Weld Range Iron Ore Project

Acid Mine Drainage Management Plan

Document Number WR15-1015-EV-PLN-001

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<thead>
<tr>
<th>REV</th>
<th>DESCRIPTION</th>
<th>ORIGINATOR</th>
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<th>DATE</th>
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<tbody>
<tr>
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## TERMS AND ABBREVIATIONS GLOSSARY

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABA</td>
<td>Acid-Base Accounting</td>
</tr>
<tr>
<td>AMD</td>
<td>Acid and Metalliferous Drainage (previously referred to as Acid Mine Drainage)</td>
</tr>
<tr>
<td>AMDMP</td>
<td>Acid and Metalliferous Drainage Management Plan</td>
</tr>
<tr>
<td>AMIRA</td>
<td>Australian Mineral Industries Research Association</td>
</tr>
<tr>
<td>ANC</td>
<td>Acid Neutralising Capacity</td>
</tr>
<tr>
<td>ANFO</td>
<td>Ammonium Nitrate Fuel Oil</td>
</tr>
<tr>
<td>ANZECC</td>
<td>Australian and New Zealand Environment and Conservation Council</td>
</tr>
<tr>
<td>ARD</td>
<td>Acid Rock Drainage</td>
</tr>
<tr>
<td>ARI</td>
<td>Annual Recurrence Interval</td>
</tr>
<tr>
<td>BIF</td>
<td>Banded Iron Formation</td>
</tr>
<tr>
<td>DITR</td>
<td>Department of Industry, Tourism and Resources</td>
</tr>
<tr>
<td>GARD</td>
<td>Global Acid Rock Drainage</td>
</tr>
<tr>
<td>H2SO4</td>
<td>Sulphuric acid</td>
</tr>
<tr>
<td>INAP</td>
<td>International Network for Acid Prevention</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>Mtpa</td>
<td>Million tonnes per annum</td>
</tr>
<tr>
<td>NAF</td>
<td>Non acid forming</td>
</tr>
</tbody>
</table>
NAG  Net Acid Generation

NAGpH  pH of the test solution in the NAG laboratory test procedure

NAPP  Net Acid Producing Potential

NATA  National Association of Testing Authorities

NPR  Net Potential Ratio

PAF  Potentially acid forming

PAF-LC  Potentially acid forming – low capacity

PER  Public Environmental Review

SRK  SRK Consulting

TDS  Total dissolved solids

UC  Uncertain (waste rock classification)

UC(NAF)  Uncertain waste rock classification, but more likely to be NAF than PAF

UC(PAF)  Uncertain waste rock classification, but more likely to be PAF than NAF
1.0 INTRODUCTION

Western Australia’s economy is heavily dependent on mineral resource projects and its future growth and development rely on the continued viability of resource development projects. The Weld Range Iron Ore Project will provide financial and social benefits for the area through employment, infrastructure and flow-on effect to the non-mining sector.

Figure 1.1 Location Map
Sinosteel Midwest Corporation Ltd (SMC) is an incorporated entity set up to conduct mineral exploration, engineering, environmental and economic studies into the feasibility to mine Weld Range 60km NW of Cue.

The Weld Range Iron Ore Project (the Project) is a direct shipping iron ore project with high grade outcrops over a 60 km strike length. SMC is targeting to export 15 million tonnes per annum (Mtpa) of iron ore over a 15 year period, however, this Management Plan covers the first 11 years of planned operations. To implement this project, major infrastructure will be designed, installed and constructed immediately, with production scheduled for 2014, and decommissioning in 2024.

There are a number of potentially significant environment impacts expected as a result of the Project. As a result, environment management plans for the significant factors have been developed as a primary method of controlling, managing and monitoring these known and expected environmental impacts. The management plans and elements of the Project’s Environmental Management System (EMS) that will be used to achieve the environmental objectives, targets and commitments of the Project and the application of mitigation measures.

It is a primary objective that all environmental impacts during operation of the Project are avoided or minimised as far as reasonably practicable; consistent with the principles of environmental protection. Environmental impacts will also be evident during construction of the Project infrastructure and the objectives and management practices within these plans will also apply to these construction activities.

Compliance with commitments outlines in this document will be internally audited by SMC and subject to external audits by the relevant regulatory agencies, including the Department of Environment and Conservation (DEC) and the Department of Mines and Petroleum (DMP).

