EcOz Environmental Services

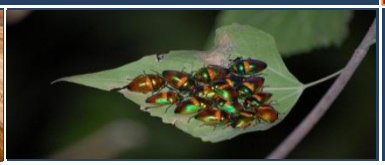
Appendix D

Sherwin Iron (NT) Pty Ltd

Sherwin Creek Iron Ore Project

Supplementary Environmental Impact Statement





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AMD Management Plan

Deposit C Sherwin Creek Iron Ore Project
Sherwin Iron Ltd

Revision No 1
March 2014

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Report

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Synopsis:	This document details the Acid Mine Drainage (AMD) Management Plan for Deposit C, Sherwin Creek Iron Ore Project based upon a detailed assessment of the acid metalliferous/mine drainage (AMD) and metal leaching potential of waste rocks and the potential impacts to the local and surrounding downstream environment.

Document Control

Revision No	Date	Author(s)	Reviewer(s)
1	19 March 2014	Edgardo Alarcón Léon	Carel van der Westhuizen

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Revision

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1	19 March 2014	Submitted to complement responses to EIS assessment	Carel van der Westhuzien
Recipients are responsible for eliminating all superseded documents in their possession			

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Abbreviations

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ASLP	Australian Standard Leaching Procedures
BoM	Bureau of Meteorology
DME	Department of Mines and Energy
EIS	Environmental Impact Statement
EL	Exploration Lease
EPA	Environmental Protection Agency
LoR	Limit of Reporting
ML	Mineral Lease
MLA	Mineral Lease Application
MCP	Mine Closure Plan
MMP	Mining Management Plan
NLC	Northern Land Council
RMCP	Rehabilitation and Mine Closure Plan
SEWPaC	Commonwealth Department of Sustainability Environment, Water, Population and Communities
WMP	Water Management Plan
WRD	Waste Rock Dump

a	annum
d	day
ha	hectare
hr	hour
km	kilometre
m	metre
min	minute
yr	year
s	second

Discipline

Acronym	Parameter Definition/(Determination)	Unit
ABA	The acid-base accounting test was developed in 1974 to evaluate coal mine waste and was modified by Sobek *et al*. in 1978. Acid-Base Accounting is a test to assess the potential of a material to produce both acid and neutralisation potential.	
ACM	Acid Consuming Materials – are materials with capacity to neutralise acid.	kgH_2SO_4/ton
AFP	Acid Formation Potential is the potential for a material to produce acid.	kgH_2SO_4/ton
AMD	Acid Metalliferous/Mine Drainage – originates when sulfide material is exposed to the atmosphere. This causes the formation of sulfuric acid and the potential outflow of acidic and usually highly metal-rich water into the environment. Potential sulfide-bearing material includes waste rock from overburden, interburden, and processed ore (tailings).	

Acronym	Parameter Definition/(Determination)	Unit
ANC	Acid Neutralising Capacity (Laboratory Analysis) - is the measure of acid neutralising capacity, usually expressed by carbonates (e.g. calcite and dolomite) and silicates.	kgH_2SO_4/ton
APR	Acid Potential Ratio (Calculation) – is the ratio of ANC/MPA and is used to classify material as either NAF or PAF (see definitions below).	
ARD	Acid Rock Drainage – the use of this term indicate natural weathering and oxidation unmined outcrops of sulfide bearing materials.	
Kinetic Testing	Tests results provide information on the rate of sulphide reaction over time, time periods for reaction, and control techniques which can optimise treatment and control to address the specific severity and duration of reaction.	
MPA	Maximum Potential Acidity or APP (Acid Production Potential) (Calculation) - It is determined by multiplying the Sulfide-S values (in %) by 30.6, which accounts for the reaction stoichiometry for the complete oxidation of pyrrotite and pyrite by O_2 to $Fe(OH)_3$ and H_2SO_4. MPA does not take into account the effect of any acid consuming materials in the rock material.	kgH_2SO_4/ton
NAF	Non Acid Forming (Calculation). Materials are classified as NAF if either: - Sulfide-S < 0.3%, or - Sulfide-S ≥ 0.3% and NAPP is negative with ANC/MPA ≥ 2.0 (see also PAF definition below)	
NAG	Net Acid Generation or NAP (Net Acid Production) (Laboratory Analysis) –hydrogen peroxide is used to accelerate the oxidation of sulphides present in the material. The acid produced may be partially or totally consumed by acid neutralising components in the material. The pH of the solution is determined and then titrated to pH 7. This gives a value for the Net acid or neutralizing potential of the sample.	kgH_2SO_4/ton
NAPP	Net Acid Producing Potential (Calculation) - NAPP = MPA - ANC. Conceptually, a negative NAPP indicates all acid produced is neutralised and a positive NAPP indicates the material is net acid producing.	kgH_2SO_4/ton
NNP	Net Neutralising Potential (Calculation) - NNP = ANC - MPA. Conceptually, a positive NNP indicates all acid produced is neutralised and a negative NAPP indicates the material is net acid producing. NNP is a conservative measure as it tends to overestimate the acid producing potential because it does not differentiate between acid producing and non-acid producing forms of sulfur.	kgH_2SO_4/ton
PAF	Potential Acid Forming (Calculation). Materials are classified as PAF if either: - Sulfide-S ≥ 0.3% and NAPP is positive, or - Sulfide-S ≥ 0.3% and NAPP is negative, but ANC/MPA < 2.0 (see also NAF definition above).	
SOR	Sulfide Oxidation Rate - Sulfide reaction over period of time.	$mgSO_4/kg/$ week
Static Testing	A static test determines both the total acid generating and total acid neutralizing potential of a sample.	
Sulfide-S	Sulfide Sulfur (Calculation) – is the sulfur in the material present as sulphide. Sulfide Sulfur = Total-S - Sulfate-S	%(w/w)
Total-S	Total Sulfur (Laboratory Analysis) – is the total sulfur in a material in all its forms.	%(w/w)

Executive Summary

The Environmental Impact Statement (EIS) for the Sherwin Creek Iron Ore Project included an assessment of the acid metalliferous/mine drainage (AMD) and metal leaching potential of waste rock and ore to ascertain the potential impacts to the local and surrounding downstream environment. The detailed assessment included the mineralogical assessment of 2,541 samples of drill cuttings and reverse circulation drilling cores and acid base accounting analyses of 26 samples from the bulk sampling area and 28 samples obtained during supplementary investigations.

The salient findings of these investigations and assessments indicated that albeit occurring in a single location in small quantities, acid forming materials are present which may have the potential to cause acid mine/metalliferous drainage and impact on the local and downstream receiving environments.

Consequently Sherwin Iron Ltd committed to implement a site-specific AMD Management Plan and additional AMD investigations and testing during mining to ensure that any potential impact is appropriately mitigated. These investigations and assessments will include:

- Implementing a strategy for the ongoing assessment of risks and management and monitoring of potential acid forming (PAF) materials during mining including setting threshold triggers and implementing appropriate mitigation.
- Employing a site-specific sampling and analysis plan to identify and characterise PAF materials.
- Designing encapsulation cells to contain PAF materials.

This AMD Management Plan addresses these aspects taking due cognisance of the requirements of the guidelines: *Management of Sulfidic Mine Wastes and Acid Drainage* (ACMER, 1999), *Managing Acid and Metalliferous Mine Drainage* (DITR, 2007) and the *Development of the Global Acid Rock Drainage Guide* (INAP, 2011).

This document should be read in conjunction with the report titled *Acid Mine/Metalliferous Drainage (AMD): Implications for Mine Waste Management Deposit C Sherwin Creek Iron Ore Project,* Pendragon Environmental Solutions, 2013.

