Annual Monitoring Review and Management Report 2021-22

MMG Rosebery

30th September 2022
Prepared by MMG

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Executive Summary

This report has been prepared in accordance with the requirements of Environmental Protection Notice's (EPN) 7153/3 and 8815/2 for the annual monitoring period 1 July 2021 to 30 June 2022.

The MMG Operating Model, Safety, Security, Health and Environment (SSHE) and Social Performance Standards allow MMG Rosebery to deliver an internal SHEC management system which facilitates continuous improvement in the management of material environmental risks. MMG Rosebery is progressively implementing MMG risk management processes to regularly review its risk profile and confirm that the right actions are occurring to mitigate risk effectively.

The 2016-2021 Environment Management Plan Review report submitted on 30 November 2021 discussed the broad environmental implications of mine activities and outlined MMG Rosebery's strategy for 2021-2025. Recent Life of Asset (LoA) planning completed in 2022 did not vary this strategy and as such it remains current and appropriate.

This Annual Monitoring Review and Management Report (AMRMR) found the environmental commitments outlined in EPN7153/3 and 8815/2 have been met. Detailed reporting on these commitments can be found in the accompanying consultancy reports, by environmental aspect (e.g., water).

Environmental improvement activities in the reporting period saw the completion of the Murchison Highway stormwater and seepage separation works. Seepage is now being pumped back into the 2/5 Dam and stormwater to the Effluent Treatment Plant.

MMG Rosebery received 4 community grievances during the reporting period. All concerns/issues were promptly addressed and closed out to the satisfaction of the grievant.

The estimate for current remediation liabilities for MMG Rosebery is AUD$77.7 million based on the approved Mine Closure Plan submitted to the EPA and MRT in 2018. MMG Rosebery are in the process of conducting detailed closure prefeasibility studies for Rosebery and Hercules to inform an updated Mine Closure Plan. This work is expected to be completed in 2023 for Hercules and in 2024 for Rosebery.

In the reporting period, 797,972 tonnes of tailings were placed in final disposal location; all waste rock was returned as mine backfill. A total of 286.7 tonnes of non-mineral waste was disposed of at the onsite landfill.

MMG completed a review into water quality monitoring results for 2021/22, the full report is encompassed in the AMRMR. Of note, there were no exceedances of the Bobadil Outfall (BO) compliance limits during the reporting year. Biological monitoring surveys of the Stitt and Ring Rivers was also undertaken. The results for the Stitt River survey reflect ongoing improvement in the condition of the lower Stitt River. The Ring River results were consistent with previous years.

A review of MMG Rosebery's air quality monitoring results for 2021/22 was completed. No compliance limits were exceeded. No exceedances of the compliance limits indicate that the Rosebery Mine activities are a low environmental risk to air quality and that the current dust mitigation controls are appropriate.

A review of MMG Rosebery's noise and vibration monitoring results for 2021/22 reporting period was undertaken and found that annual average LAeq, LA90 and LA10 15-minute noise levels were similar to those measured in the previous year.

Exceedances of air blast overpressure limits set for blasting under EPN 7153/3 occurred on 1 occasion during scheduled blasting times, however, these are not breaches of the EPN conditions as blasting occurred at depths of approximately 1 km underground with levels likely controlled by gusty weather conditions and or precipitation.

The Bobadil TSF and the 2/5 Dam TSF were managed and monitored in accordance with the Australian National Committee on Large Dams (ANCOLD) Guidelines.

1 Purpose

This report was prepared in accordance with the annual reporting requirements outlined in Environmental Protection Notice (EPN) 7153/3 (issued 10 November 2011) and EPN 8815/2 (3 Level Waste Rock Dump (WRD); issued 13 February 2015). This AMRMR report covers the period 1 July 2021 to 30 June 2022.

Requirements of these EPN's are summarised in Table 1 below.

This report is made publicly available through MMG Rosebery's community liaison office in Rosebery upon request.

Table 1: Report coverage of EPN requirements

EPN	EPN REQUIREMENT		REPORT SECTION
7153/3	G7 1	... The AMRMR must be made publicly available....	1
	G7 2.1	An Executive Summary	Executive Summary
	G7 2.2	A review of environmental aspects and impacts register against environmental controls and documentation	2.1
	G7 2.3	A review of activity compliance and annual external compliance audit against EPN requirements	5.1
	G7 2.4	Environmental planning, including objectives and targets relating to the review period and details of the forward environmental planning and forecasting process, including strategic issues for the activity, for but not limited to the management period.	1.2 and 2.3
	G7 2.5	A review of environmental commitments and process changes (including annual tonnage) for, but not limited to, the management period.	3.1and 4.4
	G7 2.6	A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations, including discharge and ambient monitoring points that illustrate significant trends.	Appendix B:
	A4-3	Analysis of yearly climate.	Appendix D:
	A5-3	Tabulated high volume air sampler, and dust and metal deposition results for the entire year, showing intermediate values as well as final monitoring results. Tabulated annual averages of the deposition increment above background, supported by deposition isopleths or graphs <of monthly results>. Summaries of all exceedances..., describing the results of any investigations undertaken and the mitigation measures that were adopted in response. Any supporting data analysis or description necessary to aid interpretation of the dataset.	Appendix C:
	M4-3	If the concentrations in effluent <from Bobadil Tailings Dam end-of-pipe discharge> of parameters <listed in EPN> do not comply with the levels specified ....(Investigation Trigger Level) ...then an investigation... must be conducted and a report summarising the outcomes of all such investigations be submitted .... in MMG Rosebery's AMRMR.	4.3 of Appendix B:

	E5-1.2	Monitor the level of groundwater contamination (mass load of pollutants) due to seepages from the Bobadil, No.2 and No.5 and rehabilitated No.1 tailings storage facilities on the Stitt River and Lake Pieman.	Appendix B
	E3	Annual biological survey and ambient water quality monitoring programme of the Stitt River and Lake Pieman .... to document ongoing environmental conditions, increase the understanding of temporal, spatial and seasonal biological and chemical changes within the lake and progress the development of site-specific toxicity guidelines for sulphate and zinc in Lake Pieman.	Appendix B and Appendix F:Appendix G:
	N1-1.8	Results of the continuous noise monitoring program and noise related complaints must be reported in the AMRMR.	3.2 and 4.6 of Appendix E:
	G7 2.7	Environmental performance, including incident management and community complaints and the corrective and preventative processes implemented.	5.2 and 6.7
	WM1 2.4	...any environmental or stability issue identified and associated with <all tailings dams>...further outlined to the Director in the AMRMR.	6.8
	G7 2.8	Any approvals or written notifications received in relation to this notice.	5.1
	G7 2.9	A summary of any rehabilitation works carried out during the period and an estimate of current remediation liabilities.	5.3
	G7 2.10 / WM3-2	An inventory of wastes disposed of on The Land during the previous 12 months, including details of the quantities of each waste and the location of its disposal.	5.4
8815/2	G4-4	Annual review of the surface and ground water monitoring program in accordance with Appendix B of the Detailed Design Report, including an assessment of surface and groundwater impacts from the 3 Level WRD	6.2 and Appendix B:
	M3 1.2	Results of 3 Level WRD surface and groundwater monitoring program	Appendix B:

2 Endorsement

"I hereby certify that to the best of my knowledge, the information within this 2021/22 Annual Monitoring Review and Management Report is true and correct and addresses the reporting requirements of EPN 7153/3".

Name: Steve Scott

Position: General Manager MMG Rosebery Date: 30/09/2022

3 Operational History

3.1 Operational History

EPN 7153/3, G6 1.1.1 Site and operational history, particularly where it relates to the environmental performance of the activity

EPN 7153/3, G7 2.5 A review of environmental commitments and process changes (including annual tonnage) for, but not limited to, the management period.

MMG Limited (MMG) acquired Rosebery in June 2009. MMG Rosebery is Australia's largest volcanic hosted metals (zinc, lead, copper, gold and silver) mine and its concentrator has been in continuous operation since 1936. As such, environmental performance at Rosebery is influenced by historical mining practices that preceded MMG's management of the operation.

The consolidated mining lease is 4,913 hectares, which includes the Rosebery mine, the decommissioned Hercules mine and more than 178 legacy abandoned mining tenements and features. The Rosebery mining operations are located within Mining Lease No. 28M/1993, approximately 300 kilometres north-west of Hobart and 125 kilometres south of Burnie.

Zinc, lead and copper concentrates and gold doré are produced at Rosebery using mechanised underground mining methods and crushing, grinding and flotation processes. Rosebery concentrates are transported by rail to the Port of Burnie where they are shipped in bulk carriers to smelters in Hobart and Port Pirie. Gold doré bars are sold to a refinery in Australia where they are refined into gold bullion.

MMG Rosebery production data is provided in Table 2. Waste rock and tailing tonnages are provided in section 5.4.1.

Table 2 Rosebery production

	Unit	2020-21	2021-22
Ore Mined*	dry tonnes	1,038,213	924,190
Ore Milled**	dry tonnes	1,021,415	940,177
Gold doré**	oz	24,595	22,285
Copper concentrate**	dry tonnes	9,738	7,003
Lead concentrate**	dry tonnes	42,927	32,988
Zinc concentrate**	dry tonnes	132,524	102,213

*Data sourced from the MMG Reconciled EOM reports – for period 1 July to 30 June.
** Data sourced from MMG Quarterly Production Reports – for periods 1 July to 30 June.

Process changes and improvement projects that have influenced Rosebery's production and environment performance in 2012-2022 are detailed in Table 3.

Table 3 Operational history and major environmental improvement projects (2012-2022)

Activity	Milestone	Details
Underground Mine	2012	Change in stability methods from mesh and bolts to fibrecrete and resin bolts, to improve ground support. Concrete batch plant used in fibrecrete approved by West Coast Council (PID 6021427).
	2014	Installation of concrete batching plant (PID 6021427) and noise attenuation wall.
	Q1 2015	Surface vent (PSF1) fan upgrade to meet increased ventilation flow demand as mine extended (Approval DA14195).

	Q3 2015	Installation of a new 120,000L capacity, self-bunded fuel bay and decommissioning of the existing fuel bay site.
Processing Plant	Q3 2014	Commissioning of refurbished MG3 Ball Mill (Approval H287020) to support increased throughput in grinding circuit and reduced grind size. No significant change in noise profile.
	Q3 2014	Installation and commissioning of a second Knelson concentrator to improve gold recovery to doré (Approval H316091).
	Q3 2015	Installation of a tertiary crushing circuit to increase throughput and enable a finer grind size, which improves recovery of all commodities and is beneficial for tailings transport.
	Jun-2021	Filter plant storm water drainage system works completed
Tailings Storage	2012	Completed Stage 7 works at Bobadil TSF, which lifted the TSF to RL 195m.
	2012	Bobadil polishing pond stability analysis to improve understanding of embankment seepage.
	2013	Completed Stage 8 embankment lift at Bobadil TSF to RL 197m (EPN 8781/1).
	2014	Completion of Bobadil polishing pond redevelopment to improve water treatment (EPN 8814/1).
	Q2 2015	Completed Stage 9A embankment lift at Bobadil TSF (EPN 9139/1).
	2016	Completed Stage 9B embankment lift at Bobadil TSF to provide storage capacity to allow continued production until 2017. Works include raising the northern portion of the facility to a crest of RL 199m using the upstream construction method and the construction of a new spillway that has been designed for closure.
	Feb-16	Construction of the 2/5 Dam TSF site to replace Bobadil has commenced. Refer to section 3.1.1 for summary of current status.
	Apr-18	Tailings deposition commenced at the 2/5 TSF.
	Dec-19	Bobadil Polishing Ponds De-sludging works. Work commenced in Q1 2020 with a floating pontoon pumping sludge within Geo-tubes.
	2020	Murchison Highway mitigation works to reduce seepage water entering the Stitt River
	Oct-2021	Bobadil TSF 10A Embankment raise completed and deposition commences.
	2021	2/5 Dam TSF Subaerial deposition infrastructure works
	Apr-2022	Bobadil TSF 10B Embankment raise completed incorporating a 9-hectare trial closure cover.
	Oct-2021	2/5 Dam TSF Stage 2 lift construction commenced
	Jun-2022	Murchison Highway stormwater and seepage separation completed
Waste rock management	2015	Commenced construction of Waste Rock Dump at the 3 Level Open Cut Area (3 Level WRD) in accordance with EPN 8815/2. Stage 1 Establishment phase has been completed and construction of Stages 1a and 1b was completed in September 2015.
Water Management	Mar-12	Site water balance developed and used on an ongoing basis to refine water management controls.
	Oct-12	Upgrade to site sewerage system.

	2012	Works on 1 Dam Surface drainage, stormwater management for 2 Dam, and hydrological studies on 1/2/5 Dam as part of site water balance model development.
	Sep-14	Construction of 3 Level diversion drain to divert up-gradient uncontaminated water to Rosebery Creek.
Closure	2012-2013	Decommissioning and removal of redundant infrastructure (old administration building, Heritage Centre, old tank on Filter Plant Road, Assay Laboratory, three sandfill and cement silos).
	2018-19	Minor Legacy workings closure project commenced
	2019	Rosebery & Hercules Closure PFS project commenced

3.2 CURRENT ENVIRONMENTAL IMPROVEMENT PROJECTS

A summary of the status of environmental improvement projects which were proposed for commencement or continuation in 2018/19, 2019/20 is provided in Table 4. Refer to section 5.3 for details on research studies undertaken to fill knowledge gaps and inform closure planning.

Table 4 Environmental improvement projects – status as at 30 June 2022

	PROJECT DETAILS	STATUS	STATUS DETAILS
1	Separation of seepage from stormwater drainage adjacent Murchison Highway	Completed	Works completed in Jun-2022

4 PLANNING

4.1 RISK ASSESSMENT

EPN 7153/3, G7 2.2 A review of environmental aspects and impacts register against environmental controls and documentation.

The annual risk profile review for Rosebery's Material risks was performed in Q1 2022. During this review a new material risk relating to the unplanned disturbance of heritage features was identified and new control measures are being put in place. Risk analysis of material risks and design of critical controls continues as part of MMG's risk management processes.

Comprehensive dam safety reviews were undertaken in September 2021 for the 2/5 Dam and Bobadil TSF.

MMG Rosebery conducted its annual review of the Environmental risk register against environmental controls and documentation in Q3 2021. Of note, MMG Rosebery is currently carrying out site specific TSF fugitive dust modelling and also investigating the feasibility of further TSF dust mitigation technologies.

4.2 ENVIRONMENTAL PLANNING

EPN 7153/3, G7 2.4 Environmental planning, including objectives and targets relating to the review period and details of the forward environmental planning and forecasting process, including strategic issues for the activity, for but not limited to the management period.

A core component of MMG's growth strategy is to identify opportunities to maximise the potential of our existing assets. MMG has a co-ordinated approach to life-of-asset (LoA) Planning which is supported by MMG Group office in Melbourne. LoA is integrated with closure planning and guides long-term business planning.

Annual LoA scenario planning enables flexible investment decisions and typically results in two business scenarios (production and productivity cases). The LoA process provides consistent direction on long-term operational strategy and guides the annual (short term) and rolling three-year (medium term) budget plans. The LoA Plan also provides a primary basis for internal, whole of life business valuation (net present value). A key constraint on the current LoA Plan is the securing of additional tailings storage capacity beyond 2024. During the reporting period MMG continued studies on extensions to the 2/5 Dam and Bobadil TSF's and at two new surface facility locations (South Marionoak and Natone Creek). Studies were also continued into the viability of underground paste-fill and other emerging tailings storage technologies, such as filtered tailings.

Given the challenges with tailings storage capacity beyond 2024 MMG's key forward environmental planning projects will include both tailings storage and closure prefeasibility studies.

4.3 OBJECTIVES AND TARGETS

EPN 7153/3, G7 2.4 Environmental planning, including objectives and targets relating to the review period and details of the forward environmental planning and forecasting process, including strategic issues for the activity, for but not limited to the management period

In support of MMG's commitment to minimise its environmental footprint and efficient use of natural resources, MMG's Executive Committee has made a commitment to align with the ICMM Mining Principles Performance Expectations. These provide a comprehensive set of environmental and social requirements, including issues such as mine closure, pollution and waste.

MMG was one of the member companies involved in the development and review process for the Performance Expectations and commenced implementation of the ICMM Performance Expectations in 2020 incorporating robust site-level validation.

At a site level MMG Rosebery creates annual business plans that are supported by department business plans. The Rosebery Environment, Community and Closure business plan outlines its 2022 environmental goals and targets as outlined in Table 5.

Table 5 Environmental targets

GOAL	TARGET	STATUS AS AT 1 JULY 2022
Improvement in environmental performance	1)Zero actual significant environmental events (rated 5 or above) 2)Zero actual environmental legal compliances (rated 4 or above) 3)>80% compliance against environmental monitoring plan	1)No significant events (> Level 4) within reporting period 2)No significant events (> Level 5) within reporting period 3)Monitoring plan implemented to >80% compliance to plan
Compliance with environmental permits & licenses.	100% close-out of any environmental compliance gaps as identified in the annual independent environmental compliance audit.	All corrective actions identified in December 2021 external audit have been closed out
Development and implementation of a climate resilience management plan	1) Gap analysis & risk workshop 2)Develop Site Climate Resilience Management Plan 3)Develop Site Greenhouse Gas Reduction Plan 4)Progress towards net zero scope 1 & 2 emissions by 2050	1)Gap analysis & risk rating workshop completed September 2022 2)Development of Site Climate Resilience Management Plan underway 3)Development of Site Greenhouse Gas Reduction Plan underway 4)not started
Progress towards performance at optimal level of compliance against ICMM Water commitment requirements	1)Gap analysis and develop an implementation plan to meet ICMM water reporting requirements 2)Commence reporting on % compliance to implementation plan	1)ATCW hydrologist engaged to refine site water balance. New flow meters installed at 2/5 Dam. New flow meters budgeted for Bobadil. 2)not started
Reduction in overall amount of land disturbance	Development of a progressive rehabilitation workplan and commence on ground works	Progressive rehabilitation completed at 2/5 Dam Stage 2 quarry during construction of Stage 2 lift Bobadil cover trial installed to inform TSF closure cover design
Integration of mine closure into life-of-asset planning	1)Hercules Closure PFS project completed 2)Progress towards completion of Rosebery Closure PFS 3)Completion of closure cost estimate audit (Deloitte) 4)Update the 5-year closure planning works schedule	1)Hercules Closure PFS project 80% complete 2)Rosebery Closure PFS 30% complete 3)not started 4)Completed and budgeted
Improvement in social performance	1)Response to any grievance within 7 days of receipt 2)75% of grievances closed out within 60 days	1)100% compliant 2)100% compliant 3)compliant 4)not yet reported

	3)15% improvement on previous quarter in average resolution time 4)Increase in community enquiries over 2022	
Develop a revised Rosebery social strategy to support the planned growth strategy	1)Rosebery Stakeholder & Community Engagement Plan (SCEP) 2)Rosebery Social Strategy	1)2nd draft under review 2) not started
GISTM compliance for TSF	1)Site gap analysis completed 2)Action plan to fulfil compliance	1)Gap analysis completed 2)Action plan underway

4.4 ENVIRONMENTAL COMMITMENTS REVIEW

EPN 7153/3, G7 2.5 A review of environmental commitments and process changes (including annual tonnage) for, but not limited to, the management period

Key environmental commitments and their current status are outlined in Table 6. Refer to Table 2 for annual tonnages.

Table 6: Environmental commitments – status as at 30 June 2022

COMMITMENT	DETAILS	CURRENT STATUS
Extend seepage collection drainage at 2/5 Dam to capture seepage from the eastern embankment	Following a release of tailings from the eastern embankment in February 2022 MMG committed to extending the seepage collection drain to the eastern embankment.	ATC Williams have commenced design work to determine whether the drainage can be gravity fed or will need to be pumped. An update will be provided in the next reporting period.
Review use of the flume for transporting tailings to Bobadil TSF	Following a tailings flume overtopping event in February 2022 MMG committed to reviewing the use of the flume	A risk assessment has been completed in consultation with an engineering consultant and options are being investigated along with expansion to Bobadil TSF. An update will be provided in the next reporting period.
Construction of the 3 Level WRD in accordance with EPN 8815/2 and submission of periodic construction audit reports.	Within 30 days of audit date	Stage 2 lift 1 of the 3 Level WRD is under construction. No waste rock is currently being disposed of on the surface. Two construction audits were conducted over the reporting period with audit reports provided to the EPA.
Installation of suitable dust suppression system to control ground level dust (Dust Mitigation Plan, submitted June 2015).	December 2020 (Approval date)	A review of the Dust Mitigation plan was completed as part of the 2/5 Dam TSF subaerial conversion submission and subsequently approved in December 2020. The review identified the current dust suppression systems onsite are sufficient to control ground level dust.

		Extra sprinklers and back up mitigation measures are being installed prior to 2021/22 summer.
Submission of a Closure Plan for 3 Level WRD.	31 October 2018 (Submission date)	Submitted by the due date, awaiting EPA response.

5 IMPLEMENTATION AND OPERATION

5.1 APPROVALS AND NOTIFICATION

EPN 7153/3, G7 2.8 Any approvals or written notification received in relation to this notice.

An update to the progress of Environmental Approvals within the reporting period are highlighted in Table 7.

Table 7: Environmental Approval update for the reporting period

ACTIVITY	REFERENCE	APPROVAL DATE	DETAILS
South Marionoak TSF	-	EIS in preparation	Notice of Intent (NOI) and EPBC referral submitted for the proposal. EIS guidelines issued in August 2021.
2/5 Dam TSF Stage 2 subaerial operation & closure	-	EIS in preparation	Notice of Intent (NOI) submitted, and EIS guidelines issued in August 2021.
2/5 Dam TSF Stage 2 BAMP and amended WQMP	PCE 9084 EPN 10620/1	July 2021	2/5 Dam Stage 2 construction works required an amended Borrow Area Management Plan (BAMP) to be submitted prior to works commencing. The amended BAMP was approved in July 2021. A review of the water quality monitoring plan was also amended and subsequently approved by EPA.

EPN 7153/3, G7 2.7 Environmental performance, including incident management and community complaints and the corrective and preventative processes implemented.

EPN 7153/3, N1 – 1.8 Noise related complaints must be reported in the Annual Monitoring Review and Management Report

For the period July 2021-June 2022, four (4) community grievances related to environmental harm & nuisance were recorded. Refer to Table 8. All grievances raised were promptly addressed by MMG Rosebery.

Table 8: Community grievances for the 2021-22 reporting year

Category	Date	Details
Noise	31/03/2022	Noise from generator left on at night
Environment	22/03/2022	Leaking water pipe near Hollywood St
Noise	28/12/2021	Noise from rock breaker on level 4
Land use and access	22/07/2021	Unauthorized placement of blast monitor on private property

- All community feedback that are frivolous, vexatious, or not valid are not included in the above table

5.2 REHABILITATION AND CLOSURE

EPN 7153/3 G7 2.9 A summary of any rehabilitation works carried out during the period and an estimate of current remediation liabilities.

5.2.1 Closure liability

The estimate of current remediation liabilities for MMG Rosebery is AUD$77.7 million, based on the Closure Management Plan submitted to EPA and MRT in May 2018. Following completion of the Closure PFS project the Mine Closure Plan will be updated. The closure liability will be revised within the updated Mine Closure Plan that will be submitted to the EPA in compliance with condition DC3 of EPN 7153/3.

5.2.2 Hercules

Hercules comprises legacy workings located on the southwest portion of the Rosebery lease. The area is managed and monitored in accordance with the approved Care and Maintenance Plan and MMG continues to undertake a work program to refine the understanding of the site and develop long term, sustainable closure designs. Over the past 12 months MMG has completed the following key technical studies within the Hercules closure prefeasibility project:

- Baseline water data collection system (quantity and quality);
- Contaminant source model;
- Hydrogeological model;
- Waste rock geochemical risk assessment.
- Waste material balance;
- Relinquishment pathway model study;
- Land use planning study;
- Structural Assessment (Hercules Mine Dam); and
- Heritage assessment.

The forward workplan involves completion of options assessments, peer review and consultation with stakeholder. This is expected to be completed within the next reporting period.

5.2.3 Bobadil Tailings Storage Facility (TSF)

Bobadil Stage 10B embankment raise was completed in Q2 2022. A field scale closure cover trial was installed and data collection has begun. The trial will monitor performance of two cover variants that aim to reduce rainfall infiltration and oxygen ingress to the underlying tailings. The monitoring results will be assessed over a number of years to validate and inform the final TSF closure cover design.

5.3 WASTE DISPOSAL

EPN 7153/3 G7 2.10 An inventory of waste disposed of on The Land during the previous 12 months, including details of the quantities of each waste and the location of its disposal.

5.3.1 Waste rock and tailings

The mineral waste mined to develop declines and access the ore body is primarily used to backfill underground mine stopes and voids. All waste rock that cannot be stored underground is sent to the surface and placed in the 3 Level waste rock dump. MMG Rosebery is currently at a waste rock deficit, as such waste rock has not been carted to surface since February 2017.

Since April 2018 tailings have primarily been deposited at the 2/5 Dam TSF. Since the completion of the Bobadil Stage 10A & 10B embankment raises, tailings are now deposited at Bobadil intermittently depending on operational strategies. Waste rock and tailings production is summarised in Table 9.

Table 9: Waste rock and tailing production (tonnes)

	JULY 2020-JUNE 2021	JULY 2021-JUNE 2022	% CHANGE
Waste rock mined	403,055	330,135	-18%
Waste rock to underground	403,055	330,135	-18%
Waste rock to 3 Level WRD	0	0	-
Dry tailings	836,224	797,973	-4.6%

5.3.2 Onsite landfill

In accordance with EPN 7153/3, Condition WM3, the Bobadil Landfill is used for the disposal of lead contaminated inert materials including used filter cloths (usually buried underground), poly pipe and other plastics, timber, rubber (but not tyres) and non-recyclable metal.

The amount of waste disposed at the authorised onsite contaminated site landfill was 286.7 tonnes in 2021/2022 (as determined by load cells fitted to the bin collection vehicle and tracked by the authorised waste management contractors, by way of a docket book). This was a decrease of 5.2% from the previous reporting year.

6 CHECKING AND CORRECTIVE ACTION

6.1 METEOROLOGICAL MONITORING

EPN 7153/3, A4-3 Analysis of yearly climate.

The meteorological monitoring results for the reporting period are summarised in Appendix D (EY, 2022).

6.2 WATER MONITORING – 3 LEVEL WASTE ROCK DUMP (EPN 8815/2)

EPN 8815/2, G4-4 Annual review of the surface and ground water monitoring program in accordance with Appendix B of the Detailed Design Report, including an assessment of surface and groundwater impacts from the 3 Level WRD.

EPN 8815/2, M3 1.2 Results of 3 Level WRD surface and groundwater monitoring program.

MMG undertook a review of the surface and ground water monitoring data for 3 Level WRD for the period July 2021-June 2022 (Refer Appendix B (Koehnken 2022) – Section 13).

During the 2021 – 2022 monitoring year, no additional waste rock was added to the 3 Level waste rock dump. All monitoring was completed as required, in accordance with the monitoring program in Appendix B of the Detailed Design Report.

All surface runoff from the 3 Level WRD continues to be collected and directed to the ETP for treatment. The report indicated surface water impacts beyond the immediate area of the WRD are minimal as all surface runoff from the 3 Level WRD is collected at the 4 Level settlement pond and directed to the ETP for treatment and discharge via the Bobadil TSF.

As previously stated, MMG is conducting a comprehensive closure prefeasibility study for the site which includes an assessment of the performance of the 3 Level WRD.

6.3 WATER MONITORING – ROSEBERY (EPN 7153/3)

EPN 7153/3, G7 2.6 A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations, including discharge and ambient monitoring points that illustrate significant trends.

EPN 7153/3, M4-3 If the concentrations in effluent [from Bobadil Tailings Dam end-of-pipe discharge] of parameters [listed in EPN] do not comply with the levels specified…….(95th Percentile Investigation Trigger Level)… then an investigation … must be conducted and a report summarising the outcomes of all such investigations be submitted … in MMG Rosebery's Annual Monitoring Review and Management Report.

EPN 7153/3, E3 Annual … ambient water quality monitoring programme… to document ongoing environmental conditions, increase the understanding of temporal, spatial and seasonal … chemical changes within the lake and progress the development of site-specific toxicity guidelines for sulphate and zinc in Lake Pieman.

Water quality monitoring results for the reporting period have been submitted to EPA Tasmania on a quarterly basis and include all water monitoring data required under EPN 7153/3. A review of the water quality monitoring data for the period July 2021-June 2022 found water quality monitoring was conducted in accordance with permit conditions.

Water chemistry results recorded at the authorised discharge point, Bobadil Outfall (BO), was 100% complaint with EPN discharge criteria for metal and other parameters.

Compliance with EPN discharge limits

- Rainfall during the 2021 - 2022 monitoring year was above average in the first half of the year, and below average during the summer months resulting in the annual total rainfall at Bobadil, 2220 mm, being close to the long-term average of 2,224 mm (1911 – 2018 at Renison Bell, Tasmania, Figure 2 2).
- The strong seasonality of rainfall was reflected in discharge from Bobadil, with the average daily flow ranging from 0.06 to 0.71 m3/s, with a median 0.21 m3/s. Low discharge during the dry summer was also attributable to the use of water at the 2/5 Dam TSF for dust suppression trials.
- The low flow through Bobadil in the summer affected pH, EC, and sulphate concentrations as described below.
- Similar to previous years, laboratory pH values are lower than in-situ measurements suggesting that the pH declined in the samples following collection. This decline does not affect metal concentrations as the metals have already been removed and captured in the TSF.
- The pH levels remained well above discharge limits in the TSF, resulting in low metal concentrations in the discharge, with no exceedances of the EPN limits for metals, WAD CN, or nutrients.
- One false exceedance due to elevated Total Petroleum Hydrocarbon was recorded on 1 February 2022 at BO. Re-analysis following silica gel (SG) clean-up of the sample returned a TPH value below the laboratory LoR. This type of interference occurs episodically at BO and systems are in place to re-analyse any sample that initially exceeds the EPN limit. As the SG treated sample result was below the EPN limit the false exceedance was not reported to the EPA.

The 95th percentile values of the samples collected between 1 July 2021 to 30 June 2022 were below the 95th percentile investigative triggers for all parameters except EC and sulphate

- The 95th percentile EC value was 1,852 uS/cm, with 4 values exceeding the investigative limit of 1,700 uS/cm and a maximum value of 1,952 uS/cm.
- The 95th percentile sulphate concentration of 1,015 mg/L exceeded the 95th percentile trigger due to 4 values exceeding 1,000 mg/L, with the highest recorded concentration of 1070 mg/L. All values >1,000 mg/L occurred in January 2022.
- MMG completed an investigation into the elevated EC and sulphate values and concluded that reduced flow through the Bobadil TSF was the underlying cause. The report was provided to the EPA. Elevated EC and sulphate during the summer months has been a common occurrence at the TSF and does not reflect a change in operations.

6.4 BIOLOGICAL MONITORING

6.4.1 Lake Pieman

EPN 7153/3, G7 2.6 A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations, including discharge and ambient monitoring points that illustrate significant trends.
EPN 7153/3, E3 An annual biological survey and ambient water quality monitoring program of the Stitt River and Lake Pieman must be undertaken in accordance with columns 1 to 4 of Table 6 of Attachment 2 and columns 1 to 6 of Table 7 of Attachment 2 to document on-going environmental conditions, increase the understanding of temporal, spatial and seasonal biological and chemical changes within the lake, and progress the development of site specific toxicity guidelines for sulphate and zinc in Lake Pieman.

An annual Lake Pieman biological monitoring program is conducted by Freshwater Biomonitoring. The program assesses the ecological status of the area in Lake Pieman influenced by the discharge from the Bobadil system. The monitoring program was undertaken from 31 January to 1 February 2022 with key findings summarised in Table 10 and detailed in Appendix F (Freshwater Biomonitoring 2022).

Table 10: Biological monitoring of Lake Pieman – key findings

NATURE OF CHANGE	FINDINGS OF MONITORING PROGRAM
Status of environmental conditions	Sampling in 2022 was shifted to summer (Jan – Feb) in an attempt to minimise the effects of fluctuating lake level, with levels in Lake Piemen generally less variable in the summer months. Sampling was timed to follow a two-week period of relative stability in lake levels Over the two weeks prior to the first day of sampling (31 January) lake levels had been relatively stable but dropped 80 cm on the second day of sampling on 1 February. Despite the drop in lake levels, visual inspection of the shoreline during sampling suggested a good level of accumulated detritus within the sampling zone on both days capable of supporting a robust shoreline biota. This is borne out by the increased diversity and abundance of macroinvertebrates and increased algae growth in summer 2022 compared to previous sampling events situated in the spring months.
Status of understanding of temporal, spatial and seasonal biological changes	**Algae:** Chlorophyll-a levels were generally low in Lake Pieman in summer 2022. Within the context of generally low chlorophyll-a levels, there was wide variation in chlorophyll-a levels between sites both upstream and downstream of the Bobadil outfall. Overall, in summer 2022 there was no apparent benthic algal response to the inflow of the Bobadil discharge. **Macroinvertebrates:** The macroinvertebrate fauna collected from the Lake Pieman shoreline in summer 2022 was characterized by generally low diversity and abundance, although both diversity and abundance were higher in summer 2022 compared to previous sampling events conducted in the spring months.

6.4.2 Ring and Stitt Rivers

EPN 7153/3, G7 2.6 A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations, including discharge and ambient monitoring points that illustrate significant trends.

EPN 7153/3, E3 Annual biological survey … to document ongoing environmental conditions, increase the understanding of temporal, spatial and seasonal biological …changes.

Routine six-monthly biological monitoring of the Ring and Stitt rivers was undertaken by Freshwater Biomonitoring during the reporting period (Appendix G: Freshwater Biomonitoring Spring 2021- Autumn 2022). The findings are summarised in Table 11 and Table 12. Monitoring locations are shown in Figure 1 and Figure 2.

Table 11: Biological monitoring of Ring River – key findings

NATURE OF CHANGE	FINDINGS OF MONITORING PROGRAM
Status of environmental conditions	The Ring River remains in a degraded condition. In both spring 2021 and autumn 2022, diversity declined moving downstream with a concomitant decline in the O/E scores moving downstream from the Williamsford site.
Status of understanding of temporal, spatial and seasonal biological changes	The TRCI macroinvertebrate assessment rated all Ring River sites in Poor or Extremely Poor condition due to low abundance and the absence to a number of expected families. The primary reasons for poor condition of river fauna communities in the Ring continue to be pollution from the Hercules mine area via Bakers Creek.

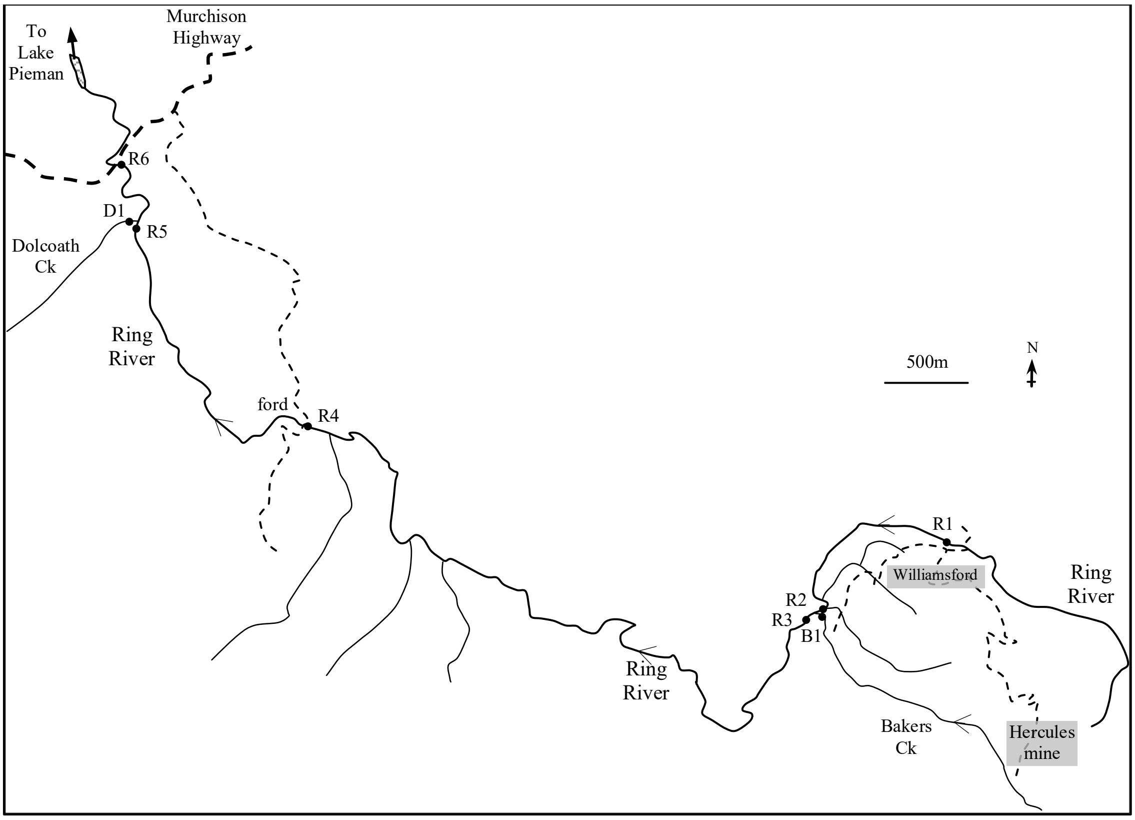


Figure 1: Ring River biological monitoring locations.

Table 12: Biological monitoring of Stitt River – key findings

NATURE OF CHANGE	FINDINGS OF MONITORING PROGRAM
Status of environmental conditions	Overall, the Stitt River is in a substantially better ecological condition than the Ring River. There appears to have been some improvement in the condition of the lower Stitt River over recent years, with a range of clean-water macroinvertebrate taxa now present at all sites in the Stitt River including in the lower reaches.
Status of understanding of temporal, spatial and seasonal biological changes	The results from spring 2021 and autumn 2022 were generally consistent with this trend, with a range of clean-water macroinvertebrate taxa present at all sites in the Stitt River including in the lower reaches. However, there continues to be a decline in diversity and O/E ratio between the upper and lower reaches of the Stitt River, likely due to ongoing seepage of mine contaminants into the lower Stitt from a range of sources. Adult and juvenile brown trout have been regularly recorded in the lower reaches of the Stitt River since autumn 2020, although the numbers of trout remain consistently lower compared to the upper reaches of the river. Nevertheless, the consistent capture of adult and juvenile trout at all sites in the Stitt River indicates that a self-sustaining population of trout now occurs throughout the Stitt River including in the lower reaches.

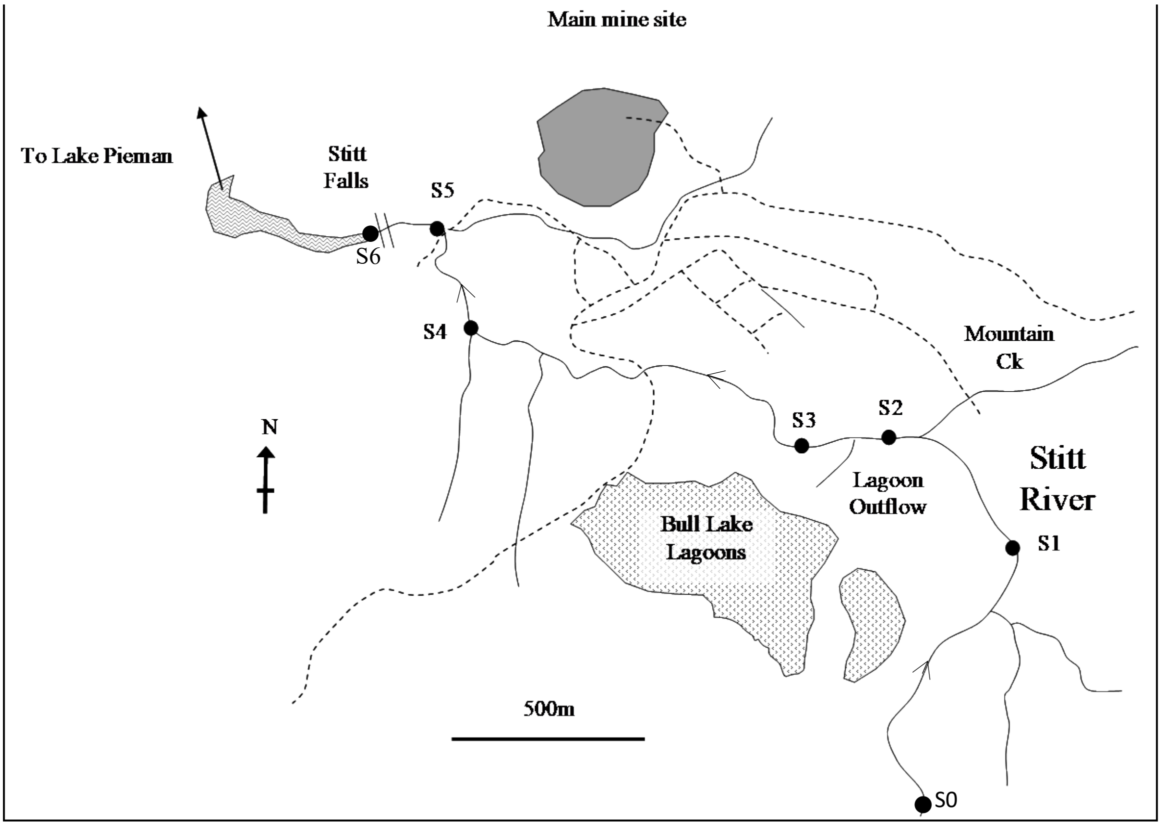


Figure 2: Map of study sites in the Stitt River catchment

6.5 DUST MONITORING

EPN 7153/3, G7 2.6 A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring location, including discharge and ambient monitoring points that illustrate significant trends. Include a review of the accuracy of the sampling procedure, sampling schedule, sample locations and test methods applied.

EPN 7153/3, A5-3 Tabulated high-volume air sampler, and dust and metal deposition results for the entire year, showing intermediate values as well as final monitoring results. Tabulated annual averages of the deposition increment above background, supported by deposition isopleths or graphs <of monthly results>. Summaries of all exceedances…, describing the results of any investigations undertaken and the mitigation measures that were adopted in response. Any supporting data analysis or description necessary to aid interpretation of the dataset.

MMG Rosebery undertook an analysis of the dust deposition and ambient air monitoring programs for the period July 2021-June 2022. The key findings and detailed monitoring results are presented as Appendix C (EY, 2022).

The report found that there were no exceedances of the compliance or trigger limits for all monitoring locations. These results indicate that mine operations present a low environmental risk to air quality and that the current dust mitigation controls are appropriate.

Based on this review, it is recommended that the air quality monitoring network be reviewed and consolidated. Considering the low environmental risk to air quality and the high annual rainfall, a small, targeted network could provide more meaningful information.