1.1 Project Background

A Public Environmental Review (PER) document was released for public comment in September 2010 and this Acid Mine Drainage Management Plan (AMDMP) represents one of the commitments in the PER.

The Weld Range Iron Ore Project is a new mining project that has progressed beyond the feasibility assessment phase and is now moving towards obtaining the necessary approvals from government regulators and development of plans for construction of infrastructure, mining operations and environmental management.
Design of waste dumps, infrastructure and mining schedules is currently in the early planning phase. For this reason, this document is best considered as a strategic plan for the prevention, control and mitigation of potential AMD issues at the Weld Range mine site. Sinosteel will review and update this document on a regular basis. The current version of the AMDMP will be used by Sinosteel in the planning and construction phases of the project so that risks associated with production of AMD can be evaluated and controlled. Over time, it will evolve into a working document that will be used by site personnel throughout the operating and closure phases of the project.

There is no specific regulatory guidance documentation issued in Western Australia that prescribes requirements for AMD studies. Sinosteel has referred to the following two documents, which represent current industry best practice for general guidance:

- Commonwealth Department of Industry, Tourism and Resources (DITR) 2007, Managing Acid and Metalliferous Drainage.

### 1.2 Acid and Metalliferous Drainage

Acid Rock Drainage (ARD) is a term to describe the potential environmental risks associated with the exposure of reactive sulphide minerals to the chemical and biological weathering effects of air, water and microorganisms. Activities such as mining involve the excavation of rocks containing sulphide minerals, which in turn presents potential ARD risks across the mine site. The drainage produced from weathering of sulphidic rocks is generally acidic with significant concentrations of soluble heavy metals and metalloids.

Adoption of the term Acid and Metalliferous Drainage (AMD) has been recommended in recent times to reflect the fact that not all problematic drainage from oxidation of sulphide minerals is necessarily acidic. Near-neutral or alkaline, but metalliferous drainage can be just as difficult to manage as acidic drainage. In addition to environmental problems caused by the acidity and metalliferous content of AMD fluids, acid generation can be mitigated by reaction with acid-neutralising minerals, especially calcium and magnesium carbonates, present in the sulphidic rocks or in regolith materials through which the AMD flows. Although the acid-neutralising reactions reduce concentrations of soluble acidity and metals, they often result in formation of a highly saline leachate (dominated by calcium and magnesium sulphates).

Potential AMD related issues may arise wherever sulphidic materials are exposed, transported, processed or stored at the mine site. These areas include:
• Open pit walls and floor
• Underground workings
• Waste rock stockpiles
• Run of mine and low grade ore stockpiles
• Tailings or rejects storage facilities
• Concentrate or Direct Shipping Ore storages
• Sediment retention ponds.

Numerous factors affect the oxidation rate of sulphide bearing rock and mine wastes and the fate of the acidic oxidation products. These include chemical, physical and biological factors, all of which need to be considered when preparing a management strategy. Dependent on the nature of the materials and the receiving environment, some of these factors will be more prominent than others.

AMD poses a potential significant risk to the operations of a mine. Once the AMD process has commenced, it can be difficult to eliminate and costly to manage. The process is likely to continue to progress until supply of oxygen, water, sulphide minerals or the sources of metalliferous leachates has been exhausted.
2.0 BACKGROUND

2.1 Project Description

Sinosteel proposes to develop a new iron ore mine at Weld Range, located approximately 65 kilometres southwest of Meekatharra and 50 kilometres northwest of Cue in Western Australia. The Project has high grade outcrops over a 60 kilometre strike length. Sinosteel is targeting to export 15 million tonnes per annum (Mtpa) of iron ore over a 15 year period.

High grade iron ore mineralisation occurs within the Weld Range as a series of outcroppings of extensive goethite - hematite lodes. Many of these outcroppings have been identified along Weld Range. The proposed Weld Range Ore Iron Project is expected to have a footprint of approximately 35.89 square kilometres. Impact on the Weld Range from mining (pits and waste dumps) is approximately 10%.

Mining will occur at two main deposits, namely Beebyn and Madoonga. The ore will be fragmented at the mine face using conventional Ammonium Nitrate Fuel Oil (ANFO) and controlled blast designs. The ore from the pits will be transported via road train to a central processing facility, located midway between the pits. The ore will be crushed, screened and stockpiled as lump and fines iron ore prior to being re-claimed and loaded onto railway wagons by an automatic rail car loader.

