

# A risk-based framework for assessing non-metalliferous contamination prior to closure at MMG Rosebery Mine, Tasmania

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## Abstract

*Mining operations often have long and complex development histories, which results in equally complex site contamination risks when approaching closure. In many cases, the environmental monitoring conducted during operation only targets the contaminants of concern associated with mineral concentrates, processing reagents, and metalliferous drainage from mine waste. At closure, the focus of environmental assessment expands from preventing offsite impacts from mineral contaminants to assessing potential impacts from all activities and contaminants used during operations based on the site's intended future use. Therefore, the greatest environmental data gaps at closure can often be due to contaminants perceived to be a lower risk, many of which are common across all mines and industrial facilities.*

*A risk-based framework has been developed to assess the contamination not associated with mineralised waste or mineral concentrates at MMG's Rosebery Mine in Tasmania. The site has been operating continuously for over 85 years and is currently scheduled to cease operations in under a decade if additional tailings storage capacity cannot be secured. The assessment framework adopts a phased, risk-based approach that employs a range of assessment techniques that can be implemented prior to closure in a staged and cost-effective process, which does not affect current operation, including:*

- *Comprehensive site history and source risk-ranking tool.*
- *Ground penetrating radar.*
- *Groundwater investigation as a tool to assess contamination migrating from suspected source areas inaccessible during operation.*
- *Targeted soil assessments.*
- *Passive soil vapour.*
- *Per- and poly-fluoroalkyl substances (PFAS) fingerprinting.*

*The presentation will draw on examples from the contamination assessment for the Rosebery closure pre-feasibility study where 76 features associated with mining infrastructure or operational practices have been identified with the potential to have resulted in soil, surface water, or groundwater contamination by non-metalliferous contaminants. Of the 76 potential source areas, 64 were identified to have a moderate or higher risk to protected environmental values, and where further assessment and possibly remediation may be required to support relinquishment of the site.*

*The risk-based approach identified a shortlist of priority features where a release of contamination may have occurred, and where early investigation and intervention was both feasible and beneficial due to an expanded range of remedial options.*

*This presentation demonstrates the value of establishing a robust assessment framework early in a closure study so that a cost-effective, staged approach to contaminant assessment and remediation can be delivered to satisfy regulatory, internal and other stakeholder requirements.*

*This proactive risk-based assessment approach provides opportunities to minimise future environmental impact, reduce total remediation costs, support stakeholder engagement and provide greater certainty for closure options, cost and schedule.*

**Keywords:** *contamination, pre-closure, remediation, risk assessment*

## 1 Introduction

Mining operations that are approaching closure often have long and complex development histories, with equally complex site contamination risks. In many cases, the environmental monitoring conducted during years of active mining only targets the main contaminants of potential concern (COPC) associated with the mineral concentrates being produced and the mine wastes being generated.

Monitoring of the expected COPC associated with mineral wastes and concentrates during the period of mine operation is conducted in line with established site environmental management plans and licence requirements, which are typically established to prevent impacts to offsite environmental receptors and nearby communities.

Of the almost 349 active mines in Australia, approximately 73% extract metallic ores (such as gold, iron ore, bauxite, copper, lead, nickel and zinc), with the remaining mines extracting non-metallic resources (such as mineral sands, coal, uranium and gemstones) (Geoscience Australia 2022). The risks and challenges associated with managing metalliferous mine wastes, such as waste rock dumps and tailings storage facilities (TSF), and acid and metalliferous drainage (AMD) at closure are the subject of established guidance documents (Department of Industry, Science and Resources 2016).

At closure, the focus of environmental assessment shifts towards assessing the impacts from a much wider range of COPC used during operations, with a requirement to consider both onsite and offsite impacts, and the suitability of the site for an often more sensitive future land use. The level of environmental investigation needed to relinquish a site is typically much more onerous than is required to meet compliance requirements during operation. Therefore, the greatest environmental data gaps at closure are often associated with perceived lower-risk contaminants, many of which have not previously been monitored, and most of which are common across most mining and mineral processing operations.

To support mine closure efforts, in the years prior to closure there is a requirement to rapidly quantify the degree of contamination that may exist within the lease area so that future remediation requirements can be accurately costed and scheduled into the closure plan. However, ongoing mining and processing activities present challenges when approaching contaminated site investigations, as access to operational areas for intrusive investigation can be challenging, and these early site contamination investigations can be invalidated by the remaining years of activity and can require repeating.

This paper presents a risk-based framework that has been developed to assess the contamination not associated with mineralised waste or mineral concentrates (referred to as non-metalliferous contamination) at MMG's Rosebery Mine in Tasmania in the years prior to closure. The environmental assessments to address non-metalliferous contamination will run in parallel with other environmental monitoring and investigations that will inform the closure requirements for mineralised waste, such as TSFs and waste rock dumps.

The framework presented will be applicable to most Australian mines that have experienced long production histories, and where operation is expected to continue for several years. While the nature of contaminants may vary, the framework to address contamination data gaps will also be applicable to many non-metallic ore mines.