As per EPN 7153/3 condition A3-4: Measurements at the 'additional sites' (BG3, AD11, AD21, AD22, AD23 and AD25) are to continue until such time as an annual pattern can be established and a full 12-month dataset is compiled. This data is to be analysed in a report presented to the Director, containing recommendations and a request for approval to remove specific 'additional sites' from the monitoring network. Monthly monitoring must continue at all of the 'additional sites' until the Director provides approval to remove the individual sites.

These additional sites have been collecting data for over 10 years which is sufficient to establish an annual pattern. As per conditions A3-4, an analysis of these sites is recommended to be able to remove these additional sites from the monitoring network. This will allow for consolidation of the monitoring network.

In the next reporting period, MMG intends to submit a formal request to amend the dust monitoring conditions, as recommended by MMG's consultant.

6.6 NOISE AND VIBRATION MONITORING

EPN 7153/3, G7 2.6 A review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations…that illustrate significant trends.

EPN 7153/3, N1 -1.8 Results of the continuous noise monitoring program and noise related complaints must be reported…

A review of the noise and vibration data for the reporting period was undertaken and found that annual average LAeq, LA90 and LA10 15-minute noise levels were similar to those measured in the previous year.

Exceedances of air blast overpressure limits set for blasting under EPN 7153/3 occurred on 1 occasion during scheduled blasting times, however, these are not breaches of the EPN conditions as blasting occurred at depths of approximately 1 km underground with levels likely controlled by gusty weather conditions and or precipitation.

Full reporting and data summaries are presented as Appendix E (Tarkarri 2022) and further details on noise related complaints can be found in section 5.2.

6.7 ENVIRONMENTAL EVENT MANAGEMENT

EPN 7153/3, G7 2.7 Environmental performance, including incident management … and the corrective and preventative processes implemented.

During the reporting period, MMG Rosebery recorded nine (9) environmental events other than those concerning compliance with EPN limits (which have been assessed separately and reported in Section 6 and referenced Appendices). All events were entered within MMG's Incident Event Management (IEM) system and preventative actions were developed and implemented to reduce the likelihood of reoccurrence.

Table 13: Environmental Incidents

Event Date	Event Description	Event Status
27.07.2021	2590364 : Residual flocculant exceedance at Bobadil Outfall – High reading during a rainfall event. Investigation was completed and corrective action put in place.	Closed
21.09.2021	2644093 : Residual flocculant exceedance at Bobadil Outfall – Investigations found that this was a false positive due to a biofilm rich in polysaccharides acting as a natural flocculant.	Closed
03.10.2021	2643066 : Retention pond overflow - Discharge of water from the Sump between cell 1 and 2 retention ponds at the filter plant. A small amount (less than 5m3) of water was discharged into the environment over a 20-minute period. Upgrades to the Filter Plant water management were subsequently completed.	Closed
19.10.2021	2658129 : Residual flocculant exceedance at Bobadil Outfall – Investigations found that this was a false positive due to a biofilm rich in polysaccharides acting as a natural flocculant.	Closed

06.11.2021	2670921 : Raw water line discharge - Raw waterline has come apart at fitting causing water to discharge over the road below the BP service station. Pipeline was subsequently repaired.	Closed
12.11.2021	2675040 : Diesel spilt on 4 level batch plant access road – Investigation found that fuel cap had come loose on delivery truck. The spill was cleaned up.	Closed
21.12.2021	2708055 : EC 95th % trigger level exceedance at Bobadil Outfall – Investigation found that reduced flows through the Bobadil TSF due to dry weather contributed to the event.	Closed
24.01.2022	2724891 : Sulphate 95th percentile trigger level exceedance at Bobadil - Investigation found that reduced flows through the Bobadil TSF due to dry weather contributed to the event.	Closed
10.02.2022	2728848 : Overtopping of Bobadil Tailings Flume – Slurry material blocked the flume which resulted in tailings and waste water overtopping into the receiving environment. MMG initiated a clean-up and intensive water quality monitoring program. A comprehensive reported was sent to EPA on 10/02/2022.	Review of the use of the flume is underway

6.8 TAILINGS DAM MANAGEMENT

EPN 7153/3, WM1 2.4 (all tailings' dams must) have any environmental or stability issue identified and associated with it reported to the Director within 24 hours of becoming aware of the issue and further outlined to the Director in the Annual Monitoring Review and Management Report.

The Bobadil and 2/5 Dam TSF's undergo monthly on-site surveillance by ATC Williams, under supervision by the Engineer of Record. Dam safety reviews were also undertaken in September 2021 on the 2/5 Dam and Bobadil TSF, as part of the biennial surveillance program for the facilities under the Australian National Committee on Large Dams (ANCOLD) guidelines. Independent technical review of the Bobadil and 2/5 TSF's was also undertaken in October 2021 by Golders.

During the reporting period there were no stability issues noted with any of MMG tailings and water dams.

7 REVIEW

7.1 EPN COMPLIANCE

EPN 7153/3, G7 2.3 A review of activity compliance and annual external compliance audit against EPN requirements.

An independent on site and remote, external audit against EPN requirements was carried out on the 12th, 13th, 26th, 27th and 28th of September. This audit report will be submitted once finalized.

8 ACRONYMS

ACRONYM	DEFINITION
AMRMR	Annual Monitoring Review and Management Report
DPIPWE	Department of Primary Industries, Water and Environment
EPA	Environment Protection Authority
EPN	Environmental Protection Notice
ETP	Effluent Treatment Plant
HVAS	High Volume Air Sampling
HAIR	Hercules Assessment Index for Rehabilitation
MRT	Mineral Resources Tasmania
PM_{10}	Fraction of total particles suspended in the air, having diameters less than 10µm
PFS	Pre-Feasibility Study
QA/QC	Quality assurance / quality control
SHEC	Safety, Health, Environment and Community
TSF	Tailings Storage Facility
TSP	Total suspended particles – the term given to the fraction of total particles suspended in the air having diameters generally less than 50µm
WRD	Waste rock dump

9 REFERENCES

Freshwater Biomonitoring (2022), Biological Condition of the Ring and Stitt Rivers: Spring 2021 and Autumn 2022

ERM (2022), MMG Air Quality Monitoring Data – Annual Report Dust Deposition and Ambient Air Quality Review September 2022

ERM (2022), MMG Annual Meteorological Review August 2022

Koehnken (2022), MMG Rosebery Water Quality Monitoring Review 2021-2022

Tarkarri (2022), Technical Memo: Rosebery mine environmental noise, ground vibration and air blast overpressure annual monitoring review 2021/2022.

APPENDIX A: LOCATION MAPS

1:7,500 (at A3)

0 200 400

metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N
W E
S

LEGEND

- Groundwater Monitoring Point
- Surface Water Monitoring Point
- Underground Workings
- Regional Road
- Regional Waterway

MMG

Annual Monitoring Review

Date | 26 SEPT 2014

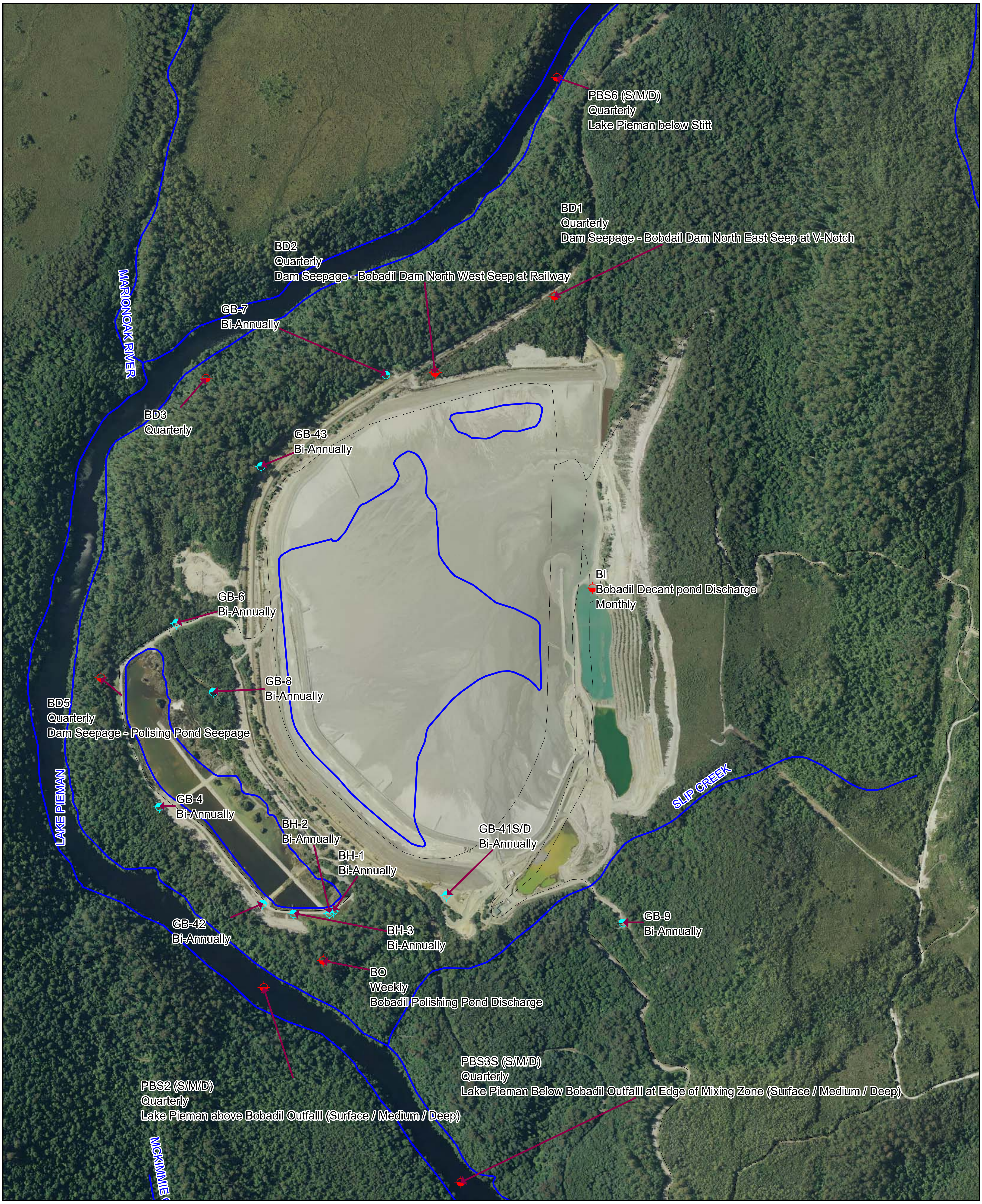
Rosebery Mill & Town Area Water Monitoring Locations

Figure A.1

S:\Environmental\Rosebery\Routine\ROE-R013_External Reporting and Communication\EPA\Annual Reporting\GIS\002_MMG Site Sampling Locations__Fig1_Site_V02.WOR

MMG Aerial Image 2014 Created by: MuellerG

28 Freshwater Place Southbank VIC 3006 Australia T +61 3 9288 0888 F +61 3 9288 0800 E gary.mueller@mmg.com W www.mmg.com



LEGEND

- Ground Water Monitoring Sample Location
- Surface Water Monitoring Sample Location
- Regional Water Way

1:7,500 (at A3)

0 125 250
metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N W E S

Annual Monitoring Review

Date | 26 SEP 2014

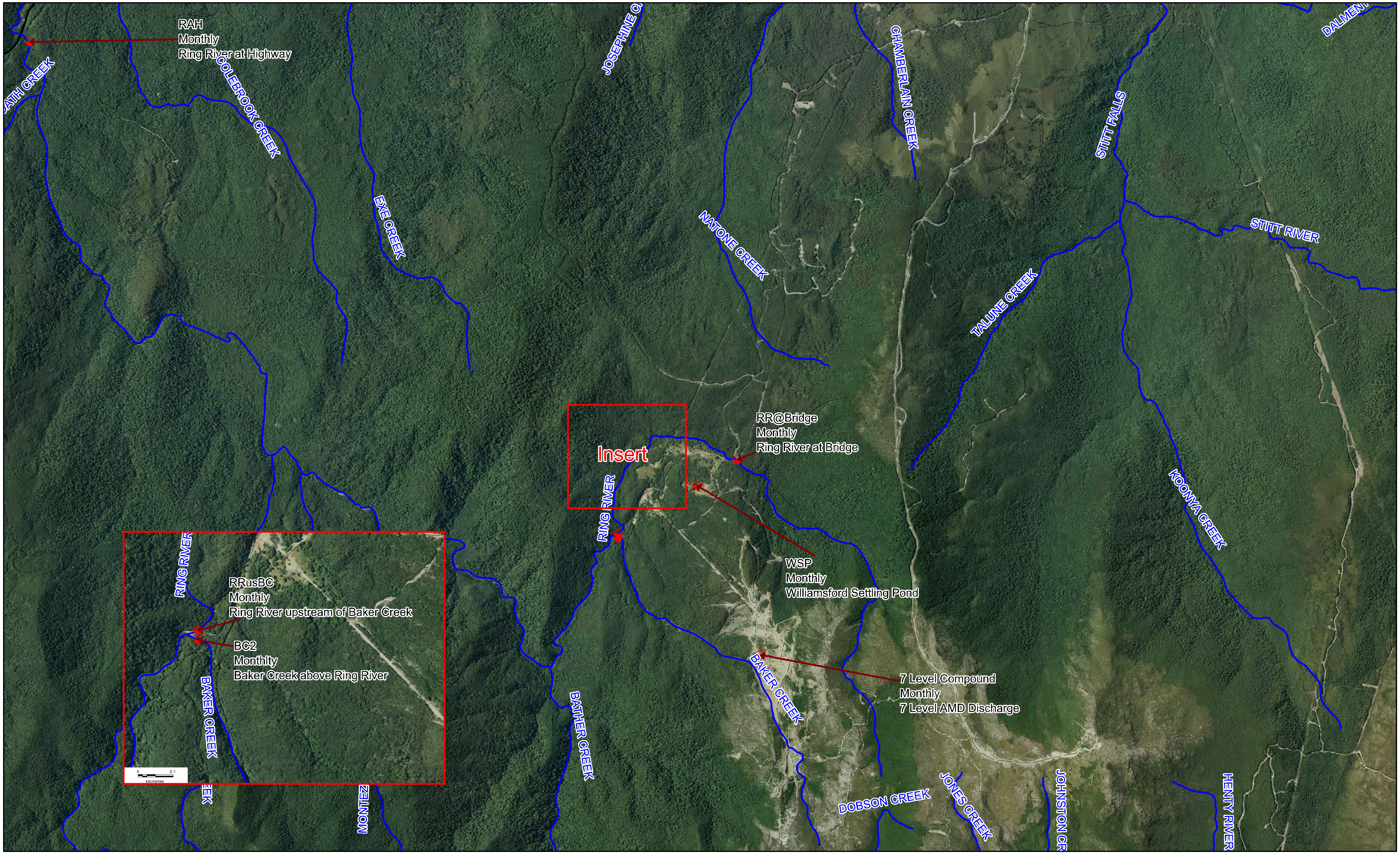
Bobadil and Lake Pieman Water Monitoring Locations

Figure A.2

S:\Environmental\Rosebery\Routine\ROE-R013_External Reporting and Communication\EPA\Annual Reporting\GIS\003_MMG Site Sampling Locations__Fig2_Boba_V02.WOR

28 Freshwater Place Southbank VIC 3006 Australia T +61 3 9288 0888 F +61 3 9288 0800 E gary.mueller@mmg.com W www.mmg.com

Data source: MMG Aerial, 2014 Created by: MuellerG



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kilometres
Scale: 1:25,000

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N W E S

LEGEND

MMG

Annual Monitoring Review

Date | 26 SEP 2014

Hercules and Mount Read Water Monitoring Locations

Figure A.3

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Data Source: MMG Aerial, 2014 Created by: MuellerG

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0 20
kilometres
Scale: 1:521,400

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N W E S

Groundwater Monitoring Sample
Surface Water Monitoring Sample
Regional Waterway

MMG

Annual Monitoring Review

Date 16 AUG 2018

No. 2 and No. 5 TSF
Area, Surface and Groundwater
Montioring Locations

Figure A.4

S:\SHEC\03 ENVIRONMENT\03 Land & Biodiversity Management\GIS\Projects\2017\PROJECT DATA\WORKSPACES
MMG Aerial Image 2014 Created by: PandelisA

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APPENDIX B: ROSEBERY WATER QUALITY REVIEW (KOEHNKEN, 2022) – INCLUDING SURFACE WATER AND GROUNDWATER MONITORING RESULTS AND REVIEW FOR 3 LEVEL WASTE ROCK DUMP

MMG Rosebery Annual Water Quality Monitoring Review 2021 - 2022

Final

31 August 2022

A Report to MMG Rosebery

Lois Koehnken

♦♦♦*Technical Advice on Water*♦♦♦

DOCUMENT TYPE:	Report	
TITLE:	Annual Water Quality Monitoring Review 2021-2022	
VERSION:	Final	
CLIENT:	MMG Rosebery	
PREPARED BY:	Lois Koehnken	Final 31 August, 2022 V1: 31 August, 2022 Draft: 12 August, 2022
DISTRIBUTED TO:	Michael Crawford, MMG Ben Osgerby, MMG	Electronic .doc, .pdf

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14.1 Surface water monitoring 55

1 Introduction

The following Tables and graphs summarise water quality results from MMG Rosebery for the monitoring period 1 July 2021 to 30 June 2022. Table 1 summarises chemical parameter names and acronyms used in the description of water quality results.

Table 1-1. Summary of terms and water quality parameter names.

Name	Description/Definition
2/5	Redeveloped 2 and 5 Tailings Storage Facility (TSF)
Al	Aluminium
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
BO	Bobadil Outfall monitoring point (licenced discharge point for MMG)
BTEX	Volatile organic compounds: benzene, toluene, ethylbenzene and xylene
Cd	Cadmium
Cu	Copper
CN	Cyanide
DO	Dissolved Oxygen – measured in either mg/L or percent saturation (%Sat)
EC	Electrical conductivity, measured in the units µS/cm
ETP	Effluent Treatment Plant
EPA	Environment Protection Authority Tasmania
Fe	Iron
GB	Groundwater bore
Mn	Manganese
NATA	National Association of Testing Authorities (Australia)
Pb	Lead
pH	Measure of concentration of hydrogen ions in water
T	Temperature
TN	Total nitrogen
TP	Total phosphorus
TPH	Total Petroleum Hydrocarbons
TSF	Tailings Storage Facility
TSS	Total suspended solids
WAD-CN	Weak acid dissociable cyanide - the component of cyanide that is most biologically available and reactive
WRD	Waste Rock Dump
Zn	Zinc

1.1 Changes to water management since EPN 7153/3 was issued

The MMG Rosebery site, including Hercules, operates under EPN 7153/3 which was issued in October 2011. Since that time, substantial changes to water management at MMG Rosebery have occurred related to the re-development of the 2/5 TSF which is now the primary site for tailings disposal. Water quality monitoring at the 2/5 TSF is governed by a revised water quality monitoring plan that was initially approved in 2018 and revised and subsequently approved in July 2021. Tailings, process water, seepage return water and some additional water required for tailings conveyance are now predominantly discharged to the redeveloped 2/5 dam, with the decant returned to the ETP for lime-dosing and discharge to Lake Pieman via the Bobadil TSF. Stormwater runoff and mine water continue to be collected, treated at the ETP and discharged via the Bobadil TSF, along with tailings. The licenced discharge point, Bobadil Outfall (BO) remains unchanged.

1.2 Environmental incidents in the July 2021 to June 2022 monitoring year

There were two environmental incidents involving tailings releases in the July 2021 to June 2022 monitoring year, both occurring in February 2022.

The first incident occurred at the 2/5 dam on February 2 when a small volume of tailings were observed in the old Clean Water Diversion channel along the eastern embankment of the dam. There was no release of material to the Stitt River, and all tailings were recovered and returned to the 2/5 dam. The incident was reported to the EPA on the day of the incident, and a report summarising the results of the environmental monitoring implemented in response to the incident was submitted to the EPA in May 2022.

The second incident occurred on February 10, 2022 and was caused by the flume conveying tailings from the ETP to Bobadil overflowing, resulting in an estimated 50 tonnes of tailings entering the drainage pathways to Primrose Creek. An obstruction in the creek where the railway crosses the creek prevented the movement of tailings further downstream. MMG implemented a comprehensive clean up strategy, and monitored the area intensively for the month following the incident. The EPA was notified of the spill on the date of occurrence, and update reports on the clean-up effort were provided to the agency. A final report summarising the monitoring results from Primrose Creek, the Stitt River and Lake Pieman was provided to the EPA in early May 2022.

1.3 Note on presentation of results

The MMG 2021-2022 monitoring results are presented in a range of graphical formats, including box-plots. Where the recent monitoring results are being compared to the EPN discharge limits at BO, or to long-term historic results such as storm water monitoring, box plots encompassing the 5th to 95th percentile values are used. Where monitoring results are presented to summarise recent monitoring results at sites without discharge limits or show long-term trends, box plots encompassing the 25th to 75th percentile values are used to provide more detail of the distribution of results.

2 Bobadil Tailings Storage Facility Discharge

The Bobadil Outfall (BO) to Lake Pieman is the licenced discharge point for MMG Rosebery. BO and the intermediate monitoring point where water is discharged from the main dam into the polishing pond (BI) is shown in Figure 2-1. A summary of the monitoring results collected during the 2021-2022 monitoring period at BO is contained in Table 2-1. BI results are discussed in Section 3.

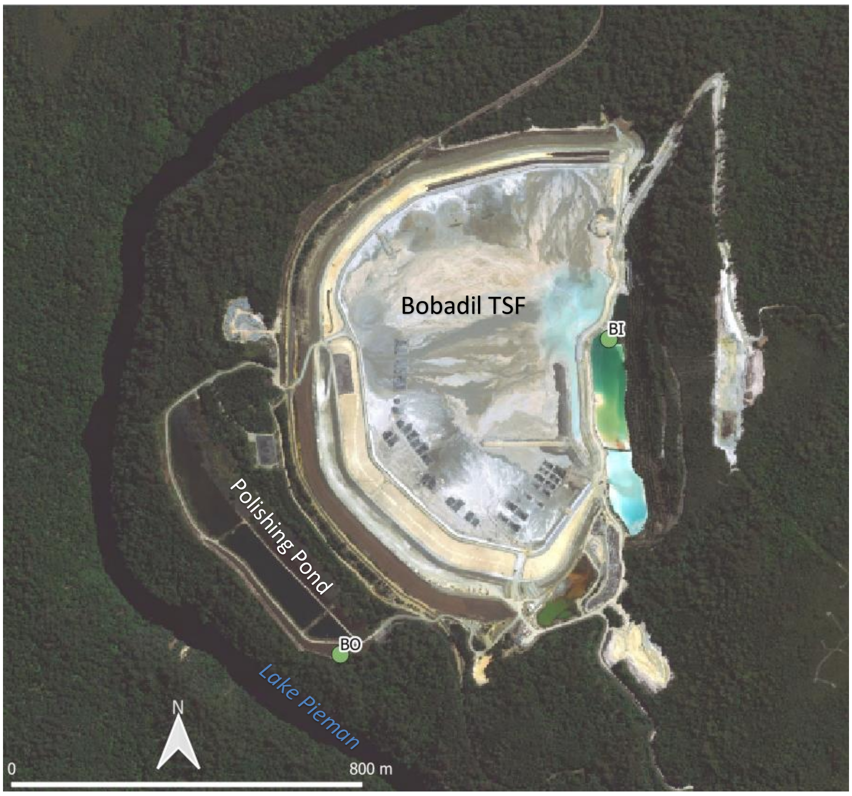


Figure 2-1. Bobadil TSF showing the main dam, Polishing Pond, discharge point from the main dam to the Polishing Pond (BI) and the licenced discharge point from the Polishing Pond (BO).

Table 2-1. Bobadil tailings discharge monitoring results during the 2021-2022 monitoring period.

Requirement	Findings
Monitoring Frequency	Continuous, weekly and monthly parameters were monitored as per requirements in the EPN with the following exceptions (notwithstanding contradictions in EPN, e.g. nutrients listed as both weekly and monthly): • Temperature is not recorded at BO on a continuous basis, but weekly results are collected. • All parameters required to be monitored on a weekly basis were determined, with some parameters monitored more frequently than required in the EPN. • The continuous flow measuring site at BO was found to have minor faults during an external review by Entura, and the site has been upgraded to provide more accurate flow results.
Compliance with EPN discharge limits	• Rainfall during the 2021 - 2022 monitoring year was above average in the first half of the year, and below average during the summer months (Figure 2-2) resulting in the annual total rainfall at Bobadil, 2220 mm, being close to the long-term average of 2,224 mm (1911 – 2018 at Renison Bell, Tasmania, Figure 2-2). • The strong seasonality of rainfall was reflected in discharge from Bobadil, with the average daily flow ranging from 0.06 to 0.71 m^3/s, with a median 0.21 m^3/s. Low discharge during the dry summer was also attributable to the use of water at the 2/5 TSF for dust suppression trials.

	• The low flow through Bobadil in the summer affected pH, EC, and sulphate concentrations as described below (Figure 2-3, Figure 2-4). • Similar to previous years, laboratory pH values are lower than in-situ measurements suggesting that the pH declined in the samples following collection. This decline does not affect metal concentrations as the metals have already been removed and captured in the TSF. • The pH levels remained well above discharge limits in the TSF, resulting in low metal concentrations in the discharge, with no exceedances of the EPN limits for metals, WAD CN, or nutrients (Figure 2-6). • One false exceedance due to elevated Total Petroleum Hydrocarbon was recorded on 1 February 2022 at BO. Re-analysis following silica gel (SG) clean-up of the sample returned a TPH value below the laboratory LoR. This type of interference occurs episodically at BO and systems are in place to re-analyse any sample that initially exceeds the EPN limit. As the SG treated sample result was below the EPN limit the false exceedance was not reported to the EPA.
Comparison with EPN investigation trigger levels	The 95th percentile values of the samples collected between 1 July 2021 to 30 June 2022 were below the 95th percentile investigative triggers for all parameters except EC and sulphate (Figure 2-4). • The 95th percentile EC value was 1,852 µS/cm, with 4 values exceeding the investigative limit of 1,700 µS/cm and a maximum value of 1,952 µS/cm. • The 95th percentile sulphate concentration of 1,015 mg/L exceeded the 95th percentile trigger due to 4 values exceeding 1,000 mg/L, with the highest recorded concentration of 1070 mg/L. All values >1,000 mg/L occurred in January 2022. • MMG completed an investigation into the elevated EC and sulphate values and concluded that reduced flow through the Bobadil TSF was the underlying cause. The report was provided to the EPA. Elevated EC and sulphate during the summer months has been a common occurrence at the TSF and does not reflect a change in operations (Figure 2-5).
Significant trends - reporting period	• Metal retention in the TSF is high due to the good pH control, resulting in low metal concentrations in the discharge from BO over the monitoring year (Figure 2-6).
Significant trends - longer period	• Zinc concentrations continued to show a decrease in 2021-2022 relative to the previous years (Figure 2-7, Figure 2-8). The median value for the present monitoring year was 0.015 mg/L, compared to 0.019 during the previous year. Possible reasons for the decrease include: additional water being used in the system to transport tailings to 2/5 dam and zinc being captured by the tailings in the 2/5 TSF. Median sulphate levels were higher as compared to the previous year with the increase attributable to the low summer rainfall, and reduced flow through the TSF to mix with the seepage from the TSF entering the Polishing Pond.
Comment	The monitoring requirements at BO should be revised to reflect the present water management system, and the lack of sewage entering the 2/5 TSF. Parameters which should be reviewed with the aim of eliminating or reducing the frequency of monitoring include: Faecal Coliform / Thermotolerant coliforms, total nutrients (which are listed on both the weekly and monthly monitoring schedule) mercury (which isn't listed in the

	monitoring schedule but has a discharge limit) and TPH which is listed as both monthly and six-monthly. Monitoring frequency should be included in the review based on the large number of parameters that are consistently below discharge targets. The monitoring frequency of parameters that have recorded below LoR levels for multiple years should be reduced.

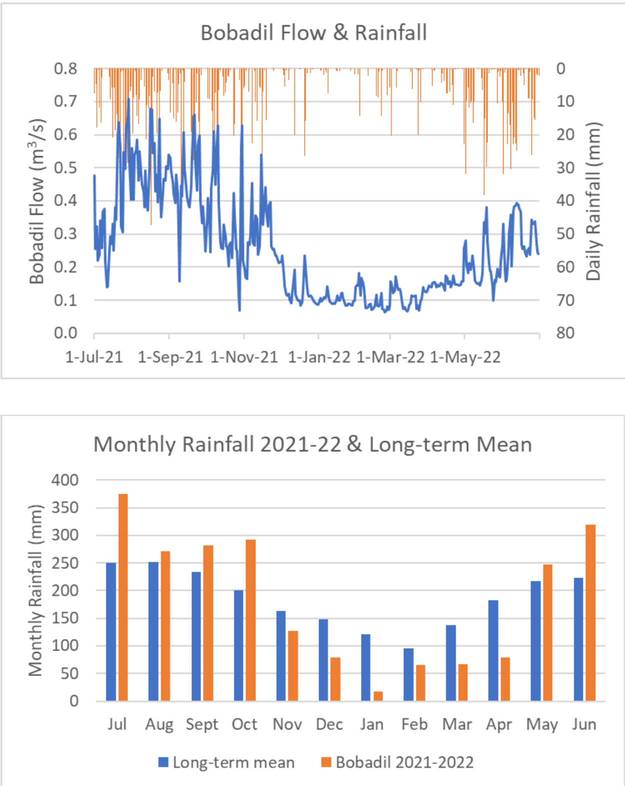


Figure 2-2. (top) Daily rainfall at Bobadil and discharge at BO 1 July 2021 to 30 June 2022, and (bottom) 2021-2022 monthly rainfall at Bobadil weather station compared to long-term (1911-2018) monthly averages at Renison Bell (Renison data from BOM).

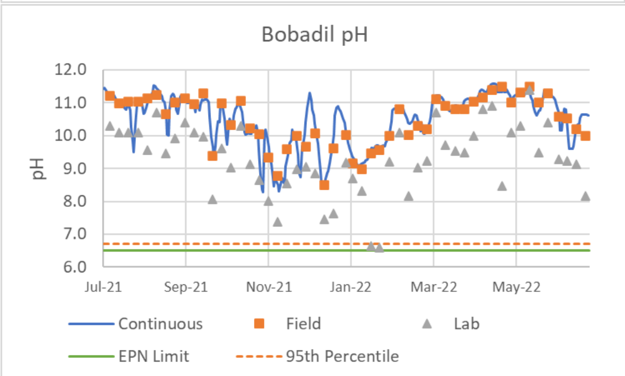


Figure 2-3. Weekly field, laboratory and continuous pH (daily averaged) results from BO, July 2021-June 2022.

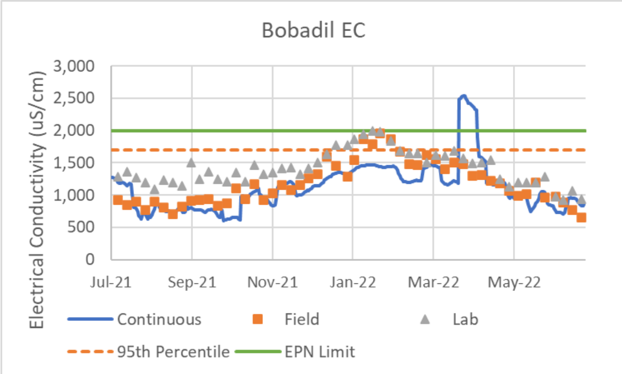


Figure 2-4. Weekly field, laboratory and continuous EC results from BO, July 2021-June 2022. The elevated continuous EC values in April 2022 are due to calibration error of the instrument.

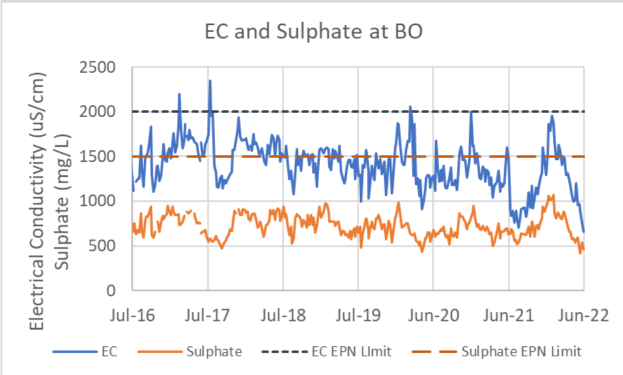


Figure 2-5. Weekly sulphate and EC results at BO rom July 2016 to June 2022 with EPN discharge limits indicated.

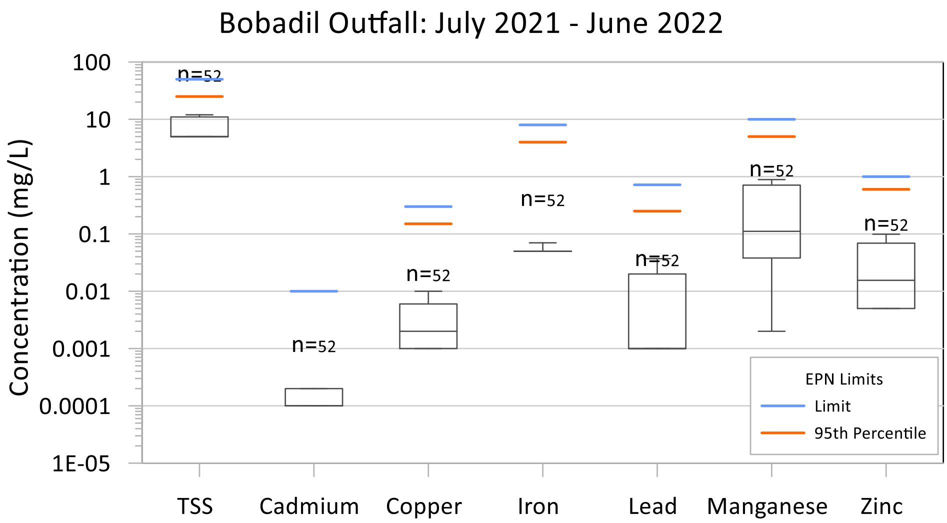


Figure 2-6. Box and whisker plot of TSS and total metal monitoring results at BO for July 2021 to June 2022 compared to EPN limits and 95th percentile trigger. The box encompasses 5th to 95th percentile values, with minimum and maximum values indicated by the whiskers.

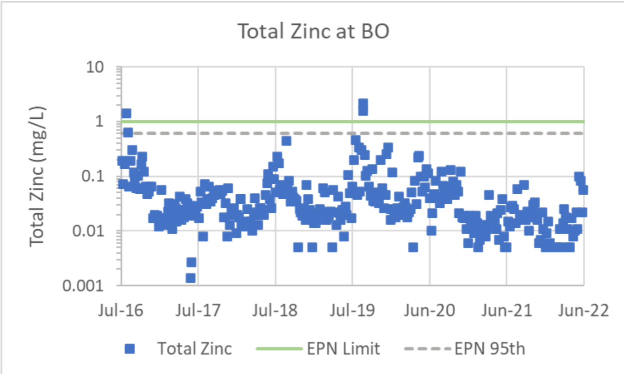


Figure 2-7. Total zinc concentrations from July 2015 to June 2022.

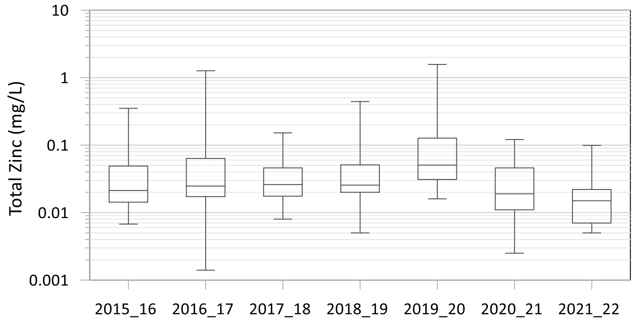


Figure 2-8. Comparison of total zinc concentrations at BO over the past 7 monitoring years (July to June). The box encompasses the 25th to 75th percentile values, and the 'whiskers' extend to the minimum and maximum values.

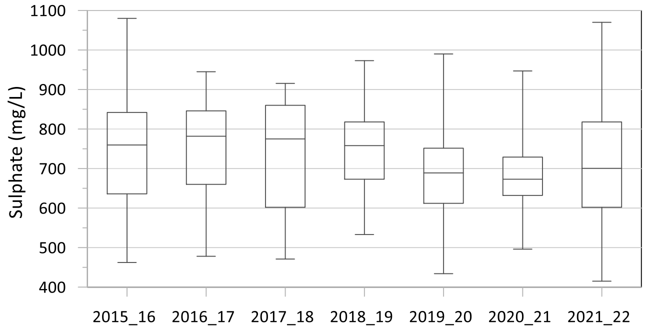


Figure 2-9. Comparison of sulphate concentrations at BO over the past 7 years. The box encompasses the 25th to 75th percentile values, and the 'whiskers' extend to the minimum and maximum values.

3 Internal Bobadil TSF Monitoring (BI and BF)

The results for monitoring at internal sites in the Bobadil TSF (BI, BF) are summarised in Table 3-1. The location of BI is shown in Figure 2-1. BF is located at the head of the flume.

Table 3-1. Summary of monitoring results from internal monitoring sites at Bobadil TSF for 2021-2022.

Requirement	Findings
Monitoring Frequency	At BI and BF all parameters were monitored 12 times on a monthly basis.
Significant trends reporting period	• pH values at BI are up to 1 pH units lower than at BF. pH at BO was considerably lower than at BI between October 2021 and March 2022 but remained within the EPN limits. (Figure 3-1). • Sulphate concentrations at the sites showed strong seasonality, with higher concentrations in the summer months. Median values increased by about 10% (623 mg/L to 687 mg/L) between BI and BO, recognising the difference in sample numbers. The higher and more uniform concentrations at BO are likely attributable to seepage input to the Polishing Pond from the main TSF (Figure 3-2). • TSS results at BF were >10,000 mg/L on all monitoring dates except 2 (September 2021 and March 2022), indicating some tailings were

	being discharge during the sampling. TSS at BI was < 50 mg/L on all monitoring dates demonstrating a high retention of solids in the TSF (Figure 3-3).
Comment	The monthly results from BF and BI are not used for day to day management of the site but are useful for understanding how water quality in the TSF is changing following the reduction in tailings deposition.

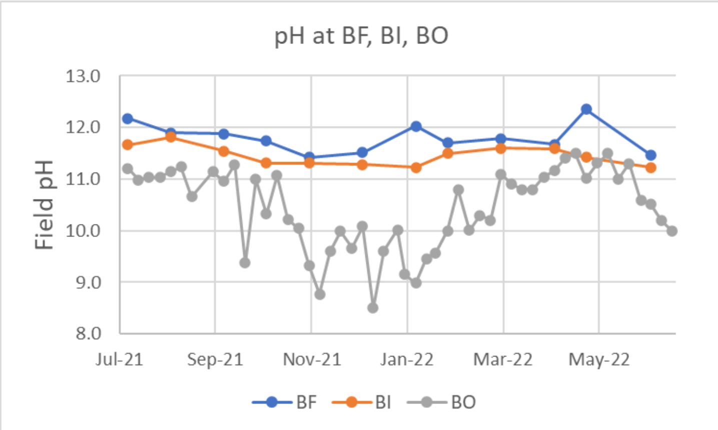
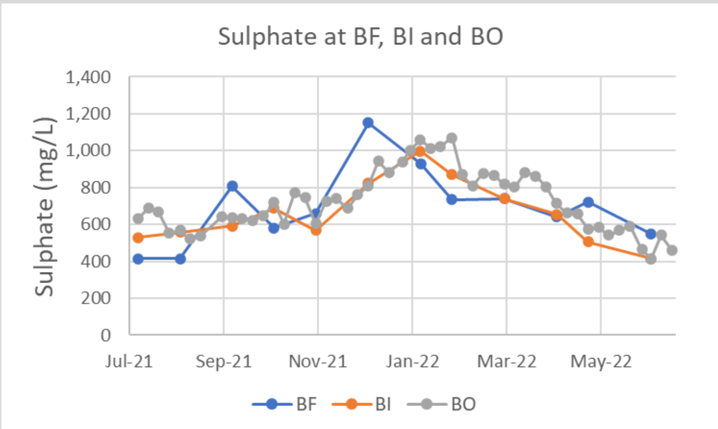


Figure 3-1 Comparison of Field pH at BF, BI and BO for July 2021-June 2022.



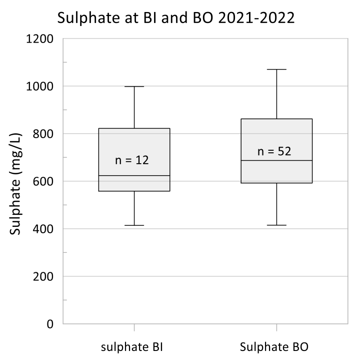


Figure 3-2. (left) Time series of sulphate at BF, BI and BO July 2021-June 2022 (right) box and whisker plots comparing concentrations at BI and BO. Boxes contain the 25th to 75th percentile values, with the minimum and maximum indicated by the 'whiskers'.

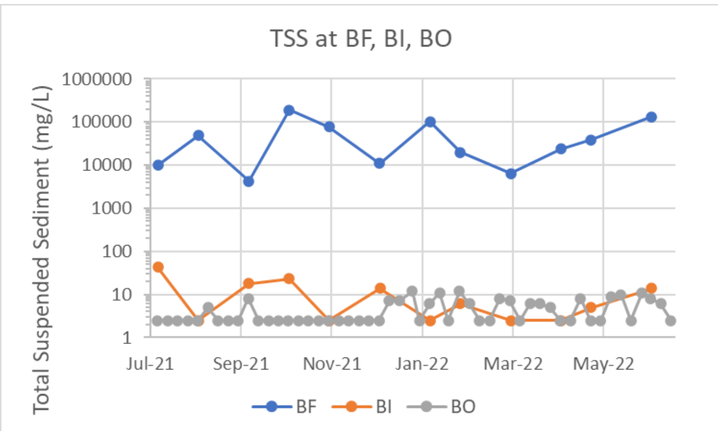


Figure 3-3. TSS at BF, BI and BO July 2021 – June 2022. Values reported as below the LoR of 5 mg/L are shown as 2.5 mg/L

4 Bobadil TSF Seeps

EPN 7153/3 includes a requirement to monitor seepage from the Bobadil Dam based on observations of seepage flows at the time the EPN was issued in 2011. The intention of seepage monitoring is to understand diffuse inputs to the environment from the TSF. Since that time, several lifts of the dam wall have been completed, and the sub-surface hydrology of the site has altered, as evidenced by the lack of flow in several historic seepage points. Other seeps have been eliminated by expansion of the TSF. The seeps that are monitored are shown in Figure 4-1 with a summary of the monitoring results contained in

Table 4-1.