1. Introduction

The Environmental Impact Statement (EIS) for the Sherwin Creek Iron Ore Project Deposit C (EcOz, 2013) included an assessment of the acid metalliferous/mine drainage (AMD) and metal leaching potential of waste rocks and ore to ascertain the potential impacts to the local and surrounding downstream environment (Pendragon Environmental Solutions, 2013). The specific scope of activities entailed:

- Characterising samples of waste rock and ore in terms of their acid production potential (APP) properties.
- Developing a conceptual site model indicating risks, opportunities, constraints and potential outcomes.
- Analysing overburden, waste rock and ore materials and assess their potential for enrichment and/or release of metals to the environment.
- Assessing the likely potential impacts and risks to surface and ground water resources and the local and surrounding environment coupled with the implications for mining and waste management.

The salient findings of these investigations and assessments (Pendragon Environmental Solutions, 2013) were:

- Geochemical and mineralogical analyses of the exploration samples indicated that concentrations of sulfide-S are predominantly low, averaging 0.03%, with the highest concentrations in ironstone sparse oolites with sporadic occurrences in shales, dolerites and sandstones.
- Most of the near (<30m depth) surface materials across the mine pit possess low S values (<0.25%) and classify as non-acid forming materials.
- The assessment of samples from the bulk sampling area indicated that 85% of the samples were, on the basis of their low sulfide-S concentrations and positive APRs, non-acid forming (NAF). The remaining 15% fell within the zone of uncertainty (when comparing net acid generating (NAG) against NAPP) or were classified as PAF materials (based on their ANC/MPA ratios <1).
- A supplementary assessment indicated that out of 28 samples, 3 classified as uncertain and 1 as PAF material.
- Paste pHs ranged between 5.4 and 8.0, averaging 6.4 (circumneutral). Electrical conductivity ranged between 8µS/cm and 105µS/cm, averaging 39µS/cm.
- The majority (84%) of samples classified as PAF materials occur outside the perimeters of the proposed open pit and/or are beneath the base thereof.
- A large number of samples comprising ferruginous sandstones, sandstones, shales and quartzite have high APRs (>10) indicating these materials have elevated potentials to neutralize acidity.

Coupled with these findings, a mine waste rock balance indicated that in a mass balance of 212Mt only 0.03% or 59,255t (or 21,550m^3) of waste rock has the potential to generate acidity.

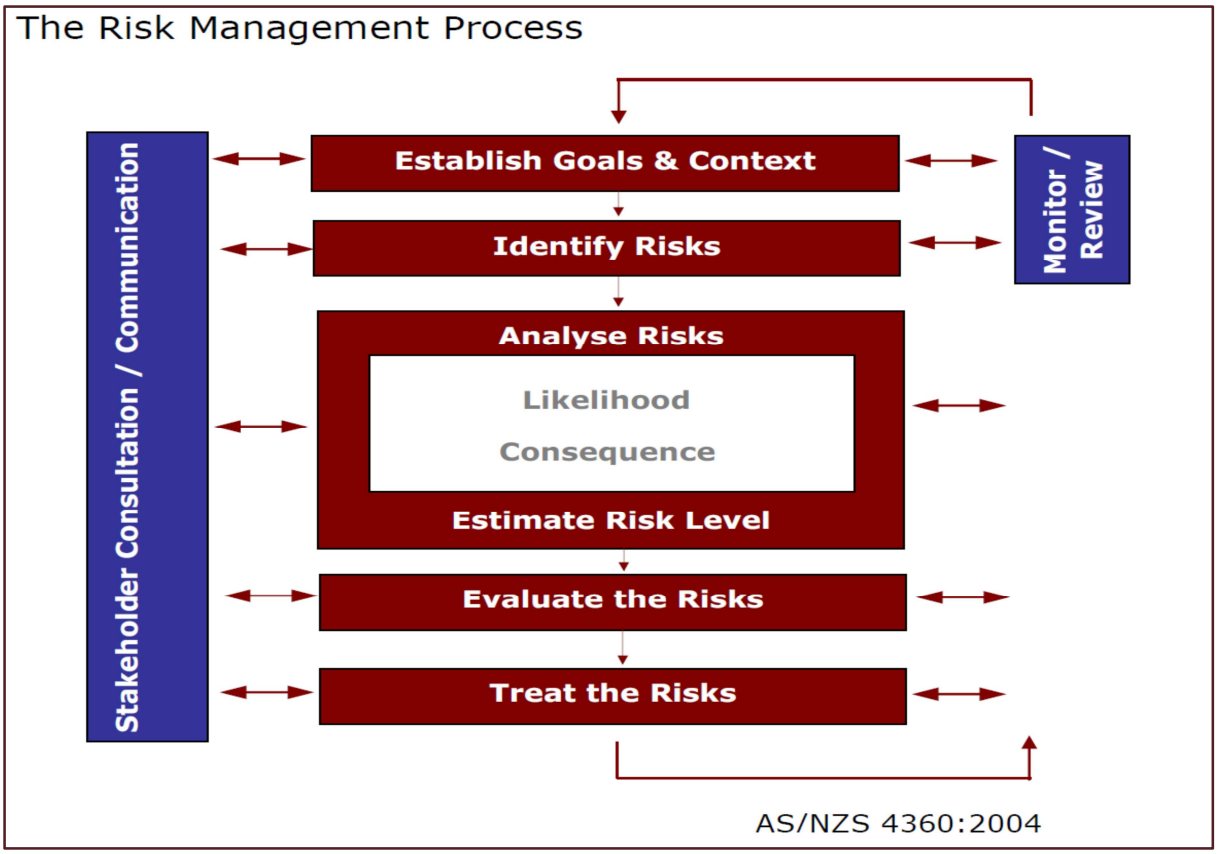
Although the potential for acid forming of the materials is low and although they occur across a small area that will be mined during the latter half of the project, these materials will require appropriate management to prevent impacts on the local and surrounding downstream receiving environments. To ensure that the risks are appropriately mitigated, a risk assessment framework has been introduced.

2. Risk Assessment Framework

2.1 Definitions

Risk: The possibility of AMD impacting upon the environment measured in terms of its likelihood and consequences (refer Appendix A).

Risk Management: The risk management process used in this document is based on the AS/NZS 4360:2004 depicted below:



Risk Manager(s): Person(s) responsible for the AMD Risk Management System.

Elimination: Stop using equipment or stop undertaking the procedure/activity causing the risk.

Substitution: Use an alternative substance, equipment or process which poses less risk.

Isolation: Separate receivers from the source of the risk.

Engineering controls: Reduce exposure to the risk by making physical changes to equipment, procedures or the work environment.

Change work practices: Adopt work procedures which minimise exposure to the risk.

2.2 AMD Risk

The risk of AMD needs to be properly understood and assessed (Appendix A) based on its relevance in the context of the development and its operating environment. The key features at Deposit C may be summarised as:

- Although the volume of PAF materials is small i.e. 59,255t (or some 21,550m^3) and occur across a small area, these materials will require appropriate management to prevent impacts on the local and surrounding downstream receiving environments.
- PAF materials will be excavated during year 4 (likely 3rd Quarter); provisions to adequately dispose of these materials will be implemented during year 3 prior to excavation and disturbance.
- The ground water level is below the base of the open pit and pit dewatering due to ground water influx will not be required. Rain falling within the perimeters of the open pit will be directed to sumps from where it will be used as a first source of water for dust suppression when available.

2.3 Risk Mitigation

Senior managers shall be responsible for approving, reviewing and updating the AMD risk mitigation activities. The selection of AMD risk mitigation methodologies shall take into account site-specific conditions, the costs associated with the proposed actions, logistics to implement the proposed procedures, effectiveness of proposed mitigation methodologies and the time required implementing them. All mitigation activities shall be reviewed regularly, taking due cognisance of field observations and monitoring data, to determine their impact on the risk and their effectiveness in the medium to long term.

