Executive Summary

Greenstone Gold Mines GP Inc. (GGM, the Proponent) proposes the establishment, construction, operation, decommissioning and closure of an open pit gold mine and ancillary activities, collectively known as the Hardrock Project (the Project). The Project is located approximately 275 kilometres (km) northeast of Thunder Bay, Ontario, in the Ward of Geraldton.

Greenstone has retained Stantec Consulting Ltd. (Stantec) to prepare environmental management plans for the Project, in support of the environmental assessment (EA) process. This report discusses preliminary criteria and provides guidance for management of waste rock to control acid rock drainage (ARD) and metal leaching potential (ML).

Approximately 550 Mt of waste rock will be generated by the Project. Waste rock will contain up to 4.0 wt% of PAG material and is not expected to generate ARD conditions for at least 70 years after exposure. The preferred mitigation option for ARD is blending PAG and non-PAG rock during deposition. The guidance for classification and blending of PAG and non-PAG rock is presented in the report.

Between 72% and 83% of waste rock associated with the clastic and intrusive rock types have elevated leaching potential. For construction of exposed mine features (e.g., roads, ore milling and processing plant area), it is recommended to use non-PAG chemical sediments, which have low ARD/ML potential. Any waste rock can be used for construction of permanently saturated structures or if they will be covered by tailings in case of internal TMF dykes. GGM is continuing the geological characterization and testing of each lithology which will be used to help refine and optimize the management of waste rock.

The current preferable option for mitigation of ML is collection of runoff and toe seepage from WRSAs and subsequent active treatment during operation. During closure, this water will be diverted to the open pit. The pit lake will be permanently stratified, at the end of closure period. Collected from the WRSAs will be sent to the lower portions of the pit lake where sulphate reducing conditions are expected to develop. This will result in the formation of metal sulphide precipitates and reduction in trace element concentrations. When the pit is full, outflow from the pit will be discharged to the Southwest Arm of Kenogamisis Lake and is expected to meet the PWQO within a very small distance from the discharge point based on the assimilative capacity of the receiver.

Following completion of the additional geochemical characterization work that is on-going a detailed waste rock monitoring program will be developed.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABA</td>
<td>acid base accounting</td>
</tr>
<tr>
<td>Al</td>
<td>aluminum</td>
</tr>
<tr>
<td>AP</td>
<td>acid generating potential</td>
</tr>
<tr>
<td>ARD</td>
<td>acid rock drainage</td>
</tr>
<tr>
<td>As</td>
<td>arsenic</td>
</tr>
<tr>
<td>Co</td>
<td>cobalt</td>
</tr>
<tr>
<td>EA</td>
<td>environmental assessment</td>
</tr>
<tr>
<td>GGM</td>
<td>Greenstone Gold Mines GP Inc.</td>
</tr>
<tr>
<td>Kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>Kt</td>
<td>one thousand tonnes (metric)</td>
</tr>
<tr>
<td>L</td>
<td>litre</td>
</tr>
<tr>
<td>m</td>
<td>metre</td>
</tr>
<tr>
<td>m²</td>
<td>square metre</td>
</tr>
<tr>
<td>mg</td>
<td>milligram</td>
</tr>
<tr>
<td>ML</td>
<td>metal leaching</td>
</tr>
<tr>
<td>mm</td>
<td>millimetre</td>
</tr>
<tr>
<td>MMER</td>
<td>Metal Mining Effluent Regulations of the Fisheries Act</td>
</tr>
<tr>
<td>Mt</td>
<td>million tonnes (metric)</td>
</tr>
<tr>
<td>NP</td>
<td>neutralization potential</td>
</tr>
<tr>
<td>NPR</td>
<td>neutralization potential ratio</td>
</tr>
<tr>
<td>PAG</td>
<td>potentially acid generating</td>
</tr>
</tbody>
</table>

*Stantec*
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWQO</td>
<td>Provincial Water Quality Objectives</td>
</tr>
<tr>
<td>Sb</td>
<td>antimony</td>
</tr>
<tr>
<td>tpd</td>
<td>tonnes per day</td>
</tr>
<tr>
<td>U</td>
<td>uranium</td>
</tr>
<tr>
<td>WRMP</td>
<td>Waste Rock Management Plan</td>
</tr>
<tr>
<td>WRSA</td>
<td>waste rock storage area</td>
</tr>
<tr>
<td>Wt%</td>
<td>weight percent</td>
</tr>
<tr>
<td>yr</td>
<td>Year</td>
</tr>
</tbody>
</table>
Greenstone Gold Mines GP Inc. (GGM, the Proponent) proposes the establishment, construction, operation, decommissioning and closure of an open pit gold mine and associated facilities, collectively known as the Hardrock Project (the Project). The Project is located in the Municipality of Greenstone, Ontario, in the Ward of Geraldton, at the intersection of Highway 11 and Michael Power Boulevard.