Figure 4-1. Seepage monitoring locations at Bobadil TSF.

Table 4-1. Summary of monitoring results from Bobadil TSF seeps in 2021 – 2022 monitoring year.

Requirement	Findings
Monitoring Frequency	Quarterly monitoring was completed as required. Samples were not collected at the following sites on the indicated dates due to a lack of flow at the site: • BD1 on any of the sampling days • BD2 in December 2021 and March 2022 • Seep BD4 has not been monitored for many years as it was covered by expansion of the TSF. Seeps in addition to those listed in the EPN are monitored.

Compliance with EPN	All parameters were determined on the collected samples as required. Flow was not recorded at BD3 on March 2022 as the sample was collected from stagnant water
Significant trends - reporting period	• Overall the water quality results are similar to previous years. • Seeps BD3 and BD5 continue to have pH in the range of 6 to 7.5 with pH in BD2 ranging between 4 and 5 in 2021 – 2022 (Figure 4-2). • Total zinc values at BD2 continue to be elevated as compared to seeps BD3 and BD5 (Figure 4-3), with a maximum zinc concentration of 1.36 mg/L in the monitoring year. • Lead results in BD2 showed a sharp decrease in June 2022 compared with historic results. Concentrations in BD3 and BD5 continued to be low, consistent with previous findings (Figure 4-4). • Sulphate concentrations in BD3 and BD5 ranged from 576 mg/L to 778 mg/L, which is in the range of the discharge from Bobadil (range = 415 – 1070 mg/L). Concentrations in seep BD2 continues to be considerably lower, <60 mg/L, suggesting the seep receives clean catchment inflow as well as seepage from the TSF. • Zinc fluxes at BD3 ranged from 0.4 to 4.0 g/day (n=3), and at BD5 from 0.6 to 5.3 g/day (n=4). Sulphate fluxes from the same sites ranged from 19 to 44 kg/day at BD3, and from 33 to 92 kg/day at BD5.
Comments	• The Closure PFS being conducted by MMG includes monthly monitoring of all TSF seepage points (n≅20; with most seeps reporting to the Polishing Pond). The aim of this monitoring is to estimate contaminant loads and provide a baseline for the 9 ha cover trial. MMG intend to use the monitoring results to redesign the seepage monitoring program following completion of the closure PFS.

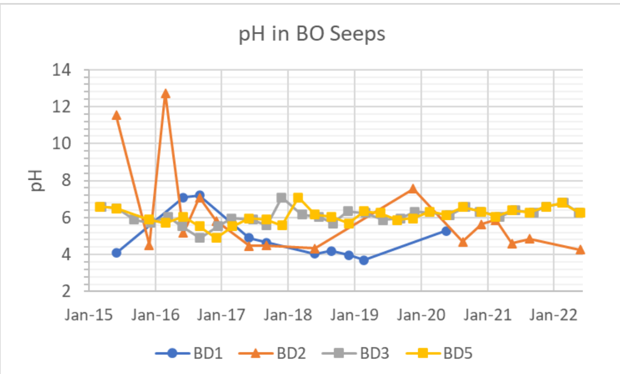


Figure 4-2. pH results from Bobadil seeps, June 2015 to June 2022.

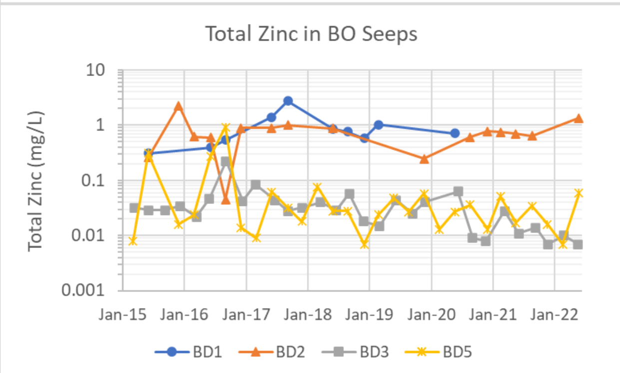


Figure 4-3. Total zinc results from Bobadil seeps, June 2015 to June 2022. Note log scale.

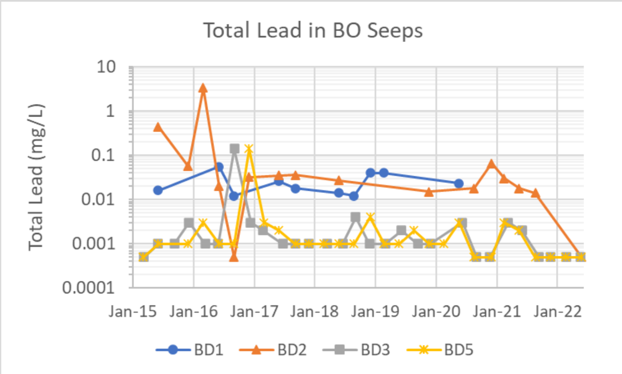


Figure 4-4 Total lead results from Bobadil seeps, June 2015 to June 2022. Note log scale.

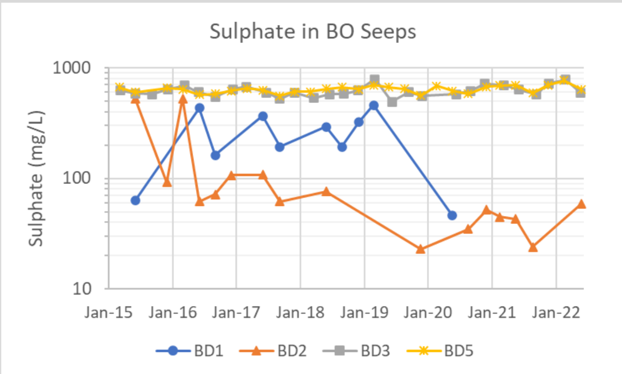


Figure 4-5 Sulphate concentrations in the Bobadil seeps June 2015 to June 2022. Note log scale.

5 Bobadil TSF Groundwater Monitoring

The location of groundwater monitoring bores near the Bobadil TSF is shown in Figure 5-1, and a summary of groundwater monitoring results is contained in Table 5-1.

Figure 5-1. Location of groundwater monitoring bores near the Bobadil TSF.

Table 5-1. Summary of the 2021-2022 monitoring results from the groundwater bores located near Bobadil TSF.

Requirement	Findings
Monitoring Frequency	• Monitoring of bores GB4, GB6, GB7S, and GB8D was completed in October 2021 and April or May 2022. Bore GB8S was only monitored in October 2021. • Bore GB5 does not exist due to expansion of the TSF facility. • Bore GB9 was decommissioned in September 2020 following approval from the EPA to discontinue monitoring at the site due to sampling difficulties.
Compliance with EPN	All parameters were determined as specified in the EPN
Significant trends - reporting period	• The results are consistent with previous monitoring. The deeper bores (GB6D, GB7D, GB8D and GB9) tend to have higher pH and higher concentrations of alkalinity (Figure 5-2, Figure 5-3). This may reflect limited impact from seepage from the TSF entering the deeper aquafers. • The shallow bores (GB4, GB6S, 7S, and 8S) generally have higher concentrations of zinc, manganese and sulphate as compared to the deeper bores, consistent with the TSF being a source to these bores (Figure 5-4 to Figure 5-6). • Bore GB7S, located between the northern extent of the dam and Lake Pieman continues to record the highest total zinc levels. The deep water in the bore (GB7D) contains comparatively low levels of zinc and sulphate. • The results continue to support a conceptual model of the shallow aquifer, composed of glacial till, being hydraulically connected to the dam, with elevated zinc, manganese and sulphate derived from the TSF seepage. The deeper groundwater system appears to be largely isolated from TSF impacts.
Other comments	The MMG Closure PFS investigations have installed and monitored several new wells over the past 18 months. These results will be integrated with the existing data set to refine the groundwater monitoring regime following completion of the Closure study.

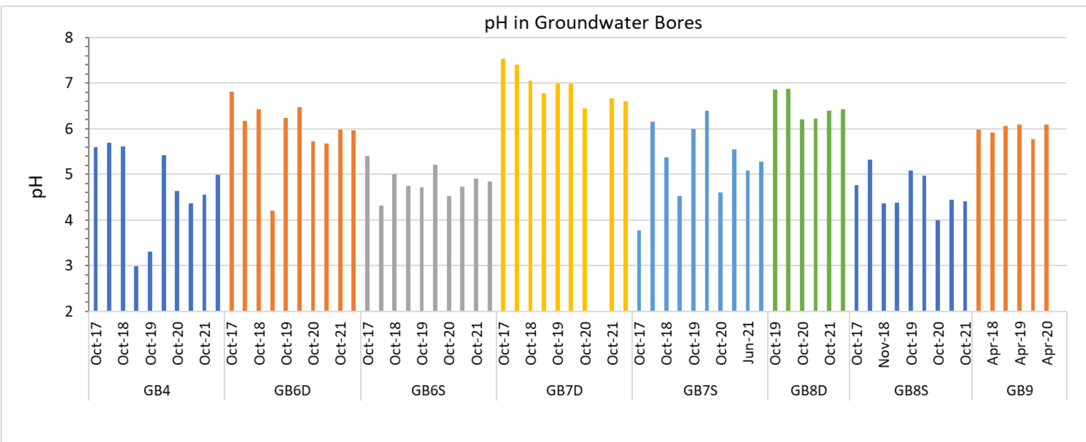


Figure 5-2. pH in groundwater samples collected near Bobadil TSF 2017 – June 2022.

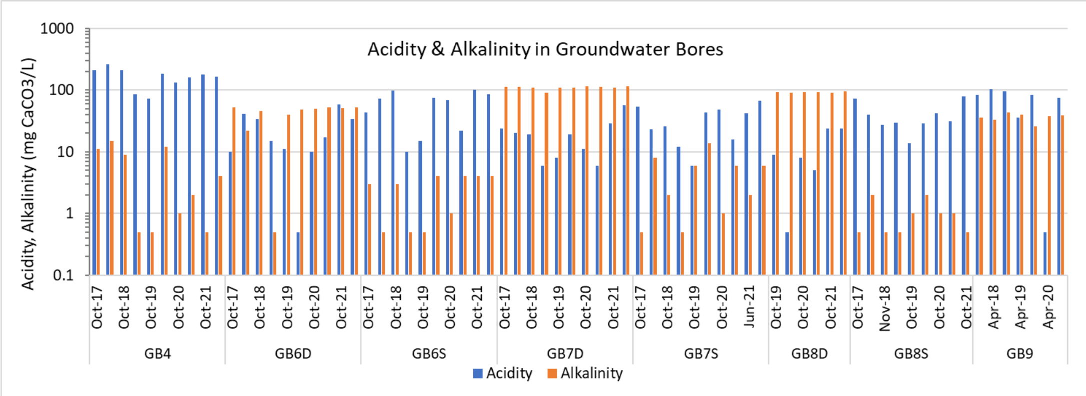


Figure 5-3. Alkalinity and acidity in groundwater samples collected near Bobadil TSF, 2017- June 2022.

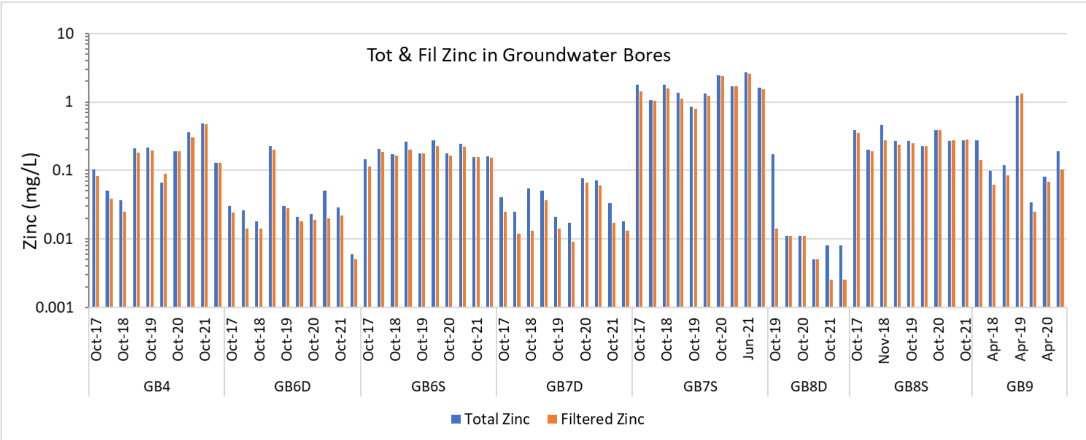


Figure 5-4. Total and filtered zinc results from groundwater samples collected near Bobadil TSF, 2017- June 2022.

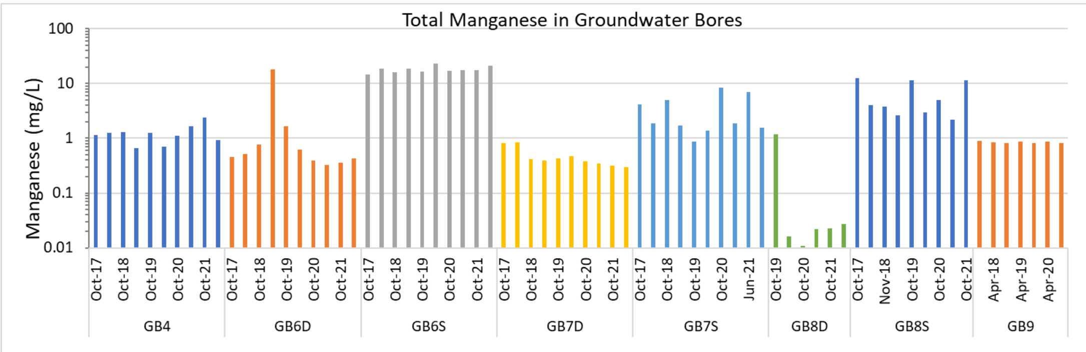


Figure 5-5. Manganese results from groundwater samples collected near Bobadil TSF 2017 –June 2022.

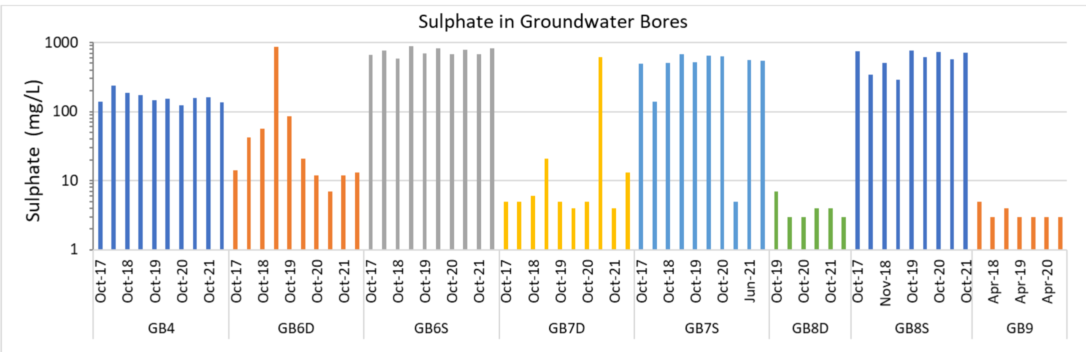


Figure 5-6. Sulphate results from groundwater samples collected near Bobadil TSF 2017 – June 2022.

6 2/5 TSF Monitoring Results

The redevelopment of the 2/5 TSF required a revision to the water quality monitoring regime listed in EPN 7153/3. The monitoring strategy has been amended twice, once in February 2018 and most recently in July 2021 based on the Pitt & Sherry (April 2021) monitoring plan. The water quality monitoring sites related to the 2/5 TSF that were sampled in July 2021 to June 2022 are listed in Table 6-1.

During the 2021 – 2022 monitoring year construction has been occurring at the 2/5 TSF, including:

- Installation of a grout curtain and French drain to separate 2/5 seepage from stormwater;
- Development of a sump and pump system to collect the 2/5 seepage and return it to the TSF;
- Collection of stormwater reporting to the MHS2 site for treatment at the ETP

Table 6-1. Summary of water quality monitoring at 2/5 dam since redevelopment of the TSF as approved by the EPA in 2021.

Water	Type of Monitoring or Location	Station Names in MMG Database
Surface Water	**Grab samples**	
	Decant Return	DW01
	Clean Water Diversion upstream of TSF	CWDD01
	Seepage Collection Drain	SCD01, SCD02
	Seepage Collection Pond	SCP01
	Discharge to Stitt River*	SD
	Stitt River upstream of 2/5	WL8
	Stitt River downstream of TSF	SR02
	Stitt River upstream of Stitt Falls	SR03
	Stitt River upstream of L Pieman (downstream of Rosebery Ck)	U/S Pie
	Seepage from TSF emanating along Murchison Highway	MHS2
	Seepage from downstream TSF emanating along Murchison Highway	MHS3
Groundwater**	Pumped from groundwater bores	GB12, 13, 14S, 14D, 15, 16, 21H, 22H, 23H, 25H, 26H, 27H, 28H

***Only monitored if there is overflow from the TSF**

***Groundwater bores previously designated as GB21 – GB28 are now designated as GB21H-GB28H to avoid confusion with bores located near the 3 Level Open Cut with the same numbering.**

During the 2021-2022 monitoring year there was one unintentional discharge of tailings from the 2/5 TSF as described in Section 1.2. There were no releases of decant water from the dam into the Stitt River. Compliance water quality monitoring is based on the sites listed in Table 6-1 and Figure 6-2, and monitoring compliance is summarised in Table 6-2.

Figure 6-1. Tailings decant and surface water monitoring associated with the 2/5 TSF. Monitoring site U/S Pie is located downstream of SR03, off of the aerial photo.

Figure 6-2. Groundwater bore monitoring locations associated with the 2/5 TSF. .

Table 6-2. Summary of monitoring results related to discharge from the 2 and 5 Dam in 2021-2022.

<table>
<tr><th>Requirement</th><th>Findings</th></tr>
<tr><td>Compliance with Water Quality Monitoring Strategy</td><td>Monitoring at 2/5 Dam was completed as required under the modified July 2021 Monitoring Plan with samples collected from all sites except:
SD: Spillway- No water quality results were collected because no water was discharged from the 2/5 TSF into the Stitt River
Parameters in addition to those listed in the monitoring strategy were reported for many of the surface water sites.</td></tr>
<tr><td>Significant trends during reporting period</td><td>TSF Decant water:
Total zinc concentrations responded to variable pH in the 2/5 TSF, with higher zinc concentrations recorded when the pH in the dam was < 7 (Figure 6-3). Total zinc in the TSF ranged from 0.12 mg/L to 1.6 mg/L as pH varied from 8 to 6.1. During periods of higher pH, more zinc is captured in the 2/5 TSF. The elevated zinc concentrations have no impact on the environment as all return water is treated in the ETP.
Sulphate and EC (Figure 6-4) showed similar trends, with EC varying between ~500 to 800 µS/cm and sulphate between 200 to 350 mg/L. Concentrations in the 2/5 TSF are substantially lower as compared to the discharge at BO, with the higher values at BO attributable to the addition of mine water, storm water and seepage from the BO TSF.
Seepage
Seepage from the dam at site SCD01 shows a strong response to rainfall, whereas seepage at SCD02 is relatively constant through the year (Figure 6-5). Flow at site SCD01 was affected by backwater issues at the V-notch site through April 2022 so the results have moderate reliability. The site has been moved upstream to improve its accuracy. Site SCD02 has been moved downstream as part of the Stage 2 embankment construction. Flow results are expected to improve in the 2022-2023 monitoring year.
The flow rates of water pumped back to the TSF from the seepage collection pond (SCP01) are very low compared to the seepage rates. This is attributable to: inaccurate metering of pump rates and the use of an additional unmetered pump to transport water to the TSF during the Stage 2 embankment construction. The company is also investigating and repairing tears in the SCP liner that could be contributing to a allowing a loss of water from the pond. Due to the flow measurement issues at SCD01 and in the SCP, there is a poor water balance across the system this monitoring year.(Figure 6-6).
The volumetric contribution of seepage pump back from SCP01 relative to the volume of water pumped back to the ETP from the 2/5 TSF is very small (Figure 6-7), recognising the limitations of the flow data.
pH values in SCD02 and the seepage pond (SCP01) are lower as compared to pH values at SCD01 or in the TSF (DW01) (Figure 6-8). pH results at SCD02 and SCP01 have remained relatively constant through the year, reversing an increasing trend since 2018. SCD01 and DW01 show a seasonal trend, with higher pH values occurring in the summer months.
Total zinc concentrations show similarities to pH, with SCD02 and SCP01 having elevated concentrations compared to SCD01 and the</td></tr>
</table>

TSF (Figure 6-9). Concentrations at SCP01 decrease during periods of high rainfall, when inflow from the low-Zn seep SCD01 increases in volume.

- Sulphate shows similar trends, with SCD02 and SCP01 having similar concentrations, except during periods of high inflow from SCD01 (Figure 6-10).
- Iron concentrations at the seepage and TSF sites show similar trends as previous years, with elevated levels in SCD02 and SCP01.
- Overall, SCD02 continues to have poorer water quality as compared to SCD01. The similarity between SCD01 and DW01 suggests that water in the TSF may be the source of the SCD01 seep, whereas SCD02 is likely derived from underlying historic acid producing material.

Trends in the Stitt River

- pH levels in the Clean Water Diversion (CWDD01) are generally lower as compared to sites in the Stitt River (Figure 6-12). The sites in the Stitt had similar pH levels during the 2021-2022 monitoring year, and generally in the range of 6 to 7.
- Total zinc at CWDD01 is consistently higher than in the Stitt at WL8, reflecting the high dilution provided by the Stitt mixing with the inflow from the cut-off drain. The source of the zinc in the cut-off drain is unknown, but could be attributable to inputs from the local geology or runoff from the road.
- Zinc concentrations consistently increase between WL8 and the upstream Lake Pieman (U/S Pie) site. There is a moderate increase in zinc between WL8 and SR02 reflecting diffuse inputs from the TSF and the activities on the northern side of the river. The largest increase in concentration occurs between SR02 and SR03 reflecting stormwater and diffuse inputs from the fill underlying Stitt Park and developments on both sides of the river. (Figure 6-13). Concentrations at the U/S Pie site were similar to the SR03 site and ranged from 0.08 to 0.36 mg/L.
- Sulphate concentrations show similar behaviour to zinc, with increased levels at CWDD01 in summer and increasing levels downstream of WL8. Overall sulphate concentrations remain low in the Stitt River, at < 20mg/L (Figure 6-14).

Groundwater:

- Similar to previous years the groundwater results vary on different sides of the TSF, and reflect regional groundwater flow combined with impacts from historic and present operations.
- GB23H, located near the western embankment continues to record relatively low pH and the highest zinc and sulphate concentrations (Figure 6-15, Figure 6-16, Figure 6-17). This is consistent with the bore intersecting water that is similar in composition to the seepage being discharged along the Murchison Highway.
- The lowest concentrations of sulphate and zinc are generally found in bores GB21H, GB15 GB16 and GB14D which are located either upslope or away from the TSF and capture the local/regional groundwater conditions.
- Sulphate and zinc concentrations in bore 14S increased substantially in May 22 compared to previous results, with zinc increasing from 0.09 to 0.23 mg/l and sulphate increasing from 2 to 190 mg/L between November 2021 and May 2022. Increases in other parameters (iron,

	manganese, calcium, magnesium) were also recorded. These increases could be related to the Stage 2 embankment lift. • All TPH and BTEX values were below the LoR except in bore GB12D and GB14S where TPH was 0.15 mg/L and 0.14 mg/L respectively. At both sites the C_{15}-C_{28} component was present, which is the range of diesel fuel. The detectable levels occurred in November 2021 at GB12D and in May 2022 at GB14S. No TPH was detected in the surface aquifer at GB12 nor the deep aquifer at GB14. Construction activities were being completed at the TSF during monitoring, but not in the immediate vicinity of the groundwater bores, so the source is unknown, and sampling errors may be responsible. • Bore GB23H, which is likely a source for the Murchison Highway seeps (MHS) shows stable sulphate and pH results in 2021-2022, but an increase in acidity (Figure 6-18). The increase in acidity may be driven by an increase in dissolved iron (Figure 6-19). Arsenic concentrations have decreased substantially in the last year, perhaps reflecting the exhaustion of the supply from the historic waste. Murchison Highway Seeps (MHS2, MHS3) • The quality of water in the MHS2 and MHS3 seeps differ considerably, with the differences consistent with the conceptual model of MHS2 being derived from seepage from the 2/5 TSF, and MHS3 reflecting groundwater draining predominantly historic fill (Figure 6-20 to Figure 6-23). • In May 2022 substantial works were completed to separate the 2/5 seepage from stormwater along the toe of the western embankment. A French drain and sump and pump system was constructed to isolate, collect and return seepage water to the 2/5 TSF. Stormwater runoff continues to report to the MHS2 monitoring site. Results from MHS2 in 2021-2022 are relatively constant until this work was completed except for February 2022 when pH and metal concentrations increased substantially, but acidity decreased (Figure 6-20, Figure 6-21).. The TSS in the sample was >2800 mg/L, suggesting that the elevated total metals are associated with particulates. Works associated with the grout curtain on the western embankment may also have affected the water quality in February. In June 2022, metal and sulphate concentrations decreased consistent with the exclusion of • seepage from the monitoring site. • In MHS3, metals and sulphate are higher in the summer consistent with the seep being derived from local groundwater percolating through local fill (Figure 6-22, Figure 6-23).
Recommendations	• Water levels in the bores should be analysed with respect to rainfall and the water level in the TSF to understand what is controlling groundwater infiltration, and identify the direction of movement. This information would provide a context for interpreting water quality in the bores. As part of the MMG Closure PFS water level and EC loggers will be installed in September 2022 to refine the groundwater model for the TSF. The results of the model should be used to guide future groundwater monitoring at the TSF.

	• Field blanks and duplicates should be included in the groundwater bore monitoring regime to evaluate the potential for contamination during sampling. • A new water quality monitoring site should be added at the ‘Sump and Pump’ system to track the quality of seepage being pumped back into the TSF. It is recommended this site is monitored on a monthly basis. • The monitoring site MHS2 should be renamed to clarify it is a stormwater site rather than a seepage site and to avoid confusion with the historic MHS2 seepage data set. It is recommended this site be monitored on a quarterly basis consistent with the other stormwater monitoring sites.

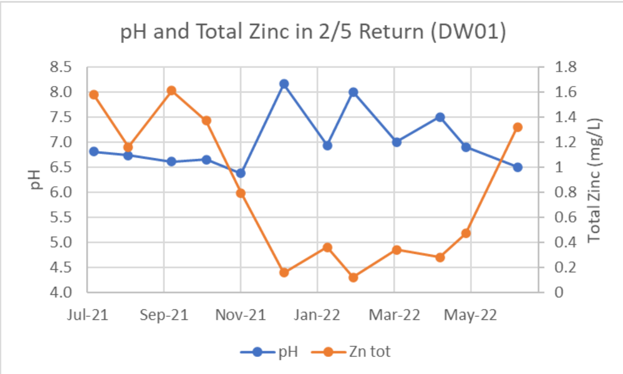


Figure 6-3. pH and total zinc in 2/5 TSF decant return (DW01), July 2021 to June 2022.

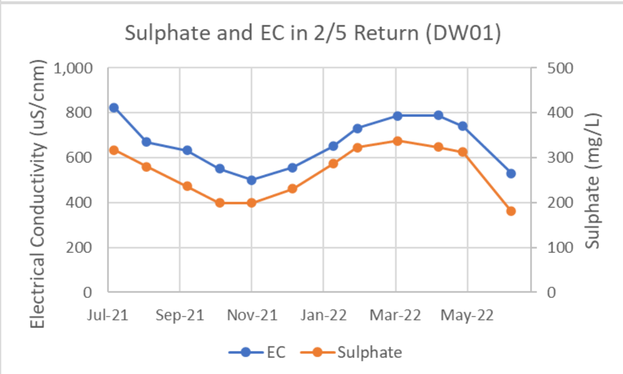


Figure 6-4. Sulphate and EC in the 2/5 TSF decant return, July 2021 to June 2022.

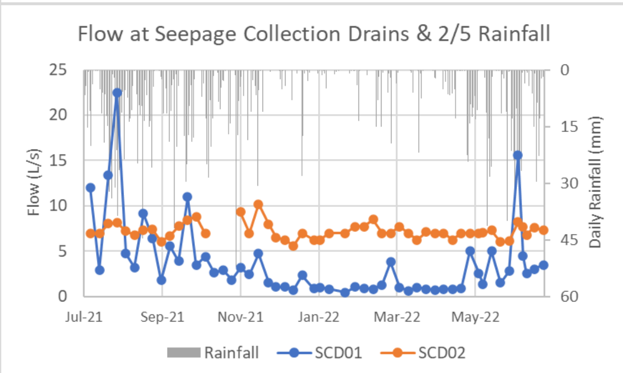


Figure 6-5. Average daily flow rates in SCD01 and SCD02 compared to daily rainfall at the 2/5 TSF.

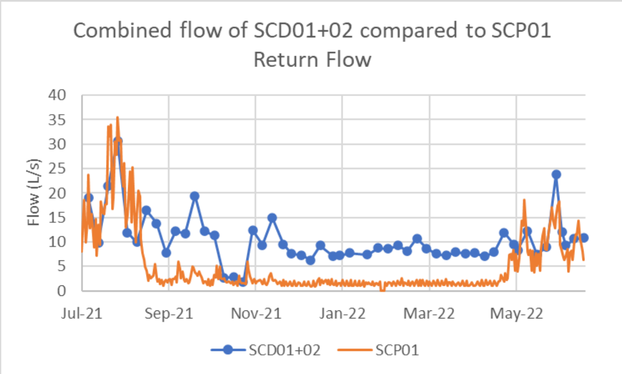


Figure 6-6. Comparison of average monthly combined flow rate in SCD01 and SCD02 with average monthly seepage return rate to 2/5 dam.

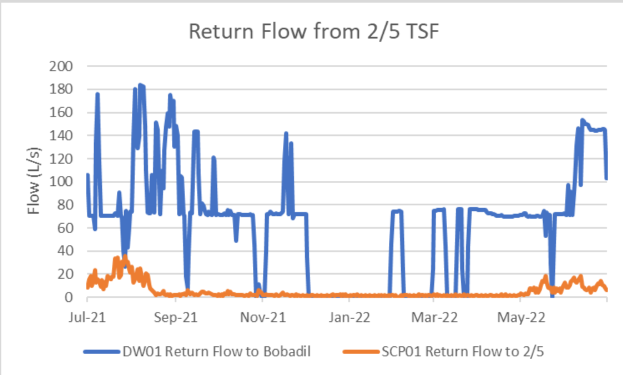


Figure 6-7. Comparison of seepage inflow to 2/5 TSF and Decant return from 2/5 dam to ETP.

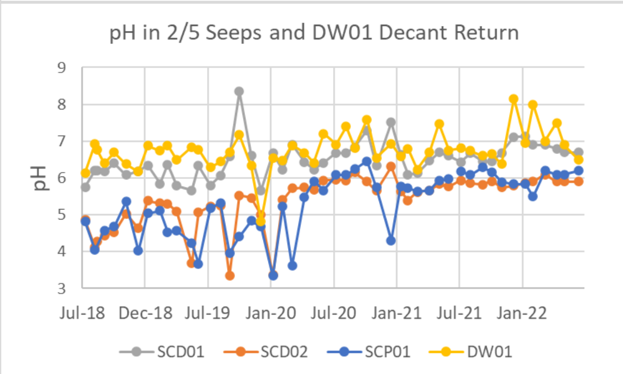


Figure 6-8. pH in 2/5 seepage drains SCD01 and SCD02 and in the seepage collection pond SCP01 July 2018 to June 2021.

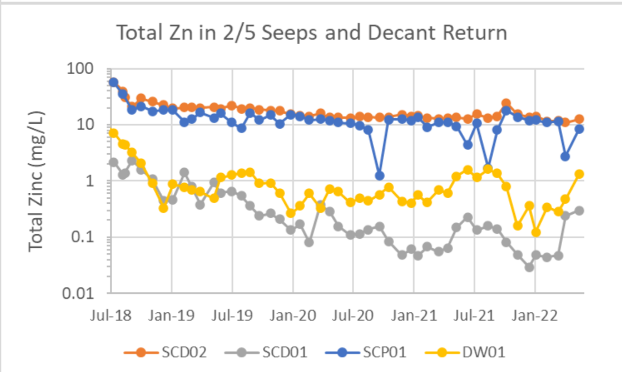


Figure 6-9. Total Zinc in 2/5 seepage drains SCD01 and SCD02, in the seepage collection pond SCP01 and the DW01 decant return to ETP July 2018 to June 2022. Note log scale.

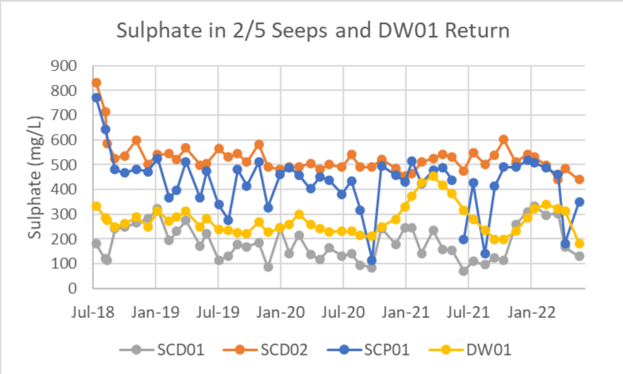


Figure 6-10. Sulphate in 2/5 seepage drains SCD01 and SCD02, in the seepage collection pond SCP01 and the DW01 decant July 2018 to June 2022.

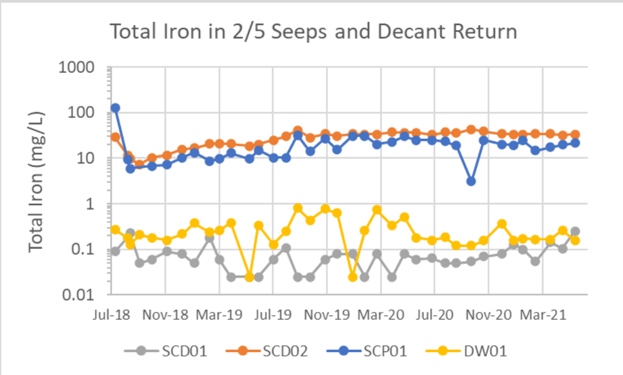


Figure 6-11. Total iron in 2/5 seepage drains SCD01 and SCD02, in the seepage collection pond SCP01 and the DW01 decant July 2018 to June 2022. Note log scale.

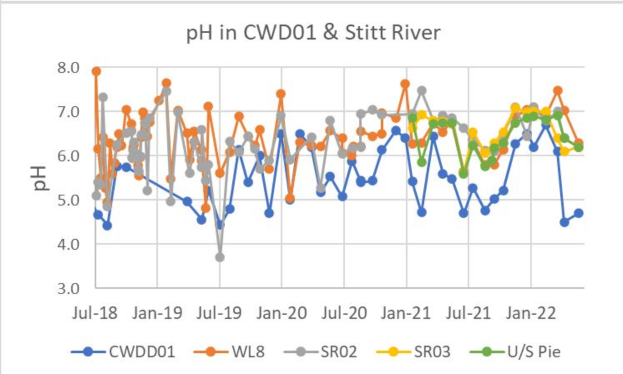


Figure 6-12. pH at Clean Water Diversion and the Stitt River at WL8 , SR02, SR03 an U/S Pie from July 2018 to June 2022.

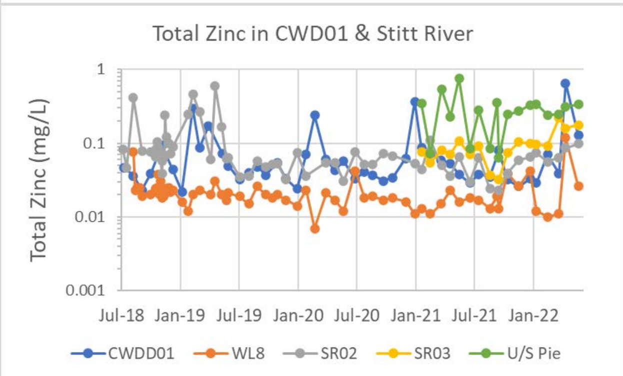


Figure 6-13. Total zinc concentration in the Clean Water Diversion and the Stitt River at WL8 and SR02 July 2018 to June 2022. Note log scale.

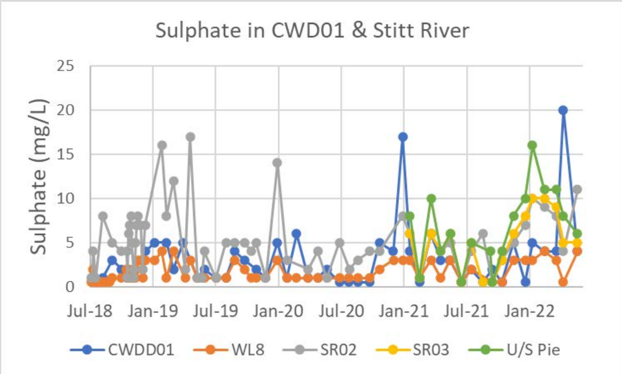


Figure 6-14. Sulphate concentrations in the Clean Water Diversion and the Stitt River sites July 2018 to June 2022.

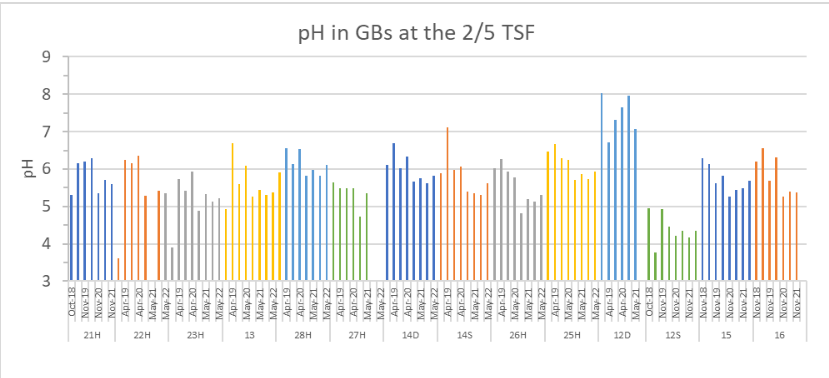


Figure 6-15. pH in the 2 and 5 ground water bores. Sites are shown in clockwise direction beginning at site GB21H, located on the southern side of the impoundment. Sites GB15 and GB16 are located east of the Stitt River. Sampling dates were Oct 18, Apr 19, Nov 19 and Apr 20, Nov 20, May 21, Nov 21 and May 22.

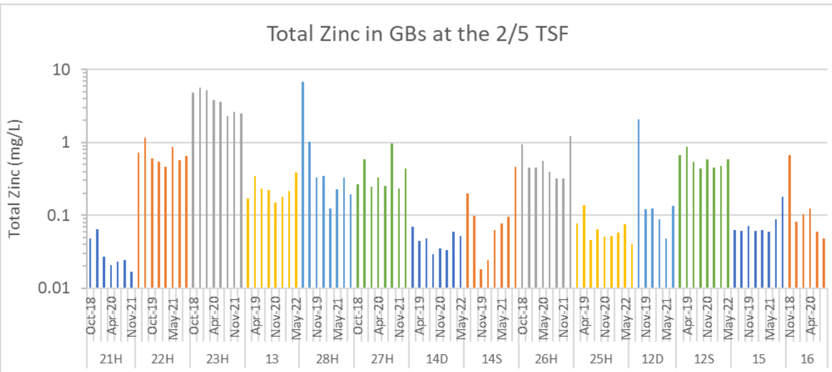


Figure 6-16. Total zinc in 2 and 5 groundwater bores. Sites are shown in clockwise direction beginning at site GB21H, located on the southern side of the impoundment. Sites GB15 and GB16 are located east of the Stitt River. Sampling dates were Oct 18, Apr 19, Nov 19 and Apr 20, Nov 20, May 21, Nov 21 and May 22.

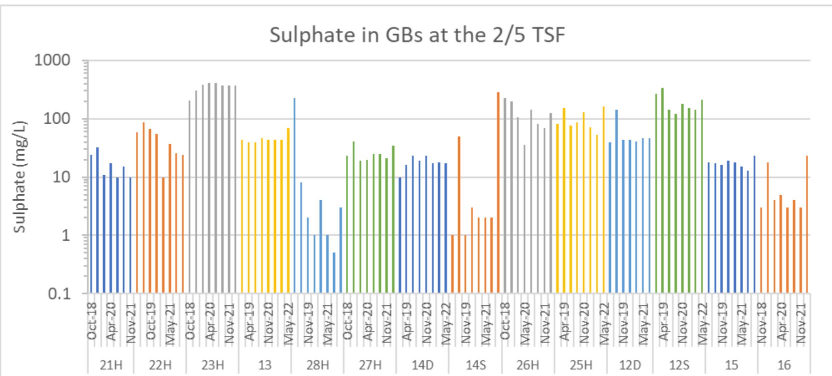


Figure 6-17. Sulphate in 2 and 5 groundwater bores. Sites are shown in clockwise direction beginning at site GB21H, located on the southern side of the impoundment. Sites GB15 and GB16 are located east of the Stitt River. Sampling dates were Oct 18, Apr 19, Nov 19 and Apr 20, Nov 20, May 21, Nov 21 and May 22.

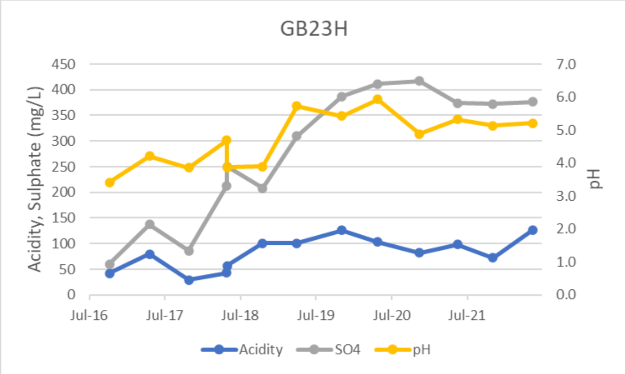


Figure 6-18. Acidity, sulphate and pH in GB23H 2016 – 2022.

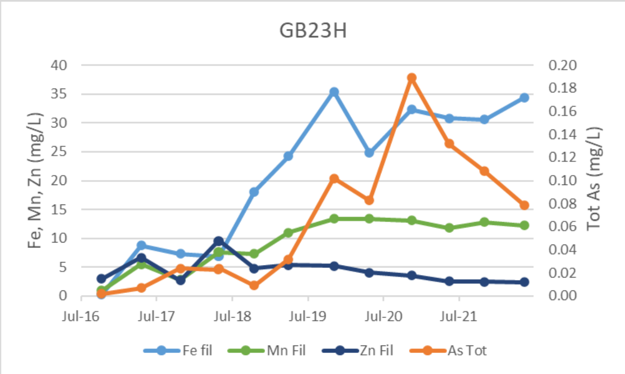


Figure 6-19. Filtered iron, manganese and zinc and total arsenic in GB23H 2016 – June 2022.

