these options are located within the Tombill Claim, which is owned by a third party. The additional costs associated with acquiring this property was identified as a key disadvantage. Options 1C and 1D were therefore screened out of the analysis.

In Study Area 2, Option 2 is sited west of Michael Power Boulevard, north of the watercourse connecting Mosher Lake and Barton Bay. Option 2A is sited further north, closer to the intersection of Michael Power Boulevard and Old Arena Road.

The options identified in the two study areas represent the most viable locations for the proposed facility. Other locations within the study areas were considered, but did not offer any environmental, operational or economic benefit over those selected.

The key assumptions used to compare Hydro One TS relocation alternatives selected for the comparative analysis are summarized in Table 4-28.

Table 4-28: Hydro One Transformer Station Relocation Design Assumptions

<table>
<tr><th>Option 1A/B</th><th>Option 1</th><th>Option 2</th><th>Option 2A</th></tr>
<tr><td colspan="4">• Designed to meet the operational needs and design requirements of Hydro One.
• Infrastructure would be limited to at or near-surface works.
• Standard mitigation measures would be applied to control construction effects.
• Access and transmission line routes would be sited to avoid sensitive environmental features where possible.
• The relocation would be completed during construction, with a passive facility and transmission line through operation and closure.</td></tr>
<tr><td>• Siting will require an extension of the existing 115 kV transmission line corridor.</td><td>• Siting will require an extension of the existing 115 kV transmission line corridor.</td><td>• Siting will require an extension of the existing 115 kV transmission line corridor.</td><td>• Siting will require an extension of the existing 115 kV transmission line corridor.</td></tr>
</table>

After an analysis of key environmental features and potential effects, Option 1A/B was confirmed to be the preferred alternative. Option 1A/B presented a number of key advantages, including the lowest cost to construct, no disturbance to wetlands, and the lowest effect on wildlife habitat. This option also has the benefit of being close to the existing 115 kV transmission line, so no extension would be required, and the site is readily accessible. This site is adjacent to the existing 115 kV transmission line and will not require the existing 115 kV transmission line to be extended. Although this option required the highest removal of forested area, the affected vegetation communities are common throughout the study area. The site has the potential to disturb areas of archaeological potential, but potential is low based on the work undertaken to date. A Stage 2 archaeological assessment will confirm if archaeological resources exist that may be disturbed by construction activities, and the PDA will be cleared of resources during Project development. The site is located within traditional use areas identified by the MNO and LLFN, but this option has the benefit of avoiding a LLFN hunting area and EFN subsistence area that would be disturbed by Options 2 and 2A. The final footprint location will be refined during detailed design based on site conditions and operational needs. Another disadvantage of Option 1A/B is that the new Hydro One TS will be located further away from the load center. The length of the 115 kV transmission line will be reduced by approximately 2 km and the length of each of the 44 kV and 12.5 kV distribution lines will be increased each by 2 km.

For the preferred alternative, a new access road and 115 kV connection are required. It is anticipated that a pole-mounted 115 kV line will be located to the west of the proposed access road to the Hydro One TS and will span a small fen adjacent to the access road, to avoid encroachment on this sensitive feature.