## 1.1 Rosebery Mine

The Rosebery Mine is located on the west coast of Tasmania, approximately 320 kilometres (km) northwest of Hobart and 120 km south of Burnie. The mine is predominantly an underground polymetallic base metal mine, with limited former open cut mining. The site commenced operation in the early 1900s and, following some temporary closures in the first few decades, has operated continuously since 1936. Surface infrastructure at the Rosebery Mine comprises the main mineral processing plant (referred to as the mill), administration buildings, a filter plant, and TSFs: Bobadil TSF and 1/2/5 Dam TSF. The Emu Bay Railway has been in use to export mineral concentrate from Rosebery to the former Zeehan smelter and to the Burnie Port for export. The Rosebery mill, filter plant and the 1/2/5 Dam TSF are all located in proximity to the Rosebery township.

Mining at Rosebery adopts a mechanised underground mining method (open stoping) that is used to extract ore from approximately 1.5 km below the surface. Historically, ore was initially hauled from the underground mine via horse-drawn carts, and then battery-powered locomotives until the early 2000s when diesel trucks replaced the locomotives.

The original infrastructure layout at the Rosebery mill included a breaker station that received crushed ore from both the underground and open cut mine, where it was fed into a slightly smaller mill that existed, which occupied a similar footprint to the present-day mill.

A major upgrade of the plant infrastructure was completed during the 1970s, which established the present-day mill arrangement, construction of a new filter plant and train-loading facility, and other associated infrastructure (Figure 1). Since the early 2000s, loaders have transferred the ore from the underground mine into 50-tonne trucks, which haul the ore out of the mine to the present-day breaker station, where it is crushed and enters the process circuit.

The mine is currently scheduled to cease operations in under a decade if additional tailings storage capacity cannot be secured. MMG requires that a closure plan, equivalent to a pre-feasibility study (PFS) level of design, is developed within at least five years of an operation's planned closure date. A contamination assessment forms part of a program of technical studies which will support the preparation of the closure PFS.

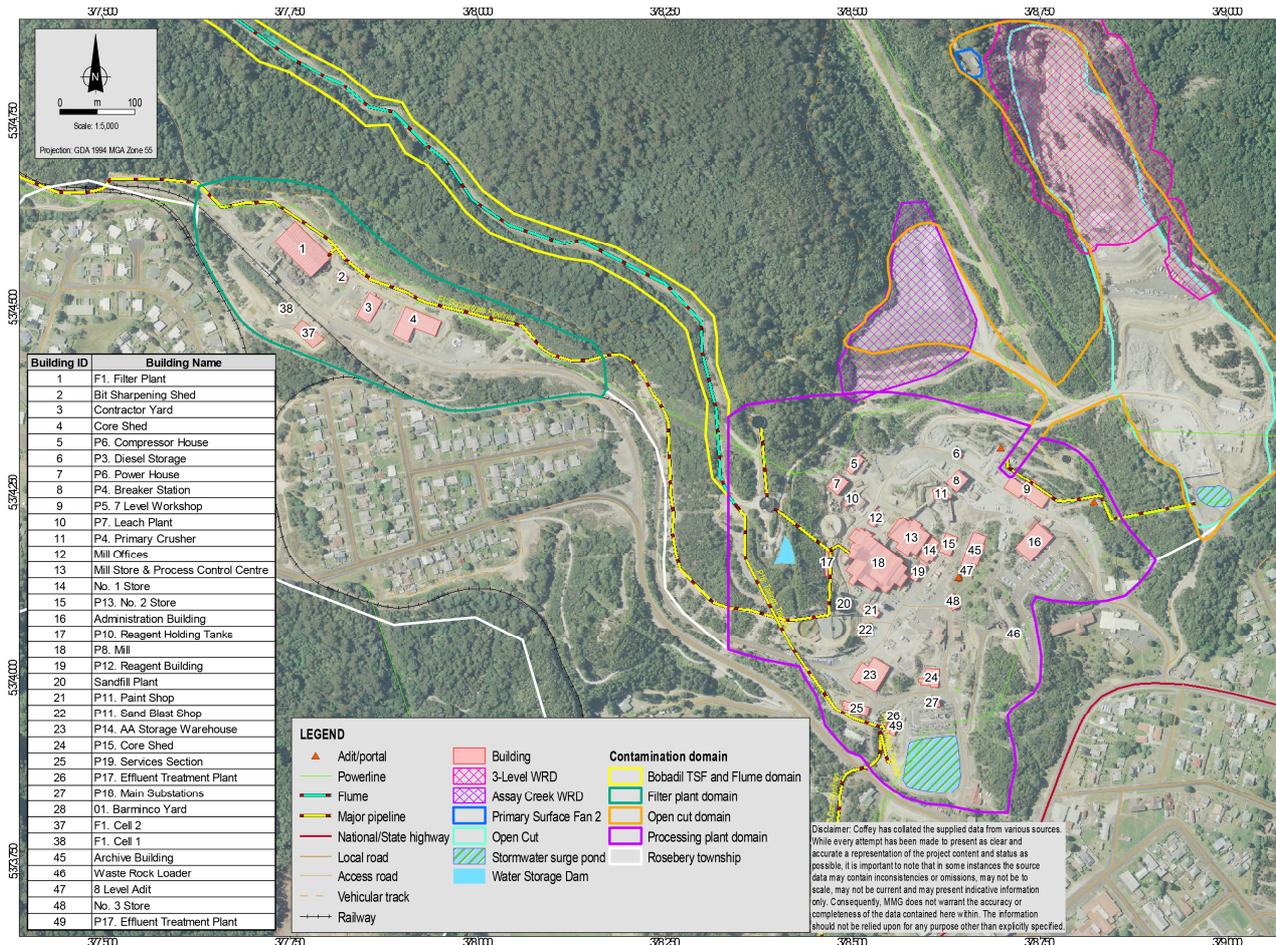
## 1.2 Regulatory setting and closure requirements