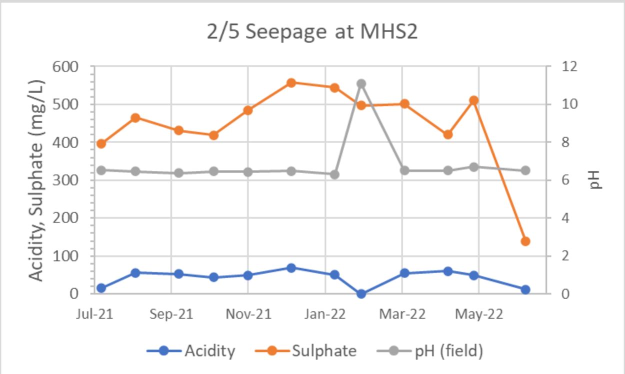


Figure 6-20. Acidity, sulphate and pH in the MHS2 Seep, July 2021 – June 2022

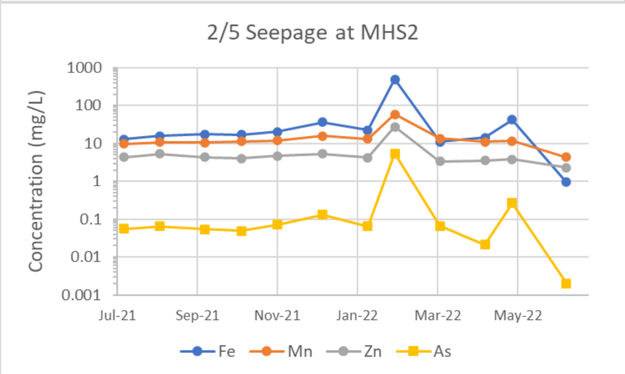


Figure 6-21. Total iron, manganese, zinc and arsenic in the MHS2 Seep, July 2021 – June 2022.

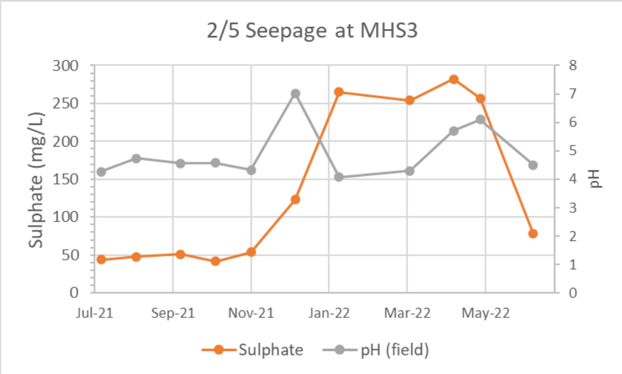


Figure 6-22. Sulphate and pH in the MHS3 Seep, July 2021 – June 2022

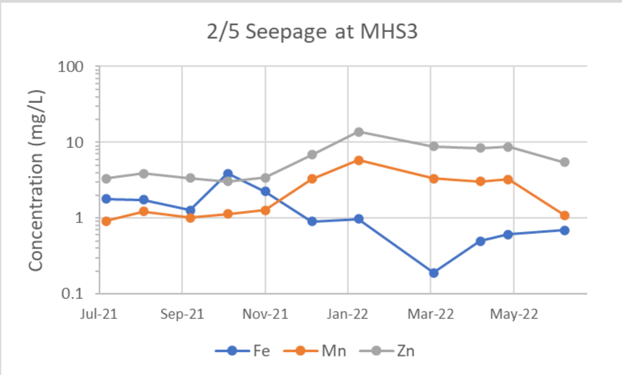


Figure 6-23. Total iron, manganese and zinc in the MHS3 Seep, July 2021 – June 2022

7 Stitt River upstream of 2 and 5 Dam

A summary of the monitoring results collected at site WL8 upstream of the 2/5 TSF is contained in Table 7-1.

Table 7-1. Summary of monitoring results from the Stitt River upstream of 2 and 5 Dam in 2021-2022.

Requirement	Findings
Monitoring Frequency	Monitoring requirements were amended in July 2021 under the revised 2/5 TSF Water Quality Monitoring Plan. • Continuous river level is recorded in the Stitt River upstream of the 2/5 TSF by Entura under contract to TasWater. Flow results based on the river level are provided to MMG Rosebery by TasWater (Figure 7-1). • Continuous Electrical Conductivity and Temperature are no longer monitored at the site, but weekly monitoring of these parameters is completed as shown in Figure 7-2. • All other parameters were monitored on a monthly basis as required.
Compliance with EPN	All parameters were determined at the required frequency with the exception of the following: • Fluoride was not determined in September 2021. It was below the LoR for all remaining months
Significant trends reporting period	• Flow in the Stitt River has been altered due to abstractions in the upper catchment during high flows associated with a hydropower diversion project. Flow at the WL8 site was relatively low in 2021 – 2022 with no events greater than 15 m^3/s recorded. Flow during the summer was very low for a prolonged period. Monitoring coincided with a range of flow rates through the year (Figure 7-1).

	• pH values were similar to previous years, with values between 5.5 and 7.5. The field and laboratory values are similar except in the autumn when the field values were higher. EC values increased during the summer months, consistent with the very low flow in the river (Figure 7-2). The laboratory EC values are consistently higher than the values recorded in the field. • Metal concentrations were low and similar to previous years (Figure 7-3). Sulphate concentrations (not shown) were below 5 mg/L during the monthly samplings, consistent with the last 3 years. • Comparing total and filtered zinc concentrations demonstrates that the highest zinc concentrations were associated with particulates, with filtered zinc values low and consistent throughout the monitoring year (Figure 7-4). TSS results from all samples were <5 mg/L, suggesting the zinc was associated with very fine particulates.
Long-term trends	• No changes have been detected in the water quality of the Stitt River compared to previous monitoring years.

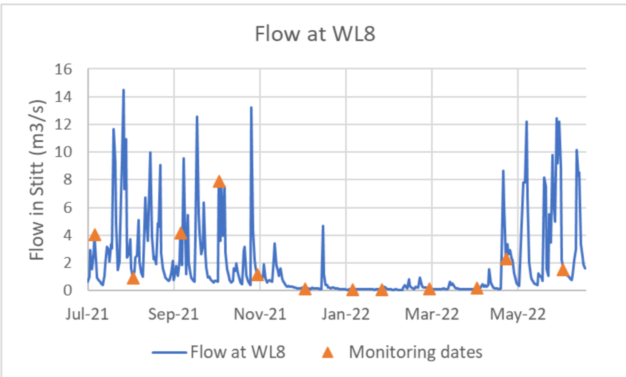


Figure 7-1. Discharge in the Stitt River at WL8 July 2021 to June 2022. Sampling dates are indicated by orange markers.

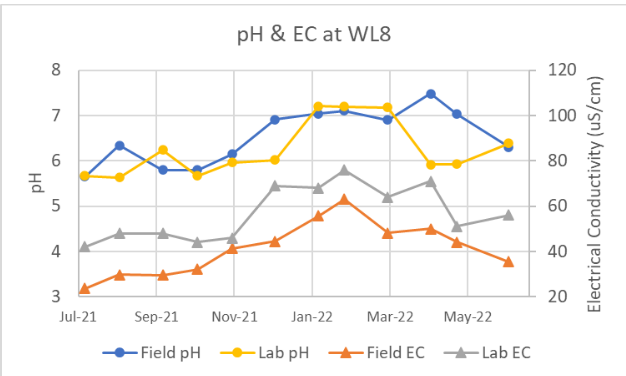


Figure 7-2. Field and laboratory pH, and Electrical Conductivity in the Stitt River July 2021 – June 2022

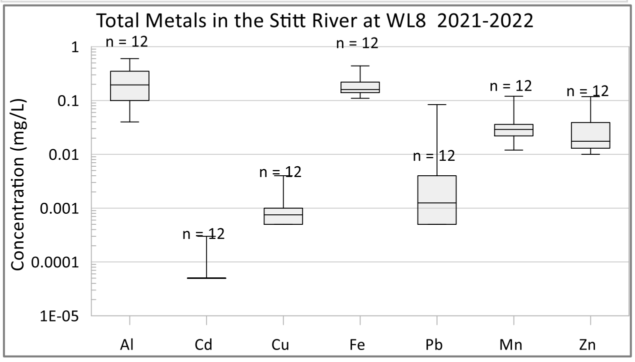


Figure 7-3. Box and whisker graph of metals in Stitt River upstream of 2 and 5 dam (WL8) for July 2021 to June 2022. Box and whisker plot as described in Figure 2-6, with the box encompassing the 25th to 75th percentile values.

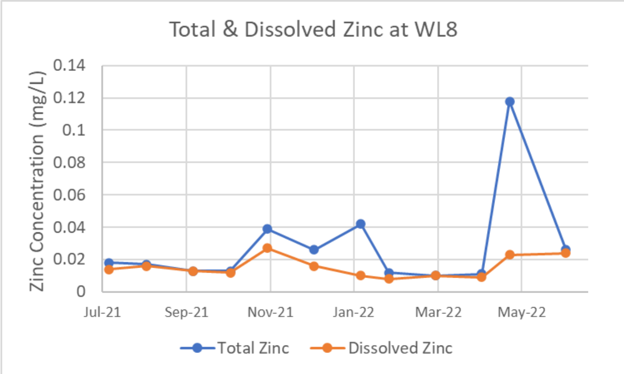


Figure 7-4. Total and filtered zinc values at WL8 in July 2021-to June 2022.

8 Hercules Monitoring

A summary of the monitoring results from the Hercules Mine site are contained in Table 8-1.

Table 8-1. Summary of monitoring results from the Hercules Mine site collected in 2021-2022.

Requirement	Findings
Monitoring Frequency	All sites were monitored for the required parameters and at the frequency required except for the following: • Continuous flow, EC, pH and Temperature are not recorded at 7L Composite, but have historically been recorded at WSP. • The WSP pond has developed a substantial leak, which resulted in no flow occurring at the downstream v-notch, where the water is sampled and flow is recorded. This has resulted on only 6 water quality samples (July to Dec 2021) being collected at WSP, and inaccurate flow rates recorded for the site. Monthly water quality sites were collected at 7L Composite site.
Compliance with EPN	Monitoring frequency and parameters determined are the only requirements in the EPN. With the exception of the previously listed data gaps all monitoring was completed as required.
Significant trends - reporting period	• Flow results at BC2 continue to be substantially lower than pre-2020 results, with an annual average flow of 0.10 m^3/s as compared to 0.40 m^3/s in the 2018-2020. This is attributable to site upgrades and improved maintenance at the site, supported by technical reviews by independent hydrographers. The 2021-2022 monitoring year had very dry summer months, with Baker Creek almost ceasing to flow (Figure 8-1). • The pH values at Ring River above Baker Creek are higher than the other two sites, consistent with historic results. The pH values recorded in the field were lower than the continuous results at BC2 and higher than the continuous results at the RR us BC (Figure 8-1, Figure 8-3, Figure 8-5). Water quality probes at these sites have been upgraded as part of the MMG PFS Closure study and the results are considered more reliable than in the past. • EC at all sites decreases with increased flow due to the inflow of surface water. The EC values recorded in the field were consistently lower than the continuous recorded values or the laboratory values (Figure 8-2, Figure 8-4, Figure 8-6).

	• The range of monthly metal concentrations is similar to previous years, with the 7Level Composite having the highest concentrations (but lowest flows). The concentrations in Baker Creek are slightly lower but flow rates are substantially higher. Concentrations in the RR us BC are the lowest, and result from the flow in the Ring River mixing with the overflow from the WSP (Figure 8-8). • Seasonal patterns continue to be present in the time-series of metal concentrations, with the highest concentrations occurring during the drier summer months (Figure 8-9, Figure 8-10). The dry summer months produced the highest zinc concentrations recorded for several years at any of the sites. • Metal and sulphate loads on monitoring days based on the water quality results and average daily flow rate are lower as compared to the previous year, presumably due to the very low rainfall resulting in reduced flushing of oxidation products from the catchment, and improved flow monitoring. The average daily zinc and sulphate fluxes from the site are estimated at 0.11 tonnes/day and 10.2 tonnes/day respectively. These results are lower than the estimate for the previous year (0.69 t/day zinc, 28 t/day SO_4), which were lower than the previous year. The marked decrease is attributable to improved flow monitoring in Baker Creek and the Ring River, and the very low flows recorded in the extended summer period. The results show Baker Creek continues to transport the largest load even with the lower flow rates (Figure 8-11). • There are substantial changes to the concentration of zinc down the length of the Ring River. Zinc concentrations at the Ring River Bridge (upstream of Hercules) ranged from 0.4 to 0.7 mg/L, which is in the range of previous years (Figure 8-12). A large increase occurs between the Bridge site and the Ring above Baker Creek site, due to the inflow from the WSP and runoff from the mine road. Baker Creek discharges the largest zinc load and enters the Ring downstream of the Ring above Baker site. The concentrations in the lower Ring River at Highway (RAH) ranged from 1.65 mg/L to 8.38 mg/L, with a net increase of between 1.2 mg/L to 7.9 mg/L compared to the Ring River at Bridge site.. • Using average daily flow from the Ring River at the Murchison Highway site and the water quality results yields the zinc and sulphate fluxes shown in Figure 8-13 and Figure 8-14. For zinc, there is a good balance between the sites for all months except December 2021 when monitoring occurred on a day with rapidly increasing flow rates. The balance between the Hercules inputs and the lower river for sulphate is not as good. These results suggest that the Hercules site is the predominant source of zinc to the lower river, but other historic acid drainage inputs are likely contributing sulphate.
Comments	• The continuous recording pH and EC probes, and field EC meters should be checked and intercalibrated as frequently as feasible. Inter-comparisons with a NATA lab is recommended • The pipeline connecting 7Level to the WSP and the WSP Pond have extensive leaks that make it impossible to obtain accurate flow measurements and provide no environmental benefit. Discharging the 7Level water into the Ring River via the WSP increases the length of the Ring that is severely impacted by acid drainage. Water

		quality in the Ring River between the WSP and the RRusBC site would improve significantly if the 7Level flow was discharged directly into Baker Creek rather than to the WSP pipeline.

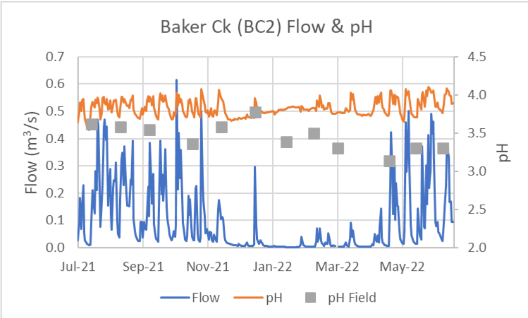


Figure 8-1. Continuous flow, pH and monthly field pH results in Baker Creek upstream of the Ring River.

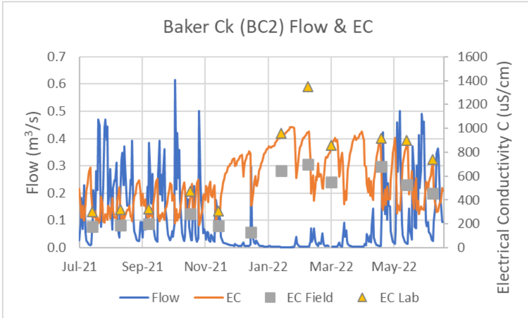


Figure 8-2. Continuous flow, EC and monthly field and laboratory EC results in Baker Creek upstream of the Ring River

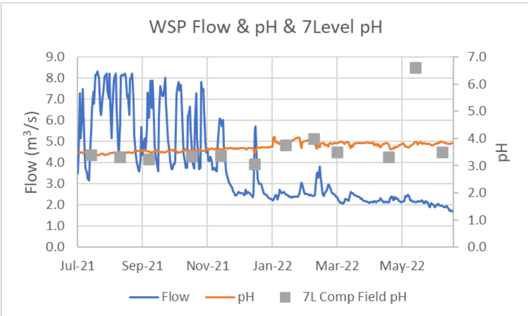


Figure 8-3. Continuous flow, pH and monthly field pH results in the Williamsford Settling Pond.

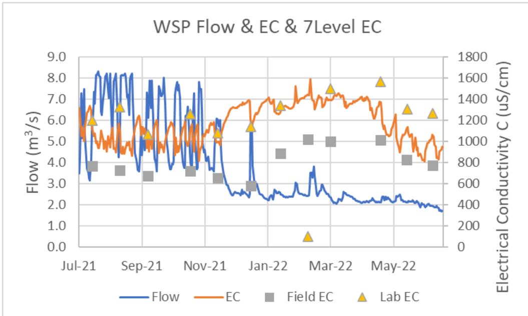


Figure 8-4. Continuous flow, EC and monthly field and laboratory EC results in the Williamsford Settling Pond

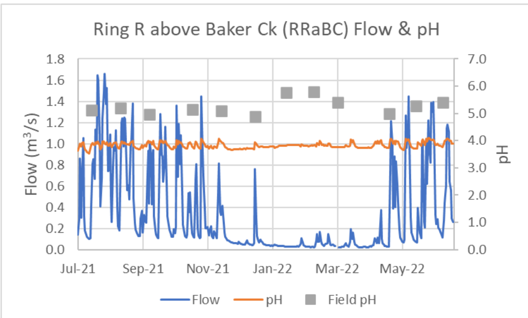


Figure 8-5. Continuous flow, pH and monthly field pH results in the Ring River upstream of Baker Creek

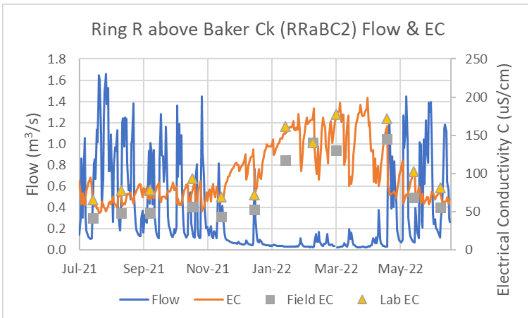


Figure 8-6. Continuous flow, EC and monthly field EC results in the Ring River upstream of Baker Creek

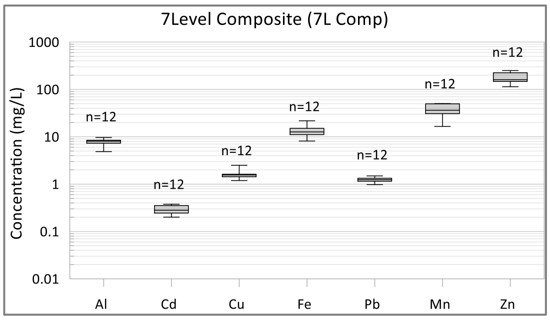


Figure 8-7. Box and whisker plot of total metal concentrations at the 7L composite site in 2021-2022. Note log scale. Box encompasses the 25th to 75th percentile values.

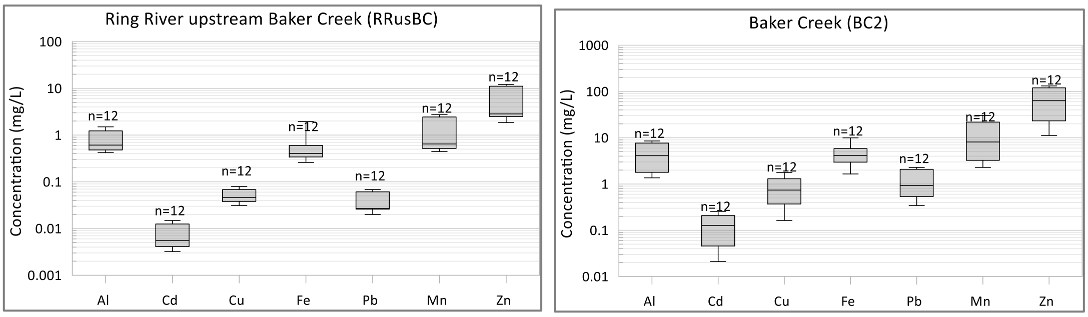


Figure 8-8. Box and whisker plot of total metal concentrations in the Ring River upstream of Baker Creek (left) and Baker Creek upstream of Ring River in 2021-2022 (right). Note log scale on Ring River graph is different from other figures (min = 0.001 mg/L, max = 100 mg/L). Box encompasses the 25th to 75th percentile values.

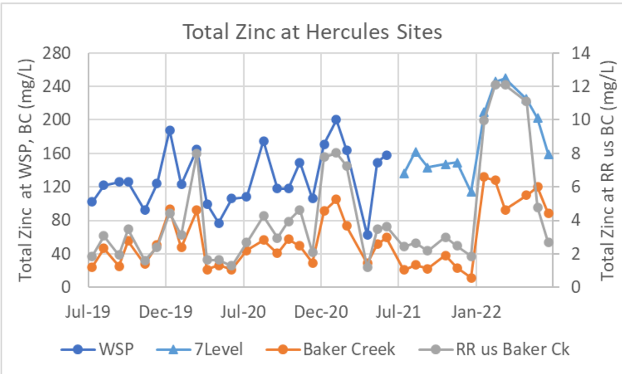


Figure 8-9. Time-series of monthly total zinc results at the 7Level Composite site, Baker Creek and Ring River above Bakers Creek. Note the Ring River results are plotted at a 20-fold lower scale. 7 Level results used in 2021-2022 due to lack of data at WSP.

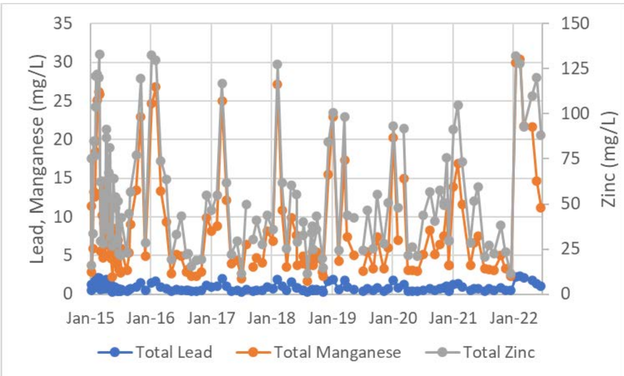


Figure 8-10. Total manganese, zinc and lead in Baker Creek showing similar seasonal trends as previous years.

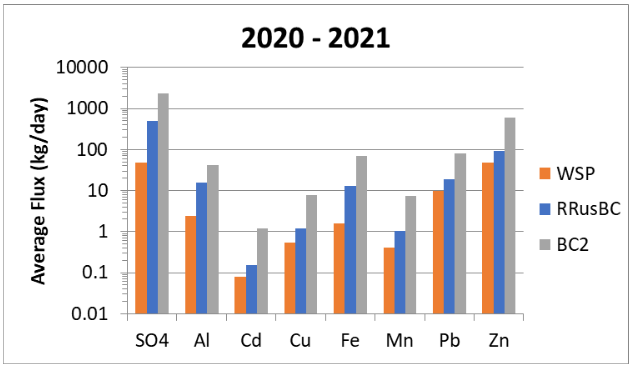
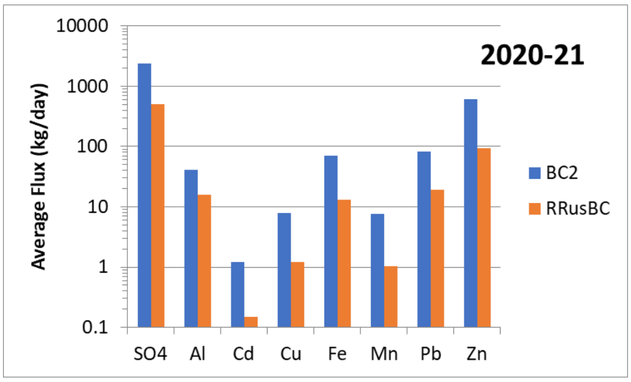
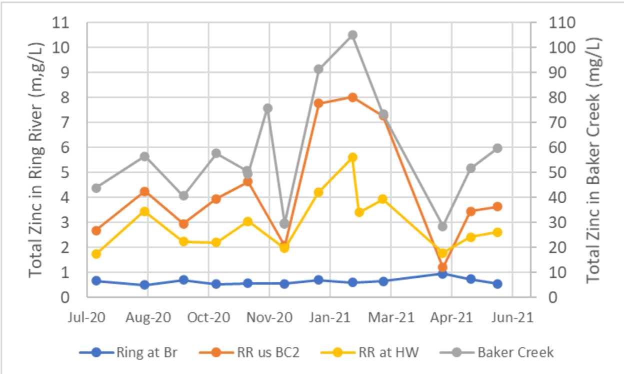


Figure 8-11. Average sulphate and total metal loads in the WSP, Ring River above Baker Creek and Baker Creek based on the monthly monitoring results and daily flow on the monitoring date 2020 – 2021 (top) and 2021-2022 (bottom). WSP results not available for 2021-2022. Note log scale





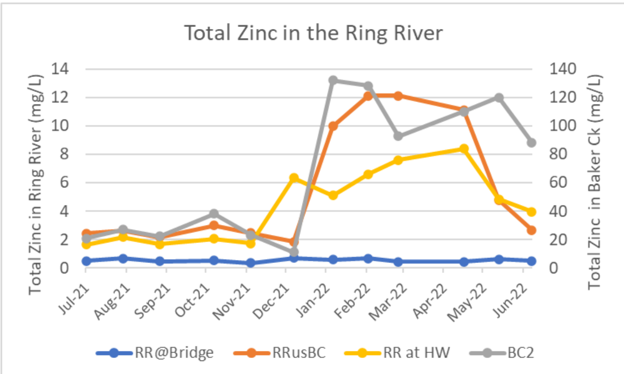


Figure 8-12. Total zinc in Ring River at Bridge upstream of WSP, upstream of confluence with Baker Creek (RR us BC), in Baker Creek upstream of Ring River and at the Murchison Highway (RR at HW). Note Baker Creek scale is 10-times greater than Ring River scale

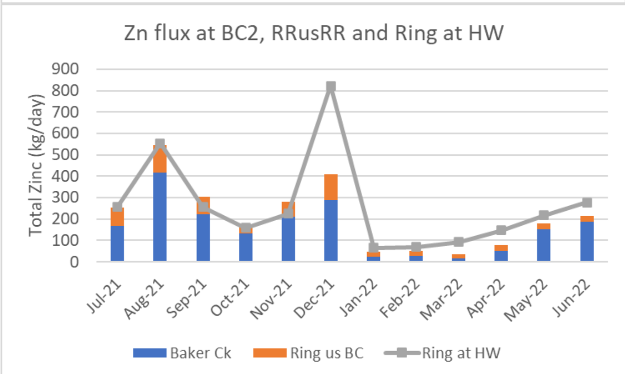


Figure 8-13. Comparison of combined zinc fluxes at Baker Creek and Ring River above Baker Creek, with zinc flux at Ring River at Murchison Highway. July 2021 to June 2022.

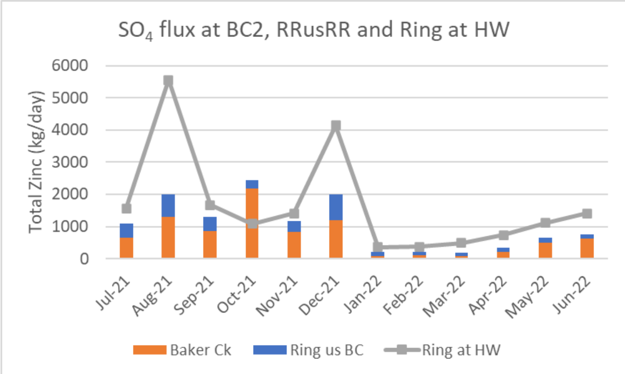


Figure 8-14. Comparison of combined sulphate fluxes at Baker Creek and Ring River above Baker Creek, with sulphate flux at Ring River at Murchison Highway Oct 2021 to June 2022.

9 Stormwater monitoring

A summary of the stormwater monitoring results collected in 2021-2022 on the Rosebery lease is contained in Table 9-1. The improved collection and treatment of stormwater on the mining lease over the past years has resulted in a large reduction of runoff from the site. All flow in upper Filter Plant Creek (FPC1 and FPC2) and Primrose Creek (PC1 and PC2) is collected and directed to the ETP for treatment. Site FPC3 is located downstream of the Filter Plant ponds and collects predominantly runoff from the residential area, including inflows from historic waste rock located around the residential area. Filter Plant Creek ultimately enters Lake Pieman in the flooded arm of the Stitt River.

Water diverted away from the site via Assay Creek enters the Stitt River below Stitt Falls. Water that has come in contact with the WRD areas is collected and directed to the ETP for treatment and discharge via Bobadil.

Rosebery Creek is relatively undisturbed in its headwaters, has been diverted around the current MMG operational area in its middle reaches, and drains areas containing waste rock in its lower reaches. Rosebery Creek flows into the Stitt River upstream of Stitt Falls.

Table 9-1. Summary of stormwater monitoring results collected on the Rosebery mine lease in 2021-2022.

Requirement	Findings
Monitoring Frequency	Quarterly sampling was completed at all stormwater sites as required.
Compliance with EPN	All sites were monitored for the required parameters at the required frequency. • No samples were collected at FPC1 in December 2021 or June 2022 due to lack of flow • No samples were collected at FPC2 in December 2021 or March 2022 due to lack of flow • No samples were collected at PC1 in March 2022 due to lack of flow There were no accidental releases of stormwater to the environment during the monitoring year.
Significant trends - reporting period	• Stormwater captured wet and dry periods (Figure 9-1). In Assay Creek, flows of 17 L/s were recorded in September 2021, which was the highest flow rate at any site except RC2. In Rosebery Creek, flow was recorded continuously during the year, with maximum flow rates of about 0.6 m^3/s (Figure 9-6).

	• The results at AC1 are higher as compared to AC2, which is attributable to clean water being diverted away from the WRD entering the creek between the two sites. The results were within the historic range of results except for iron which was elevated at AC1 in December 2021 and March 2022. Flow during these sampling runs was negligible due to the prolonged dry summer (Figure 9-2). • In Primrose Creek, the PC1 results were within the historic ranges, and the PC2 results were generally within historic ranges, although lead was lower than previously recorded in March 2022. The concentrations decrease between the sites (Figure 9-3). • In Filter Plant Creek, the FPC1 and FPC2 metal results were elevated in September 2021. TSS values at the sites were 1,170 mg/L and 140 mg/L, respectfully, suggesting the elevated concentrations were due to the high level of particulates. The monitoring results from the other sampling runs were within historic ranges. In FPC3, lead and zinc concentrations were lower in December 2021 and March 2022 as compared to historic results (Figure 9-4). • In Rosebery Creek, the results were within historic ranges. The monitoring results show a large increase in all parameters between the RC1 and RC2 monitoring sites. This is due to stormwater and other diffuse inputs (Figure 9-5). The flow monitoring site has been externally reviewed and found to inaccurately record high flows. The infrastructure will be upgraded in the 2022-2023 monitoring year. • Concentrations in Rosebery Creek were within the historic range except in March 2022 when iron and manganese concentrations at RC1 exceeded previous levels (Figure 9-6). This is a clean water site and the elevated results reflect the dry summer conditions and inflow of groundwater. Flow in lower Rosebery Creek at RC2 ranged from 4 to 98 L/s on the monitoring days, and the associated calculated zinc loads ranged from 6.5 to 19.3 kg/day. The loads are within the historic range of results (Figure 9-6). • Average zinc loads in Rosebery Creek upstream of the Stitt based on the 31 measurements obtained since September 2014 are 22 kg/day, with a median value of 13 kg/day.
Comments	Stormwater monitoring should be revised to reflect water streams leaving the lease site rather than streams that are collected within the Lease site and directed to the ETP. The Closure PFS has completed extensive additional stormwater monitoring and it is recommended that this information should be used to update and refine the stormwater monitoring regime.

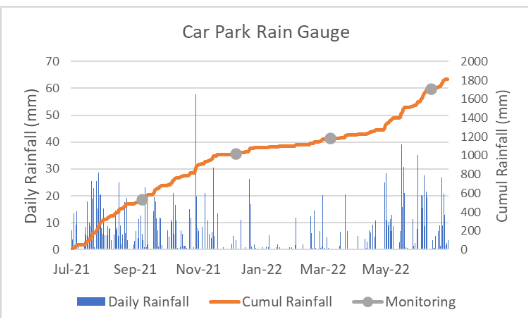
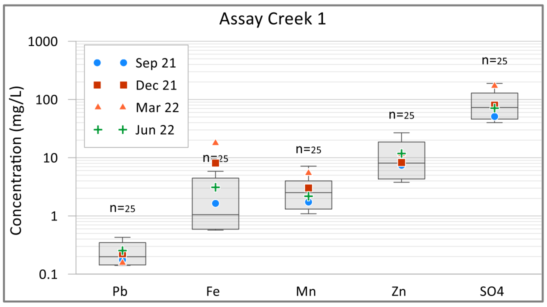


Figure 9-1. Daily rainfall during monitoring year and dates of quarterly stormwater sampling.



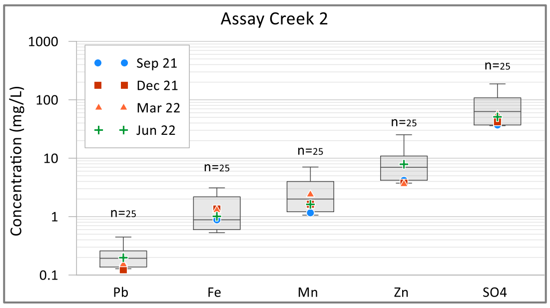
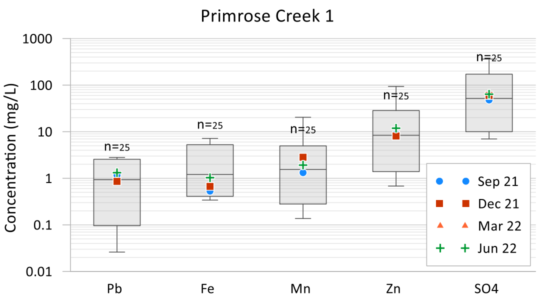


Figure 9-2. Total lead, iron, manganese, zinc and sulphate concentrations in Assay Creek 1 and Assay Creek 2 stormwater sites. The boxes encompass the 5th to 95th percentile monitoring results collected between January 2015 and June 2021, and the monitoring results collected from July 2021 to June 2022 are shown as data points.



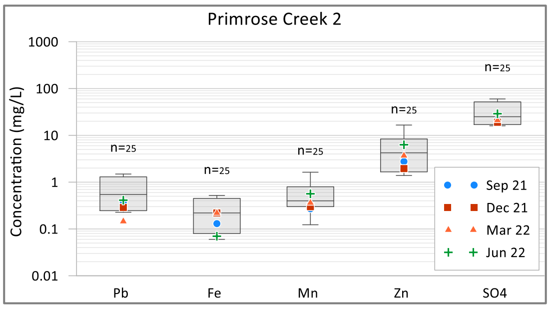
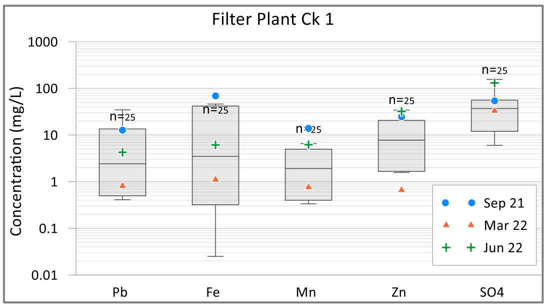


Figure 9-3. Total lead, iron, manganese, zinc and sulphate concentrations in Primrose Creek stormwater sites PC1 and PC2. The boxes encompass the 5th to 95th percentile monitoring results collected between January 2015 and June 2021, and the monitoring results collected from July 2021 to June 2022 are shown as data points.



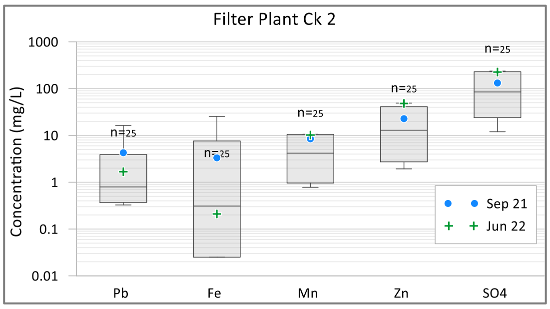
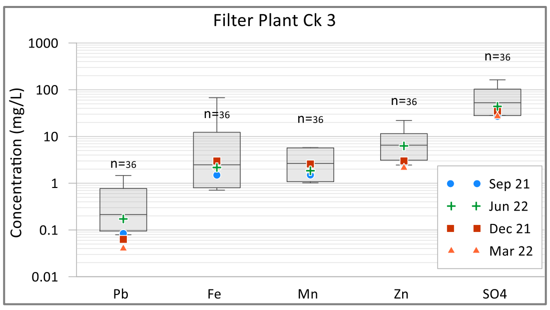


Figure 9-4. Total lead, iron, manganese, zinc and sulphate concentrations in Filter Plant Creek stormwater sites FPC1, FPC2 and FPC3. The boxes encompass the 5th to 95th percentile monitoring results collected between January 2015 and June 2021, and the monitoring results collected from July 2021 to June 2022 are shown as data points.



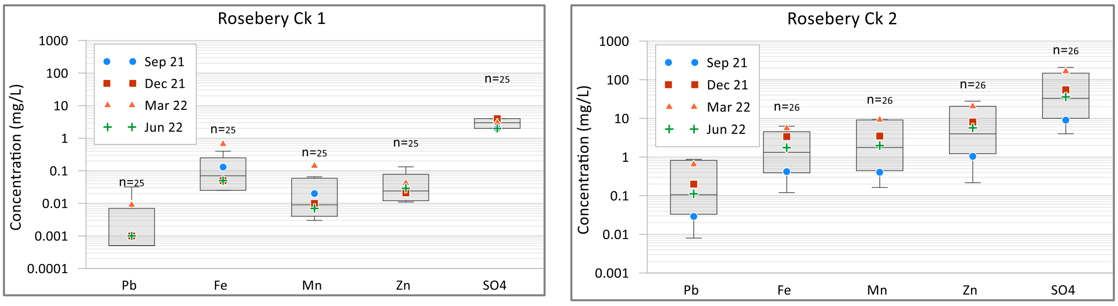


Figure 9-5. Total lead, iron, manganese, zinc and sulphate concentrations in Rosebery Creek stormwater sites RC1 and RC2. The boxes encompass the 5th to 95th percentile results collected between January 2015 and June 2021, and the monitoring results collected from July 2021 to June 2022 are shown as data points.

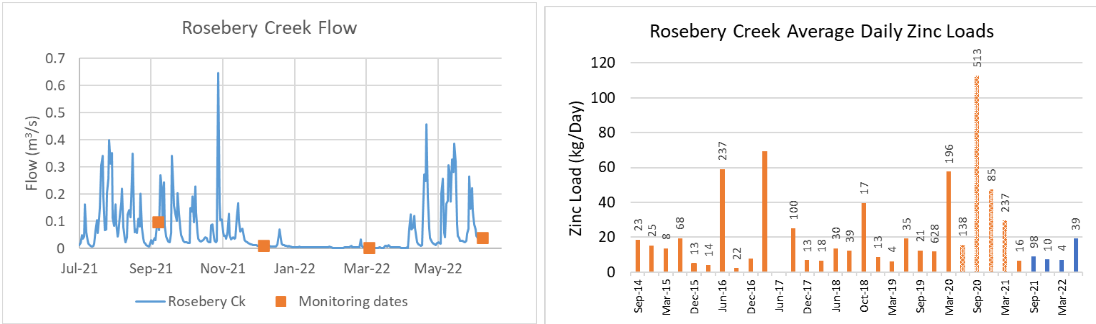


Figure 9-6. (left) Discharge in Rosebery Creek July 2021 to June 2022 and monitoring days (right) Estimated zinc loads at RC2 based on flow measurement at Rosebery Creek gauging site on monitoring days. Data labels indicate the flow rate in Rosebery Creek in L/s on the sampling day. Stippled fill indicates estimated flow, blue bars show 2021-2022 results.

10 Underground Mine Water Monitoring

A summary of the underground mine water monitoring results is contained in Table 10-1.

Table 10-1. Summary of underground mine water monitoring results for 2021-2022.

Requirement	Findings
Monitoring Frequency	Monthly sampling was completed at all sites as required.
Compliance with EPN	All required parameters were monitored.
Comments	At the 17L Pump monitoring results are consistent with concentrations recorded since March 2020, when levels decreased most likely due to an increase in water use underground. Values at all sites are within the range of previous results (Figure 10-1).

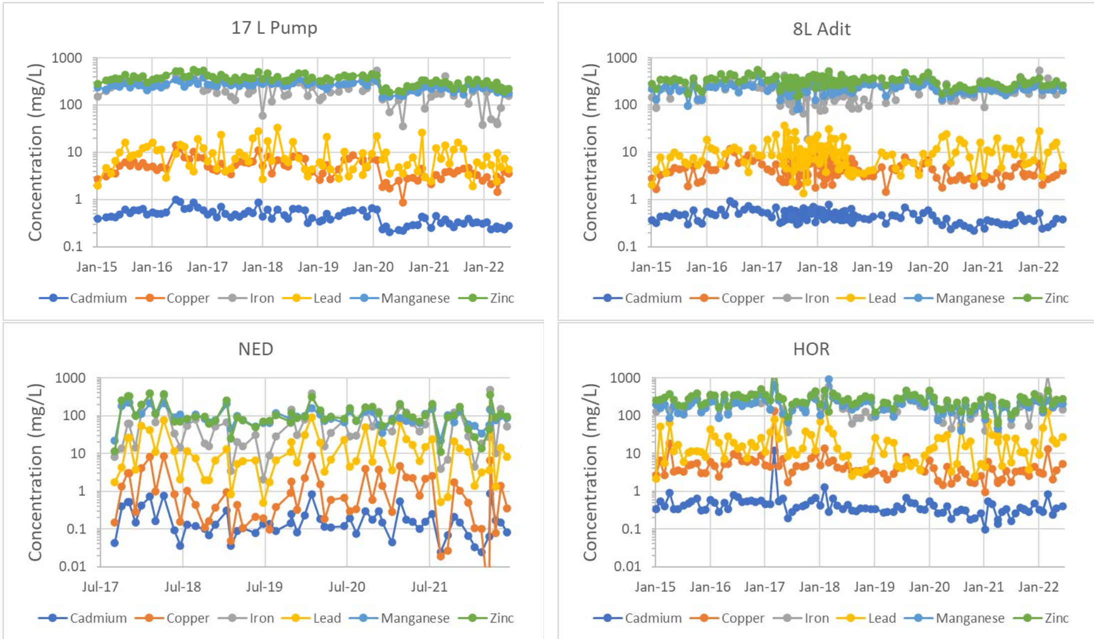


Figure 10-1. Total metal concentrations at underground sites through July 2022. The time series for NED is shorter due to no access to site between 2015 and 2017.