Taking cognisance of site-specific conditions at Deposit C and the volume of PAF materials that may need to be disposed of appropriately, the following methodologies are practical in nature and achievable on site:

Table 2.1: AMD Mitigation Methodologies.

Methodology	Requirements	Advantages	Disadvantages
Delineation, selective handling and encapsulation	▪ Identification and quantification of PAF materials ▪ Identification of materials that are geochemically and geotechnically stable for encapsulating ▪ Physical and chemical properties of materials for encapsulation to prevent oxygen/water ingress and leaching ▪ Hydrology and hydrogeology of the PAF cell and surrounding area ▪ Mining method (i.e. blasting, excavation/mining equipment)	▪ Inhibit ingress of oxygen and water ▪ Adaptable to site environmental conditions ▪ Cells may be constructed away from post-mining open water bodies and groundwater recharge zones. ▪ Geological location and presence of alkaline materials may minimize construction requirements	▪ Reactive materials are to be excavated/covered immediately to prevent prolonged exposure to oxygen and water ▪ Costs and methodology used to segregate PAF from alkaline material ▪ Uncertainty of long-term geochemical/ geotechnical/physical stability and cell sustainability.
NAF/PAF Blending	▪ Identification, quantification and balance of sulfide/alkaline materials ▪ Quantify sulfide/alkaline oxidation rates by regulating oxygen, water bacteria or other limiting factors such as environmental conditions ▪ Control of alkalinity and acidity interactions to precipitate and immobilise oxidation products and other soluble constituents ▪ Mining method (i.e. blasting, excavation/mining equipment)	▪ Improved management by better definition of NAF/PAF ratios ▪ Presence of alkaline materials may minimize requirements for treatment and construction ▪ May improve water quality if alkaline leachates were to occur ▪ Dominance of alkaline materials may ensure circumneutral to alkaline drainage ▪ Reduces sulfide oxidation by yielding oxidising environments with circumneutral pHs	▪ Segregation of PAF/NAF materials may be difficult ▪ Definition of NAF/PAF ratios requires rigorous material characterisation and laboratory and field kinetic testing ▪ Uncertainty in geochemical processes and likelihood of alkaline deficiencies increasing the likelihood of AMD formation ▪ Achieving uniform mixing rates ▪ May require addition of alkaline chemicals to abate acidic drainage ▪ Requires encapsulation to prevent leaching of reactive alkaline materials ▪ Costs: material characterisation and segregation methodologies

Methodology	Requirements	Advantages	Disadvantages
Alkaline Treatment			In addition to the above: ▪ Neutralizing acidity is limited by the solubility of the input alkaline material ▪ The use of chemicals require additional treatment, management and logistical support ▪ Alkaline conditions may exceed permit requirements and also impact water quality in the downstream environment

NAF/PAF blending methodologies have been favoured at some sites due to the likelihood of improving PAF management by using on-site alkaline materials but it invariably requires some form of encapsulation. The alkaline treatment methodology is generally not preferred as it implies additional costs to import chemicals and also require additional management and treatment. However, this technology may be applied at sites where extreme PAF with no or little NAF concentrations exist and/or where other remedial approaches have failed.

The primary objective is to contain the PAF materials and prevent contact between the sulfide bearing mineral and oxygen and/or water. At Deposit C the PAF bodies are relatively small and isolated and evaporation exceeds rainfall by several orders of magnitude which may limit the quantity of water that may infiltrate waste bodies. Infiltration can be prevented or inhibited by using soil/rock covers, including the use of sealing layers comprising clay and/or crushed weathered NAF materials.

The choice of methodology is generally dictated by the applicability/practicality and the economic and environmental factors surrounding the site. Since the extent of the PAF zone at Deposit C is localized and the anticipated volume small, the management and treatment of these materials may be limited to excavation (year 4) with care and immediate placement in a pre-constructed (year 3) cell. Capping, and consequently encapsulation of the PAF materials will be undertaken continuously as the cell is filled from one end to another before the materials are exposed to air and/or rain for prolonged periods. This methodology is considered the most sustainable as the others require higher levels of management and equipment.

3. AMD Risks and Management

3.1 General

3.1.1 Life Cycle Approach

The life cycle approach is designed to promote better environmental practice and continuous environmental improvement and awareness of AMD issues and risks (Figure 3.1).

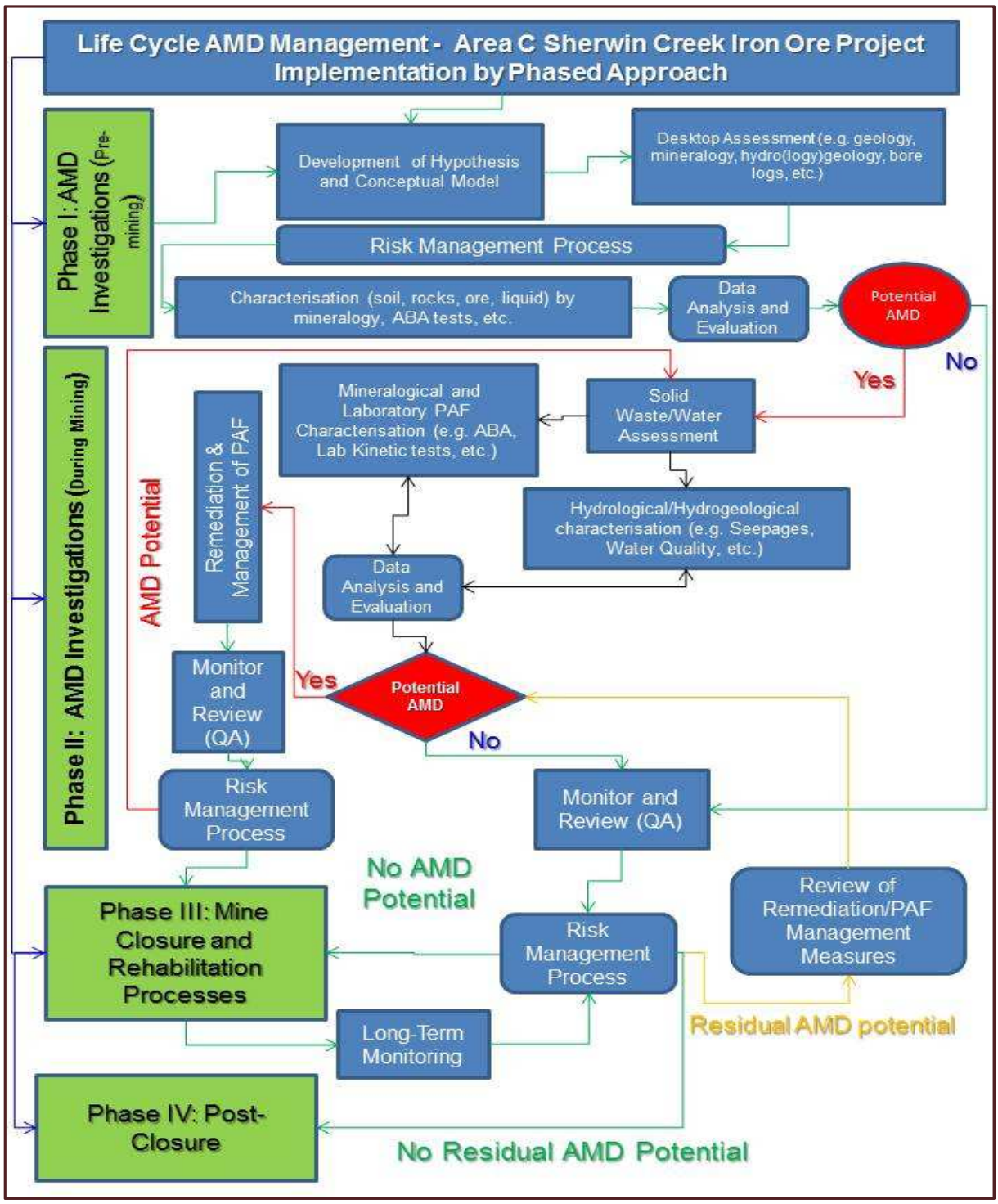


Figure 3.1: Life Cycle AMD Management.