GGM has retained Stantec Consulting Ltd. (Stantec) to complete the federal and provincial environmental assessment (EA) process for the Project. In support of the EA, a geochemical testing program (Stantec 2015; 2016a) was completed to characterize the acid rock drainage (ARD) and metal leaching (ML) potential of overburden, waste rock, ore, and tailings materials that will be generated as part of the mine construction and operations. The results of the geochemical characterization program were used to support the development of the mine plan, the completion of water quality predictions and development of the Water Management Plan for the Project (Stantec 2016b).

The Project is estimated to generate approximately 550 Mt of waste rock and 15 Mt of overburden that will be placed in dedicated locations for long-term storage with a limited quantity used in construction of Project infrastructure.

1.1 WASTE ROCK MANAGEMENT PLAN OBJECTIVES

The primary objective of this WRMP is to provide the geochemical testing and characterization program that will be implemented to guide the use, storage, and management of waste rock for the Project. Specifically, this first WRMP iteration discusses:

- identify criteria for waste rock use based on the ARD/ML characteristics;
- procedures to be implemented during operations to classify and manage various waste rock lithologies for ARD; and
- methods to control ARD from waste rock storage based on the geochemical properties of the material.

This WRMP has been developed based on the geochemical characterization program that has been completed to-date (Stantec 2015; 2016a). This work will continue during the mine life and the results will be used to inform adaptive management and update the WRMP as required.

This WRMP is closely integrated with other management plans that have, or will be, developed as part of the Project. Specifically, a Water Management Plan (Stantec 2016b) has been developed to address water management activities related to the WRSAs and ore stockpiles based on the current geochemical characterization and criteria identified in this WRMP. A Conceptual Closure Plan has also been developed for the Project to guide the development of the Project to meet final closure requirements (Stantec 2016c).
HARDROCK PROJECT - WASTE ROCK MANAGEMENT PLAN

Introduction
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Details on the Project are included in the Project Description, discussed in Chapter 4.0 of the EA. The Site Plan is included in Figure 1-1 and the site layout for the WRSA is provided in Figure 1-2.
Figure No. 1-2: Site Layout and Waste Rock Catchment Areas

Legend

Key Project Components
- Access Road
- Diversion Channel
- Fresh Water Pipeline
- Haul Road
- New Power Line 115kv
- Power Line Realignment 44kv
- Natural Gas Line
- Tailings Pipeline and Overhead Powerline

Existing Features
- Highway
- Major Road
- Local Road
- Contour (1 m Intervals)
- Watercourse - Permanent
- Watercourse - Intermittent
- Catchment Area
- Wetland (Eco-Site Based)
- Wetland (Unevaluated - MNRF Data)
- Waterbody

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.

January 2016

Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Site Layout and Waste Rock Catchment Areas
2.0 WASTE ROCK STORAGE AND USE

Preliminary estimates indicate the requirement for waste rock during construction through LOM to be about 31 Mt. This estimate includes both waste rock need during initial construction phases (approximately 3.5 Mt) for access roads and pads and initial starter dams for the TMF. The balance of waste rock will be required during operations for raising of the TMF dams and general mine construction.

Waste rock will be placed in a series of storages areas located in close proximity to the open pit. This includes four WRSAs (A, B, C and D) located around the majority of the open pit perimeter while accommodating the ore milling and processing plant area and avoiding overprinting the Southwest Arm Tributary. A portion of WRSA A will also be extended into the open pit area during backfilling of the eastern-most area of the main open pit (Figure 1-1).