11 Lake Pieman Monitoring

A summary of the monitoring results collected from Lake Pieman is contained in Table 11-1.

Table 11-1. Summary of monitoring results from Lake Pieman in 2021-2022.

Requirement	Findings
Monitoring Frequency	Quarterly water quality sampling and lake profiling was completed as specified in the EPN.
Compliance with EPN	There are no requirements in the EPN other than monitoring frequency and parameters determined. All parameters were determined as required.
Significant trends - reporting period	Operations of the Bastyan Power Station varied during monitoring, with continuous high operation in September 2021, no operation in December 2021, and variable operation in March and June 2022. Discharge from BO was low during each monitoring run, with flows of < 0.8 m^3/s. The EC, temperature and water quality results (Figure 11-2 to Figure 11-7) reflect these flow conditions: • The high power station discharge in September 2021 resulted in low EC values, and low zinc and sulphate concentrations. Slightly higher and variable EC was recorded at PBS3, which is located downstream of the BO inflow and upstream of the Stitt River. No known input from MMG occurs in this area so the source of the variability at PBS3 is unknown. • December 2021 was very dry, and the power station had not operated for several weeks prior to sampling. Flow from Bobadil was low, ~0.2 L/s. EC and temperature results (Figure 11-3) show the lake was stratified, with warmer high EC water overlying more dilute and cooler bottom water. Zinc concentrations were elevated, with mid-

	water at site PBS4 (upstream of the Stitt River) having a concentration of 0.19 mg/L. Total zinc in the BO discharge was <0.01 mg/L, strongly suggesting that the source of the zinc is other inflows, such as the Stitt. Sulphate concentrations were also elevated in December 2021, with maximum concentration in the mid-depth water of the lake at PBS3. • In March and June 2022, the power station was operating intermittently and EC, zinc and sulphate concentrations were lower as compared to December, and similar to historical results when the station is operational. • Although the December 2021 results are elevated, they remain within the range of concentrations recorded in the lake over the past years. • The concentration of zinc in the BO discharge shows no correlation with the concentration of zinc in the lake (BO concentrations shown in Figure 11-4, Surface). This is consistent with the variable rates of mixing that occur in the lake, and the contribution of zinc from other sources. • The filtered zinc results show little difference from the total values for most sites and dates, except in September 2021 when total values at PBS6 in the mid and bottom waters was substantially higher than the filtered results (Figure 11-6). • Sulphate concentrations were ≤12 mg/L except in December 2021, when concentrations ranged up to 81 mg/L in the mid-depth sample at PBS3 (no graph shown). This site and depth also recorded the highest EC value of 208 µS/cm (Figure 11-2). • The median and 95th percentile values for total zinc across all sites were 0.018/L and 0.053 mg/L, respectively, which are above the ANZG (2018) 95th percentile trigger value of 0.008 mg/L. The median is similar to the 90th percentile protection level (0.015 mg/L). These results are well below the No Observable Effects levels of 0.23 mg/L obtained through site specific toxicity testing by MMG using Pieman water and a local ceriodaphnia in 2006. The results for copper were low in 2021-2022, with the median value below the LoR of 0.001 mg/L, and the 95th percentile 0.002 mg/L These values are similar the ANZG (2018) trigger value of 0.0014. The results for cadmium and lead were also below ANZG (2018) 95th percentile values.
Longer term trends	The results from 2021-2022 are consistent with the understanding of mixing within Lake Pieman, and highlight the role hydrology, and especially the power station operations play in mixing in the lake. Sources other than BO are substantial contributors to water quality in the lake.
Comments	The collective Lake Pieman results clearly demonstrate that water quality risks are greatest when the Bastyan Power station is not operating. These conditions should be targeted for monitoring during the dry summer months if feasible (e.g. if the power station is to be shut down for an extended period). Hydro Tasmania should be consulted to identify when these periods are likely to occur. Specific flows do not need to be targeted during the other seasons.

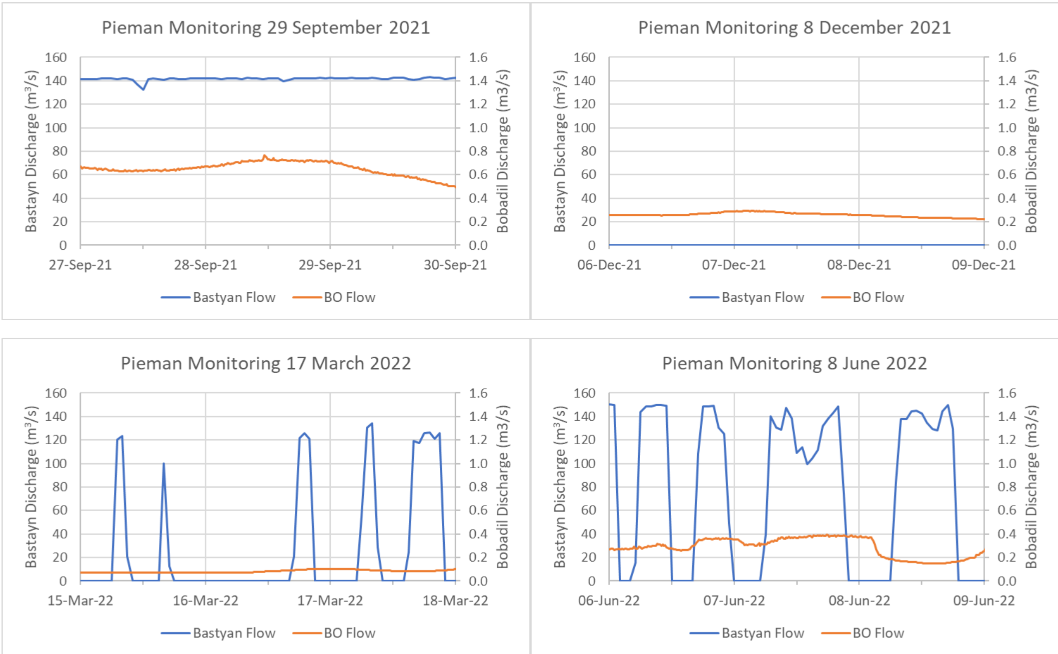


Figure 11-1. Discharge at Bastyan Power Station and Bobadil TSF the two days prior to, and on the day of, Lake Pieman monitoring (sampling dates shown on each graph). Note 100-fold difference in scales for the two discharge sites.

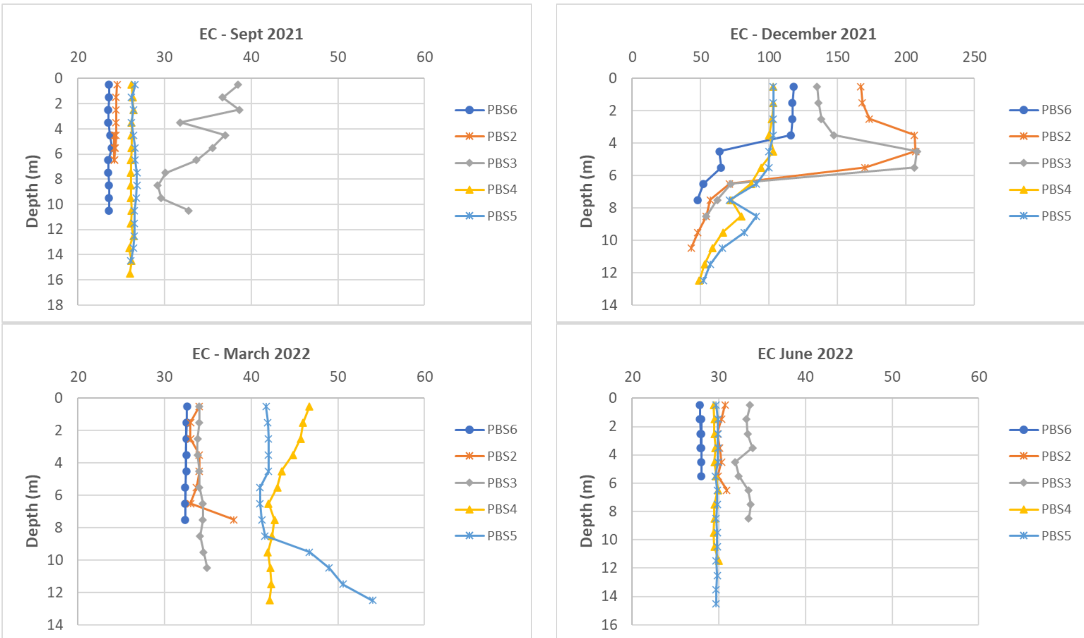


Figure 11-2. Electrical conductivity results for Lake Pieman monitoring sites on each monitoring date in 2021-2022. Results are listed in a downstream direction, e.g. PBS6 is at the upstream end of L Pieman. Note EC scale on December 2021 is different

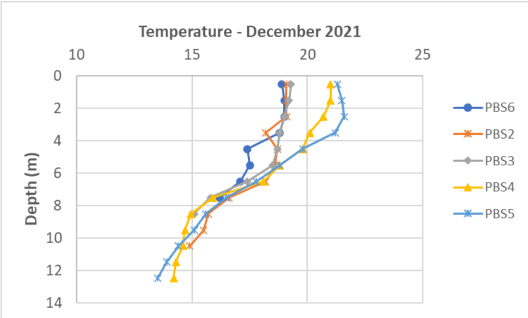
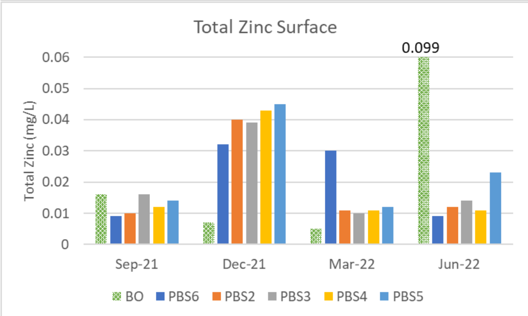
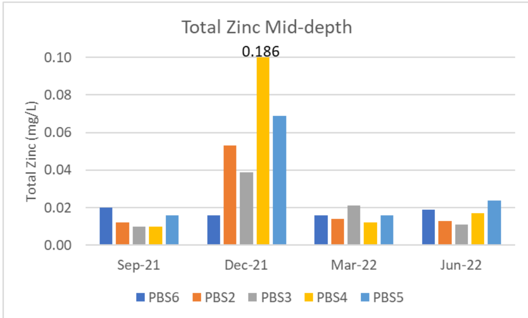


Figure 11-3. Temperature profiles in Lake Pieman in December 2021.





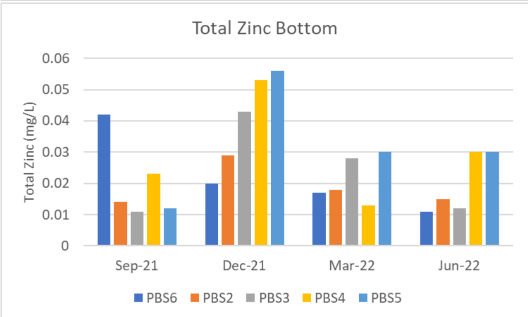
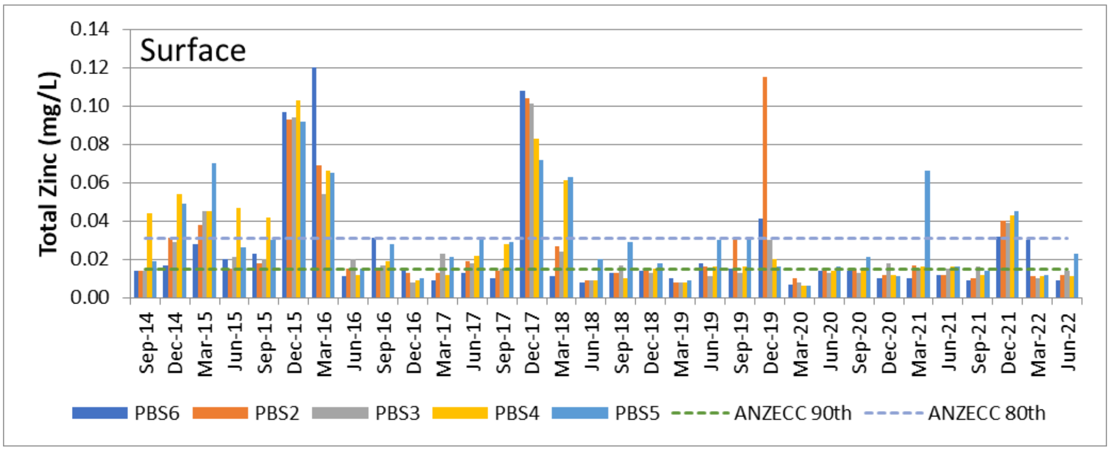


Figure 11-4. Total zinc concentrations in surface, mid-depth and bottom water samples in Lake Pieman in 2021-2022. The surface graph also shows the total zinc concentration in the BO discharge the day before or on the day of Lake Pieman monitoring. Note different axis for mid-depth.



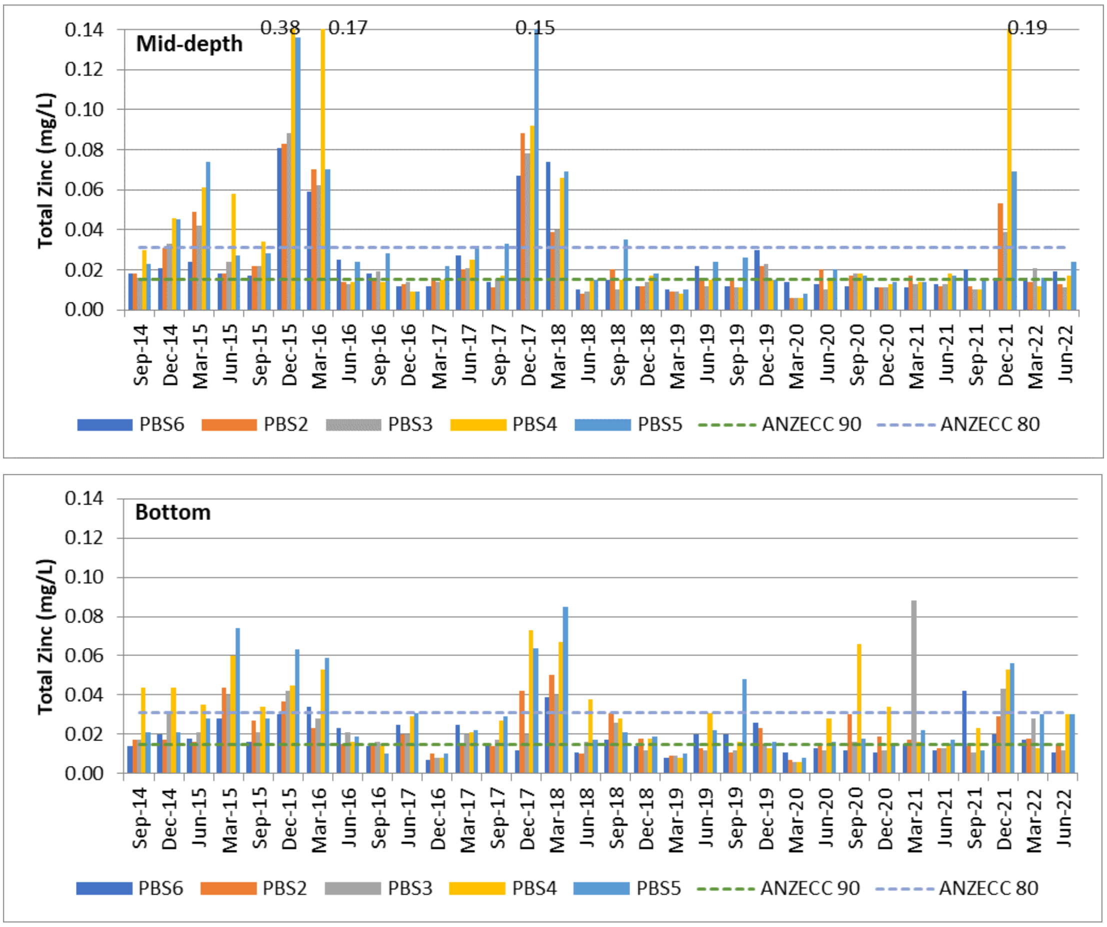
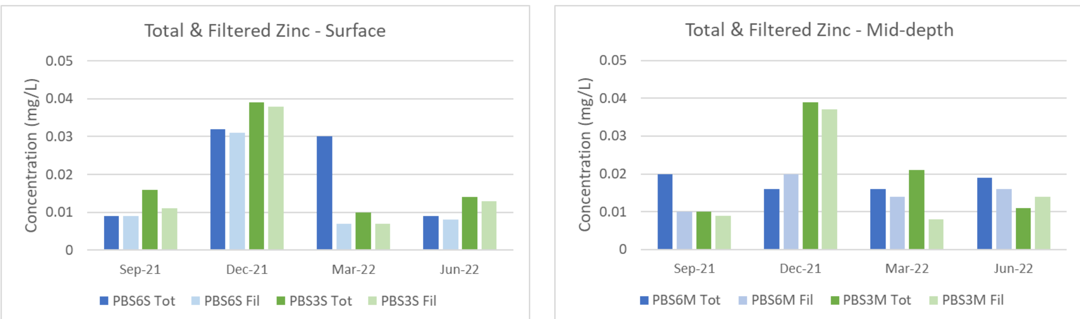


Figure 11-5. Total zinc in surface (top), mid-depth (middle) and bottom water (bottom) samples from September 2014 to June 2022. Labels indicate concentrations that extend beyond the limit of the graph in mid-depth graph.



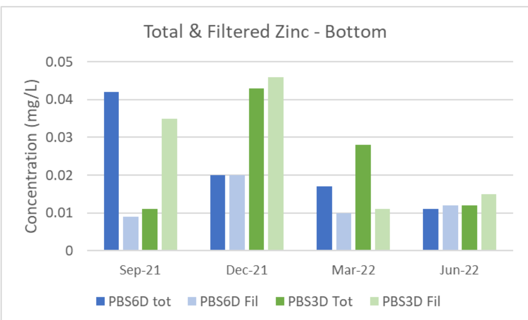


Figure 11-6. Comparison of total and filtered zinc results from PBS6 (upstream BO inflow) and PBS3 (downstream BO inflow) between Sept 2021 and June 2022.

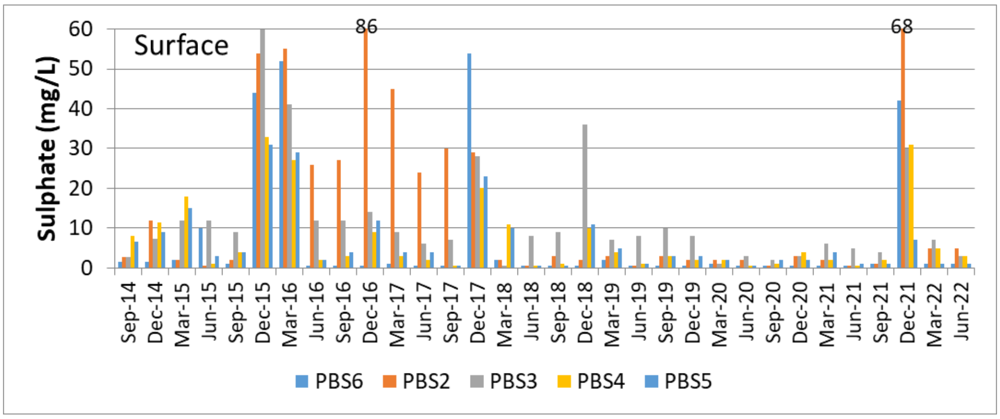


Figure 11-7. Sulphate concentrations in Lake Pieman surface water samples 2014 – 2022.

12 Review of Sampling Procedures and QA/QC of water quality monitoring

Item 2.6 under part G7 of the EPN contains a requirement that the Annual Review include a review of field monitoring procedures, and accuracy of analytical procedures. MMG Rosebery has provided the information upon which the summary in Table 12-1 is based.

Monitoring information provided by MMG Rosebery includes Surface Water and Ground Water Monitoring Procedures that clearly outline the roles and responsibilities of each team member involved in monitoring, data management and reporting, and provides references to the standard methods that are to be adopted for the collection of samples and reporting of results. The procedures include timelines for completing tasks to ensure that reporting requirements under the EPN can be met, and to ensure that management is aware of potential environmental issues as they arise.

No site visit was completed as part of this review, but procedures have remained unchanged since the last site auditing visit in 2018 when all sites requiring monitoring were visited with the exception of the underground sites. All monitoring locations have remained unchanged since the last site visit, except for the inclusion of some new sites associated with the 2/5 TSF and Stitt River. The staff have confirmed that there have been no changes to the monitoring procedures in the 2021-2022 year.

Based on information provided by the company, a new QA/QC program was implemented in 2019/2020 to ensure consistency between all environmental field technicians. The program consists of a series of field task observations to verify both technician competency and compliance with site procedures. Results are recorded and analysed with feedback provided to improve sampling consistency.

No laboratory visit or audit has been included as part of this review, but all results included in this review were completed in a NATA certified laboratory (ALS) which is subject to ongoing review and QA/QC checks under the NATA certification process. The laboratory runs duplicates of 1 in every 20 samples which must pass the internal QA/QC limits of the laboratory. Based on this, much of the discrepancies between the Compliance and Field duplicate samples are likely attributable to environmental variability rather than errors in sampling or analysis.

Table 12-1. Summary of field monitoring practices, applicability of monitoring sites and monitoring frequency, and analytical methods used by MMG Rosebery during the 2021-2022 monitoring year.

Requirement	Findings
Accuracy of the Sampling Procedures	• Water quality samples are collected by trained environmental contractors or the professional environmental staff at MMG Rosebery according to the standard monitoring procedures established by MMG. Samples required for EPN compliance are collected and submitted to a NATA approved lab using appropriate CoC procedures (ALS Melbourne). Field duplicates are collected at a rate of 1 per 20 samples and are also submitted to the primary lab with the locations selected on a random basis. The Relative Percent Difference (RPD) between the primary and duplicate sample results are tracked, and all discrepancies greater than 50% are noted in the data base. • A comparison of the weekly compliance results with field duplicates for a total and filtered metal (total and filtered zinc), nutrient (total nitrogen) and a 'general' parameter (total calcium) collected at BO are shown in Figure 12-1 through Figure 12-3. The compliance and duplicate total zinc values show some discrepancies, which is likely attributable to varying amounts of particulate matter in the samples. • The compliance and duplicate samples for filtered zinc show good agreement for 9 out of the 12 sampling dates when duplicates were selected. There is a large discrepancies in the August 2021 sample. On this date the total, filtered and duplicate total zinc values were all below the LoR. The elevated duplicate filtered zinc sample was investigated by the laboratory and found to be within experimental variation by the laboratory. No apparent cause was identified and this value is considered an outlier. In November 2021, the duplicate filtered zinc value was 0.02 mg/L as compared to the compliance sample of 0.0025 mg/L. The total zinc result on this day was also 0.02 mg/L. It is plausible that some fine particulates were in the duplicate sample that were not removed during filtering. It is also possible the sample was not filtered as required. A review of the documentation indicates this was the only filtered sample included in the duplicate list so filtering may have been overlooked. • TN values differed by up to 1.1 mg/L, which is also likely due to different amounts of fine particulates in the samples. • Calcium showed good agreement between the compliance and duplicate data sets. • The MMG Rosebery Mill is responsible for maintenance of the pH and EC probes used for continuous monitoring. MMG contract Entura to manage the water level probe at BO, the water level probe at the clean water diversion at 2/5 dam and the water level and water quality probes at Hercules. • Field probes are calibrated weekly as part of the routine monitoring by monitoring personnel according to the established procedures. Backup field instruments are

	calibrated and maintained on site. There are some discrepancies between continuous recording EC, field EC and laboratory EC at BO and at the Hercules monitoring site, and between field and continuous pH readings at the Hercules sites. Intercalibration between the continuous probes and the field and laboratory probes should be routinely conducted.
Applicability of sampling schedule and monitoring locations	• The sampling schedule at the BO outfall is suitable for capturing the water quality variability at the point of discharge. The continuous pH measurements at BO guides management of the ETP and provides an accurate indicator of the discharge water quality. • The monitoring plan and supplementary monitoring carried out by MMG for 2/5 dam is adequate to capture environmental releases from the dam to the environment should they occur, and to guide internal management. • There are inconsistencies within the EPN with respect to monitoring frequency at a number of sites, with parameters required to be monitored on both weekly and monthly, or monthly and 6-monthly basis. These should be reviewed and corrected. • The monitoring schedule and parameters required to be determined at all sites should be reviewed to ensure the information gained is relevant to present operations and providing useful information. The review should identify parameters at BO which are consistently below the discharge limits and could be considered for less frequent monitoring or elimination from the monitoring schedule.
Accuracy of analytical test methods	All field and analytical methods used in the determination of water quality parameters are consistent with established and appropriate methods. Analytical results are determined by independent NATA registered laboratories, and all water quality results provided by the labs incorporate QA/QC information, including results for blanks and replicates. The results from all internal and laboratory duplicate analyses are maintained within the water quality database along with the primary sample results enabling comparison of results. NATA registered labs only report results which are within the internal QA/QC limits of the lab, so the laboratory analyses are considered accurate within the context of NATA testing.
Recommendations	The MMG Closure PFS is providing a wealth of new information about the water quality and hydrology of the site. The results from these intensive investigations should be used as the basis to revise the monitoring regime at MMG. The construction works at the 2/5 TSF associated with the Stage 2 embankment will also affect the hydrology of the area and will necessitate a review of monitoring sites, frequencies and parameters at the TSF.

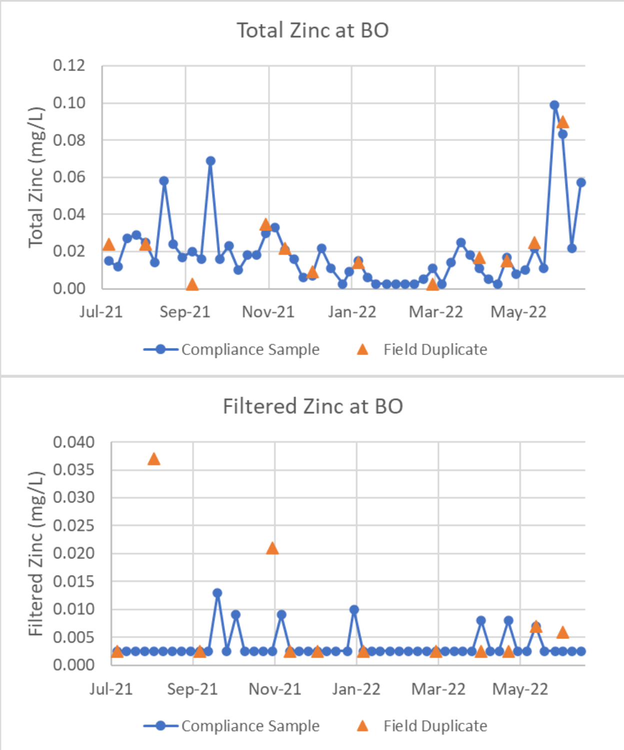


Figure 12-1. Comparison of weekly compliance sampling with field duplicates in (top) total zinc and (bottom) filtered zinc results collected at BO 2021-2022.

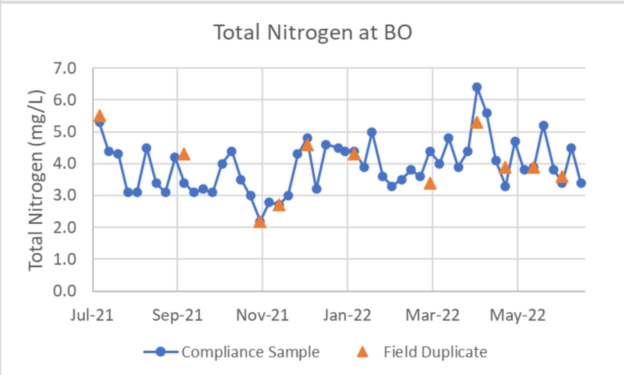


Figure 12-2. Comparison of total nitrogen results at BO in weekly compliance monitoring and Field duplicate samples collected in 2021-2022.

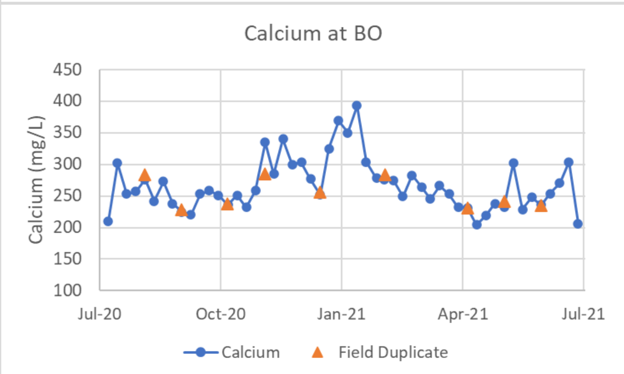


Figure 12-3. Comparison of total calcium at BO in weekly compliance monitoring and in field duplicate samples collected in 2021-2022.

13 3 Level Waste Rock Dump (EPN 8815/2)

During the 2021 – 2022 monitoring year, no additional waste rock was added to the 3 Level waste rock dump.

13.1 Surface water monitoring

A summary of the monitoring results collected from surface water sampling sites is contained in Table 13-1.

Table 13-1. Summary of surface water monitoring results for 3 Level WRD in 2021-2022.

Requirement	Findings
Monitoring Frequency and Parameters	Surface water monitoring is required to be completed on a quarterly basis as the 2015 EPN specifies monthly monitoring for 3-years, followed by quarterly thereafter. Monitoring was completed as required at all sites for all parameters when water was present. • No sample was collected at OC3 in March 2022 due to a lack of flow • No samples were collected at OC5 in December 2021 or March 2022 due to a lack of flow
Compliance with EPN – Assessment of surface water impacts from the 3 Level WRD	The EPN requires an assessment of surface water impacts associated with 3 Level WRD. • Surface water impacts beyond the immediate area of the WRD are minimal as surface runoff from the 3 Level WRD is collected at the 4 Level settlement pond and directed to the ETP for treatment and discharge via the Bobadil TSF. There were no discharges from the settlement pond to Rosebery Creek during the 2021-2022 monitoring year. • pH and zinc results from OC3, OC4 and OC5 are within the range of previous results, with OC3, located at the toe of the WRD having the lowest pH and highest zinc values (Figure 13-1, Figure 13-2). In 2021-2022 zinc in OC3 ranged from 68 mg/L to 205 mg/L , which is the highest concentration recorded since 2017. The OC3 results since 2020 are showing an increasing trend. Maximum filtered zinc concentrations at OC4 and OC5 were 12.3 mg/L and 1.59 mg/L, respectively. • OC5 continues to have the highest pH values and generally the lowest zinc concentrations consistent with this site being the clean water diversion. • Average zinc and sulphate concentrations in Rosebery Creek are consistent with historic results, except at RC1000 which is above the influence of the 3L WRD. The annual averages are skewed by elevated concentrations recorded in June 2022 for these parameters and other metals. The source of the increase is unknown. • Total zinc increases with distance downstream, reflecting diffuse inputs rather than surface discharge from the WRD or open cut as all runoff is collected and directed for treatment (Figure 13-3, Figure 13-4).

	• A time-series of total zinc upstream (RC1) and downstream of the 3L WRD area (RC2) is shown in more detail in (Figure 13-5). Concentrations at RC2 are up to 100-fold higher than RC1. RC1 shows relatively uniform zinc concentrations since 2014, whereas RC2 shows episodic elevated zinc values, including an elevated value during the dry March 2022 period. • Other metals at the site recorded concentrations within the range of previous monitoring (Figure 13-6). The results reflect rainfall patterns, with the September 2021 results towards the lower range of concentrations and the March 2022 concentrations near maximum concentrations.
Significant trends - longer period	All surface runoff from the 3L WRD continues to be collected and directed to the ETP for treatment. The increase in zinc and sulphate in Rosebery Creek is attributable to diffuse sources entering the waterway. There continues to be a large increase in zinc at RC1820 as compared to RC1 (10-fold) but only a small increase in sulphate (<10 mg/L) suggesting the zinc may be derived from sources other than sulphide oxidation.

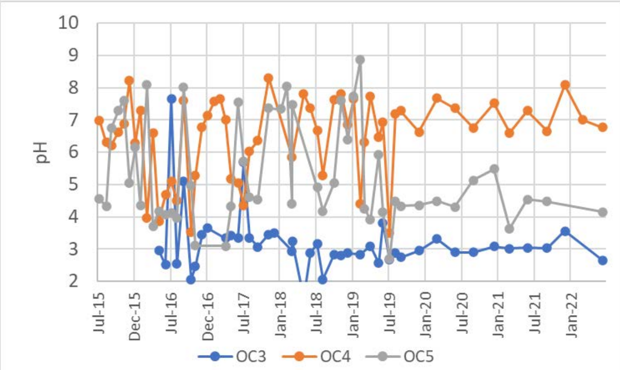


Figure 13-1. Time-series of pH in OC sites June 2015 – June 2022.

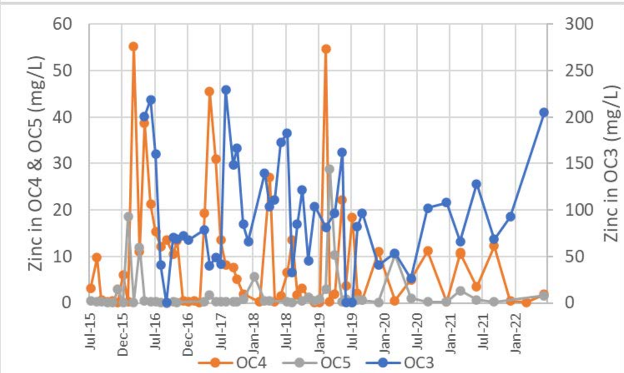


Figure 13-2. Time-series of total zinc in OC sites June 2015 – June 2022.

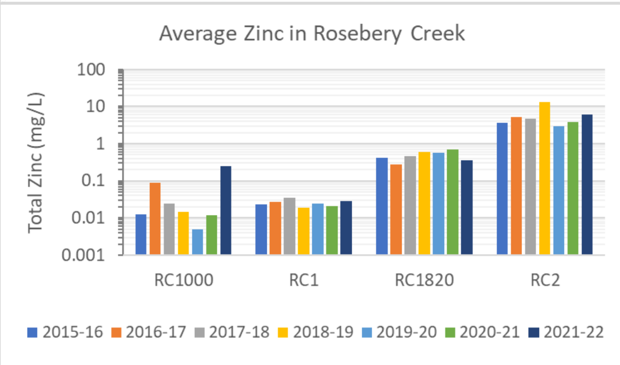


Figure 13-3. Average total zinc concentrations in Rosebery Creek in 2015 – 2021 monitoring years RC1000=background, RC1=upstream of WRD and open cut, RC1820 downstream of 3L WRD and open cut, RC2=upstream of confluence with Stitt River below all mine inputs.

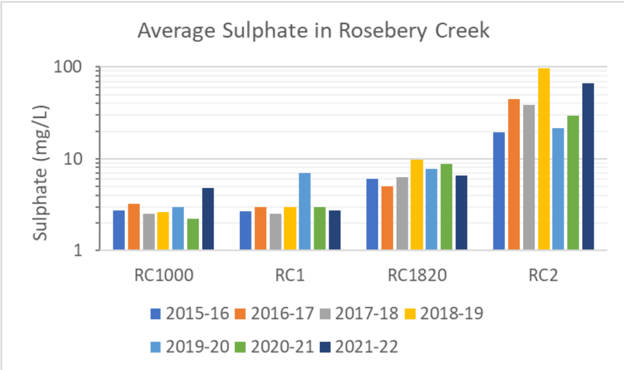


Figure 13-4. Average sulphate concentrations in Rosebery Creek in 2015 – 2022 monitoring years.

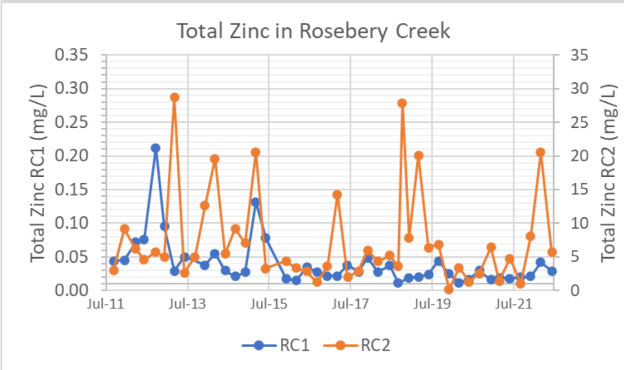


Figure 13-5. Comparison of total zinc concentrations at RC1 and RC2 from July 2011 to June 2022.

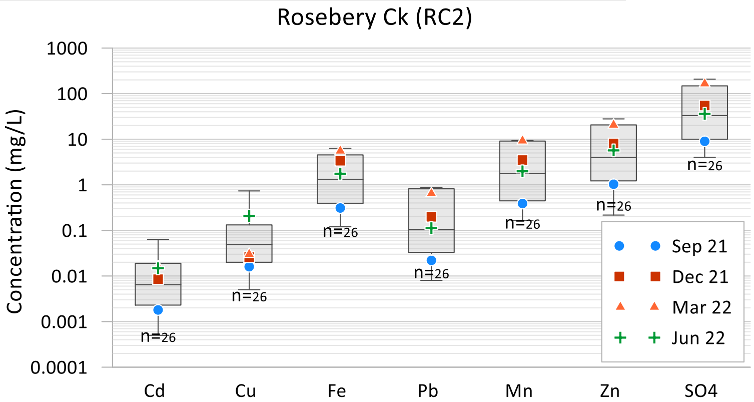


Figure 13-6. Total metals and sulphate at RC2 in 2021-2022 compared to results from Jan 2015 to June 20. The boxes encompass the 5th to 95th percentile values.

13.2 Groundwater monitoring

A summary of the monitoring results collected from ground water sampling sites is contained in Table 13-2.

Table 13-2. Summary of groundwater monitoring results at 3 Level WRD 2021-2022.

Requirement	Findings
Monitoring Frequency and Parameters	Groundwater sampling at the 3 Level WRD was completed on a six-monthly basis as required. Parameters were determined as required when water was able to be collected from the bores. • GB25D is no longer monitored as it was difficult to sample and the EPA approved removal of the site from the monitoring schedule in September 2020. • No field measurements were completed for bores GB36 and GB44 in October 2021, and no field measurements or water samples were able to be collected from the same bores in April 2022. Additional parameters are reported for the ground water bores that are not listed in the EPN.

Compliance with EPN – Assessment of groundwater impacts from the 3 Level WRD	The EPN requires an assessment of groundwater impacts associated with 3 Level WRD. The relative position of the groundwater bores is shown in Figure 13-7. • Monitoring results were within the range of previous results for pH, zinc, and sulphate (Figure 13-8 to Figure 13-10) except at GB46 where the recorded pH in April 2022 was lower than previous results. • Bores near the top of the valley (GB21-GB25) continue to have higher pH and lower zinc and sulphate concentrations as compared to bores located downslope of the WRD and open cut. • The bores at the base of the WRD (GB27, GB36, GB44, GB46) are characterised by low pH and elevated zinc and sulphate concentrations. • Bore GB27, located within the PAF material in the WRD has consistently recorded the highest concentrations with lead, manganese and zinc levels of 1-2 g/L and sulphate concentrations of ~10 g/L (Figure 13-11), and the lowest pH values. • Water levels in the bores at sites upslope of the WRD (GB21, GB22, GB23) showed little change at most sites between April 2021 and November 2022. Between Oct/Nov 2021 and Apr/May 2022 water level decreased substantially in all bores where level was recorded. At GB21 and GB46, water level decreases of between 2.5 and 3.0 m were recorded. The water level results are consistent with regional groundwater in elevated areas decreasing over the very dry summer months. The large decreases likely promoted the draining of oxidation products from the area, accounting for the elevated metal and sulphate concentrations recorded in Apr/May 2022.

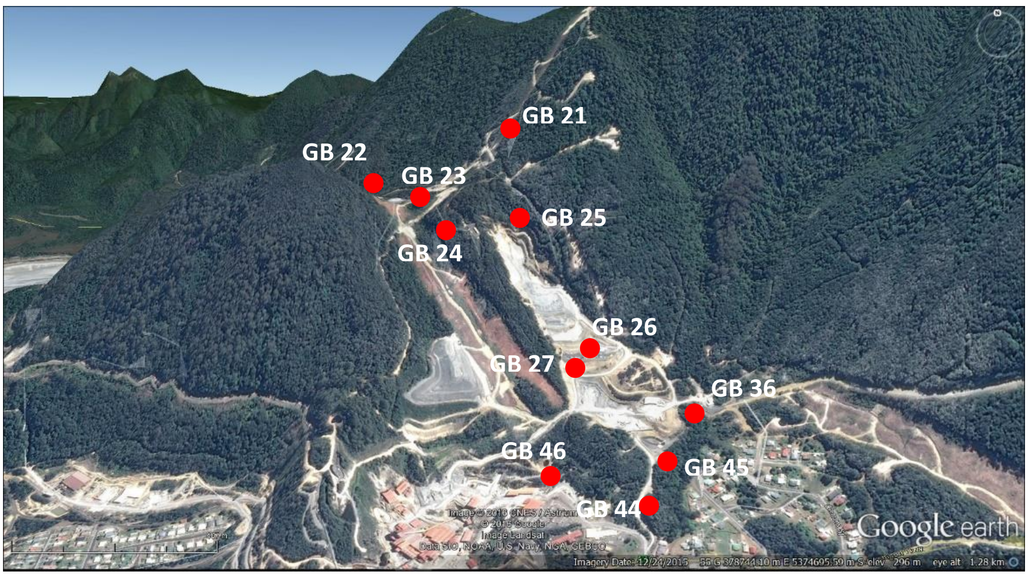


Figure 13-7. Vertically exaggerated view of 3L WRD showing approximate relative position of groundwater bores.

Significant trends - longer period	Bores GB23 continues to record elevated zinc (11-14 mg/L) and sulphate (103-126 mg/L) concentrations even though it is located well above the open cut and WRD. Identifying the source of this groundwater would be useful for understanding diffuse inputs to Rosebery Creek.

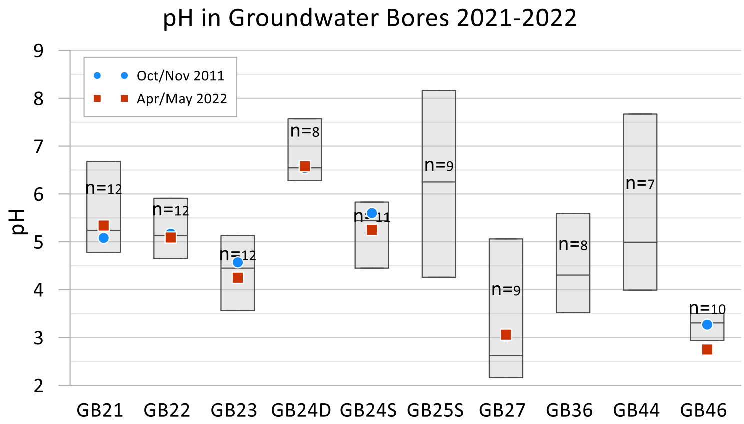


Figure 13-8. pH in groundwater at 3 Level WRD. Box encompasses the 5th to 95th percentile values from 2015 to June 2021, with the 2021-2022 results shown as data points. No data points indicate pH was not recorded at the site.