In Tasmania, the responsibility for the management of contaminated land is shared by the Environment Protection Authority (EPA) and local councils under the *Environmental Management and Pollution Control Act 1994* (Government of Tasmania 1994).

The Rosebery Mine is regulated primarily through the mining lease 28M/1993 and managed under several environmental protection notices (EPNs). Two EPNs and one Permit Conditions Environmental (PCE) are currently active for the Rosebery Mine and specify rehabilitation requirements for the site under the EMPCA. The EPNs and PCE require the leaseholder to assess the environmental condition of the Rosebery Mine and associated infrastructure, to inform the level of risk posed by residual contamination to protected environmental values (PEVs) and future site users.

Contamination investigations are required, at closure, to be consistent with the guidance provided in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (National Environment Protection Council 2013) (herein referred to as the ASC NEPM [2013]), relating to the design and implementation of site contamination investigations for soil, groundwater and soil vapour.

The contamination assessment scope specifically excluded contamination associated with mineralised waste and AMD, as these aspects will be addressed by a separate study for the closure PFS.



**Figure 1 Rosebery Mine layout and key features (tailings storage facilities located out of frame to the northwest and southwest)**

## 2. Site contamination assessment framework

### 2.1 Assessment framework requirements

To meet the closure requirements, an assessment framework was required for the Rosebery Mine that allowed a staged approach to assessing all non-metalliferous contamination issues and also balance the following priorities identified by MMG and Tetra Tech Coffey:

1. Where contamination is reasonably suspected based on current or former site activities, early investigation is required to inform what remediation or other management may be required at or prior to closure. These investigations should adopt methods that minimise impacts to the mine's ongoing operation.
2. The framework must progress the site towards meeting the regulatory requirement for site closure, which are based largely on guidance in the ASC NEPM (2013).
3. In areas of the site where potentially contaminating activities are likely to continue, the framework must stage environmental assessments to avoid unnecessarily repeating significant environmental assessment.

In addition to these priorities, the staging of early environmental assessment work should recognise that where non-metalliferous contamination is present, and may have entered groundwater or surface water, a sufficiently robust monitoring dataset will typically be required by regulators to demonstrate an acceptable

level of risk posed to the environment and nearby communities. This commonly requires groundwater and surface water monitoring over a period of several years.

The environmental challenges at the Rosebery Mine are common across most active mines that have long development histories, and where an understanding of all contamination that may be present across the lease area is sought in the years prior to site closure.

## **2.2 The risk-based framework for addressing non-metalliferous contamination**

The risk-based framework for assessing non-metalliferous contamination at Rosebery Mine is presented in Figure 2. The framework reflects the guidance provided by Schedule B2 of the ASC NEPM (2013), which recommends that the minimum requirements for completing site contamination assessments should include two stages of investigation: a preliminary site contamination investigation (PSCI) and a detailed site contamination investigation (DSCI).

## **3 Application of the assessment framework at the Rosebery Mine**

This section provides a summary of assessment progress at the Rosebery Mine site based on the risk-based framework outlined in Section 2.2 and outlines the assessment methods proposed to progress the site towards closure.

### **3.1 Preliminary site contamination investigation**

A PSCI was completed for the Rosebery Mine, adopting an approach consistent with the requirements of the ASC NEPM (2013). The purpose of the PSCI was, among other things, to develop a comprehensive conceptual site model that considers all non-mine waste contamination sources, pathways and environmental and human health receptors (consistent with Schedule B2 of ASC NEPM 2013 and ASTM International 2008).

