Hellyer Gold Mines Pty Ltd

Environmental Management Plan
Tailings Reprocessing PCE 7386

8 October 2017

This Environmental Management Plan (EMP) was prepared by:

CALOUNDRA ENVIRONMENTAL PTY LTD
PO Box 242
Golden Beach Queensland 4551

Contact: Stephen Kent
Telephone: 0417 574 799
E mail stephen@caloundraenv.com.au

in conjunction with:

HELLYER GOLD MINES PTY LTD
Registered Address:
Cradle Mountain Link Road
Waratah, Tasmania 7321

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ANCOLD	Australian National Committee on Large Dams
ANZECC	Australian and New Zealand Environment Conservation Council
AMD	acid and metalliferous drainage
AHD	Australian Height Datum
ASGR	acid sulfate generation rate
BoM	Bureau of Meteorology
BPEM	best practice environmental management
BSM	Bass Metals Ltd
DoE	Department of Environment
DPEMP	Development Proposal and Environmental Management Plan
DPIPWE	Department of Primary Industries, Parks, Water and Environment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMPCA	*Environmental Management and Pollution Control Act 1994*
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
ERP	Environmental Rehabilitation Plan
GHD	GHD Pty Ltd
HGM	Hellyer Gold Mine Pty Ltd
HZCJV	Hellyer Zinc Concentrate Project Joint Venture
IVY	Ivy Resources Pty Ltd
LIST	Land Information System Tasmania
LUPAA	*Land Use Planning and Approvals Act 1993*
ML	megalitres (10^6 L)
µg	micrograms (10^{-6} g)
MNES	matters of national environmental significance
MPA	maximum potential acidity
m/s	metres per second
NAF	non–acid forming
NAG	net acid generation
NAPP	net acid producing potential
NBES	North Barker Ecological Services
NEPMs	National Environment Protection Measures
PAF	potentially acid forming
PRT	process residue tailings
PWS	Parks and Wildlife Service
RL	relative level (in metres)
RMS	*Nothofagus*/*Phyllocladus* short rainforest
RMT	*Nothofagus*/*Atherosperma* tall rainforest
TALSC	Tasmanian Aboriginal Land and Sea Council
TSF	tailings storage facility
TSPA	*Threatened Species Protection Act 1995* (Tasmania)
TSS	total suspended solids

1 Introduction

Hellyer Gold Mine Pty Ltd (HGM) is proposing to recommence tailings mining and reprocessing operations at Hellyer in accordance with the requirements and authorisations in environmental licence PCE 7386. In their current state, the existing sulfidic tailings will be producing acid and metalliferous drainage (AMD) for decades if not longer. This will in turn adversely impact surface water quality downstream of the site. HGM has a plan to retreat the tailings, which (at a minimum) will result in 55% of the tonnage and 75% of the sulfur being converted into saleable product and exported from the site. HGM is also planning to configure its mining plan to maximise early remediation of exposed sulfidic tailings, therefore reducing the environmental risks associated with the site as soon as practicable after operations recommence.

This Environmental Management Plan (EMP) is submitted:

- To review the significant environmental aspects of the tailings mining and reprocessing operations.
- To update the site's EMP relating to this activity.
- To specifically comply with the PCE 7386 conditions noted below. As can be seen in Section 2.1, the Hellyer Zinc Concentrate Project Joint Venture (HZCJV) obtained PCE 7386 in October 2006 and operated under that approval until 31 August 2008. As a result, the requirement for a triennial EMP review was not met.

1.1 Procedural PCE 7386 Conditions

G4 No Changes without Approval

None of the following changes, if they may cause or increase the emission of a pollutant or otherwise result in environmental harm may take place in relation to the activity without a new permit from the relevant planning authority (where the authority determines that a permit is required), or if no such permit is required, the prior written approval of the Director.

1.1 a change to a process used in the course of carrying out the activity;

1.2 the construction, installation, alteration or removal of any structure or equipment used in the course of carrying out the activity; or

1.3 a change in the nature of materials used in the course of carrying out the activity.

G7 EMP Reporting

Unless otherwise specified by the Director in writing:

1.1 A comprehensive EMP review must be submitted to the Director for approval by 31 January 2008 and for every 3 years thereafter, by the third yearly anniversary. Each EMP review must include but is not limited to:

1.1.1 site and operational history, particularly where it relates to the environmental performance of the activity (e.g. monitoring);

1.1.2 short, medium and long term strategic management and planning issues, and production and process changes that are likely to impact on production efficiency, the quantities produced and environmental performance of the activity;

1.1.3 a review of the Closure Plan as specified in Condition DC4;

1.1.4 any specific information required by the Director in writing, and

1.1.5 any other environmentally relevant matter relating to the period of the EMP.

1.2 The final version of each triennial EMP review must be made publicly available by the person responsible for the activity.

HGM has discussed the recommencement of tailings mining and reprocessing operations at Hellyer with the Waratah–Wynyard Council's Manager Development and Regulatory Services, who noted that, on the basis of discussions, the operation would be in accordance with the original land use permit and, as a result, a new development application would not be required. A copy of this EMP is provided to the Council.

HGM contends that the recommencement of tailings mining and reprocessing operations as described in this EMP will:

- Ensure compliance with the tenets of PCE 7386;
- Ensure that the operation will not cause or increase the emission of a pollutant or otherwise result in environmental harm;
- Through the application of modern AMD assessment and management techniques, reduce the emissions of pollutants from the site and provide a stable long-term closure plan for the site.

1.2 The Proponent

Hellyer Gold Mines Pty Ltd (HGM) is a subsidiary company of NQ Minerals Plc (NQM). NQM is a UK-listed, Australia-focused exploration and mining company, targeting projects where past exploration work has established the presence of mineral occurrences. NQM also owns 100% of the issued share capital in NQ Minerals Pty Ltd, ACN 165 670 271. NQ Minerals is an Australian company registered in Queensland.

NQM completed the acquisition of 100% interest in the polymetallic Hellyer Mine in Tasmania on 18 May 2017 by buying HGM and its parent companies. The company aims to commence production in early 2018 under existing environmental licence PCE 7386, following a period of refurbishment and environmental remediation work.

HGM owns Consolidated Mining Lease (CML) Number 103M/87 over the area and environmental licences PCE 7386 (tailings mining and reprocessing) and PCE 7759 (Fossey underground mine).

2 Scope and History of the Proposal

2.1 Hellyer Mine

The Hellyer ore body was discovered by Aberfoyle Resources Limited in 1983. The ore body was located 4 km north of the Que River deposit (Figure 2) and shown to contain approximately 15 million tonnes of ore. Aberfoyle Resources developed the Hellyer Mine following the passage through the Tasmanian Parliament of *The Hellyer Mine Agreement Ratification Act* in 1987. Full-scale production commenced in February 1989.

The original development was based on a minimum mining production rate of 1,000,000 tpa, which increased to 1,490,000 tpa.

Aberfoyle was purchased by Western Metals Resources Limited in 1998. Western Metals ceased mining the Hellyer orebody in April 2000 and ceased production in June 2000, and the company was then placed in receivership in July 2003.

The Hellyer tailings dam resource consists of sulfide tailings from the former Hellyer mining and milling operation, stored subaqueously. In 2006, it was reported as a JORC-compliant resource estimated at 9.5 Mt containing gold, silver, lead and zinc.

Intec Hellyer Metals Ltd (Intec) acquired the Hellyer assets from the receiver to Western Metals in January 2004. The assets included the Hellyer tailings resource, the Hellyer mill (under care and maintenance) and various exploration tenements.

Intec and Polymetals (Hellyer) Pty Ltd (Polymetals) formed the Hellyer Zinc Concentrate Project Joint Venture (HZCJV) in 2006. Under this agreement Polymetals obtained PCE 7386 on 10 October 2006, refurbished the Hellyer mills and acted as the operator of the HZCJV until the HZCJV ceased on 31 August 2008. The Hellyer operation continued under Intec control until 9 September 2008 when it was placed into care and maintenance by Intec.

During December 2008, Intec agreed to sell the Hellyer site to Bass Metals Ltd (BSM). The sale process was finalised during early 2009. BSM operated the site, obtained PCE 7785 and PCE 7759 and developed the Fossey underground mine, which operated until March 2012 when the site was placed into care and maintenance due to low metal prices, lower-than-planned metal recoveries and higher-than-expected operating costs.

BSM sold the Hellyer tailings resource, the Hellyer mills and plant and CML 103M/87 to Ivy Resources Pty Ltd (IVY) in February 2013. IVY retained the site in its care and maintenance status and formed HGM to evaluate the treatment of the Hellyer tailings for gold and silver recovery.

As noted above, NQM completed the acquisition of 100% interest in the polymetallic Hellyer Mine in Tasmania on 18 May 2017 by buying Keen Pacific Ltd, which owned 100% of IVY.

2.2 Legislative Approval

As noted above, HGM holds CML 103M/87 over the area and the environmental licences PCE 7386 (tailings mining and reprocessing) and PCE 7759 (Fossey underground mine). HGM plans to reprocess tailings under PCE 7386 and to extend the operational life until 2028.

2.3 Relevant Legislation, Regulations, Codes and Policies

HGM operates under and complies with a variety of Acts, Regulations, policies and guidelines that are likely to be significant for this development, including:

- *Aboriginal Relics Act 1975*
- *Crown Land Act 1976*
- *Environmental Management and Pollution Control Act 1994* (and associated policies and Regulations)
- Environment Protection Policy (Noise) 2009
- *Environment Protection and Biodiversity Conservation Act 1999*
- *Forest Practices Act 1985*
- *Historic Cultural Heritage Act 1995*
- *Land Use Planning and Approvals Act 1993*
- *Mineral Resources Development Act 1995*
- *National Parks and Reserves Management Act 2002*
- *National Environment Protection Council (Tasmania) Act 1995*
- *Native Forestry Agreement Act 1980*
- *Native Title (Tasmania) Act 1994*
- *Forestry (Rebuilding the Forest Industry) Act 2014*
- *Resource Management and Planning Appeal Tribunal Act 1993* and associated amendments.
- State Policy on Water Quality Management 1997
- *Threatened Species Protection Act 1995*
- *Water Management Act 1999* and associated Regulations
- *Weed Management Act 1999*
- *Workplace Health and Safety Act 1995.*

3 Description of Project

HGM is proposing to recommence mining and reprocessing tailings currently stored in the main tailings storage facility (TSF) and its eastern and western arm impoundments as authorised by PCE 7386. The operation can run until at least May 2019 by depositing process residue tailings (PRT) into the finger pond, and or to May 2020 by raising the finger pond dam embankment to RL 654, 654, albeit at a lower than planned processing rate, (both options with a water cover over the PRT).

HGM is evaluating alternative tailings storage options to provide PRT storage capacity past this time, including: utilising the eastern arm and the finger pond for tailings storage in perpetuity; raising the shale quarry dam wall to increase capacity in that dam; investigating whether an additional raise to the existing TSF dam wall can be constructed; evaluating the potential for a small dam on Mill Creek above the current eastern arm; and evaluating the construction of a new TSF (TSF 2) approximately 550 m downstream of the existing main Hellyer TSF dam wall. The construction and use of TSF 2 provides an opportunity to increase the stability of the existing TSF dam wall, improve long-term water quality and reduce the long-term risk of sulfide oxidation on site. At this stage in HGM's evaluation process, TSF 2 appears to be a superior option, and as such is referred to in this EMP as the option of choice. However, evaluation remains ongoing.

Other alternatives to additional dam construction would be to passivate the highly sulfidic tailings and construct a lime-dosed paste tailing, which would remain geochemically and geotechnically stable in the long term. There are risks associated with this alternative, in terms of capital and operational cost and geochemical feasibility.

At this stage HGM has a conceptual plan to construct TSF 2 approximately 550 m downstream of the existing main Hellyer TSF dam wall. The TSF 2 will be used to store all PRT formed when the existing tailings are reprocessed through the existing mills (Section 3.5). It is proposed that TSF 2 will be constructed in two stages:

1. A starter dam will be constructed to RL 638 m to accommodate approximately 2 Mt, i.e. 4 years' production of PRT.
2. Downstream construction will then be used to raise the dam wall to an ultimate height of RL 646 m to contain approximately 5 Mt of tailings in total.

The final height will be just below the current crest of the main dam, which is RL 650 m. The downstream toe of the ultimate dam will be constrained on the western abutment adjacent to the existing power transmission line running in a north–south alignment.

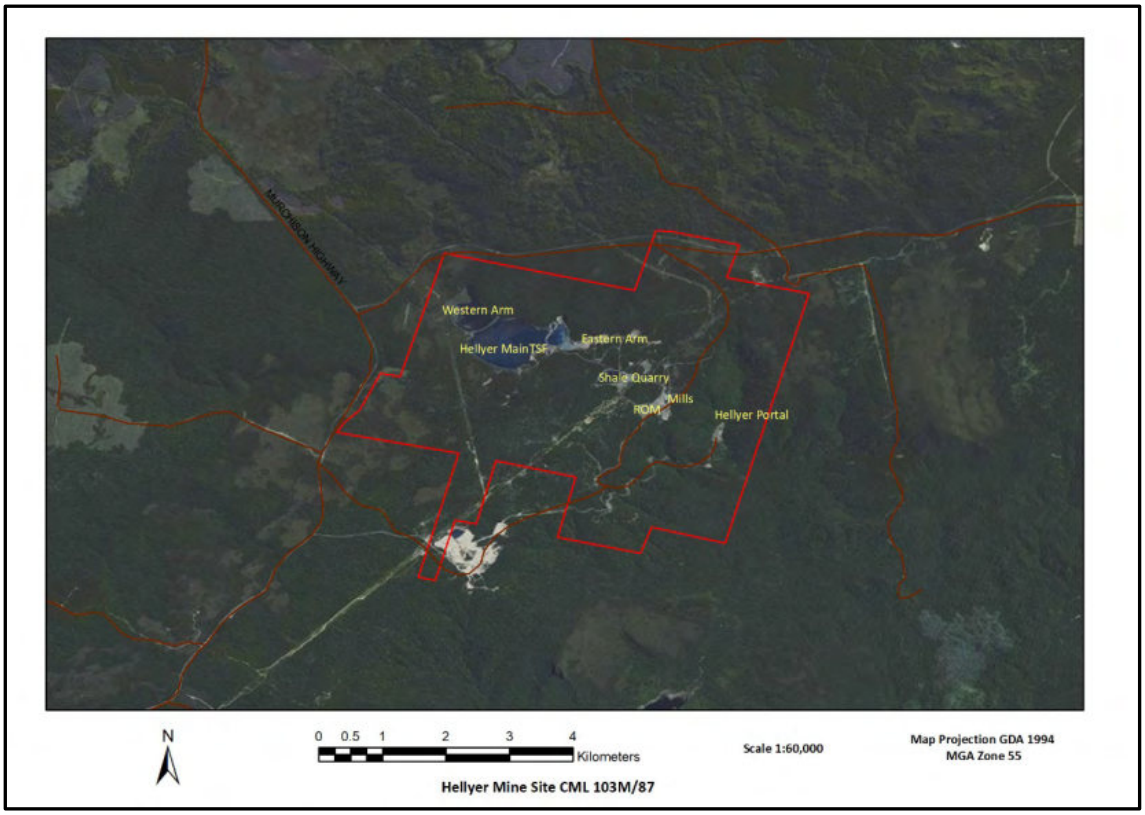
HGM will develop a Development Proposal and Environmental Management Plan (DPEMP) to accompany an eventual development application to the Waratah–Wynyard Council to obtain approval to construct and utilise additional tailings storage. Extensive approval delays could make the project uneconomic.

3.1 Location

The Hellyer Mine, main TSF, proposed TSF 2, concentrator and associated infrastructure, plant and equipment are located entirely on CML 103M/87 about 80 kilometres south of Burnie in North West Tasmania. Figure 1 shows the location of the site in relation to North West Tasmania. Figure 2 shows the Hellyer site and the lease boundaries.

Figure 1 Locality plan

Figure 2 CML 103M/87



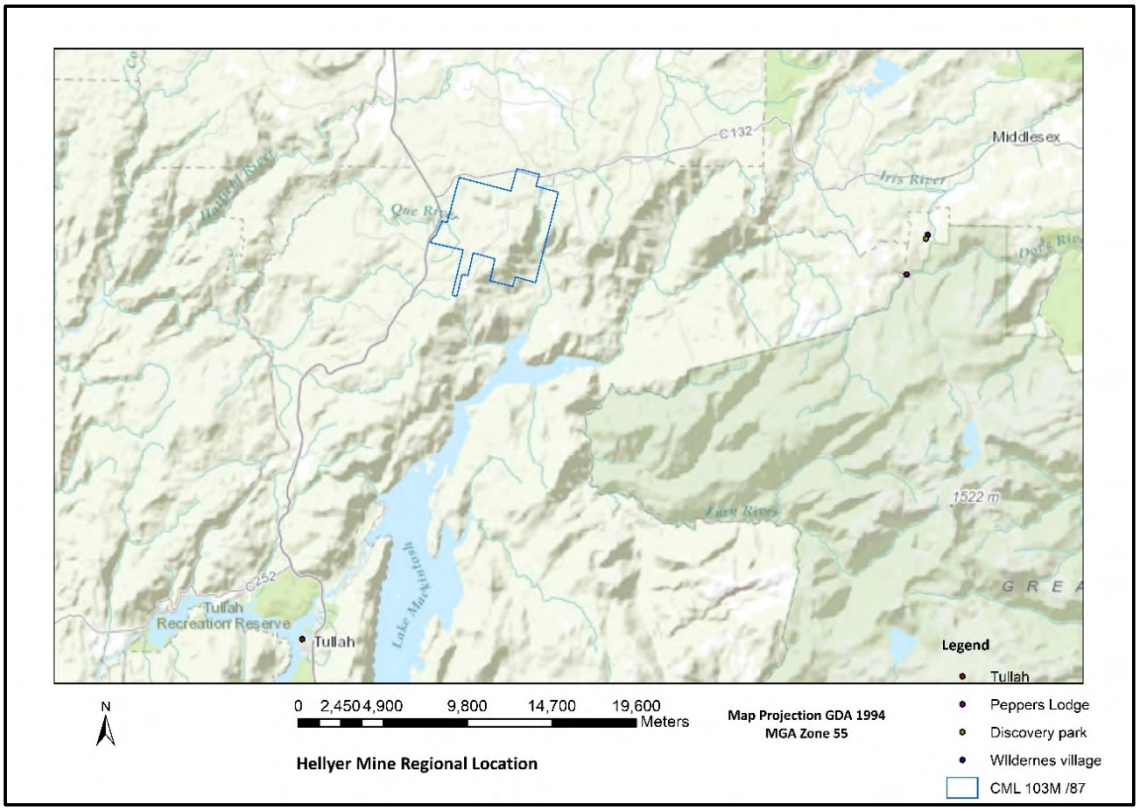
The Hellyer mill and tailings storages are located on the edge of the Que River plateau, approximately 700 m above sea level, with the Southwell River valley a short distance to the east. Prior to mine development on the site, the land area in the vicinity of the concentrator had been disturbed by logging, construction of an electrical transmission line and mineral exploration activities.

3.2 Land Use and Tenure

HGM owns CML 103M/87 in which the Hellyer Mine operates and in which the proposed TSF 2 will be situated. The underlying land tenure is Crown land. The proposed TSF 2 sits within the boundary of an area of Permanent Timber Production Zone Land, hence the land managers are Sustainable Timber Tasmania (formerly Forestry Tasmania). Figure 2 shows CML 103M/87. HGM owns the infrastructure and facilities at Hellyer, while BSM owns the Que River Mine lease (68M/1984), shown to the south of CML 103M/87 in Figure 4.

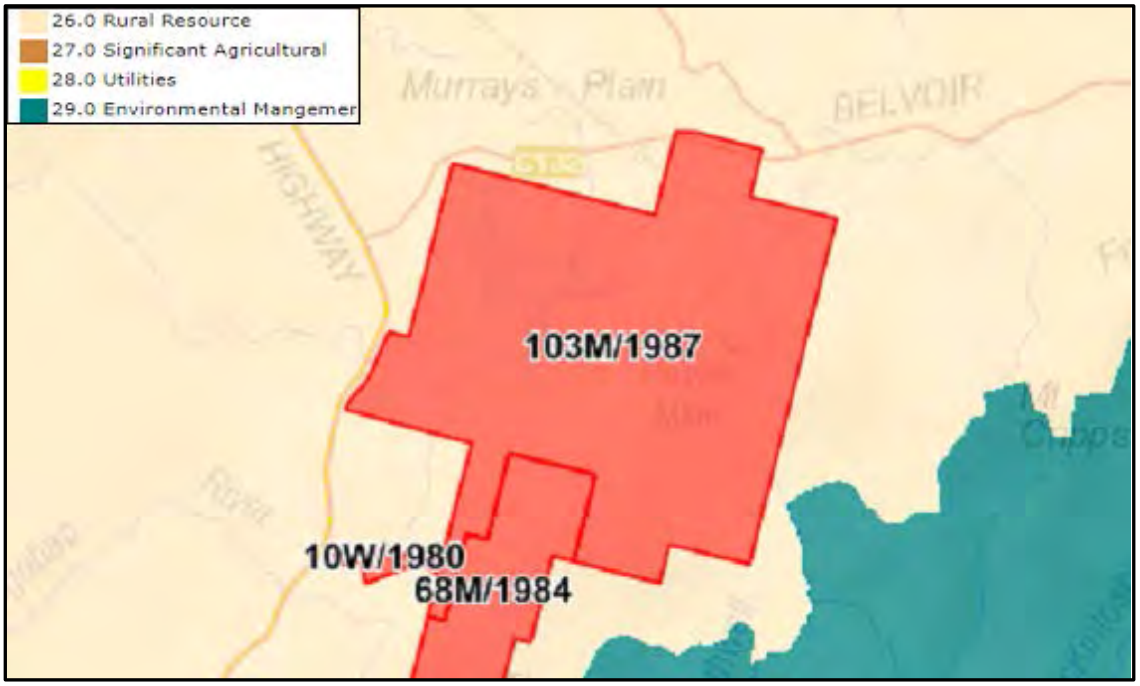
The nearest sensitive land uses are in the tourist hotels along the Cradle Mountain Road (C132) more than 17 kilometres to the east; the township of Tullah located more than 20 kilometres to the south (Figure 3) and the township of Waratah some 21 kilometres to the north-west.

Figure 3 Regional location



The area surrounding the lease has been zoned Rural Resource by the Waratah–Wynyard Council (see Figure 4), according to the Waratah–Wynyard Interim Planning Scheme 2013. The zone purpose of Rural Resource is to provide for the sustainable use or development of resources for agriculture, aquaculture, forestry, mining and other primary industries, including opportunities for resource processing. In Figure 4, mining leases 68M/1994 and 10W/1980 are owned by BSM.

Figure 4 Hellyer Mine – zoning

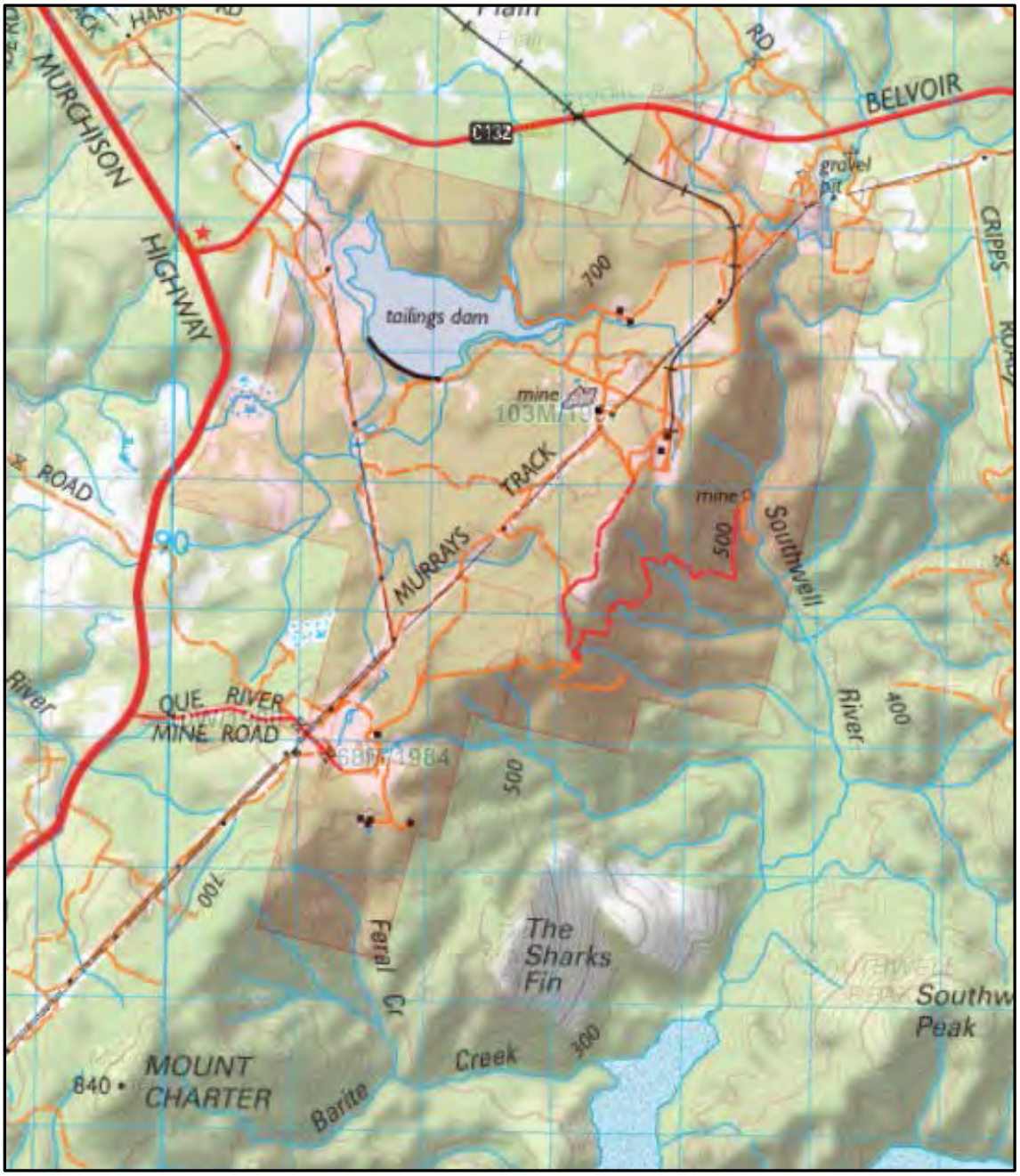


Source: LIST Maps *(http://www.thelist.tas.gov.au/listmap)*

3.3 Topography

The Hellyer operation (comprising the mineral processing facilities and infrastructure, the former Hellyer underground mine and the Fossey development) is located on the Que River plateau at approximately 700 mAHD, which is bounded to the east by the Southwell River valley, which is steeply sloping with thick rainforest cover, descending to around 400 mAHD. To the west of the divide, the site slopes generally to the west where the Que and Bulgobac rivers flow to the south and west. The evenness of the topography to the west along the plateau is demonstrated by the presence of major power transmission lines, which cross the mining lease (Figure 5). Figure 5 also shows mining leases 68M/1994 and 10W/1980 (shaded in light red), which are owned by BSM.

Figure 5 CML 103M/87 local topography



Source LIST Maps (*http://www.thelist.tas.gov.au/listmap*)

3.4 Climate

The site is situated in the cool temperate climatic zone. The prevailing winds are north-westerly to south-westerly. At approximately 700 mAHD, the Hellyer area has a climate characterised by cool temperatures and high annual rainfall.

Weather records were kept on site between 1985 and 1994. Temperature, rainfall and evaporation data from this time are provided in Figure 6. Rainfall exceeded evaporation by more than 4:1 with no months where evaporation exceeded rainfall. Average monthly rainfall figures for the Hellyer site exhibit a range from approximately 85 mm in February to 270 mm in August. The mean maximum temperature ranges from 29°C in January to 11°C in July.

The closest active Bureau of Meteorology (BoM) weather station is located at Waratah (Mount Road, 12 km to the west of the site at an altitude of 609 m AHD). The average rainfall and temperature records (1882–2013) for Waratah are shown in Table 1. Annual rainfall is likely to be similar to that at Waratah.

Rainfall distribution in western Tasmania is generally high throughout the year, with June to September being the wettest months and December to March the driest. Drought conditions are rare.

Figure 6 Climatic averages – Hellyer 1985 to 1994

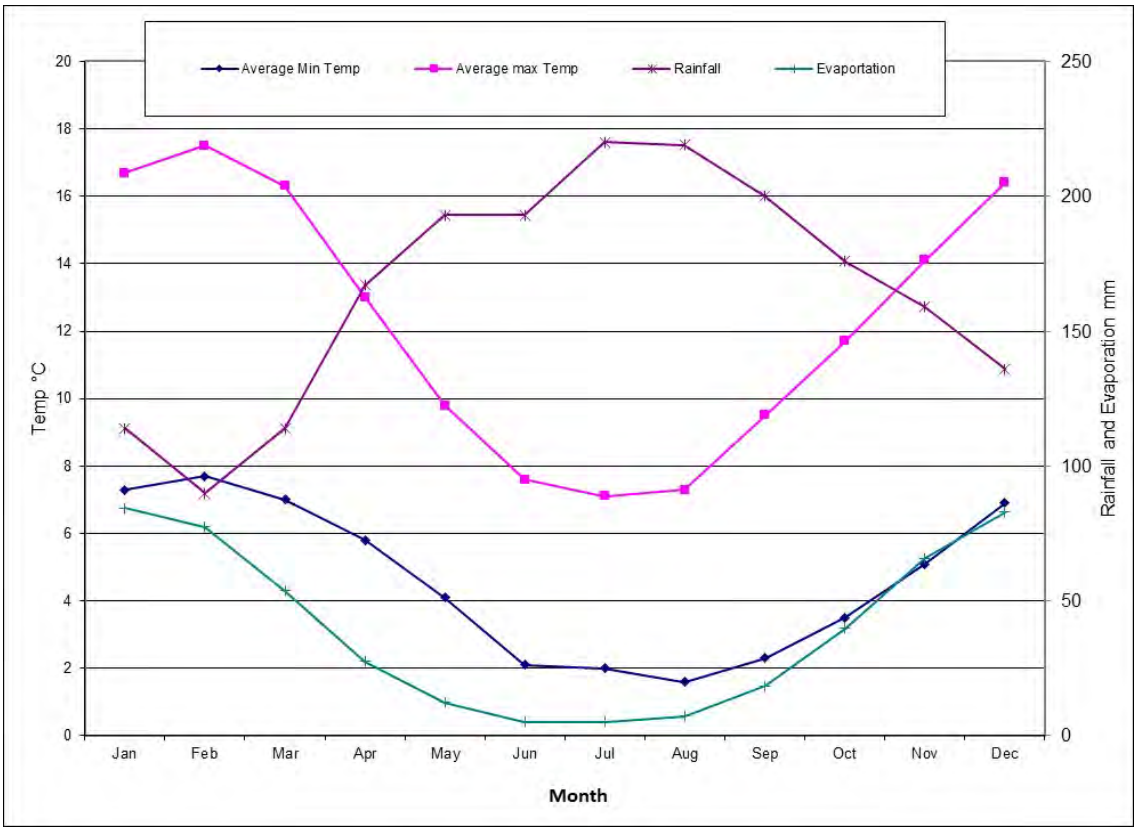


Table 1 Climatic data Waratah

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	17.6	18	15.7	12.5	9.9	7.9	7.2	7.9	9.7	11.8	13.9	16	12.3
Mean minimum temperature (°C)	6.3	7	5.9	4.3	2.8	1.5	0.8	0.9	1.7	2.7	3.8	5.2	3.6
Mean monthly rainfall (mm)	110	91.9	123.2	170.8	214.8	226.1	248.9	256.2	226.4	198.4	162.1	139.5	2180.2
Highest monthly rainfall (mm)	285.8	217.9	315	380.3	644.8	598.8	527.3	568.9	486.7	564.5	425.7	357.9	3126.4
Lowest monthly rainfall (mm)	10.8	10	4.3	7.8	37.6	25.4	77.5	70.9	68.8	36.7	13.9	16.4	1408.6

3.5 Mining and Processing

The project involves mining approximately 10 Mt of tailings from the existing main TSF, which comprises the main dam and its eastern and western arms (Figure 7) and the potentially shale quarry. The tailings will be processed to form three high-grade metal concentrates (lead, zinc and precious metals/pyrites). Previously, in the period 2006–2008, reprocessing of tailings produced a single bulk concentrate, which was of lower value than the combined value of the currently proposed concentrates (as measured by payable metal per tonne). The metallurgical process will utilise the same flotation approach that was previously employed in the treatment of ore and retreatment of tailings at Hellyer, which was approved by PCE 7386. As such, the processing will utilise the existing plant and machinery installed in the Hellyer mill. The metal concentrates produced will be sold under contract to base metal smelters in the region (including Tasmania and mainland Australia) and pyrite processing facilities in China.

Processing the tailings in this manner will significantly reduce the quantity of new process residues that will need to be stored as tailings (approximately 55% reduction by weight). This is because the precious metal/pyrite concentrate will contain a significant proportion of the pyrite mineralisation previously considered to be waste and stored as tailings.

This processing approach should provide both economic benefits (lower production costs) and environmental benefits (lower overall potential for sulfide oxidation).

Mining of existing tailings is planned to commence in April 2018. The project has a mine life of 10 years plus a period of refurbishment and remediation as shown in Table 2. This shows the mining schedule based on current knowledge. It will no doubt be subject to change as more data is acquired through geochemical, geotechnical and metallurgical testwork. HGM will provide an updated mine schedule and plan to the EPA and to Mineral Resources Tasmania at least 30 days before the commencement of mining.

Figure 7 Site plan Hellyer

Annual milling throughout is expected to start at 720,000 tpa, ramping up to 1.2 million tpa after 24 months.

Subject to economic viability (including market prices prevailing at the time), the scope of the project may be extended to include the processing of tailings material currently stored in the shale quarry.

Most of the tailings currently stored in the TSF at Hellyer will be recovered by dredging (Section 3.5.1). This will be followed by hydraulic mining to wash as much remnant tailings as practical to a collection sump (Section 3.5.2).

3.5.1 Dredge mining

Dredging is an excavation activity or operation carried out at least partly underwater, for the purpose of gathering up tailings (ore) to be pumped as slurry to the holding tanks adjacent to the main TSF and from there to the mills. All pumping will be via a pipeline running between the mining and processing areas.

Strengths of this mining method include:

- high availability and throughput
- low dust creation
- no need for haulage roads
- not affected by saturated soft tailings as equipment does not need to traverse the tailings
- low operating cost.

3.5.2 Hydraulic mining

This method uses a powerful jet of water to dislodge the mine tailings from exposed surfaces into a sump, forming a slurry which will then be pumped to the holding tanks adjacent to the main TSF and from there to the mills. This method can be carried out from the top down or bottom up. Plate 1 shows a hydraulic water cannon being used to move large blocks of tailings. It should be ideal for moving remnant tailings from the main TSF dam wall after the water level is temporarily lowered to dredge the lower reaches of the dam.

Plate 1 Hydraulic water cannon in use

Strengths of this mining method include:

- low dust creation
- low operating costs
- no need for haulage roads

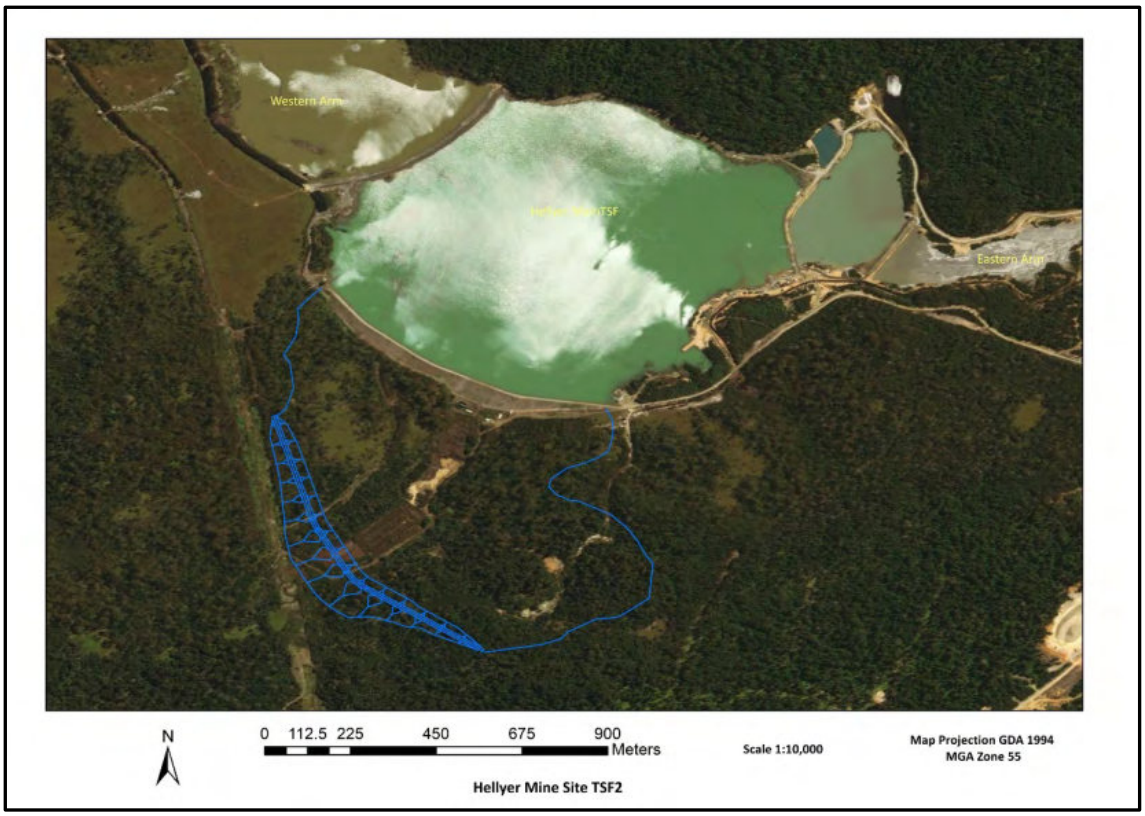
- not affected by saturated soft tailings, as equipment does not need to traverse the tailings.