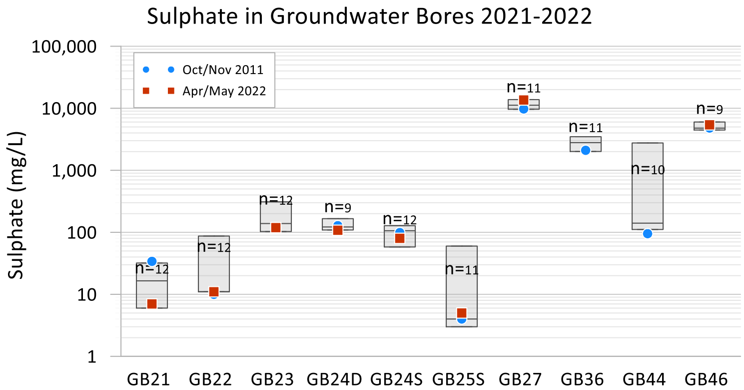


Figure 13-9. Sulphate in groundwater at 3 Level WRD. Box encompasses the 5th to 95th percentile values from 2015 to June 2021, with the 2021-2022 results shown as data points. No data points indicate sulphate was not recorded at the site.

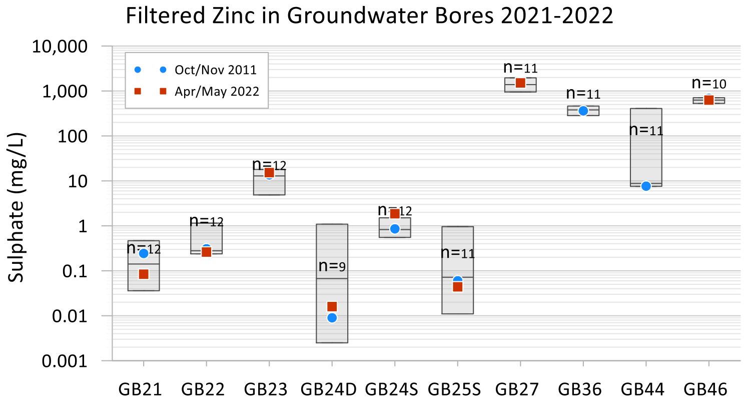


Figure 13-10. Dissolved zinc in groundwater at 3 Level WRD. Box encompasses the 5th to 95th percentile values from 2015 to June 2021, with the 2021-2022 results shown as data points. No data points indicate filtered zinc was not recorded at the site.

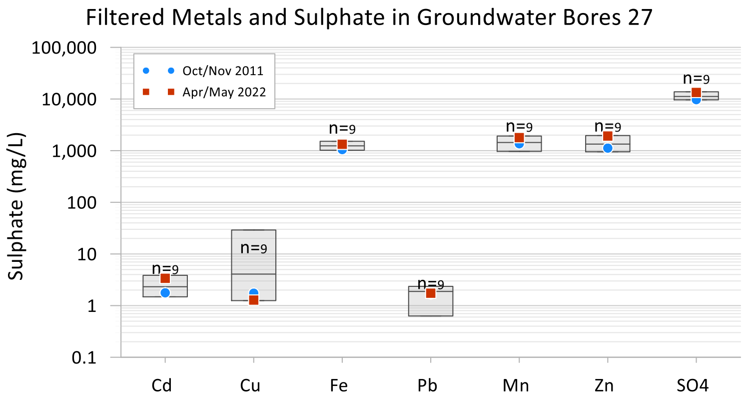


Figure 13-11. Filtered metals in GB27. Box encompasses the 5th to 95th values from 2015 to 2021. Data points show values recorded in October 2021 and April 2022.

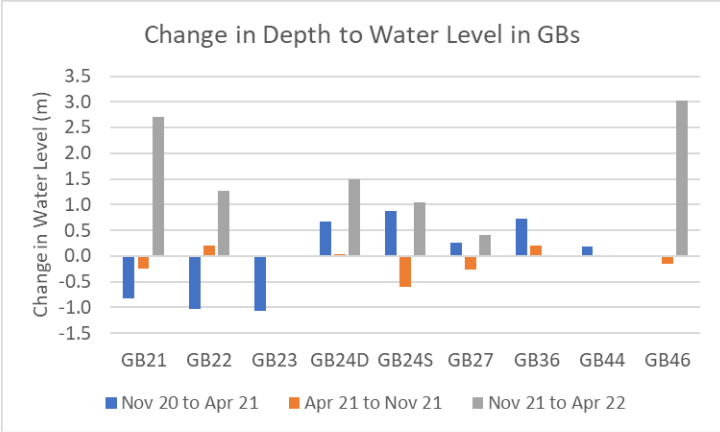


Figure 13-12. Change to the depth to water in the bores between sampling dates. A positive change indicates lower water level (e.g. greater depth to water surface). If no bar is shown it indicates water level was not reported for the monitoring period.

13.3 Lysimeter Gas Sampling

A summary of the gas monitoring results collected from the lysimeters in the 3 Level WRD is presented in Table 13-3.

Table 13-3. Summary of lysimeter gas monitoring results from 3 Level WRD in 2021-2022.

Requirement	Findings
Monitoring Frequency and Parameters	Gas monitoring is required to be implemented at six horizontal gas monitoring pipes over the full construction of the WRD. Only the Stage 2 gas lysimeter has been installed. There are gas lysimeters installed in the Test Pads, but they do not reflect what is occurring within the main dump. Monitoring of the Test Pad ceased in October 2020, and the results until that date are only included here to provide an indication of changes over time within the material. Monthly monitoring for O_2, CO_2 and SO_2 was completed at all sites as required.
Compliance with EPN	The EPN sets a Preliminary Performance Objective of <3% *in situ* O_2 for the gas lysimeters. • All reported O_2 concentrations at the Stage 2 G1 lysimeter exceeded this value during the July 2021 – June 2022 monitoring period (Figure 13-13) indicating oxygen is not being excluded from the waste rock dump. The concentration in the lysimeter is similar to the atmospheric value of 20.95 %. Sulphide oxidation is not inhibited at these oxygen levels. • CO_2 levels in the Stage 2 gas lysimeter varied from 0.025% to 0.045% over the 12-months (Figure 13-14). The six-months of 0.045% readings are the highest sustained values recorded in the gas lysimeter
Significant trends	The results are consistent with the WRD not being fully constructed and capped.

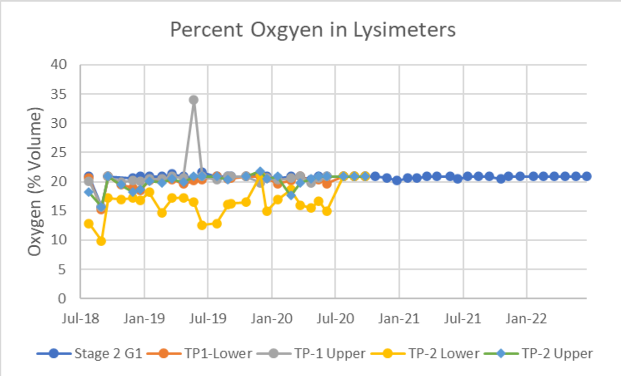


Figure 13-13. Oxygen results from the lysimeters installed in the 3L WRD July 2018 to June 2022.

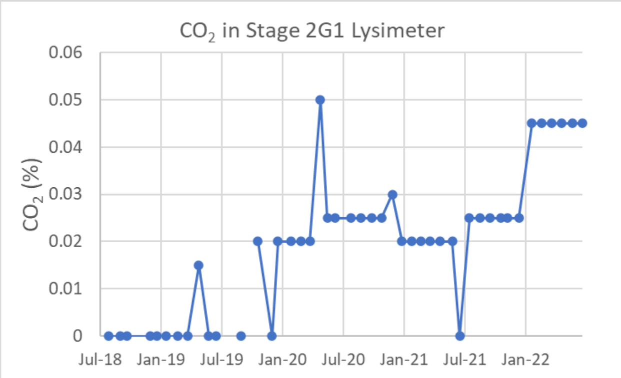


Figure 13-14. Carbon dioxide concentration in Stage 2 gas lysimeter, July 2018 to July 2022.

13.4 Lysimeter Water Sampling

A summary of the water quality monitoring results collected from the lysimeters installed in the 3 Level WRD is presented in Table 13-4.

Table 13-4. Summary of water quality results from lysimeters in 3 Level WRD in 2021 - 2022.

Requirement	Findings
Monitoring Frequency and Parameters	Water testing is required to be completed at six lysimeters across the completed footprint of the 3 Level WRD. To date, two lysimeters have been installed and are monitored on a monthly basis with samples collected if water is present. In 2021-2022, 12 monthly samples were collected in Stage 1 L1 and 6 monthly samples were collected from Stage 2 L1, with the lysimeter dry the other 6 months. All parameters were analysed as required.
-Compliance with EPN	The EPN sets Preliminary Performance Objectives for pH, EC, Acidity and Alkalinity as indicated in Table 13-5. • pH values are within Performance Objectives in both lysimeters. • All EC values exceeded the Performance Objective at the Stage 1 L1 lysimeter. EC values in the Stage 2 L1 lysimeter were all well below the target. • Acidity values achieve the Performance Objective threshold in both lysimeters. • Minimum alkalinity values were at or above 1 mg/L at both sites, thus achieving the Performance Objective. • Sulphate in Stage 1 L1 ranged from 847 mg/L to 1,100 mg/L, but in Stage 2 L1 were all <5 mg/L, suggesting oxidation is occurring at the Stage1 L1 site.

- The pH and alkalinity values in the Stage 1 lysimeter combined with the elevated sulphate concentrations at the site are consistent with the dump creating neutral mine drainage. The generated sulphate contributes to the elevated EC value.

Table 13-5. Summary of water quality in lysimeters measured between July 2021-June 2022. L= lab result, F = Field reading

	Min pH	Max EC	Max Acidity	Min Alkalinity	Comment
Prelim. Perf Target	>4.5 pH unit	<600 µS/cm	<50 $mgCaCO_3$	>1 $mgCaCO_3$	
Stage 1-L1	6.4 L 6.2 F n=12	1940 F 2290 L n=12	35 n=12	11 n=12	Max alkalinity =44 mg/L
Stage 2-L1	5.9 L 7.1 F n=6	69 F 14 L n=6	1 n=6	1 n=6	5 acidity values<1 mg/L

- Sulphate results in Stage1 L1 ranged from 950 to 1,080 mg/L, but in Stage 2 L1 were <1 mg/L on all sampling runs. This indicates that oxidation is occurring in the area monitored by the Stage 1 L1, but not near the Stage 2 L1.
- Metal concentrations in the Stage 1 and Stage 2 lysimeters are relatively low. Maximum zinc concentrations were 0.10 mg/L in Stage1 L1 and 0.03 in Stage1 L2. Cadmium, copper and lead had median values below 0.01 mg/L (Figure 13-15).

Significant trends	The water quality results are similar to previous years and consistent with sulphide oxidation occurring within the waste rock dump and being neutralised by carbonate to produce 'neutral rock drainage'.

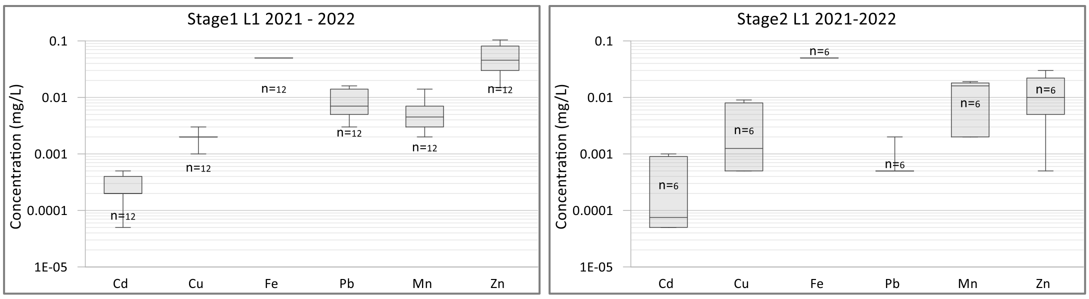


Figure 13-15.Filtered metal concentrations the Stage 1 and Stage 2 lysimeters, July 2021 – June 2022. The box encompasses the 25th to 75th percentile values.

14 South Hercules Mine Phase 1 (EPN 8034/1)

The South Hercules mining lease is managed by MMG Rosebery under a Care and Maintenance Plan approved by the EPA Tasmania in May 2015. No mining activity was undertaken within the July 2021 to June 2022 reporting period.

14.1 Surface water monitoring

A summary of the monitoring results collected from surface water sampling sites is contained in Table 13-1.

Table 14-1. Summary of surface water monitoring results for South Hercules July 2021 to June 2022.

Requirement	Findings
Monitoring Frequency and Parameters	MMG monitored surface water on a monthly basis at sites MPW and BC2 consistent with the Closure Plan (GHD 2015). All parameters were monitored on a monthly basis as required.
Compliance with EPN – Assessment of surface water impacts from S. Hercules	• The only compliance criteria in the Closure Plan is monitoring. • pH values are consistent with previous monitoring with pH values at BC2 lower than at MPW due to the influx of acidic water from the Hercules mine site (Figure 14-1). • Zinc and sulphate increase by about 10-fold between the two sites. Manganese is consistently about 6 mg/L at MPW, but ranges from 6 to 14 mg/L at BC2, suggesting that other inflows are contributing about 6 mg/. The PFS Closure study has tentatively identified level 5 and 6 adits as a source of this input. (Figure 14-2, Figure 14-3). • The MPW results show small seasonal changes, while the seasonal variability at the downstream site is much higher, due to the inflow of surface and possibly groundwater (including inflow from adits) from the Hercules mine site. • There is a substantial increase in metal concentrations between the MPW and BC2 monitoring sites due to inflows from the decommissioned Hercules site, which enter Baker Creek downstream of the South Hercules site (Figure 14-4).
Significant trends - longer period & comments	The water quality results are consistent with previous results since the site entered care and maintenance. The monitoring requirement should be reviewed as many parameters have shown long-term stability and could be eliminated from the monitoring schedule or reduced in monitoring frequency (e.g. mercury, nutrients, major ions).

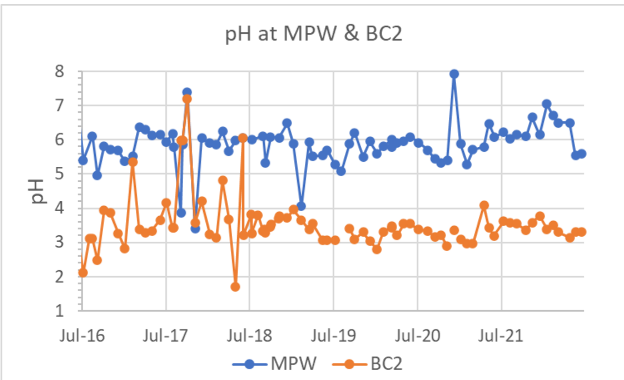


Figure 14-1. pH at the South Hercules surface water monitoring sites MPW and BC2, July 2015 to June 2022.

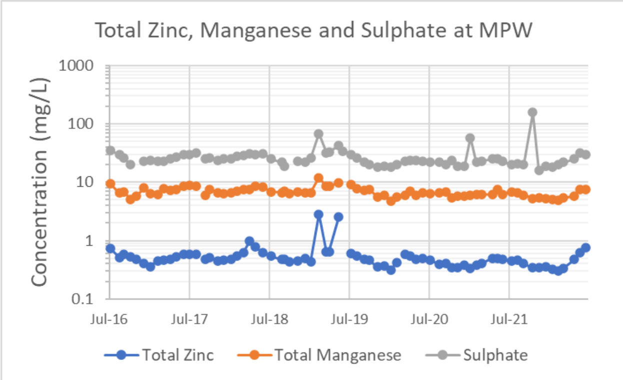


Figure 14-2 total zinc, manganese and sulphate concentrations in the Mine Pit Water at the South Hercules 2015 to June 2022. Note log scale.

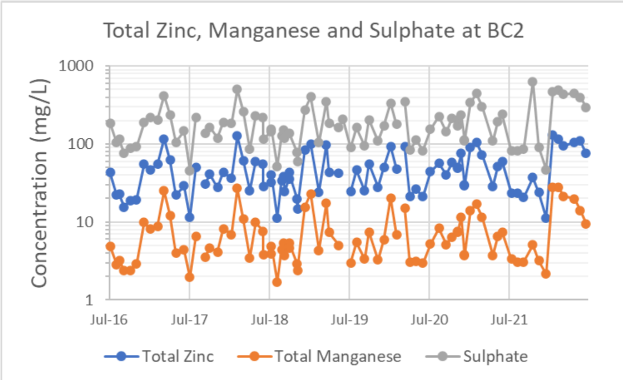


Figure 14-3 Total zinc, manganese and sulphate concentrations at Bakers Creek above Ring River (BC2), July 2015 to June 2022. Note log scale.

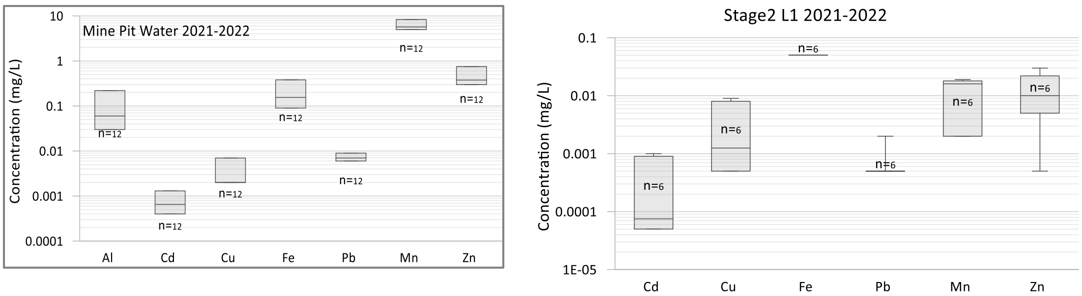


Figure 14-4. Total metal concentrations in the (left) Mine Pit Water at South Hercules and (right) Baker Creek above Ring River. Note difference in log scales with Baker Creek scale 100-times higher than MPW. The box encompasses the 25th to 75th percentile values.

APPENDIX C: ANNUAL AIR QUALITY REVIEW (EY, 2022)

Annual Air Quality Review - FY22

MMG - Rosebery Mine

26 September 2022

Building a better working world

Executive Summary

MMG's Rosebery Mine has an obligation under its Environmental Protection Notice (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) to report annually on aspects of its air quality monitoring programmes (EPN 7153/3 conditions A2-A5, G7 2.7 & PCE 9084 conditions A4-5 & G6 1.7). The air quality monitors include high volume air samplers (HVAS) with co-located DustTraks and dust deposition gauges (DDG). The EPN and PCE include compliance and trigger limits for ambient particulate matter (TSP, PM_{10}) and metals concentrations (lead, cadmium, zinc) and dust deposition rates.

The FY22 period had no deviations from the EPN monitoring requirements as all analysis was completed by ALS Environment in compliance with the Australian Standard for analysis (a NATA accredited laboratory – NATA Accreditation No. 825).

A total of six HVAS samples were considered invalid during FY22 monitoring period. Discussions between MMG and ALS concluded that the issue was due to water damage or moisture on the filter papers due to storage methods. To avoid this issue occurring in the future, the laboratory suggested the filters are placed into individual plastic ziplock bags prior to returning the filter papers for analysis which will minimise sample contamination.

The HVAS and DDG compliance against the relevant EPN and PCE conditions are presented in Table 1 and Table 2, respectively. There were no reported exceedances of the trigger or compliance levels in FY22. No exceedances of the compliance limits indicate that the Rosebery Mine activities are a low environmental risk to air quality and that the current dust mitigation controls are appropriate.

Based on this review, it is recommended that the air quality monitoring network be reviewed and consolidated. Considering the low environmental risk to air quality and the typical high amount of annual rainfall, a small targeted network could provide more meaningful information regarding the mining operations dust impact.

In addition to the annual air quality review, the dust management performance was also reviewed. The review concluded the Rosebery Mine should continue its current mitigation management and mitigation measures. It is also recommended that the proposed mitigation and inspection triggered levels are reviewed within three years to understand if they are sufficient to assist in the continued control of dust from site.

Table 1: HVAS Compliance against EPN Condition A2 and PCE Condition A4

Averaging period	Pollutant	AD3	AD2.1	Giblin St	Alec St	AD3	AD2.1	Giblin St	Alec St
		Trigger Level				Compliance Limit			
24 hour average	TSP	√	√	√	√	-	-	-	-
	PM_{10}	√	√	√	√	√	√	√	√
	Lead (as TSP)	√	√	√	√	-	-	-	-
	Cadmium (as PM_{10})	√	√	√	√	-	-	-	-
	Zinc (as PM_{10})	√	√	√	√	-	-	-	-
Annual average	TSP	-	-	-	-	√	√	√	√
90 day average	Lead (as TSP)	-	-	-	-	√	√	√	√

Notes:
Green ticks denote compliance with the respective trigger level or compliance limit
Grey crosses denote exceedances of the respective trigger level
Red crosses denote exceedances of the respective compliance limit

Table 2: DDG Compliance against EPN Condition A3 and PCE Condition A5

Site	Monthly Deposited Dust above background	Monthly Total Deposited Dust	Annual Average Deposited Dust above background	Annual Average Total Deposited Dust
	Trigger Level		Compliance Level	
AD3	√	√	√	√
AD4	√	√	√	√
AD11	√	√	√	√
AD21	√	√	√	√
AD22	√	√	√	√
BG3	√	√	√	√

Notes:
Green ticks denote compliance with the respective trigger level or compliance limit
Grey crosses denote exceedances of the respective trigger level
Red crosses denote exceedances of the respective compliance limit

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1. Introduction

MMG's Rosebery Mine is an underground polymetallic base metal mine located in the township of Rosebery, Tasmania. MMG has an obligation under its Environmental Protection Notice (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) to report annually on aspects of its meteorological, dust deposition and ambient air quality monitoring programmes (EPN 7153/3 conditions A2-A5, G7 2.7 & PCE 9084 conditions A4-5, G6 & M3).

Condition EPN 7153/3 requires that an analysis of the annual air quality is performed annually. MMG Rosebery Mine engaged EY to complete the annual air quality analysis for FY22. This report provides a summary of the dust deposition and air quality monitoring data against the EPN and PCE conditions. In addition, a review of the dust mitigation plan was performed to understand if the current plan is sufficient to minimise environmental risk.

The purpose of this report is to understand the environmental risk from the operations and activities at the Rosebery Mine and recommend additional monitoring or mitigation where deemed necessary.

1.1 EPN and PCE Requirements

MMG is required to comply with the conditions detailed in EPN 7153/3 and PCE 9084. Table 3 and Table 4 present the compliance limits and trigger levels for the high volume air sampling (HVAS) and dust deposition gauges (DDG) respectively. As per paragraph 2 in section A3 of EPN 7153/3, monthly deposition measurements must be adjusted to account for the background deposition rate. For each sampling month, the background is defined as the minimum of the measured dust deposition rates. Table 5 outlines the sections of this report that address conditions of the EPN section A5-3 Reporting of monitoring.

Table 3: HVAS compliance limits and trigger levels

Pollutant	Compliance limit	Trigger levels
Total Suspended Particles (TSP)	0.090 mg/m^3 annual average	0.150 mg/m^3 24 hour average
Particulate Matter sub 10 micron (PM_{10})	0.150 mg/m^3 24 hour average	0.050 mg/m^3 24 hour average
Lead (as TSP)	0.0015 mg/m^3 90 day average	0.0087 mg/m^3 24 hour average
Cadmium (as PM_{10})	-	0.000003 mg/m^3 24 hour average[1]
Zinc (as PM_{10})	-	0.015 mg/m^3 24 hour average[1]

1. *24 hour average was not specified within the EPN and PCE documents but was applied to be consistent with the other trigger level averaging periods*

Table 4: Dust deposition gauge compliance limits and trigger levels

Pollutant	Compliance limit	Trigger levels
Deposited dust	2.0 g/m^2/month as an annual average increase above background at/or beyond the site boundary.	2.0 g/m^2/month as an increase above background at/or beyond the site boundary (monthly trigger level).
Deposited dust	4.0 g/m^2/month as an annual average at/or beyond the site boundary.	4.0 g/m^2/month as total deposition experiences at/or beyond the site boundary (monthly trigger level).

Table 5: EPN A5-3 conditions and relevant sections of this report

EPN A5-3 condition		Report section
3.1	tabulated high volume air sampler, and dust and metals deposition results for the entire year, showing intermediate values as well as final monitoring results	Final monitoring results are provided in Section 3.1 and 3.2 with additional plots provided in Appendix A
3.2	tabulated annual averages of the deposition increment above background, supported by deposition isopleths or graphs	Section 3.2 with additional plots in Appendix A
3.3	monthly deposition isopleths or graphs of total dust and metal deposition and increment above 'background'	Section 3.2 with additional plots in Appendix A
3.4	Summaries of all exceedances occurring within the reporting year, describing the results of any investigations undertaken and the mitigation measures that were adopted in response	Section 3.1 and 3.2
3.5	Any supporting data analysis or description necessary to aid interpretation of the dataset	Additional plots provided in Appendix A

1.2 Monitoring Locations

As dictated within EPN 7153/3 and PCE 9084, the locations and ID's for the air quality monitoring sites are presented in Table 6 and Figure 1. The monitoring network, required by EPN 7153/3, consists of four HVAS locations measuring both TSP and PM_{10} and eleven DDG's installed across the township of Rosebery, including a background gauge at the Rosebery golf course (BG3). As the criteria presented in Table 4 are applicable to locations at or beyond the site boundary, the trigger levels do not apply to the DDG's AD1.1, AD2, AD5, AD23 and AD25 as they are located within the site boundary. The dust deposition results at these locations are presented in Appendix A.

Table 6: Monitoring locations

Monitoring site ID	Monitoring location description	Location (WGS 84 Zone 55S)	
		Easting (km)	Northing (km)
HVAS (EPN)			
AD2.1	Former PMR Training Centre on Arthur Street	378.63	5,374.00
AD3	15 Beech Street (near the Filter Plant)	377.71	5,374.49
Giblin St	Giblin Street	378.63	5,373.18
Alec St	Alec Street	378.97	5,373.41
DDG (EPN within the site boundary)			
AD1.1	Mine Office Building on Hospital Road	378.81	5,374.19
AD2	Former PMR Training Centre on Mill Road	378.66	5,373.91
AD5	Breaker Station/Crusher	378.65	5,374.23
AD23	Filter Plant Carpark	377.78	5,374.51
AD25	Passing Bay on Filter Plant Road	378.27	5,374.21
DDG (EPN at/or beyond the site boundary)			
AD3	15 Beech Drive (near the HVAS)	377.70	5,374.49
AD4	Near Rosebery Station	378.61	5,373.18
AD11	Front yard of 1 Howard Street	377.90	5,374.38
AD21	Backyard in 9 Murchison St	379.07	5,373.89
AD22	Frontyard of 21 Dalmeny St	379.29	5,373.60
BG3	Rosebery Golf Course	375.59	5,372.78

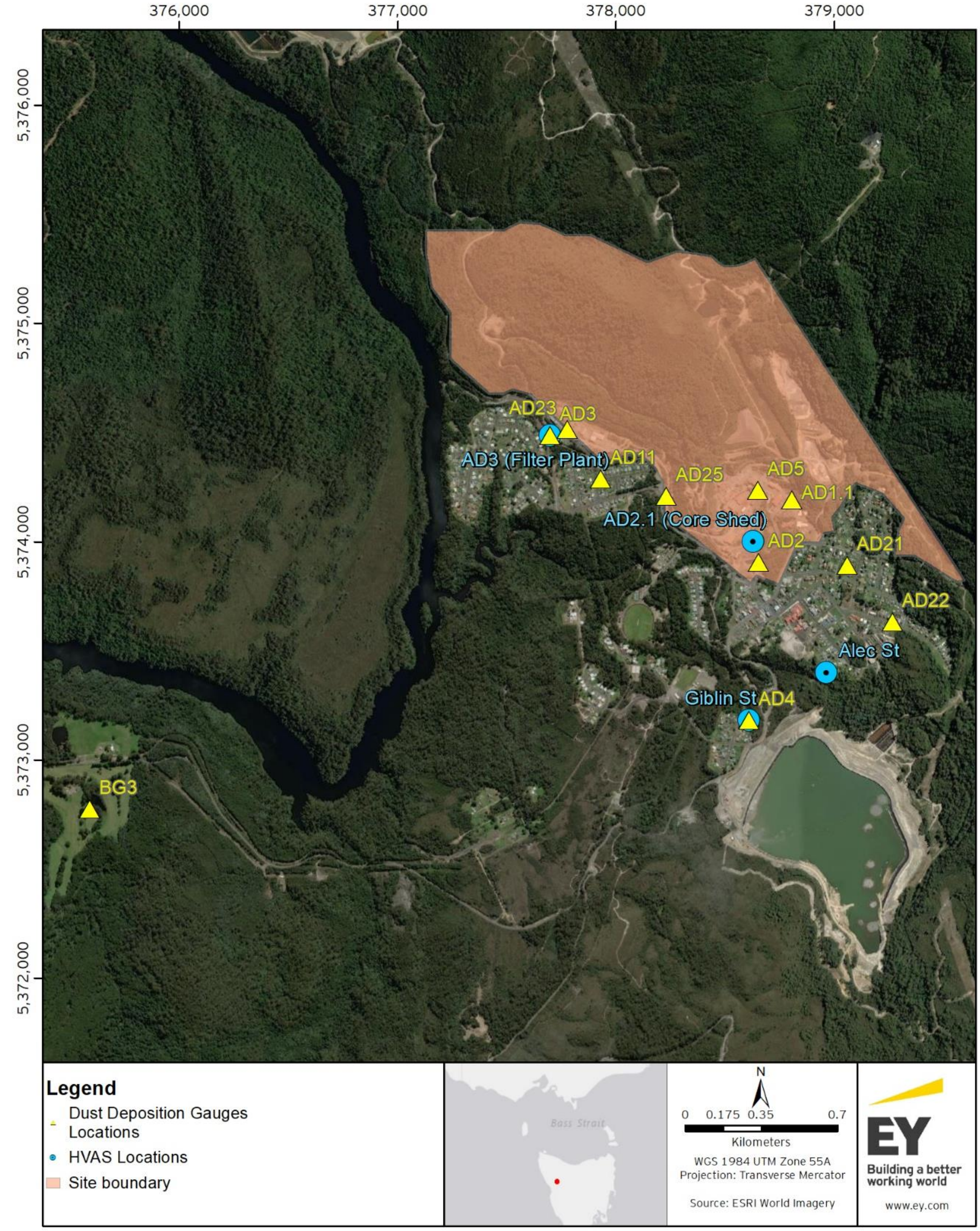

Figure 1: Air Quality Monitoring Locations

2. Sampling Procedures

2.1 High Volume Air Sampling

The HVAS monitors sample TSP and PM_{10} which is then analysed for compositions of lead (as TSP), cadmium (as PM_{10}) and zinc (as PM_{10}). Arsenic and copper are also analysed, however trigger levels and compliance limits of these substances are not included as part of EPN/PCE requirements. Sampling of 24 hour average concentrations (µg/m^3) occurs 1 in every 6 days.

A total of six samples were considered invalid during FY22 monitoring period as summarised in Table 7. Discussions between MMG and ALS concluded that the issue was due to water damage or moisture on the filter papers during transport. To avoid sample contamination occurring in the future, ALS suggested that the filters are placed within individual plastic ziplock bags prior to transporting for analysis.

All HVAS monitors were externally calibrated by Ecotech on 18 January 2022 with periodic internal flow calibrations completed throughout the year.

Table 7: Invalid samples

Sample date	Location	Air pollutant	Comment
3/06/2022	Giblin St	PM_{10}	Results considered invalid due to water damage and moisture on filter papers
9/06/2022	AD3 (Filter Plant)	TSP	
9/06/2022	AD3 (Filter Plant)	PM_{10}	
15/06/2022	Giblin St	PM_{10}	
21/06/2022	AD3 (Filter Plant)	TSP	
21/06/2022	AD2.1 (Core Shed)	PM_{10}	

Sampling and analysis of TSP was performed using the EA143-MV method and referenced to Australian/New Zealand Standards AS/NZS3580.9.3:2015: Determination of suspended particulate matter – Total suspended particulate matter (TSP) – High volume sampler gravimetric method (Australian and New Zealand Standards, 2015).

Sampling and analysis of PM_{10} was performed using Australian Standards AS3580.9.6:2015: Determination of suspended particulate matter – PM_{10} high volume sampler with size-selective inlet – Gravimetric method, Monitoring Analysis (Australian Standards, 2015).

TSP, PM_{10} and metals analysis was performed by a NATA accredited laboratory (ALS Environmental – NATA Accreditation No. 825, Site No. 1656). The HVAS samples were then digested in nitric acid and analysed for metals by inductively coupled plasma mass spectrometry (ICPMS).

There were no recorded deviations from the sampling procedures for the HVAS sampling in FY22. The HVAS air monitoring complies with the applicable elements of EPN condition M1 as samples are analysed as per Australian Standard at a NATA accredited laboratory.

2.2 Dust Deposition Gauges

Monthly dust deposition gauge bottles are sent to ALS Environmental for analysis (NATA Accreditation No. 825, Site No. 13778). Total solids (mg), total insoluble matter (TIM, g/m^2/month), total soluble matter (g/m^2/month) and metals (arsenic, cadmium, copper, lead, manganese and zinc, µg/m^2/month) are analysed. Note that only TIM has trigger levels and compliance limits in EPN 7153/3.

Sampling for total soluble matter, TIM and total solids was conducted referencing Australian Standards AS/NZ 3580.10.1 2016: Methods for sampling and analysis of ambient Determination of particulate matter - Gravimetric method (Australian Standards, 2016).

There were no recorded deviations from the sampling procedures for the DDG sampling in FY22. The dust deposition monitoring complies with the applicable elements of EPN condition M1 as samples are tested at a NATA accredited laboratory which is analysed as per Australian Standards.

2.3 Sampling Quality Assurance and Quality Control Procedures

MMG Rosebery has a number of internal sampling quality assurance and quality control (QAQC) procedures. Weekly procedures are completed for the air quality data which includes verification quality checks of the DDG, HVAS and DustTrak data. This includes analysis of the data to identify any inconsistent or incorrect results. The sampling quality control requirements detailed in the QAQC procedure includes taking field and laboratory blanks at set frequency as referenced in the relevant Australian Standards. In addition to the QAQC procedures, the real time DustTrak concentrations and weather data are displayed within the Environmental Department office. Inspection and mitigation trigger alerts are automatically generated as per the Dust Mitigation Plan (MMG, 2020) and are sent to relevant employees via email.

3. Air Quality Monitoring Results

3.1 High Volume Air Sampling

This section presents the results of the FY22 HVAS monitoring data and analysis. Table 8 summarises the HVAS data and the compliance against the trigger level and compliance limits as noted by the green tick. Exceedances of the trigger levels are denoted by a grey cross with exceedances of the compliance limit shown by a red cross.

The 24 hour average and 90 day average provided in Table 8 represent the maximum averages for FY22.

In FY22, there were no exceedances reported of the trigger levels or compliance limits for all HVAS locations. Six sampling results were considered invalid due to water damage and moisture on the filter papers. Where the analysis results were reported below the limit of reporting, half the limit of reporting was adopted for reporting.

The graphical results for all HVAS data are presented in Appendix A.

Table 8: HVAS monitoring results

Averaging period	Pollutant	Trigger level (mg/m3)	Compliance limit (mg/m3)	AD3 (mg/m^3)			AD2.1 (mg/m^3)			Giblin St (mg/m^3)			Alec St (mg/m^3)		
				Value	TL	CL	Value	TL	CL	Value	TL	CL	Value	TL	CL
24 hour average [a]	TSP	0.150	-	0.026	√	-	0.068	√	-	0.032	√	-	0.028	√	-
	PM_{10}	0.050	0.150	0.013	√	√	0.032	√	√	0.015	√	√	0.015	√	√
	Lead (as TSP)	0.0087	-	0.0012	√	-	0.00085	√	-	0.000089	√	-	0.000063	√	-
	Cadmium (as PM_{10})	0.000003	-	0.0000014	√	-	0.0000014	√	-	0.00000015	√	-	0.00000015	√	-
	Zinc (as PM_{10})	0.015	-	0.00045	√	-	0.00062	√	-	0.00004	√	-	0.00005	√	-
Annual average	TSP	-	0.090	0.011	-	√	0.027	-	√	0.010	-	√	0.011	-	√
90 day average [b]	Lead (as TSP)	-	0.0015	0.00036	√	-	0.00044	√	-	0.000027	√	-	0.000030	√	-
Number of valid data points (TSP) [c]				59			61			61			61		
Number of valid data points (PM_{10}) [c]				60			60			59			61		
Number of invalid data points (TSP) [c]				2			0			0			0		
Number of invalid data points (PM_{10}) [c]				1			1			2			0		

Notes:

[a] The 24 hour average represents the max in FY22

[b] The 90 day average represents the max in FY22

[c] Six sampling results were considered invalid due to water damage and moisture on the filter papers.

Green ticks denote compliance with the respective trigger level or compliance limit

Grey crosses denote exceedances of the respective trigger level

Red crosses denote exceedances of the respective compliance limit

Dash ('-') denotes no trigger level or compliance limit in the EPN or PCE

3.2 Dust Deposition Gauges

This section presents the results of the FY22 DDG monitoring data and analysis.

Table 9 summarises the dust deposition against the trigger levels and compliance limits as presented in Table 4. The monthly deposition and background contributions for DDG at or beyond the site boundary are presented in Figure 2. All monthly dust deposition gauge results are presented in Appendix A.

It is important to note that six or more months were considered invalid at each location due to high rainfall events flooding the gauges, as shown in Table 9. As less than six months of data was considered valid for locations AD3, AD4, AD11 and AD21, the annual averages are not considered representative annual averages. However, as the invalid data are due to large amount of rainfall, the dust deposition during these periods would typically be low. This means that the calculated annual averages with the less than six months of data is a conservative representation of the annual conditions.

No exceedances of the trigger or compliance limits were reported for any deposition gauges at or beyond the site boundary for FY22.

Table 9: DDG monitoring results at or beyond the boundary

Site	Number of valid samples	Monthly Deposited Dust above background ($g/m^2/month$)		Monthly Total Deposited Dust ($g/m^2/month$)		Annual Average Deposited Dust above background ($g/m^2/month$)		Annual Average Total Deposited Dust ($g/m^2/month$)	
Trigger level		2		4		-		-	
Compliance limit		-		-		2		4	
AD3	5	0.20	√	0.50	√	0.080	√	0.34	√
AD4	5	0.40	√	0.80	√	0.18	√	0.44	√
AD11	5	0.50	√	0.70	√	0.22	√	0.48	√
AD21	5	1.0	√	1.2	√	0.30	√	0.56	√
AD22	6	1.0	√	1.2	√	0.45	√	0.70	√
BG3	6	0.70	√	0.90	√	0.28	√	0.53	√

Notes:
Green ticks denote compliance with the respective trigger level or compliance limit
Grey crosses denote exceedances of the respective trigger level
Red crosses denote exceedances of the respective compliance limit
The minimum monthly deposited dust value across six locations was adopted as background

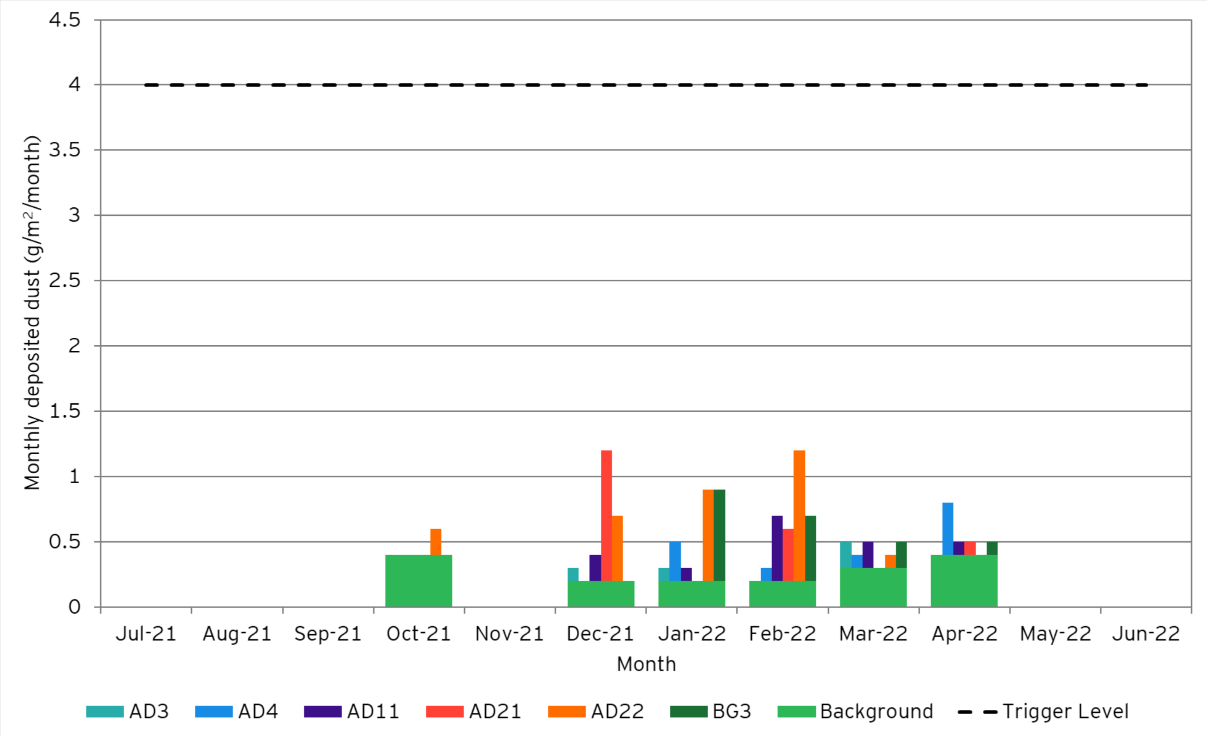

Figure 2: Total monthly deposition for sites at or beyond the site boundary

3.3 Summary

There were no exceedances of the compliance or trigger limits for all HVAS and DDG locations.

As no exceedances of the compliance limits were reported, it is indicated that MMG's Rosebery Mine is a low environmental risk to air quality and that the current dust mitigation controls are appropriate.