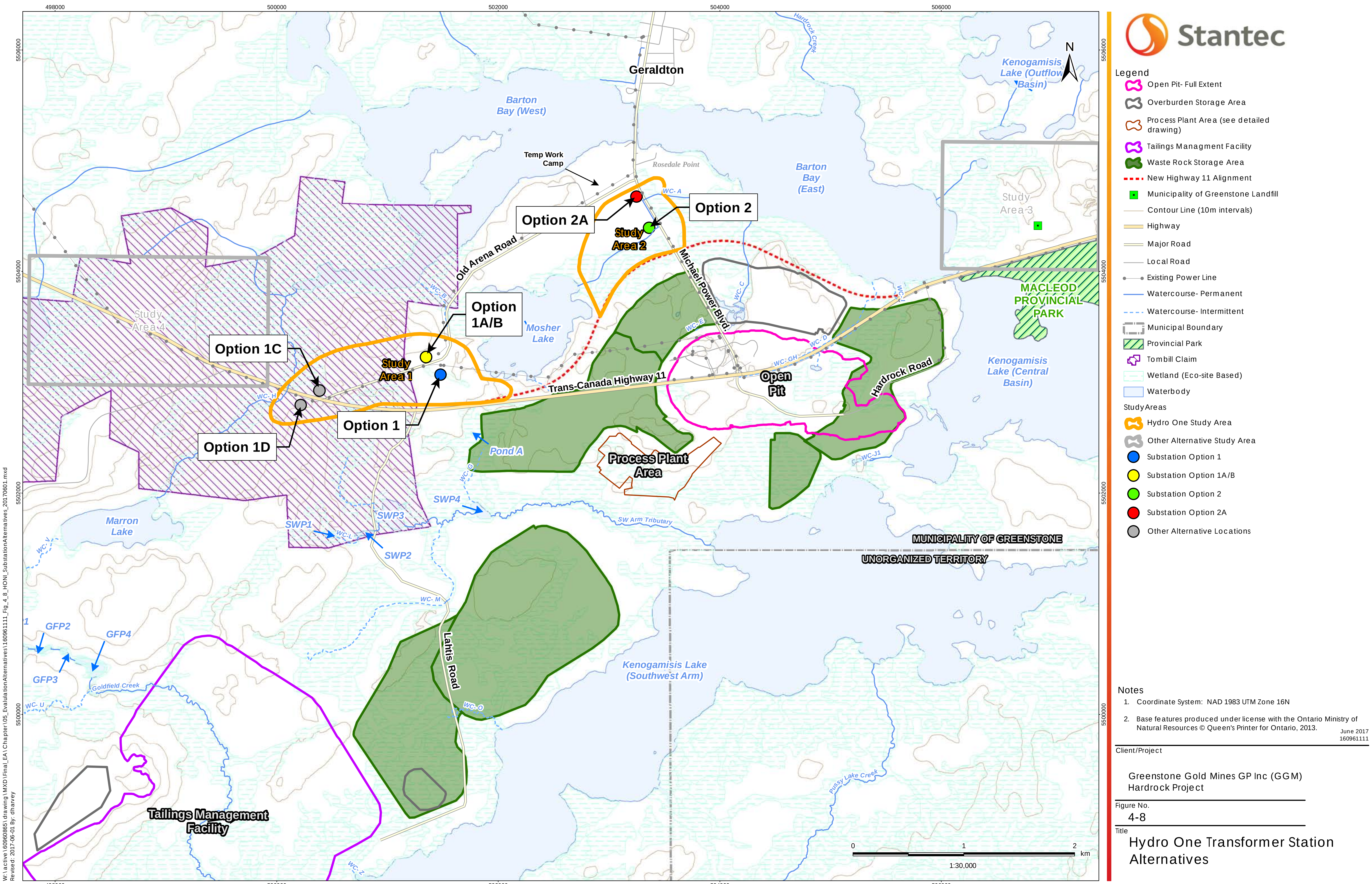
The primary advantage of Option 1 is the lowest cost similar to Option 1A/B. This option would also not require an extension to the 115 kV transmission line. However, the site would require construction of a new 200 to 300 m access road, which would have additional effects on existing vegetation. Similar to Option 1A/B, the site is located within traditional use areas identified by the MNO and LLFN, but this option has the benefit of avoiding a LLFN hunting area and EFN subsistence area that would be disturbed by Options 2 and 2A. This site is also located within a wetland community identified as a sparse treed fen, which has been identified as potential habitat for the taiga alpine butterfly Species of Conservation Concern. The Hydro One TS footprint would bisect this narrow, linear wetland, not only removing a portion of the habitat, but also affecting wetland function through fragmentation. Due to the potential effects on this sensitive wetland community and Species of Conservation Concern, this site was determined to be not preferred.

As noted earlier, Study Area 2 was determined to be the least preferred location for the Hydro One TS. The comparative analysis confirmed that Option 2 would require the highest removal of wetland, and would also affect a number of wildlife habitats, including for eastern wood-pewee, moose and waterfowl. This option also has the highest construction cost and vegetation clearing, due to the need to realign and build a new segment of 115 kV transmission line of about 1.5 km to feed the new Hydro One TS, and the highest construction complexity and stability issues due to the wetland. In addition, the site would disturb traditional use areas identified by LLFN, the MNO and EFN, and areas of archaeological potential have been identified that would require additional assessment.

Option 2A does not have the same construction complexity as Option 2, since it avoids locating the Hydro One TS in a wetland area. This option does require the highest forest removal, similar to Option 1A/B, and in addition it would result in further vegetation removal through the construction of approximately 2 km of new 115 kV transmission line. This line would have to cross through about 500 m of wetland, resulting in some wetland disturbance and removal, since this distance is too great to be spanned by the line. This option shares the highest construction cost with Option 2 due to the need for the 115 kV transmission line. The Option would also affect habitat for eastern wood-pewee and moose late winter cover, traditional use areas identified by LLFN, the MNO and EFN, and areas of archaeological potential have been identified that would require additional assessment.

The detailed evaluation of Hydro One TS relocation alternatives, including consideration of the components of the environment is found in Appendix G10. A summary comparison is provided in Table 4-29. The Hydro One TS relocation alternatives that were considered in the comparative analysis are identified on Figure 4-8.