#### **3.1.1 Site history review**

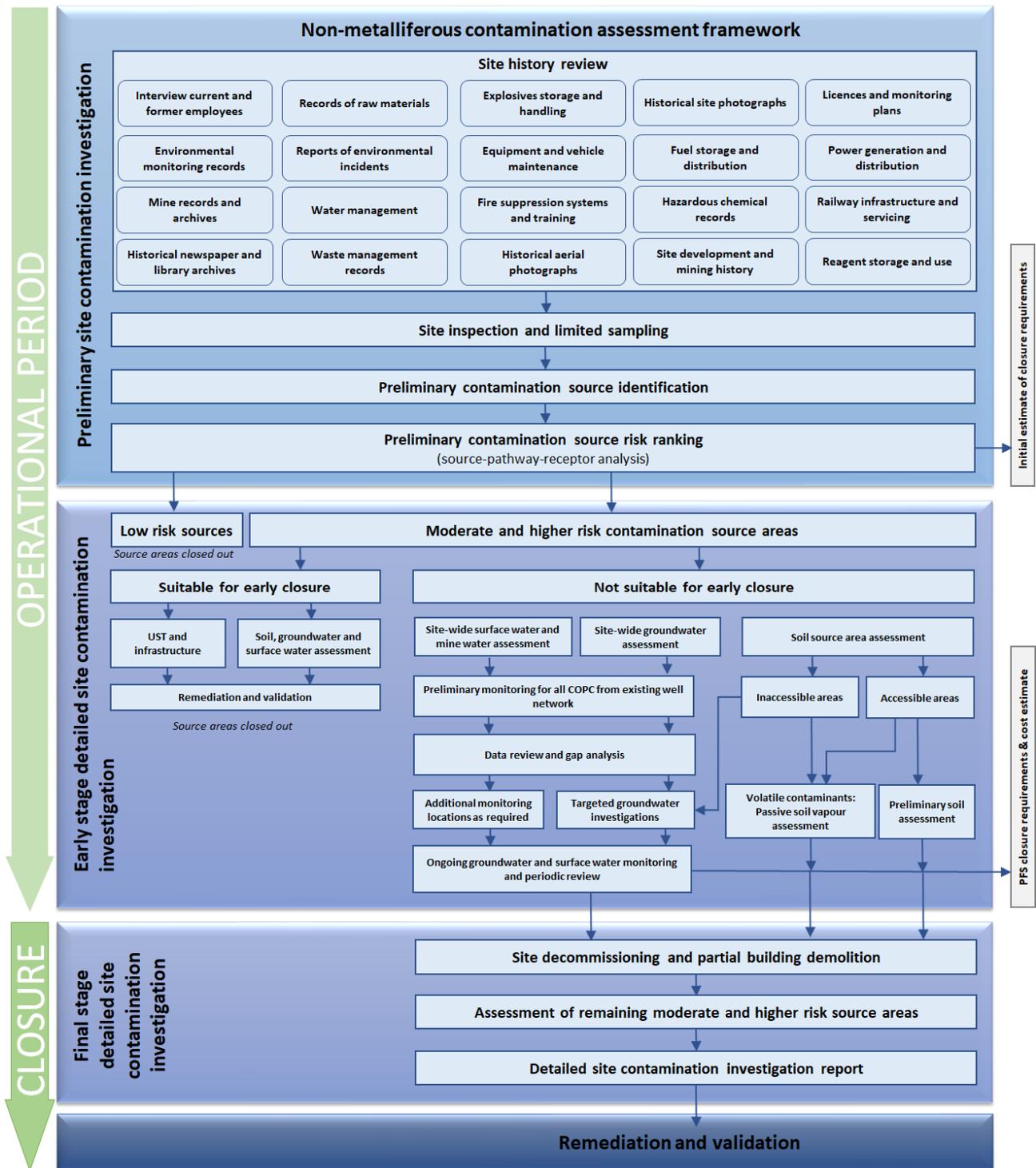
A desktop review was completed to identify current and historical land uses and mining practices that might have led to contamination of soil, groundwater or surface water. This review was based on digital and physical MMG records, publicly available database records (such as EPA Tasmania, business records, and hazardous material records), and a range of other publicly available historical records (listed in Figure 2).

A comprehensive reconstruction of the site's development history was considered critical to achieving a reliable PSCI, so considerable effort was put into database and archival searches and interviews of current and former employees.

#### **3.1.2 Site inspection and limited sampling**

Site inspections were conducted by Tetra Tech's contamination experts during June 2020 and March 2022. Critically, MMG employees familiar with the Rosebery site and other key staff, some of whom were retired, accompanied Tetra Tech during the site inspections. The site inspection allowed for verification of site features and processes identified in the site history review (Section 3.1.1) and supported the preliminary contamination source identification process (Section 3.1.3).

Suspected contaminating activities were confirmed so that an appropriate sampling and analysis plan could be developed, including analysis for an appropriate selection of COPCs. A range of surface water and groundwater sampling locations were ultimately identified downgradient of site features that might pose contamination risks. These locations were included in MMG's ongoing quarterly water monitoring program for an extended suite of COPC identified by the PSCI.