2.2 Waste Rock Characterisation

Sinosteel engaged SRK Consulting (SRK) to carry out a geochemical characterisation program to assess the potential for AMD from rock exposed during mining. The rock is likely to be exposed in waste rock dumps, low grade ore stockpiles and the mine pit walls.

The geochemical investigation was carried out in two phases. The first phase was designed to identify lithologies that may produce acid and those that may consume acid, and to assess the overall variability of acid generation potential (i.e. iron sulphide minerals) and acid neutralisation capacity in the lithological units. In the second phase, additional samples were submitted for static testing to improve the acid generation potential and acid neutralisation capacity classification of some rock types and degree of weathering. Selected samples were also subjected to kinetic testing procedures to establish the potential acid generation and metal leach rates that may occur within the waste landform.
A total of 339 samples comprising 265 waste material and 74 ore grade samples were assessed for their acid generation properties. Of these samples, 192 were from the Madoonga deposit and 147 from the Beebyn deposit.

The samples were broadly separated into three classes, depending on their potential to generate acid as follows:

- **PAF** - Where static testing provided clear evidence of net acid generation.
- **NAF** - Where static testing provided clear evidence that the samples were net acid consuming.
- **Uncertain (UC)** - Where static testing did not provide clear evidence of net acid generation of consumption.

All ore grade rock at Madoonga is expected to be NAF.

Combined results for Madoonga samples suggest that 88 to 90% of waste material is expected to be non-acid forming (NAF). Approximately 8 to 10% of the waste material is expected to be potentially acid forming (PAF). The PAF lithologies include Banded Iron formation (BIF), hydrated goethitic clays (hydrate), mafic to ultramafic igneous rock (mafic) and shale. The acid generating properties of up to 3% of the waste material is expected to be uncertain.

Combined results for Beebyn samples suggest that 99% of waste material is expected to be NAF and 1% PAF. All of the ore grade material is expected to be NAF.

While in many cases the criteria for classification are site specific, generally accepted criteria have been developed that usually provide reasonable accuracy with respect to net acid generation. The criteria that have been adopted by SRK are based on methods described in the ARD Test Handbook (AMIRA, 2002) and the net potential ratio (NPR) method described by Price (1997).

NPR is defined as the ratio of acid neutralising potential to acid generating potential, with both measures reported in units of kilograms H$_2$SO$_4$ equivalents per tonne. The NPR classifications and the criteria defining the classifications are shown in Table 2.1.

<table>
<thead>
<tr>
<th>Classification</th>
<th>NPR Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAF</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Table 2.1 AMD Classification Scheme Based on NPR
The AMIRA classification system relies on measurement of NAGpH, the net acid production potential (NAPP) and the NAG (pH 4.5). NAPP is defined as the arithmetic difference between acid generating potential and acid neutralising potential, with both measures reported in units of kilograms H$_2$SO$_4$ equivalents per tonne. NAGpH and NAG (pH 4.5) are parameters provided by the Net Acid Generation (NAG) laboratory test; NAGpH is the pH of the solution following complete oxidation of the test sample with hydrogen peroxide and NAG (pH 4.5) is the amount of acid produced by the hydrogen peroxide acid as measured by titration of the test sample solution to a pH endpoint of 4.5.

The AMIRA classifications and the criteria defining the classifications are shown in Table 2.2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Sub-class</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAF</td>
<td>PAF</td>
<td>NAPP values positive and NAG pH &lt; 4.5</td>
</tr>
<tr>
<td></td>
<td>PAF-LC</td>
<td>Low capacity PAF material with NAG &lt; 5 kg H$_2$SO$_4$/tonne</td>
</tr>
<tr>
<td>NAF</td>
<td>-</td>
<td>NAPP values negative and NAG pH &gt; 4.5</td>
</tr>
<tr>
<td>Uncertain</td>
<td>UC(PAF)</td>
<td>Negative NAPP , but NAG pH &lt; 4.5</td>
</tr>
<tr>
<td></td>
<td>UC(NAF)</td>
<td>Positive NAPP value, but NAG pH values ≥4.5. Some of the sulphur is possibly present in these samples in non-pyritic forms</td>
</tr>
</tbody>
</table>

Estimates of the masses of the various waste rock lithologies and ore grade materials at Madoonga and Beebyn are presented in Table 2.3 and Table 2.4 respectively.
### Table 2.3 Estimates of the Masses of Various Waste Rock Lithologies and Ore grade Materials in each AMD Class at Madoonga