As part of this work, the existing 44 kV distribution line will also need to be rerouted to follow the new Highway 11 route along the perimeter of the PDA. This will provide the shortest distance between the two connection points for the line, and will limit effects on the environment. Alternative routes in the region north of the PDA would result in increased vegetation clearing, habitat fragmentation, and construction costs, with no operational benefit. Routes to the south of the PDA are not considered feasible, since both connecting points for the line are located north of the PDA and skirting the site to the south would allow the transmission line to be located closer to the load center, which as operational benefits in terms of delivery of power. In addition, the Ministry of Transportation has a stated preference for reducing encroachment and crossing of the Highway 11 corridor. Therefore, southern alternatives were not considered for the distribution line relocation.



Stantec
Legend
Open Pit- Full Extent
Overburden Storage Area
Process Plant Area (see detailed drawing)
Tailings Managment Facility
Waste Rock Storage Area
New Highway 11 Alignment
Municipality of Greenstone Landfill
Contour Line (10m intervals)
Highway
Major Road
Local Road
Existing Power Line
Watercourse- Permanent
Watercourse- Intermittent
Municipal Boundary
Provincial Park
Tombill Claim
Wetland (Eco-site Based)
Waterbody
Study Areas
Hydro One Study Area
Other Alternative Study Area
Substation Option 1
Substation Option 1A/B
Substation Option 2
Substation Option 2A
Other Alternative Locations
Geraldton
Barton Bay (West)
Barton Bay (East)
Kenogamisis Lake (Outflow Basin)
Kenogamisis Lake (Central Basin)
Kenogamisis Lake (Southwest Arm)
Temp Work Camp
Rosedale Point
Option 2A
Option 2
Study Area 2
Option 1A/B
Option 1C
Option 1
Option 1D
Study Area 1
Study Area 3
Study Area 4
Mosher Lake
Marron Lake
Old Arena Road
Michael Power Blvd.
Trans-Canada Highway 11
Hardrock Road
Lahtis Road
Open Pit
Process Plant Area
Tailings Management Facility
MACLEOD PROVINCIAL PARK
MUNICIPALITY OF GREENSTONE
UNORGANIZED TERRITORY
Pond A
SWP1
SWP2
SWP3
SWP4
GFP2
GFP3
GFP4
SW Arm Tributary
Goldfield Creek
Pussy Lake Creek
Hardrock Creek
Notes
1. Coordinate System: NAD 1983 UTM Zone 16N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
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Client/Project
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project
Figure No.
4-8
Title
Hydro One Transformer Station Alternatives
1:30,000

Table 4-29: Summary of Hydro One Transformer Station Relocation Analysis

Key Differentiating Factors	Option 1A/B	Option 1	Option 2	Option 2A
Vegetation Communities	**Advantage -** Higher forest removal, but effects are expected to be minimal because the types of communities are abundant in the region. No wetland removal.	**Major Disadvantage -** Greatest effect on wetland function through disturbance of a sensitive wetland community.	**Disadvantage -** Highest amount of forest removal and highest amount of wetland removal required.	**Disadvantage -** Highest amount of forest removal required, and minor wetland disturbance.
Wildlife and Wildlife Habitat	**Advantage -** Lowest effect on wildlife and wildlife habitat.	**Major Disadvantage -** Greatest effect on wildlife habitat expected as habitat for taiga alpine butterfly, a SOCC will be removed.	**Disadvantage -** Minor disturbance to potential eastern wood-peewee habitat, moose late winter cover and waterfowl stopover and staging areas.	**Disadvantage -** Minor disturbance to potential eastern wood-peewee habitat and moose late winter cover.
Cost	**Advantage -** Comparatively lower cost to establish the transformer station and associated power lines.	**Advantage -** Comparatively lower cost to establish the transformer station and associated power lines.	**Disadvantage -** Comparatively higher cost to construct due to the need for a 115 kV power line.	**Disadvantage -** Comparatively higher cost to construct due to the need for a 115 kV power line.
Technical Feasibility	**Advantage -** Lowest construction complexity.	**Disadvantage -** Increased complexity and stability issues due to wetland presence.	**Major Disadvantage -** Comparatively higher construction effort due to 115 kV line extension. Increased complexity and stability issues due to half of the transformer station footprint being within wetland.	**Disadvantage -** Comparatively higher construction effort due to 115 kV line extension. Increased complexity due to wetland presence.
TLRU	**Major Advantage -** Avoids hunting area identified by LLFN and subsistence area identified by EFN.	**Major Advantage -** Avoids hunting area identified by LLFN and subsistence area identified by EFN.	**Major Disadvantage -** Potential to interfere with traditional activities identified by LLFN, the MNO and EFN.	**Major Disadvantage - Potential to interfere with traditional activities identified by LLFN, the MNO and EFN.
OVERALL	**PREFERRED**	**NOT PREFERRED**	**NOT PREFERRED**	**NOT PREFERRED**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Acoustic Environment
- Groundwater
- Surface Water
- Fish and Fish Habitat
- Community Services and Infrastructure
- Operational Health and Safety
- Labour and Economy
- Heritage Resources
- LRU