**Figure 2 Risk-based framework for assessing non-metalliferous contamination prior to closure**

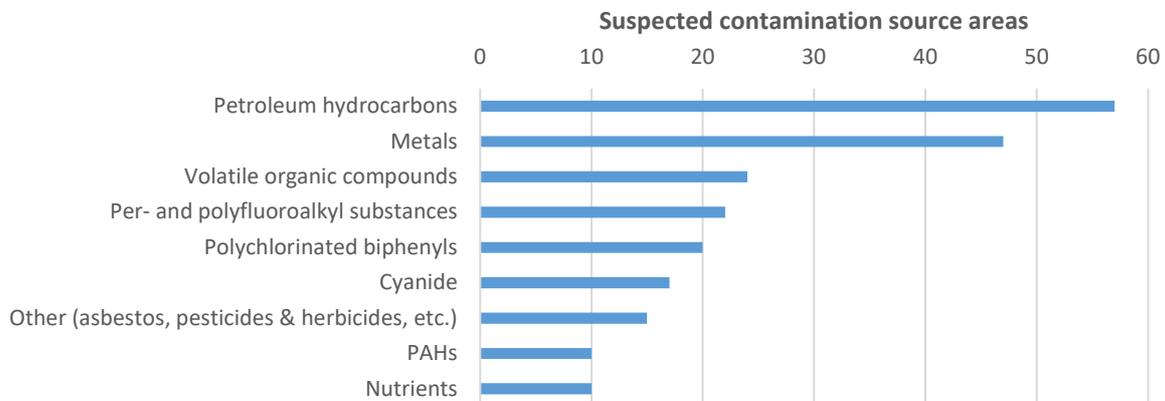
### 3.1.3 Preliminary contamination source identification

The PSCI identified 76 features within the study boundary where mining infrastructure or mining practices might have resulted in soil, surface water, or groundwater contamination. Individual features could be broadly classified into the following potentially contaminating activities:

- Non-mineralised waste disposal (such as landfills).
- Hazardous chemical storage and use (explosives).

- Mechanical maintenance and repair.
- Hydrocarbon fuel storage and use.
- Power generation.
- Electrical distribution and transformers.
- Reagent storage and use.
- Foam fire suppression systems.

Source areas can have multiple contaminating activities that require consideration, or they may be better assigned to a 'general' classification based on the varied activities or processes that may have occurred in the area. The preliminary assessment assigned each source area one or more chemical contaminant groups that are commonly associated with the potentially contaminating activity (consistent with Appendix A, Schedule B2 of the ASC NEPM 2013). Petroleum hydrocarbons, volatile organic hydrocarbons and metals (associated with non-mineralised mine waste sources) were the most common contaminant groups suspected (Figure 3).



**Figure 3 Summary of general chemical contaminant groups associated with each suspected source area**

Each of the 76 potential contamination source areas was assessed to identify whether the activity might be more likely to have affected the PEVs of:

- **Land** – based on State Environment Protection Policy (2002) Prevention and Management of Contaminated Land (Government of Victoria 2002).
- **Surface water** – set by Environmental Management Goals for Tasmanian Surface Waters: Catchments within the Circular Head and Waratah/Wynyard Municipal Areas (Department of Primary Industries, Parks, Water and Environment 2000).
- **Groundwater** – set by the State Policy on Water Quality Management 1997 (Government of Tasmania 1997).

Of the 76 source areas, 72 might have resulted in residual soil impact, 63 may have also resulted in groundwater contamination, and six may have impacted nearby surface water.

### 3.1.4 Preliminary contamination source risk ranking

Preliminary risk rankings were assigned to each potential source area based on observations made during the site inspections, the results of the site history and desktop review, and professional judgement. The risk rankings take account of whether potential source-pathway-receptor linkages are complete and consider the PEVs of land, surface water and groundwater.

The assessment matrix used to rank risk considered both the likelihood of a complete source-pathway-receptor linkage and the severity of the potential impact to a PEV. Both severity and likelihood criteria were established for the site to provide consistency through the assessment. The risk-ranking approach determined priority for further investigation, and summarised the potential source type, COPCs and identified where potentially complete receptor linkages may be present.

Of the 76 potential source areas identified, 12 were considered to have negligible or low risk and did not require further assessment (Table 1). The remaining 64 potential source areas were considered to have moderate or higher risk ranking and warranted further assessment (Table 1). The Rosebery mill area (processing plant domain; Figure 4) contained the highest number of potential contamination sources, which is consistent with the high density of industrial activities in this area.

**Table 1 Summary of identified contaminant source areas by assessment domain and risk ranking**

Preliminary risk ranking	Number of source areas	Number of source areas by assessment domains						
		2/5 TSF	Bobadil TSF	Underground mine	Open cut	Filter plant	Processing plant	Rosebery township
Major	12		1				9	2
High	17	2	1		4	1	9	
Moderate	35	1		2	2	4	26	
Low	9			1	1	2	5	
Negligible	3					1	2	