HGM is planning to utilise the services of Professor David Williams, Golder Professor of Geomechanics at the University of Queensland, to provide a peer review for the dam design on the proposed TSF 2. As Williams' research interests include tailings properties and the physical and numerical modelling of mine tailings deposition, HGM will also ask him to review the hydraulic mining plan and develop testwork to evaluate the risks associated with moving the tailings and identify strategies to maximise success and / or alternatives to ensure that tailings are kept saturated.

3.5.3 TSF 2

The environmental aspects associated with TSF 2 (Figure 8) will be assessed through submission of a development application and DPEMP to the Waratah–Wynyard Council and referral of such to the EPA for assessment.

Figure 8 Proposed site location local context



TSF 2 will be used to store approximately 5 Mt of PRT. TSF 2 will likely be a zoned earth and rockfill dam with a clay upstream core, rockfill downstream shoulder and filters between the clay core and rockfill to minimise piping risk.

The dam wall is currently planned to be 26 m high with the ultimate crest at RL 646.0 m. The ultimate water level is planned to be at RL 644.5 m with the final PRT height at RL 642.5 m, providing a minimum 2 m water cover over the PRT. It is envisaged that geochemical testwork will define the final water cover requirement and provide data on the final geochemical stability of the impounded PRT.

The fully saturated PRT will fill the void between TSF 2 and the main TSF dam wall, which currently has a maximum water level at RL 649.4 m.

The water released by the PRT deposition in TSF 2 will be pumped back to the existing dam for reuse in the dredging operation. The TSF 2 decant arrangement could be a pontoon located at the north-east or south-east end on natural ground. It is envisaged that the return of supernatant water will be managed

to ensure that PRT will be maintained in a fully saturated state to reduce AMD development. According to the Gard Guide (2017a) the disposal of acid generating materials below a water cover is one of the most effective methods for limiting AMD generation. In water, the maximum concentration of dissolved oxygen is approximately 30 times less than in the atmosphere. More importantly, the transport of oxygen through water by advection and diffusion is severely limited relative to transport in air. For example, the diffusive transfer of oxygen in water is on the order of 10,000 times slower than diffusive transfer in air.

4 Refurbishment and Remediation

Refurbishment and environmental remediation is planned to commence in December 2017. The refurbishment will be focused on the current milling and grinding plant and associated infrastructure. Some new slurry tanks will be installed.

A new tailings collection sump below the mills, designed to stop tailings from running down Mill Creek, will be developed by HGM before production commences. The proposed sump location is shown in Figure 29. Instead of the clay lined sump cleaned out weekly using an excavator as practiced by BSM, HGM plans to install a deeper concrete sump which will utilise a pump back system to return tailings to the mill tailings discharge tanks.

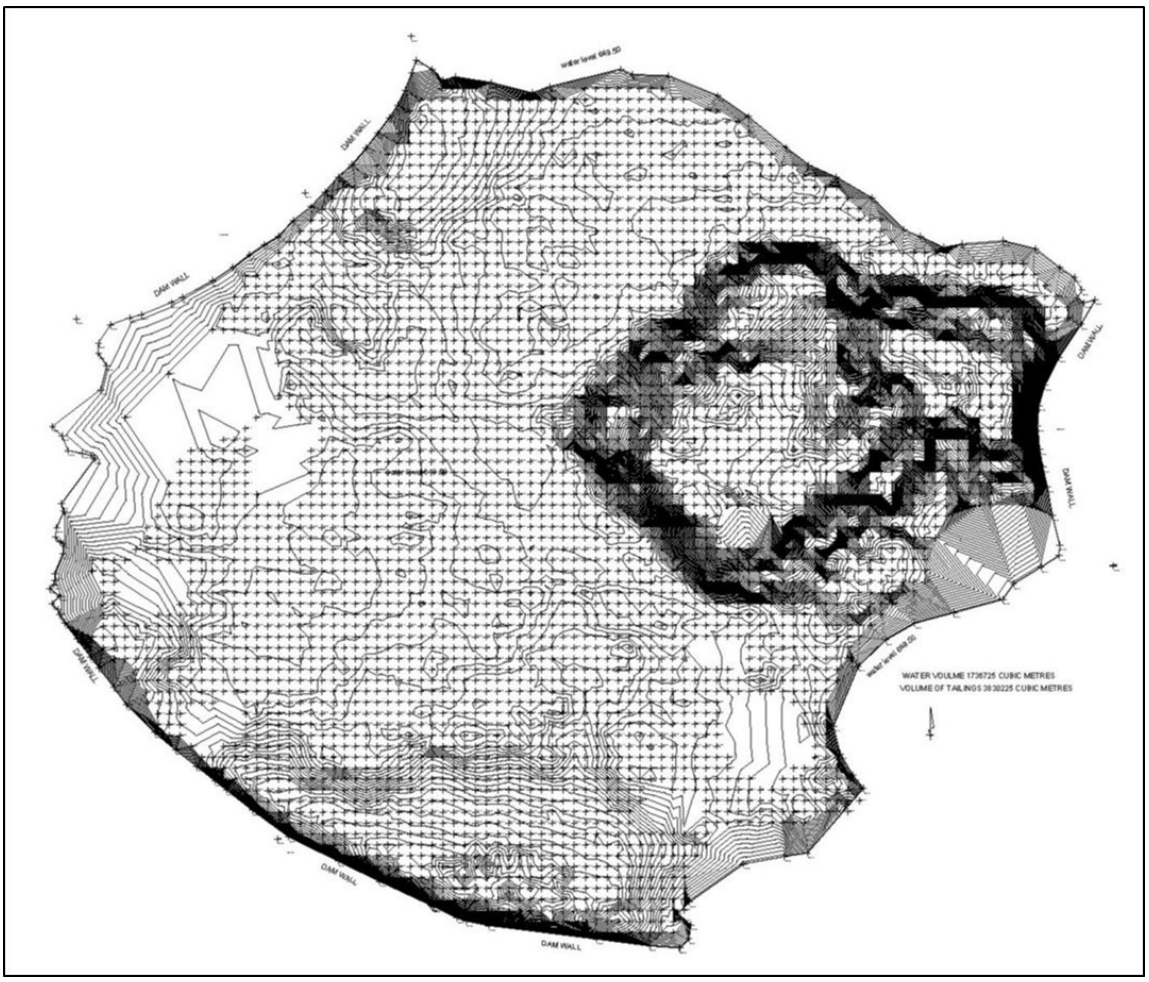
HGM will clean up Mill Creek by utilising excavator removal and truck haulage to dig out exposed tailings and remove them from the upper TSF catchment. The upper reaches of the eastern arm impoundment where tailings are exposed will also require the use of excavator removal and truck haulage to remove these tailings from the upper TSF catchment. The characteristics of these tailings are described in Section 6.1.4.2. The tailings (and associated mud sludges picked up) will be hauled to the western arm impoundment, where alkalinity will be added. The “tailings” will be temporarily stored in a designated and surveyed area of the western arm impoundment against the embankment wall so that they are submerged. During this process, HGM will add a lime slurry to the western arm and monitor field pH at the Western Arm outlet at least every 8 hours to ensure that AMD is not forming.

As soon as TSF 2 is operational, the tailings will be moved into TSF 2 by using a slurry pump.

Refurbishment also includes recommissioning the dredge and cleaning out the finger pond to increase its carrying capacity. The base of the finger pond contains approximately 114,000 t of Hellyer tailings and at least five years of hydroxide sludges and alkalinity from unreacted lime slurry. Based on the current lime budget for the finger pond, since March 2012 an estimated 1,500 t of lime has been slurried into the finger pond. It is expected that up to 70% of this has remains unreacted due to the short residence time and lack of effective mixing. As a result, there is expected to be approximately 1,000 t of carbonate alkalinity available in this material. This alkalinity and the tailing beneath will be moved using the dredge into the Polymetals hole (Figure 9) in the main TSF. From there the tailings will be re-dredged for processing. Once processing commences, initial PRT formed will be placed into the finger pond. Once the TSF 2 is operational, the PRT will be moved into TSF 2 by using a slurry pump.

After the PRT has been slurry pumped to TSF 2, the remaining eastern arm tailings will follow.
Once the finger pond and the eastern arm have been cleaned out, the eastern arm embankment will be disassembled and the material removed. The rocks in the embankment wall will be sampled and geochemically tested by static acid–base accounting. Potentially acid forming (PAF) materials will be further tested for stored acidity. Any stored acidity will be neutralised using sufficient lime to neutralise the net acid producing potential (NAPP). Once this has occurred the material should be able to be stored subaqueously to prevent further sulfide oxidation. Non–acid forming material (NAF) will be stockpiled for use in the construction of TSF 2.

Figure 9 Polymetals hole in main TSF



Remediation timing is shown in Table 2. The complete rehabilitation of Mill Creek and the eastern arm areas is currently scheduled to commence in July 2022, after the eastern arm tailings have been moved from the area to TSF 2.

5 Mining and Processing Schedule

HGM's current mine schedule allows for 359,507 t of PRT to be stored temporarily in the finger pond. This provides time until May 2019, by which time TSF 2 should be approved and constructed.

These areas provide sufficient subaqueous storage of PRT until at least May 2019 by depositing PRT into the finger pond, and or to May 2020 by raising the finger pond dam embankment to RL 654 (albeit with a reduction in tailings processing rate), should the base approval timeline for TSF 2 be delayed.

When TSF 2 is available, all PRT from ongoing processing will be stored in that storage option. The PRT and tailings from the finger pond and the eastern arm will be transferred to TSF 2 using a slurry pump. This will facilitate the complete rehabilitation of Mill Creek and the eastern arm areas.

Table 2 Project schedule

Proposed schedule	**Tailings/PRT (tonnes)**	**Start**	**Finish**
Remediation works		**1 Dec 17**	**18 June 22**
Excavate exposed tailings in upper reaches of eastern arm and Mill Creek: evaluate, treat and temporarily store in western arm impoundment		1 Dec 17	31 Dec 18
Commission dredge and move finger pond tailings into Polymetals hole (allowing buffer around embankment wall)	114,000	1 Feb 18	31 Mar 18
Relocate eastern arm tailings into TSF 2	580,000	15 Jan 21	1 May 22
Remove eastern arm dam embankment and dredge tailings for processing	225,000	13 May 22	18 Jun 22
Mining and processing		**1 Apr 18**	**21-Jan-27**
Initial dredging of main TSF (10 m deep and >300 m from main dam wall)	2,172,562	1 Apr 18	1 Oct 20
PRT from mills into finger pond TSF 2 stage 1 mining	359,507	1 Apr 18	1 Apr 19
PRT from finger pond into TSF 2	359,507	1 Aug 19	1 Jan 21
Dredging of main TSF (10 m deep and >50 m from main dam wall)	1,825,368	10 Oct 20	13 May 22
Dredging of main TSF bench 2 (15 m deep and >50 m from main dam wall)	1,552,271	20 June 22	5 Sep 23
PRT from mills into TSF 2 stage 1 dam	2,500,000	1 May 19	4 Sep 23
Dredging of western arm tailings	500,000	7 Sep 23	10 Jan 24
Dredge tailings in dam buffer zone upstream from western arm dam embankment	188,362	10 Jan 24	27 Mar 24
Dredge tailings from downstream buffer zones western arm and finger pond	245,955	28 Mar 24	10 Jun 24
Hydraulic mine western arm, sluice into collection sumps	10,000	28 Mar-24	7 Apr 24
Lower water level (638m RL) in main dam and dredge main dam tailings	1,854,878	11 Jun 24	28 Dec 25
PRT from mills into TSF 2 stage 2 dam	1,799,516	6 Sep 23	21 Jan 27

5.1 Phase 1 Main TSF – Initial Dredge

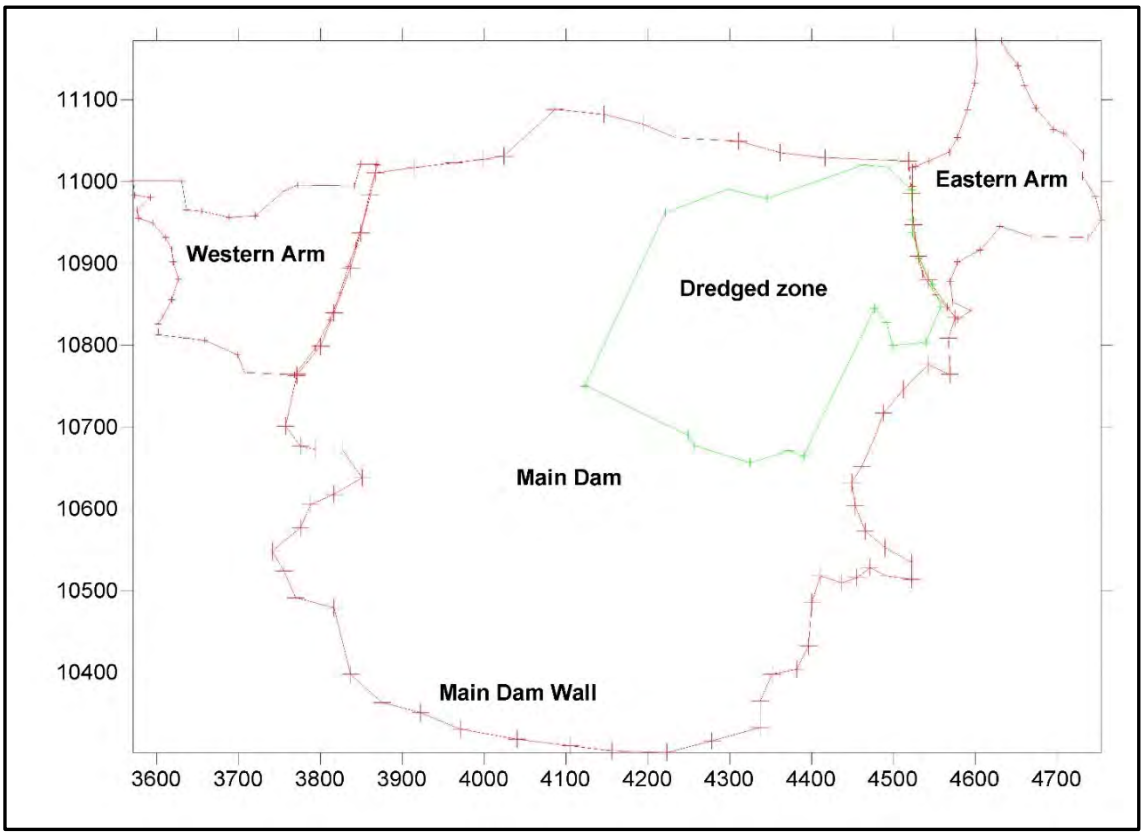
Tailings extraction from the main TSF mining operation is scheduled in two phases based on the operating limits of the existing dredge (approximately 14.5m vertically).

The spillway invert of the main TSF is at 649.4 m RL (GHD, 2017) consequently the first two dredge cuts (9.5m and 14.5m deep) are expected to take tailings down to 635 m RL and leave a minimum of 1 m water over any undredged tailings in the shallow (<2m) areas of the dam. At present, PCE 7386 precludes dredging within 300 m of the main dam wall. HGM has engaged GHD to evaluate the geotechnical and dam safety aspects of this exclusion zone, as well as the buffer requirements between dredging operations and all current embankments. Once GHD has provided recommendations, HGM will provide this report to the EPA and request a permit variation for the main dam wall exclusion zone in accordance with the engineering recommendations and water quality requirements.

This first phase of dredging will exclude tailings that are located in buffer zones extending downstream from the finger pond dam and western arm dam embankments.

The dredging is expected to remove >95% of the accessible tailings in this first of main TSF dredging.

Figure 10 Main TSF tailings zones



5.2 Phase 2 – Western Arm

The extraction of the western arm tailings will follow the first phase of the main TSF dredging. The majority of tailings in this area will be removed by dredging. The first stage of dredging will extract those tailing outside of an buffer zone extending 50m upstream of the western arm dam embankment. Once these tailings have been removed the tailings located in the buffer zone will then be dredged.

Once the tailings have been dredged from the western arm the water level between the western arm and the main dam will equalised and the embankment wall will be removed and the tailings beneath it and in the

downstream buffer zone dredged. At the same time the finger pond embankment will be removed and the tailings beneath this will also be dredged and recovered for processing.

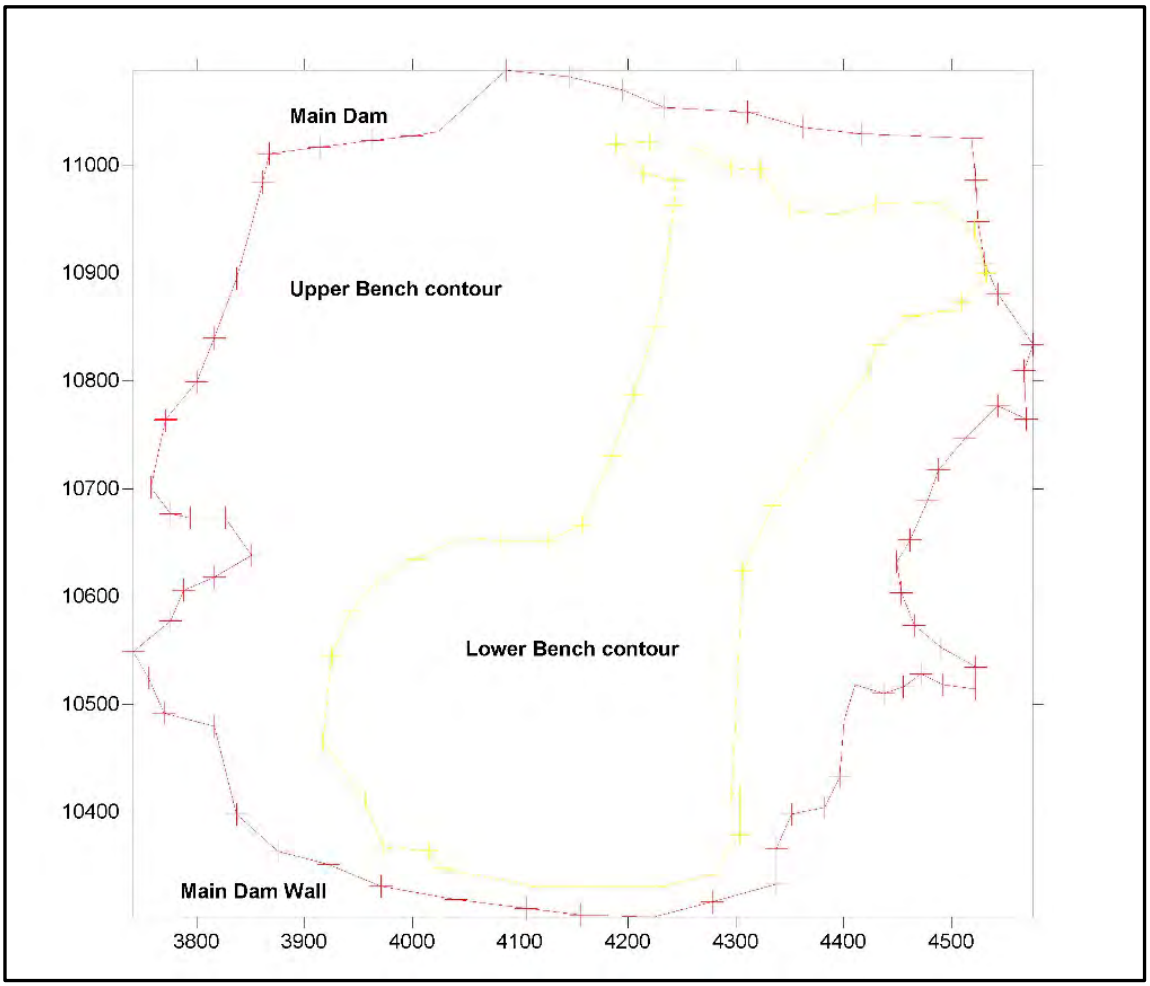
Once this is complete the water level across each of the impoundment areas in the main dam will be progressively lowered – using a siphon mechanism and the existing decant system – to approximately 638 m RL. During this process of lowering the water level any newly exposed remnant tailings will be washed by hydraulic mining (water cannons) into either the impoundment area still covered with water within the main dam or, if appropriate, into sumps fitted with sump pumps. Some excavator or dozer assistance may be needed around the verges In combination this will ensure both maximum utilisation of the ore reserve and prevention of AMD formation, which could occur if the sulfidic tailings were left exposed.

5.3 Phase 3 – Main Final Dredge

Once the water level in the main dam has been dropped to 638m RL the lower benches of the main dam can be dredged. This lower dredge zone is indicated by the yellow line in Figure 11 below. The tailings in this zone continue down to 627.5m RL and should be accessible with the water level at 638m RL. However if it is necessary to further lower the water level to accurately dredge the remaining tails then any tails that are exposed in the process will be hydraulically mined as described above in order to recover them and prevent oxidation and AMD formation.

As with the first dredge cut, the dredging is expected to remove >95% of the tailings in the lower bench.

Figure 11 Main TSF deeper dredge cut



After the final dredge cut, the water level will again be lowered by using a siphon mechanism and the existing decant system. All remnant tailings will be removed by water cannons into a sump, from where they can be slurry pumped to the shore tanks and from there to processing.

The main TSF will then be allowed to refill with water. At this stage, all internal impoundments will have been removed, which means that any and all remaining sulfidic material will remain submerged under a deep water cover in perpetuity. Wetlands systems will then be developed around the shallower verges of the dam.

5.4 Phase 4 – Shale Quarry

Assuming that HGM mines the Polymetals reprocessed tailings in the shale quarry, the tailings will be extracted from the shale quarry using the same technology applied in the main TSF.

Removing the tailings from the shale quarry will also remove the issue with tailings becoming exposed and oxidising as the water level drops. Final decisions on whether to mine the shale quarry will depend on economics. These decisions will likely be made in 2026 and will depend to a large extent on then metal prices and operational efficiencies. Assuming mining takes place, a decision whether to leave the shale quarry dam wall in place will be made at that time. If the dam wall is left, the quarry will likely fill to the point of direct connectivity with the Hellyer void.

6 Environmental Aspects and Their Management

In 2006, Polymetals identified geochemical issues and acidic supernatant water in the TSF as the biggest risk on site. Dam failure was the next biggest risk. In 2009, BSM identified similar risks and risk levels but identified AMD from sulfidic tailings oxidation more specifically than Polymetals had.

HGM believes that these aspects remain the major environmental risks at the Hellyer site. In developing this EMP, HGM has been able to apply advanced AMD characterisation and mitigation techniques to the geochemical issues on site.

6.1 AMD

AMD is drainage or seepage that has been affected by the products of sulfide oxidation. It is characterised by low pH and high sulfate and metal concentrations. AMD is caused by the oxidation of sulfide minerals in the presence of water.

Sulfide oxidation is a natural weathering process that produces acid. This acid is neutralised by natural buffering reactions. If the rate of acid generation exceeds the rate of acid neutralisation, then AMD can occur. Pyrite oxidation requires three basic ingredients: pyrite, oxygen and water.

Equation 1 Pyrite oxidation

$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)^3 + 2\ H_2SO_4$

The maximum rate of oxidation of a material containing pyrite is referred to as the Intrinsic Oxidation Rate and is expressed as kg $O_2/m^3/s$. Values typically range from 10^{-10} to 10^{-6} kg $O_2/m^3/s$. Oxygen transfer to the pyrite mineral surface is generally the limiting factor. Consequently, inhibiting the transfer of oxygen to sulfides present in the pyrite is the most common method of preventing AMD formation.

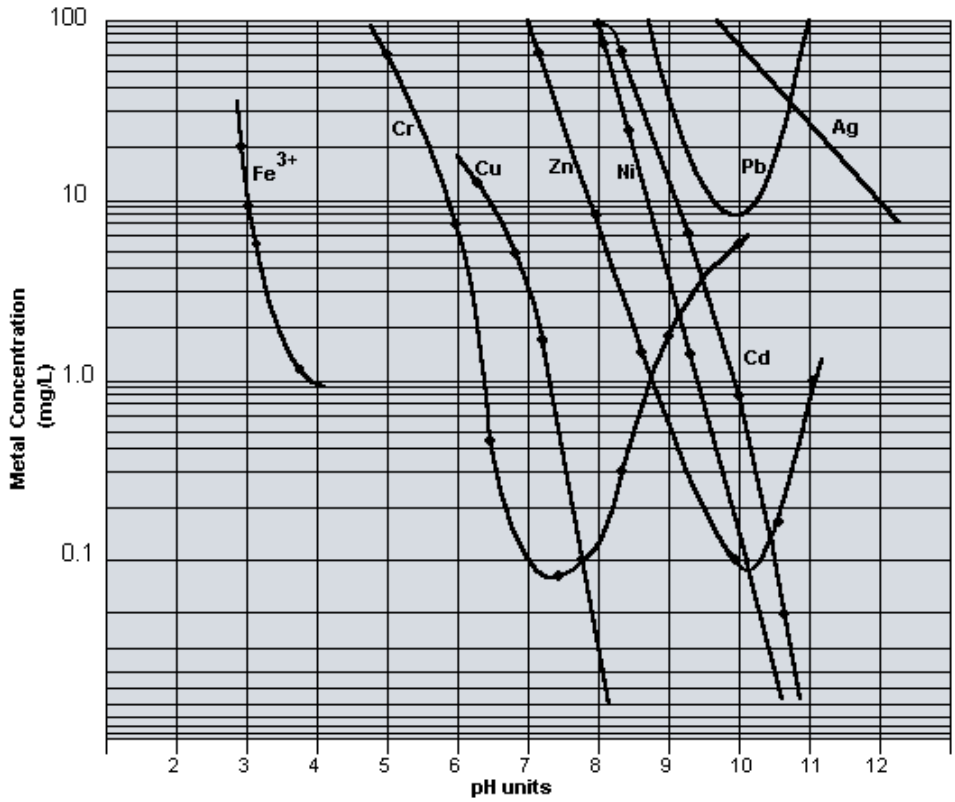
There is always concern about the risk of submerged tailings oxidising in the absence of O_2. This can occur when the pH drops below 3.5 and or there is a high concentration of Fe^{3+}. Mitigating factors are that ferric hydroxide is likely to start to precipitate at quite low pH. Also, the oxidation of ferrous to ferric by O_2 is actually quite slow at low pH. Singer and Stumm (1970) found that the oxidation rate of Fe^{2+} (Equation 2) is slow (t50 around 1000 days) and is independent of pH when less than 3.5. A common misunderstanding is that ferric iron can oxidise pyrite indefinitely in the absence of oxygen. As indicated by reaction (Equation 2), oxygen is required to generate ferric iron from ferrous iron. Also, the bacteria that may catalyse this reaction (primarily members of the *Acidithiobacillus* genus) are obligate aerobes. Therefore, some nominal amount of oxygen is needed for this process to be effective even when catalysed by bacteria, although the oxygen requirement is less than for abiotic oxidation (Gard Guide, 2017b).

Equation 2 Oxidation of Fe^{2+}

$$Fe^{2+} + H^{+} + \frac{1}{4}O_{2(aq)} \rightarrow Fe^{3+} + \frac{1}{2}H_2$$

As a consequence, it is probable that any ferric present in solution will be used up quite quickly and further production of ferric will be quite slow. Therefore, it is probable that, with minimal input, the lime containing systems will already have sufficient alkalinity to re-equilibrate at greater pH.

Figure 12 Metal hydroxide solubility curve



By raising the pH value of a solution with a common alkaline material such as lime or sodium hydroxide, the corresponding metallic hydroxide compounds become insoluble and precipitate from solution. The metal hydroxide solubility curve shows the solubility of the common heavy metal ions and their respective solubility versus pH.

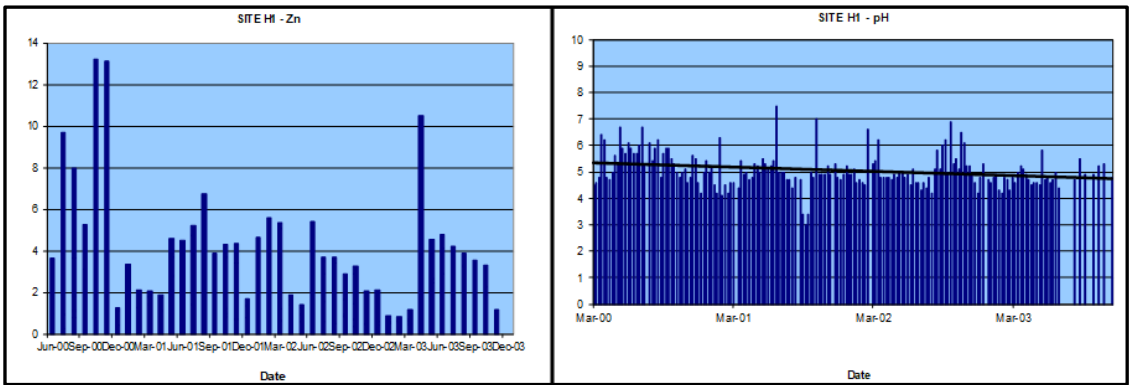
Source: http://www.hofflandenv.com/hydroxide-precipitation/

Disposal of acid generating materials below a water cover is one of the most effective methods for limiting AMD generation. In water, the maximum concentration of dissolved oxygen is approximately 30 times less than in the atmosphere. More importantly, the transport of oxygen through water by advection and diffusion is severely limited relative to transport in air. For example, the diffusive transfer of oxygen in water is on the order of 10,000 times slower than diffusive transfer in air. Results of field and laboratory testing have confirmed that submergence of AMD generating materials is one of the best available methods for limiting AMD generation over the long term (MEND, 2001).

6.1.1 Background

The environment at Hellyer has long been adversely impacted by AMD caused by the oxidation of exposed sulfide tailings, particularly in the eastern arm of the main TSF since the closure of the Hellyer Mine by Western Metals in 2000. Figure 14 through to Figure 17 are Google Earth images that show tailings exposed above the eastern arm since 2006. Figure 14 is a Google Earth image from before the Polymetals operation constructed the eastern arm embankment. Hellyer tailings can be seen in the upper eastern reaches of the main TSF. These tailings remain grey, potentially indicating minimal pyrite oxidation, however it is believed that exposed tailings along Mill Creek oxidised with consequent acidity flowing through the tailings into the TSF. Water quality graphs from this time (Figure 13) show the impact of the AMD.

Figure 13 TSF outfall: Zn concentrations and pH from Jan 2000 to Dec 2003



The seasonality of the emissions can be seen with autumn rains flushing acidity from the oxidising tailings into, and then out of, the main TSF.

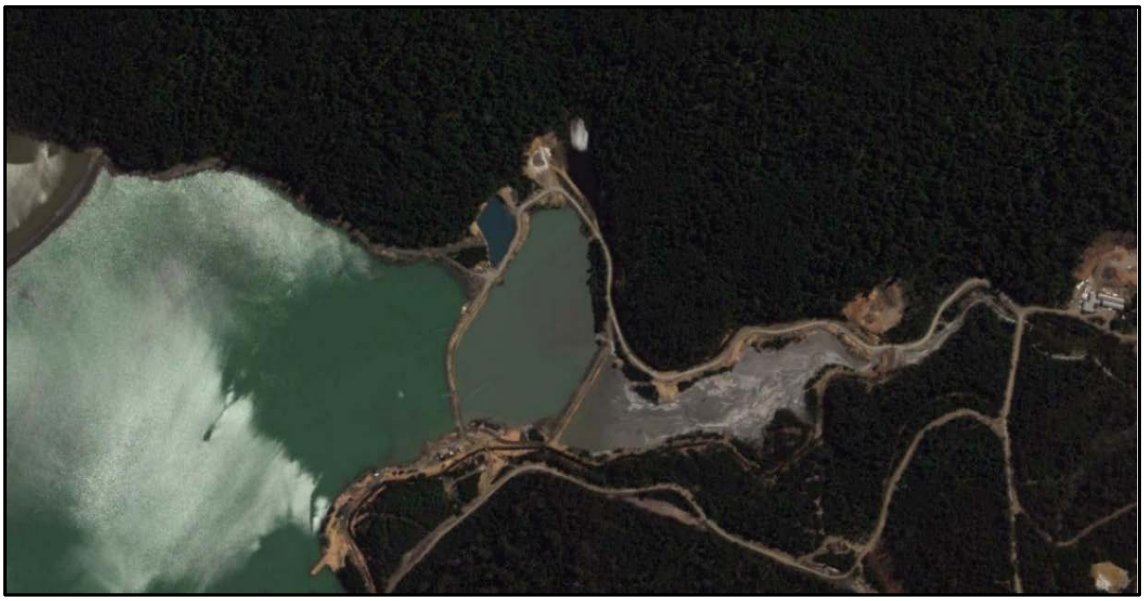
After the eastern arm embankment was constructed, tailings continued to be washed down Mill Creek after spilling from milling and processing operations (Plate 2). The height of the tailings built up due to spillages and eventually they were left exposed. Figure 15 shows that in 2012 the tailings are grey and appear fresh and saturated, whereas in Figure 16, by late 2013, the tailings are obviously desiccating and show significant iron staining, indicating that pyrite oxidation is occurring. By November 2015, in Figure 17, the spillway of the eastern arm embankment has been raised to flood the tailings. Oxidation is now more evident in the distal reaches where tailings remain exposed, and less so against the embankment wall.

Figure 14 Eastern arm 2006

Source: Google Earth image September 2006

Plate 2 Mill Creek September 2008

Figure 15 Eastern arm January 2012



Source: Google Earth image January 2012

Figure 16 Eastern arm December 2013

Source: Google Earth image December 2013

Figure 17 Eastern arm November 2015

Source: Google Earth image November 2015

Water quality records for pH at the TSF outfall (Figure 19) paint a similar picture, with pH dropping steadily after the Hellyer operation closed in 2000, increasing during the Polymetals operation, dropping during Intec's tenure, then increasing under BSM, only to drop again from 2012 when the processing stopped delivering alkalinity to the TSF and the exposed tailings oxidised. Since mid-2016, when IVY had raised the water level in the eastern arm and increased alkalinity dosing into the eastern arm spillway, the pH – although not reaching the target of 8.0 – stabilised.

The pH in the main TSF is important due to the relationship between a pH above 8.0 and total zinc concentrations at the TSF outfall. This was described in the Polymetals DPEMP (2006). In Figure 13 it can be seen that zinc concentrations increased after the closure of the Aberfoyle operation. The main reason for this is that during operations, the average pH in the tailings dam was much higher, as can be seen in Figure 18. This would have led to high zinc precipitation rates within the TSF.

AMD discharge from the Hellyer ROM (run of mine) area and ore stockpiles also flowed down Mill Creek, adding to the AMD loads from 2006, until in recent years the stockpiles were removed and the site general manager capped the ROM with a compacted lime mixture.