Preferred Alternative:

The Hydro One 44 kV distribution line will be realigned to follow the perimeter of the PDA along the Highway 11 route. The Hydro One TS will be relocated west of Mosher Lake, north and west of Old Arena Road. The infrastructure will be designed to Hydro One standards. It is anticipated that the precise footprint may be refined in the field, during the detailed engineering following additional geotechnical and site investigations.

4.2.18 MTO Patrol Yard

The following alternatives were considered for the MTO Patrol Yard as part of the initial screening:

- MTO Patrol Yard Relocation (if required):
  - West of Project site on Highway 11
  - East of Project site on Highway 11

The initial screening identified that the preferred alternative for the MTO Patrol Yard relocation was west of the Project.

The MTO Patrol Yard along Highway 11, located just east of the PDA, will need to be relocated as part of Project development.

Alternatives for the MTO Patrol Yard include locations either east or west along Highway 11, since direct access to the highway must be maintained to meet the MTO's operational needs. Either location would be directly adjacent to the existing highway in previously disturbed areas, so minimal effects to the natural environment would be expected. A location west of the PDA was selected as the preferred site, since it maintains direct access to Highway 11 and is located in an area where municipal services (such as potable water) can be provided relatively efficiently. This area is in close proximity to the Project, reducing the overall PDA.

A location east of the PDA maintains direct access to Highway 11, but has technical, economic and environmental constraints. A location to the east of the PDA is constrained by the location of the WRSAs and Highway 11. GGM does not own lands east of first bridge and municipal servicing is also limited. This location would bring the MTO Patrol Yard in closer proximity to MacLeod Provincial Park which may result in potential environmental effects.

As noted, discussions are ongoing with MTO to confirm if the Patrol Yard must be relocated. The west alternative will be used only if the existing Patrol Yard requires removal.

The initial screening identified that the only feasible alternative for the MTO Patrol Yard was west of the PDA. As a result of the initial screening, a comparative analysis was not required.

The preferred location for the MTO Patrol Yard is identified on Figure 4-5.

Preferred Alternative

The MTO Patrol Yard will be relocated to west of the PDA near the existing intersection of Highway 11 and Lahtis Road.

4.2.19 Closure

Following operation, a Closure Plan will be implemented in compliance with the *Mining Act* to remove unneeded facilities and rehabilitate the mine site. The primary objective of rehabilitation and closure activities is to establish self-sustaining physical, chemical and biological stability of the site, and to meet desired end land functions and uses. A Conceptual Closure Plan is provided in Appendix I.

The Closure Plan will be compliant with the Ontario *Mining Act* and describe the approaches that would be followed with respect to the decommissioning, removal, and disposal of equipment and structures, and for rehabilitation, closure, and care and maintenance of remaining facilities.

Progressive rehabilitation activities will be carried out where possible throughout the LOM. After closure, rehabilitation measures will return the PDA to a productive end land use that is physically and chemically stable. Monitoring and treatment of effluent during post-closure would continue as long as there is a need to do so.

Alternatives for closure have been considered at a conceptual level, with the final details to be confirmed during ongoing consultation with the MNDM and other regulatory authorities as part of the closure planning processes.

At the end of operation of the Project, the main features requiring closure will include the open pit, water management and drainage systems, WRSAs, ore and overburden stockpiles, TMF, buildings, and infrastructure.

4.2.19.1 Open Pit

The following alternatives were considered for open pit closure as part of the initial screening and comparative analysis:

- Open Pit Closure:
  - natural filling with water
  - enhanced filling with water
  - backfill with waste rock

The primary intent of rehabilitation and closure of the open pit is to achieve a physically safe and chemically stable environment. Alternatives that were considered to close the open pit include natural filling and enhanced filling. Backfilling with waste rock was not considered feasible as a primary option for waste rock management, because although this approach may be environmentally preferred, this operation would involve a much greater movement of waste rock along the same scale as the initial open pit excavation, which is not economically feasible. The comparative analysis confirmed that the preferred alternative for open pit closure was enhanced filling. The rationale for considering alternative methods related to open pit closure, and the results of the analysis are described below.