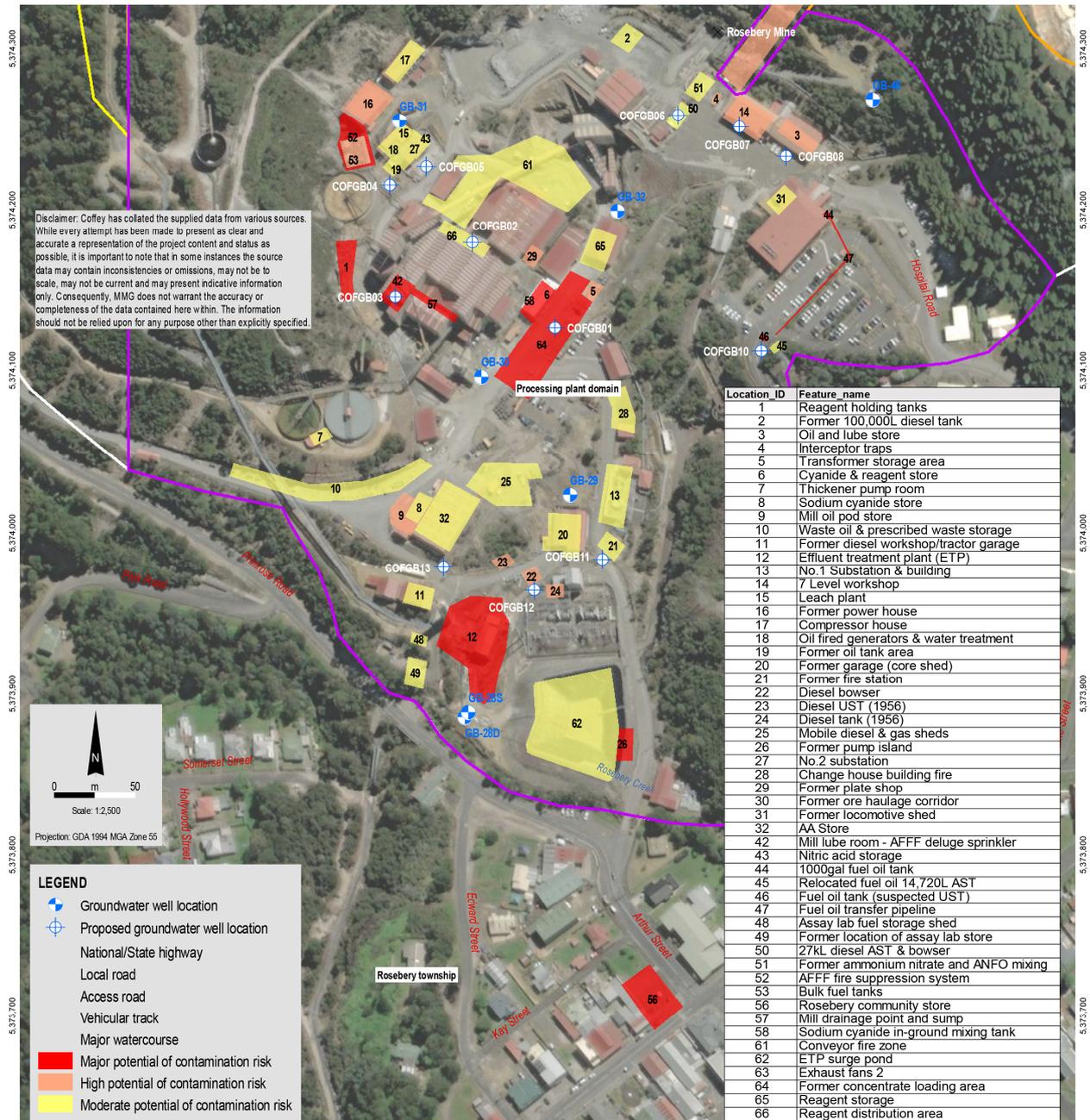
### 3.2 Early stage detailed site contamination investigation

The contamination investigations at the Rosebery Mine have progressed to the early stage DSCI (Figure 2).

The 12 low-risk contamination sources are considered to be effectively closed out by the PSCI and no further work is proposed. The remaining 64 moderate- and higher-risk contamination source areas identified by the PSCI were reviewed to consider which areas could potentially be assessed prior to full site closure in 2027. The aim of the review was to produce a shortlist of potential candidate sites based on the following variables:

- Likelihood of contamination being present at concentrations requiring remediation or management.
- Current access constraints for sampling.
- Current and likely future use of suspected source areas.
- Priority for early decommissioning and closure (e.g. former explosives store).
- Nature of suspected contamination and risk of ongoing/worsening groundwater contamination over time (with the aim to reduce long-term remediation costs by acting earlier).

The moderate- and higher-risk source areas have been divided into two groups based on suitability for early closure. A program of work planned to assess the two groups is described in the following sections.



**Figure 4 Map of potential contaminant source areas in the mill domain with preliminary risk-ranking results**

### 3.2.1 Source areas suitable for early closure

#### 3.2.1.1 Tank removal program

Records indicated that, historically, up to six underground storage tanks (USTs) were installed within the processing plant domain, and two USTs offsite at the former Rosebery Community Store (a company owned and operated business within the Rosebery township). The USTs are no longer in use, but as there are no records of decommissioning, they are suspected to remain in place.

A site inspection was conducted to refine the suspected location of the six USTs based on both historical documents and photos, as well as present-day observations of tank vents and transfer lines. Search area boundaries were established during the inspection to guide a future geophysical survey using a ground penetrating radar (GPR) to verify the presence and location of USTs.

Confirmed USTs will be removed by licensed tank removal specialists and a program of soil validation, groundwater assessment and remediation completed (where required).

### **3.2.1.2 Redundant infrastructure**

The suspected source areas were reviewed to identify areas with moderate- or higher-risk rankings positioned away from active mining and mineral processing areas. Discussions were held with MMG to confirm which sites were unlikely to be used or disturbed further in the future. Examples of source areas with potential for early closure included:

- Former explosives store.
- Former fuel depot.
- Transformer storage area.
- Redundant sections of the Emu Bay railway.