The life cycle approach for AMD management commences with pre-mining investigations and assessments and subsequently continues until after rehabilitation and closure and generally entails a phased approach during which activities are prescribed by the outcomes of early investigation and assessment of the risk of the potential for AMD. The framework articulated in Figure 3.1 aims to focus on early identification of AMD and its risk to direct the effort on prevention or minimisation rather than treatment and/or control. The blue lines in the flowchart link the main phases of mining; the green lines indicate a pathway without a potential for AMD, the orange lines pathways with residual AMD and the red lines a pathway with AMD potential. This AMD Management Plan is to be included in the overall Mine Management Plan and will be reviewed, amended and improved if and when required.

3.1.2 Potential Contamination Pathways and Receptors

A source-pathway-receptor conceptual site model is depicted in Figure 3.2. Sulfur bearing mine spoils is the primary source of contaminants and may be released through soils and water (primary release mechanisms and media) and through several exposure pathways and routes to ecological and human receptors. Whilst Figure 3.2 indicates potentially complete future exposure pathway (do nothing scenario), by means of risk assessments, appropriate measures (i.e. isolation and encapsulation) are devised and implemented to close the pathway.

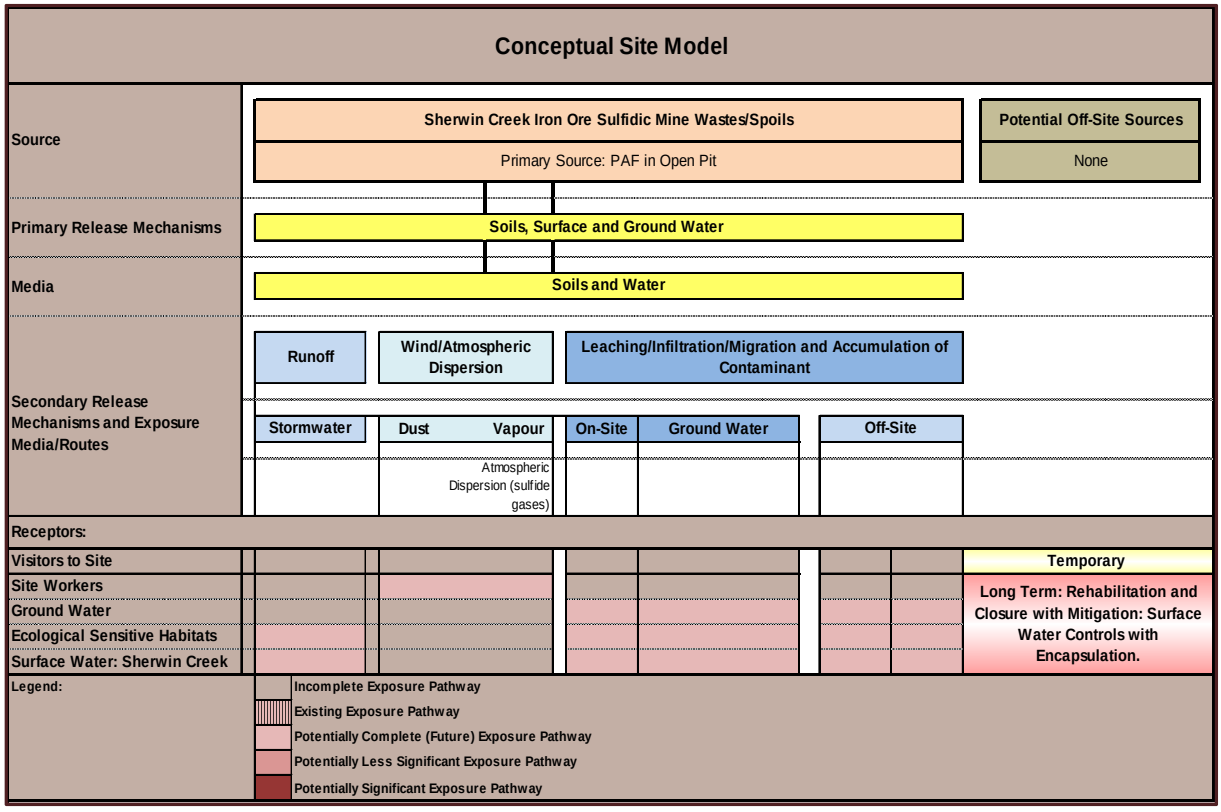


Figure 3.2: Contaminant Pathways and Receptors.

3.2 Site specific Risk Assessment

The life-of-mine risk assessment in Table 3.1 includes key parameters such as environmental, human health and commercial risks and is to be reviewed and implemented when mining commences with continuous reviews and amendments if and when required thereafter.

Table 3.1: Risk Assessment, Mitigation and Management.

Risk Identification and Analysis				Inherent Risk Rating			Control/Mitigation Measure	Residual Risk Rating			Further Actions
Number	Issue	Cause	Impact	L	C	R		L	C	R	
Surface Soils, Surface Water and Groundwater											
Activity: Mining method entails excavation in benches and partial backfilling of open pits.											
Social/Cultural											
1	Social/Cultural Environmental	PAF Materials and WRDs	Exposed acid water bodies	B	3	M	PAF encapsulation and construction of geotechnically and geochemically stable WRDs	B	2	L	Limit accessibility Monitoring
Extraction of Iron Ore and AMD											
2	Excavation within and/or in proximity to PAF materials	Open Pit	Contamination of surface and ground water	D	3	H	Demarcate, progressively excavate and implement measures such as burial, sealing and compaction to contain/encapsulate/cover and prevent PAF materials to oxidise. Bench where possible in lengths that permit easy and quick extraction, remediation and closure.	B	2	L	Construct cell in which PAF materials can be placed and covered in a mined out section of the open pit near foot wall. Develop surface covers.
3	Removal of overburden, ore and waste rocks.		Pit excavation: Expose PAF to the atmosphere and trigger oxidation	**D**	**3**	**H**	Where PAF is exposed, compact sides and base and seal off the excavation before backfilling.		2	**L**	Implement cover systems to contain and encapsulate PAF materials. Monitor.
4	Extraction of Ore	Benching and ore extraction.	Ingress of oxygen and/or water into PAF bearing zones.	D	**3**	H	Demarcate and bench to selectively remove overburden, ore and extract exposed PAF materials.	**B**	2	**L**	Assure cover is thick enough to prevent oxidation of PAF materials. Provide surface covers. Monitor.
5	Interconnection of PAF with surface/rain-runoff water via bench excavations.		Oxidation of PAF materials and production of acid leachates.	**C**	4	**H**	Immediately compact and cap exposed PAF materials.	**B**	2	L	Monitoring of capping performance. Monitoring of surface and ground water. Review management plans.
6	Acid water discharge		Impact to receiving overburden and water bodies	C	3	H	AMD will be managed and treated by daily monitoring key parameters such as pH. If pH<4.6, then: ▪ Neutralise solutions to pH (5.6 to 8.5) using neutralising agents such as calcite pellets, lime sands, etc. ▪ Remove metals using suitable filtration and flocculation.	B	2	L	Investigate and provide additional controls. Assess and monitor impacts of acid and/or saline residual waters in overburden, waste rock and ore bodies.
Reference should be made to Appendix A. Notes: L denotes Likelihood, C Consequence and R Risk Rating.											