The key assumptions used to compare open pit closure alternatives are summarized in Table 4-30.

Table 4-30: Open Pit Closure Design Assumptions

Open Pit Natural Filling	Open Pit Enhanced Filling
• Progressive filling through gravity drainage and infiltration.	• Active use of additional water sources and pumping to reduce filling and closure timelines. • Water will be pumped into the open pit from the TMF, collection ponds, and potentially from the Southwest Arm of Kenogamisis Lake to reduce the filling time. • Pit lake stratification, additional treatment if required (e.g., constructed wetland) and ongoing monitoring will be used to manage the potential release of parameters of potential concern.

Natural filling includes the creation of a lake through progressive filling of the open pit with water that will drain by gravity and natural infiltration of groundwater without the addition of water from surface water sources. The primary benefit of this approach is the minimum amount of active management required. This would result in longer timelines for filling, and would require additional safety measures and ongoing monitoring during the filling period, which could be up to 147 years. This approach would also allow groundwater to infiltrate into the open pit over a longer time period, resulting in the collection of more groundwater from historical tailings, improving groundwater quality over this period.

Enhanced filling uses additional water sources to enhance the rate of filling including stormwater from the Project, recycled water from the TMF, and controlled water taking from the Southwest Arm of Kenogamisis Lake. This was selected as the preferred alternative because it will reduce the time until the open pit is filled. Although this alternative may direct water from Kenogamisis Lake to supplement filling, water takings will be controlled and should not affect overall lake water levels. Directing water from sources such as the TMF to the open pit will allow for final rehabilitation efforts to be carried out and to improve water quality conditions. The pit lake will store this water in a stratified condition to limit potential for the release of parameters of potential concern, which would be carefully monitored based on treated effluent discharge criteria. Further effluent quality control may be applied during discharge, such as the use of constructed wetlands to meet effluent criteria. This alternative presents an overall benefit to water quality for the Project, by managing potentially contaminated water from other sources at a single point.

Another advantage of enhanced filling is reducing the length of time for the open pit to fill to a level close to the existing water table level of the area (approximately 16 years). Reducing the time to fill the open pit will, in turn, reduce the exposure time and oxidation potential of exposed material in the open pit walls, resulting in reducing metal leaching and acid generating conditions. Creation of a pit lake earlier in the closure phase would allow for earlier wildlife access to the rehabilitated habitat. A reduced fill time will also reduce the costs associated with managing and monitoring filling activities, reduce the time needed to manage the risk to the general public from inadvertent access, and reduce the time to achieve a stabilized, self-sustaining water management condition.

For both alternatives, open pit filling will result in progressive increases in groundwater levels back to baseline conditions in the area of the former cone of depression around the open pit, normalizing conditions over time. The time for recovery of water levels will be dependent on the open pit filling time. The recovery of groundwater levels during open pit filling will affect groundwater flow directions and may result in changes in groundwater quality. However, this effect would be relatively consistent for both alternatives and would result in a localized effect.

Due to the shape of the open pit, there may be the possibility to fill a portion of the east end of the open pit with waste rock, while still allowing for safe operation in the western portion of the pit. This would not result in full closure of the open pit, but this could provide a number of benefits if used in combination with filling, including reducing the volume of water and time needed to fill the open pit, and reducing the amount of waste rock that will need to be managed on the surface. Partial filling of the open pit with waste rock will be considered during operation, and implemented if feasible.

The detailed evaluation of open pit closure alternatives, including consideration of the components of the environment is found in Appendix G11. A summary comparison is provided in Table 4-31.

Table 4-31: Summary of Open Pit Closure Analysis

Key Differentiating Factors	Open Pit Natural Filling	Open Pit Enhanced Filling
Groundwater	**Advantage -** Groundwater quality improvements over a longer period of time from the collection of water from the historical tailings in the open pit as it fills with water.	**Disadvantage -** Reduced timeframe to collect water from the historical tailings in the open pit.
Surface Water	**Disadvantage -** No change to surface water anticipated, but also limited ability to manage contaminated water sources such as the TMF to facilitate Project closure.	**Advantage -** Limited potential for effects on water quantity and flow if water taking from Kenogamisis Lake is implemented, but overall benefit to Project water quality by facilitating closure activities and managing contaminated water sources at a single location.
Wildlife and Wildlife Habitat	**Disadvantage -** The creation of the pit lake will occur over a longer duration, extending wildlife access restrictions.	**Advantage -** Creation of a pit lake earlier in the closure phase would allow for earlier wildlife access to the rehabilitated habitat.
Cost	**Disadvantage -** Longer duration of filling anticipated to result in increased costs over time.	**Advantage -** Shorter duration of filling anticipated to result in cost savings over time and reduction in rehabilitation security.
Technical Feasibility	**Disadvantage -** Provides an effective and proven closure method; however, the time required for this process is substantially longer than enhanced filling.	**Advantage -** Provides an effective and proven closure method reducing closure timelines.
OVERALL	**NOT PREFERRED**	**PREFERRED**