The location of the WRSAs were selected to be reasonably close to the open pit to reduce the overall Project environmental footprint, and to limit energy consumption and dust generation associated with shorter material hauling distances. The WRSAs have been designed to maintain short-term and long-term physical stability. Based on the foundation conditions, segments of the WRSA embankments have been designed with average slopes of 2H:1V to 4H:1V. The footprints of WRSAs A, B, C, and D are approximately 133 ha, 79 ha, 116 ha, and 221 ha, respectively.

Two contingency waste rock storage areas, Contingency AC and Contingency D (Figure 1-2), have been identified that may be used if required for waste rock storage or for the temporary storage of topsoil and overburden soils for rehabilitation efforts. Contingency WRSAs would be used in the event that portions of the foundation conditions of primary areas, based on conditions in the field, are deemed not suitable for anticipated capacities as mining progresses. The contingency WRSAs may also be used in the event that waste rock volumes are slightly higher than expected or increase based on refinement to the mine plan as mining advances.

Prior to developing a WRSA, perimeter ditches and storage ponds will be constructed to collect seepage and runoff from the WRSA. Perimeter ditches are to direct water to the collection ponds by gravity, wherever possible. Low areas, where gravity drainage of the ditches to the collection ponds is not practical, will drain to small sumps, with the water pumped to the collection ponds. Details are provided in the Water Management Plan related to WRSA surface and seepage collection and management (Stantec 2016b)

Specifications for WRSAs and in-pit backfill are presented in Table 2-1, and the location of the WRSAs is shown in Figure 1-2.
**HARDROCK PROJECT - WASTE ROCK MANAGEMENT PLAN**

Waste Rock Storage and Use  
January 2016

**Table 2-1: Waste Rock Storage Area Capacities and Geotechnical Design Parameters**

<table>
<thead>
<tr>
<th>Waste Rock Storage Area</th>
<th>Capacity (kt)</th>
<th>Height (m)</th>
<th>Footprint (ha)</th>
<th>Geotechnical Parameters</th>
<th>Active Dumping (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Overall Slope (rise:run)</td>
<td>Catch Bench Width (m)</td>
</tr>
<tr>
<td>A</td>
<td>73,600</td>
<td>93</td>
<td>69</td>
<td>1:2</td>
<td>7</td>
</tr>
<tr>
<td>A_Tailings</td>
<td>27,500</td>
<td>45</td>
<td>57</td>
<td>1:4</td>
<td>27</td>
</tr>
<tr>
<td>A_Extension</td>
<td>13,900</td>
<td>93</td>
<td>-</td>
<td>1:2</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>87,300</td>
<td>93</td>
<td>79</td>
<td>1:2 or 1:2.5</td>
<td>7 or 12</td>
</tr>
<tr>
<td>C</td>
<td>80,200</td>
<td>95</td>
<td>71</td>
<td>1:2</td>
<td>7</td>
</tr>
<tr>
<td>CC</td>
<td>42,400</td>
<td>85</td>
<td>45</td>
<td>1:2</td>
<td>7</td>
</tr>
<tr>
<td>D</td>
<td>302,100</td>
<td>93</td>
<td>220</td>
<td>1:2.5 to 1:3</td>
<td>12 to 17</td>
</tr>
<tr>
<td>In-Pit</td>
<td>21,400</td>
<td>260</td>
<td></td>
<td>1:1.6</td>
<td>30</td>
</tr>
<tr>
<td>Contingency AC</td>
<td>45,500</td>
<td>54</td>
<td>43</td>
<td>1:2.3</td>
<td>12</td>
</tr>
<tr>
<td>Contingency D</td>
<td>325,100</td>
<td>93</td>
<td>205</td>
<td>1:2.3</td>
<td>12</td>
</tr>
</tbody>
</table>
3.0 GEOCHEMICAL CHARACTERIZATION AND ARD/ML MANAGEMENT CRITERIA

The geochemical testing programs were completed to characterize the ARD/ML potential of waste rock (Stantec 2015; 2016a). The following sections provide a brief overview of the geology for the Project area and characterization work for the waste rock based on the work completed by Stantec (2015; 2016a) and GGM.