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Mass (t)</th>
<th>NPR AMD Classification Scheme</th>
<th>AMIRA AMD Classification Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NAF</td>
<td>PAF</td>
</tr>
<tr>
<td>Waste Rock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIF</td>
<td>42,846,416</td>
<td>38,666,278</td>
<td>3,135,104</td>
</tr>
<tr>
<td>Detrital</td>
<td>9,419,835</td>
<td>9,419,835</td>
<td>0</td>
</tr>
<tr>
<td>Felsic volcanics</td>
<td>10,548,108</td>
<td>10,548,108</td>
<td>0</td>
</tr>
<tr>
<td>Hydrated</td>
<td>17,223,346</td>
<td>15,501,011</td>
<td>1,148,223</td>
</tr>
<tr>
<td>Mafic</td>
<td>37,908,914</td>
<td>33,918,502</td>
<td>1,995,206</td>
</tr>
<tr>
<td>Magnetite</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shale</td>
<td>12,831,818</td>
<td>6,753,588</td>
<td>4,052,153</td>
</tr>
<tr>
<td>Total waste rock</td>
<td>130,778,437</td>
<td>114,807,322</td>
<td>10,330,686</td>
</tr>
<tr>
<td>Distribution (%)</td>
<td>88%</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>Ore Grade</td>
<td>Mass (t)</td>
<td>NPR AMD Classification Scheme</td>
<td>AMIRA AMD Classification Scheme</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NAF</td>
<td>PAF</td>
</tr>
<tr>
<td>High alumina</td>
<td>1,369,288</td>
<td>1,369,288</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>High silica</td>
<td>8,471,622</td>
<td>8,471,622</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Low alumina + silica</td>
<td>40,303,640</td>
<td>40,303,640</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Total ore grade</td>
<td>50,144,550</td>
<td>50,144,550</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>50,144,550</td>
</tr>
</tbody>
</table>

Table 2.4 Estimates of the Masses of Various Waste Rock Lithologies and Ore grade Materials in each AMD Class at Beebyn
<table>
<thead>
<tr>
<th></th>
<th>Hydrated</th>
<th>Mafic</th>
<th>Magnetite</th>
<th>Shale</th>
<th>Total waste rock</th>
<th>Distribution (%)</th>
<th>Ore Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>210,973,420</td>
<td>226,560</td>
<td>0</td>
<td>233,244,792</td>
<td>99%</td>
<td>48,406,353</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>208,461,832</td>
<td>226,560</td>
<td>0</td>
<td>230,733,204</td>
<td>1%</td>
<td>8,776,403</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>2,511,588</td>
<td>0</td>
<td>0</td>
<td>2,511,588</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>210,973,420</td>
<td>226,560</td>
<td>0</td>
<td>210,973,420</td>
<td>99.6%</td>
<td>0</td>
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<tr>
<td></td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4%</td>
<td></td>
</tr>
<tr>
<td>Ore Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High alumina</td>
<td>8,776,403</td>
<td>8,776,403</td>
<td>0</td>
<td>0</td>
<td>8,776,403</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High silica</td>
<td>1,947,083</td>
<td>1,947,083</td>
<td>0</td>
<td>0</td>
<td>1,947,083</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low alumina +</td>
<td>37,682,867</td>
<td>37,682,867</td>
<td>0</td>
<td>0</td>
<td>37,682,867</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total ore grade</td>
<td>48,406,353</td>
<td>48,406,353</td>
<td>0</td>
<td>0</td>
<td>48,406,353</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3 Mine Waste Disposal Strategy

Madoonga’s waste dump areas are planned at the north side of the pit to avoid environmental issues related to fauna and flora located in the valley south of the pit (Figure 2.5). The Madoonga waste dumps are designed to provide a large storage capacity in the vicinity of the pit area.

Beebyn site currently has three planned waste dumps (Figure 2.5). The first will be a large dump servicing the Beebyn Main pit which has been configured so that the dump ramps are aligned with the south wall pit ramps to provide short waste haulage. Two smaller waste dumps are planned to service the Beebyn West pit. The Beebyn Main pit waste dumping area is south of the pit area to minimise interaction with infrastructure, located north of the Beebyn Main pit. The Beebyn West waste dump is located north of the pit. This has been designed large enough to accommodate the waste from the eastern pod. A separate ramp which aligns with the pod’s exit is also located to minimise the haul distance. As the dump location is away from the main Beebyn infrastructure, the location of the waste dump is less critical.