The following criteria were considered in the comparative analysis for this Project component, but based on the potential for effects, were not determined to be Key Differentiating Factors:

- Atmospheric Environment
- Acoustic Environment
- Fish and Fish Habitat
- Vegetation Communities
- Community Services and Infrastructure
- Operational Health and Safety
- Labour and Economy
- Heritage Resources
- TLRU
- LRU

Preferred Alternative

To expedite the filling of the open pit, enhanced filling operations are planned and include pumping water from the TMF, the WRSA ponds (via pond M1), and from the Southwest Arm of Kenogamisis Lake. These efforts will reduce the final open pit filling time to approximately 16 years, from the estimated 147 years required for natural filling. The time period for pumping will be confirmed based on monitoring results and maybe increased or decreased based on actual field conditions.

4.2.19.2 Storage and Stockpiles

The following alternatives were considered for storage and stockpiles closure as part of the initial screening:

- Storage and Stockpiles Closure:
  - cover and vegetate
  - no cover

The initial screening identified that the preferred alternative for storage and stockpiles closure was cover and vegetation. The rationale for considering alternative methods related to storage and stockpile closure, and the results of the analysis are described below.

The WRSAs, overburden storage areas and ore stockpile must be rehabilitated or treated to maintain permanent physical stability and effluent quality.

Alternatives that were considered for rehabilitating the WRSAs, overburden storage areas and stockpile include stabilizing then covering or revegetating, or no cover.

It is expected that the ore stockpile will contain ore extracted from the open pit during operation, to be processed during the LOM. This stockpile will be consumed through processing and will not remain at closure, thus not requiring rehabilitation beyond revegetating the exposed area.

The preferred alternative for closing the WRSAs, overburden storage areas and stockpile was determined to be stabilization with revegetation. This is the standard approach for NAG waste rock, which involves cover by revegetation with plant species, for aesthetic purposes and to reduce the potential effects of erosion and provide for other uses such as terrestrial habitat.

The initial screening identified that the preferred alternative was stabilization with cover or revegetation. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

During construction of the WRSAs, grading will be completed to direct water from the storage areas down either the ramp or channeled sections of the slopes to promote runoff and reduce infiltration into the WRSAs. At completion, minor re-contouring of the plateau will be carried out promote surface drainage and shedding of water from the storage areas, and the embankment slopes will be contoured (as required) to address the physical stability of the slopes. Once completed, the WRSAs will be covered with a storage and release cover to further reduce infiltration by promoting runoff and evapotranspiration. The cover will be vegetated with plant species that will be selected to reduce erosion potential and enhance natural revegetation of the WRSAs. Rehabilitation targets are for approximately 40% coverage of the WRSAs with the focus being placed on the plateaus and benches, allowing natural revegetation of the slopes.

The overburden materials will be characterized and stockpiled based on material properties for reuse during progressive rehabilitation efforts in accordance with the Soil Management Plan and applicable regulatory guidelines, including *Ontario Regulation 153/04*. Once stockpiles are completed, they will be graded and seeded to prevent erosion.

Further detail on the vegetative cover can be found in the Conceptual Closure Plan (Appendix I). Additional details associated with the cover for the WRSAs (performance and composition) as well as the final grading will be provided in the final Closure Plan.

4.2.19.3 Tailings Management Facility

The following alternatives were considered for TMF closure as part of the initial screening:

- TMF Closure:
  - cover and vegetate
  - water cover

The initial screening identified that the preferred alternative for TMF closure was cover and vegetation. The rationale for considering alternative methods related to TMF closure, and the results of the analysis are described below.

The TMF will hold the tailings solids and the TMF reclaim pond. At the completion of mining, the TMF must be rehabilitated or treated to achieve permanent physical stability and effluent quality. This includes ensuring the long term physical stability of tailings dams and other containment structures.

The preferred alternative to close the TMF was determined to be covering the TMF with low permeability material and revegetating it. In the case of NAG tailings, such as for the Project, the tailings surface can be vegetated directly without the requirement of a layer of topsoil. The tailings would be covered and revegetated with native, or other acceptable, plant species. The primary advantages of this alternative include reduced costs, reduced infiltration of precipitation through the tailings, reduced dust generation, the potential to develop terrestrial habitat, and lower environmental risk related to dam failure.