3.3 Staged AMD Management Plan

3.3.1 Phase I: Pre-Mining AMD Investigations

Pre-mining investigative activities included Acid Mine/Metalliferous (AMD) investigations and assessments (Pendragon Environmental Solutions, 2013) which indicated that PAF materials are

present at the site. Further detailed assessment indicated that these materials are confined to a small area and are small in volume.

Following the pre-mining assessments further investigation and assessment were committed to in the EIS. These investigations and assessments included continuous ore grade control, ABA tests where needed, segregation and encapsulation:

- Continuous grade control (years 1 and 2) with dependability on mineralogical analysis and assessment, particularly on XRF scans and with limited laboratory assays analysis. Grade control in year 3 will include additional field measurements and complemented with laboratory AMD analytical investigations where needed.
- This phase of characterisation will assist with an early identification of PAF materials and with the refinement of the PAF/NAF materials ratio and therefore with recalculations of the block model. This will also trigger actions such as demarcations and isolation of zones at which PAF materials may exist. Depending on the economic value, extent and risks that the materials may represent, these will be excavated to be encapsulated and/or isolated and covered permanently by the pit-backfilling activities.

3.3.2 Phase II: AMD Investigations during Mining

The investigations and risk assessments in Phase I provided an understanding of the risk of AMD associated with mining activities and detailed various methods that may assist with prevention of AMD and prevention of the potential negative long-term environmental consequences. During Phase II, the life-of-mine risk descriptors and their potential hazards are assessed in terms of mine planning, timing and activity plans (Figure 3.3).

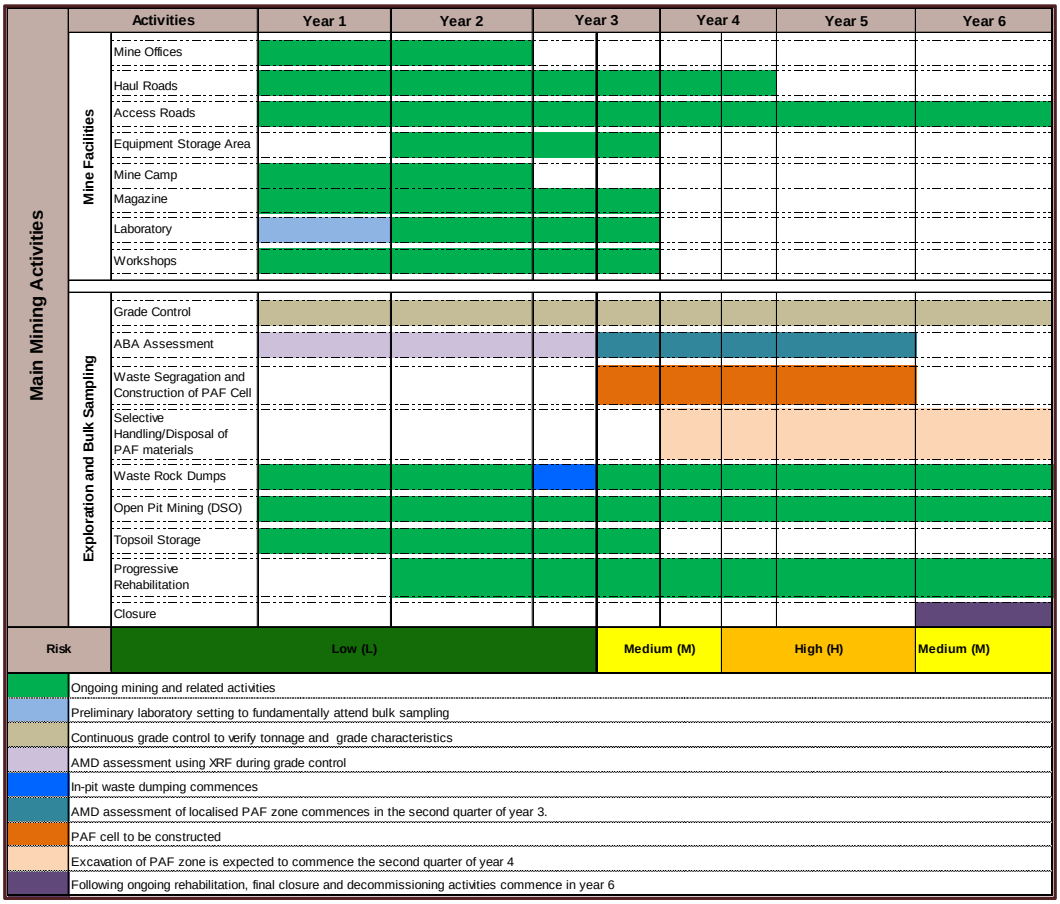


Figure 3.3: Mining Program (from start-up to year 6).

In the absence of PAF materials, mining during the first few years has a lower incidence and therefore a lower hazard (Figure 3.3). At the start of year 3, particularly around the 3rd quarter, mining will progress into the northern part of Deposit C. The mid-northern part in which PAF materials were delineated during Phase I (Figure 3.4) will now be subject to grade control to verify tonnage and grade characteristics. The mineralogical evaluations that form part of the grade control in conjunction with the triggers detailed in Table 3.2 will determine the need for PAF management controls, ABA assessments and construction of the cell for the encapsulation of PAF materials.

Specifically Phase II will incorporate:

- Demarcation, control and monitoring of excavated materials, particularly PAF zones, during mining.
- Gradual removal and disposal of PAF materials in a dedicated cell with continuous compaction and capping.
- On-going monitoring and assessment to refine potential impacts on local ecosystems and downstream environments.

Table 3.2: Triggers for Field Spoil Characterisation and Disposal.

XRF Assessment	Paste pH Assessment	Geochemical Characteristic	Further Assessment
Total S < 0.25%	<4.6	*Uncertain/NAF*	Paste pH - ABA
Total S < 0.25%	>4.6	NAF	NIL
Total S >0.25% - <0.30%	<4.6	*Uncertain/NAF*	XRF, paste pH, ABA
Total S>0.25% - <0.30%	>4.6	NAF	Paste pH – ABA
Total S>0.30% - 0.75%	>4.6	*Uncertain/PAF*	XRF, paste pH - ABA
Total S>0.30% - 0.75% - >0.75%	<4.6	PAF	ABA, Kinetic testing

The primary threshold and trigger values and their implications with regard to waste disposal are:

- Total-S < 0.25%. A limited number and/or selected samples (refer Table 3.3) will be sent for ABA laboratory analytical assessment to ascertain whether these are NAF and to assess the neutralising capacity of these materials. These materials are to be disposed of as NAF. The low grade ore and waste rock fall in this category.
- Total-S > 0.25% but < 0.30%; materials will undergo field paste pH testing. If the paste pH is below 4.6 materials will undergo ABA laboratory analytical assessment. These materials, pending the outcome of the field and laboratory testing will be disposed of as NAF or PAF.
- Total-S > 0.30%; materials will undergo field paste pH and ABA laboratory analytical testing but is most likely to be disposed of as PAF materials.
- Total-S > 0.75%; because the geochemical characteristics of these materials are well defined, they would not be subjected to further laboratory assessment and will be disposed of as PAF materials in an encapsulated cell.

The field paste pH test (1:4 w/w solid:liquid) is a simple method for determining readily available acidity and alkalinity and the immediate reactivity of sulphides and acid neutralising minerals (Appendix B). The approach adopted for the site includes a combined assessment of XRF and field paste pH which will ultimately determine the NAF/PAF characteristic of the materials in question. Where identified as uncertain, materials will undergo further assessment prior to disposal as either NAF or PAF. During mining, as a first order field approach, if after the XRF and paste pH tests there are still uncertainty, taking cognisance of ABA testing during earlier grade control, the materials are to be disposed of as PAF.