Figure 18 TSF outflow – pH versus total zinc – operations compared with closure

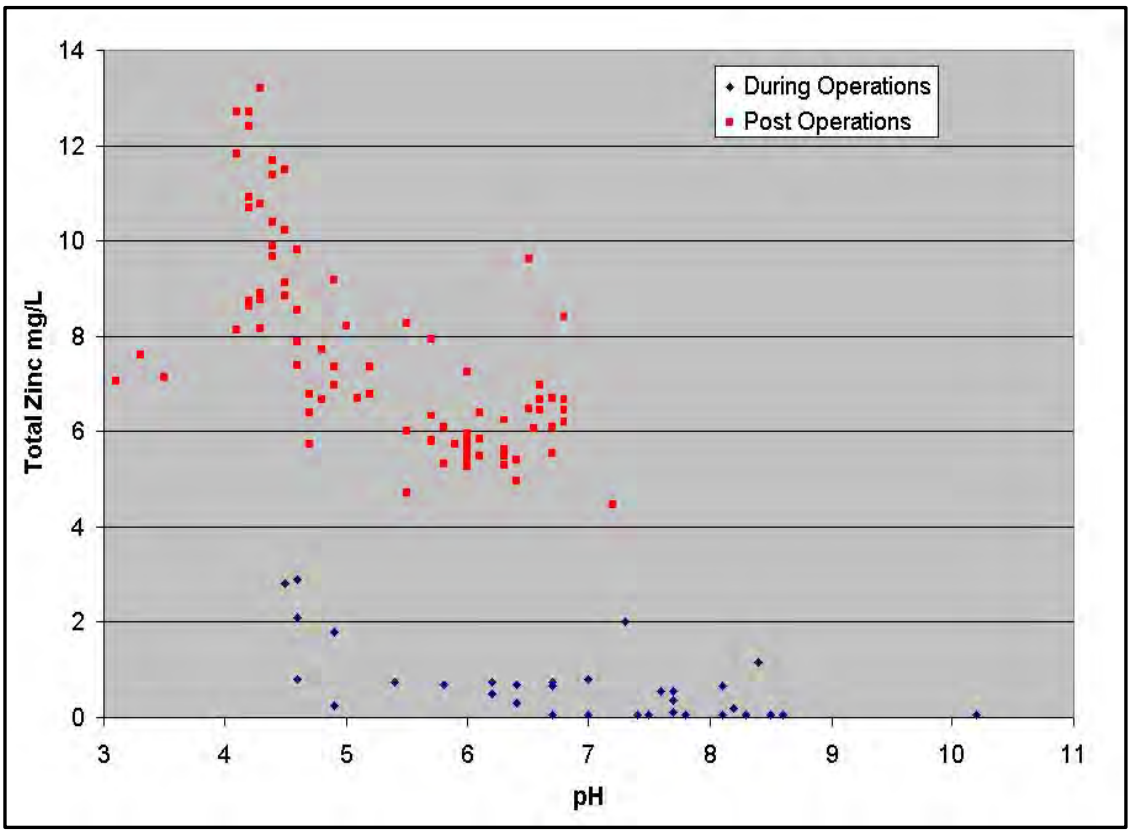
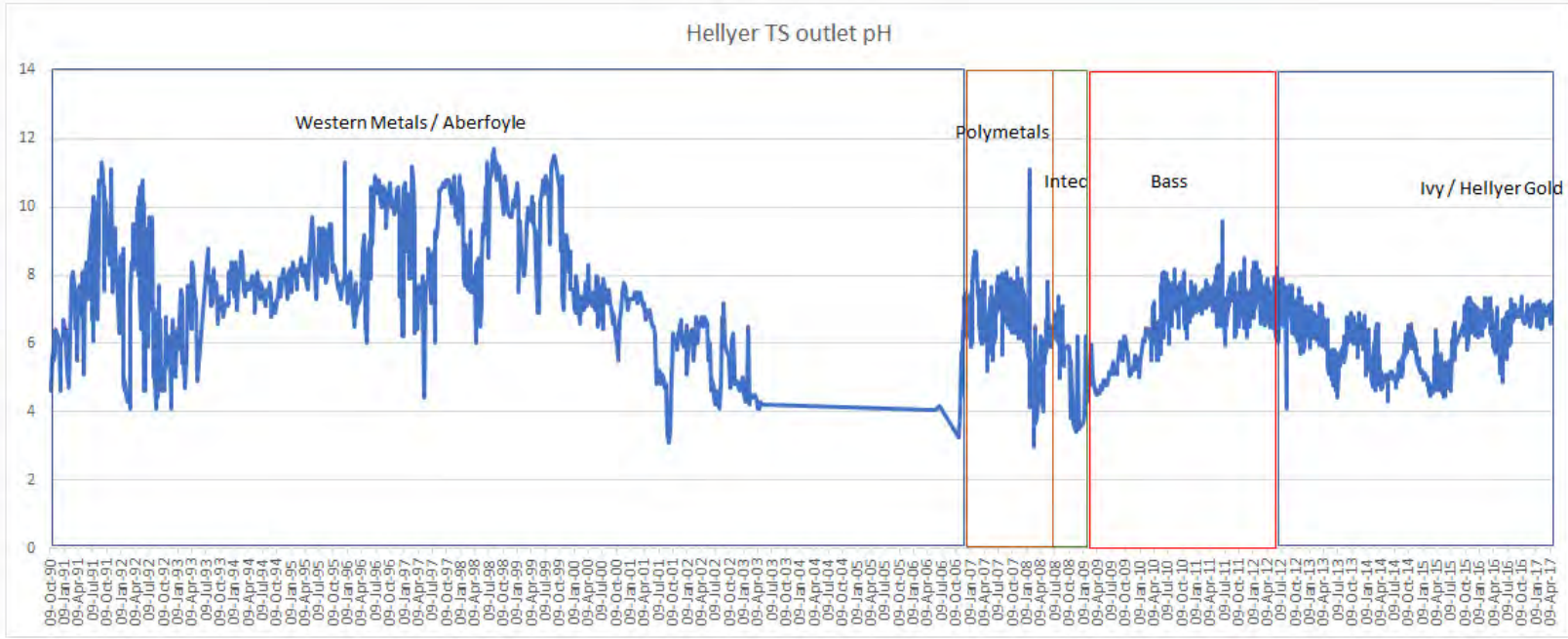


Figure 19 TSF outfall pH



6.1.2 Evaluation of acid forming characteristics

A number of test procedures are typically used to assess the acid forming characteristics of mine waste materials. The most widely used assessment methods are the acid–base account (ABA) and the net acid generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid–base account: The acid–base account involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases and weathering of silicates). The values arising from the acid–base account are referred to as the maximum potential acidity (MPA) and the acid neutralising capacity (ANC), respectively. The difference between the MPA and ANC value is referred to as the net acid producing potential (NAPP).

The MPA is calculated using the total or sulfide sulfur content of the sample. This calculation assumes that all of the sulfur (S) measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid according to the reaction shown in Equation 1.

According to this reaction, the MPA of a sample containing 1% S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). Hence, the MPA of a sample is calculated from the sulfur content using the following formula:

Equation 3 Maximum potential acidity

MPA (kg H_2SO_4/t) = (sulfur %S) × 30.6.

The acid formed from pyrite oxidation will, to some extent, react with acid neutralising minerals contained within the sample. This inherent acid neutralisation is quantified in terms of the ANC and is commonly determined using the modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

The NAPP is a theoretical calculation commonly used to indicate if a material has the potential to produce acid. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

Equation 4 Net acid producing potential

NAPP = MPA – ANC

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

The ANC/MPA ratio is used as a means of assessing the risk of acid generation from mine waste materials. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. Generally, an ANC/MPA ratio of 3 or more signifies that there is a high probability that the material is not acid generating.

Net acid generation (NAG) test: The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide

to rapidly oxidise any sulfide minerals contained within the sample. During the NAG test, both acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed in the same units as NAPP, that is, kg H_2SO_4/t.

The standard NAG test involves the addition of 250 mL of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight, and the following day the sample is gently heated to accelerate the oxidation of any remaining sulfides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the pH and acidity of the NAG liquor are measured. The acidity of the liquor is then used to estimate the net amount of acidity produced per unit weight of sample.

6.1.2.1 Geochemical classification categories

The acid forming potential of a sample is classified – on the basis of the acid–base account and NAG test results – into one of the following categories:

- non–acid forming (NAF)
- potentially acid forming (PAF)
- acid forming (AF)
- uncertain (UC).

Non–acid forming (NAF): A sample classified as NAF may, or may not, have a significant sulfur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and a final NAGpH ≥4.5.

Potentially acid forming (PAF): A sample classified as PAF always has a significant S content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circumneutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH <4.5.

Uncertain (UC): An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH >4.5, or when the NAPP is negative and NAGpH <4.5). Uncertain samples are generally given a tentative classification that is shown in brackets, e.g. UC (NAF) or UC (PAF).

Acid forming (AF): A sample classified as AF has the same characteristics as the PAF samples; however, these samples also have an existing pH of <4.5. This indicates that acid conditions have already developed, confirming the acid forming nature of the sample.

6.1.3 Existing environment

At Hellyer there is a legacy of AMD from past practices over several decades:

- The shale quarry dam walls contain some pyrites which oxidised after construction. This appears to have significantly reduced in recent years.
- The ability of the shale quarry to hold water is compromised by a direct hydraulic connection to the Hellyer void in the north-eastern corner. Since the shale quarry dam wall was raised in 2006, seepage into the Hellyer void has increased due to the extra head. The regular water addition also reflects the loss of water from the shale quarry through evaporation and seepage more than changes in the underground void water level.

- Parts of the western embankment wall appear to contain pyrite, resulting in oxidation near the dam wall.
- Tailings in the western arm impoundment were not placed against the dam wall to reduce its permeability, as required by the then tailings management plan. As a result, the western arm embankment acts as a leaky aquitard and the western arm impoundment does not hold water and needs water dosing during summer to keep tailings submerged.
- Issues with the eastern arm are described in Section 6.1.1.

A significant consequence of these legacies is that the current proposal to mine these tailings, passivate them where necessary and store them subaqueously in perpetuity presents an opportunity to cost-effectively remediate the AMD legacies and improve the quality of surface water emissions from the site.

6.1.4 Potential effects

The main risk of AMD formation will come from the oxidation of sulfidic (pyritic) tailings. The development of low pH and high metal concentrations can consequently have a severe impact on surface and groundwaters.

With regard to the short-term mining plan, there are three uncertainties and potential risks to be addressed:

- Leaving the currently submerged eastern arm tailings in situ until TSF 2 is operational and the PRT has been moved to TSF 2, expected to be by May 2022.
- Management of tailings and associated material cleaned up from the upper reaches of the eastern arm and Mill Creek; remediation of these to prevent further AMD generation.
- Entry to the main TSF of acidity loads which contribute to low pH and high metal concentrations.

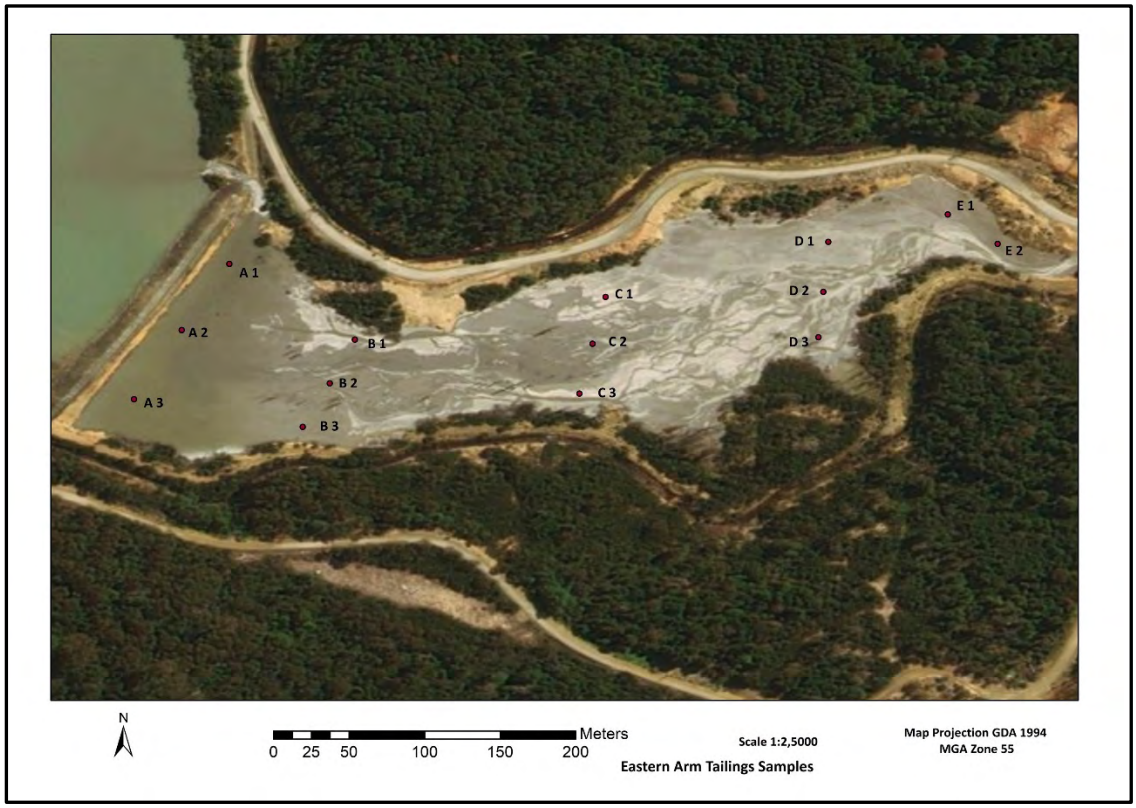
These issues are addressed in Sections 6.1.4.3, 6.1.4.4 and .

6.1.4.1 AMD assessment eastern arm

The analyses defined in Section 6.1.4.2 were undertaken to assess the AMD potential of the eastern arm tailings, specifically the risks involved and possible remediation required.

The locations of the tailings sampling are shown in Figure 20.

Figure 20 Tailings samples



6.1.4.2 Geochemical testwork and classification

The geochemistry testwork is based around static testwork.

Static

- Full acid–base accounting of eastern arm tailings and samples from Mill Creek.
- Analysis of maximum possible acidity from both pyrite and secondary sulfates from mineralogy for eastern arm and Mill Creek samples.

Table 3 gives the comparison of the sulfide S (CRS) with Total S showing that 30−40% of the total S used to calculate the maximum potential acidity (MPA) in NAPP is not from sulfide minerals. The greatest component of this non-sulfide S is likely to be from barite. Total S is in the range 14.1−27.8 wt.% across the sample set with generally greater concentrations in the samples closer to the Mill Creek feed point (C, D and E samples) and generally greater concentrations in the deep samples compared to surface samples at the same points. Sulfide S was assessed by using the chromium reducible sulfide (CRS) method as described by Schuman et al. (2012).

Table 3 Total S (LECO), sulfide S, organic and inorganic carbon assays.

Sample	Total S (wt.%)	Sulfide S (wt.%)	Total C (wt.%)	Organic C (wt.%)	Inorganic C (wt.%)
A1 – Shallow	17.4	11.74	0.28	0.19	0.09
A1 – Deep	17.4	11.86	0.54	0.34	0.20
A2 – Shallow	14.1	8.92	1.42	1.27	0.15
A2 – Deep	15.8	10.71	0.87	0.60	0.27
A3 – Shallow	16.0	10.36	1.00	0.78	0.23
A3 – Deep	14.9	10.39	1.88	1.72	0.16
B1 – Shallow	20.8	15.37	0.25	0.18	0.06
B1 – Deep	19.3	11.41	0.18	0.11	0.07
B2 – Shallow	20.4	13.57	0.30	0.22	0.09
B2 - Deep	17.6	9.64	0.19	0.08	0.10
B3 – Shallow	17.5	11.21	0.41	0.28	0.13
B3 – Deep	16.7	9.19	0.25	0.11	0.13
C1 – Shallow	19.2	11.62	0.22	0.14	0.08
C1 – Deep	23.9	18.41	0.51	0.13	0.38
C2 – Shallow	21.9	16.26	0.40	0.13	0.27
C2 – Deep	19.7	11.44	0.17	0.10	0.07
C3 – Shallow	19.7	12.44	0.23	0.13	0.10
C3 – Deep	17.4	11.79	0.39	0.18	0.21
D1 – Shallow	19.4	11.95	0.24	0.18	0.06
D1 – Deep	27.8	22.83	0.56	0.14	0.41
D2 – Shallow	19.7	12.72	0.13	0.07	0.06
D2 – Deep	27.4	21.95	0.48	0.09	0.38
D3 – Shallow	26.6	21.15	0.47	0.10	0.37
D3 – Deep	19.8	11.36	0.10	0.05	0.06
E1 – Shallow	17.5	10.21	0.07	0.03	0.05
E1 – Deep	23.1	16.83	0.31	0.08	0.23
E2 – Shallow	20.8	12.67	0.03	0.03	0.00
E2 – Deep	22.0	15.42	0.23	0.05	0.18

ABA characterisation consisted of MPA (based on Total S), MPA* (based on CRS S), ANC, NAPP and NAPP* for estimation of total amounts in the eastern arm impoundment (Table 4). Correction of the MPA using the CRS sulfide S (MPA*) is necessary given the significant non-sulfide S content to better represent the net acid producing potential (NAPP*). Further correction of MPA* (to give MPA**) can be done using the pyrite sulfide S content as determined from quantitative XRD analysis.

Table 4 ABA analyses

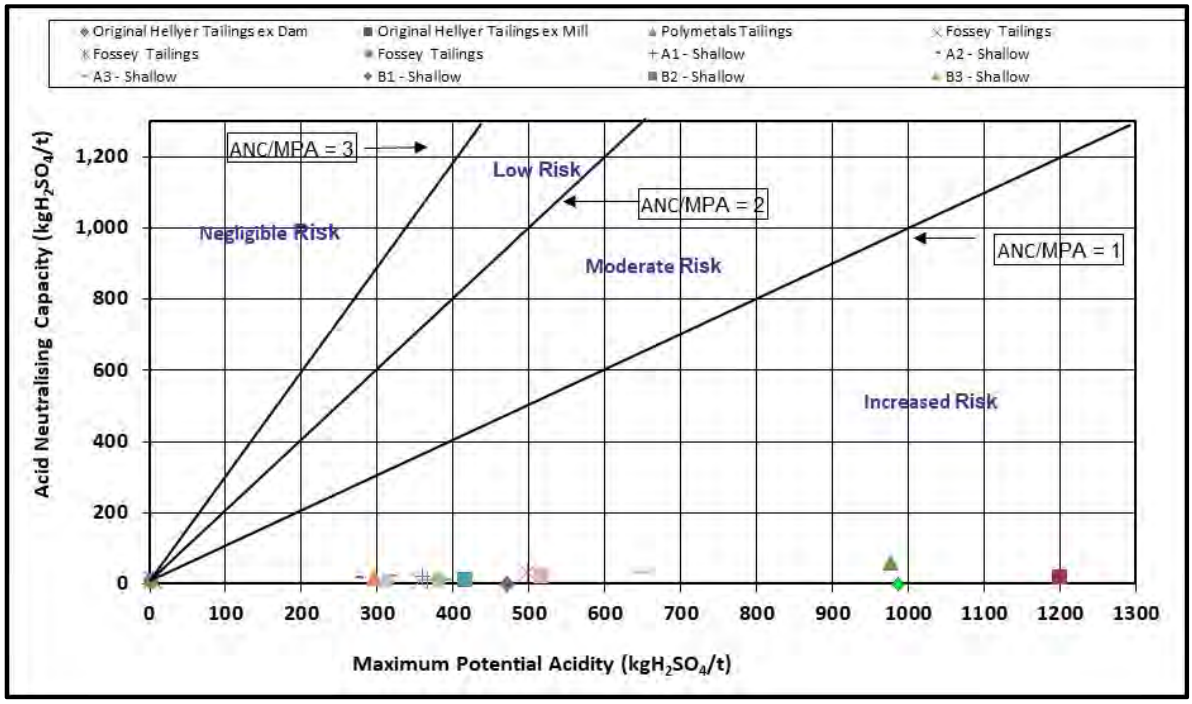
Sample	ANC (kg H_2SO_4 t^{-1})	ANC(C) (kg H_2SO_4 t^{-1})	NAPP (kg H_2SO_4 t^{-1})	NAPP* (kg H_2SO_4 t^{-1})
A1 – Shallow	21	7.6	511	338
A1 – Deep	23	16	510	340
A2 – Shallow	17	12	414	255
A2 – Deep	26	22	457	302
A3 – Shallow	21	18	468	295
A3 – Deep	21	13	435	297
B1 – Shallow	6.8	5.0	630	463
B1 – Deep	11	5.8	580	338
B2 – Shallow	12	7.3	612	403
B2 – Deep	12	8.5	526	283
B3 – Shallow	16	11	520	327
B3 – Deep	16	11	495	265
C1 – Shallow	7.3	6.9	580	348
C1 – Deep	34	31	697	529
C2 – Shallow	32	22	639	466
C2 – Deep	11	5.5	592	339
C3 – Shallow	12	8.2	591	369
C3 – Deep	26	17	507	335
D1 – Shallow	10	4.7	583	355
D1 – Deep	36	34	814	662
D2 – Shallow	11	4.9	591	378
D2 – Deep	34	31	804	637
D3 – Shallow	32	30	782	615
D3 – Deep	7.4	4.6	598	340
E1 – Shallow	8.0	3.7	527	304
E1 – Deep	22	19	685	493
E2 – Shallow	–0.5	0.0	637	388
E2 – Deep	17	15	656	455

ANC – AMIRA ARD Test Handbook method. All Fizz Rating 1 except B1 – Shallow, C1 – Shallow, D3 – Deep and E2 – Deep, which were Fizz Rating 0. ANC(C) – based on inorganic carbon assay, NAPP = 30.6 × wt.% total S – ANC, NAPP = 30.6 × % sulfide S – ANC.*

The total NAPP* (CRS sulfide) acidity of the 28 samples ranges from 255 to 662 kg H_2SO_4 t^{-1}. There is no significant inorganic carbon (i.e. carbonate) neutralisation. There is some minor organic carbon (Table 3), which may assist heterotrophic bacterial action to reduce oxygen availability at neutral pH.

All of the sample are PAF and in the 'High' risk category. Figure 21 compares ABA risks for original Hellyer tailings, Polymetals tailings, Fossey tailings and the eastern arm tailings, most of which have been exposed for between five and seven years. The eastern arm tailings have less potential acidity than Hellyer or Polymetals tailings but more than Fossey tailings. All have minimal ANC.

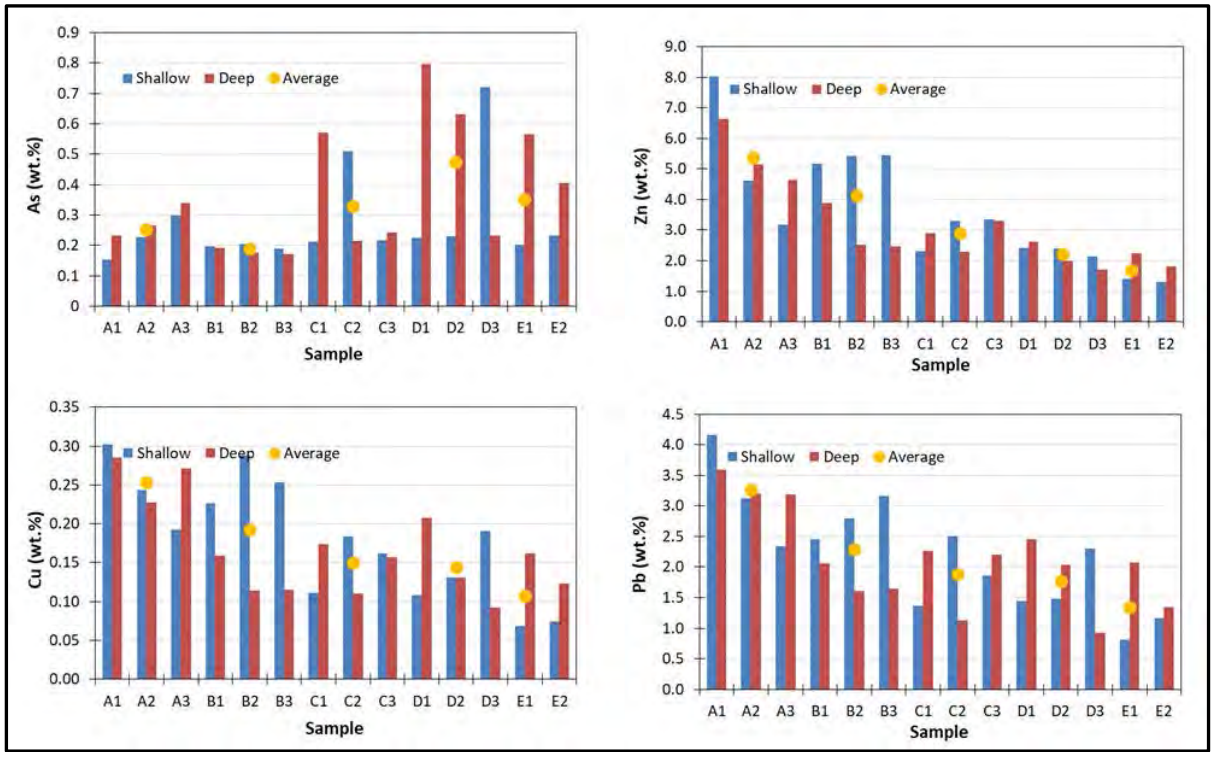
Figure 21 ABA risk categorisation



Mineralogy

As well, bulk assays for the 28 samples were undertaken for reconciliation with XRD to cross-check mineralogy and determine amorphous (non-XRD) mineralloids (potentially fast release). Results for major metals of concern are shown in Figure 22.

Figure 22 Bulk assay data eastern arm samples



The significant information from bulk assay data is:

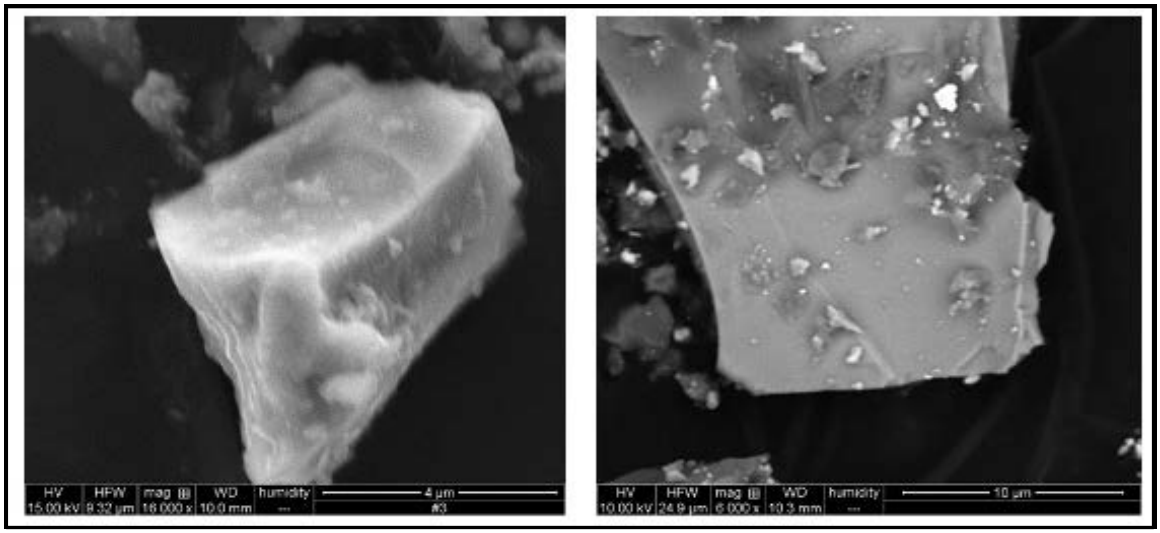
- Cu, Pb and Zn concentrations generally decrease from the eastern embankment wall to Mill Creek.
- Arsenic is variable with spikes in some samples, but generally increases in concentration from the eastern embankment wall to Mill Creek.
- Elements are consistent with the structural forms of the mineral phases in the quantitative XRD including K, Mg, Fe, Ca, Ba, Si and Al.
- There is no significant Se in the samples.

Stored Acidity

In addition to acid produced by oxidation of pyrite, in many long-term AMD wastes (rock and tailings), the formation of secondary acid sulfates, particularly jarosites and schwertmannite, can release acid at pH above 2.5 slowly over many years. No jarosite was detected in any of the XRD analyses. This stored acidity needs to be considered in addition to the conventional pyrite acidity in full assessment of AMD potential. The results of sequential extraction on the tailings show negligible elemental S or rapidly soluble acid sulfates, with jarosite S (HCl extractable S) in the range 0.2–0.4 wt.% corresponding to 1.6–3.2 wt.% jarosite. Some double counting (CRS and residue) of sphalerite and galena leads to greater cumulative S concentration as compared to Total Leco S. The slow release of acid from jarosite at this concentration will probably be mostly neutralised by the slow release of silicate ANC.

Analytical scanning electron microscopy (SEM) has been used to examine the reacted state of the as-received sulfide and neutralising (alumino)silicate minerals in the composites, particularly any protective surface layers and passivation of the pyrite surfaces that would indicate reduced rates of AMD release after storage (Figure 23). Pyrite particles are not heavily reacted and are covered in oxidised products. This is consistent with passivated pyrite surfaces at near-neutral pH.

Figure 23 Examples of pyrite particles from Composite (A) and Composite (B)



Composite (A) (left; secondary electron image)) and Composite (B) (right; backscattered electron image).

The silicates and aluminosilicates examined also show extensive reaction and dissolution with low concentrations of remaining metal cations consistent with their ion exchange with protons providing acid neutralisation (non-carbonate) during the long time in eastern arm tailings storage.

NAG Tests and NAPP vs NAG

NAG tests (kinetic, sequential), for estimation of total acidity in eastern arm tailings, results are provided in Table 5. The reactive nature of these high-pyrite samples required reduction of the

standard AMIRA sample size (2.5 g) to 0.5 g to avoid boil-over of the peroxide in the first stage of the test. The results have been scaled up to match conventional NAG test data. The sequential NAG results (Table 5) also show that acid is generated in Stages 2 and 3 to complete the full estimation of total amounts in eastern arm storage.

The comparison of NAPP* versus Total NAG_7 (Figure 24) shows good agreement between MPA*−ANC (i.e. NAPP*) and Total titratable acidity (sum of titration to pH 7 for all NAG stages) to pH 7 suggesting that most acidity is from pyrite oxidation rather than metal precipitation.

Figure 24 NAPP* versus Total NAG_7

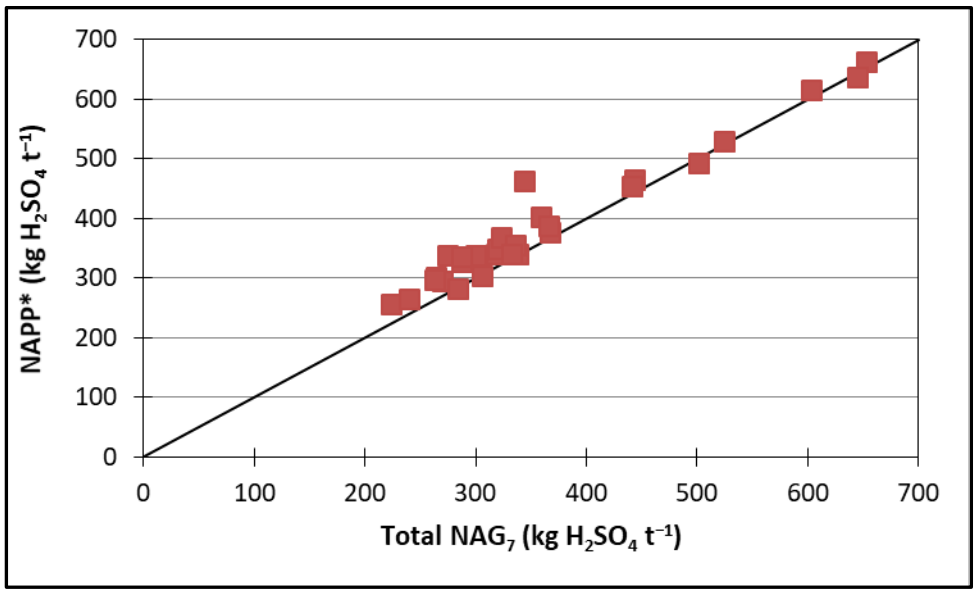


Figure 24 shows good agreement between MPA*−ANC (=NAPP*) and total titratable acidity to pH 7 (Total NAG7) indicating that there is little metal acidity.

Table 5 NAG results for samples. $NAG_{4.5}$, NAG_7, NAPP*– kg H2SO4 t^{-1}.

Sample	Stage 1[1]			Stage 2			Stage 3			Total	
	NAG pH	$NAG_{4.5}$	NAG_7	NAG pH	$NAG_{4.5}$	NAG_7	NAG pH	$NAG_{4.5}$	NAG_7	$NAG_{4.5}$	NAG_7
A1 – Shallow	2.38	155	232	3.00	22	29	4.77	0	14	177	275
A1 – Deep	2.20	156	265	2.80	41	47	4.84	0	5.9	198	319
A2 – Shallow	2.40	138	199	3.29	13	20	4.23	1.0	5.4	151	224
A2 – Deep	2.39	154	223	2.97	24	30	3.97	1.5	9.8	180	264
A3 – Shallow	2.37	173	232	2.95	25	30	3.83	1.9	8.2	199	270
A3 – Deep	2.44	126	228	3.03	23	29	3.73	2.9	6.8	152	263
B1 – Shallow	2.26	180	244	2.58	77	84	3.88	3.9	16	261	344
B1 – Deep	2.31	188	228	2.73	54	59	4.02	2.9	13	245	300
B2 – Shallow	2.24	199	264	2.56	76	83	3.76	4.9	12	280	359
B2 – Deep	2.24	203	237	2.90	31	35	4.58	0	11	234	283
B3 – Shallow	2.33	165	242	3.04	27	35	4.50	0	9.3	192	287
B3 – Deep	2.39	167	203	3.10	21	27	4.58	0	9.1	188	240
C1 – Shallow	2.28	182	218	2.56	81	95	4.25	1.0	7.3	264	320
C1 – Deep	2.13	281	342	2.34	150	168	3.36	10	16	441	525
C2 – Shallow	1.87	253	308	2.42	106	126	3.57	5.8	9.7	365	444
C2 – Deep	2.27	212	265	2.67	55	66	4.98	0	6.3	267	338
C3 – Shallow	2.30	191	234	2.61	74	79	4.38	0.98	11	267	323
C3 – Deep	2.32	191	237	2.78	40	45	4.76	0	5.4	231	287

Table 5. Continued.

Sample	Stage 1[1]			Stage 2			Stage 3			Total	
	NAG pH	$NAG_{4.5}$	NAG_7	NAG pH	$NAG_{4.5}$	NAG_7	NAG pH	$NAG_{4.5}$	NAG_7	$NAG_{4.5}$	NAG_7
D1 – Shallow	2.28	229	273	2.71	49	55	4.68	0	7.8	278	336
D1 – Deep	2.09	396	479	2.33	152	162	3.35	8.3	13	556	653
D2 – Shallow	2.20	249	292	2.70	57	65	3.83	3.4	11	310	367
D2 – Deep	2.07	403	470	2.37	149	159	3.41	9.2	15	562	644
D3 – Shallow	1.94	384	442	2.42	136	148	3.53	7.8	12	527	603
D3 – Deep	2.17	235	265	2.67	53	60	4.10	1.4	8.2	290	333
E1 – Shallow	2.05	209	248	2.81	37	43	4.53	0	14	246	305
E1 – Deep	2.02	289	349	2.37	133	142	3.53	7.3	11	429	502
E2 – Shallow	2.01	279	298	2.69	51	59	4.56	0	8.7	331	366
E2 – Deep	2.16	261	296	2.43	121	134	3.65	6.3	12	389	441

Sequential NAG test conducted according to the AMIRA ARD Test Handbook method, using 0.5 g of sample rather than the usual 2.5 g sample mass.

6.1.4.3 Retaining the currently submerged eastern arm tailings in situ

Changes in acid and neutralisation release resulting from dredging and pumping a 40 wt.% slurry from (as originally proposed) the eastern arm to the main TSF (and eventually to the TSF 2) is being estimated using comparison of a quiescent and agitated slurry over time. The agitation with air exposure will simulate faster oxygen transfer (than quiescent conditions) to pyrite surfaces that may be exposed during this operation. This assumes that, after transfer, quiescent conditions will be re-established under the new water cover. However, the continuing agitation test provides a worst-case estimation. Composites (40 wt.%) of near dam (A) and far from dam (B) have been prepared and tested.

Across a period of 15 days, the initially stirred, then quiescent samples have remained at pH 7.7 in-pulp for both composites. For the continuously stirred (worst case) over 10 days, the pH has also remained in the range 6.7−7.6 for Composite (A) and 7.1−8.1 for Composite (B). These periods are clearly much longer than any duration of disturbance likely to be caused by the dredging / pumping transfer.

Across a period of 15 days, the initially stirred, then quiescent samples have filtrates remaining near pH 7.5 and no measured acidity for either composite. For the continuously stirred (worst case) over 10 days, the pH has reduced slightly to the range 6.5−6.7 for both composites. The titrated acidity and the Eh (solution redox potential) have been slowly increasing for both composites (more for Composite (B)) across this period. There is evidence of some acid release in the first 24 hours for Composite (B) (far from dam) but not for Composite (A) (near dam). These periods are still longer than the duration of any disturbance that is likely to be caused by the dredging / pumping transfer.

Although the testwork was designed for transfer to the main TSF, the results have application to eventual transfer to the TSF2 and also inform views on current AMD generation in the eastern arm. The neutral in situ pH in the jar tests described in Section 6.4.4 and shown in Table 10, when combined with the neutral pH after stirring and quiescence, indicates that although the eastern arm tailings are highly pyritic, they are not generating significant amounts of AMD in situ.

As a result, it is proposed that further limited testwork is undertaken prior to remediation work to quantify the degree of alkalinity addition needed to passivate the “tailings” prior to final deposition.

6.1.4.4 Remediation of Mill Creek and the upper reaches of the eastern arm impoundment

As can be seen in Table 3, Table 4 and Figure 21, and as described above, when the exposed tailings are excavated and placed underwater in the western arm, there is a risk of acidity release when these tailings are agitated (as will occur when the tailings are excavated and moved). There is also an almost certain and significant risk of pyrite oxidation if the tailings are excavated and left exposed to atmospheric oxygen.

Interim results for the exposed tailings (E samples in Table 4) show a NAPP of between 304 and 493 kg H_2SO_4 t^{-1}. The surface samples have the lowest NAPP and the lowest ratios of CRS, possibly indicating some oxidation of the pyrite in the near-surface layers. As a result, HGM is prepared to commit to adding sufficient lime as an alkalinity reagent to the tailings and associated wastes to neutralise them before placing them temporarily in the western arm impoundment as described in Section 4. This should be a worst-case scenario.

As a consequence, it is proposed that further limited testwork is undertaken prior to remediation work to quantify the degree of alkalinity addition needed to passivate the “tailings” prior to final deposition.

HGM will provide a final AMD management and mitigation plan to the EPA for approval at least 30 days before commencing remediation works. The Plan will include:

- A description of how remnant tailings and associated mud sludges are to be removed from Mill Creek.
- A description of how the tailings and associated mud sludges will be transported from their locations in Mill Creek to the Western Arm impoundment.

- A description on how they will be deposited into the Western Arm impoundment.
- Mitigation measures to prevent spillage between the locations.
- Monitoring to be undertaken during the remediation program.