Water cover would involve flooding the TMF to maintain tailings in a saturated state, and is typically employed to provide an oxygen barrier to prevent development of ML/ARD for PAG tailings. This alternative is costly, as dams may have to be reinforced or raised to support the large volumes of water required to fully flood the tailings area. Impounding such a quantity of water would require ongoing maintenance and monitoring of water quality and dam stability. Since current indications are that the tailings will include negligible PAG material, this alternative is not attractive from both a cost-effectiveness and environmental perspective.

The initial screening identified that the only feasible alternative was cover and revegetation. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

At closure, a slope stability assessment is to be carried out for the TMF embankments. If required, the slopes will be stabilized (regraded or buttressed) to increase the factor of safety such that it meets the requirements set out by the Canadian Dam Association in *Technical Bulletin – Geotechnical Considerations for Dam Safety* (CDA 2007).

The top surface of the TMF will be covered by media which can support the development of a soil cover which will promote evapotranspiration, reduce infiltration through the tailings, and prevent runoff from coming into contact with the tailings surface. As the TMF will undergo progressive rehabilitation during operation, the design and performance criteria for the final cover to be constructed over the south cell will be confirmed based on the results of the north cell rehabilitation and water quality monitoring.

4.2.19.4 Buildings and Infrastructure

The following alternatives were considered for buildings and infrastructure closure as part of the initial screening:

- Buildings and Infrastructure Closure:
  - removal and disposal
  - reuse

The initial screening identified that the preferred alternative for buildings and infrastructure closure was removal and disposal. The rationale for considering alternative methods related to buildings and infrastructure closure, and the results of the analysis are described below.

There are a number of buildings and related structures within the PDA that will require closure, including the process plant, crushing plants, explosives facility, power plant, LNG plant, mine dry and administration building, truckshop, warehouse and office, and recycling and sort facility. Buildings and other structures must be removed from the PDA to an extent that is consistent with the specified future use of the land.

Project infrastructure that would require closure includes roads (e.g., site access road, haul roads, construction access roads, other smaller roads around WRSAs), pipelines (e.g., tailings discharge and reclaim lines, water distribution system, and other water management lines), transmission lines and mine equipment (e.g., crushers, conveyors and mobile heavy equipment).

Transmission lines, pipelines, water distribution and management lines and other structures must be dismantled and removed from the PDA, transportation corridors must be closed off and revegetated, and machinery, equipment and storage tanks will be removed from the PDA to an extent that is consistent with the specified future use of the land.

Alternatives that were considered for buildings and infrastructure closure include removal and disposal or reuse of acceptable buildings and related infrastructure/equipment.

The preferred alternative was identified as the removal and disposal from the PDA. Although this alternative will result in increased costs in order to meet closure requirements, advantages of this approach include minimal residual environmental effects in the PDA and potential opportunities to mitigate costs through the resale or recycling of appropriate materials.

Buildings that are maintained would have to be made safe for public or general use, and associated infrastructure would remain (e.g., such as access roads, transmission line, water management facilities). The disadvantages of this approach include limiting the naturalization potential of the PDA, and the absence of an interested party to take over the ownership of the property. Since no agreement is currently in place, this option is not considered feasible at this time. However, GGM remains open to considering opportunities to transfer infrastructure to other users, where opportunities are identified (e.g., transmission line).

The initial screening identified that the only feasible alternative was removal and disposal. As a result of the initial screening, a comparative analysis was not required.

Preferred Alternative

Removable assets will be taken from buildings and sold or disposed of prior to removal and disposal of the buildings. Following removal of the assets, most buildings will be sold or recycled as steel scrap. Foundations will be broken or blasted down to or below ground level, where possible, and then backfilled to create natural-looking landforms consistent with the *Mine Rehabilitation Code of Ontario* (Schedule 1 of *Ontario Regulation 240/00: Mine Development and Closure Under Part VII of the Act* [O. Reg. 240/00]).

Former building sites, foundations and laydown areas will be capped with overburden. Building site areas will be regraded to blend into the surrounding grades and the surface will be loosened or capped with local soils of a type suitable for natural revegetation.

At the end of the mine life (or during operation if specific components are no longer needed), infrastructure, equipment and mining materials are to be removed from the PDA, or in some cases rendered unusable. This includes buildings, pipelines, aggregate sources, lighting and security, service water supply, water management facilities, petroleum products, and potential sources of polychlorinated biphenyls in accordance with O. Reg. 240/00.

The majority of these works will be carried out within the first five years of closure; however, some facilities (i.e., access roads and the ETP) may be required for care and maintenance during closure. Facilities will be removed or rehabilitated when they are no longer required during closure.