### **3.2.2 Source areas not suitable for early closure**

Most suspected source areas are located within the mill and other areas of active use and are therefore unsuitable for early closure. In many cases, potential impact may exist beneath buildings containing mineral processing equipment; therefore, the potential for direct assessment is limited until demolition can occur.

The following sections describe alternative and indirect environmental assessment methods that are proposed to assess these areas prior to closure so that an initial assessment of contamination can be provided to inform the PFS closure requirements and remedial cost estimates (Figure 2).

#### **3.2.2.1 Site-wide surface water and mine water monitoring**

Site runoff from the active mining and mineral processing areas, seepage points, and other mine water discharges provide sampling locations that may assist with identifying upstream contamination source areas that are otherwise inaccessible and not suitable for early closure (Figure 2).

The mine water management system collects runoff, seepage, and other mine water from across the Rosebery Mine site and directs it through the effluent treatment plant (Feature 12 in Figure 4), where lime dosing is used to precipitate metals prior to discharge to the Bobadil TSF. All water sources and transfers around the site were mapped, and included:

- Stormwater runoff from across the site, either in constructed drains or natural streams.
- Water seepages from embankments and retaining walls.
- Dewatering from the underground mine.
- Adit drainage from underground mine.
- Tailings slurry.
- Treated water from the effluent treatment plant.
- Supernatant TSF water and various points through polishing ponds prior to release.

Where identified water discharge points were downstream of suspected contamination sources, water samples were collected for analysis of the relevant COPCs. Two rounds of site-wide surface water and mine water monitoring have been completed, with analysis focused on the COPCs associated with potentially contaminating activities identified by the PSCI (Figure 3).

Results from the initial monitoring events have supported a preliminary data review and gap analysis (Figure 2), which informed recommended improvements to MMG's routine surface water monitoring

program so that any improvement in trends over time can be used to support closure. Key points along the water management system and receiving waterways are now monitored for the extended suite of COPC.

In addition to refining where contamination may be entering the water management system through monitoring of individual water sources, the site-wide surface water and mine water quality data will support the assessment of possible contamination issues that may be present at closure when active water management will cease and natural drainage resumes.

### **3.2.2.2 Site-wide groundwater assessment**

Two rounds of site-wide groundwater monitoring for the extended suite of COPC have been completed using the existing groundwater monitoring network. The results were used in conjunction with the outcomes of the PSCI to support a gap analysis that identified the need for an additional 17 groundwater monitoring wells to be installed across the Rosebery Mine.

All proposed groundwater monitoring locations have been nominated based on their position downgradient of a suspected contamination source area, or as close as is currently possible without causing significant disruption to the mining and mineral processing operations. Groundwater investigation has been adopted as a preferred method of assessing potential impacts from higher-risk source areas, particularly those source areas not suited to direct soil assessments, such as where drill rig access is limited.

All monitoring wells will be installed to the target depth of 2–3 m below the water table using a combination of push tube or solid auger drilling to refusal and rotary air hammer into the bedrock, where required. Aquifer hydraulic conductivity testing will be conducted at selected locations to support the future assessment of contaminant fate and transport, and the assessment of different remediation options that may be required.

### **3.2.2.3 Preliminary soil assessment**

Soil investigations are required at most of the suspected contamination source areas that were identified with moderate or higher risk; however, extensive soil assessments are not feasible in many locations due to access limitations or the ongoing use of the site prior to closure.

As part of the early stage DSCI, soil source area assessments are planned, with the aim of:

- Confirming whether suspected contamination is present.
- Identifying if the release of contamination is ongoing and early intervention or mitigation is required to minimise impact and remedial work required at closure.
- Supporting MMG's internal closure cost estimates and scheduling of future work that may be required.

A site-wide targeted soil assessment has been designed based on 39 soil bores that are proposed in current or former site features assessed to have a moderate or higher risk of soil contamination by PSCI. The targeted soil assessment aims to provide a low-cost, preliminary assessment of those higher-risk locations that are at least partially accessible but not suitable for closure to inform MMG's estimate of soil volumes that may require remediation or management at closure.

All proposed soil investigation locations have been nominated based on their position either within the suspected area of soil contamination, or as close as is currently possible without causing significant disruption to the mining and mineral processing operations.

A range of soil sampling methods will be adopted that allow for increased access and reduced disturbance to the ongoing mining and mineral processing activities. Table 2 presents a summary of the advantages and disadvantages of the different sampling methodologies available that may be considered at each location based on the site constraints and sample requirements.

All soil samples will be field screened for volatile contaminants using a photoionisation detector. Where surface sources of contamination are suspected, the analysis of samples will be phased to target initially

surface (or sub-slab) and samples collected in the first metre. Laboratory analysis will be based on the suspected COPCs associated with each suspected source area. Deeper samples (typically collected from bedrock or the water table, whichever is shallowest) will also be collected and sent to the laboratory so that where contamination is confirmed, further analysis and vertical delineation can be completed.