Based on this review, it is recommended that the air quality monitoring network be reviewed and consolidated. Considering the low environmental risk to air quality and the typical annual rainfall, a small targeted network could provide more meaningful information regarding the mine's dust impact.

As per EPN 7153/3 condition A3-4:

> *Measurements at the 'additional sites' (BG3, AD11, AD21, AD22, AD23 and AD25) are to continue until such time as an annual pattern can be established and a full 12-month dataset is compiled. This data is to be analysed in a report presented to the Director, containing recommendations and a request for approval to remove specific 'additional sites' from the monitoring network. Monthly monitoring must continue at all of the 'additional sites' until the Director provides approval to remove the individual sites.*

These additional sites have been collecting data for over 10 years which is sufficient to establish an annual pattern. As per conditions A3-4, an analysis of these sites is recommended to be able to remove these additional sites from the monitoring network. This will allow for consolidation of the monitoring network.

4. Review of Dust Management Performance

MMG's Rosebery Mine has a dust mitigation plan (MMG, 2020) that outlines the dust mitigation measures to reduce the environmental risk associated with the generation of dust due to the operations and activities at the mine. This plan fulfils the requirements of section A6 of EPN 7153/3.

The dust mitigation plan and review includes the following:

- Sources of potential dust from the Rosebery Mine.
- Details on the real-time monitoring network (four DustTrak's co-located with the HVAS monitors and site meteorological monitoring).
- The real-time inspection and mitigation level triggers, as presented in Table 10.
- General responses when real-time inspection or mitigation level triggers occur.
- Meteorological conditions that are considered conducive to dust events.

The trigger levels as presented in Table 10.

Table 10: Real Time Dust Trigger Levels

Averaging period	Inspection Level (µg/m^3)	Mitigation level (µg/m^3)
15 minutes	300	500
60 minutes	200	350

Source: (MMG, 2020)

4.1 Summary of Inspection and Mitigation Level Alerts

The number of alerts and alert days[1] of the inspection and mitigation levels, as described in Table 10, are summarised in Table 11. The provided 15-minute and 60-minute rolling averages reported by the telemetry network were used in the analysis. In late 2020, with the assistance of EPA Tasmania, site specific calibration factors were applied to the DustTraks to reduce the amount of dust alarms of 'inspection' and 'mitigation' levels due wood fire smoke haze from nearby residence. It is recommended that the calibration factors are validated yearly to assess their appropriateness.

It is noted that there were negative concentrations observed for the AD2.1 and Alec Street DustTraks in September 2021, however, these have not been removed for this analysis.

The alerts recorded in September were found to be due to planned burns in locations near the mine (EPA Tasmania, 2021). MMG completed an investigation for the alerts of AD2.1 and AD3 observed in January 2022, the outcome of this investigation was due to bushfires in Tullah located seven km to the north east from site.

[1] An alert day is defined as a day where one or more alert of the mitigation or trigger level is raised.

Table 11: Number of alerts and alert days

	Averaging period	Monitoring site ID			
		AD3 (Filter Plant)	AD2.1 (Core Shed)	Giblin Street	Alec Street
Number of alerts					
Inspection level	15-minute	432	315	0	43
	60-minute	915	626	0	0
Mitigation level	15-minute	37	0	0	26
	60-minute	216	45	0	0
Number of alert days					
Inspection level	15-minute	4	2	0	4
	60-minute	5	3	0	0
Mitigation level	15-minute	2	0	0	4
	60-minute	2	1	0	0
Data capture		99.5%	99.2%	99.3%	99.8%

Note: Data capture excludes missing data points invalidated during the data analysis. These invalidated data points were included in the real-time alerts.

4.2 Summary of Dust Management Performance

Analysis of the air quality monitoring network (HVAS and DDG monitoring data) shows that the performance of the dust management plan at the Rosebery Mine is sufficient in mitigating fugitive dust.

There were a number of alerts of the inspection and mitigation levels of the DustTrak monitoring network throughout FY22. The majority of the alerts received occurred at Core shed (AD2.1) and Filter plant (AD3) were due to bushfires in the nearby area.

4.3 Recommendations for Future Dust Management

Based on the review of air quality monitoring network, it is recommended that the Rosebery Mine continue its current mitigation management and mitigation measures. It is also recommended that the mitigation and inspection trigger levels are reviewed every three years to understand if they are sufficient to assist in the continued control of dust from site.

5. References

DEHP. (2022). *Environmental Authority EPML00731213.* Queensland Department of Environment and Heritage Protection.

EPA Tasmania. (2021). Notes on MMG Rosebery DustTrak and High-Volume sampler particle-monitoring to Q3 2021. Tasmania, Hobart: EPA Tasmania.

MMG. (2020). Dust Mitigation Plan. *Rosebery Mine*. MMG Limited.

MMG. (2022a). *DRM Dust Deposition 2021.xlsx.* MMG Dugald Rive Mine.

MMG. (2022b). per coms between Bec Chalmer and Andrew Holzheimer.

Standards Australia. (2016). *Methods for Sampling and Analysis of Ambient Air, Method 10.1: Determination of Particulate Matter - Deposited - Gravimetric Method.* Standards Australia.

Appendix A Additional Plots

Additional HVAS Data

The individual day 24 hour HVAS plots are presented in Figure 3 to Figure 7. The 90 day average lead (as TSP) is presented in Figure 8.

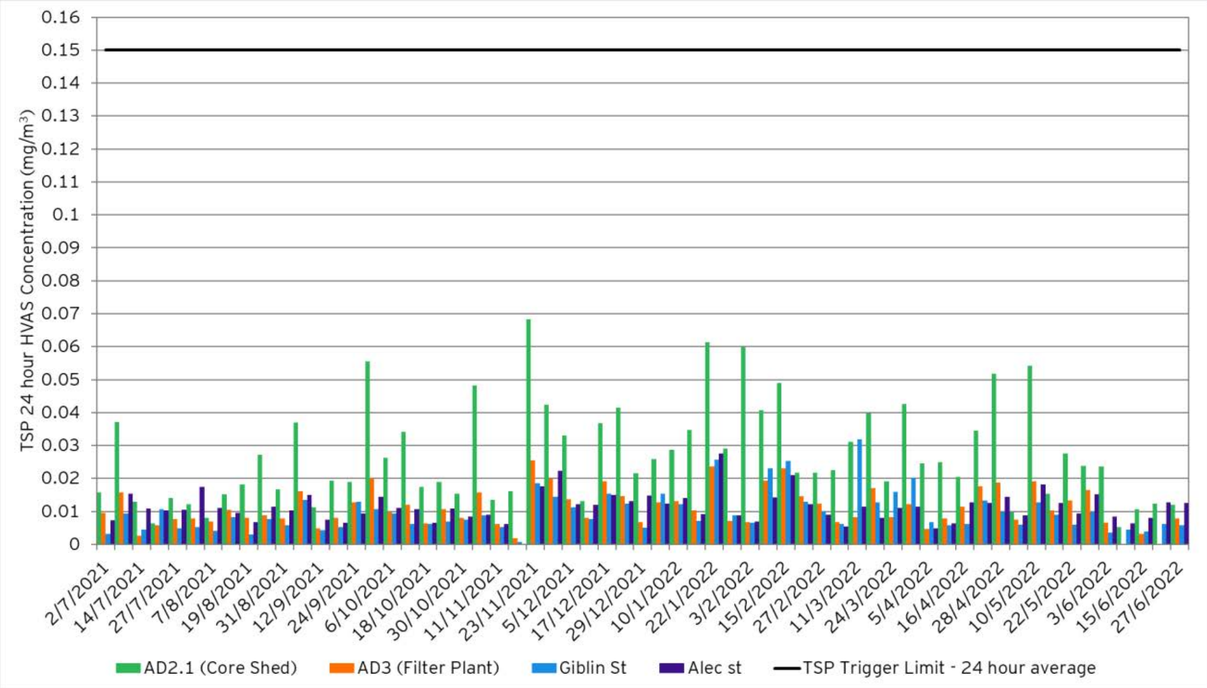

Figure 3: TSP HVAS 24 hour averages for FY22

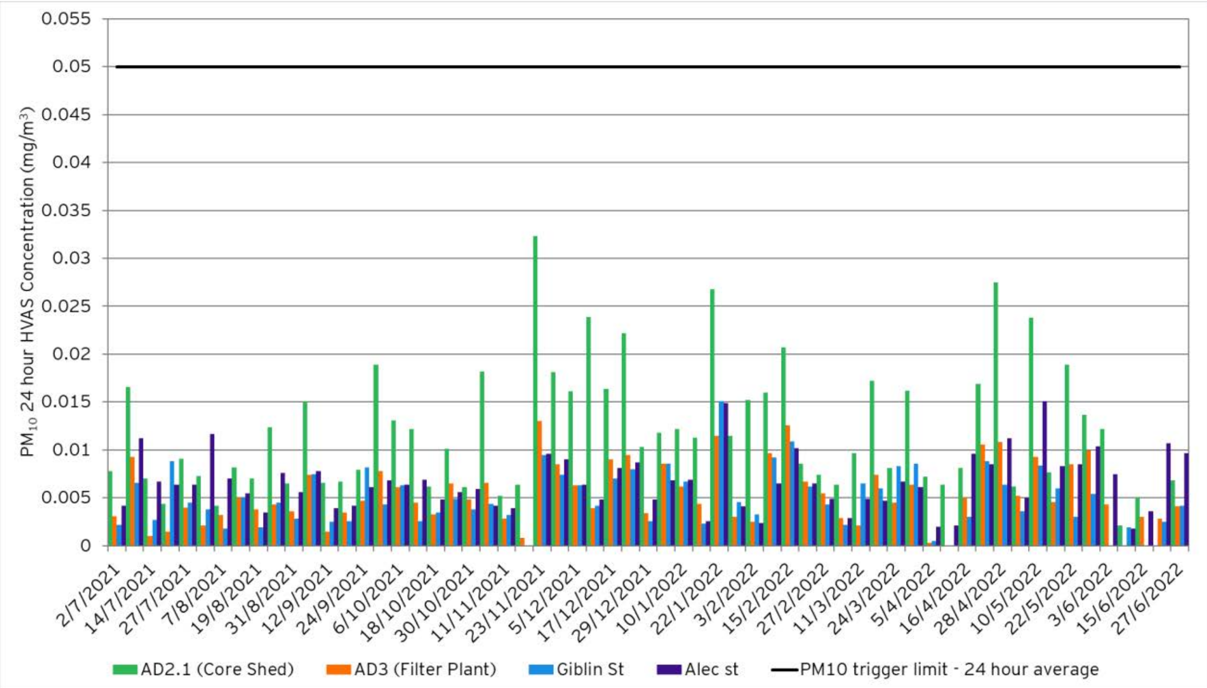

Figure 4: PM_{10} HVAS 24 hour averages for FY22

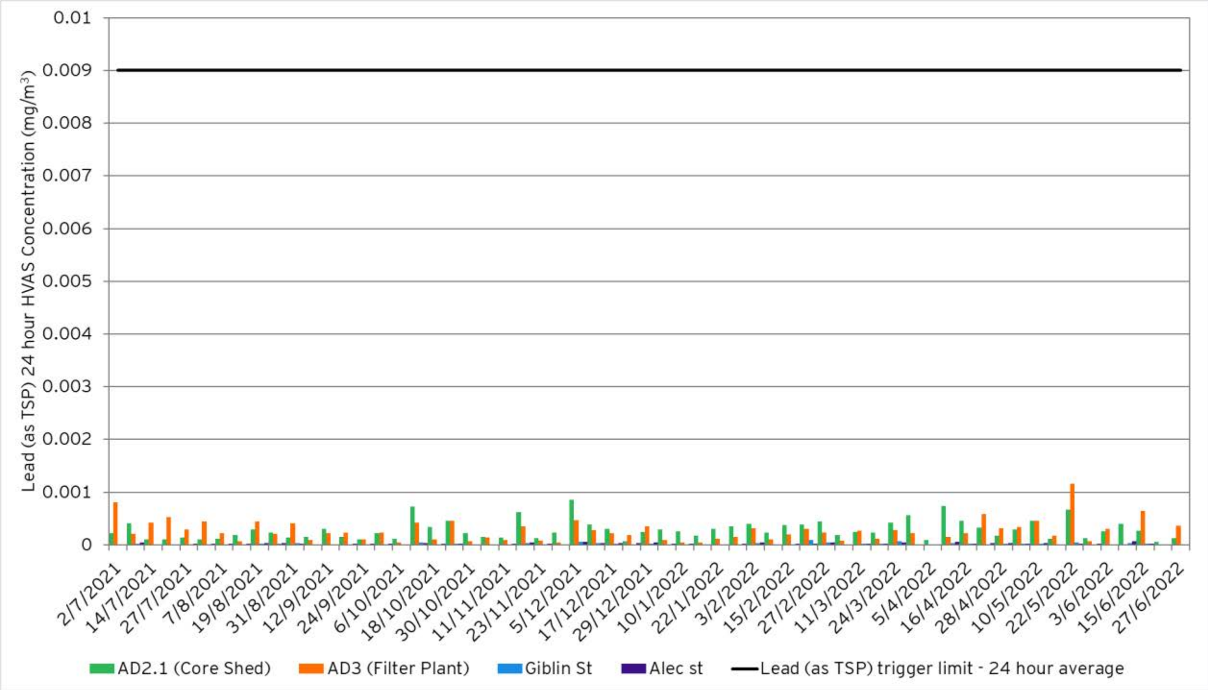

Figure 5 Lead (as TSP) 24 hour averages for FY22

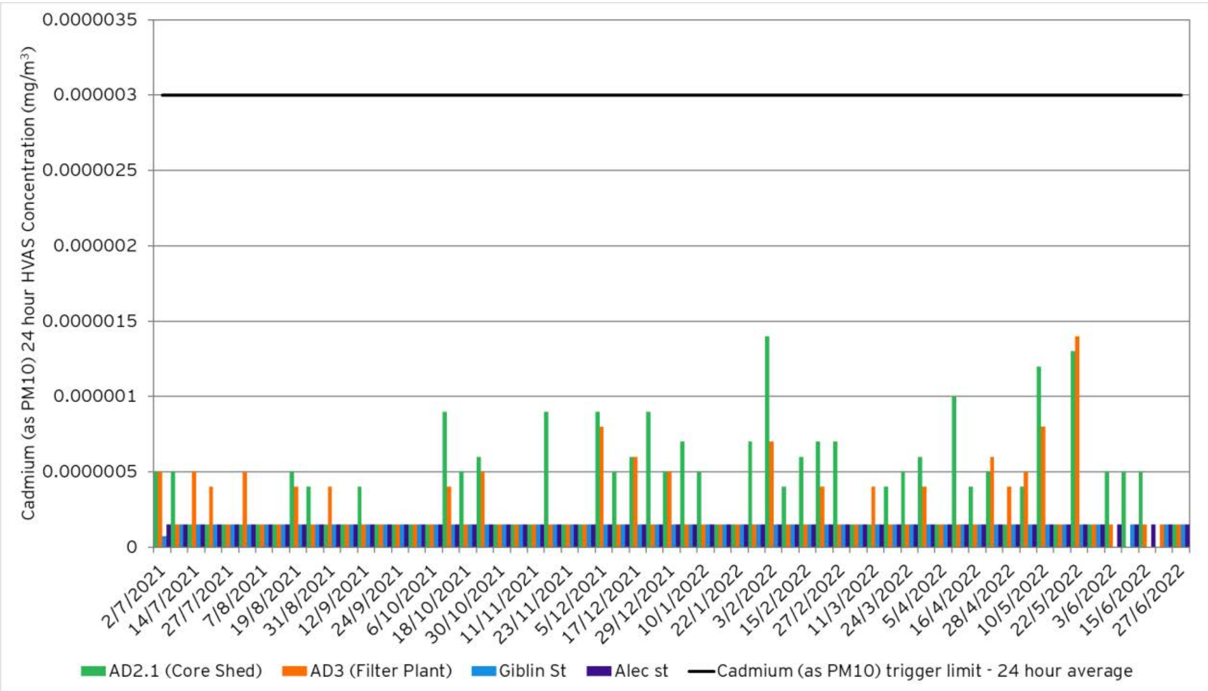

Figure 6: Cadmium (as PM_{10}) 24 hour averages for FY22

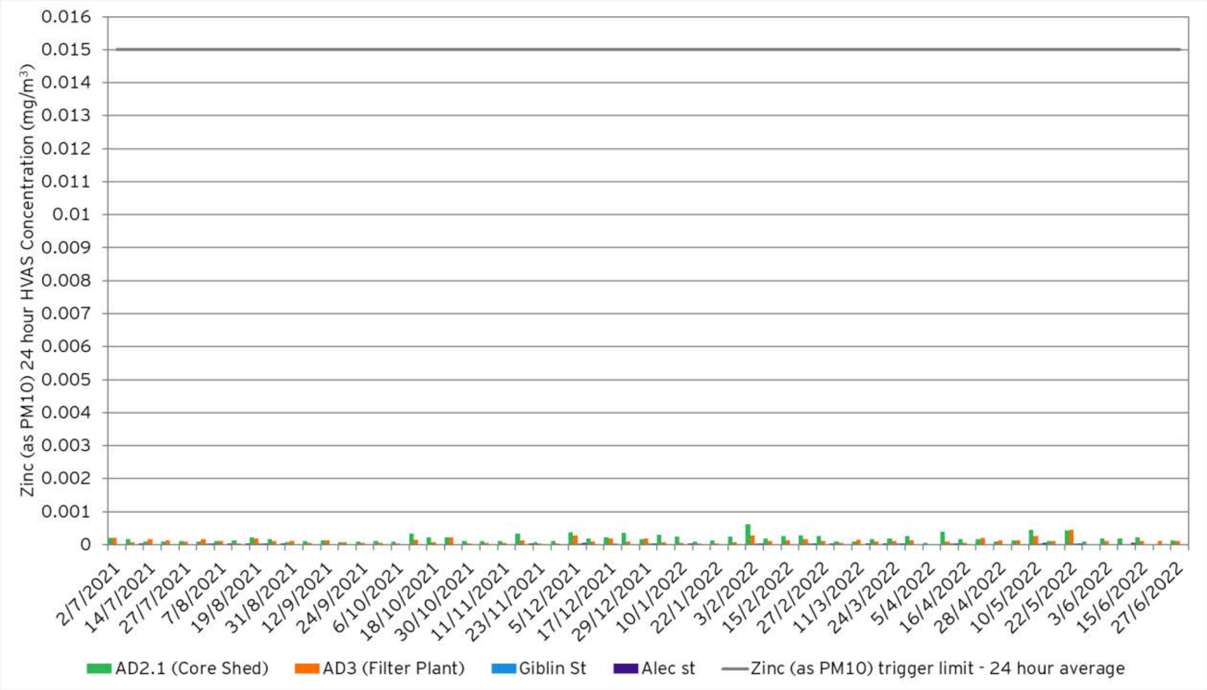

Figure 7: Zinc (as PM_{10}) 24 hour averages for FY22

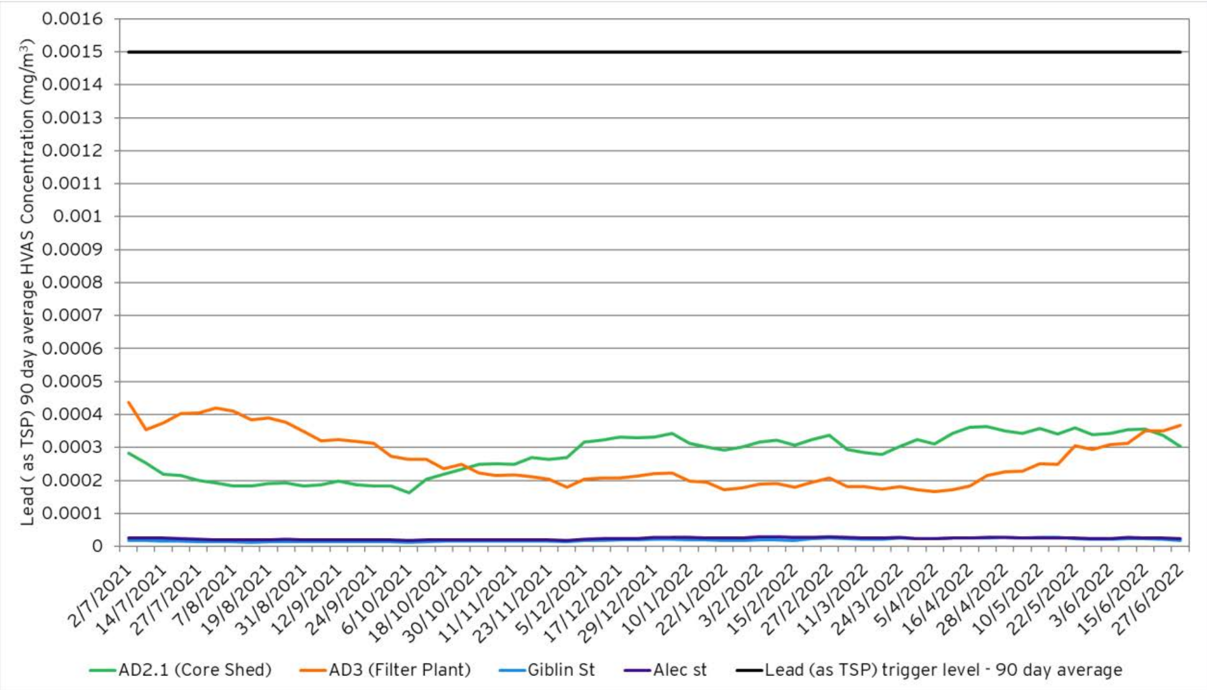

Figure 8: Lead (as TSP) HVAS 90 day average for FY22

Deposited data

The monthly deposition and monthly deposition above background for sites at or beyond the boundary are presented Figure 9 and Figure 10. The monthly dust deposition at all sites is presented in Figure 11.

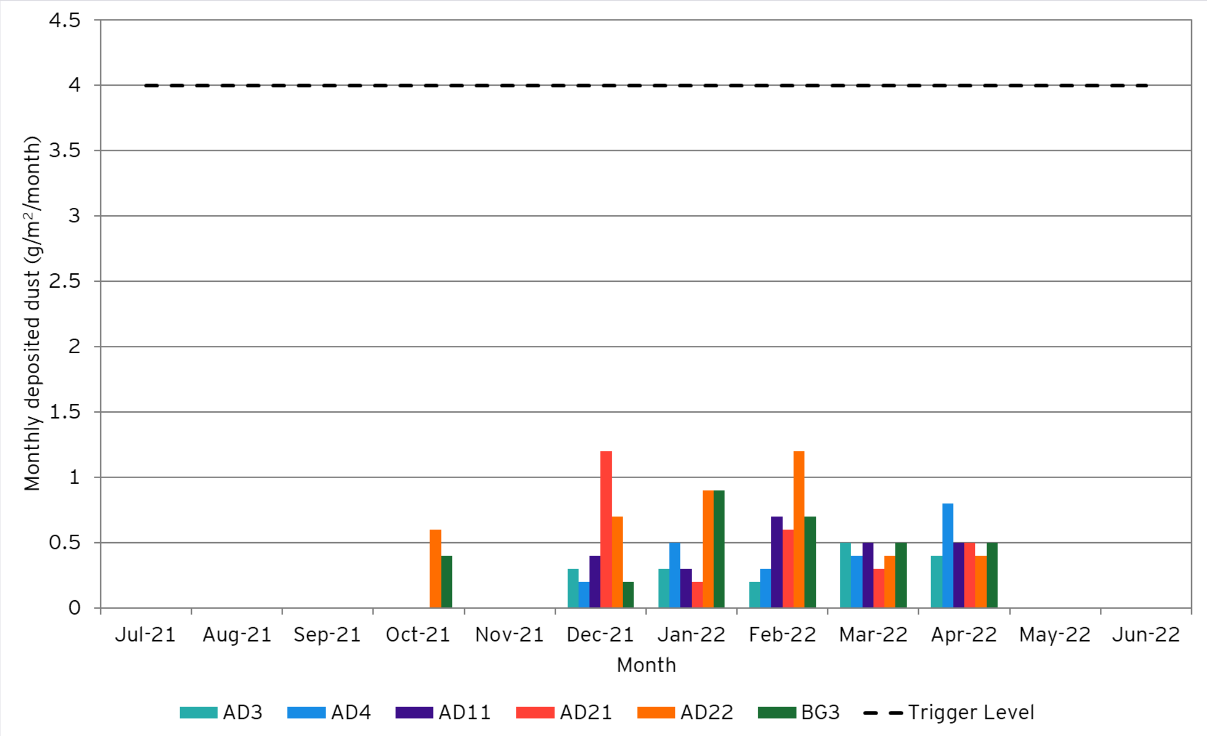

Figure 9: Monthly deposition for sites at or beyond the site boundary

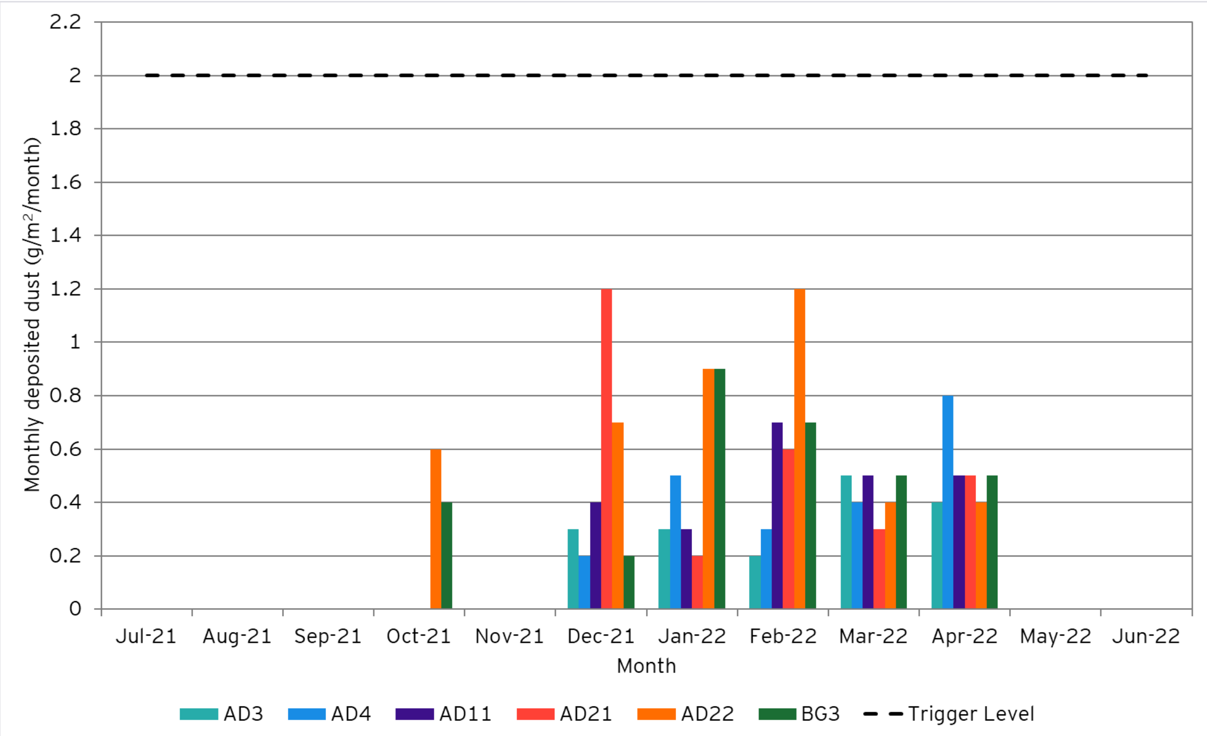

Figure 10: Monthly deposition above background for sites at or beyond the site boundary

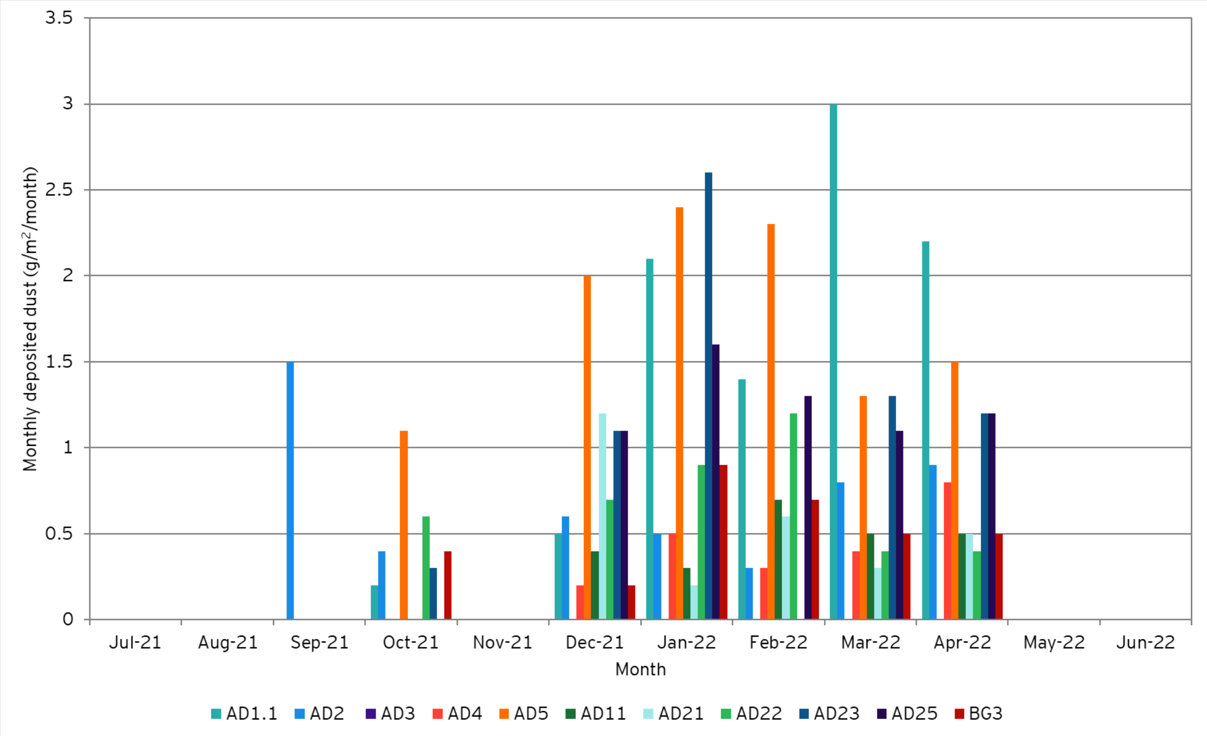

Figure 11: Monthly deposited dust at all sites

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Our report may be relied upon by MMG Rosebery Mine for the purpose of review the meteorological and air quality data in regarding to their Environmental Protection Notice's (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) only pursuant to the terms of our engagement letter dated 28 June 2022. We disclaim all responsibility to any other party for any loss or liability that the other party may suffer or incur arising from or relating to or in any way connected with the contents of our report, the provision of our report to the other party or the reliance upon our report by the other party.

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APPENDIX D: ANNUAL METEOROLOGICAL REVIEW (EY, 2022)

Annual Meteorological Review - FY22

MMG Rosebery Mine

9 September 2022

Building a better working world

Executive Summary

MMG Rosebery Mine has an obligation under its Environmental Protection Notice's (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) to report annually on aspects of its meteorological, dust deposition and ambient air quality monitoring programmes (EPN 7153/3 conditions A2-A5, G7 2.7 & PCE 9084 conditions A4-5, G6 & M3).

As per EPN Condition A4-3, an analysis of the annual climate is required. The meteorological review for FY22 shows that westerly winds dominate during the afternoon hours at Rosebery mine, particularly at the 2/5 Dam and Carpark stations. The low wind speeds observed are likely due to the surrounding terrain that shelters the mine site. Temperature, relative humidity and rainfall data for FY22 indicated that the mine experiences a cool, wet and humid climate with wetter winter and autumn months and drier summers.

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1. Introduction

MMG Rosebery Mine has an obligation under its Environmental Protection Notice's (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) to report annually on aspects of its meteorological, dust deposition and ambient air quality monitoring programmes (EPN 7153/3 conditions A2-A5, G7 2.7 & PCE 9084 conditions A4-5, G6 & M3).

As per EPN Condition A4-3, an analysis of the annual climate is required. MMG Rosebery Mine engaged EY to complete the annual review for the FY22 period. This report provides a summary of the recorded annual meteorological data, compares the variability between the three stations and the diurnal and seasonal variability of wind speed and direction, temperature, relative humidity, and rainfall.

2. Monitoring Locations

MMG Rosebery Mine operates three meteorological stations with 10 m masts that are located close to the mine, as presented in Figure 1.

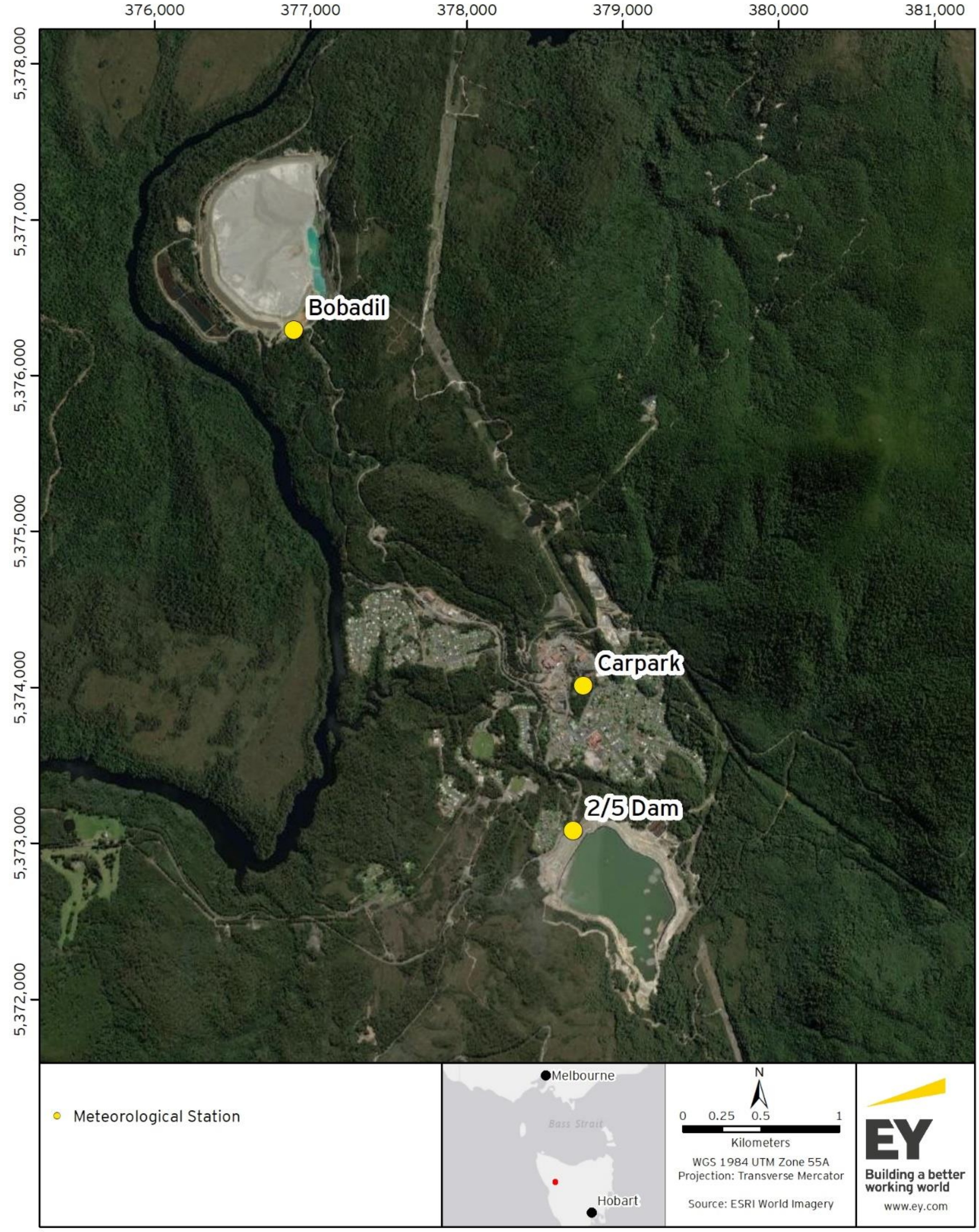


Figure 1: Meteorological Station Locations

3. Meteorological Analysis

The meteorological stations at the Rosebery Mine record wind speed and direction, temperature, relative humidity and rainfall with values reported on a 10 minute and hourly basis.

ERM completed a comparison exercise to confirm the averaging technique for the hourly data for the FY19 Annual Meteorological Review[1]. The comparison showed that the hourly vector averaging technique was considered appropriate for use in the data analysis. As this methodology is still currently used by MMG, the hourly data was used for this meteorological review.

3.1 Comparison of Data

The meteorological dataset was confirmed taking into consideration calibrations, data statistics and comparison to historical data. All three meteorological stations passed the calibrations completed in October 2021. The comparison steps considered the following from the Australian Standards AS3580.19:2020 - Methods for sampling and analysis of ambient air[2]:

- All data shall be treated as 'valid' unless there is evidence or sound scientific principles which support the 'invalidation' of the data;
- When data are 'invalidated' it should be confirmed that previous reported data are not affected;
- When critical criteria or operational criteria exceed the specified control limits, data shall be 'invalidated' back to the most recent calibration or 'valid' measurements; and
- Identify causes of 'invalidation' of data, such as power failure or instrument malfunction.

An error with the wind speed sensor at the Bobadil location was observed from May 2022 to the end of FY22. The cause of the error has not yet been determined[3]. Due to the error in the wind speed sensor, the wind speed and direction data from the Bobadil location was removed from 16 May to 30 June 2022 and excluded from the annual review.

A summary of the FY22 meteorological review is presented in Table 1.

Table 1: Summary of Meteorological Review – FY22

Summary and Meteorological Parameter		Station		
		2/5 Dam	Bobadil	Carpark
Data Capture (%)	Wind speed and direction	99.95%	87.60% [a]	99.86%
	Temperature	99.95%	99.97%	99.86%
	Relative Humidity	99.95%	99.97%	99.86%
	Rainfall	99.95%	99.97%	99.86%
Data Quality [b]	Wind speed and direction	High	High	High
	Temperature	High	High	High
	Relative Humidity	High	High	High
	Rainfall	High	High	High
Variability between sites	Wind speed and direction	Predominate westerlies	Predominate westerlies	Predominate northerlies and south westerlies
	Temperature	Little variability between the three sites with the warmest mean temperatures observed in		

[1] ERM (2019) Annual Meteorological Review – Rosebery Mine, Project No.: 0516238, ERM, issued 6 August 2019.

[2] Australian Standard AS3580.19:2020 (2020). Methods for sampling and analysis of ambient air, Method 19: Ambient air quality data validation and reporting

[3] MMG (2022) per coms between Bec Chalmer and Michael Crawford, received 15 July 2022.

Summary and Meteorological Parameter		Station		
		2/5 Dam	Bobadil	Carpark
		January 2022 and cooler mean temperatures observed in June 2022.		
	Relative Humidity	Little variability between the three sites with higher humidity observed in winter and lower humidity observed in summer.		
	Rainfall	Similar trends observed between the three sites with June 2021 being the wettest month, Lower rainfall was observed at the Carpark station.		

Notes:
a. Due to an error with the wind speed sensor, the wind speed and wind directions from the Bobadil station was excluded from 16 May 2022.
b. Data quality is based on instrument maintenance and calibrations as per manufacturer's standards.

3.2 Wind Speed and Wind Direction

Wind roses were used to understand the dominant wind patterns at Rosebery Mine. Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (N, NNE, NE, etc.). The bar at each wind direction in the wind rose represents winds blowing from that direction, e.g. north. The length of the bar represents the frequency of occurrence of winds from that direction, while colour of the bar corresponds to wind speed category. With the resulting figure, it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

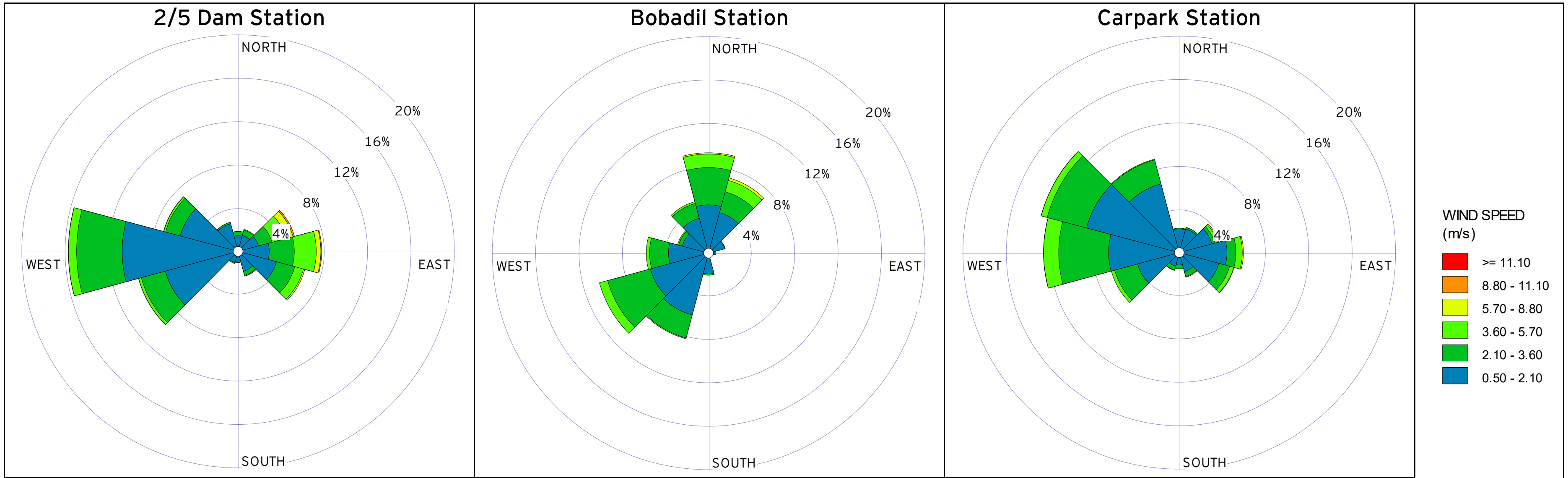
Wind roses for FY22 for the three stations onsite are presented in Figure 2. The 2/5 Dam and Carpark wind roses show predominate westerly wind directions with infrequent easterlies. The Bobadil wind rose shows the predominate winds were south westerly and northerly. The differences in the dominant wind directions are most likely a consequence of the surrounding terrain, with the dominant westerly flow in the region being slightly modified by the hills.

The wind roses indicate that wind speeds were very low at Rosebery mine for FY22, with a high frequency of calm conditions[4]. These low wind speeds are likely a result of the surrounding hilly terrain that shelter the site from winds.