6.1.4.5 Timing of a follow up audit to evaluate the success of the works. Acidity loads into the main TSF

The testwork referred to in Section 6.1.4.3 above provides a significant insight into acidity sources for the main TSF. The testwork was designed to determine how much acidity would be produced when the eastern arm tailings were agitated during dredging and pumping to the main TSF or the TSF2.

The test (stirred vigorously and then quiescent compared with continuously stirred) is being carried out on the composite eastern arm deeper samples. These samples were pretested for solids wt.% and adjusted to 40 wt.% and then mixed eastern arm tailings and main TSF dam water (50% each) before the kinetics were recorded: pH continuously, Eh, EC, acidity daily and full solution assays weekly. A near dam Composite (A) and the far from dam Composite (B) were set up. The main observations and conclusions to date are summarised below.

The particle size distributions (psd) of each composite were measured to assess any effects of differences in surface areas in interpreting the in-pulp and solution filtrate measurements. The psd plots are shown in Figure 25. The psd results indicate a significant difference between the composite samples. Tailings near the dam wall have a largely bimodal distribution, peaking near 10 µm and 80 µm, d(0.5) 10 µm, d(0,9) 70 µm. The far from dam wall tailings are generally coarser, and have a trimodal distribution peaking near 20 µm, 100 µm and 140 µm, with d(0.5) 25 µm, d(0,9) 240 µm. Despite these differences in psd, there is no obvious difference in the behaviour of the two composites compared in the continuously stirred or quiescent procedures.

Figure 25 Particle size distributions of Composite (A) – near dam

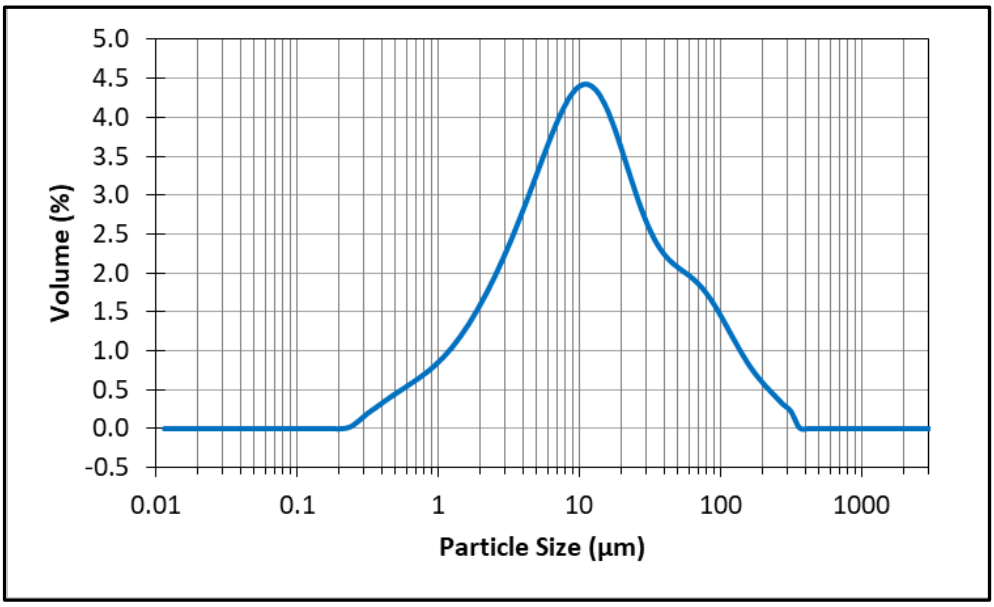
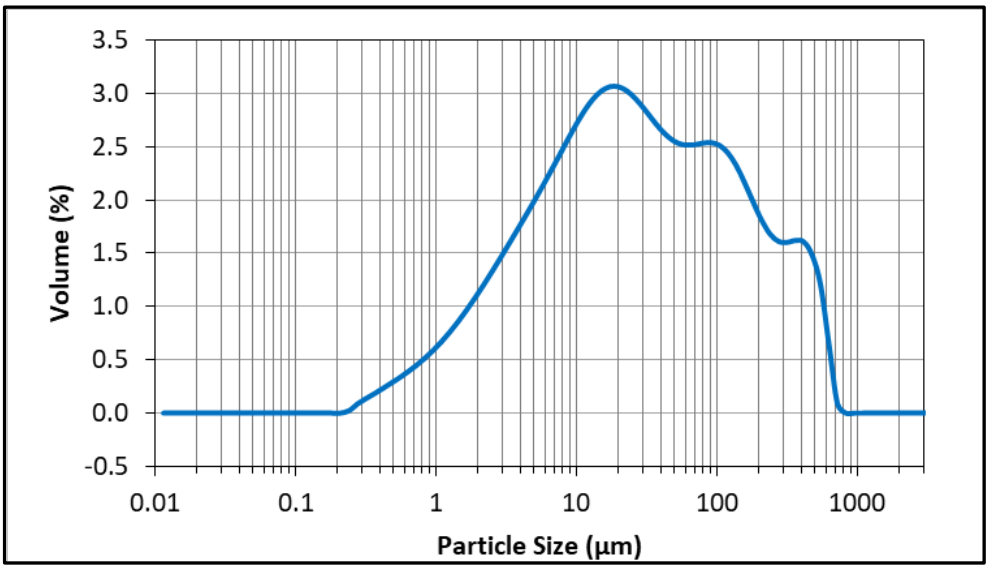
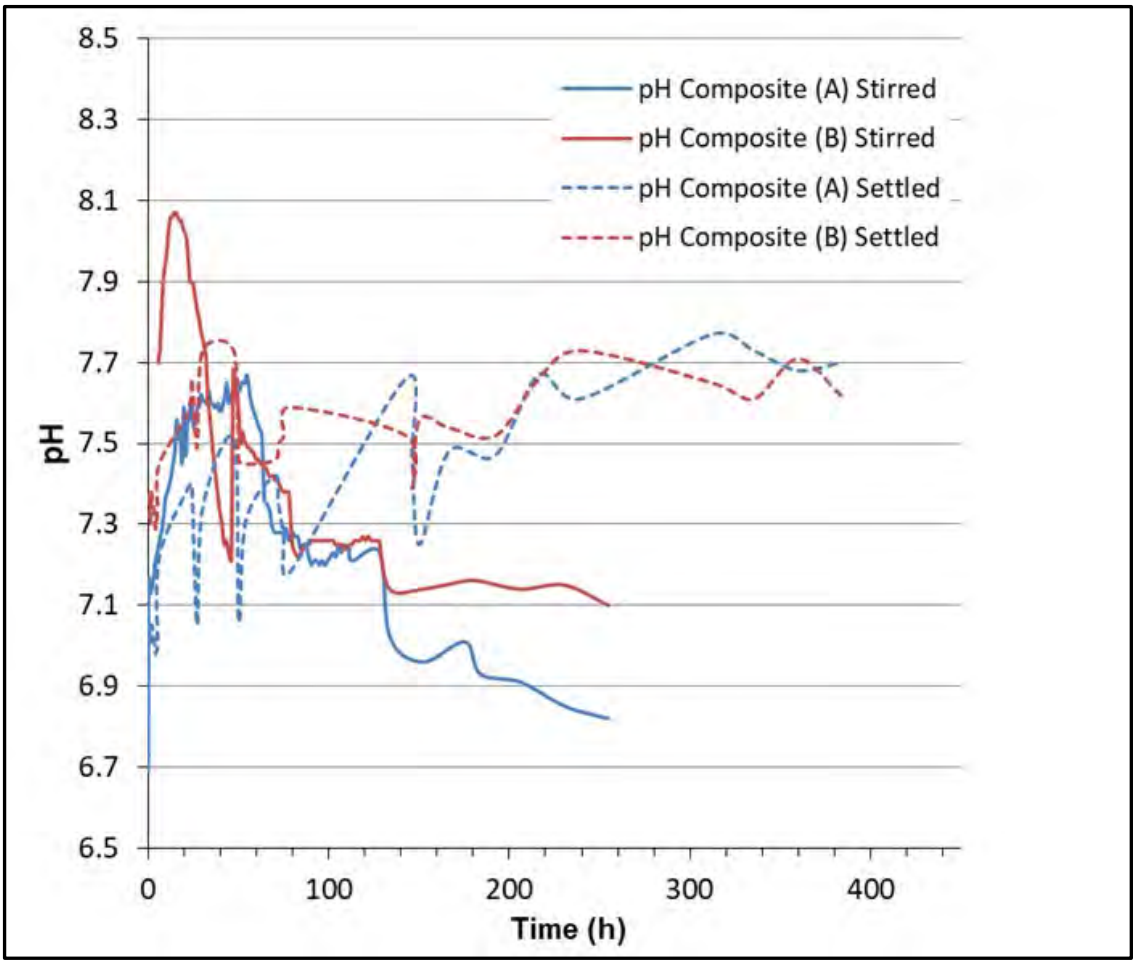


Figure 26 Particle size distributions of Composite (B) – far from dam



Across a period of 15 days, the in-pulp measurements of initially stirred, then quiescent samples have remained at pH ≈7.7 for both composites (Figure 27). For the continuously stirred (worst case) tests over 10 days, the pH has also remained in the range 6.7−7.6 for Composite (A) and 7.1−8.1 for Composite (B). These periods are clearly much longer than the duration of any disturbance likely to be caused by the dredging / pumping transfer.

Figure 27 In-pulp pH measurements for stirred and settled Composites (A) and (B).



Across a period of 15 days, the initially stirred, then quiescent samples have filtrates remaining near pH 7.5 and no measured acidity for either composite (Figure 28). For the continuously stirred (worst case) over 10 days, the pH has reduced slightly to the range 6.5 to 6.7 for both composites. The titrated acidity and the Eh have been slowly increasing for both composites (more for Composite (B)) across this period. There is evidence of some acid release in the first 24 hours for Composite (B) but not for Composite (A). These periods are still longer than the duration of any disturbance likely to be caused by the dredging transfer. Some monitoring of the filtrate when the far from dam end of the eastern arm is being dredged may be suggested but the quiescent results show that this is probably not required after the transfer.

Figure 28 Filtrate pH measurements for stirred and settled Composites (A) and (B).

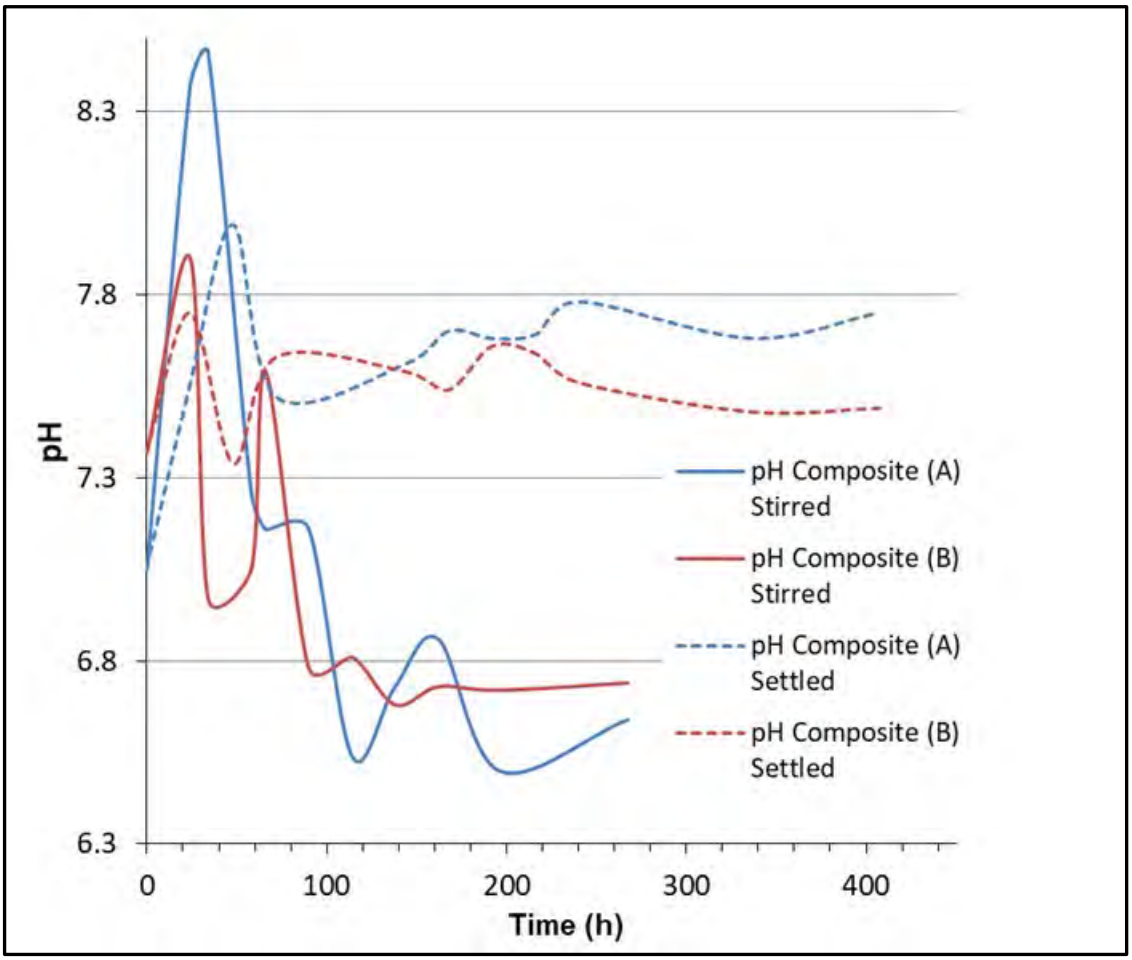


Table 6 Selected in leachate elemental assays (mg L^{-1}).

Sample	Al	As	Au	Ba	Ca	Cd	Co	Cu	Fe	K	La	Li	Mg
Composite A Stirring - 162 h	<0.02	<0.01	<0.01	0.01	630	0.27	0.08	<0.01	<0.01	6.0	<0.005	0.02	60
Composite B Stirring - 162 h	0.09	<0.01	<0.01	0.01	730	0.50	0.12	<0.01	<0.01	11	<0.005	0.04	71
Composite A Settled - 168 h	<0.02	<0.01	<0.01	0.01	160	<0.005	<0.005	<0.01	0.02	2.5	<0.005	0.01	29
Composite B Settled - 168 h	<0.02	<0.01	<0.01	0.01	150	<0.005	<0.005	<0.01	<0.01	2.9	<0.005	0.01	37
Composite A Stirring - 267 h	<0.02	<0.01	0.04	0.01	870	0.61	0.12	<0.01	<0.01	12	<0.005	0.03	82
Composite B Stirring - 267 h	<0.02	<0.01	0.06	0.02	790	0.50	0.12	<0.01	<0.01	21	<0.005	0.04	110
Composite A Settled - 336 h	<0.02	<0.01	<0.01	0.02	170	<0.005	<0.005	<0.01	0.01	3.2	<0.005	0.009	34
Composite B Settled - 336 h	<0.02	<0.01	<0.01	0.01	180	<0.005	<0.005	<0.01	<0.01	3.6	<0.005	0.01	45

Sample	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Zn
Composite A Stirring Day 7	12	0.01	28	0.05	<0.05	0.11	920	<0.01	<0.01	1.0	<0.01	2.4	37
Composite B Stirring Day 7	20	<0.01	15	0.02	<0.05	1.1	1210	<0.01	<0.01	0.93	<0.01	2.3	46
Composite A Unstirring Day 7	0.87	0.02	17	<0.005	<0.05	0.01	170	0.02	<0.01	1.6	<0.01	0.51	0.02
Composite B Unstirring Day 7	1.6	0.02	15	<0.005	<0.05	0.02	180	0.03	<0.01	1.6	<0.01	0.59	0.03
Composite A Stirring Day 12	26	<0.01	21	0.10	0.37	0.42	1250	<0.01	<0.01	1.5	<0.01	3.0	90
Composite B Stirring Day 12	33	<0.01	19	0.08	0.34	0.49	1620	0.03	<0.01	0.64	<0.01	2.3	49
Composite A Unstirring Day 14	0.95	<0.01	18	0.05	0.29	<0.01	180	<0.01	<0.01	1.2	<0.01	0.43	0.07
Composite B Unstirring Day 14	2.2	<0.01	18	0.06	0.26	<0.01	210	<0.01	<0.01	1.4	<0.01	0.55	0.13

The metals released from these systems (Table 6) indicate:

- Dissolution of some reactive silicates probably giving slow ANC (not measured in Sobek ANC) seen in Ca, Mg, K, Na, Si.
- Higher release in continuously stirred composites of Zn, Cd, Pb, Mn, Ni.
- No significant release even in stirred systems of Cu or As.
- Likely safe control of metals in agitated then quiescent transfer.

The lack of acidity production in the eastern arm tailings potentially indicates that the Mill Creek drainage is the principal source of acidity into the main TSF rather than the eastern arm tailings. HGM will remove, passivate and manage this potential source to prevent further AM D production.

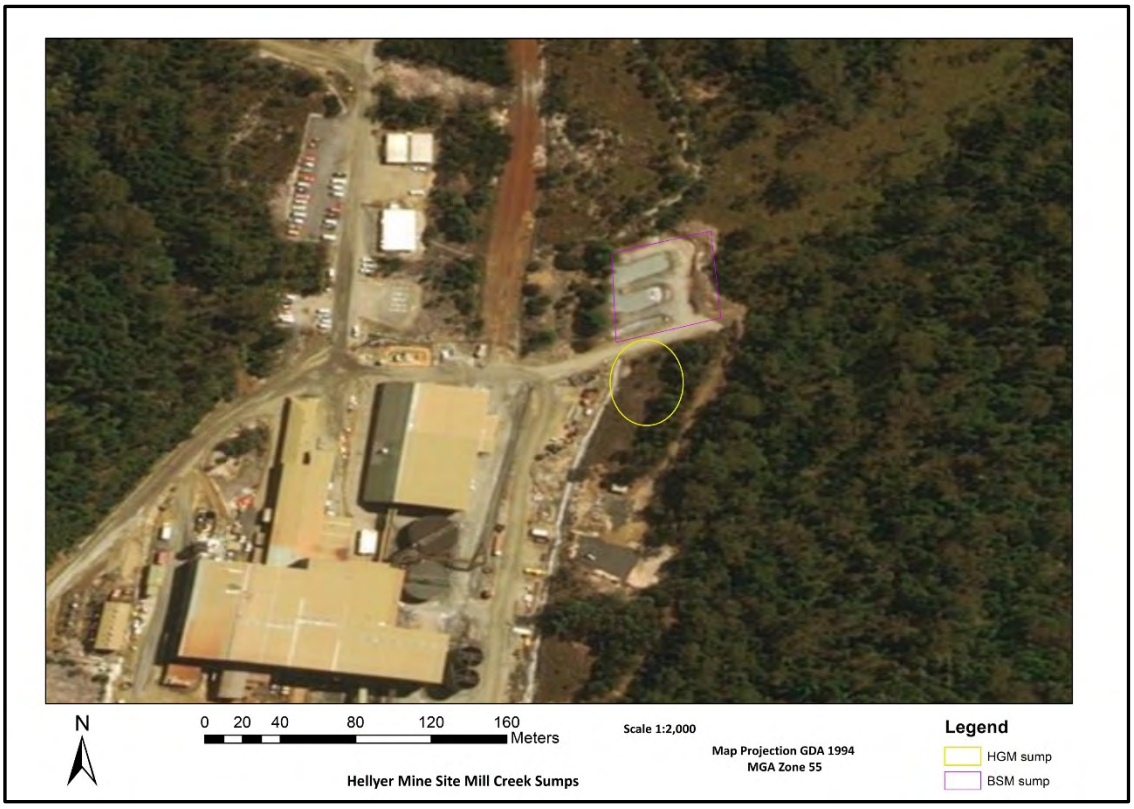
6.1.4.6 Unquantified AMD issues

Geo Environmental Management (2006) identified AMD production in the ROM area and at remnant ore stockpiles below the ROM. At that time, ore spread over the surface of the old ore stockpile pad and spillage along the old conveyor line had been left to oxidise since the Aberfoyle closure. Surface run-off and seepage from this area drained to the TSF via Mill Creek. Geo Environmental Management estimated an acidity load of 0.3 t/day from this area. Since that time, the ore stockpiles have been removed and the ROM capped with what appears to be a compacted lime mix. Information on the extent of the remediation works or on any validation sampling is unavailable.

Sampling of drainage lines below this area and above Mill Creek has been reinstated to provide data on the efficacy of the remediation works.

PCE 7759 required Bass Metals to install a sump in Mill Creek to prevent tailings washing from the mills into Mill Creek and from there into the TSF. Figure 29 shows the location of the BSM sump and the proposed HGM replacement sump. No evidence has been found indicating whether the BSM sump was rehabilitated with its contents stored to prevent sulfide oxidation. It is assumed that at some stage the contents were removed to the TSF. It is possible that they remain in situ covered by clay or peat.

Figure 29 Mill Creek sump



6.1.5 Mitigation and management

Managing the impact of AMD is best undertake by identifying and passivating the source of AMD. Until test results described above, it had been assumed that cleaning up Mill Creek and removing the eastern arm tailings to TSF 2, possibly with passivation, would prevent further acidity loads entering the main TSF and causing surface water management problems. It is possible that the eastern arm embankment wall contains some pyrites. The raising of the spillway has flooded more of the dam wall rocks and since this time, pH has been easier to maintain at a higher level with less acidity generated. Further investigations are warranted.

An additional AMD classification and management report will be provided to the EPA before 1 December 2017 to further describe the results of longer term kinetic tests. Results to date indicate that these will likely show a reduced risk from AMD than that presented by initial static tests which provide a worst-case scenario for AMD management.

HGM will commission an AMD audit report on the site to quantify sources of AMD and provide this to the EPA before 1 December 2017.

HGM will implement active water management to better control the pH in the main TSF as described in Section 6.2.5. Assuming the eastern arm dam wall does contain some pyrites, HGM will disassemble and remove the embankment completely after the PRT in the finger pond and eastern arm tailings have been moved to the TSF2. The wall materials will be tested for acid–base accounting and passivated prior to geochemically secure storage subject to the approval of the EPA.

HGM notes that the eastern arm tailings may not be representative of all potential sources of AMD as noted above. HGM is however confident that the mitigation works proposed in this Section and the active water management proposed in Section 6.2.5 is commercially feasible due to the robust economics of the proposed operation, the ready availability of finance for the operation and economic modelling which included lime addition at dosing rates similar to those previously used by Polymetals (8kg/t of tailings milled) as a starting point.

The mitigation works proposed in this Section should reduce the lime dosing rate as acidity sources are attenuated. The removal of pyrite from existing tailings to from PRT should also assist. Testwork has shown that the tailings from the main TSF mill feed has a NAPP of 778 kg H_2SO_4 /t which reduces to 209 kg H_2SO_4 /t for PRT.

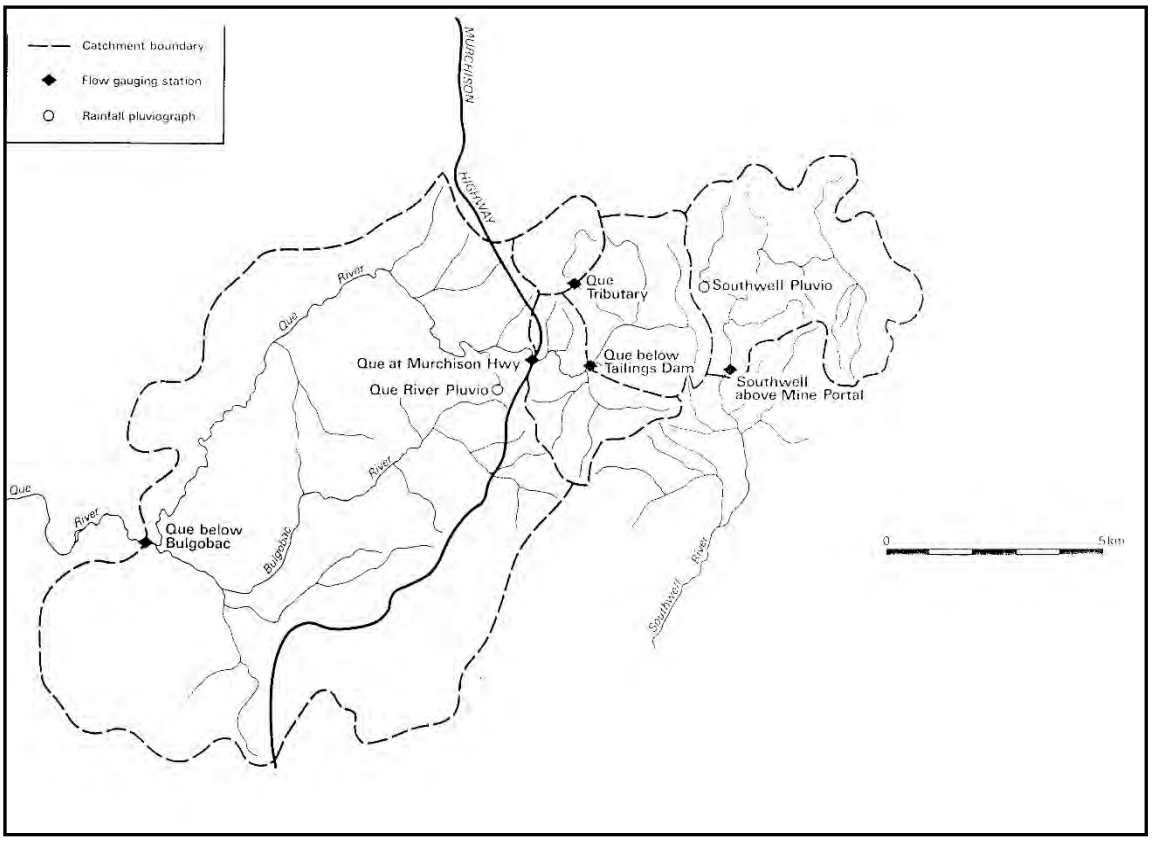
6.2 Surface Water

6.2.1 Existing environment

6.2.1.1 Hydrology

The Hellyer Mine lies in the headwaters of the Que and Southwell river systems. The regional drainage pattern, including catchment boundaries and flow gauging stations, is shown in Figure 30. The Que River flows from the mining lease in a south-westerly direction, where it joins the Huskisson River before flowing into the Pieman River. The Southwell River flows in a southerly direction past the former Hellyer underground mine portal before emptying into Lake Mackintosh, a Hydro-Electric Corporation constructed storage.

Figure 30 Catchment boundaries and hydrology



6.2.1.2 Que River catchment

This catchment contains the Hellyer concentrator site, existing main TSF, access roads and the closed Que River Mine to the south.

The tributaries of the Que River dissect the Que River plateau, and flow in a generally south-westerly direction. Some areas of the Que River catchment have been substantially disturbed. In the west and north of the catchment are the Murchison Highway and the Cradle Mountain Link Road. To the north of the Cradle Mountain Link Road are eucalypt plantations on freehold land. Major TasNetworks high voltage transmission line corridors trisect the area. In the east, the native forests have been logged. The southern portion contains the Que River Mine.

TSF2 will be contained entirely within the Que River catchment.

Que River flows have been monitored at the Murchison Highway. Flow data from the Hydro Tasmania gauging station are summarised in Figure 31.

Figure 31 Que River flow data

Location	Year span	Average monthly peak flows (m^3/s)	Average monthly flow (m^3/s)
Que River at Murchison Highway	1987–1998	3.20	1.07
Que below Bulgobac Creek	1987–1995	22.56	6.03

6.2.1.3 Southwell River

The Southwell River has a catchment of approximately 16 km^2. The Southwell River gorge is in a steep precipitous valley, which runs north–south and is thickly forested. The catchment has been disturbed to a limited extent by decades-old logging operations, tree plantation establishment, TasNetworks transmission line works and the Cradle Mountain Link Road.

The original Hellyer underground mine portal is located close to the Southwell River, which then drains in a southerly direction to Lake Mackintosh.

6.2.2 Surface water quality

6.2.2.1 Southwell River

Reasonable quality creek water and uncontaminated intercepted groundwater are directed from the Hellyer Mine portal into the Southwell River.

The Southwell River is, in general, slightly acid in pH, low in conductivity (indicating organic acids) and carries low to moderate concentrations of most metals.

6.2.2.2 Que River

All site discharge except for seepage from around the Hellyer and Fossey adits reports to the Que River, which then reports to the Huskisson River and in turn to the Pieman River.

The Que River is a moderately to severely disturbed system, which has received water discharge from both the Hellyer and Que River mines into its headwaters for decades. Discharges from the Que River Mine emanate from its settling dam, which overflows regularly during winter and intermittently during summer. The Hellyer TSF with its larger catchment overflows most days of the year. Comparing the calculated fluxes of metals and sulfates discharged from the Hellyer TSF and the Que River settlement dam shows that the mean fluxes from Que River generally exceed the fluxes from Hellyer by a factor of between 22.2:1 for Total Zn to 4.1:1 for Total Al, for the decade from 2006 to 2016.

Table 7 shows selected water quality parameters in the Que River at the Murchison Highway gauging station, which is 2.8 km below the Hellyer TSF outflow and 3.6 km below the Que River settlement dam outflow.

Table 7 Que River at Murchison Highway Sep 06 – May 17

	Acidity to pH 8.3 mg/L	Ph	Al (Total) mg/L	Cd (Total) mg/L	Cu (Total) mg/L	Pb (Total) mg/L	Ni (Total) mg/L	Zn (Total) mg/L
Mean	10.06	6.12	0.59	0.004	0.02	0.07	0.02	0.87
Median	8	6.21	0.47	0.002	0.01	0.05	0.019	0.68
Maximum	37	8.1	3.16	0.098	0.12	0.56	0.06	6.48
Std. deviation	7.29	0.88	0.44	0.01	0.01	0.08	0.01	0.71
90th percentile	22	7.2	1.04	0.006	0.03	0.14	0.04	1.69
75th percentile	12	6.77	0.72	0.004	0.02	0.08	0.03	1.02
20th percentile	5	5.37	0.28	0.0013	0.008	0.01	0.01	0.40
10th percentile	4	4.9	0.21	0.001	0.006	0.007	0.01	0.287
ANZECC*			0.15#	0.0008	0.0025	0.0094	0.017	0.031

* Australian and New Zealand Environment Conservation Council (ANZECC) guidelines for surface waters for the protection of 80% of species (disturbed ecosystem)

Total Al guideline value for pH>6.5, which is above both the median and mean values at the site.

All of the total metal concentrations in Table 7 are above the ANZECC trigger level values for the protection of 80% of species, except for the 10th percentile for total Pb. No specific water quality objectives currently exist for the Que River. Site-specific water quality objectives can be established where sufficient scientific data is available. Where data is not available, the water quality objectives default to the trigger values in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (ANZECC, 2000) and in a moderately to severely disturbed ecosystem such as the Que River, the default ANZECC guidelines of 80% species protection for aquatic ecosystems apply. The emission limits set for the Hellyer TSF outflow reflect the

PEVs through the implementation of best practice environmental management as determined by the EPA in setting site limits.

6.2.3 Performance standards

Emission limits have been set by the EPA to manage the point source pollution (the TSF outflow) to safeguard the protected environmental values (PEVs) for the receiving waters, in this case the Que River.

The environmental authority for the tailings reprocessing operation, PCE 7386, sets emission limits from the main TSF in its condition EF2. Table 8 provides these emission limits.

Table 8 TSF discharge emission limits

Parameter	Minimum emission limit mg/L
pH	8 (pH units)
Sulfate	300
Total lead	0.6
Total zinc	0.8
Total copper	0.2
Total aluminium	0.5
Total arsenic	0.02
Total suspended solids	30

Historically, zinc has been the most difficult limit to meet at the TSF outfall. The AMD-related reasons for this are discussed in Sections 6.1.1 and 6.1.3. Figure 32 shows emission limits compared to compliance limits for the above parameters except pH and Total Zn (see Figure 33) since 2015. Significant improvements and stability are noticeable since 2016. HGM's improved management protocols, such as adding a lime slurry directly into the eastern arm spillway and into the western arm impoundment before they overflow into the main TSF, have been responsible for most of the improvements seen in Figure 32. Figure 33 shows the pH and Total Zn in the TSF discharge since late 2015. There has been a steady decline in Zn concentrations since an autumn flush in May 2016.

Figure 32 Emission improvements since 2016.

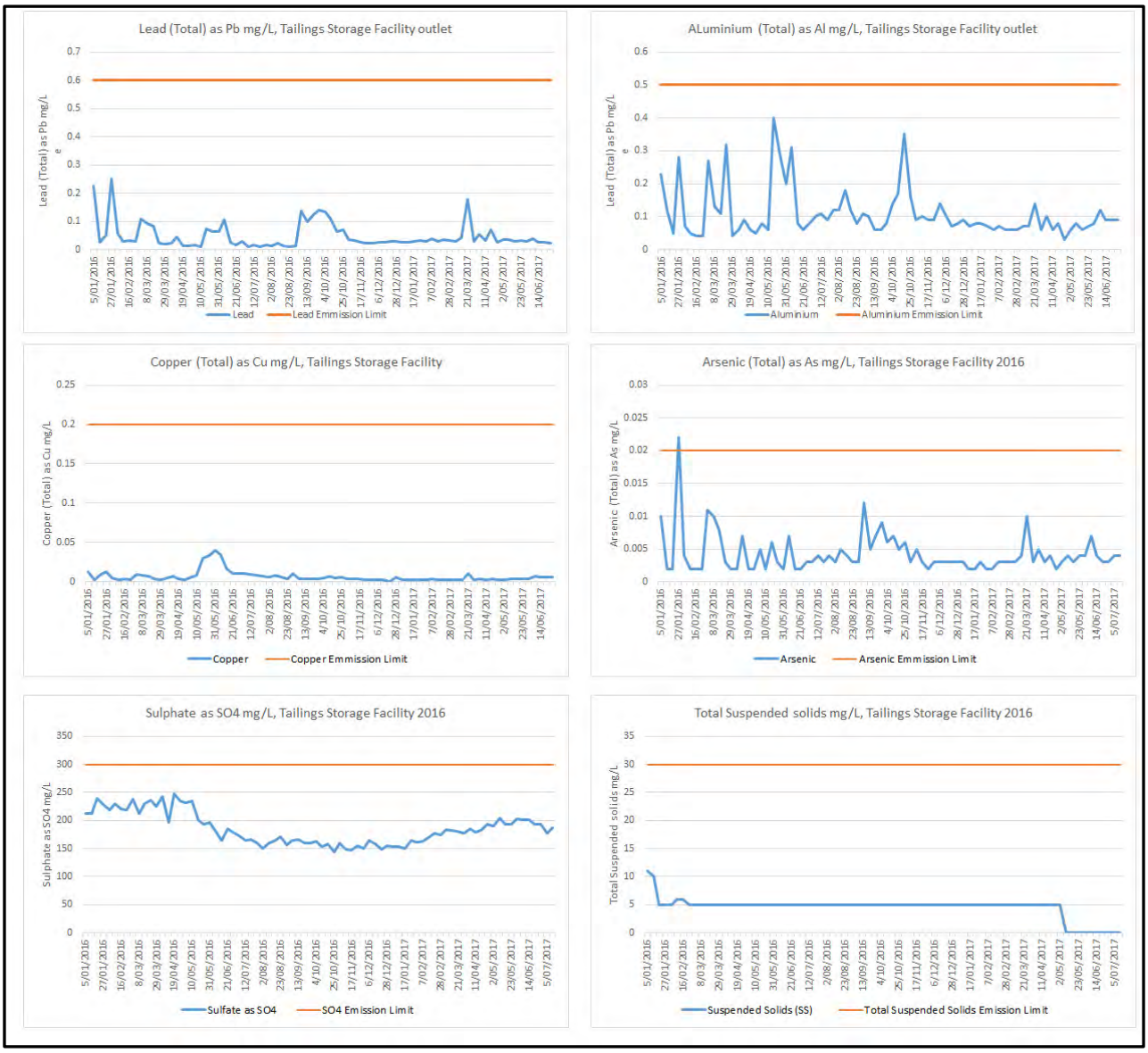
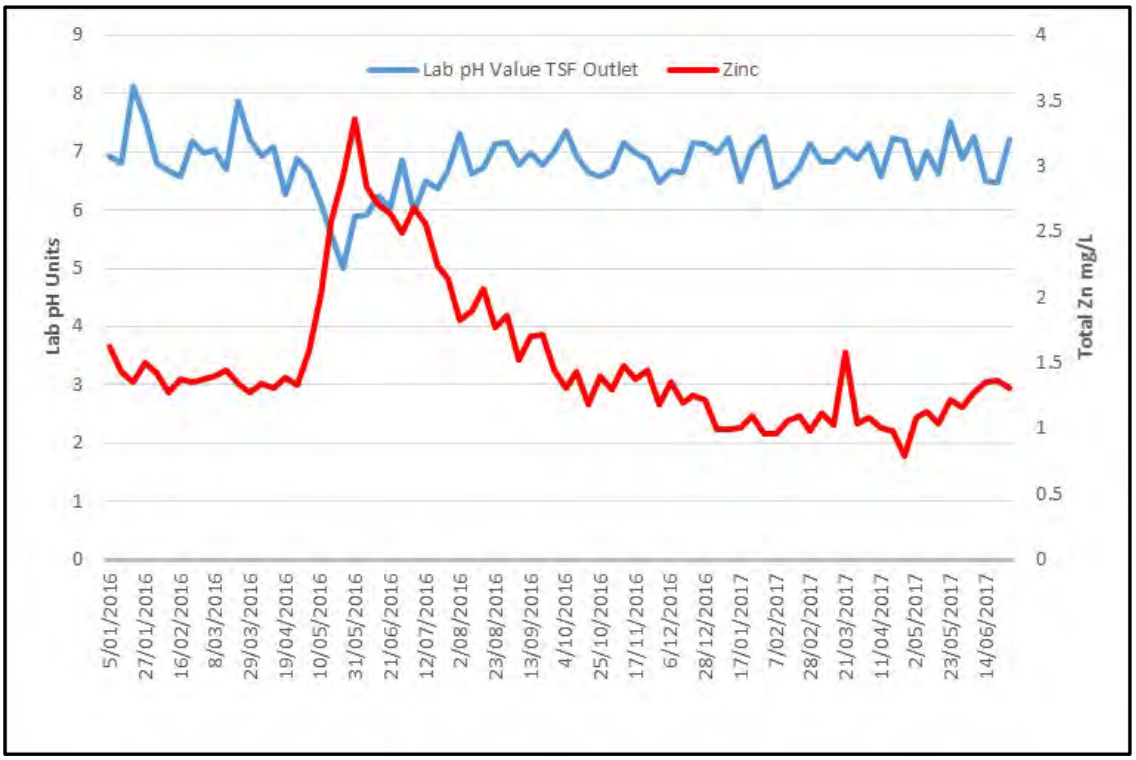
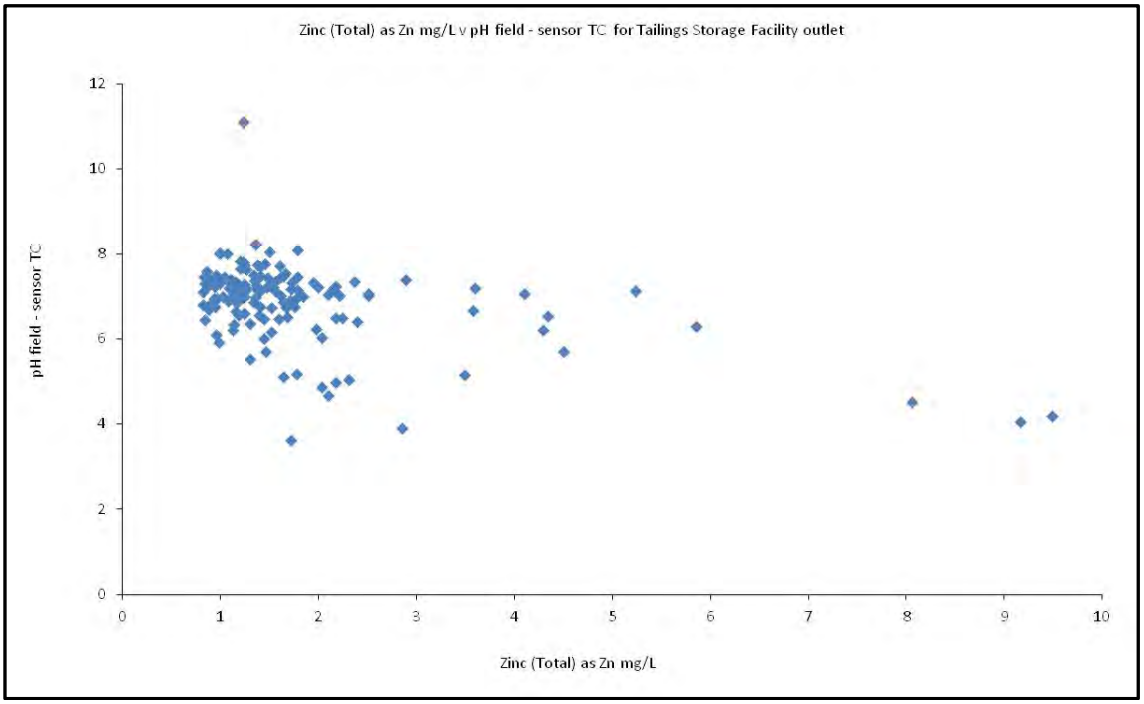


Figure 33 TSF discharge pH and Total Zn since January 2016



As noted in Table 8, environmental licence conditions for the site since 2006 have required a minimum pH of 8.0 and a maximum Total Zn of 0.8 mg/L at the TSF outfall. Figure 34 shows the relationship between the TSF outfall discharge pH and the Total Zn from mid-2006 until mid-2012. When the pH is above 8.0, the discharge is usually compliant. A review of long-term water quality records indicates that with good management procedures and the remediation proposed by HGM, this should be readily achievable going forward.