3.1 GEOLOGY

The Project is located within the east-west trending, isoclinally folded Wabigoon Subprovince, of the Archean Superior Province. The local setting is represented by the southern meta-sedimentary unit of the Beardmore-Geraldton Greenstone Belt, which is interpreted as a sequence of interlayered sandstone-argillite (greywacke and arenite) and minor polymictic conglomerate with multiple horizons of chemical sediments (Lafrance et al. 2004). The majority of chemical sediments is represented by banded iron formation. Intrusive rocks include the Hardrock Porphyry, diorite, gabbro, and Proterozoic diabase dikes. Sulphide replacement zones are hosted in chemical sediments and are usually less than a metre across. Extrusive igneous rocks are minor and include an ultramafic talc-rich unit, basalt, and lapilli tuff, which range in composition from mafic to felsic.

All rocks have undergone metamorphism at least to a schist facies grade; therefore, for simplicity, the prefix “meta” will be dropped from the name of the rocks and units. GGM has developed over 24 main lithologic codes with numerous sub lithologic codes. The following provides a summary of the seven main rock groups and their corresponding percentage of the waste rock to be generated from the Project:

- 11% - Chemical Sediments (C) – chert, banded iron formation;
- 72% - Clastic Sediments (S) – mudstone, siltstone, sandstones, conglomerate;
- 0.4% - Extrusive Rocks (E) – ultramafic, mafic, intermediate, felsic;
- 16% - Intrusive Rocks (I) – ultramafic, mafic, intermediate, felsic;
- 0.9% - Metamorphic Rocks (M) – marble, schist;
- 0.04% - Non-ore Veining (V) – carbonate, quartz-carbonate, quartz, magnetite, and sulphide; and
- 0.06% - Host Rock Replacement (R) – magnetite, sulphide, arsenopyrite-silica.

The primary waste rock to be generated during the Project include the Clastic Sediments that represent about 72% of the waste rock, with the Chemical Sediments and Intrusive Rocks representing the next main rock types. Together these three lithologies represent 99% of the waste rock to be generated by the Project.
3.2 GEOCHEMICAL CHARACTERIZATION

The geochemical testing program began in 2013 for the Project and has continued through 2015. Between 2013 and 2015, five hundred and thirteen (513) samples representing waste rock, ore, overburden and tailings were tested for acid base accounting (ABA), shake flask extraction and total metals. Composite samples for each of these of these materials were subjected to laboratory and field kinetic tests. In addition, GGM analyzed approximately 8,000 samples for total sulphur, total carbon and trace element content in order to produce a block model to estimate percentages of potentially acid generating (PAG) materials. The field kinetic testing program was continued through 2015 along with some additional testing to support tailings porewater characterization.

The following section presents a summary of the geochemical characterization for ARD and ML potential based on Stantec (2015) and Stantec (2016a) for the major waste rock lithologies.

3.2.1 ARD Potential

The CTotal/STotal ratios were related to neutralization potential ratio (NPR) as shown of Figure 3-1. NPR of criteria of 2 was used to produce thresholds for ARD classification. For samples with a NPR value below 2, the highest CTotal/STotal value was 0.8. This value was selected as the CTotal/STotal threshold for ARD classification and all model blocks with CTotal/STotal < 0.8 were classified as PAG material. The block model indicates that waste rock will contain up to 4.0 wt% of PAG material based on this NPR criteria.

Conservative estimates indicate that minimum ARD onset time for PAG rock is approximately 70 years (Stantec 2016a). No PAG samples were found in clastic sediments (S) and intrusives rock (I) as a result these lithologies are classified as non-potentially acid generating (non-PAG). PAG samples are found as replacement zones generally occurring in or in contact zones associated with banded iron formation (chemical sediments). The replacement zones are usually less than a meter across, making lithology-based segregation not feasible during operation. However, mixture of replacement zones with other lithologies still can constitute minable blocks classified as PAG based on total carbon and total sulphur grades as discussed in the previous paragraph. These PAG blocks may be separated with conventional mining equipment, if required.

3.2.2 ML Potential

ML potential was based on a comparison of average annual concentrations from leachates to the Metal Mining Effluent Regulation (MMER) limits and the Provincial Water Quality Objectives (PWQO) (Stantec 2015 and 2016a). The PWQO values are used as preliminary screening criteria to determine ML potential. The leachates were generated from composite samples of major lithologies under field conditions in 2014 and 2015. Between 2014 (Year 1) and 2015 (Year 2) a decrease in leaching potential for various parameters was identified (Stantec 2016a). To provide a conservative assessment of long-term leaching potential, the leaching rates based on
Based on leachate quality and water quality model predictions, the chemical sediments are classified as having a low ML potential. Clastic sediments and intrusives are currently classified as materials with elevated ML potential, which is being further evaluated as discussed below.