Figure 2.5 Proposed Locations of Waste Dumps and Associated Infrastructure
3.0 AMD RISK ASSESSMENT

The level of risk posed by potential AMD issues depends on the following main factors:

- Characteristics of the waste materials:
  - Acid producing potential.
  - Acid neutralising potential.
  - Existing salinity and potential to generate additional salinity.
  - Solubility of metals and metalloids under neutral and acidic conditions.
  - Physical properties including drainage characteristics, particle size, mechanical strength and the presence of dispersive clays.

- Waste landform design.

- Characteristics of the receiving environment.
  - Hydrology.
  - Climate.
  - Hydrogeology.
  - Flora and fauna (including stygofauna).

3.1 Waste Characteristics

Comprehensive geochemical waste characterisation conducted by SRK has indicated that almost all of the waste rock from Beebyn is predicted to be NAF, while approximately 10% of waste rock from Madoonga is classified as PAF. By comparison with waste rock from mine sites with known AMD issues, such as black shale waste from the Mt Whaleback mine, the acid generating capacity of Madoonga PAF waste is relatively low and the concentrations of salts and metals are also expected to be relatively low.

The waste rock is expected to be heterogeneous comprising mainly boulders and cobbles of relatively high strength materials with lesser amounts of fine textured wastes that include clays. In addition the waste rock is likely to have a relatively high bulk permeability (with respect to air and water), which increases the potential for interaction with meteoric water and oxygen. This, however, may be controlled to a certain degree by segregation of the waste types by lithology and degree of weathering. Overall, the potential for oxidation reactions is high for this material as oxygen replenishment may occur at a faster rate. However, the low rainfall climatic conditions are expected to minimise the rate of flushing of soluble contaminants from the exposed wastes.
3.2 Waste Landform Design

Design features of the waste landforms will include:

- Engineered surface water drainage to assist drainage and direct surface water flows around
  the base facility.

- Armouring to resist erosion from flood events and surface water flows.

- Seepage interception trenches will be installed downstream of the embankment toes of
  waste rock and low grade ore storages. Runoff from the trenches will be collected in sumps
  and pumped back into the plant, or possibly directed via channelled flow to the pit void at
  closure.

- Placement such that groundwater seepage flows will be towards the pit during operation of
  the mine.

- Geotechnical modelling will be undertaken to ensure long term physical stability of the
  facility.

- Rehabilitation will take place with soil and native vegetation, most likely using a ‘store and
  release’ cover system which are suited to the environmental conditions.

During the operation of the mine the waste facilities will be managed to ensure it functions as
designed. Repair and maintenance work will be carried out on a routine basis and an appropriate
monitoring program implemented. On this basis potential risks to the environment will be significantly
reduced during the operating lifetime of the mine.

Progressive rehabilitation of the facility using an appropriate cover system will provide long term
mitigation of environmental risks. Key design features of the cover system will be to reduce water
infiltration rates, reduce oxygen ingress to PAF materials, provide a growth medium for establishment
of native vegetation and improve the quality of surface runoff.

3.3 Receiving Environment Characteristics

The surrounding environment is not considered to be sensitive to potential AMD impacts from the site
due to:

- The semi-arid climate. As annual evaporation potential is significantly higher than
  precipitation, the potential for leaching in the long term though the waste rock dumps is
  predicted to be very low. The mine can however from time to time experience extreme
  rainfall events as a result of subtropical cyclonic systems moving across WA from the
  northwest coastal regions.
• The nearest river, the Sanford River (a tributary of the Murchison River), is located approximately 25 kilometres to the west of the mine site. The results of modelling at Madoonga Creek (Worley Parsons 2008) suggest that all runoff during 20-, 50- and 100-year ARI design flood events will be contained within a significant salt pan depression immediately north of the Madoonga tenement. Thus there will be little or no outflow through Madoonga Gap.

• The groundwater down gradient from the proposed waste dumps is unlikely to be used for extraction for consumption by humans. Most of the groundwater beneath the waste dumps will flow towards the pit as a result of the cone of depression caused during mine dewatering.