Figure 34 TSF discharge pH versus Total Zn



6.2.4 Surface water assessment of potential impacts

When Polymetals commenced dredging, an extensive program of monitoring at distances from the dredge head was undertaken to evaluate the impact of dredging on water quality. This included TSS and metal analyses. These are presented below.

6.2.4.1 Dredge impacts

Disturbance of sediments from the dredging operation was limited to the immediate locale of the dredge. This is reflected in the turbidity results graphed in Figure 35. There was a reasonably consistent drop in turbidity away from the dredging operation (Figure 35).

Figure 35 Turbidity from dredging operation

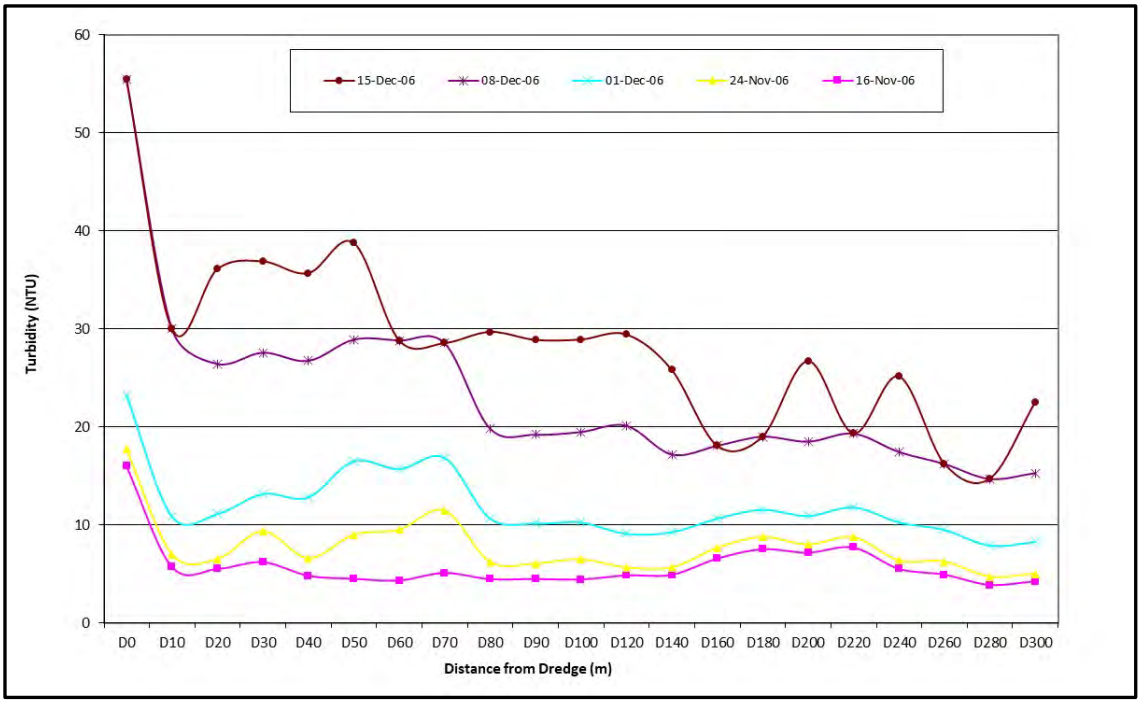
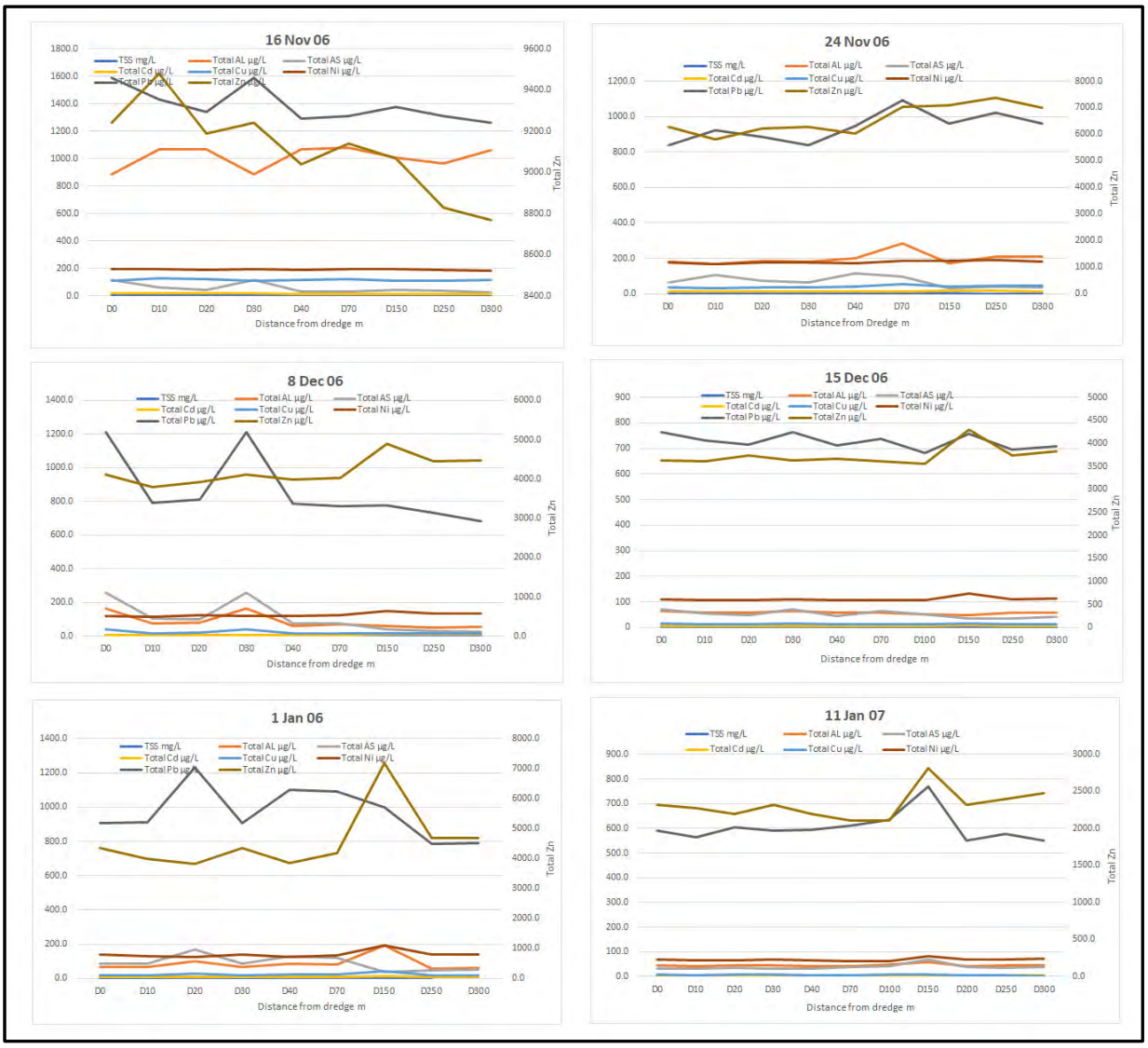


Figure 36 shows chemical analyses of samples taken at increasing distances from the dredging operation between 16 November 2006 and 11 January 2007, i.e. during the first three months of the dredging operation. These show that water chemistry is not explicitly related to the dredging but is more related to oxidation by-products within the dam. The chemistry at that time was controlled by acidity within the water column, which was in turn controlled by lime addition from the mills and or (in the opposite direction) acidity emanating from oxidising sulfidic material. At that time remnant ore stockpiles and sulfides left around the ROM were contributing an estimated acidity load of 0.3 t/day (Geo Environmental Management, 2006) into the main TSF. As noted in Section 6.1.4.6, these have been removed and or remediated, although HGM cannot verify the quality of this remediation work. To manage the potential impact of acidity, HGM proposes to actively manage water quality and to audit AMD production on site.

Results of water chemistry surrounding the dredging operation are shown in Figure 36. In these charts, the horizontal axes show the distance from the dredge D in metres.

Figure 36 Dredge chemistry Dec 06 – Jan 07



6.2.5 Surface water management and mitigation of impacts

The main TSF is critical to maintaining water quality off site, with discharge from the TSF reporting to the Que River. As noted in Section 6.1.1 and shown in Figure 18 and Figure 34, surface water management will focus on adding alkalinity to maintain the TSF supernatant water at pH 8.0 or higher to reduce Zn concentrations in the outfall. In addition, the remediation of Mill Creek and removal of exposed sulfidic tailings from the upper reaches of the Eastern Arm impoundment, as described in Section 4, should mean that adding alkalinity to tailings discharged from the mill will provide for the maintenance of pH 8.0 in the main TSF. This will ensure that ferrous iron is rapidly converted to ferric iron to form a hydroxide precipitate. This will enhance coprecipitation of other metals including zinc, lead and arsenic and should result in minimal increases in metal concentrations at the TSF outlet.

The primary method of alkalinity addition will be lime dosing into the tailings discharge line at the mills. This will ensure good mixing and will reduce acidity release during the turbulence between the mill discharge and the finger pond. This will be backed up by active water quality management.

Active water quality management will include sampling pH in the main TSF at the TSF outfall. The pH will need to be maintained between pH 8 and 10 by changing the lime dose rate from the mill using the existing lime dosing line. Variable-speed peristaltic pumps will be used to provide this functionality from the lime dosing system at the mill. Direct dosing of the TSF water body at the finger pond outlet, the eastern arm spillway and into the western arm as currently occurs may continue to be required.

6.3 Groundwater

6.3.1 Existing environment

The area has a high rainfall averaging 2.24 m/year (Section 3.4) and relatively low evaporation rate averaging 0.48 m/year. The mine site is located on a plateau which would have been a natural recharge area before mining. Groundwater would have discharged by seeps and springs in the valleys running out to the north-west and to the east. Based on observations in open boreholes away from the mine in 1998, the pre-mining groundwater levels above the orebody may have been in the range 675 to 685 m RL.

Golder detailed natural discharge to the steeply incised Southwell River and its tributaries along the western valley side and also to the broad Que River valley. The gullies show continuous water flow after days without rain, indicating groundwater base flow (Golder, 1999). The hydrogeological units at this site mainly constitute a fractured rock aquifer where groundwater is stored and transmitted by fractures, joints and other discontinuities within the rock mass. Although the shale and sandstone and coarser grained sediments within the sequence may have primary porosity, secondary porosity mechanisms are expected to dominate flow processes. Reports have described groundwater flow as being from the south and east to the north, based on measured water levels and a consideration of the topography (Golder, 2006).

6.3.1.1 Hellyer underground mine

The mined Hellyer orebody lies in a north-plunging broad anticline of Cambrian volcanics. It extends over about 850 m north–south, plunging to the north. The mine excavations extend from about 100 m depth (600 m RL) at the southern end to 500 m depth (200 m RL) at the northern end. The main access to the mine was via a 1.2 km long adit from the Southwell River valley east of the mine at around 390 m RL.

The TSF centroid is 1.5 km west of Hellyer void with its spillway level invert and water surface at RL 649.50 m AHD.

The adit slopes gently down away from the mine towards the portal. Groundwater inflow to the adit was estimated in 1998 at 9 L/s but a significant part of this came from shallow groundwater in the more weathered zone near the portal.

Mining ceased in 2000. A concrete plug was placed in the adit in November 2000 and final grouting of the plug completed in February 2001 to minimise the flow of water from the mine into the Southwell River. The plug is located approximately 580 m from the portal. The mine water level, as monitored by pressure transducer, rose from the adit plug level (390 m RL) in February 2001 to a relatively stable level of about 665 m RL in November 2002.

Mine drainage in 1997–1998 required an average pumping rate of 39 L/s. The majority of this was considered to come from groundwater seepage into the mine with smaller contributions from water used in mining and water entering from the surface via the crater over the north end of the mine. Direct rainfall into the crater was estimated to average 2 L/s.

Backfill for the mined excavations was obtained from the shale quarry developed just west of the orebody.

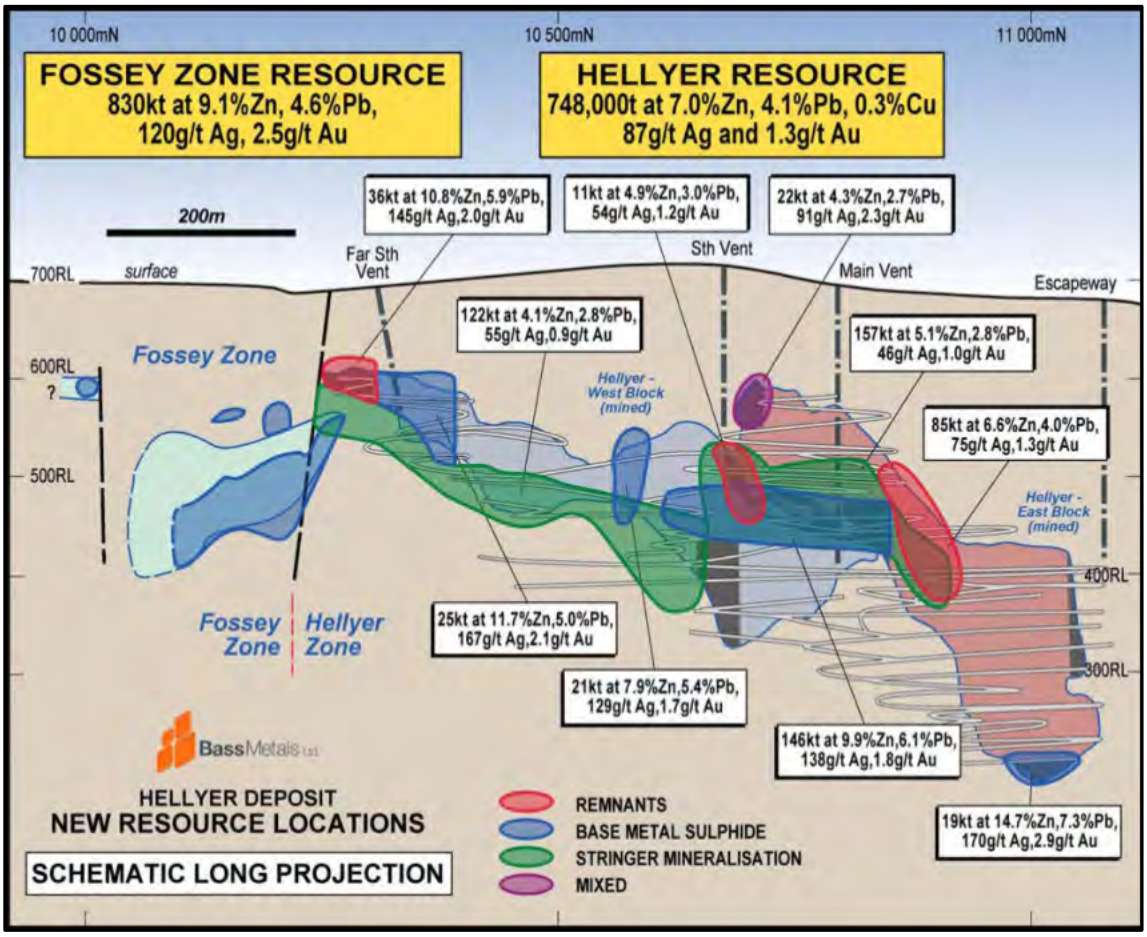
In 2006, the total recharge water supply to the mine and shale quarry was estimated at around 9 L/s. This estimate matches the outflow estimates of 4 L/s from the shale quarry and 5 L/s from Jed's Spring.

Water injection test by Golders in Sep 2000 indicated typical hydraulic conductivity of the rock mass in the vicinity of 10^{-8}m/s with localised more conducive zones of about 10^{-6}m/s.

6.3.1.2 Fossey underground mine

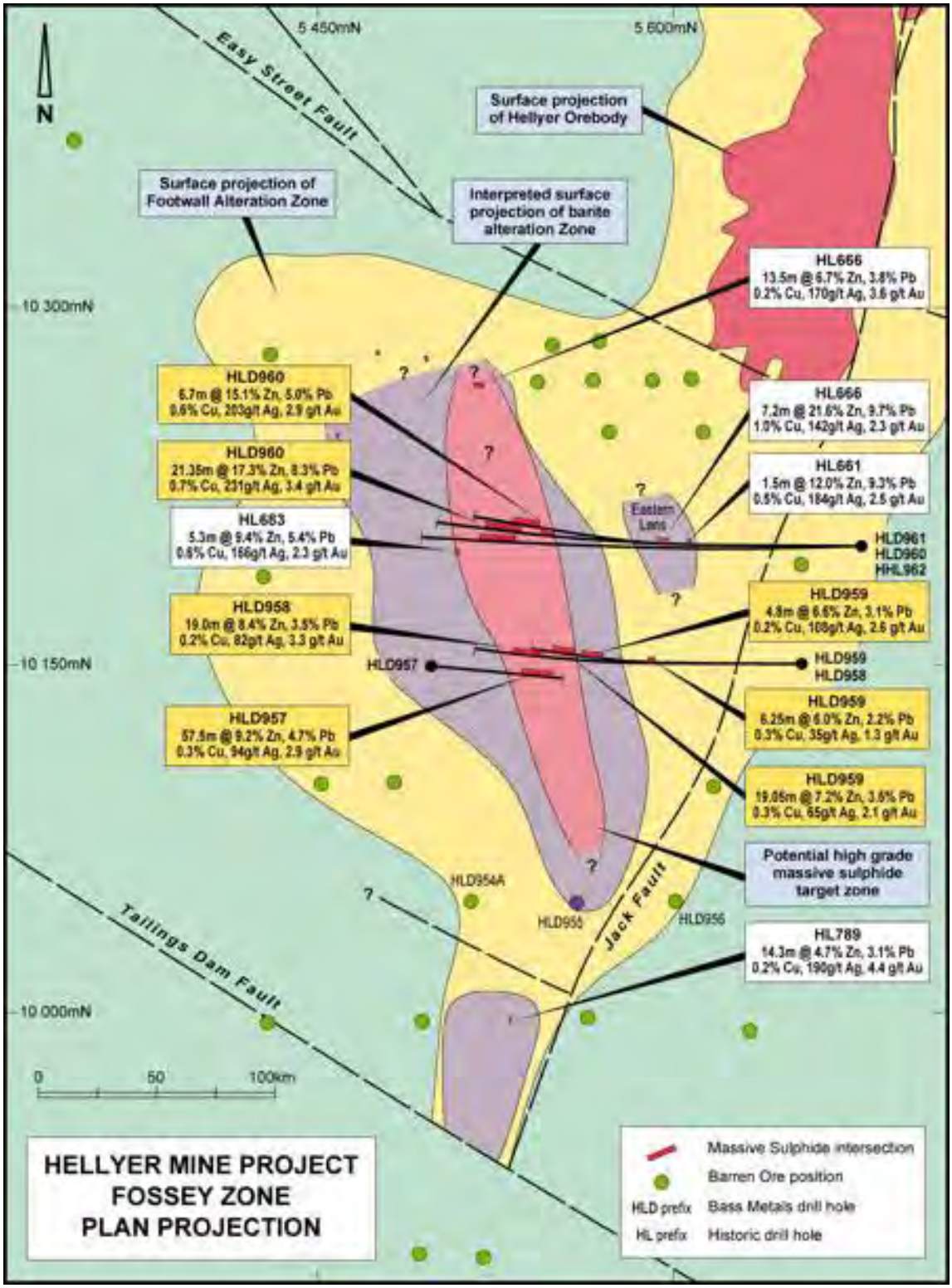
The Fossey orebody is located south-west of the mined-out Hellyer orebody with a separation of about 150 m of rock between the two orebodies. The location of the Hellyer underground void and the Fossey void is shown in Figure 37 and Figure 38. BSM established the Fossey underground mine in 2010 with a decline approximately 900 m long providing access to the planned stopes within the Fossey orebody.
From the early stages of decline development, delays were caused by groundwater inflows. Excessive water inflows, increased costs and low metal recovery led to a mine shutdown in May 2012. A plug (designed by Pitt & Sherry), was inserted in the decline in July 2012 to allow the mine to flood, thereby reducing the potential for oxidation of sulfides that could generate AMD discharge.

Figure 37 Hellyer and Fossey ore bodies



From Bass Metals

Figure 38 Simplified geological map Fossey



From Bass Metals

6.3.1.3 Conceptual groundwater model Hellyer

During mining of Hellyer, a drawdown cone developed as groundwater seeping into the mine excavations was removed. Recharge to groundwater from rainfall would have locally increased due to ground deformations above the mine and particularly the development of the crater over the north end of the mine. It is not known how effectively the backfill in this crater was placed and compacted to shed water or minimise entry of water.

After mining, the adit plug appears to have been effective in minimising the flow of water from the mine to Southwell River. The mine water level in the void stabilised by November 2002.

Looking at the topographic catchment area around the mine (Figure 40), it is considered that recharge from rainfall over an area extending about 900 m north–south by 250 m to 450 m wide over the mine and along its east side, would be entering the groundwater system up-gradient of the mine. Assuming a relatively high recharge rate equal to 25% of average rainfall over this area, the contribution to groundwater would average 5.6 L/s (Golder, 2006).

Mining One (2013) identified three major faults in the area:

- Jack Fault: a steeply dipping fault which runs north-north-east along and through the Hellyer orebody, and runs along the east side of the Fossey orebody
- East Street Fault: This fault runs east-south-east across the south end of the Hellyer orebody and underlies the Fossey orebody
- Tailings Dam Fault: A steeply dipping fault passing south-south-east of the Fossey orebody.

These can be seen in Figure 40 along with surface contours, the Hellyer orebody and the main TSF.

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Figure 39 Regional geology and Hellyer groundwater monitoring locations

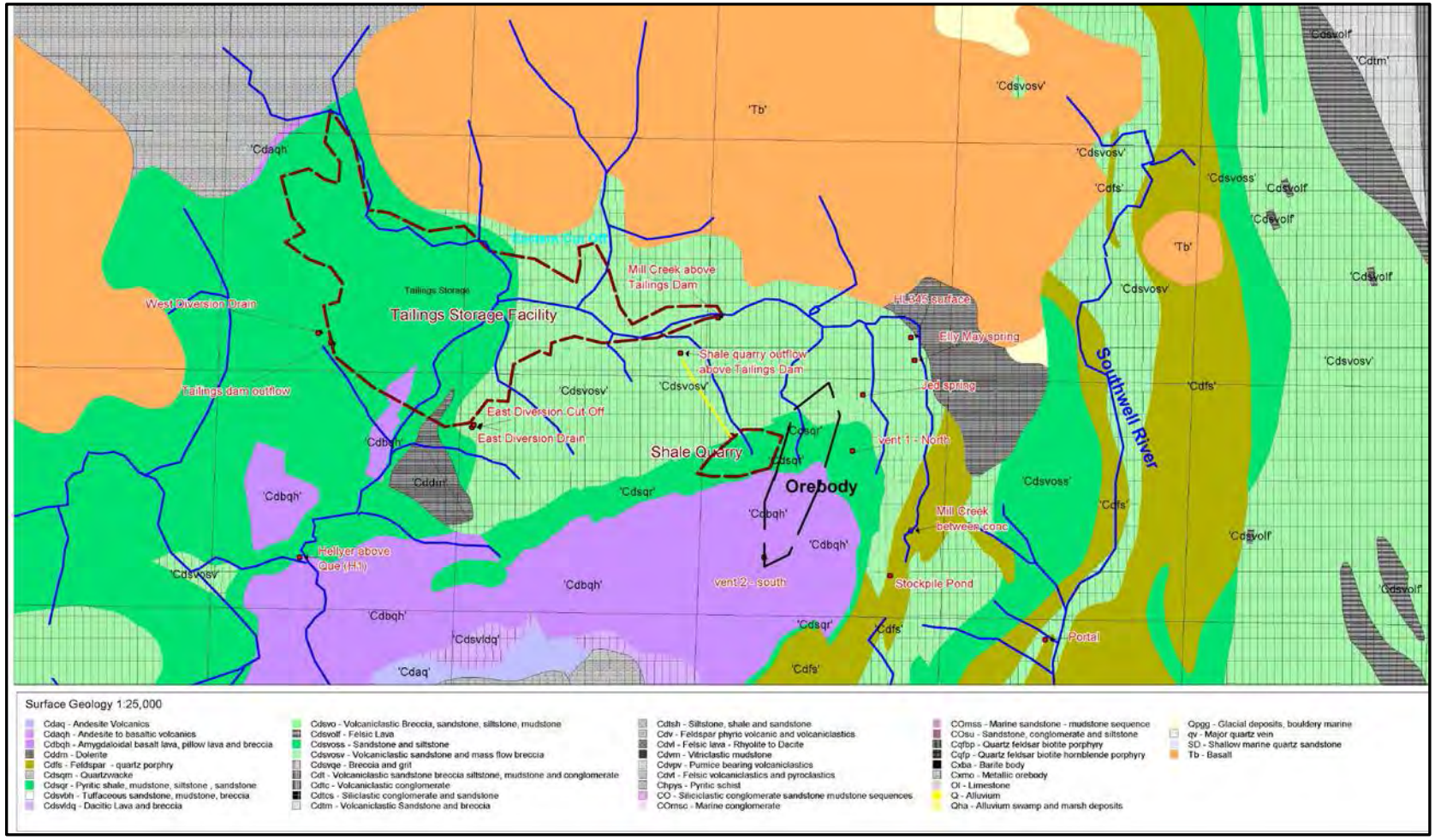
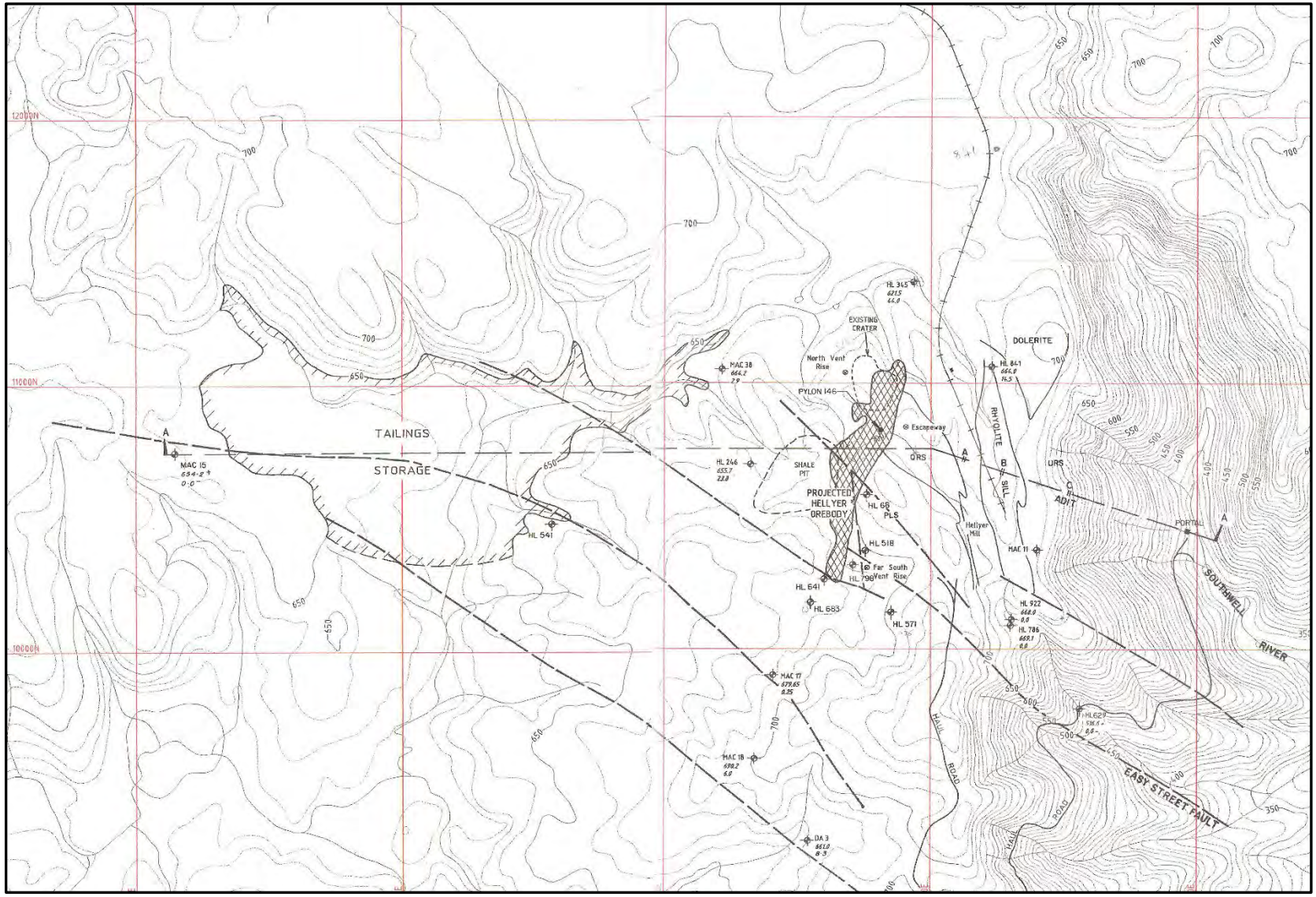


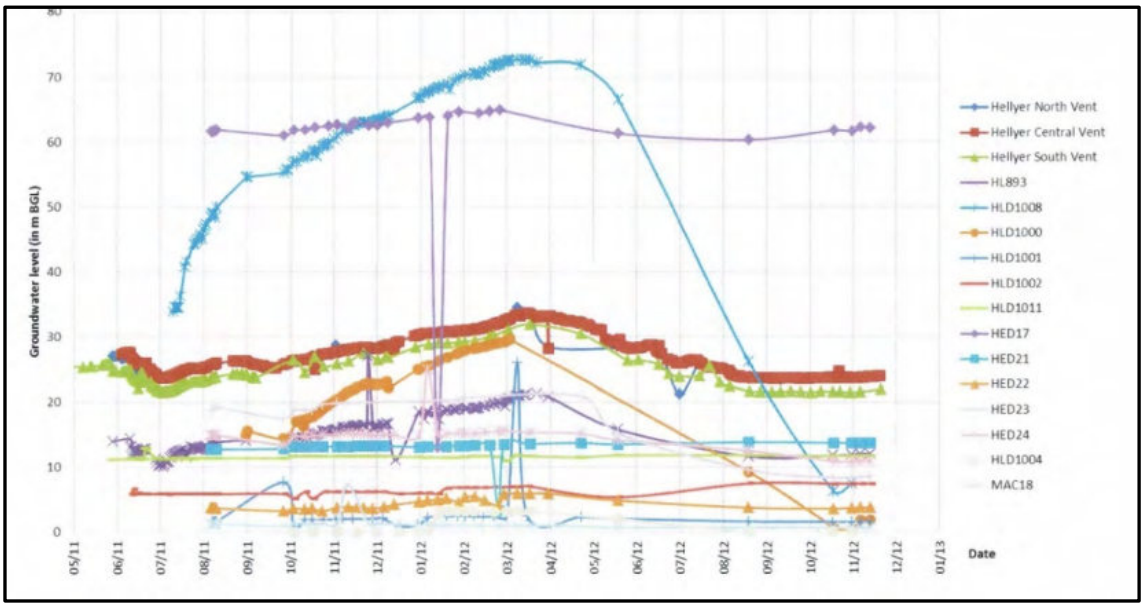
Figure 40 Contours and fault lines Hellyer Mine area 2006



6.3.1.4 Groundwater underground voids

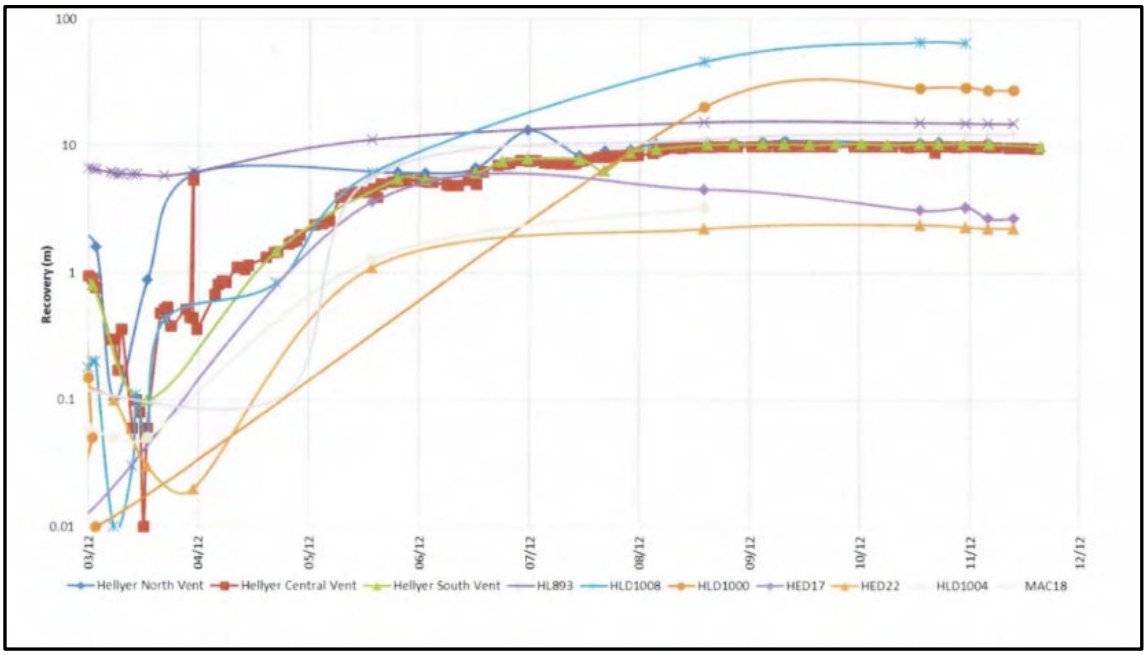
Data on groundwater levels is provided from the various ventilation shafts connected to the Hellyer Mine and to the Fossey Mine, as well as groundwater monitoring wells around the area. Hydrographs built from historical and recent records show a decrease in groundwater levels from the period 2010 to mid-2011, then a sharp increase in groundwater level across the site since July 2011 (Figure 41).