GGM is continuing the geological characterization and testing of each lithology. The testing program will be continued to evolve through the LOM and used to help refine and optimize the management of waste rock.

The current testing program includes the following components:

- GGM conducted sampling and multi-elemental analysis on approximately 4,000 samples of waste rock and ore;
- approximately 20 composite samples for major lithologies with different As and metal grades were created for laboratory and field kinetic tests, which started in 2015; and
- the field kinetic testing program initiated in 2013 will continue through 2016 to provide an indication of long-term metal leaching rates and monitor the declines observed in 2015.

The results of these studies will be used to refine the waste rock management plan for the Project.
Figure 3-1: NPR$_{Sid}$ vs C$_{Total}$/S$_{Total}$ for Individual Samples from Different Lithological Units.
4.0 METHODS FOR ARD/ML CONTROL

Four approaches can be considered to address the ARD/ML potential from waste rock and are discussed in this section:

- reduce sulphide oxidation resulting in lower acid generation and metal release;
- neutralize acid by co-deposition of PAG and non-PAG waste rock;
- reduce movement of acid and metals within pore water by reducing infiltration by implementing progressive rehabilitation measures; and
- collection and treatment of drainage from waste rock.

A brief summary of these approaches is presented below. Detailed plans for managing ARD/ML waste rock will be developed annually during the production schedule stage of mine planning.

4.1 REDUCTION IN SULPHIDE OXIDATION

Reduction in sulphide oxidation rates by two to three orders of magnitude can be achieved by limiting oxygen availability and saturating PAG materials with water (Elberling et al. 2003). One method to achieve this is by submerging waste rock with elevated ARD potential in water, such as an open pit. This will be considered for rehabilitation of the initial starter or satellite pits, and during later stages of operations when partial backfilling of the eastern portion of the open pit occurs.

A second method is to place waste rock with elevated ARD potential where it will be permanently covered with saturated material and isolated. For the Project waste rock with elevated ARD/ML potential could be used for construction of permanently saturated portions of internal TMF dykes.

4.2 BLENDING OF PAG AND NON-PAG WASTE ROCK

As discussed in Section 3.2, the volume of PAG waste rock generated by the Project will be low with the majority of the waste rock having high neutralization potential. As a result, co-disposal of PAG and non-PAG waste rock is the preferred approach to manage the small volume of PAG waste rock. For overall management of PAG waste rock, the following criteria were developed to evaluate the blending requirements and to guide the deposition planning for the PAG waste rock.

4.2.1 Blending Requirements

The objective co-deposition is to sufficiently mix PAG and non-PAG rock so that the PAG rock does not acidify, resulting in neutral drainage from WRSAs. This approach also reduces concentrations of metals such as Co, which is less mobile in non-acidic conditions.
HARDROCK PROJECT - WASTE ROCK MANAGEMENT PLAN

The geochemical basis for blending is discussed by (Mehling et al. 1997) and involves layering of PAG and non-PAG rock based on geochemical characteristics. The geochemical requirements for the blending can be summarized as follows:

1. non-PAG rock layers should be always above PAG deposition areas to provide alkalinity (dissolved neutralization potential [NP]) that will migrate into the PAG layer below;

2. the acid producing rate in the PAG areas should not exceed rate of alkalinity supply from layer above. This requirement can be achieved by controlling the maximum thickness of PAG layer ($H_{\text{PAG max}}$); and

3. the non-PAG rock layer should have more net NP than net AP (acid generation potential) of the PAG layer below. This requirement can be satisfied by maintaining a minimum thickness of the non-PAG layer ($H_{\text{non-PAG min}}$) and minimum distance of the PAG area from the lift base face ($L_{\text{PAG min}}$).