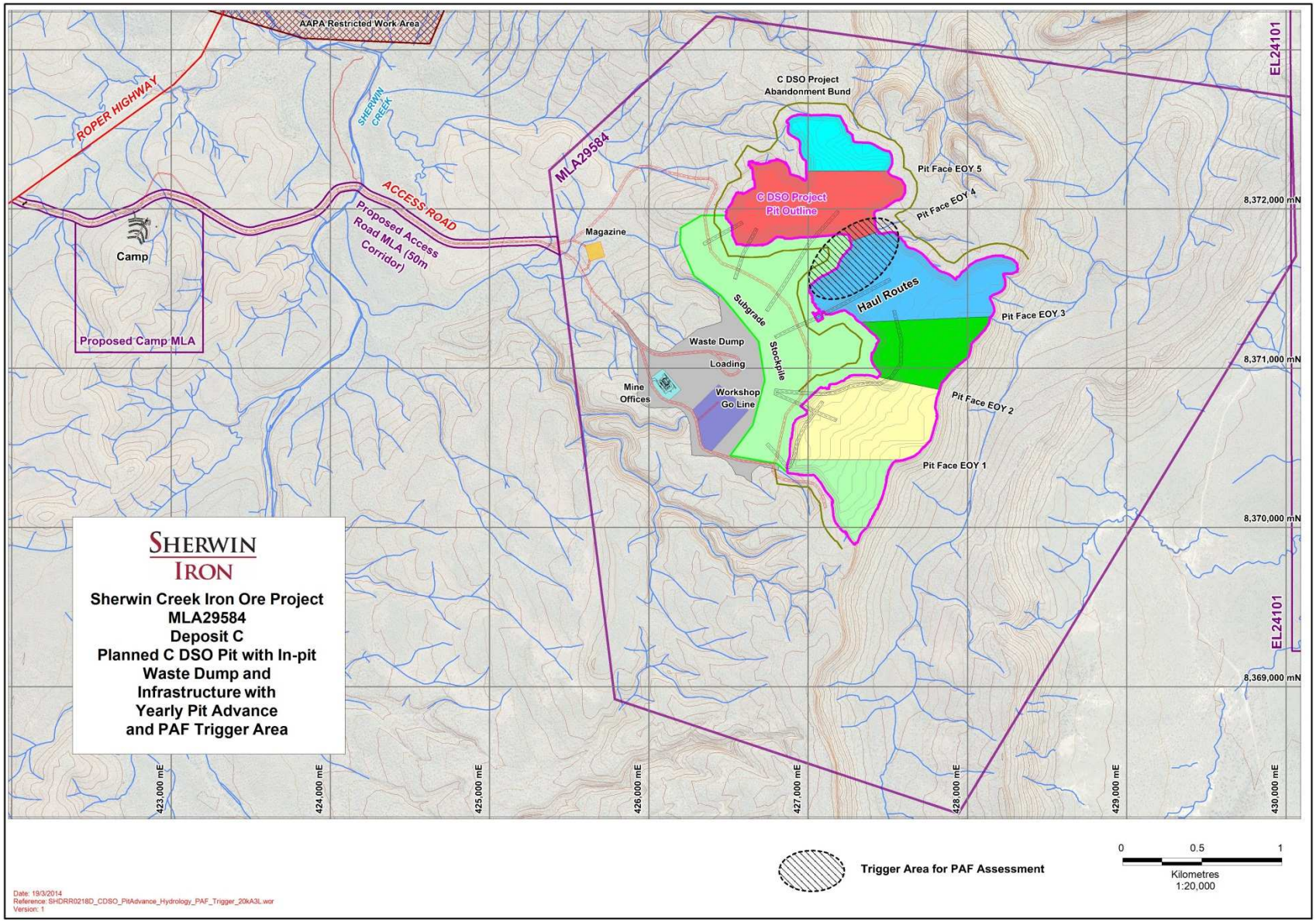


Figure 3.4: Mining Schedule and Location of PAF.

Sampling Frequency

Earlier geochemical, ABA and NAG characterisations indicated that a Total-S concentration of 0.30% is an appropriate boundary between NAF and PAF materials (Pendragon Environmental Solutions, 2013).

Grade control by means of drilling and mineralogical assessment during mining are continuous and approximately a year ahead of excavating the ore. Whilst drill patterns, orientations and frequencies depend on a number of variables, the spacing between bores is generally 4m by 4m. The depth of drilling is determined by the proposed depth of the pit, generally between 10m and 40m. Grade control thus facilitates extraction of representative samples at various depths for mineralogical screens to ascertain the quality of the ore and Total-S (%) concentrations and provides, in addition, a means to ascertain the geochemical properties of the ore and waste rock well in advance of mining.

In view of the findings of the Phase I investigations and the above, the following sampling frequencies are to be adopted:

Table 3.3: Sampling Frequencies.

Activities	Depth (m)		Depth mAHD		Surface Area	Step 1	Step 2 (QA Action)		Step 3 (dependent on Step 1)			Total	
						Mineralogy	If S (<0.25%)		If S (0.25% to 0.30%)		If S (>0.30%)		
	from	to	from	to	m^2	XRF (scan/assay)	Field Paste pH	ABA Tests (if needed)	Field Paste pH	ABA Tests	ABA Tests	XRF	Field/ Laboratory
During Mining	0	10	130	120	230,488	40	10	3	15	4	6	40	38
	10	20	120	110	142,728	40	15	3	20	4	8	40	50
	20	30	110	100	127,130	60	15	5	20	6	10	60	56
	30	40	100	90	93,769	80	15	5	25	8	12	80	65
	40	50	90	80	73,746	100	20	7	25	10	16	100	78
					Total	**320**	**75**	**23**	**105**	**32**	**52**	**320**	**287**

Regardless of the lithology and stratigraphical domains, a number of samples are to be screened for PAF characteristics in relation to depth (Table 3.3). The rationale entails the assessment of about 5% of the total number of samples across each layer at every 10m depth. Because PAF materials were detected at depth, the frequency of sampling increases with depth. In general, the indicative sampling frequency presented in Table 3.3 aims at:

- Accurately defining the spatial distribution of PAF materials in- and outside the pit shell.
- Updating the preliminary mass balance model.
- Adequate quantification and disposal of PAF and NAF materials.

As indicated elsewhere, this may be modified during mining but the overall approach remains valid.

Waste, Low Grade Ore and Ore Material Management

The findings and observations indicated in the report titled *Acid Mine/Metalliferous Drainage (AMD): Implications for Mine Waste Management Deposit C Sherwin Creek Iron Ore Project,* Pendragon Environmental Solutions, 2013, remain relevant and valid for this management plan. However, the Phase II investigations and assessments during mining will provide a new expanded data set and consequently a refined geochemical characterisation which will include:

- Delineation and definition of NAF/PAF characterisations of waste rocks and low and high grade

ores.

- Refinement of the block model to improve waste rock/ore delineation with regard to NAF/PAF characterisation.

The DSO high-grade iron ore is confined to the lower ironstone units. Low grade materials range between 3m and 5m in thickness and comprise clay or shale band iron bearing siltstones. The high, medium and low grade ore will be mined but stockpiled separately in the ROM area. If low grade materials and/or any other materials, are found to contain PAF materials, these will be disposed of with the high-sulfur bearing materials.

Disposal/Encapsulation of PAF Materials in a Cell

A WRD is to be constructed to the western high wall of the open pit during the first year of operations (Figure 3.5). In-pit dumping of wastes is expected to start during year 3 slightly ahead of the construction of the PAF cell (Figure 3.5); the current mass balance indicates that one cell will suffice. However, there is ample space to extend this cell should the need arise.