Figure 41 Groundwater level monitoring 2011–2012



The recovery (increase in water level to static conditions after the pumping stops) measured from ground level is more rapid for the bores located in the vicinity of the mine void, with hydrographs showing a greater amplitude. However, it is also noted that some bores located downstream, such as MAC18, HED17, HED23 and HED24, are impacted by both drawdown and recovery. It is likely these bores are somehow connected to the aquifer and are impacted by the mine development. The analysis of the recovery observed between March and November 2012 shows that levels have completely recovered since September 2012 (Figure 42).

Figure 42 Groundwater monitoring showing recovery 2012



Based on the historical and current records, it is possible that the water quality from the Fossey void samples indicates some mixing of the water from Hellyer void and the surrounding recharge, with a variable proportion of dilution of the void waters by shallow, and hence fresher, groundwater.

Detailed profile sampling (every 50 m) was undertaken by Bass Metals in 2008 on the main vent and the south vent. Results show a strong increase in mineralisation with depth for the main vent, while the south vent records remain relatively unchanged with depth.

A comparison between the 2008 main vent results at a depth of 300 m and Jed's Spring two-year average (up to 2008) shows a strong relationship between both sampling points for the period. It is also considered that water travelling from the shale quarry to the Fossey void could be a possibility.

6.3.1.5 Groundwater quality

With regards to groundwater quality in the Hellyer void, the discharge from Jed's Spring is considered an important indicator. The results are summarised in Table 9 with trends over time shown in Figure 43.

In Figure 43, the red rectangle indicates the period when Fossey was mined, with the consequent inrush of groundwater. This period seems to correlate with spikes in metal and acidity concentrations, indicating that groundwater in the Hellyer void had dropped, thus increasing AMD production, providing evidence for Mining One's theory of leakage from the Hellyer void into the Fossey void.

It was noted by Golder in 2006 that the local spring flows were clear and surrounded by deposited iron. From this it was inferred that ferrous iron is held in solution in the low-oxygen mine environment. When the mine water reaches the surface, oxygen levels increase and the iron deposits as ferric iron.

Site investigations in 2006 by Golder (2006) identified five groundwater discharge locations:

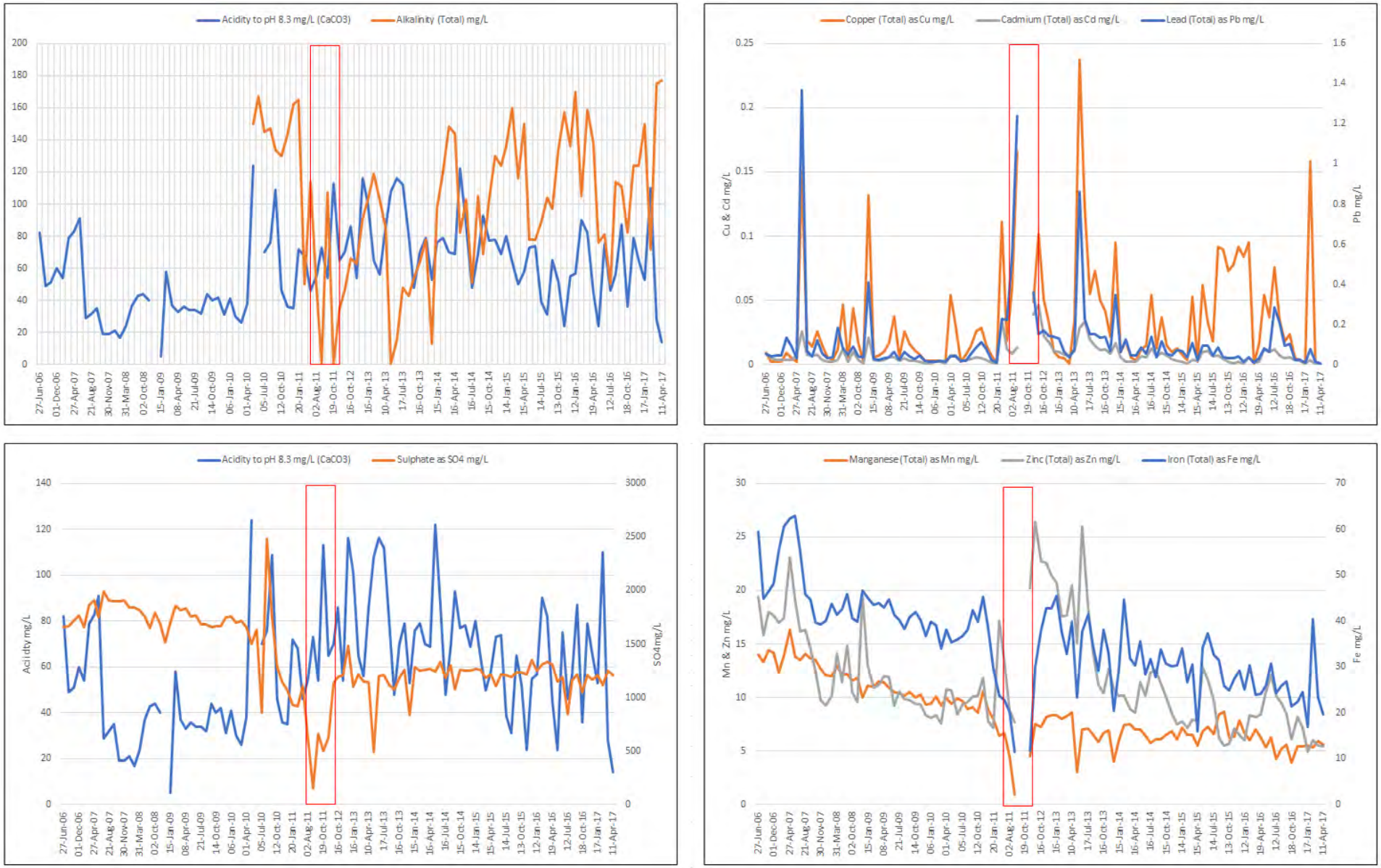
- adit portal – pool of water showing iron staining – outflow of approximately 0.5 L/s
- overflow from the shale quarry
- Jed's Spring
- Elly May's Spring
- Borehole HL345 – small artesian flow.

These groundwater discharge locations are shown in Figure 39, along with surface monitoring locations.

Table 9 Jed's Spring key water quality parameters 2006–2017

	Laboratory pH units	**Acidity to pH 8.3 mg/L ($CaCO_3$)**	**Alkalinity (Total) mg/L**	**Cadmium (Total) as Cd mg/L**	**Copper (Total) as Cu mg/L**	**Iron (Total) as Fe mg/L**	**Lead (Total) as Pb mg/L**	**Manganese (Total) as Mn mg/L**	**Nickel (Total) as Ni mg/L**	**Zinc (Total) as Zn mg/L**	**Sulfate as SO_4 mg/L**
Maximum	7.82	124	167	0.047	0.237	62.9	1.37	16.3	0.668	26.4	2480
90th percentile	6.97	97	150	0.01865	0.0675	46.2	0.2265	13.5	0.5385	19.85	1846
75th percentile	6.715	77.75	132	0.01	0.03775	42.875	0.13075	11.325	0.43	16.1	1750
Median	6.5	57	102	0.0058	0.015	38.35	0.062	8.875	0.343	11.2	1290
20th percentile	6.22	36	50	0.0025	0.004	30.4	0.035	6.55	0.285	9.26	1134
10th percentile	6.09	30.5	35	0.002	0.002	27.2	0.023	6.075	0.2635	8.01	928.4
Mean	6.44	60.31	93.59	0.01	0.03	37.82	0.13	9.11	0.37	12.84	1407.61
Std deviation	0.66	27.03	46.81	0.01	0.04	9.75	0.22	2.99	0.11	4.70	403.94

Figure 43 Jed's Spring water quality trends



6.3.2 Performance requirements

Groundwater emissions from mining activities must comply with the following:

- State Policy on Water Quality Management 1997
- *Environmental Management and Pollution Control Act 1994*
- *Water Management Act 1999*
- *Groundwater Act 1985.*

6.3.3 Potential effects

Potential effects on groundwater include the following:

- impacts to groundwater quality from AMD associated with the main TSF
- as the main TSF water level is lowered by 10 m and then by a further 10 m (Table 2) to drop the dredge and access lower tailings, this could induce seepage into the TSF, potentially affecting water levels in the underground voids.

6.3.3.1 Seepage assessment underground voids

There is the potential for impact on groundwater as the main TSF water level is lowered to access tailings below the first dredge cut.

The TSF centroid is 1.5 km west of Hellyer void with its spillway level invert and water surface at RL 649.50 m AHD. Packer testing undertaken by Golder through Hellyer basalt shows a rock mass hydraulic conductivity of around 10^{-8} m/s. It was noted, however, that some results were influenced by significant fractures, especially within the Southwell Group (Figure 38), which stands stratigraphically higher than the Basalt and the Que River Shales, which present slightly higher hydraulic conductivities of around 10^{-6} m/s. The fracture zones with relatively high permeability were encountered at 228 m and 384 m depth (Golder, 2009). Figure 37 shows the ground level in the vicinity of RL 700 m AHD over the ore bodies, which means the higher permeable fracture zones sit at RL 472 m AHD and RL 316 m AHD respectively. From Figure 40 it can be seen that these permeable fracture zones are significantly deeper than the base of the TSF.

It follows from this that any infiltration from either underground void into the TSF when the water level is dropped by 10 m in 2024 would be minimal and would be more likely be due to infiltration from rainwater recharge.

6.3.4 Groundwater management

Management of impacts to groundwater quality from AMD associated with the main TSF is described in Sections 6.1.5 and 6.2.5.

If groundwater from either underground void infiltrates into the TSF, the reduced water level in the void would expose sulfides and likely recommence sulfide oxidation in the void, resulting in AMD by-products such as acidity and dissolved metals. To mitigate against this, HGM will monitor water levels in the voids at the central vent (near the shale quarry) for the Hellyer void and at the Fossey vent rise for the Fossey void. HGM will maintain records of these water levels in its water quality database. Once water levels start dropping, HGM will pump supernatant water from the TSF back into the relevant void. As can be seen above, the estimated natural recharge rate is 5.6 L/s.

The mitigation measures currently in place – as a result of management plans set up after submission and approval of the Polymetals DPEMP (2006) and reflected in PCE 7386 – protect surface waters from fuel and oil, sewage and off-site discharges and will also protect groundwater.

6.4 Tailings

Existing tailings at Hellyer form the ore source for the mining and processing operation under PCE 7386. This is described in Section 3.5 Mining and Processing . The initial resultant PRT will be stored temporarily under water in the finger pond. This is also described in Section 3.5 Mining and Processing . Following this, PRT will

be stored under a water cover in TSF 2. This will be subject to assessment in the approval process for the new TSF.

6.4.1 Assessment of potential impacts

Tailings cores were collected from the eastern arm for geochemical analyses (Figure 20 and Figure 45). Subsamples of the cored material were also taken for jar testing. The subsamples were taken from the deeper cores, as they were considered more representative of the entire tailings mass. Subsamples of tailings were collected by mixing the entire core sample and allowing the solids to settle.

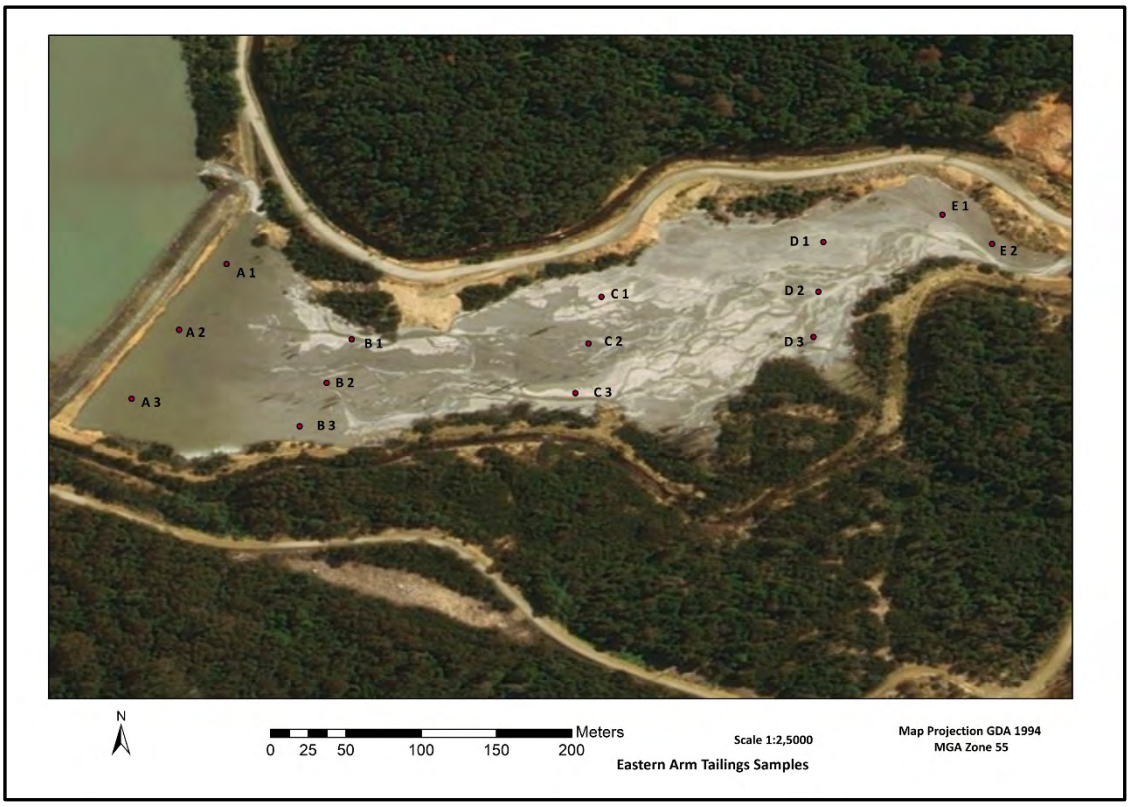
For surface water analysis, a portion of the subcore of tailings was then placed into a jar and mixed by hand with one batch of TSF outlet water sampled on the same day. The tailings were then measured in situ for pH, Eh, conductivity and temperature. By the next morning, the solids in the samples had settled (Figure 44).

Figure 44 Samples A3 and B1 – overnight solids settling

After settling for 17 hours, the water samples were analysed for total metals, and acidities were calculated using the metal concentrations. Iron was assumed to be ferric iron for the calculation, meaning that calculated acidity estimates are likely to be conservative. The settled tailings solids were laboratory dried and weighed.

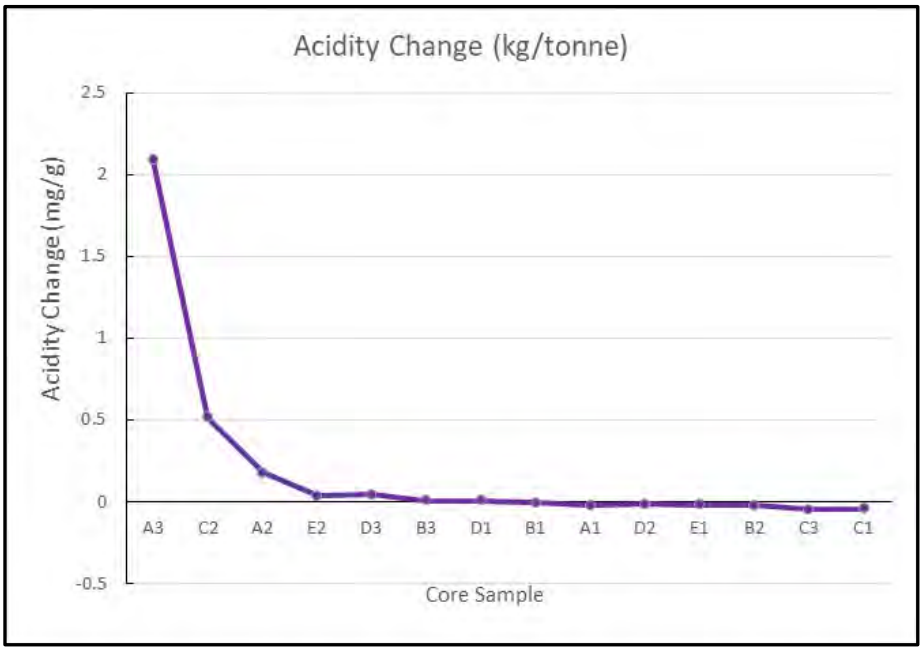
The results of chemical analyses and measurements for the supernatant liquor after 17 hours of settling are presented in Table 10. In Table 10, the TSF outlet sample represents the baseline TSF water quality.

Figure 45 Eastern arm samples



The acidity levels in Table 10 were calculated based on metal concentrations measured in the supernatant water. The total acidity within the supernatant was then divided by the mass of tailings in each jar to calculate the acidity change relative to the mass of tailings. The *x*-axis of Figure 46 is in order of highest to lowest calculated supernatant acidity concentration. Figure 46 shows that 3 of the 14 samples resulted in a substantive increase in acidity concentration. The remaining sample either produced or consumed relatively minor quantities of acidity as a result of being mixed with the tailings water.

Figure 46 Acidity change (mg $CaCO_3$ eq.) per mass of tailings each jar



A key factor to note is that the in situ pH for all the samples was >7.0. This mitigates against the risk of oxidation of Fe^{3+} to Fe^{2+} in the absence of oxygen and at pH <4.

Table 10 Jar tests water chemistry

Core ID	A1-D	A2-D	A3-D	B1-D	B2-D	B3-D	C1-D	C2-D	C3-D	D1-D	D2-D	D3-D	E1-D	E2-D	TSF outlet
After initial mix															
Temp °C (0 hr)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7	7.1	7.1	7.1	7.1	
Cond µS/cm (0 hr)	497	484	490	487	485	430	546	491	496	510	574	488	530	521	462
pH (0 hr)	7.74	7.24	7.19	7.27	7.3	7.21	7.43	7.15	7.29	7.31	7.37	7.27	7.29	7.26	7.3
Eh mV (0 hr)	175	67	64	147	168	168	144	110	170	200	198	182	194	233	223
Eh mV SHE (0 hr)	374	266	263	346	367	367	343	309	369	399	397	381	393	432	422
Total metals after 17 hours' settlement															
Al Total µg/L	103	76	94	92	48	125	73	65	91	126	96	131	35	89	88
As Total µg/L	<15	<15	<15	<15	<15	<15	<15	<15	16	36	34	20	59	39	<15
Ba Total µg/L	924	637	756	635	404	1090	336	938	353	596	402	1220	423	568	28
Ca Total mg/L	63.8	65	57.3	59.3	59.8	61.5	62.7	58.7	60.5	65	77.6	58.4	67.8	65.7	57.2
Cd Total µg/L	8	3	2	<2	<2	<2	<2	<2	<2	<2	<2	2	<2	5	4
Co Total µg/L	4	5	6	5	5	5	<2	6	4	4	4	6	5	7	6
Cr Total µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cu Total µg/L	8	4	6	7	4	10	4	5	3	8	6	13	4	13	6
Fe Total µg/L	249	1910	4080	233	125	401	184	1870	142	452	291	837	126	481	290
K Total mg/L	1.35	1.17	0.89	1.04	1.13	1.18	1.29	0.89	1.22	1.12	1.38	0.99	1.31	1.1	0.83
Mg Total mg/L	11.9	11	10.5	10.4	10.6	10.8	17.3	10.3	11.3	10.9	12	10.3	11.4	10.7	10.1
Mn Total µg/L	608	719	569	624	608	598	556	641	706	653	657	628	713	728	539
Na Total mg/L	6.55	6.54	6.18	6.22	6.44	6.41	6.52	6.23	6.4	6.4	6.76	6.25	6.42	6.21	6.19
Ni Total µg/L	11	12	13	14	14	14	<10	17	13	12	13	17	16	21	19
Pb Total µg/L	206	72	94	249	198	205	198	135	111	310	294	314	300	692	34
Sulfate mg/L	191	200	192	193	191	193	216	191	187	197	231	191	207	204	180
Zn Total µg/L	731	1320	1050	1100	948	1080	95	1470	679	893	494	1330	982	1900	1320
Weight of sample g DMB	67.6	48.6	14.2	102	154	119	150	25.9	79.7	96.6	218	136	154	184	0
Jar volume L	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
Acidity (Total)	2.57	7.65	13.20	3.07	2.25	3.64	1.24	7.77	2.04	3.59	2.36	5.33	2.33	5.38	3.33

Core ID	**A1-D**	**A2-D**	**A3-D**	**B1-D**	**B2-D**	**B3-D**	**C1-D**	**C2-D**	**C3-D**	**D1-D**	**D2-D**	**D3-D**	**E1-D**	**E2-D**	**TSF outlet**
Acidity change mg/l	–0.76	4.32	9.87	–0.26	–1.08	0.31	–2.09	4.44	–1.29	0.26	–0.96	2.01	–1.00	2.05	0.00
Acidity change mg/g tailings	–0.02	0.18	2.08	–0.01	–0.02	0.01	–0.04	0.51	–0.05	0.01	–0.01	0.04	–0.02	0.03	0.00

DMB = dry matter basis

6.4.2 Existing environment

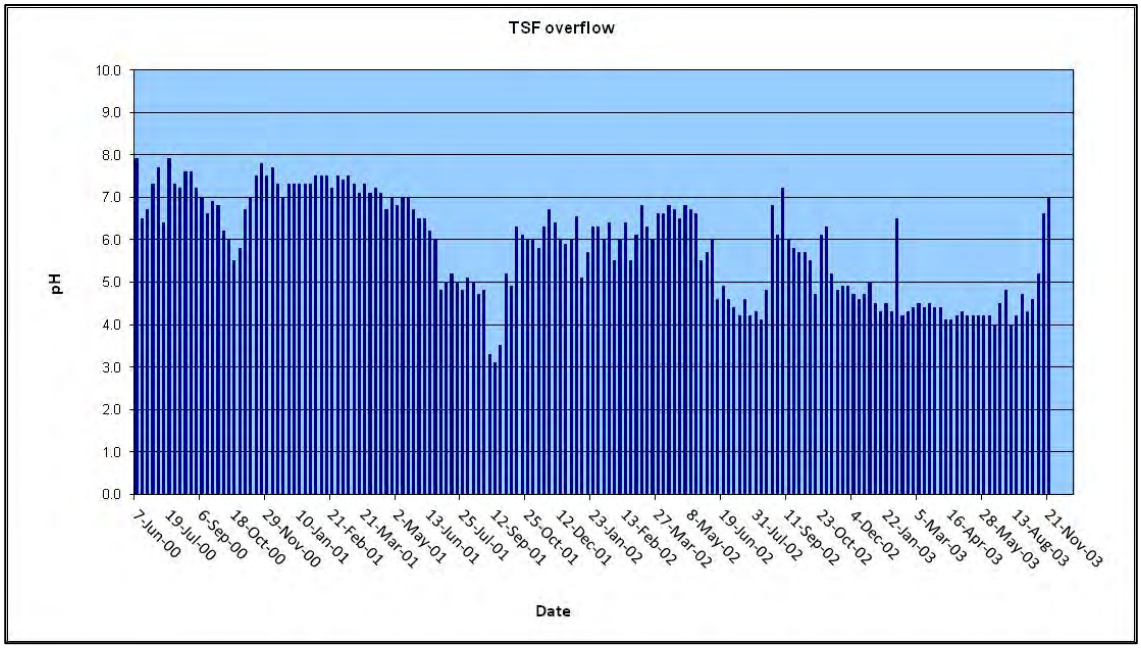
Tailings storage at Hellyer is summarised in Table 11 below.

Table 11 Tailings storage Hellyer

Location	Tailings	Condition/comment
Shale quarry	Polymetals tailings	Needs water delivery to maintain tailings under water cover
Main TSF	Original Hellyer tailings, Fossey tailings	Tailings under several metres of water
Eastern arm impoundment	Original Hellyer tailings, Fossey tailings	Tailings exposed in upper recaches or under less than 500 mm water cover near embankment wall
Western arm impoundment	Polymetals tailings, original Hellyer tailings, Fossey tailings	Embankment wall leaks, meaning that water delivery to inundate tailings is required

Subaqueous deposition of tailings has been used at Hellyer because the Hellyer tailings oxidise rapidly. After the site closed in 2000, water quality in and discharging from the TSF deteriorated, with low pH and high Pb and Zn concentrations (Figure 47, Figure 48 and Figure 49).

Figure 47 TSF discharge pH 2000–2003



The downward trend of pH was mitigated by the application of lime by care and maintenance caretakers on site in 2003.

Figure 48 TSF discharge Total Zn 2000–2003

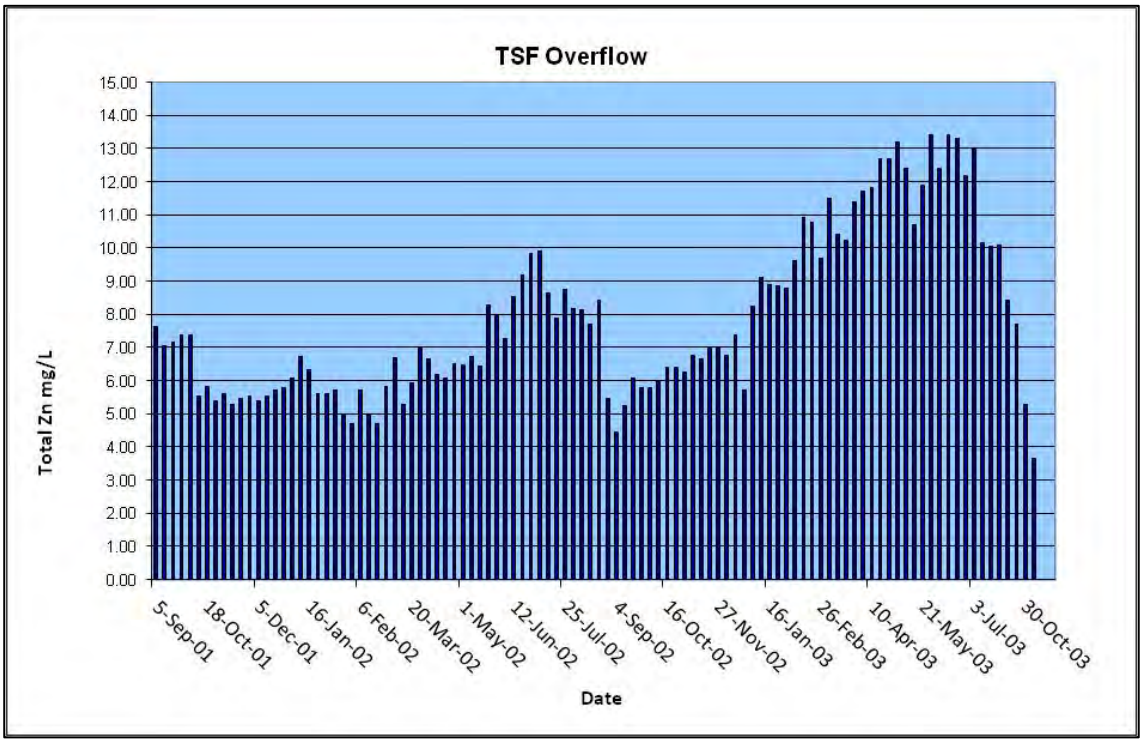
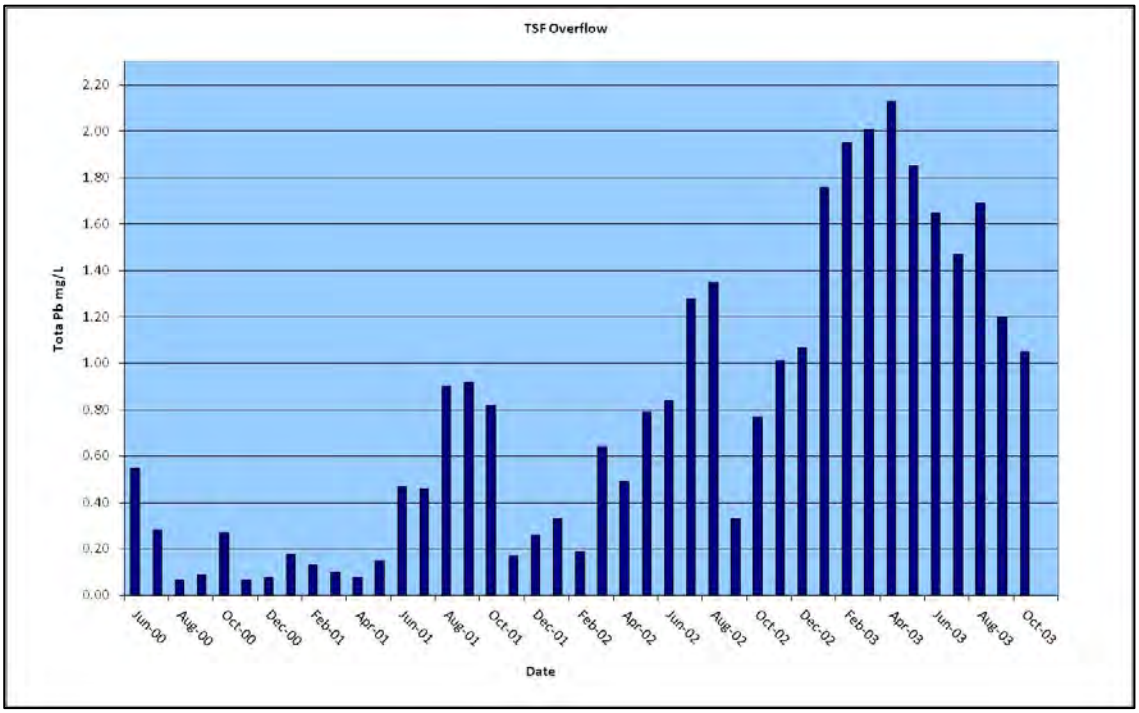


Figure 49 TSF discharge Total Pb 2000–2006



The deterioration in water quality is thought to be caused by a combination of acidity from exposed tailings in Mill Creek and from AMD production within the water column as fine-grained tailings remobilise and oxidise.

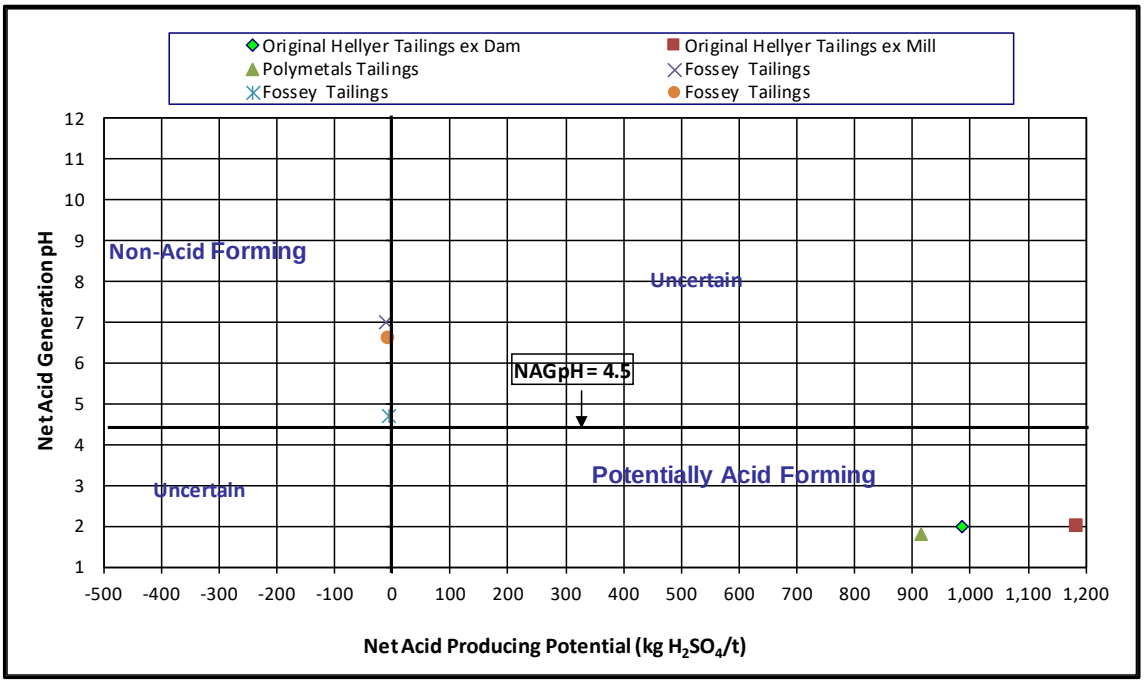
6.4.2.1 Acid forming characteristics

Geochemical test work performed on the tailings in the main Hellyer TSF includes geochemical characterisation of Hellyer tailings by EGi (1990) and Environmental Scientific Services (2001),

characterisation of Polymetals tailings in 2006 and geochemical characterisation of Fossey tailing undertaken by Bass Metals in 2012. This test work is summarised in Table 12 and Figure 50.

These investigations have been described in the Polymetals DPEMP (2006) and Bass Metals DPEMP (2012). They found that the Hellyer and Polymetals tailings contain high sulfur, have a low acid neutralising capacity and are potentially acid forming (PAF). The Fossey tailings, although high in terms of acid producing potential, are geochemically lower in terms of acid generation characteristics than original Hellyer tailings and the Polymetals tailings, with lower overall sulfur and higher acid-neutralising capacity. Recent analyses for sulfur in Fossey tailings were adjusted to account for barite which precipitates S. These results show much higher S concentrations (Table 3).

Figure 50 Acid–base plot for contained Hellyer tailings



Lysimeter testing on original Hellyer tailings indicated that processes of sulfide oxidation may occur within the tailings under a 600 mm water cover. This program also found that sulfide oxidation and acid generation effectively ceased in tailings sitting in a lysimeter with a 25 mm cover of agricultural lime and under a 600 mm water cover (Environmental Scientific Services, 2001).

Table 12 Geochemical summary Hellyer tailings

Client sample ID	pH[1]	EC[1]	Total sulfur	Sulfide S	MPA[2]	ANC[2]	NAPP[2]	NAG_{pH}	ANC/MPA ratio	Sample classification
		(µS/cm)	(%)		(kg H_2SO_4/t)					
Original Hellyer tailings at the dam discharge	6.7	1370	32.2	32.20	986	0	986	2.00	0.00	Potentially acid forming
Original Hellyer tailings at the mill discharge	11.6	4060	39.2	39.20	1200	16	1184	2.00	0.01	Potentially acid forming
Polymetals tailings	7.8	0.798	32.1	31.90	977	61	916	1.80	0.06	Potentially acid forming
Fossey tailings	9.7	169		0.11	3.3	13.8	–10.4	7.00	4.10	Non–acid forming
Fossey tailings	9.6	94		0.12	3.7	9.9	–6.2	4.70	2.69	Non–acid forming
Fossey tailings	9.6	105		0.07	2.1	7.2	–5.1	6.60	3.36	Non–acid forming

Notes

1. Current pH and EC provided for 1:5 sample:water extracts

2. Sulfide S ~ Total oxidisable sulfur; MPA = maximum potential acidity; ANC = acid neutralising capacity; NAPP = net acid producing potential; and NAG = net acid generation

6.4.3 Potential effects

The most significant effect of the tailings storage, and the issues noted in Table 11 and described in Section 6.1 and Section 6.2.4, is that AMD forms when tailings are not inundated and fully saturated. This reports mainly as high Zn concentrations in the main TSF outfall and elevated metal concentrations and low pH downstream in the Que River.

6.4.4 Tailings management

For the first phase of HGM tailings reprocessing (Section 5.1), all existing Hellyer tailings will be stored under a significant water cover in the main TSF. With the TSF outfall at RL 649.5, the depth of water cover over the current tailings is >2 metres.

Until TSF 2 is operational (Section 3.5.3 and Table 2), PRT will be stored under water in the finger pond. Once TSF 2 is operational, all PRT will be transferred to TSF 2 and stored in that facility under a minimum water cover of 2 m.

6.4.4.1 Finger pond storage

GHD has undertaken comprehensive dams inspections for HGM, and before that for Bass Metals. In 2017, for HGM, GHD assessed the depth of the finger pond and its capacity. This is shown in Table 13. In Table 13, the storage volumes allow for a 28 m wide fill zone upstream of the finger pond wall to act as foundation material to facilitate act a finger pond dam raise if necessary and a 40 m dredge offset from the downstream side (west) of eastern arm embankment wall to maintain its stability.

At present the finger pond has a crest at 650.5 RL. The eastern arm dam to the east of the finger pond has a crest at 652 RL. The spillway was originally set at 650 RL but appears to have been raised by installing a concrete weir over the spillway invert to 651.0 RL.