The second requirement, maximum thickness of areas for PAG deposition was estimated using Equation 4-1.

$$H_{\text{PAG max}} = \frac{\text{Alk} \times \text{Inf}}{(\text{Rso}_4 \times \text{Conv} \times \text{Wk} \times \rho \times \text{SF})}$$  \hspace{1cm} (Eq. 4-1)

The numerator of this equation represents annual alkalinity supplied by infiltration from the non-PAG layer per square metre and the denominator is annual acidity production in the PAG layer per cubic metre. The inputs to the equation and related assumptions are listed below:

- **Alk** – alkalinity in pore solution infiltrating from the non-PAG rock, 62 mg CaCO3/L. This value is the 2015 average alkalinity observed in field leach bin WR-S2 (Table 4-6, Stantec 2016a). This value is conservative as it represents the lowest average alkalinity observed among all field leach bins containing the major waste rock lithologies.

- **Inf** – infiltration rate 458 L/m²/yr (or 458 mm/yr). After rehabilitation of the WRSAs, infiltration is assumed to be 60% of average annual precipitation (764 mm/yr, Stantec 2016b).

- **Rso₄** - sulphate leaching rate from PAG layers estimated from regression analysis between average 2015 sulphate leaching rates and concentration of sulphide sulphur shown of Figure 4-1. The sulphate leaching rate of 8.5 mg/kg/week was calculated and used as input to equation 4-1 for average sulphide sulphur content in replacement zone samples (10 wt% see Table 4-3 in Stantec 2016a).

- **Conv** – Conversion factor for rate from sulphate mg/kg/week to mg CaCO₃/kg/week, 1.05, mole/mole or unitless

- **Wk** - number of week in year, 52.2 weeks/yr

- **ρ** – bulk density, 2130 kg/m³ (G-Mining 2015, pers. comm.)

- **SF** - scaling factor reducing sulphate leaching to full scale dump is 0.036, unit less (See Table 5-2 and related text in Stantec 2016b), unitless.
The resulting maximum thickness of the PAG rock layer \( (H_{\text{PAG, max}}) \) is 0.79 m, which was rounded up to 0.8 m for practical purposes.

To satisfy the third requirement for blending listed above, the minimum thickness of non-PAG rock \( (H_{\text{non-PAG, min}}) \) and minimum distance of the PAG layer from the lift base face \( (L_{\text{PAG, min}}) \) were estimated using equation 4-2 and 4-3, respectively.

\[
H_{\text{non-PAG, min}} = H_{\text{PAG, max}} \times \frac{\text{Net AP}_{\text{PAG}}}{\text{Net NP}_{\text{non-PAG}}}
\]  
(Eq. 4-2)

- \( H_{\text{PAG, max}} \) - maximum thickness of PAG rock layer, 0.8 m
- \( \text{Net AP}_{\text{PAG}} \) - net acid potential of PAG rock. Average net acid potential for replacement zone is 264 kg CaCO$_3$/t (Table 4-3, Stantec 2016a).
- \( \text{Net NP}_{\text{non-PAG}} \) - net neutralization potential of PAG rock. Average net acid potential for chemical sediments is 55 kg CaCO$_3$/t. This value is conservative because it represents the lowest average Net NP among major non-PAG rock types (Table 4-3, Stantec 2016a).

Based on these inputs, the estimate minimum thickness of non-PAG rock is 3.84 m and for management purposes is rounded up to 4 m. The minimum distance of the PAG layer from the lift base face \( (L_{\text{PAG, min}}) \) was calculated from the minimum total thickness of PAG and non-PAG layers and a face angle as follows:

\[
L_{\text{PAG, min}} = \frac{(H_{\text{PAG, max}} + H_{\text{non-PAG, min}})}{\text{tangent (FA)}}
\]  
(Eq. 4-3)

Where:
- \( H_{\text{PAG, max}} \) - maximum thickness of PAG rock layer, 0.8 m (from Eq. 4-1);
- \( H_{\text{non-PAG, min}} \) - minimum thickness of non-PAG rock layer above PAG rock 4 m (from Eq. 4-2);
- FA – face angle 37 degrees (Table 2-1)

This thickness was calculated to be 6.36 m and rounded up to 6.4 m for practical purposes.