The PAF cell is to be located (Figure 3.5) at the eastern low wall of the open pit away from the high wall where rain water may pond during the wet season. The cell will be constructed with side-walls and bases of crushed NAF materials up to 5.0m thick (Figure 3.6). Following placement of the PAF materials the cell will also be covered using crushed NAF materials to 5.0m thick. The process of placement and covering will be continuous to facilitate immediate and permanent capping aimed at prevention of the interaction of PAF materials with the atmosphere, particularly with rainfall. If disposal of these materials due to operational activities cannot take place immediately, materials will be provisionally encapsulated with NAF materials to then adequately be disposed of when operations permit.

Additional Technical Measures

Sherwin is committed to implement this AMD Management Plan and is aware that prevention will help avoiding many of the long-term issues and difficulties faced at mine rehabilitation and closure. Additional activities and/or measures committed to and incorporated in the AMD Management Plan include:

- Geotechnical and geochemical classification of clay and weathered NAF materials to assess suitability for constructing impermeable bases and covers for the PAF cells. Current physical assessments indicate that surface soils are largely non-dispersive with low liquid limit and plasticity indexes. While these soils are significant in the low lying areas, soils across the higher lying open pit are thin and largely absent. However, small volumes of clay were located in the southern part of the mine within the current bulk sampling area. These clays are dedicated for construction in facilities where impermeable clay liners or covers will be required. Weathered (fracturing is largely absent) bedrock across the mining area appears to be very competent. Consequently, taking cognisance of the low angles and heights of the pit walls, WRDs and the PAF cells, structural failures are unlikely to occur. Further geotechnical investigations and assessments will be undertaken as mining progresses.

- Ingress of oxygen and water into the PAF cell is to be prevented by engineered dry covers. The applicability of store-release covers for the WRDs is currently being investigated further.

- Monitoring will include ponds at the plant, open pit and WRDs.

- PAF Management: AMD management processes implemented in year 1 will be reviewed and

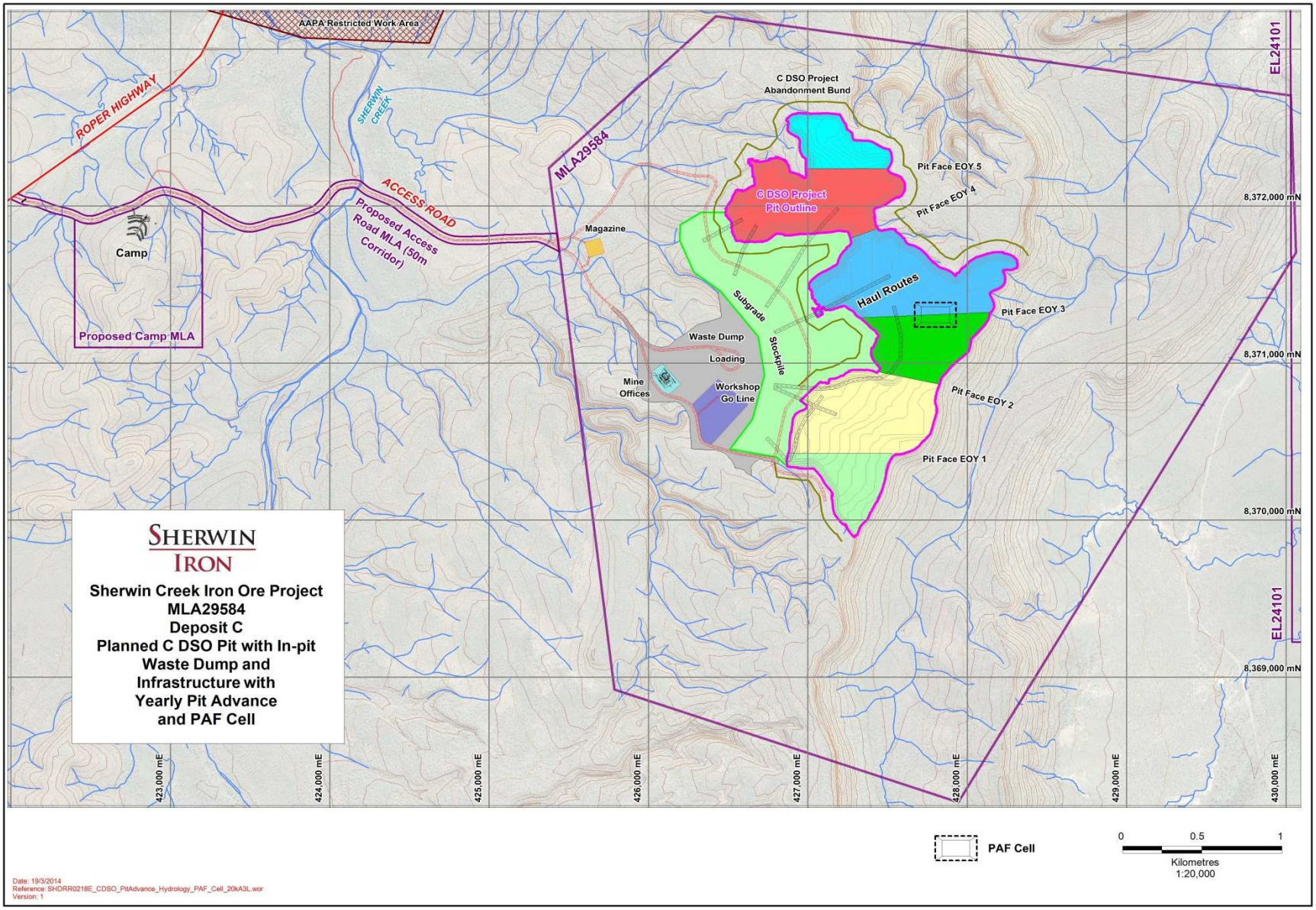


Figure 3.5: Location of PAF Cell.