**Table 2 Soil sampling methods – advantages and constraints**

Method	Desirable conditions	Constraints	Method advantages
Hand auger	Shallow soils and limited vertical impact Difficult access	Difficult to penetrate gravels and hard soils Difficult to recover loose, dry soils Cross-contamination can occur Advancement beyond 1 m can be difficult	Inexpensive Continuous grab samples possible
Test pits	Shallow soil impact (<3 m)	Large disturbance and operating area required Increased effort to reinstate ground Limited depth Potential for disturbed samples and cross-contamination	Allows detailed observation of the soil profile Suited to locations where visual targeting of contaminants is required Representative soil samples are collected from the centre of the excavator/backhoe bucket Relatively fast to execute Generally, the lowest cost of the mechanical sampling methods
Push tube	Soils (<10 m)	May be blocked by large gravels Will reach refusal more easily than solid augers Gravels or other hard layers and some anthropogenic material (e.g. bricks) can block the sampler and limit sample retrieved Requires drill rig access	Recovers continuous core with minimal disturbance More suitable than auger drilling where volatile organic compounds (VOCs) are to be analysed Soil profile can be readily logged Dedicated disposable liner reduces potential for cross-contamination
Solid auger	Soils and soft rock (<10–15 m)	Can be difficult to accurately assess changes in stratigraphy Requires drill rig access High disturbance is less suited to VOC analysis Samples must be recovered from discrete depths from the auger tip after raising the auger rods	Can achieve greater penetration through hard layers and anthropogenic material

### 3.2.2.4 *Passive soil vapour assessment*

Semi-quantitative passive soil vapour assessments represent a valuable alternative assessment approach in active mine areas where volatile organic compounds (VOCs) are suspected to be a COPC in either groundwater or soil. This assessment method is typically less invasive and easily installed at a greater number of locations, without affecting operation, for a lower cost than soil and groundwater investigations (Interstate Technology & Regulatory Council 2007).

Passive soil vapour assessments using Waterloo Membrane Samplers (WMS) are planned at Rosebery Mine below concrete slabs in suspected VOC soil or groundwater contamination source areas to semi-quantitatively ‘sniff’ the subsurface. This assessment approach aims to confirm the presence or absence and identity of VOCs in the subsurface, support scoping the PFS closure requirements and costs estimates, and inform future quantitative soil or groundwater assessment required during final stage detailed site contamination investigations (Figure 2) once full site access is available.

A semi-quantitative passive soil vapour assessment can be adopted as an alternative to extensive intrusive soil investigations at selected locations where:

1. VOCs are suspected as one of the primary soil or groundwater COPCs.
2. Drill rig access is limited or would substantially impact the mining or milling operations.
3. Concrete slabs are present.

The WMS are suspended in a shallow (0.5–1 m deep) borehole below the building slab. The samplers are temporarily sealed beneath the slab to allow soil vapours to pass into a sample vial, which is filled with a sorbent medium. Typically, the passive samples are deployed for a set time, which allows calculation of an equivalent concentration in air, and then the vials are removed and transported to the laboratory for VOC analysis.

One of the benefits of using WMS is that they can be drilled and installed using an electric hand drill where drill rig access is otherwise not possible. At the Rosebery Mine, passive soil vapour assessments are proposed in two main suspected source areas: the former ‘Plating Shop’ (Feature 29, Figure 4) and the main mill building (Feature 57, Figure 4).

## 4 Conclusion

This paper presents the process and value of establishing an assessment framework for non-metalliferous contamination early in a closure study so that a cost-effective, staged approach to contaminant assessment and remediation can be delivered to satisfy regulatory, internal and other stakeholder requirements.

The assessment framework adopts a phased approach that aims to meet both the long-term regulatory requirements to relinquish the site and MMG’s short-term need to adequately estimate the costs and time required to achieve closure without unnecessary duplication of work.

The value of a comprehensive site history has been demonstrated at the Rosebery Mine site, with 76 features associated with mining infrastructure or operational practices identified, with the potential to have resulted in soil, surface water, or groundwater contamination by contaminants not associated with mineralised waste.

The preliminary contamination source risk-ranking approach described identified 64 potential contamination sources areas with a moderate or higher risk to PEVs. The assessment framework was applied to identify source areas that were suitable for early assessment, remediation and closure. Most suspected source areas were located within the mill and other areas of active use and were therefore unsuitable for early closure.

Many of these source areas were also inaccessible for direct sampling and required alternative or indirect environmental assessment techniques to identify and provide a preliminary assessment of contamination. Techniques that can be used to identify and confirm the presence of contamination in inaccessible suspected source areas so that they can be included in the assessment framework and closure planning process included:

- Comprehensive site history and source risk-ranking tool.
- GPR.
- Surface water runoff and groundwater sampling as tools to indirectly assess contamination migrating from inaccessible source areas.
- Targeted soil assessments.
- Passive soil vapour assessment.

This assessment approach provides opportunities to identify current releases and minimise future environmental impact, reduce total remediation costs, support stakeholder engagement and confidence, and provides greater certainty for closure options, costs and schedule.

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