Table 13 Finger pond PRT storage capacity

RL m	Area m^2	Volume m^3	Volume (cumulative) m^3	Storage capacity tonnes @ 1.3t/m^3
637	0	0	0	0
638	5,500	2,750	2,750	3,575
641	16,300	32,700	35,450	46,085
644	25,500	62,700	98,150	127,595
647	36,500	93,000	191,150	248,495
650	47,000	125,250	316,400	411,320
651	49,700	48,350	364,750	474,175
652	92,000	70,850	435,600	566,280
653	92,000	92,000	527,600	685,880
654	92,000	92,000	619,600	805,480

As described in Section 5, the initial phase of mining until the TSF 2 is operational has been forecast to last until May 2019. During this time 359,507 t of PRT – which equates to a volume of 276,544 m^3 at a settled density of 1.3 t/m^3 – can be stored below the 650 m RL, providing >1.0 m of water cover over the PRT. As can be seen in Table 13 and Figure 51, the finger pond dam wall can be raised by up to 4 m to 654 m RL to accommodate a total of 805,480 t of PRT.

To utilise the finger pond for PRT storage, HGM plans to

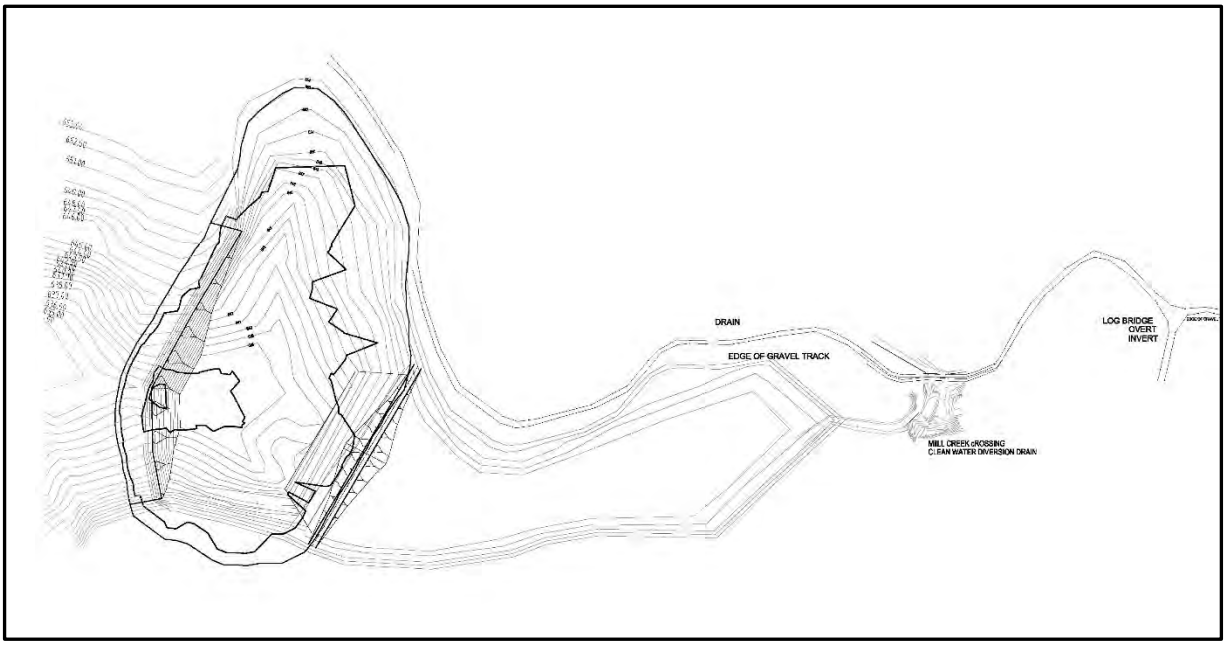
- dredge the finger pond to full depth, then install foundation material upstream of the existing bund wall to act as a base for the finger pond dam raise. This is a contingency in case the dam wall does need to be raised

- leave a 40 m dredge offset from the downstream (western) side of the eastern arm wall and leave the eastern arm tails at their existing RL 651 m.

If needed, GHD will design and supervise construction of the temporary dam and obtain approval from DPIPWE Water Management branch for dam safety assessment.

The maximum height for PRT deposited is RL 654 m. This provides a 0.5 m water cover and does not impact the clean water diversion drains above the RL 655 m level.

Figure 51 Finger pond contours



6.4.5 Mitigation of impacts

A critical factor in storage of PRT is the potential for further sulfide oxidation.

This will be managed by:

- keeping the PRT submerged beneath a minimum of 1.0 m of water
- removing the PRT to TSF 2 from August 2019 and completing slurry pumping the PRT into TSF 2 by February 2021
- monitoring the water in the eastern arm and if necessary applying additional alkalinity to maintain the pH above 7.0
- monitoring water quality in the main TSF outflow as described in Section 6.2.5
- implementing active water quality management as described in Section 6.2.5 to maintain a minimum pH of 8.0 in the supernatant water of the main TFS.

6.4.6 Geotechnical issues and dam safety.

GHD has provided the latest Hellyer Mine Tailings Storage Facilities Comprehensive Surveillance Review in March 2017. GHD has been engaged to assess dam safety issues during mining, including the design, surveillance and construction of TSF 2.

6.5 Biodiversity and Natural Values

6.5.1 Existing environment Hellyer Mine

Miedecke (1987) described flora and fauna habitat surveys conducted in April 1987. One hundred and twenty-nine taxa of higher plants were observed at the Hellyer site. Twenty-eight species were endemic to Tasmania.

The plant communities are typical of north-western Tasmania. These communities characteristically form a complex mosaic of different stages of successful development. These are a function of time since last burning, together with local effects of elevation, soil types and drainage.

The Hellyer area has a habitat structure of dense temperate rainforest interspersed with wet sclerophyll forest, which is common along the Tasmanian west coast.

6.5.1.1 Rainforest

The rainforest area encompassing the site includes five communities. On the soils formed on basalt, the forests are either dominated by myrtle *(Nothofagus cunninghamii*) and sassafras *(Atherosperma moscahatum)* or by myrtle and tea tree *(Leptospermum lanigerum).*

On the soils formed on the Mt Read volcanics, three other rainforest communities are also found. The most common of these communities is dominated by myrtle, celery top pine *(Phyllocladus aspleniifolius)* and leatherwood *(Eucryphia lucida).* The second of these communities is dominated by myrtle and the third community is found where emergent eucalypts have died. It is dominated by celery top pine.

6.5.1.2 Open forest

Smithton peppermint *(Eucalyptus nitida)* – Brookers gum (*E. brookerana*). Smithton peppermint dominates this community over most of its area. Brookers gum occupies the more poorly drained sites. Epacrids, particularly goldiewood *(Monotoca glauca), Monotoca submutica* and mountain berry *(Cyathodes parvifolia)* dominate the understorey of this community over most of the area. However, where fire has been recent native iris *(Diplarrena latifolia)* or other graminoids are dominant, and where fire has been absent for more than half a century, rainforest species, particularly celery top pine, dominate the understorey.

6.5.1.3 Tall open forest

Typically gum topped stringybark *(Eucalyptus delegatensis)*; this community occupies the better sites in terms of drainage and fertility.

6.5.1.4 Sedgeland

Sedgeland is dominated by buttongrass *(Gymnoschoenus sphaerocephalus).* Sedgeland occupies the poorly drained and frequently burned sites on the Mt Read volcanics to the south and west of the existing main TSF. The buttongrass sedgeland found in this area is characterised by a relatively high cover of forbs and grasses and relatively low cover of shrubs when compared to the similar communities on quartzite.

6.5.1.5 Riparian complex

Fine textured and relatively fertile fluvial deposits are found along rivers and streams and below rainforest throughout the area. These spatially restricted environments support a large proportion of the species and communities recorded in the area. A community closely resembling a short alpine herbfield appears to be maintained by heavy grazing pressure of marsupials. The endemic herb *Gunnera cordifolia* dominates most of the area of this community.

6.5.1.6 Fauna

The distribution of fauna at the Hellyer site reflects the fact that mining and processing operations have occurred in the vicinity since the early 1980s when the Que River Mine was established. Immediate habitat has been replaced by infrastructure and in some cases rehabilitated land. This favours some species, such as reptiles, at the expense of others.

Outside the immediate footprint of the mine and processing facilities, available habitat in the various vegetation communities is believed to be typical of the Tasmanian west coast.

6.5.2 Biodiversity and Natural Values management

6.5.2.1 Performance requirements

Fauna and flora management must comply with the following statutes:

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Threatened Species Protection Act 1995*
- *Nature Conservation Act 2002*
- *Crown Lands Act 1976*
- *Weed Management Act 1999.*

6.5.2.2 Potential effects

6.5.2.2.1 Threatened vegetation communities

There will be no clearing of threatened vegetation during the currently approved operation. There may be some vegetation clearance during exploration works in regard to TSF 2. This should be minimal and less than 1 ha in total footprint.

6.5.2.2.2 Declared weeds and pathogens

The Hellyer site has remained relatively free of weed species over the past two decades.

6.5.2.2.3 Threatened fauna

The currently approved operation should not increase the risk to threatened fauna on site. There may be some vegetation clearance during exploration works in regard to TSF 2 and this could potentially increase the risk to threatened fauna, particularly in regard to denning habitat.

6.5.2.3 Avoidance and mitigation measures

6.5.2.3.1 Threatened vegetation communities

The Hellyer tailings reprocessing is an existing approved operation and no additional impact on threatened flora is envisaged, other than that associated with the construction of TSF 2, which will be assessed following submission of a separate DPEMP. Therefore, no additional management or mitigation measures are warranted. Nonetheless, HGM will institute and implement the measures outlined in Section 6.5.3.3 as good conservation practice.

6.5.2.3.2 Declared weeds and pathogens

Weed management forms part of the general environmental management of the site to prevent the spread of weed species into the site, manage any existing weed species and prevent recruitment in other areas.

Specific gorse management will include:

- Remove all small plants by hand.
- Spray larger plants with Garlon 600 (mixing ratio 200 mL to 100 L water) and Grazon DS (mixing ratio 300 mL to 100 L water).
- Regularly inspect (monthly) to monitor any regrowth, should it occur, and reapply chemicals to new growth if necessary.

There are few infestations of gorse on site. Where there are multiple plants, they are relatively small. Regular spraying should be adequate to control these infestations.

6.5.2.3.3 Weed hygiene measures

With a single dedicated entrance to the site from the Cradle Mountain Link Road, the implementation of a weed hygiene plan to prevent the spread of weeds into or out of the site should be effective. HGM will maintain a 50 m wide weed-free buffer zone between the site and the road entrance. The zone will be inspected by site personnel on a monthly basis; the presence of any weeds will trigger immediate action to remove the weeds.

6.5.2.3.4 Threatened fauna

As indicated above, it is unlikely that the operation will result in adverse impacts to fauna. Nevertheless, the following fauna management plan (Section 6.5.3) will be implemented during exploration and development works for the proposed TSF 2.

6.5.3 Exploration works TSF 2 fauna management plan

This management plan applies to Tasmanian devils and spotted-tailed quolls within the HGM proposed TSF 2 survey area at Hellyer. The objectives of this management plan are to:

- protect Tasmanian devils and spotted-tailed quolls
- maintain the abundance and geographical distribution of Tasmanian devils and spotted-tailed quolls
- minimise the impact to natal den sites and breeding activities of Tasmanian devils and spotted-tailed quolls
- mitigate against any potential negative impacts on Tasmanian devils and spotted-tailed quolls from the Hellyer TSF 2 development works.

6.5.3.1 Target species Tasmanian devil (Sarcophilus harrisii)

Status: Endangered (TSPA) / ENDANGERED (EPBC Act)

6.5.3.1.1 General information

The Tasmanian devil has been listed on the TSPA and EPBC Act due to the threat to the species brought about by the devil facial tumour disease, which has ravaged some populations. This species was once also widespread on mainland Australia but it is thought to have become extinct on the mainland centuries ago.

The Tasmanian devil is primarily a carrion-eater that is generally nocturnal. During the day, it will retire to a cave, hollow log or thick scrub.

The Tasmanian devil (*Sarcophilus harrisii*) is Australia's largest surviving marsupial carnivore and only specialist scavenger. Although variable in size, adult males can weigh up to 12 kg (average 10 kg) and be 30 cm high at the shoulder, with females weighing up to 7 kg on average (Lachish et al., 2009). Devils have a short life span, generally no more than 6 years (Lee & Cockburn, 1985) The species is now confined to Tasmania where it is widely distributed across all environments throughout the state.

Devils are usually solitary animals, but they share continuously overlapping home ranges and come into contact with other devils around prey carcases and during the mating season (Lee & Cockburn, 1985). They mate once a year, giving birth in April through to July, and can produce up to four young which develop for up to 20 weeks in the pouch. The young are fully weaned at 10 months of age.

Animals typically travel around 8 km a night, although individuals have been recorded covering more than 50 km in a single night. They have home ranges of 8 to 20 square kilometres (800 to 2,000 ha), although more recent studies suggest smaller ranges, probably reflecting higher carrying capacity (Lachish et al., 2009). Their home ranges overlap to a very large extent with those of other individuals, but they forage separately and are antagonistic towards each other on meeting. The average density of pre-disease devils in unmodified habitat ranges between 0.3 and 0.7 per square kilometre (DPIPWE, 2010). As a result of the high degree of shared range, the clearance of an area equal to one home range (15 km^2) can affect up to 80% of the population to some degree.

The overlapping ranges and high density of animals results in a population of devils that utilises the whole of the landscape as a single entity. Pemberton (1990) showed that for a population of 250 devils occupying about 45 km^2 – each devil having a home range of about 15 km^2 – about 30% of animals share a majority of their home range and about 80% have at least some overlap of the home range. The high degree of overlap reflects a myriad range of home range shapes.

Devils displaced by habitat loss will move to other home ranges, but ultimately the population will decrease due to the limits of carrying capacity. This is likely to be over a period of the lifespan of the displaced animals. If native nonbreeding habitat is lost, a population can be sustained if the abundance and seasonal availability of prey is sustained. If the abundance and seasonal availability of prey is not sustained, then the carrying capacity and the population size will fall.

It is likely that the potential exploration area (proposed TSF 2 inundation area) supports between 0.2 and 0.3 individual animals.

6.5.3.2 Target species spotted-tailed quoll (Dasyurus maculatus maculatus)

Status: Rare (TSPA) / VULNERABLE (EPBC Act)

6.5.3.2.1 General information

Tasmania is the stronghold for the spotted-tailed quoll although the species occurs at naturally low densities. The species' core habitat area is described as a strip across northern Tasmania on lowland, fertile sites with predictable rainfall, with peripheral habitat and lower densities occurring south of this northern strip and in areas of the southern forests and the south-west. The spotted-tailed quoll is generally a forest-dwelling species, most common in wet forest types, but also found in dry forest, woodland and coastal heath. Spotted-tailed quolls actively hunt small birds, mammals, reptiles and insects. They are solitary with home ranges of about 1,500 ha and generally occurring at densities of about 1 per 300 ha but can be higher in core habitat.

It is considered likely that the spotted-tailed quoll occurs in the proposed TSF 2 area because the forests are suitable habitat. It is likely to be present in relatively low numbers, possibly as part of 1–2 individuals' ranges.

6.5.3.3 Mitigation of potential impacts

6.5.3.3.1 Roadkill minimisation strategy

The following will be introduced into the site's induction and training processes:

- Training on fauna identification, the roadkill issue and strategies to reduce potential impact, including training on what to do if a fauna collision occurs while driving (included in the fauna protocol).
- All vehicles will yield right-of-way to wildlife where possible.
- Most on-site vehicle movements will occur during daylight hours. Drivers will be reminded that extra vigilance and caution is particularly important from early April to mid-September when sunrise occurs after 7:00 am and sunset occurs before 6:00 pm. During this time, dawn and dusk (twilight periods) are closer to the hours of human activity and therefore there is more likely to be interaction between fauna and vehicles. This will be emphasised during training and reiterated before this time of the year.
- Restricting speed limits on internal mine roads to a maximum of 40 km/h during daylight, reduced to 20 km/h during twilight.
- Install roadkill warning and speed limit signs at regular intervals along the main site entrance road to remind staff and other road users of the roadkill issue.
- Install speed advisory signage for twilight and night-time driving to encourage slower driving speeds after dark.
- All vehicles will use high radiance (high intensity spot) and wide dispersal (wide angle pair) lighting.
- Undertake routine roadkill monitoring throughout the operational period of the mine.
- Establish a system for reporting of collisions and near misses with wildlife so that hotspot locations can be identified and mitigated.
- Any collisions with threatened fauna should be reported to DPIPWE within 5 days.
- Remove roadkill of all animals from the internal mine roads on a daily basis to discourage quolls and devils from scavenging on the road. Carcases will need to be taken from the site and disposed of, not thrown into the bushes, to avoid attracting scavengers. Devil carcases will be frozen and made available to the Save the Tasmanian Devil Taskforce, if requested by that agency.

- Internal road surfaces will be made lighter to make animals feel more conspicuous and exposed, thus discouraging them from lingering on the road. Road and track upgrades are to comprise a light-coloured surface.

6.5.3.3.2 Loss of habitat

- Vegetation clearance will be limited to an absolute minimum necessary to place infrastructure and undertake operations.
- Extent of vegetation clearance will be pegged/flagged in the field prior to commencement of clearing operations.
- All works, vehicles and materials should be confined to the works area, and stored on previously disturbed/cleared areas.
- Cleared trees and logs will be stored until the end of the exploration period.
- On completion of exploration activities, the cleared areas will be rehabilitated to ensure the native vegetation regenerates to recreate habitat in the long term.

6.5.3.3.3 Direct and indirect effects on devil and quoll within and adjacent to the impact area

Pre-clearance surveys of areas greater than 1 ha will be undertaken utilising the following protocols:

- If occupied natal dens are found, they should be protected from disturbance by a 150 m buffer. These can then be cleared only during the nonbreeding season (between 1 February and 31 May).
- If an active den is found, further investigations will be required to determine whether it is a natal den, with vulnerable young. If so, clearance will need to be delayed within 150 m of the site until after January. Any losses to individual animals caused by clearance will require offsetting through a predetermined donation fee to the Save the Tasmanian Devil Program.
- Remote sensor camera surveys or sand traps will be used to determine activity of any potential dens located during pre-clearance surveys.
- Restricted entry tape and warning signs will be erected to indicate the location of all known active dens, with signs stating the required buffer distance.
- Den surveys should be undertaken by a suitably qualified ecologist during the breeding season.
- Limit human activity to within the operational area of the mine, with no unnecessary activity or excursions out of this area.

6.5.3.3.4 Mine site interactions with devil and quoll during operation

- Implement protocol for when devils or quolls are encountered – staff instruction on interacting with devils or quolls, injured, dead or alive.
- All drill holes will be temporarily capped on completion of drilling and permanently capped as soon as possible. Drill holes will be monitored regularly to ensure the caps remain in place.
- Best practice waste disposal and storage methods/procedures will be implemented, particularly for food wastes, in order to discourage scavenging by quolls and devils. For example, ensure that all domestic waste is placed in bins with either catches or weighted lids.
- All rubbish is to be removed off site and not permanently stored or disposed of on site.
- Roadkill carcases collected from internal roads will be removed and disposed of off site.

6.5.3.4 Reporting and evaluation

The HGM Site General Manager will be responsible for implementing this plan. Environmental reporting will address all requirements documented above in the mitigation section, and will specifically address measures taken to address all of the issues raised. Evidence and data are required to document the implementation of this management plan. Information is to include measures taken, data collected, quantification of data where relevant (e.g. amount of vegetation clearance, amount of roadkill), issues with any of the management requirements and, if required, alternative strategies devised or proposed.

The following items will be addressed within the environmental reporting:

- loss of habitat
- direct effects on devil and quoll during vegetation clearance within the impact area

- indirect effects on devil and quoll within habitats adjacent to the impact area
- mine site interactions with devil and quoll during operation.

6.6 Heritage

The proposed Hellyer retreatment process does not cover any previously undisturbed sites and no previously undiscovered evidence of European or Aboriginal cultural heritage is expected to arise during its operations.

6.6.1 Aboriginal heritage

Miedecke (1987) reported that a study of the Hellyer Mine site area was carried out in April and May 1987. This included a literature search. The field study was carried out in May 1987 and involved a systematic survey of the then proposed tailings dam site, the concentrator site and the haulage road between the portal and the mill. The survey was carried out over two days with no Aboriginal sites detected.

McCullough Robertson undertook a due diligence on the potential Hellyer acquisition for NQM in March 2017. They requested a desktop assessment of the area of CML 103M/87 to confirm whether any Aboriginal relics have been recorded. Aboriginal Heritage Tasmania (AHT) advised that there are no Aboriginal relics recorded within the project area. Further, AHT, referring to Meidecke's report, advised that an archaeological survey was undertaken at the Hellyer Mine site in 1987, and no relics were identified at that time. As a result, AHT is of the opinion that the area has a low probability of Aboriginal relics being present.

AHT has advised that it has no objection to the project proceeding.

AHT has also advised that, if at any time during works the presence of Aboriginal relics is suspected, works must cease immediately and AHT must be contacted for advice.

6.6.1.1 Performance requirements

The project must comply with:

- *Tasmanian Aboriginal Relics Act 1975*
- *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984.*

6.6.1.2 Potential effects

While very unlikely due to the previously disturbed nature of the site, the project has the potential to inadvertently destroy or damage Aboriginal cultural heritage that may exist on the site.

6.6.1.3 Mitigation and management measures

HGM will comply with the requirements of the *Aboriginal Relics Act 1975*. If any major disturbance of previously undisturbed land around the project footprint is planned, HGM will commission appropriate surveys and apply for appropriate permission prior to disturbance. In the first instance, an assessment will be carried out to determine whether disturbance can be avoided.

Should Aboriginal relics be discovered during construction or operations, they will be left undisturbed and reported to the Director, Parks and Wildlife Service (PWS) in accordance with the *Aboriginal Relics Act 1975*, and to the Tasmanian Aboriginal Land and Sea Council.

Under no circumstances will Aboriginal or European artefacts be removed, destroyed or interfered with by HGM's employees, contractors or subcontractors.

HGM will incorporate the requirements of an Unanticipated Discover Plan during operations.

6.6.2 Historic heritage

The Hellyer Mine is relatively modern in terms of west coast mines; it had a short life of less than 20 years and had no town site or main highway associated with it. These factors tend to limit the heritage values of

the site and as a consequence most old workings were removed during the original rehabilitation process. In terms of mining heritage, the discovery and development of the original project marked the use of techniques that are now commonplace and did not warrant registration on the Tasmanian Heritage Register at the time of the 2000 closure.

Kostoglou (1999) conducted an archaeological survey of the Hellyer Mine in 1999 for Mineral Resources Tasmania. He noted that the concrete adit portal itself is the only feature at this site that was deemed to be of any nominal heritage-related significance.

6.6.2.1 Existing conditions

No heritage properties, sites and/or values – as listed on the National Heritage List, Register of the National Estate, Tasmanian Heritage Register or the Tasmanian Historic Places Inventory – exist in the area of the proposed site.

6.6.2.2 Performance requirements

The project must comply with the *Historic Cultural Heritage Act 1995.*

6.6.2.3 Potential effects

Operation of the proposed facility and associated infrastructure will not have any impact on any listed heritage properties and/or values as no places or sites exist in the site that are listed on the National Heritage List, Register of the National Estate, Tasmanian Heritage Register or the Tasmanian Historic Places Inventory.

6.6.2.4 Mitigation and management measures

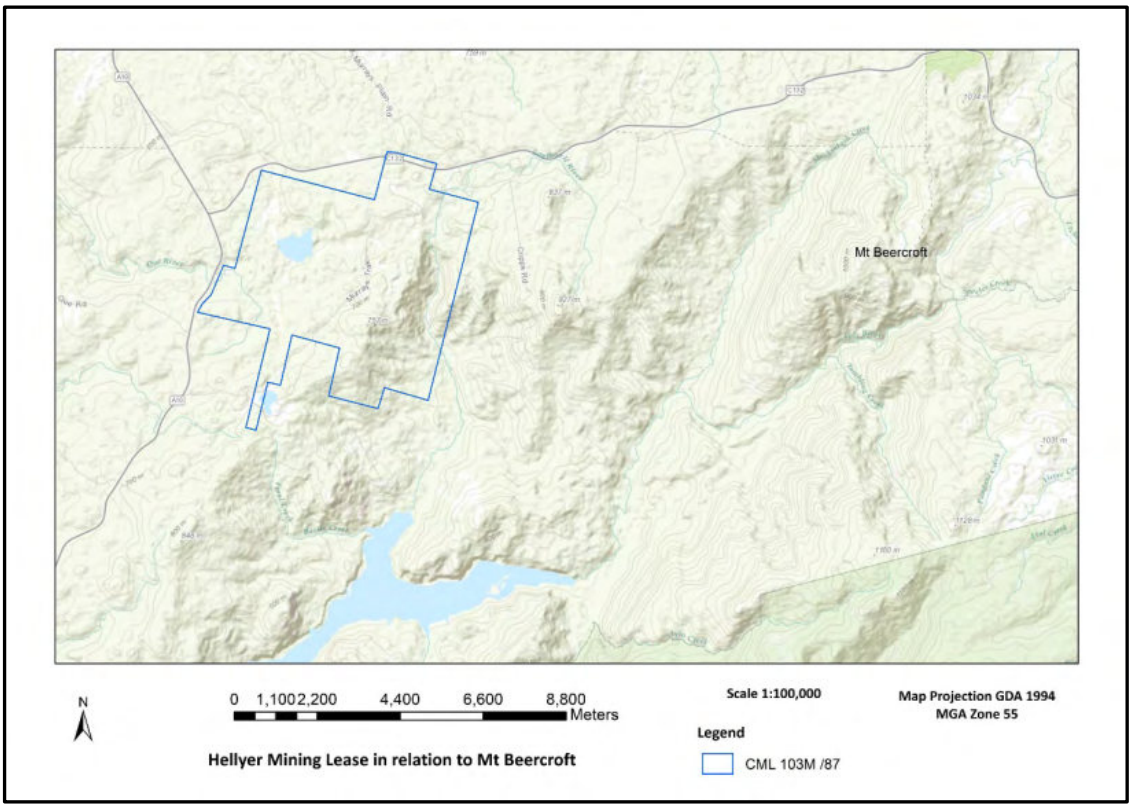
No additional mitigation is considered necessary.

6.7 Visual Amenity and Landscape

6.7.1 Existing environment

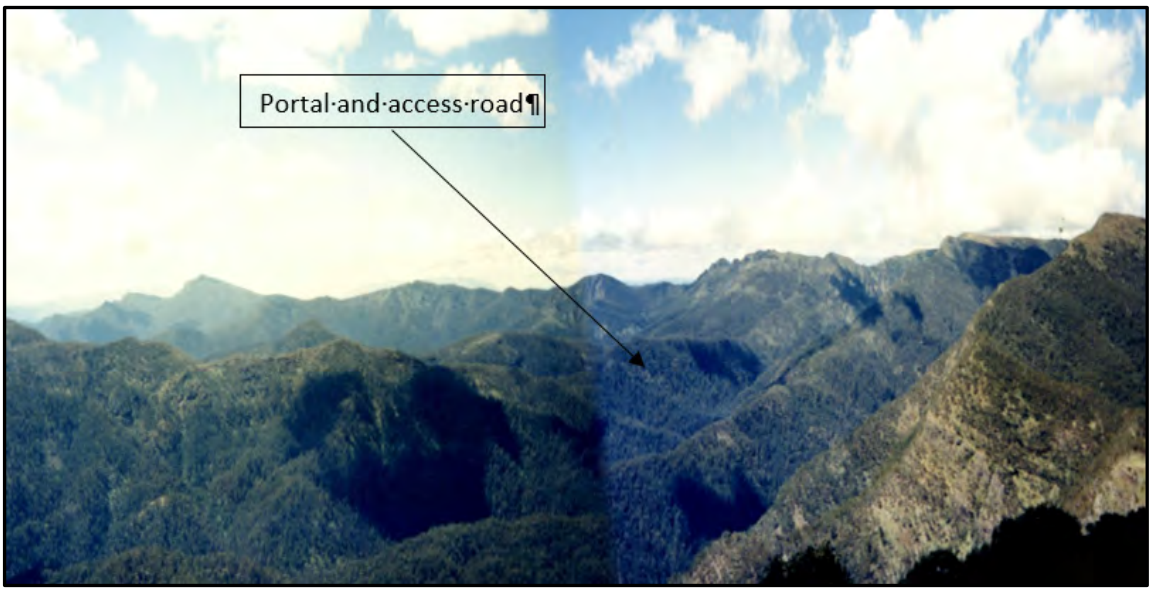
The Hellyer Mine is not a conspicuous visual intrusion in the landscape. The proposed TSF 2 will not be an obvious element in the landscape. The Que River and Hellyer operations have been operating or disturbed since 1980. Figure 52 shows the Hellyer lease in relation to Mt Beercroft, which is one of the highest peaks in the district. Figure 53 provides a photo montage taken from the peak of Mt Beecroft in the mid-1990s.

Figure 52 Location in relation to Mt Beercroft



The site is not visible from the north or the west, where stands of vegetation block any views of the mine and facilities from both the Cradle Mountain Link Road and the Murchison Highway.

Figure 53 View from Mt Beercroft



6.7.2 Mitigation and management measures

HGM will ensure that a buffer of vegetation is maintained along the ridgelines to the east of the old haul road between the mills and the southern end of the lease.

No additional mitigation or management is necessary.

7 Rehabilitation and Closure

This rehabilitation and closure plan updates the closure plan provided by Polymetals in 2006. It also draws on closure planning and principles espoused by BSM in its Hellyer Mine Plan DPEMP (2009).

As TSF 2 is developed, an updated Environmental Rehabilitation Plan will be required. This will be assessed during the approval process for TSF 2.

7.1 Closure Planning Objectives

This rehabilitation and closure plan has been developed in accordance with key objectives of the Strategic Framework for Mine Closure (ANZMEC 2000):

- to protect the environment, public health and safety by using safe and responsible closure practices
- to reduce or eliminate adverse environmental impacts as part of mine closure
- to establish conditions which are consistent with the Hellyer lease area becoming a healthy modified ecosystem
- to reduce the need for long-term monitoring and maintenance by establishing effective physical and chemical stability of disturbed areas.

Prior to long-term closure, HGM will need to ensure that the site does not provide a long-term risk to the surrounding environment by:

- progressively rehabilitating the site as much as practicable in accordance with operational plans
- preventing the introduction of noxious weeds and pests
- reshaping disturbed land so that it is stable, adequately drained and suitable for the desired long-term land use
- minimising the long-term visual impacts,
- minimising the potential for erosion by wind and water
- revegetating the area with plant species consistent with the approved post-operational land use
- meeting all statutory requirements
- making the area safe
- removing all plant, machinery, structures, facilities and equipment from the site unless agreed otherwise with key stakeholders
- providing environmentally sound waste disposal at the site, including any radioactive material
- monitoring and managing revegetated areas until the vegetation is self-sustaining.

Figure 54 Site plan Hellyer

7.2 Prevention of Environmental Harm

7.2.1 Financial assurance provision

Caloundra Environmental has conducted a preliminary assessment to identify key environmental aspects associated with the site. Environmental aspects were assessed by identifying and reviewing known emissions from the site since its closure in 2000. Reports compiled by Aberfoyle regarding site emissions and environmental aspects prior to 2000 were also reviewed. Reports provided to the EPA by site operators between 1998 and 2017 have been reviewed to assess the environmental issues and risks and followed up with several site inspections and data reviews.

This assessment encompasses the environmental aspects of the site which have the capacity to cause environmental harm if the operation was to cease in the first three years of operation. The cost estimates assume that the current environmental aspects remain in situ, i.e. existing tailings remain in place and are not replaced to a significant degree by PRT.

An environmental financial assurance (bond) of approximately $1,900,000 is held by Mineral Resources Tasmania against the tenement. The last known review of the bond occurred when BSM received PCE 7759 for the Fossey underground mine in 2010.

As described in the above EMP, the key environmental aspects of concern are related to surface water emissions (6.2.1) and are mainly caused by AMD from exposed or oxidising sulfidic tailings (Sections 6.1.1, 6.1.3 and 6.4.2).

Table 14 provides summary financial assurance estimates for the site in its current condition, based on the discussions above. More detail on each of these cost estimates is also provided below.

Table 14 Bond estimates summary

Item	Works	Cost estimate
Shale quarry	Bentonite seal tailings and wall fissure, limestone cover tailings	$471,603
Eastern arm	Remove exposed tailings from Mill Creek and upper eastern arm, passivate and store in western arm under water, apply limestone, sand cover over tailings in eastern arm	$134,400
Western arm	Bentonite seal tailings dam wall, limestone, sand cover over tailings	$382,089
Main TSF	Cover tailings with 25 mm limestone, sand mixture	$519,908
Total estimated FA requirement		**$1,508,000**

7.2.2 Environmental aspects

7.2.2.1 Tailings dam (main TSF)

The dam was designed and constructed and is maintained to ANCOLD standards and is stable. However, since that time dam construction standards have changed. Dams are now required to have filter system to prevent piping failures. As it is virtually impossible to retrofit a filter system, HGM plans to construct and operate TSF 2 downstream of the main TSF. All PRT will be stored in the TSF 2. Future engineering amendments may be made to the main TSF dam wall such as buttressing. This will depend on final engineering recommendations for long term water storage.

The total tailings dam catchment area covers around 70 ha. The middle TSF covers approximately 50 ha. The bond proposed above reflects the need to keep tailings submerged and prevent remobilisation of sulfidic tailings into the water column. The current approval allows for tailings to be covered with a layer of limestone and sand and, above that, a minimum 2 m of water to minimise the generation of AMD.

The bond estimates for the main TSF are shown in Table 15.

Table 15 Bond estimates main TSF

Item	Cost estimate
Limestone/sand application over tailings in situ over 50 ha.	$519,908

Prices on the supply of –2 mm agricultural limestone were sourced by Polymetals for rehabilitation in 2006 then updated by BSM in 2010. This cost has been updated since 2010 by applying Hobart CPI increases since 2010. These costs have been used for all tailings coverage in dams in this report.

7.2.2.2 Eastern arm (TSF)

The eastern arm of the TSF contains long-term exposed tailings (Section 6.1 and 6.1.1).

HGM plans to remove all eastern arm tailings and the embankment wall to TSF 2 once this facility is operational. This is described in Section 4.

Upon early or final closure, all exposed tailings in the eastern arm and remnant in Mill Creek will need to be inundated or removed, passivated and stored under water. There is sufficient space in the western arm impoundment near the south dam wall to store the exposed tailings and potentially PAF material won from Mill Creek under water. This storage will need to be geochemically stable to prevent AMD formation. For the purposes of this FA assessment, a lime dosing rate of 5 kg/t has been assumed. A report by Schumann et al. (2009) showed that blending 3% calcite with 5% pyrite reduces oxidation rates by 10 to 40 times and is capable of passivating sulfides for at least 100 years. Recent geochemical testwork has shown that the eastern arm tailings currently stored under water are not oxidising and as such can be left in situ at least in the short term.

Table 16 Bond estimates eastern arm

Item	Cost estimate
Excavate exposed tailings from eastern arm and Mill Creek and haul to western arm impoundment	$36,815
Lime addition to passivate tailings and Mill Creek material	$14,137
Limestone/sand application over tailings in situ over 4.2 ha	$83,448
Total	**$134,400**

7.2.2.3 Western arm (TSF)

Tailings from the Polymetals operation and the Fossey Mine were deposited into the western end of the western arm impoundment. The design of the clay core in the western arm embankment required tailings to be spigotted off the wall where the low permeability of the tailings against the wall would ensure that the western arm would hold water. The distal deposition carried out meant that water in the western arm leaks through the embankment wall into the main TSF.

As a consequence, works are needed to seal the western arm wall. The application of a bentonite layer against the wall and the application of a limestone cover over the existing tailings have been allowed for in the FA estimate in Table 17.

Table 17 Bond estimates western arm

Item	Cost estimate
Bentonite supply and placement	$173,594
Limestone/sand application over tailings in situ over 18.5 ha	$208,495
Total	**$382,089**

7.2.2.4 Shale quarry

The shale quarry was used as a TSF for the majority of the HZCJV and contains ~1.0 million tonnes of tailings. The capacity of the quarry was increased by constructing a water-retaining dam around the low western side of the pit. After Polymetals ceased depositing tailings into the quarry, it was noted that the water cover was inadequate, with beaches forming over approximately half the tailings due (it appeared) to a direct hydraulic connection between the shale quarry and the Heller void on the north-eastern corner. This has been confirmed and described in Section 6.3.1.4. This led to oxidation of sulfides and formation of AMD.

The shale quarry needs to be remediated to permanently inundate the tailings. In 2010 GHD proposed sealing the edge of the tailings using bentonite and clay to provide a low-permeability barrier between the water cover and the wall fissures (Figure 55).

A GHD report in 2010 on sealing the shale quarry wall was used to assess costs. Bentonite supply and placement costs were calculated pro rata for volumes while costs were increased for CPI.