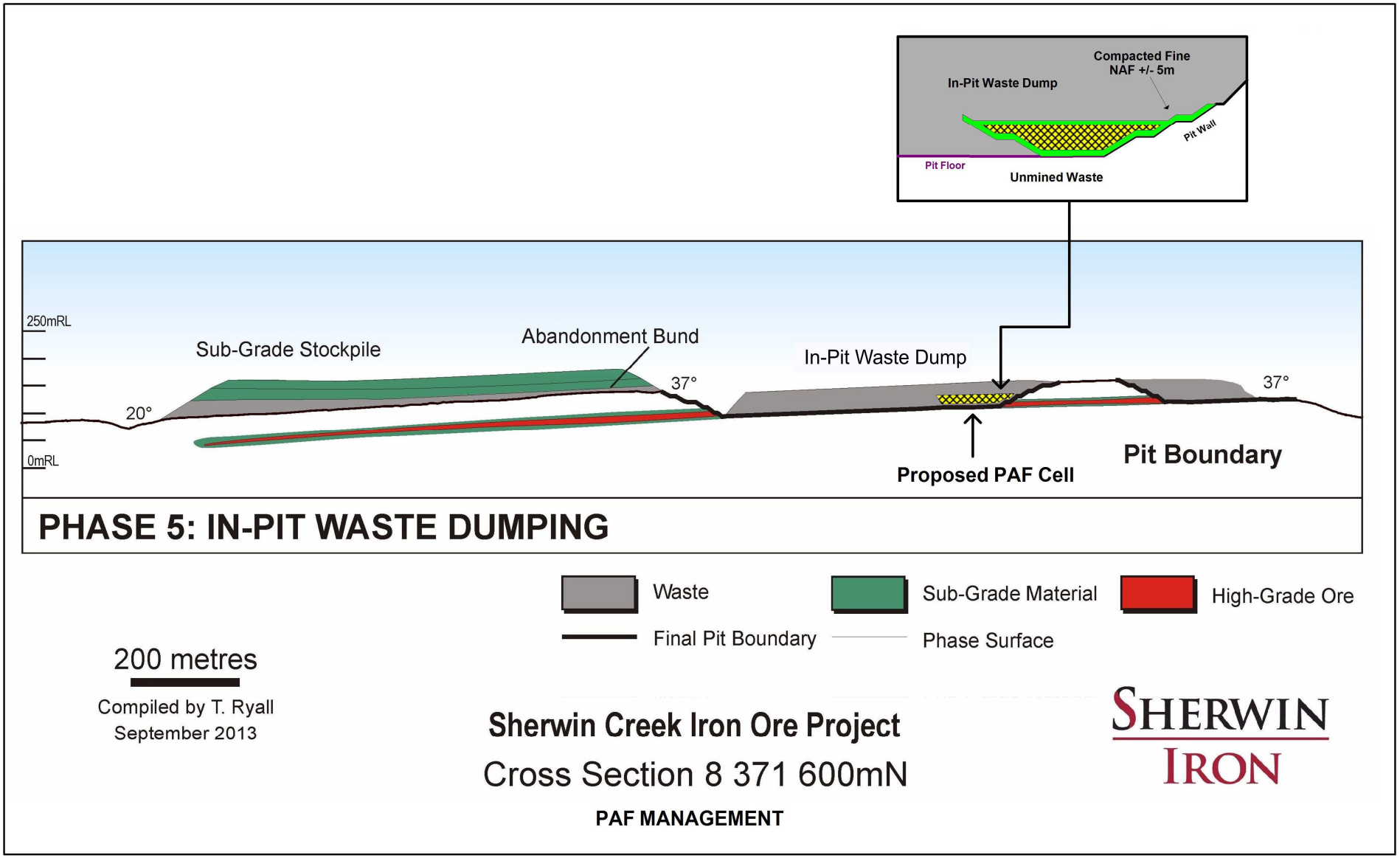


Figure 3.6: PAF Cell.

Note: The PAF materials will be encapsulated by crushed NAF materials and will be compacted to prevent ingress of oxygen and water into the PAF materials.

improved continuously, if and when required, to achieve full encapsulation of all PAF materials. The proposed location of the PAF cell has the capacity to be extended to accommodate more materials should the need arise. In this event a new design will be undertaken immediately and will be incorporated into the overall waste rock design and construction program. Should PAF materials be encountered earlier, albeit unlikely given the confidence of the current assessments, they will be small in volume and will be temporarily stored (encapsulated) for final disposal in the PAF cell.

- Reporting and Data Evaluation: Data acquired during the various investigations and assessments, including exploration/feasibility and operations, will provide the basis for revising the current Closure Plan in consultation with relevant stakeholders. Relevant information will be included in the annual Mine Management Plan (MMP).

If goals and milestones are achieved during mining, it is likely that monitoring during rehabilitation and closure will be significantly reduced in scope and frequency.

3.3.3 Phase III and IV: Rehabilitation, Closure and Post Mining

Although the primary activities to prevent AMD formation will be completed during mining and operational phases, post-mining rehabilitation and closure will substantially rely on monitoring. Approaches, methodologies and controls will be evaluated and amended, if required, continuously using monitoring data and if residual AMD is detected additional management and controls will be incorporated into the AMD remediation and management program (Figure 3.1).

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Appendices

Appendix A: Risk Assessment Criteria.

Appendix B: Field pH Testing (based on the method of Sorbek *et al*, 1978, with modifications by Page, 1982).

Appendix A: Risk Assessment Criteria

Risk Assessment Criteria: Risk Rating

Consequence		
1	Insignificant	No measurable impact on the environment. No injuries. Low-nil financial loss.
2	Minor	Minor, temporary environmental impact. No publicity likely and no stakeholder concerns. First aid treatment required. Medium-low financial loss.
3	Moderate	Substantial temporary or permanent minor, localised environmental damage. Stakeholder enquires (this may include government, unions or public). Medical attention required. High-medium financial loss.
4	Major	Substantial or permanent environmental damage. Prosecution possible. Loss of company credibility and high stakeholder interest. Permanent injuries. High financial loss.
5	Catastrophic	Widespread severe and permanent environmental damage. Major stakeholder and media interest. Prosecution likely. Permanent injury or death. Extreme financial loss.

Probability/Likelihood			Likelihood Criteria
A	Rare:	Practically impossible, will only occur in exceptional circumstances. Has never occurred in the industry.	0-1%
B	Unlikely:	Could occur at some time but highly unlikely. Has occurred in the industry previously.	1-10%
C	Moderate:	Might occur at some time. Has occurred in associated companies previously.	11-50%
D	Likely:	Known to occur or will probably occur in most circumstances. Has occurred several times/year in associated companies.	51-90%
E	Almost certain:	Common or repeating occurrence. Is expected to occur several times/year in any associated business.	91-100%

		Consequence				
		1	2	3	4	5
Likelihood	A	1	3	6	10	15
	B	2	5	9	14	19
	C	4	8	13	18	22
	D	7	12	17	21	24
	E	11	16	20	23	25

	Extreme risk	Intolerable
	High risk	Intolerable or tolerable
	Medium risk	Tolerable or acceptable
	Low risk	Acceptable

Appendix B: Field pH Testing

Introduction

Care must be taken to ensure electrode life and accuracy of pH measurements.

1. The electrode must not remain in the sample longer than necessary for a reading, especially if more alkaline then pH 9.0 or more acidic than pH 2.0.
2. The electrode should be washed with a jet of distilled water from a wash bottle after every measurement (sample or buffer solution).
3. The electrode should be dipped in dilute (0.1N) hydrochloric acid for a few seconds and washed with distilled water to remove any calcium carbonate film which may form, especially from alkaline samples.
4. Drying out of the electrode should be avoided.
5. The electrode is cleaned and suspended in distilled water, (which is protected from evaporation) for storage.
6. Place the pH meter in its standby position when the electrode is not in a solution.

The pH meter and electrode should be standardised with buffer solutions differing by 3 or 4 pH units (at 7.0 and 4.0), before starting a series of measurements. After every tenth measurement, recheck the standardisation with both buffers. Care should be taken not to contaminate one buffer with another buffer or with the test solution. Never return used standard buffers to their stock bottles.

Chemicals

1. Standard Buffer solutions: pH 4.0 and 7.0.
2. Distilled water (H_2O).

Equipment and Materials

1. pH meter - equipped with a combination electrode.
2. Paper cups 150ml capacity.
3. Plastic cups.
4. Stirring Rod.
5. Wash bottle containing distilled water.
6. Balance - can be read to 0.1g.

Procedures

1. Turn on pH meter, adjust temperature setting and "zero" pH meter as per the instruction manual.
2. Place pH 4.0 and 7.0 standard buffers in two plastic cups (one buffer in each cup).

   Note: never return used buffers to stock bottles.
3. Place electrode in the pH 7.0 buffer.
4. Adjust pH meter to read 7.0.
5. Remove the electrode from the buffer solution and wash with a jet of distilled water from a wash bottle.
6. Place the electrode in the pH 4.0 buffer and check the pH reading.

   Note: if the pH meter varies more than ±0.1 pH units from 4.0, something is wrong with the pH meter,

electrode or buffers.

Samples for this test should be the finer portions (<4mm and <75µm) of broken and or pulverised waste/ore materials mixed with deionised water.

7. Weigh or measure 20g of air-dry test material and 20ml of distilled water. Mix thoroughly for 5sec with the stirring rod.
8. Let stand for 10 min.
9. Insert electrode(s) into the container, and stir the supernatant liquor by swirling the electrodes slightly. Protect the electrodes taking care not to contact the sealed particles, moving the electrode carefully about to insure removal of the water film around the electrode. Electrodes are easily scratched.
10. When the reading remains constant, record the pH and remove the electrode from the supernatant and carefully wash the electrode with distilled water. If all pH measurements are completed, the electrode should be stored in a beaker of distilled water.

Note: After every 10 samples, check the meter calibration with the standard buffer solutions.