• Surrounding flora and fauna are not likely to come into direct contact with mine site discharges as a result of the proposed surface water management control measures. Therefore no pathway is thought to exist at this time linking these receptors with potential sources of AMD at the mine site.
4.0 AMD MANAGEMENT PLAN

4.1 Management Objectives

The principal objective of the Sinosteel AMDMP is to ensure that all mine waste with potential to generate AMD is contained and isolated so it does not result in long term impacts on the surrounding environment.

In the event that PAF wastes or other materials with potential to form AMD are encountered, the objectives for management are to:

- Identify potential acid generating materials
- Segregate potential acid generating materials from benign materials
- Store potential acid generating materials in a manner that does not generate leachate.

4.2 Management Strategies

Sinosteel's approach to managing AMD is, in order of decreasing priority, to:

- Define the location and maximum amount of existing and potential acidity
- Avoid disturbance of PAF materials where possible
- Store excavated PAF materials in an environment that minimises exposure to air and water
- Mitigate impacts of acidity and soluble contaminants when generation of AMD is unavoidable.

4.3 Materials Characterisation

SRK was contracted by Sinosteel to provide a comprehensive pre-mining waste characterisation of waste rock likely to be exposed or excavated during the life of mine at Madoonga and Beebyn.

Test requirements for pre-mining and on-going waste characterisation include:

- Static testing (NAG, Acid Base Accounting (ABA)) based on total sulphur and Acid Neutralising Capacity (ANC)) of samples of the mineralised waste.
- Static testing (NAG, ABA) of samples of the un-mineralised waste.
- Kinetic testing of selected mineralised waste samples (free draining column leach tests).
- Kinetic testing of selected un-mineralised waste samples (free draining column leach tests).
Elemental analysis of selected mineralised and un-mineralised waste samples.

Water leachate testing of selected mineralised and un-mineralised waste samples.

Review of the SRK waste characterisation data indicates that a criterion of 0.2% total sulphur as a cut-off grade for NAF materials is appropriate. Adoption of this criterion may lead to misclassification of 3% of materials, which is considered as an acceptable risk for these types of waste and the characteristics of the receiving environment. Based on the results of waste characterisation work conducted to date, BIF, hydrated, mafic and shale materials contained more than 0.2% total sulphur will be managed as PAF.

Additional analyses of waste materials will be undertaken during the operation of the mine to verify the predictions of the pre-mining waste characterisation work. Representative samples of the following materials will be collected for laboratory analyses:

- Materials from lithologies previously classified as NAF that contain visible iron sulphide minerals.
- Waste rock materials excavated from lithologies or pit depths that were not part of the proposed pit development when samples for the SRK waste characterisation were selected.
- Waste materials that will be used for encapsulation of PAF wastes.
- Waste materials retained for rehabilitation of the waste landforms upon closure.

Sinosteel will continue to complete kinetic tests on waste rock and tailings samples during operations as defined in the National Handbook “Managing acid and metalliferous drainage” (DITR 2007) to continually improve waste material management. Kinetic tests using blends of different materials (e.g. acid-generating and acid consuming materials) may be established to explore AMD management options.

4.4 Waste Management Strategies

4.4.1 Stockpiling

Stockpiling PAF materials will be minimised where possible as significant amounts of acid and salts can build up, especially in porous stockpiles if left in oxidising conditions for even short periods.

Drainage from stockpiles of high alumina and high silica ore grade materials will be captured, treated if necessary and used at the mine site rather than being discharged to the environment.

4.4.2 Encapsulation of PAF Wastes

To manage the waste materials appropriately, waste rock dumps will be designed with two objectives:
To limit contact between PAF materials and percolating oxygenated water.

To minimise the likelihood that seepages will exert a detrimental effect on local surface and ground water quality, for example, by capturing and managing waste dump drainage appropriately, and if practicable, locating the PAF material away from existing water courses and flood prone areas.

To meet these objectives, the following management strategy based on encapsulation of PAF waste, as shown in Figure 5.1, is proposed.

The base layer of the dump (A) will be constructed of NAF material. The purpose of this layer will be to raise the PAF material above the original ground and prevent direct contact of PAF material with any water flowing at the interface of the original ground and the dump. The minimum thickness of the base layer will be determined based on information such as the saturated and unsaturated hydraulic properties of the base layer, estimates of rates of infiltration into the waste from rainfall, natural seeps and flood levels.