Removal or decommissioning will occur for linear infrastructure, including pipelines, access roads and culverts, and powerlines not required to support open pit filling and monitoring. Where required, facilities which are necessary for the proper care and maintenance of the PDA during closure will be left in place and later removed/rehabilitated once they are no longer required during closure.

4.3 SUMMARY OF THE EVALUATION OF ALTERNATIVES

The evaluation of alternatives included a three-step process that began with the identification of a long list of potentially feasible alternatives for each Project component.

An initial screening was then undertaken to identify a reasonable range of alternative methods for each of the Project components that would be subject to the comparative analysis. The initial screening assessed the methods based on a high-level evaluation of the potential environmental (i.e., natural, social, economic, cultural and built environment) effects and on the overall potential for efficiency for construction, operation and closure of the Project components, and eliminated those methods that could not be feasibly implemented to support the Project. The rationale for inclusion or exclusion of each alternative method is provided Table 4-6. Based on the initial screening a number of Project components were carried forward for comparative analysis. In addition, TMF and WRSA alternatives were assessed following the ECCC Guidelines.

The comparative analysis assessed the alternative methods for each Project component against a number of VCs/criteria and related indicators. Further details regarding the method for the evaluation process and the rationale for selection of the VCs/criteria and indicators are provided in Section 4.1. Both quantitative and qualitative observations were used to identify the potential for effects for each indicator under the alternative method being assessed. Based on the potential for effects, a summary comparison for each VC/criterion was undertaken for Key Differentiating Factors, resulting in the comparative ranking of each alternative method based on key advantages and disadvantages. Following a review of these rankings, the results of the initial screening and the results of the assessment, preferred alternative methods for the Project components were identified. The preferred alternative methods are summarized in Table 4-32.

Table 4-32: Summary of Preferred Alternative Methods

Project Component	Preferred Alternative Method(s)
WRSA	• WRSA-4 with combined above ground and in-pit storage of non-segregated waste rock
TMF	• TMF-8 with conventional impoundment disposal and downstream construction
Process Plant	• onsite location • cyanidation for gold recovery, supplemented with gravity separation • process water supply from reclaim water recycled from TMF and site contact water collection system, and groundwater from historical underground workings
Ore Stockpile, Crushing Plant and Mill Feed Ore Storage Area	• onsite ore stockpile, crushing plant and storage area

Table 4-32: Summary of Preferred Alternative Methods

Project Component	Preferred Alternative Method(s)
Goldfield Creek Diversion	• Goldfield Creek diversion Option 6 (diversion northeast to Southwest Arm Tributary)
Highway 11 Realignment	• Route 1D (optimized) (revised alignment based on Route 1D to address safety concerns and improve sight distance)
Historical Tailings and Other Contaminated Soil	• removal of existing tailings where feasible • manage on site or remove for management as required
Aggregate Sources	• use a combination of existing quarries or pits, mined waste rock and new aggregate sources
Contact Water Collection, Treatment and Discharge	• open pit contact water directed to historical underground workings for storage and dewatering • collect runoff locally and treat through central collection ponds and/or ETP prior to discharge • treat contact water through coagulation and filtration in the ETP
Sewage Treatment Facility for Mine Site	• sewage treatment plant with surface water discharge
Potable Water Supply	• connection to the Geraldton municipal potable water system
Explosives Management	• manage explosives onsite
Power Source and Associated Infrastructure	• natural gas-fuelled power plant for primary power source • 44 kV tie-in to existing transmission line and temporary generation for temporary and backup power
Waste Management	• truck non-hazardous and hazardous waste offsite to licensed disposal facilities
Mining Equipment Fuel Type and Source	• use diesel for the short term • potential use a blend of LNG and Diesel, and a LNG plant with trucked diesel for the long term
Site Infrastructure and Support Facilities	• permanent site access via the western leg of existing Highway 11 • establish buildings and support facilities onsite • temporary camp located near Old Arena Road and Michael Power Boulevard • sewage treatment for the temporary camp through a connection to the municipal system
Hydro One TS Relocation	• Hydro One TS north and west of Old Arena Road near Mosher Lake
MTO Patrol Yard	• MTO Patrol Yard west of PDA on Highway 11
Closure	• open pit enhanced filling with water • cover and vegetate WRSAs to the extent possible • cover and vegetate TMF to the extent possible • buildings and infrastructure removal and disposal

These preferred alternative methods were carried forward for the Project description and effects assessment and collectively form the Project. The methods used to conduct the environmental effects assessment of the Project are described in Chapter 6.0 (EA methods). A detailed analysis of potential effects resulting from the Project and identification of mitigation measures was undertaken for the individual VCs in Chapters 7.0 through 19. 0. Additional supporting information to this alternatives assessment is provided in Appendices G1 through G11.

4.4 REFERENCES

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