### 4.2.2 Guidance for PAG Rock Management

The guidance for identification and blending of PAG and non-PAG rock can be summarized in the following steps:

1. document lithology, mineralization and alteration of a mining block;
2. take representative samples of blast-drillhole cuttings from all blocks regardless lithology;
3. analyze samples for total concentrations of C and S;
4. average \( C_{\text{Total}} \) and \( S_{\text{Total}} \) for whole block and calculate ratio average \( C_{\text{Total}} \) to average \( S_{\text{Total}} \). If this ratio \( (C_{\text{Total}}/S_{\text{Total}}) > 0.8 \) the block of waste rock is classified as non-PAG. Otherwise, it is classified as PAG rock;
5. After blast, muck pile of the waste rock is marked using two categories:
   
   A. Non-PAG waste rock; and
   
   B. PAG waste rock.

6. PAG rock should not be used in the first layer of the WRSA. A minimum thickness of 4 m of non-PAG waste rock should be placed as the first layer in the WRSA to provide additional safety measures against remaining acidity that may migrate through the pile;

7. Deposit PAG rock within the central portion of the pile maintaining a minimum buffer of 6.4 from the lift face;

8. PAG layer thicknesses should be maintained at or below 0.8 m with at least a 4 m thick layer of non-PAG waste rock above and below; and

9. The topmost layer of the WRSA, excluding soil cover, should be built from non-PAG rock.

4.3 Waste rock covers

WRSA will be progressively rehabilitated and covered to the extent possible with a store and release cover during operation and closure to reduce infiltration into waste rock, which subsequently decreases the rate of pore water movement through the waste rock matrix and reduces the volume of toe seepage after closure. Furthermore, the construction of the WRSA will incorporate drainage management to promote runoff and reduce infiltration rates. Cover requirements will be refined during the mine life based upon on-going monitoring to validate geochemical and model predictions.

4.4 Collection and treatment

Collection of runoff and toe seepage from the WRSAs and TMF has been incorporated into the Project design. Water collected in the seepage collection system for the TMF will be pumped back to the TMF and used to meet mill reclaim demands. Water collected in the runoff and seepage collection system around the WRSAs is transferred to the main mine water pond (Pond M1) and be used to meet mill reclaim demand. Excess water from the Pond M1 will be directed to the effluent treatment plant and discharged to the Southwest Arm of Kenogamisis Lake in accordance regulatory approvals.
Figure 4-1:  Relationship between 2015 Sulphate Leaching Rate and Sulphide Sulphur Content
5.0 WASTE ROCK FOR USE DURING CONSTRUCTION

It is estimated that approximately 3.5 Mt of waste rock and overburden will be required for construction. Any waste rock can be used for construction of permanently saturated structures (e.g., base internal TMF dykes) or if they will be covered by tailings in case of internal TMF dykes. For construction of mine features, such as roads or pads for the processing plant area, it is recommended to use non-PAG rock with low ML potential.

To address ML, chemical sediments have the lowest ML potential among major rock types and may be appropriate for use during construction. This will be confirmed based on the additional testing underway.
6.0 CONCLUSIONS

Approximately 550 Mt of waste rock will be generated by the Project. Waste rock will contain up to 4.0 wt% of PAG material and is not expected to generate ARD conditions for at least 70 years after exposure. The preferred mitigation option for ARD is blending PAG and non-PAG rock during deposition. The guidance for classification and blending of PAG and non-PAG rock is presented in the report.

Between 72% and 83% of waste rock associated with the clastic and intrusive rock types have elevated leaching potential. For construction of exposed mine features (e.g., roads, ore milling and processing plant area), it is recommended to use non-PAG chemical sediments, which have low ARD/ML potential. Any waste rock can be used for construction of permanently saturated structures or if they will be covered by tailings in case of internal TMF dykes. GGM is continuing the geological characterization and testing of each lithology which will be used to help refine and optimize the management of waste rock.

The current preferable option for mitigation of ML is collection of runoff and toe seepage from WRSAs and subsequent active treatment during operation. During closure, this water will be diverted to the open pit. The pit lake will be permanently stratified, at the end of closure period. Collected from the WRSA water will be sent to the lower portions of the pit lake where sulphate reducing conditions are expected to develop. This will result in the formation of metal sulphide precipitates and reduction in trace element concentrations. When the pit is full, outflow from the pit will be discharged to the Southwest Arm of Kenogamisis Lake and is expected to meet the PWQO within a very small distance from the discharge point based on the assimilative capacity of the receiver.

Following completion of the additional geochemical characterization work that is on-going a detailed waste rock monitoring program will be developed.
7.0 REFERENCES