During construction there will be areas of PAF rock that are uncovered and potentially exposed to rain. These exposure times will be minimised as far as possible through scheduling mining or dumping and planning the location of the PAF material in the dump. In order to reduce the load of oxidation products that could be released from PAF material during construction, a layer of low permeability NAF material (B) will be placed over the NAF base layer and under the PAF rock (C). The purpose of layer B will be to limit the rate of downward movement of water and therefore reduce the rate of release of any AMD produced. It is likely that a small portion of water moving downward through the dump will exit the dump at the base and continue to move downward towards the groundwater table.

The waste rock dump will be constructed in several lifts. The number of lifts will be based on geotechnical stability and mine scheduling requirements. Truck and dozer movement on the top surface of the lifts will compact the material and reduce the permeability to water. This will have the benefit of reducing the permeability of the top surface of each lift, potentially reducing water infiltration and promoting runoff. These benefits will be maximised through dump design aspects such as surface contouring and drain construction. Construction design of the dump drainage management system will be focused on shedding all storm runoff as quickly as possible to avoid any temporary pond of rain water on the dump surface.

Batters of the dumps will be constructed of materials resistant to erosion. Batter slopes will be chosen to reduce rates of erosion and thereby maintain the NAF cover. Any PAF material will be encapsulated well away from the dump edge (at least 20 metres) to not only restrict air and water ingress but also allow for later re-profiling of outer batters if so required.
Cut off drains and diversion channels will be constructed to prevent runoff from undisturbed lands contacting the dumps and to separate dump runoff from water running off undisturbed land. Dump runoff will be channelled to settling ponds to detain sediment.

Water drainage lines passing under the dumps that may transport seepage from the dumps will be managed separately.

As studies of the deposit, geochemistry of the waste and other aspects of the project provide further data related to waste rock management the options for alternative strategies will be considered. It is possible that the proposed strategy will be modified in the future during operations to better manage waste material and the potential for AMD.

![Figure 4.1 Encapsulation of PAF Waste Rock](image)

**Figure 4.1 Encapsulation of PAF Waste Rock**

### 4.4.3 Acidity Neutralisation

Neutralisation of PAF through engineered treatment is the least preferred management option due to the difficulty and cost of mixing lime or calcite-rich waste rock with PAF wastes, the low reactivity of lime and reduced neutralising capacity over time as iron, aluminium and gypsum coat the lime particles. Alternative neutralising agents include soda ash (sodium carbonate), caustic soda (sodium hydroxide) or magnesium oxide.

Neutralisation of either PAF waste or AMD seepage, if required, will be conducted in consultation with relevant authorities and geochemical consultants.
4.4.4 Rehabilitation and Closure

PAF material will be covered on both of the side slopes (batters) and top surface with NAF material. A cover (D) designed to limit the infiltration of rain will be constructed on the top surface of the dump as shown in Figure 4.1. It will extend laterally beyond the PAF material. The final design of the cover will be determined based on the annual rainfall, rainfall intensity distribution and potential evapotranspiration. The design would likely include features to promote water shedding of excessive storm runoff while promoting retention of normal rain water to infiltrate into the upper cover units to sustain vegetation and subsequent evapotranspiration.

Engineered features will include appropriate slopes, berms and drains. The top surface of the cover (E) will be suitable for supporting vegetation. The design of the cover has not yet been finalised but is likely to include topsoil and subsoil stripped from the pit surface and waste rock dump footprints prior to starting construction of the pit and dumps.

All materials with potential value for rehabilitation and closure will be identified prior to clearing or excavation, samples collected for laboratory testing to confirm their suitability and stored appropriately until required.

Field trials will be conducted prior to rehabilitation of waste dumps to optimise material selection, appropriate cover thickness and placement methods and to ensure that establishment of native plants will be successful.

4.5 Monitoring

The main purpose of a monitoring program is to provide relevant information that can be used by project planners and site managers as a basis for informed decision making (DITR 2007).

The following objectives that the AMD monitoring strategy is expected to meet are:

- Establishment of existing (baseline) conditions. Establish baseline environmental conditions (physical, chemical, and biological) prior to mine development. Areas particularly sensitive to changes are identified as part of this process.
- Quantitative laboratory assessment of AMD potential.
- Groundwater and surface water drainage monitoring. Early identification of the onset or indications of future release of AMD is essential for implementing effective mitigating strategies.
- Understand contaminant transport processes. Characterise physical and/or geochemical conditions to evaluate the rate of movement of potential contaminants to the receiving environment. This will be undertaken during operational life of the mine.
• Assess impacts to the receiving environment. Characterise current conditions to evaluate potential impacts to the environment. This will be undertaken during operational life of the mine.