Figure 55 Shale quarry sealing

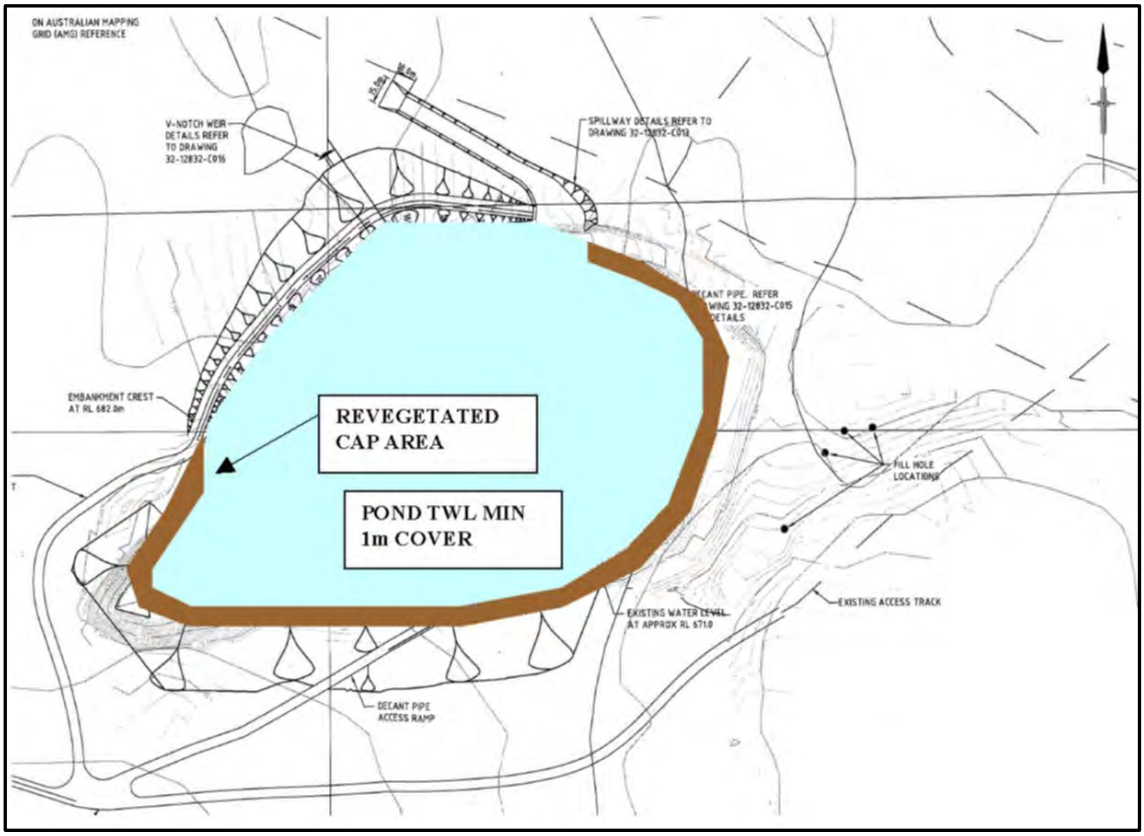


Table 18 updates the 2010 GHD cost estimates to seal the shale quarry by applying Hobart CPI increases to unit costs.

Table 18 FA estimates shale quarry

Item	Cost estimate
Sealing dam wall with bentonite and clay, supply and placement	$389,143
Limestone/sand application over tailings in situ over 2.5 ha	$82,460
Total	**$471,603**

7.2.3 Rehabilitation timeline

A timeline for rehabilitation work is provided in Table 19. This reflects HGM's current mine plan and schedule.

Table 19 Rehabilitation and remediation works planned

Proposed Works	Start	Finish
Eastern arm		
Excavate exposed tailings in upper reaches of eastern arm and Mill Creek: evaluate treat and temporarily store into western arm impoundment	1 Dec 17	31 Dec 18
Commission dredge and move finger pond tailings into Polymetals hole (allowing buffer around embankment wall)	1 Feb 18	31 Mar 18
Eastern arm tailings into TSF 2	15 Jan 21	1 May 22
Remove eastern arm dam embankment and dredge tailings for processing	13 May 22	18 Jun 22
Western arm		
Dredging of western arm	7 Sep-23	10 Jan-24
Remove dam buffer zones western arm and western arm dam embankments (90 days) and dredge tailings	10 Jan-24	27 Mar-24
Hydraulic mine western arm sluice into collection sumps	28 Mar-24	7 Apr-24

HGM will review the rehabilitation plan initially 12 months after the commencement of operations and then again when the TSF 2 is operational and at that time will also review the financial assurance requirements for the operation. By this time some of the above works to mitigate against environmental harm will have been completed and with the TSF 2 operational some closure risk will have increased. Therefore at this time the bond should be adjusted accordingly.

7.3 Final Rehabilitation Summary

On permanent closure, the rehabilitation items and domains noted below will need to be addressed. These have been predicated on stabilising the site and providing conditions that will facilitate restoration in accordance with the principles noted in Section 7.1. A summary of closure cost estimates is provided in Table 20.

Table 20 Final rehabilitation and closure summary cost

Item	Works	Cost estimate
Water treatment plant	Remove pumps, disconnect services	$5,500
Hellyer mills, buildings, plant and equipment	Disassemble and remove buildings, clean free of hazardous goods	$3,421,029
ROM area	Validate rehabilitation, revegetate	$3,003
Primary and secondary stockpile areas	Validate rehabilitation, revegetate	$5,826
Main TSF	Develop wetlands in shallow areas of western and eastern arms	$72,135
Landfill	Validate rehabilitation, clay cap and revegetate	$11,522
Core sheds	Remove buildings, revegetate	$34,400
Roads	Rip, contour, revegetate	$93,460
Subsidence areas	Fill, erect warning signs	$13,392
Hydrocarbons	Remove hydrocarbons from bunds, bioremediate, validation sampling	$74,169
Water pumps	Remove pumps, disconnect services	$11,000
Hellyer mine adit	Security fencing, revegetation	$22,920
Fossey decline plug	Security fencing, revegetation	$22,920
Basalt quarry	Revegetation	$28,972
Power supply infrastructure	Remove power lines, substations and switchyards	$251,820
Geology centre	Remove buildings, revegetate	$49,780
Administration building	Remove buildings, revegetate	$19,731
Miscellaneous	Disconnect remote services, mobilisation and demobilisation, concrete removal, contamination assessment	$889,332
Disturbed areas	Revegetation	$495,000
Maintenance and monitoring plan	Five years' water monitoring and dam safety inspections	$235,160
Total estimated closure cost		**$5,761,070**

The environmental aspects relating to permanent closure of the site are described below by area and where appropriate by item.

7.3.1 Water treatment plant

This plant sits below the main TSF and is designed to treat up to 220 L/s of dam discharge water. On closure, the water treatment plant will need to be disassembled and removed.

7.3.2 Hellyer concentrator buildings, plant and equipment

On final cessation of site activities, all plant, equipment and buildings will need to be cleaned free of surplus reagents, chemicals and hydrocarbons etc. Most reagents and chemicals will be returned to the appropriate suppliers. Radiation gauges will be removed, packed, transported and disposed of in compliance with the requirements of the Health and Physics Branch of the Department of Health and Human Services.

On final cessation of site activities, all buildings will need to be disassembled and removed. Cost has been allowed for concrete slabs and footings to be covered with 500 mm of topsoil to act as a bed for vegetative regrowth.

The main office building, which contains asbestos building materials, will be dismantled by a licensed asbestos removal contractor. Selected small concrete slabs will be broken up and assessed for recycling potential, with the remainder used as fill.

7.3.3 ROM area

BSM undertook rehabilitation of the ROM during 2012. PAF material was scraped off the area and disposed of on site. The ROM area was then covered with clays which were compacted with a sheep's foot roller. Lime was placed over the clays to incorporating additional alkalinity. Validation sampling and revegetation will be needed on mine closure.

7.3.4 Main TSF

On final closure, any remnant tailings in the main TSF will be covered more than 20 m of water. The distal reaches of what are now the eastern and western arms however will provide shallow areas where sulfidic tailings were once stored. To mitigate against any remnant sulfides oxidising, HGM will develop wetlands in these areas in line with the "mushy cover" method developed by Brett and French (2008) for the Henty Pond B to keep all remnant sulfides fully saturated.

7.3.5 Mill Creek

After cessation of operations, the creek will need to be inspected, with sampling for traces of residual tailings or other waste from the milling operation. If necessary, the creek will be cleaned and waste either placed into the TSF or removed to a licensed landfill, as appropriate.

7.3.6 Landfill

The landfill is situated to the north-east of the core sheds and was used by Aberfoyle and Western Metals to dispose of inert waste, mainly packaging materials (Western Metals, 2000). Drainage from the tip area flows into Mill Creek and consequently to the eastern arm of the TSF. During these operations, hazardous and contaminated wastes were removed by approved contractors and disposed of in licensed landfills on the north-west coast.

This area was progressively rehabilitated by Western Metals as the working face of the tip advanced. The final area will need to be clay capped and revegetated on closure.

7.3.7 Core sheds

On final closure all buildings, plant and equipment in the area will need to be removed and the area revegetated.

7.3.8 Roads

There are approximately 13 km of site roads (excluding the haul road). It is expected that the major roads will be left intact so that TasNetworks can maintain the two major transmission lines that bisect the lease. Formal documentation of TasNetworks' requirements will be established closer to the time of permanent cessation. It is estimated that approximately 20 ha of roads and tracks will require rehabilitation on final closure. The owner of the land under the Crown, after the mining lease has been surrendered, will be Parks and Wildlife. Before any roads are removed, a consultation programme will take place regarding future requirements. It is likely that some minor roads and tracks will be retained for the future needs of other organisations, such as Telstra and apiarists. Other potential users include BSM, which has right of entry to Fossey and Que River.

7.3.9 Subsidence areas

Some subsidence exists above the Hellyer orebody. There is a small area adjacent to the power lines along the entry road and a small sinkhole to the south of the shale quarry.

Plate 3 Southern sinkhole

The areas of subsidence on the lease need to be filled with rock and solids to make the area safe, and to ensure that surface run-off is directed away from the area of broken ground. However it mat not be practical or safe to fill the southern sinkhole in which case, to prevent unintended access, suitable berms or barriers will be in place, together with signage.

7.3.10 Hydrocarbons

All hydrocarbon tanks on site are above ground. On final closure, the tanks will be removed and the areas sampled for contamination of surrounding soils. If validation sampling shows hydrocarbon contamination, bioremediation will be set up on concrete pads behind the current mill buildings. Any land farming/ treatment on site of contaminated material will require approval from the EPA.

7.3.11 Water pumps

On final cessation of site activities, the water supply system at the Southwell River, including water pumps and the pipes, will need to be removed and the area ripped to facilitate revegetation.

7.3.12 Hellyer Mine adit

When Western Metals closed the original Hellyer underground mine, the mine adit was sealed with a concrete plug some 800 m into the mine. The plug was fully engineered and specifically designed to accommodate a full hydraulic head of some 300 m plus appropriate safety factors. The plug and the interior of the adit were inspected during a validation period of three years. No concerns with the integrity or suitability of the plug have been uncovered.

Mine water seepage through or around the plug, and also where it artesianally reports to the surface, is alkaline, indicating that pyrite within the mine is covered by water and is not oxidising. The water quality in the underground mine void reports to the surface at Jed's Spring and Elly May's Spring to the north of the shale quarry and from there to the eastern arm of the TSF. In 2006, Aquatic Science reviewed the water quality on site for the Polymetals DPEMP and noted that Jed's Spring was very high in iron. It was postulated that in the mine void the absence of oxygen would have prevented iron from falling out of solution. The iron is likely to be in the form of ferrous iron, which is soluble. When the spring surfaces, the iron would then come into contact with the oxygen in the air and start to precipitate. This precipitation would be quite rapid due to the high pH and the large quantity of ferric iron (a catalyst for

the oxidation). It was also postulated that water emanating from these springs would improve in quality as the AMD that formed during the time taken for the void to fill was diluted with fresh groundwater.

Vandal-proof barriers will need to be positioned once future access to the plug is not required.

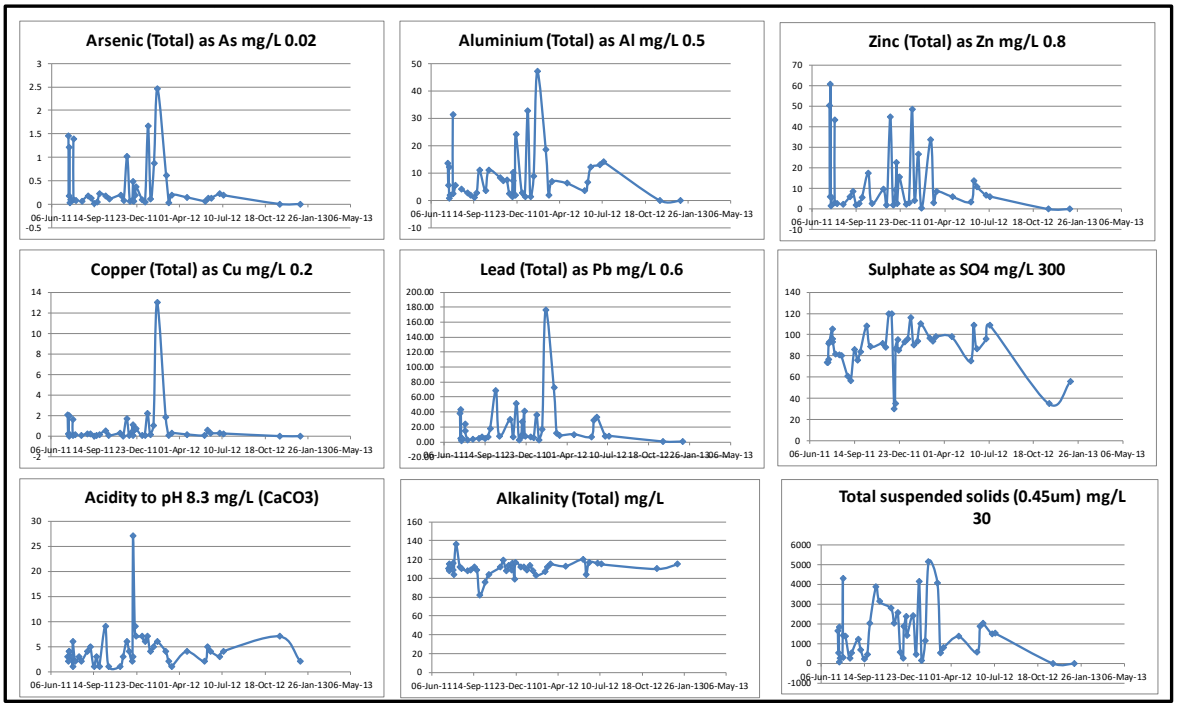
The adit area contains settlement ponds, which intercept stormwater prior to it entering the Southwell River catchment. These ponds will be inspected and cleaned prior to cessation of operations.

7.3.13 Fossey underground mine

BSM operated the Fossey underground mine under PCE 7759 until it closed in 2012. The operation and closure of the Fossey underground mine are not associated with this EMP under PCE 7386. Nonetheless HGM understands that the EPA wishes to understand the closure implications and potential costs associated with the Fossey underground mine and as a result has included detial in this section.

pitt&sherry were engaged to undertake the preliminary design and estimate of a portal plug for the main Fossey Mine decline. This was installed to allow the underground void to fill with groundwater. The design was based on a static water pressure head of 153 m and a density of groundwater of 1,000kg/m^3. It is believed the plug was installed in late 2012. Figure 56 shows the water quality trends for 2012 through 2013 as the void filled. This indicates that the plug was successful and that pollutant levels from the void should remain satisfactory providing that the plug is kept in place.

Figure 56 Fossey Underground water quality



Drainage from the decline reports to the settlement ponds below the Hellyer adit, which intercept stormwater prior to it entering the Southwell River catchment. These ponds will be inspected and cleaned prior to cessation of operations.

The provision of additional security fencing as per the Hellyer adit should suffice for closure cost estimates.

7.3.14 Basalt quarry

The basalt quarry was used for road base during the Aberfoyle operation (Western Metals, 2000). It is located to the west of the entrance road to the site (see Figure 54). When no longer needed,

rehabilitation of this quarry will begin by replacing lost topsoil; subsequently, hydroseeding or hand seeding will be carried out.

7.3.15 Power supply infrastructure

Tower 146 is a part of Transend's main 220 kV transmission line between the Reece Dam on the Pieman River and Sheffield. It is considered critical to the security of the power supply to the north-west of the state and is likely to remain after mining ceases on the lease. The tower is inside the surface expression of subsidence. Significant ground movement ceased with the end of mining activity. Kevin Rosengren (1998) assessed this and believes that no further movement will occur.

Local power supply infrastructure will be removed once it is no longer needed for mining or rehabilitation activities.

7.3.16 Geology centre

On closure, this facility will be sold and removed by the purchaser or disassembled and taken off site for disposal and the site will be rehabilitated.

7.3.17 Administration building

The administration office is a demountable building and is easy to remove. The area including the car park and mill surrounds will be ripped and contoured and then revegetated.

7.3.18 Miscellaneous

On final cessation of site activities, all septic tanks will be pumped clean of all solid and liquid waste. The tanks will then be broken down to a minimum depth of 300 mm below finished ground level and subsequently filled completely with clean material.

Tailings and water pipelines will be removed and disposed of in the on-site landfill as an inert waste.

This section includes an allowance for mobilisation and demobilisation of contractors and heavy equipment.

7.3.19 Disturbed areas

Disturbed areas resulting from either recent or legacy activities, excluding roadways, constitute some 20 ha in area. Rehabilitation strategies vary for each area, dependent upon the existing substrate and the availability of rehabilitation substrate immediately adjacent to each area.

In general, disturbed areas will be ripped to a minimum of 300 mm depth, and 250 mm of soil/clay substrate will be spread to provide a revegetation substrate. During the autumn months, fertilisation and seeding with provenance species will take place.
Specific fertiliser mixes and seed types will be determined by experienced consultants prior to closure. The underlying tenement holder of the land, Parks and Wildlife, will be consulted prior to revegetation of individual areas to ensure consistency with final land use objectives.

Areas requiring vegetation are accounted for in the individual domain areas. In addition to these areas, miscellaneous cleared or severely disturbed areas requiring vegetation total approximately 15 ha.

7.3.20 Rehabilitation maintenance and monitoring plan

The final closure plan allows for five years of monitoring and maintenance. This includes surface water quality monitoring and dam safety inspections. Surface water sampling is expected to involve three sites: Southwell River below Portal, Combined Discharge at H1 and Main TSF Discharge, sampled monthly for the first 12 months, then quarterly. Photo monitoring of revegetation and site inspections for weeds will also be necessary.

7.4 Closure Cost Offsets

To calculate the cost of final site closure (i.e. after all the tailings have been reprocessed and the site has been fully rehabilitated and the lease relinquished to the Tasmanian Government), the Mines – Bond Calculation Sheet developed by GHD for Mineral Resources Tasmania in 2006 was used. Where specific cost items were not available in this calculator, the rehabilitation liability calculator developed by URS Australia Pty Ltd for the Queensland Government was used. This provides a reasonably up-to-date and comprehensive closure cost calculator which allows for distance and isolation, so is applicable to Hellyer in north-west Tasmania.

Some costs will be recovered upon sale of plant and equipment from the processing facility after permanent cessation. Como Engineers Pty Ltd provided BSM with an Independent Technical Experts Valuation of the Hellyer assets in December 2008. This valued the plant at:

- new replacement cost (excluding civils, construction and commissioning) $48,614,285
- current value as a going concern $24,307,143
- auction value (to be dismantled and removed from site) $4,793,429.

As can be seen above, the current value of plant and equipment from the processing facility is potentially greater than the calculated closure cost. It is proposed that the current bond remain in place until TSF 2 has been approved and a closure review has been finalised. HGM is planning for TSF 2 to be approved by October 2018. In May 2019, the tailings reprocessing will have been operating for 12 months, at which time the bond should be reviewed again. By this time, a more accurate evaluation will be available of the environmental risks and timing associated with the hydraulic mining of remnant tailings as the main TSF water level is dropped.

HGM expects to provide security against these risks in a staged manner for each phase of mining.

8 Other Aspects

Environmental aspects not explicitly covered in this EMP, such as dangerous good management or emergency services facilities, have been assessed by HGM as low risk with little or no change required from the original operation, and as such, no change to current management procedures (as dictated by PCE 7386 and the original EMP).

9 Monitoring

The monitoring program approved for PCE 7386 is believed to be sufficient for the ongoing operation. However, given that the water monitoring requirements of PCE 7759 also apply to the site and cover facets such as the Fossey void, which are not part of PCE 7386 requirements, it is suggested that PCE 7759 monitoring requirements apply going forward.

9.1 Water Monitoring Sites Hellyer

The following sites have formed the basis of past water quality audits to understand water management issues on the lease.

Figure 57 Schematic map of the Hellyer mine lease

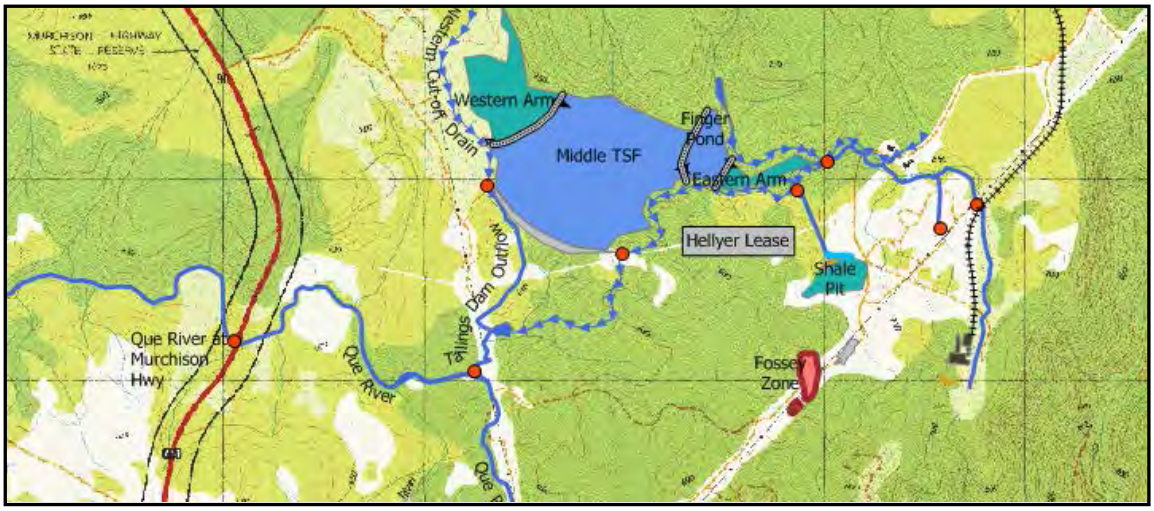


Figure 58 Schematic map sample points around the Hellyer TSF

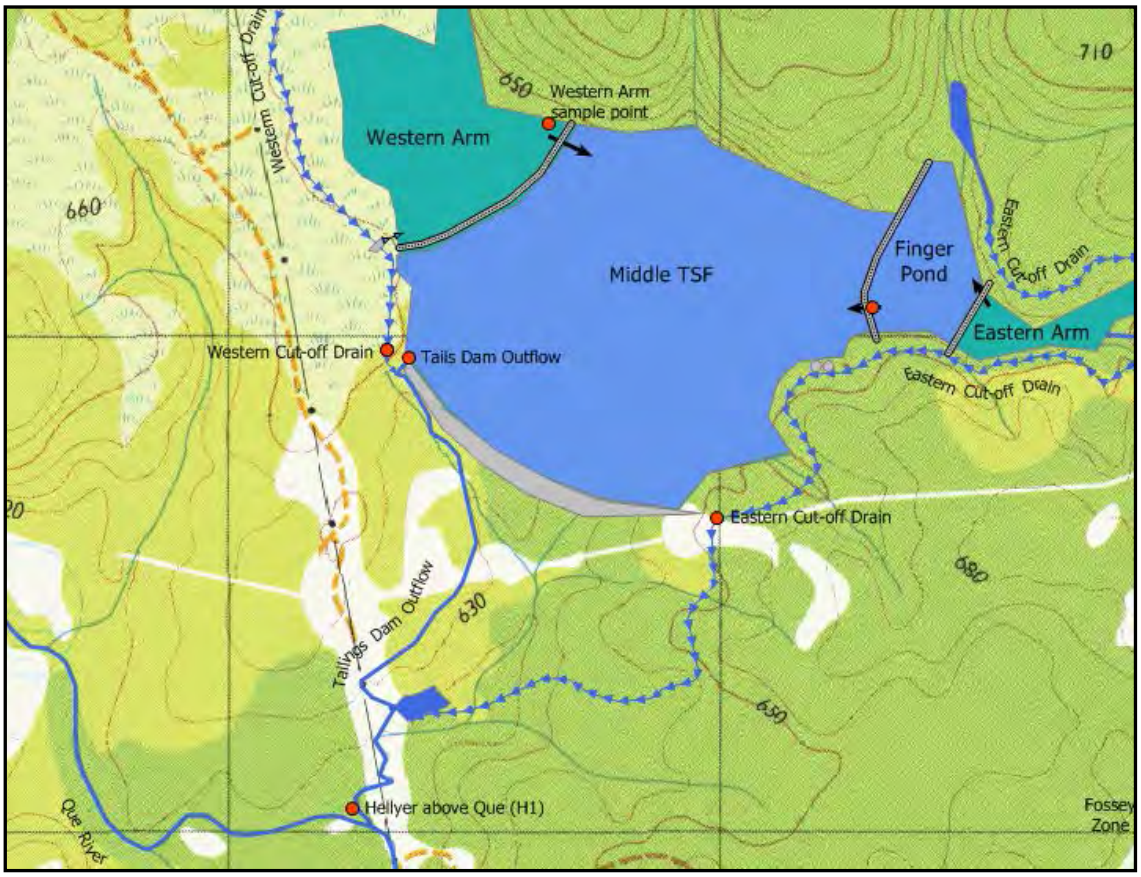


Figure 59 Schematic map Mill Creek sample points

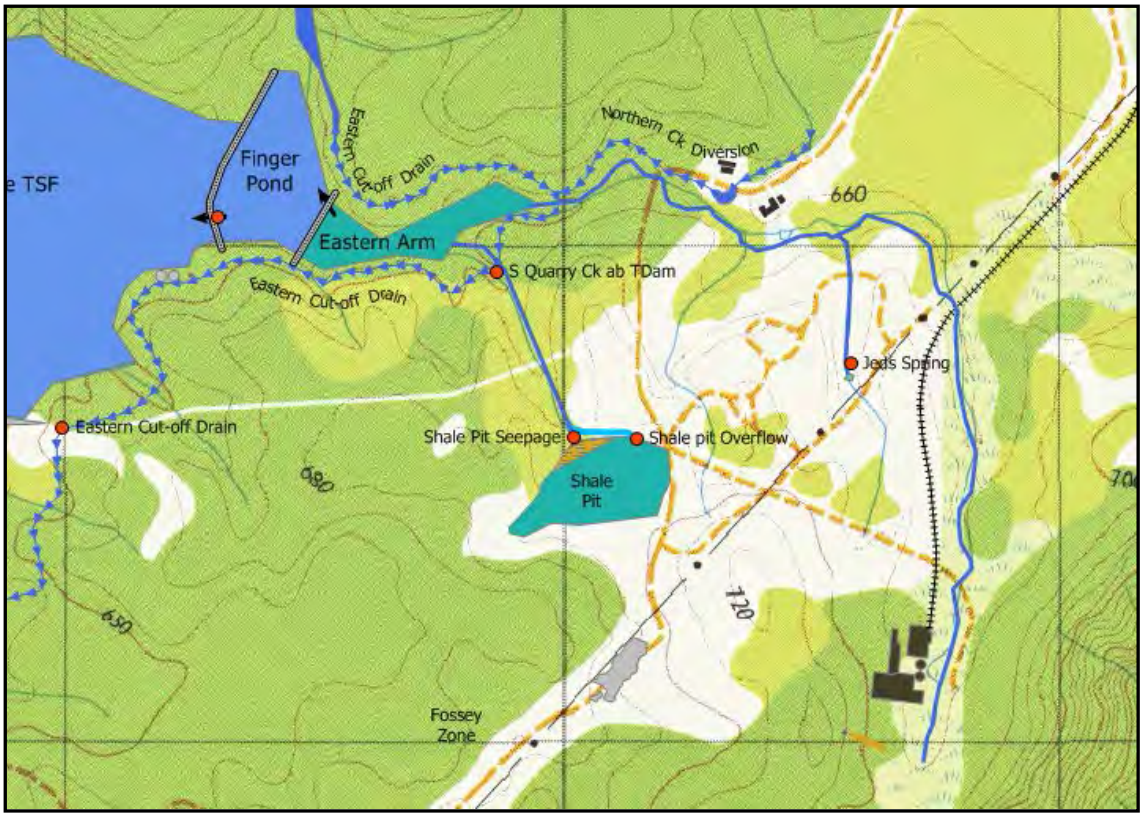
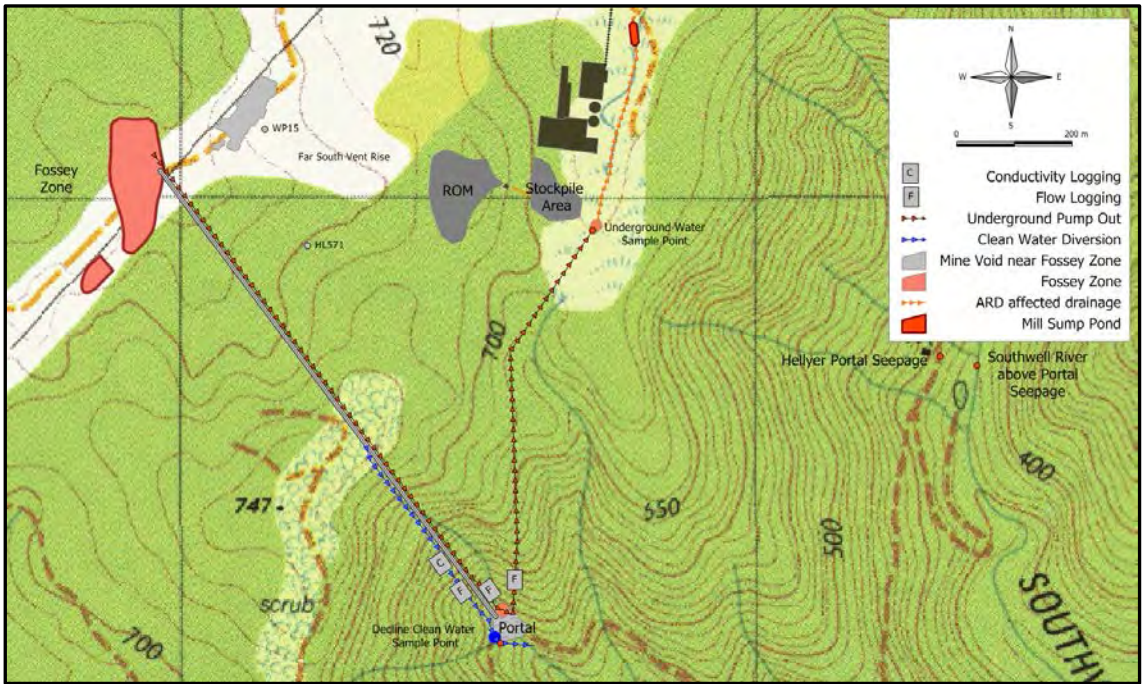


Figure 60 Schematic map water diversion to Southwell River and Mill Creek collection sump



9.1.1 Monitoring plan

The locations of sampling sites recommended for the monitoring of the Hellyer lease are listed in Table 21. The frequency of monitoring is summarised in Table 22. The frequency of measurement of field parameters (pH, temp, conductivity, and flow) is determined according to the expected impact of operations on water quality.

Table 21 Water sampling locations

Site	Site name	Latitude	Longitude
1	Que River at Murchison Highway	41°.34.608’	145°40.953’
2	Hellyer adit seepage	41°.34.883’	145°44.000’
3	Southwell River above portal seepage	41°.34.900’	145°44.050’
4	TSF outlet	41°34.213’	145°41.922’
5	Western cut-off drain	41°34.198’	145°41.870’
6	Eastern cut-off drain	41°34.386’	145°42.347’
7	Finger pond outlet	41°34.159’	145.42.576’
8	Western arm	41°33.953’	145°42.110’
9	Mill Creek	41°34.148’	145°43.089’
10	Jed’s Spring	41°34.329’	145°43.491’
11	Shale quarry	41°34.403’	145°43.094’
12	Shale quarry wall V-notch	41°34.406’	145°43.088’
13	Fossey settlement basin	41°35.135’	145° 43.453’
14	Mill Creek collection sump	To be determined	To be determined
15	Mill Creek drainage below ROM	To be determined	To be determined
16	Fossey void Fossey vent rise	41°34.35’	145°45.43’
17	Hellyer void central vent	41°34.27.7’	145°43.23’

Datum WGS 84.

Table 22 Summary of surface water monitoring

Site	Short name	Field parameters				Laboratory analyses							
		pH	Cond.	Temp	Flow	Total metals	Dissolved metals	Sulfate	Acidity*	TSS	Alkalinity*	Lab pH	Majors (Na, K, Mg, Ca)
1	Que River at M Hwy	M	M	M	cont.	M	M	M	M*	M	M*	M	M
2	Hellyer portal	Q	Q	Q	Q	Q	Q	Q	Q*	Q	Q*	Q	Q
3	Southwell	Q	Q	Q	Q	Q	Q	Q	Q*	Q	Q*	Q	Q
4	TSF	D	D	D	D	M	M	M	M*	M	M*	M	M
5	West drain	W	W	W	—	See monitoring triggers							
6	East drain	W	W	W	—	See monitoring triggers							
7	Finger pond	W	W	W	—	M	M	M	M*	M	M*	M	M
8	Western arm	M	M	M	—	M	M	M	M*	M	M*	M	M
9	Mill Creek	W	W	W	W	M	M	M	M*	M	M*	M	M
10	Jed's Spring	W	W	W	W	M	M	M	M*	M	M*	M	M
11	Shale quarry seepage	W	W	W	W	M	M	M	M*	M	M*	M	M
12	Shale quarry V-notch	W	W	W	W	M	M	M	M*	M	M*	M	M
13	Fossey settlement basin#	T	T	T	T	M	M	M	M*	M	M*	M	M
14	Mill Creek collection sump	D	D	D	D	M	M	M	M*	M	M*	M	M
15	Mill Creek drainage below ROM	W	W	W	W	M	M	M	M*	M	M*	M	M

Monitoring frequency D= daily, W= weekly, T = tri -weekly (Mon., Wed., Fri.), M= monthly, Q= quarterly, cont. = continuous.
 # Fossey settlement basin to be monitored if mining or exploration works recommence in the Fossey underground mine.

Explanatory notes for Table 22

Conditional analyses
* Request that lab does not perform acidity if lab pH is greater than 8.3.
* Request that lab does not perform alkalinity if lab pH is less than 4.5.

Monitoring triggers for western cut-off drain and eastern cut-off drain
The eastern and western cut-off drains do not need samples collected for laboratory analyses unless field monitoring (pH, conductivity) indicates that sources of AMD have been captured in the clean water cut-offs.

If pH or conductivity fall outside the normal background range (Table 23) immediate investigation will commence into the source of the pollutants. All parameters (total and dissolved metals, sulfate, acidity, TSS, alkalinity, lab pH, Ca, Mg, Na, K) will be sampled.

Table 23 Monitoring triggers

Site	Field pH	Field conductivity (µS/cm)
Eastern cut-off	If pH is <4.5, investigate & collect samples	If conductivity is >100 µS/cm, collect samples*
Western cut-off	If pH is <4.5, investigate & collect samples	If conductivity is >100 µS/cm, collect samples*

** note cut-off drains are expected to exceed 100µS/cm during extreme low flows.*

Hellyer portal and Southwell above portal
The Hellyer portal and Southwell above portal will be sampled on a quarterly basis, but inspected monthly at a minimum.

Metals suite
The following metals will be included in the analysis of total and dissolved metals: aluminium, arsenic, cadmium, cobalt, chromium, copper, iron, manganese, nickel, lead and zinc.

9.1.2 Groundwater

The Hellyer void level will be monitored at North, South and Central Vents on a monthly basis. The analytical parameters will be the same as for surface waters (Jed's Spring) shown in Table 22. The Fossey void water levels will be monitored at the Fossey vent rise. Groundwater levels will be monitored monthly. The analytical parameters will be the same as for surface waters (Jed's Spring) shown in Table 22.

10 PCE and EMP Review

HGM proposes that a comprehensive EMP be provided to the EPA 12 months after the recommencement of mining, this will include an environmental rehabilitation plan review.

11 Specific Commitments

The tailings collection sump below the mills, designed to stop tailings from running down Mill Creek, will be reinstated by HGM before production commences including tailings return to the mill tailings discharge tanks.

Once GHD has provide recommendations on safe buffer distances between dredging operations, existing dam walls and embankments, HGM will provide this report to the EPA and request a permit variation for the main dam wall exclusion zone in accordance with the engineering recommendations.

HGM will provide an AMD audit report to the EPA before 1 December 2017 to identify and quantify where possible all sources of AMD entering the main TSF.

HGM will provide a final AMD management and mitigation plan to the EPA for approval at least 30 days before commencing remediation works. The Plan will include:

- A description of how remnant tailings and associated sludges are to be removed from Mill Creek.
- A description of how the tailings and sludges will be transported from their locations in Mill Creek to the Western Arm impoundment.
- Mitigation measures to prevent spillage between the locations.
- Monitoring to be undertaken during the remediation program.

Timing of a follow up audit to evaluate the success of the works.

An additional AMD classification and management report will be provided to the EPA by 1 November and or at least 30 days before commencing remediation works, to further describe the results of static and longer term kinetic tests.

In May 2019, the tailings reprocessing will have been operating for 12 months, at which time rehabilitation plan and financial assurance provision will be reviewed. HGM will provide an updated environmental rehabilitation plan to the EPA within 30 days after the 12 month anniversary of the recommencement of mining and processing operations.

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LIMITATIONS OF REPORT

Purpose of Report

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