• Continuous improvement. Assess the performance of waste management practices, including the engineered designs to reduce, prevent, control, or treat AMD. The monitoring program should be reviewed and updated, as required, during the mining process.

The development of a monitoring strategy will be completed prior to operations commencing on site. Baseline data essential for compiling the strategy document should be gathered during the feasibility and planning stages.

Suitable groundwater and surface water monitoring locations will be identified at least six months before mining operations commence. Factors that will be considered when selecting monitoring locations include:

• A detailed knowledge of the hydrogeology and surface drainage of the site to ensure that bores are positioned in locations that will detect potential AMD before environmental impacts are realised.

• Ease of access by site personnel with compromising personal safety or mining activities in all weather conditions.

• Including locations in a similar hydrological setting to that of the receiving environment, but are unlikely to be impacted by any mining related activities. Reliable baseline data is required so that any changes in water quality by causes other than natural variations are easily detected.

The following field parameters will be measured for all water samples:

• pH.

• Electrical Conductivity (EC).

• Temperature.

• Dissolved oxygen.

All samples for laboratory testing will be collected by following procedure outlined in Australian New Zealand Standard 5667:1998. Samples required analysis for soluble metals will be filtered on site, preserved with addition of acid, and transported to the laboratory within 24 hours.

Water samples will be tested by a NATA-accredited laboratory for the following parameters:

• pH.

• Total Dissolved Solids (TDS).
• Acidity and alkalinity.
• Major anions including calcium, magnesium and sodium.
• Major anions including chloride and sulphate.
• Soluble metals and metalloids including aluminium, arsenic, barium, copper, iron, manganese and zinc.
• Other potential environmental contaminants as indicated by current and future studies at the mine site and relevant scientific literature.

4.6 Trigger Criteria

Specific trigger values for the assessment of site monitoring data are required to be established during baseline data collection. Specific numerical criteria are usually only required for water quality assessment and AMD geochemical assessment of wastes (waste rock and fine rejects).

Criteria for AMD classification of waste rock are discussed in Section 4.3. An interim criterion of 0.2% total sulphur will be used for segregation of NAF and PAF BIF, hydrated, mafic and shale wastes has been proposed.

Criteria for assessing surface water and groundwater quality will eventually be based on site-specific values developed along the guidelines provided in the Australian and New Zealand Guidelines for Fresh and Marine Water (ANZECC 2000). Until sufficient data has been provided to provide reliable trigger values, the following interim criteria will be adopted:

• Groundwater. Livestock drinking water quality for cattle (ANZECC 2000).
• Surface water. ANZECC 2000 criteria for 95% protection of species in slightly to moderately disturbed freshwater aquatic ecosystems.

4.7 Contingencies and Treatment Options

Appropriate management responses will be required when potential environmental impacts are occurring or are about to occur. Suitable treatments can be chemical (blending/neutralisation), physical (containment), or a combination (blending and containment). Treatment is required in situations when:

• Acidic and/or metalliferous leachate requires neutralisation prior to discharge to the environment.
• Waste rock or fine rejects become net acid generating.
• Structural failure of waste storage facilities results in exposure and oxidation of PAF materials.

Given the expected low AMD potential of the materials, a combination of the following treatment systems would be effective:

• Re-circulation of minor acidic discharges back into the process water circuit.
• Passive treatment systems such as wetlands or seepage interception drains lined with crushed limestone.
• Provision for active dosing with hydrated lime, magnesia or caustic soda if highly acidic discharges are produced on site and require treatment. Treated water may be suitable for on-site uses such as process water or dust suppression.
• At the time of mine closure any contaminated seepage discharge can be diverted into the mine voids which are expected to contain pit lakes but remain groundwater sinks.

4.8 Performance Indicators

No environmental impacts from AMD including acidic water runoff from waste dumps and ore stockpiles during construction and operation activities.

4.9 Auditing and Data Evaluation

Review of waste characterisation, surface water and groundwater monitoring data will be reviewed by competent site personnel or consulting scientists on an annual basis.

4.10 Review and Revision

The management plan will be reviewed as known or suspected PAF material is located. The management plan will also be updated to incorporate any changes to existing legislation and guidelines for management of PAF materials and AMD.
5.0 REFERENCES