Seasonal wind roses for each meteorological station are shown in Figure 3 to Figure 5. There was minimal seasonal variation in wind direction at the 2/5 Dam and the Carpark stations, with easterly winds being slightly more common in autumn and winter. South westerly winds dominated at the Bobadil station during summer, while northerly winds were more frequent in winter. Both northerly and south westerly winds were frequent during spring at the Bobadil station.

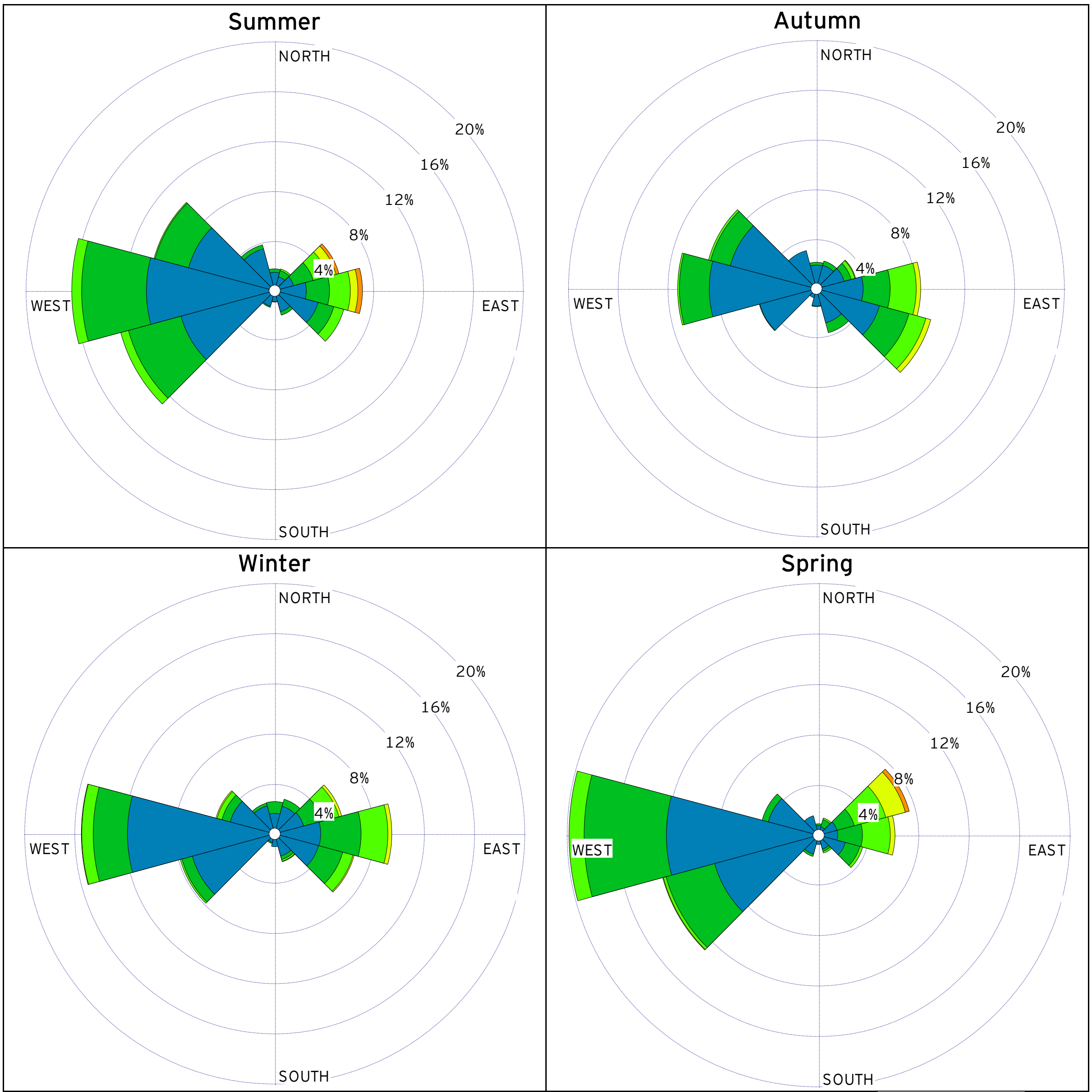
The time of day wind rose for each meteorological station are shown in Figure 6 to Figure 8. Westerly winds were particularly dominant during afternoon hours (between 12pm and 6pm) at the 2/5 Dam and the Carpark station. South westerly winds were also frequent at the Bobadil station in the afternoon (between 12pm and 6pm), highlighting the dominance of westerly winds in the region.

[4] Calm conditions are defined with a wind speed less than 0.5 m/s.



Average Wind Speed (m/s)	Calm Winds (%)	Data Availability (%)	Average Wind Speed (m/s)	Calm Winds (%)	Data Availability (%)	Average Wind Speed (m/s)	Calm Winds (%)	Data Availability (%)
1.2	36	99.99	1.1	34	88	1.1	33	99.99

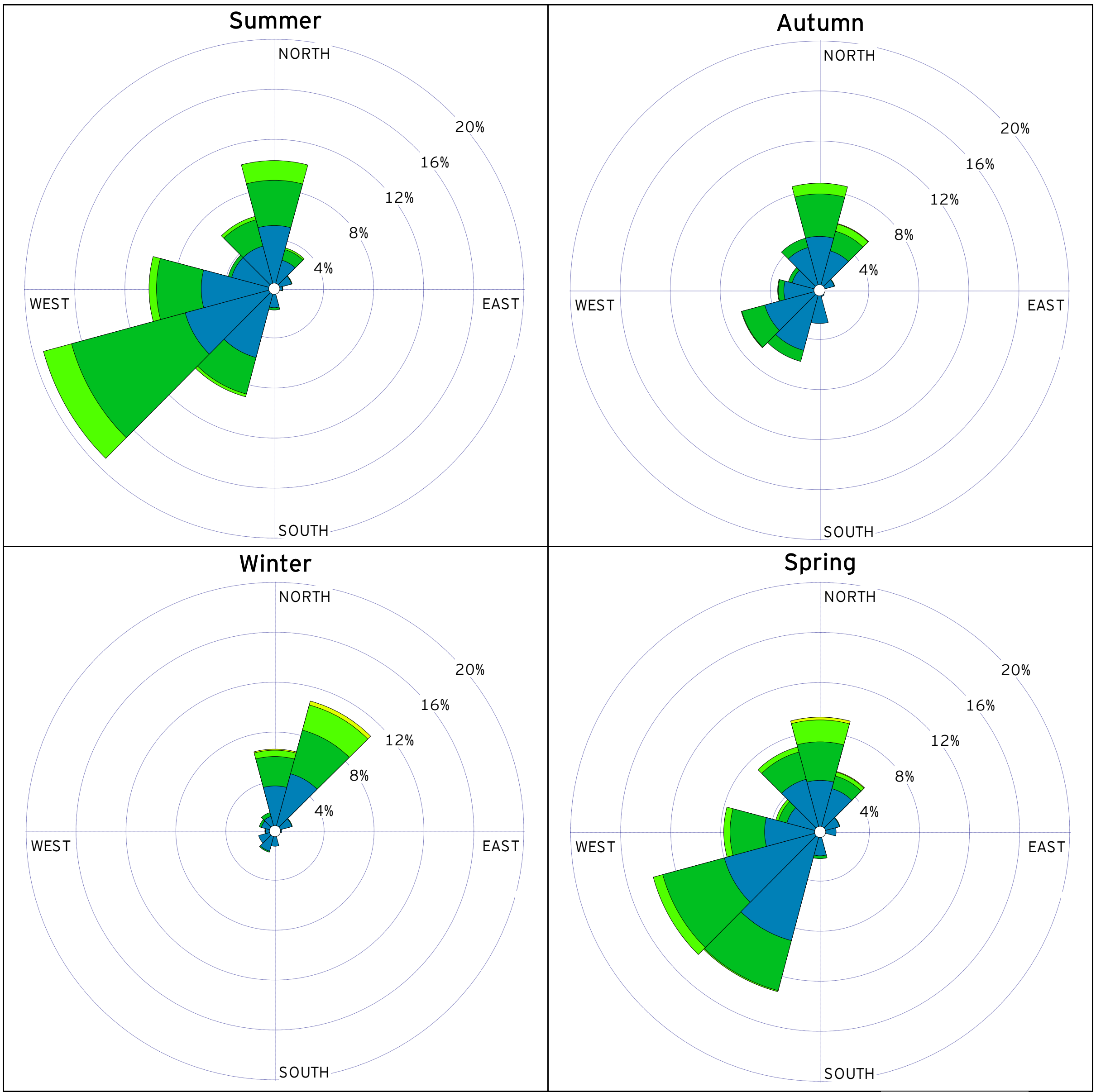
Figure 2: Annual Wind Roses for FY22



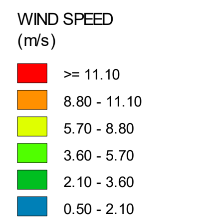
Season	Average Wind Speed (m/s)	Calm Winds (%)
Summer	1.4	31
Autumn	0.97	40
Winter	1.1	38
Spring	1.3	37

WIND SPEED (m/s)
- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Figure 3: Seasonal Wind Roses– 2/5 Dam Station

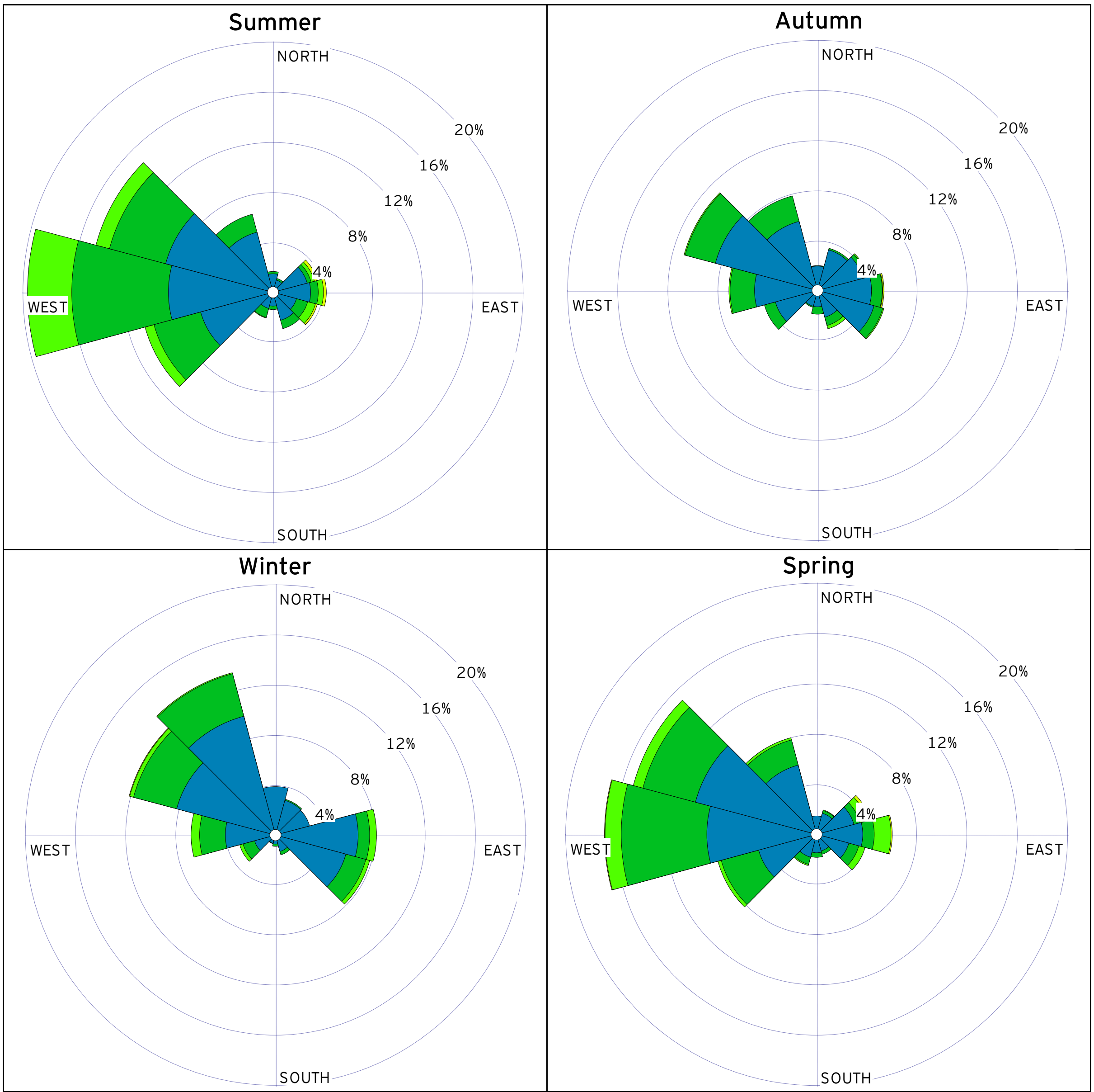


Season	Average Wind Speed (m/s)	Calm Winds (%)
Summer	1.3	34
Autumn	0.77	42
Winter [a]	1.0	23
Spring	1.2	34



a. *Due to an error with the wind speed sensor, the wind speed and wind directions from the Bobadil station was excluded from 16 May 2022.*

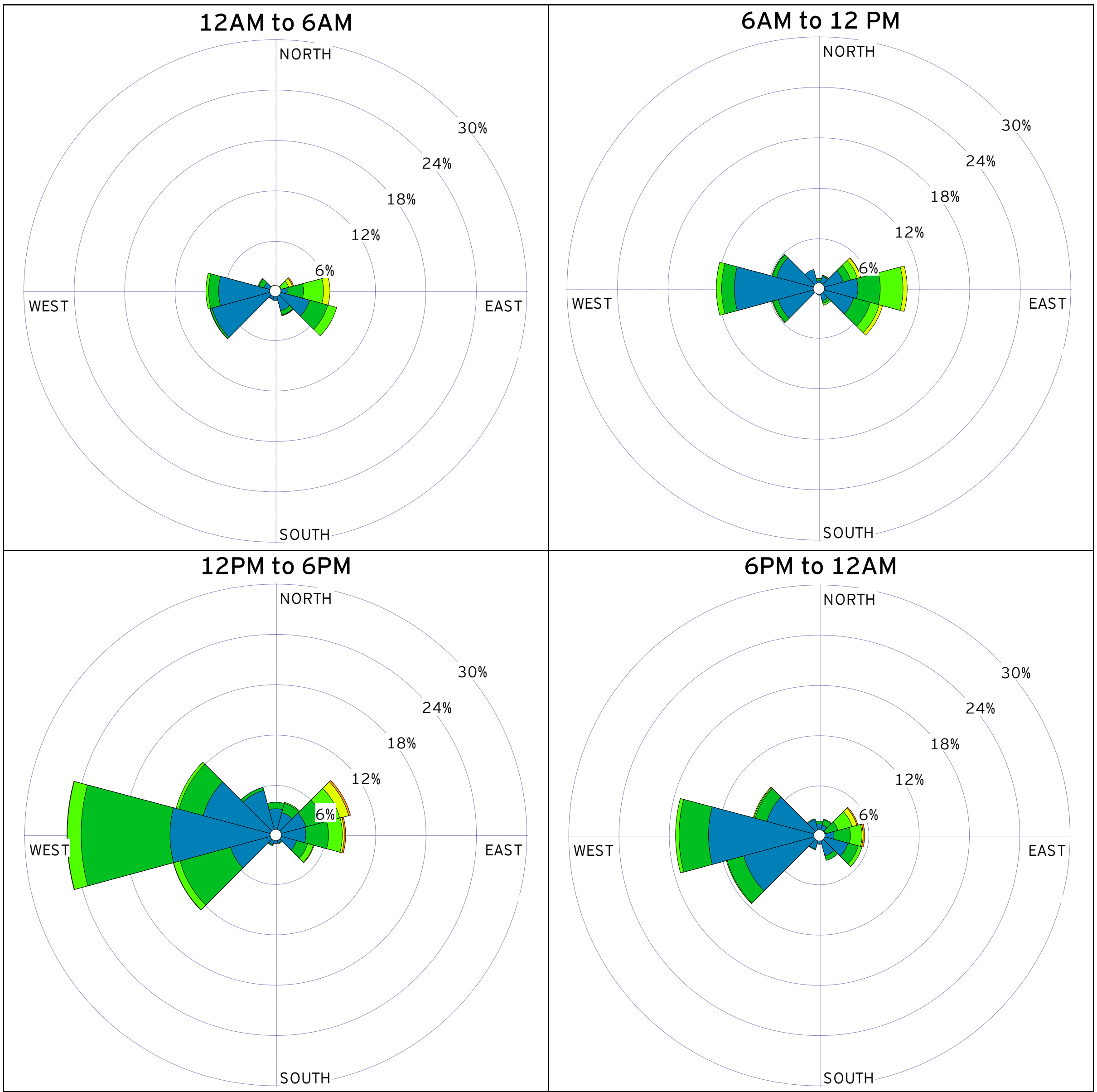
Figure 4: Seasonal Wind Roses– Bobadil Station



Season	Average Wind Speed (m/s)	Calm Winds (%)
Summer	1.4	27
Autumn	0.80	42
Winter	0.96	36
Spring	1.3	28

WIND SPEED (m/s)
- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Figure 5: Seasonal Wind Roses– Carpark Station



Season	Average Wind Speed (m/s)	Calm Winds (%)
12AM to 6AM	0.78	57
6AM to 12PM	0.98	43
12PM to 6PM	1.8	10
6PM to 12AM	1.1	35

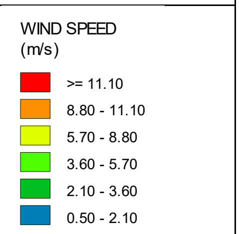
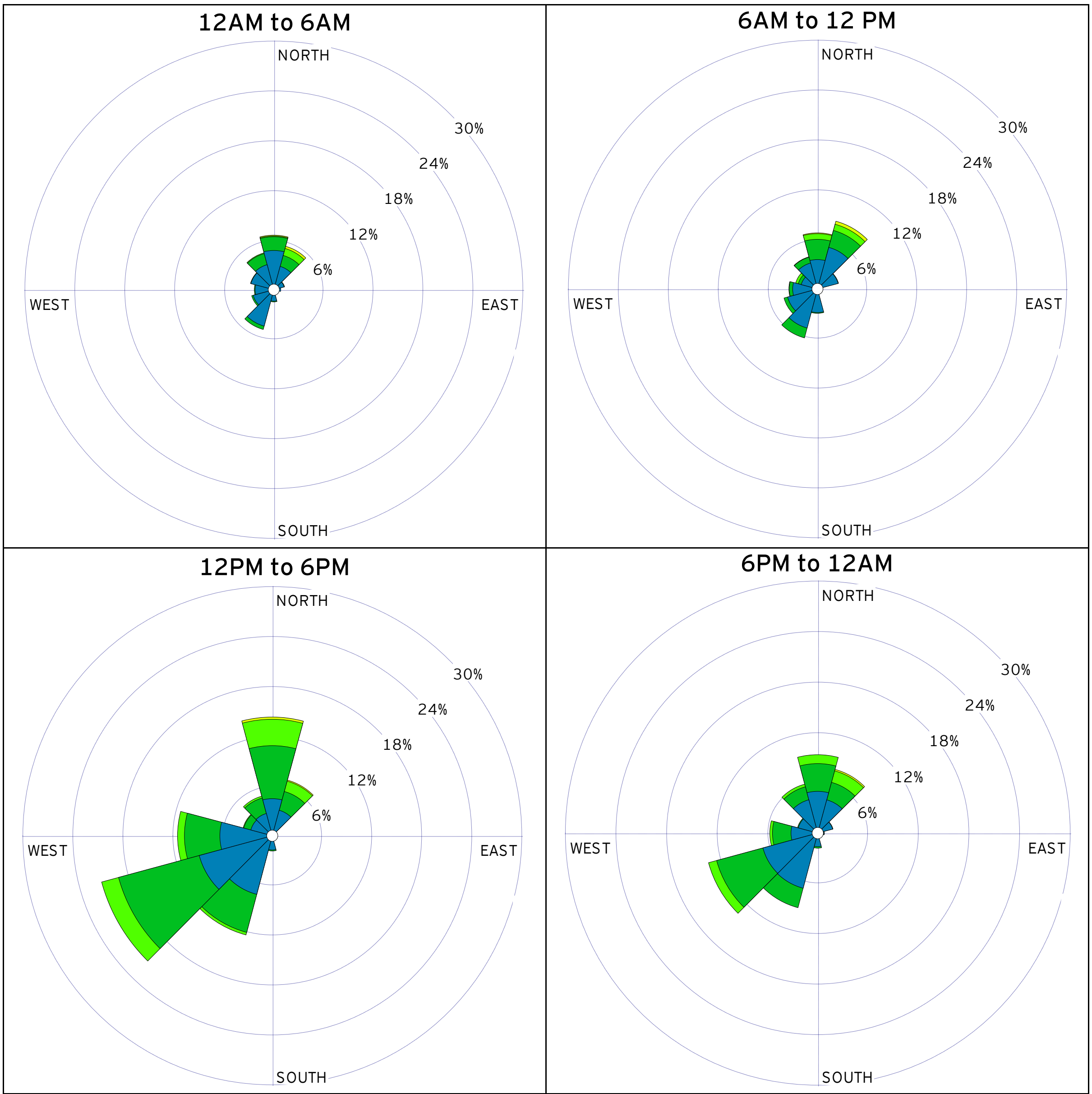


Figure 6: Time of Day Wind Roses – 2/5 Dam



Season	Average Wind Speed (m/s)	Calm Winds (%)
12AM to 6AM	0.55	53
6AM to 12PM	0.72	45
12PM to 6PM	1.9	9.2
6PM to 12AM	1.2	28

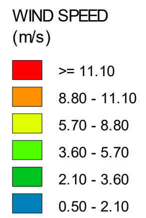
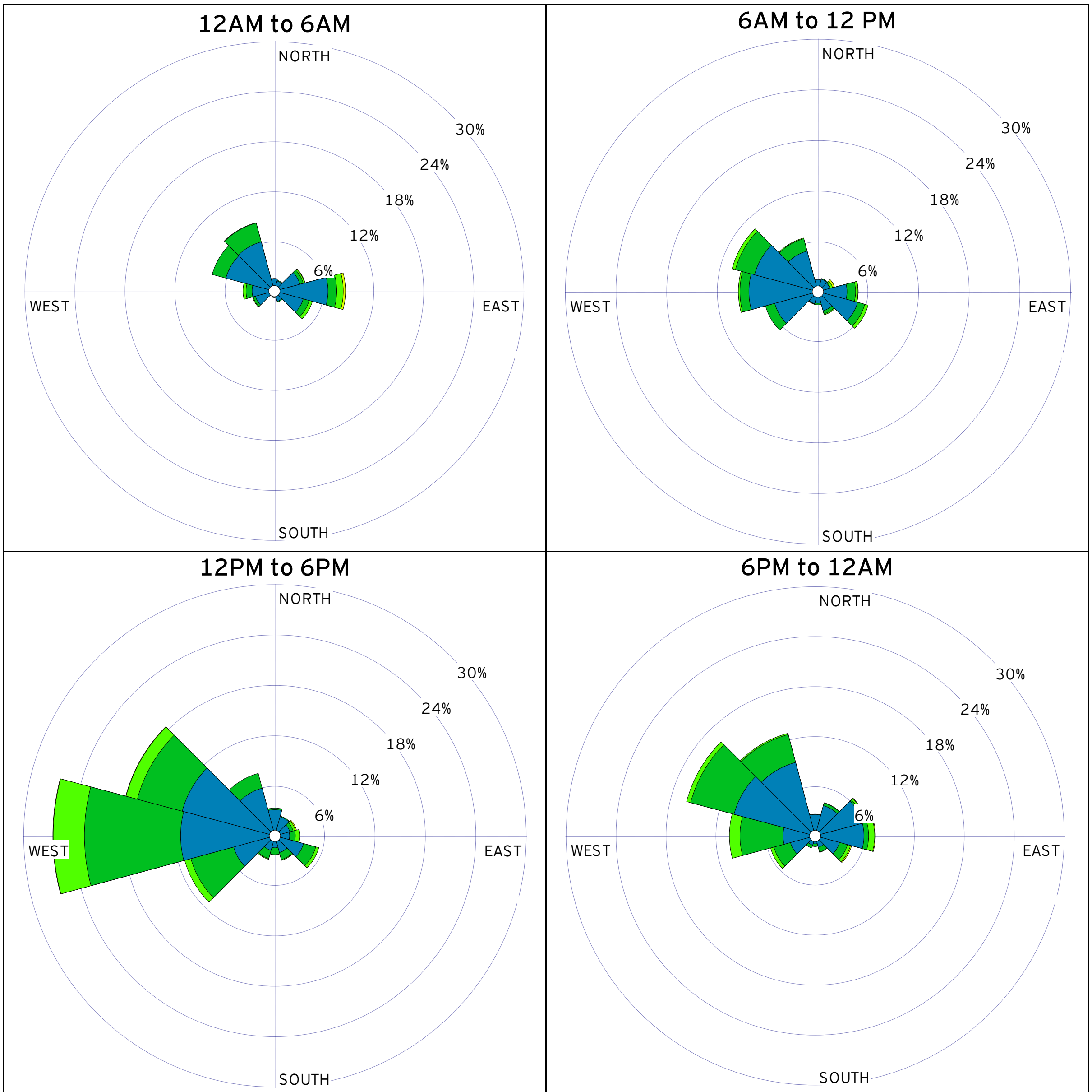


Figure 7: Time of Day Wind Roses – Bobadil



Season	Average Wind Speed (m/s)	Calm Winds (%)
12AM to 6AM	0.66	54
6AM to 12PM	0.78	44
12PM to 6PM		
6PM to 12AM	1.3	25

WIND SPEED (m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Figure 8: Time of Day Wind Roses – Carpark

3.3 Temperature

The mean, maximum and minimum monthly temperatures at the three weather stations are presented in Figure 9 to Figure 11. These figures show that the site experiences a cool climate with the warmest temperatures occurring in January 2022 (~32 °C) and the coolest temperatures occurring in August 2021 (~ -0.7°C).

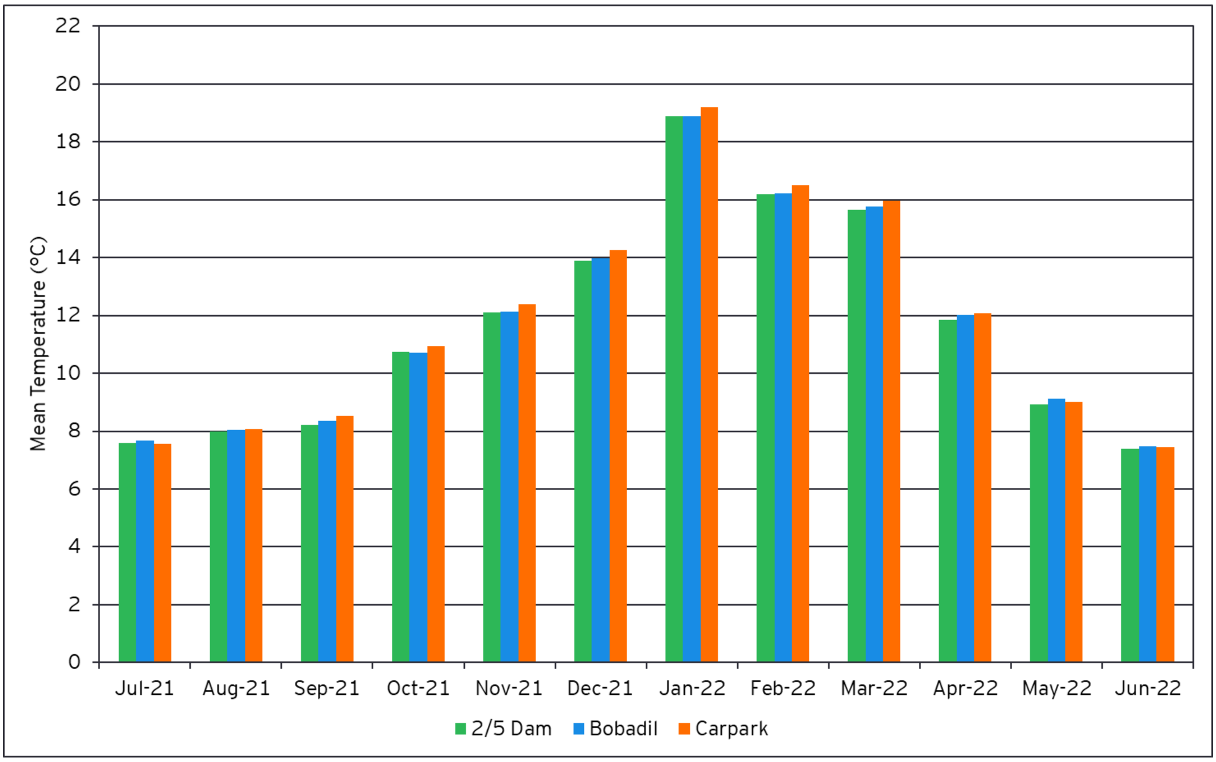


Figure 9: Mean Monthly Temperatures at All Stations

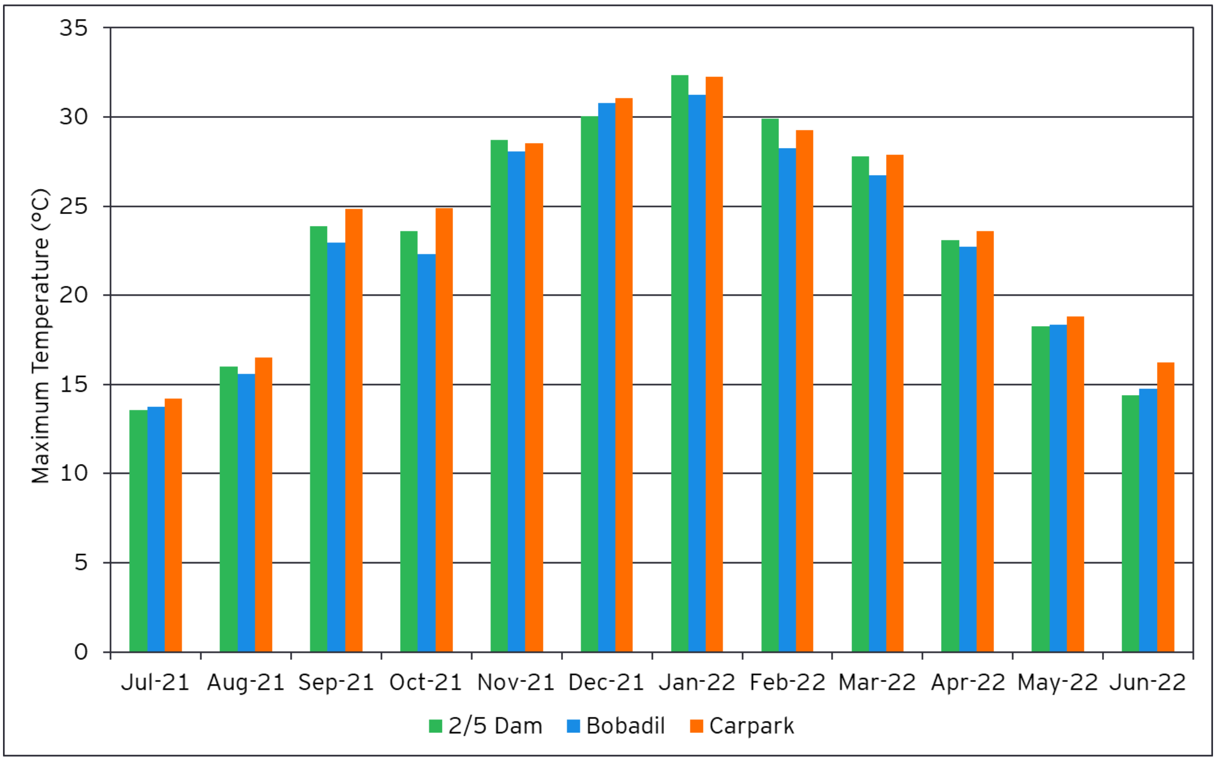


Figure 10: Maximum Monthly Temperatures at All Stations

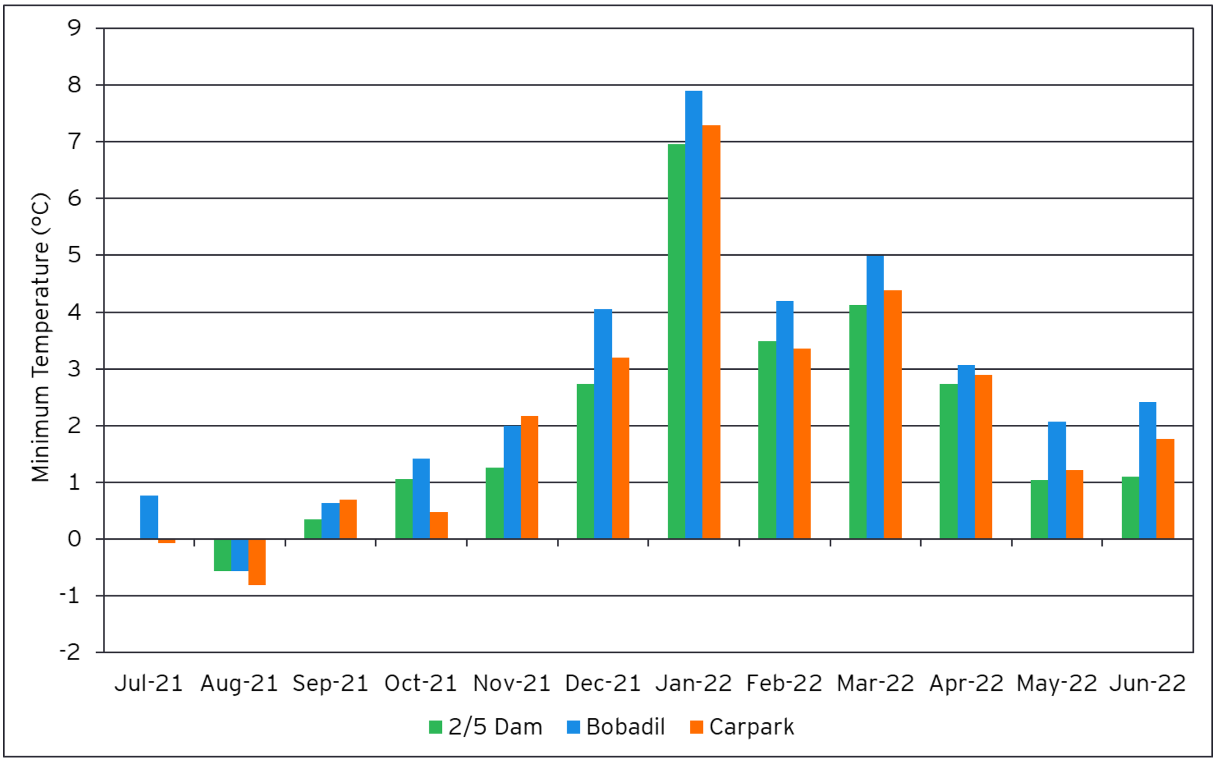


Figure 11: Minimum Monthly Temperatures at All Stations

3.4 Relative Humidity

The mean relative humidity at the three weather stations are presented in Figure 12. Humidity was highest in winter months (~90%) and lowest during the spring and summer months (~70%).

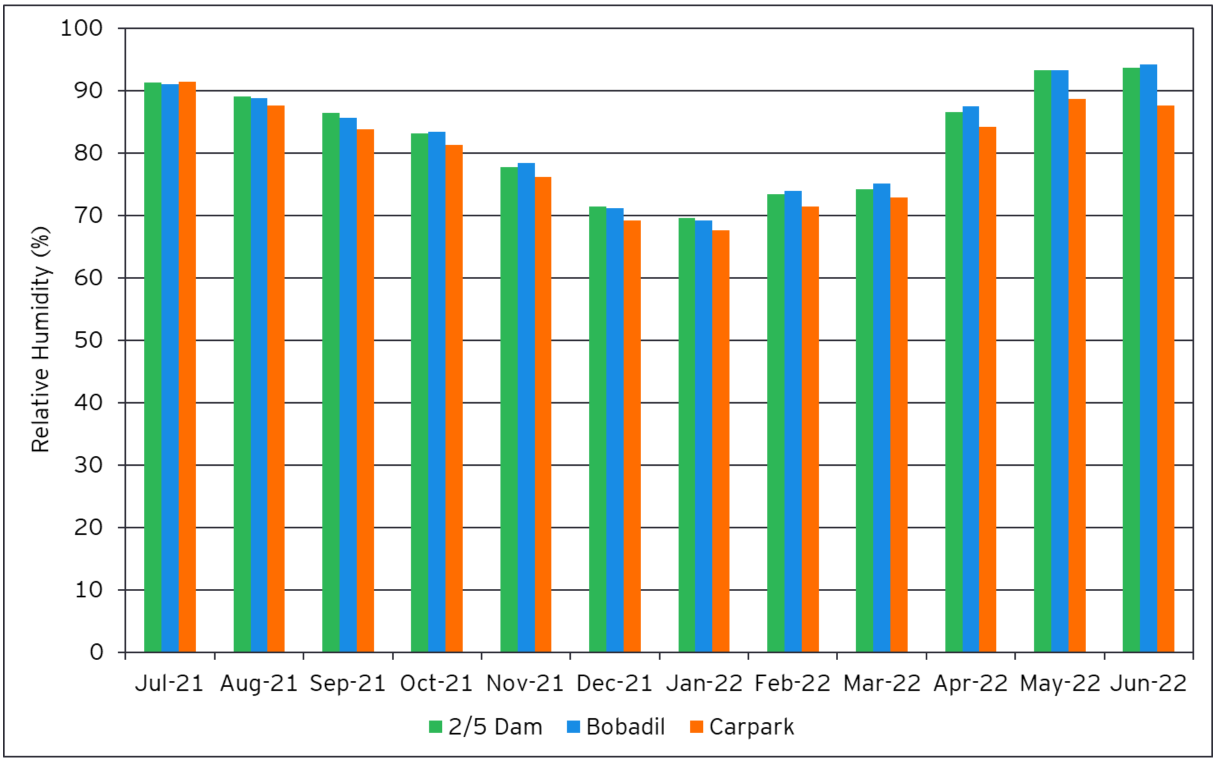


Figure 12: Mean Monthly Relative Humidity at All Stations

3.5 Rainfall

The total monthly rainfall at all stations is presented in Figure 13. This figure shows that the site experienced a wet winter with less rainfall observed in the summer months. The highest rainfall was observed for all stations in July 2021. The lowest rainfall was observer for all stations in January 2022. Rainfall was generally lower at the Carpark station for FY22 compared to the other two stations which was also observed in FY21. FY22 experienced more total rainfall compared with the FY21 annual meteorological review.

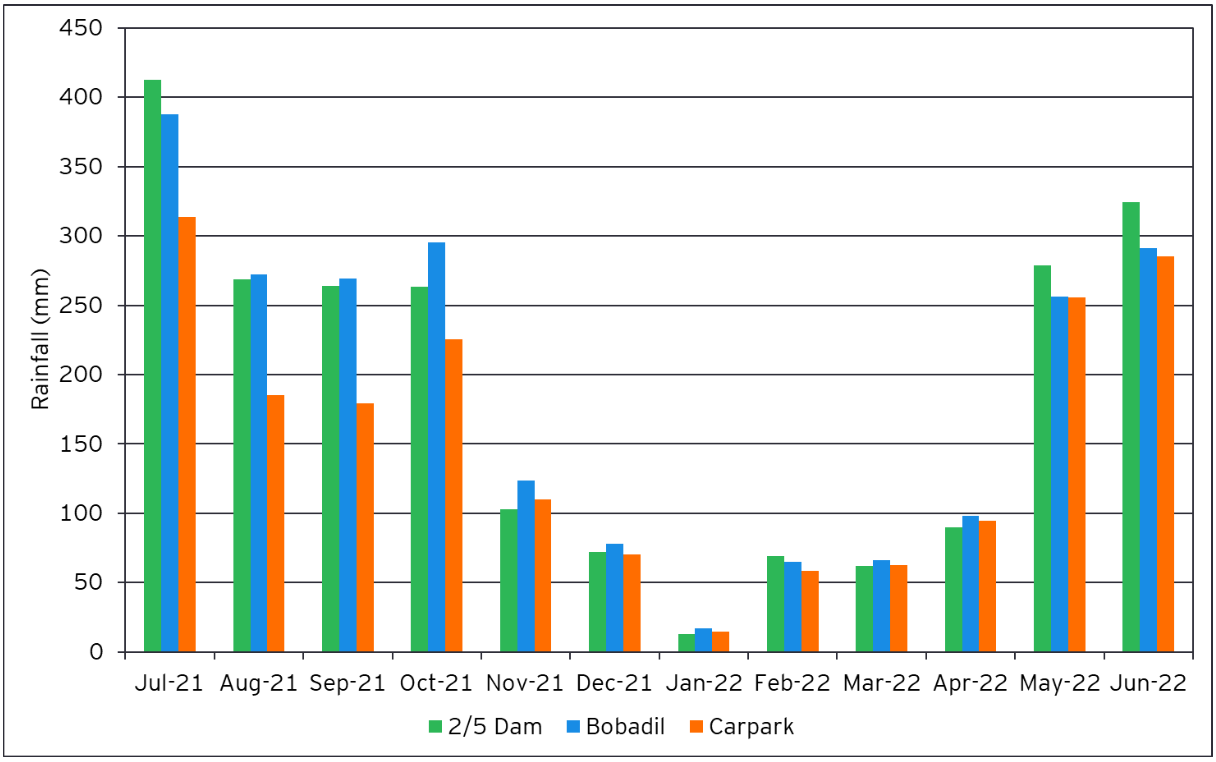


Figure 13: Total Monthly Rainfall at All Stations

4. Meteorological Summary

A summary of the meteorological parameters for the FY22 period for all stations are provided in Table 2.

The meteorological review for FY22 shows that westerly winds dominate during the afternoon hours at Rosebery mine, particularly at the 2/5 Dam and Carpark stations. The low wind speeds observed are likely due to the surrounding terrain that shelters the mine site. Temperature, relative humidity and rainfall data for FY22 indicated that the mine experiences a cool, wet and humid climate with wetter winter and autumn months and drier summers.

Table 2: FY22 Meteorological Data Summary

Location	Mean air temperature (°C)	Maximum air temperature (°C)	Minimum air temperature (°C)	Average wind speed (m/s)	Average relative humidity (%)	Total Rainfall (mm)
2/5 Dam	11.6	32.4	-0.57	1.26	82	2,222
Bobadil	11.7	31.2	-0.57	1.19	83	2,220
Carpark	11.8	32.2	-0.81	1.18	80	1,855
Average	11.7	31.9	-0.65	1.21	82	2,099

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ED 0922

Our report may be relied upon by MMG Rosebery Mine for the purpose of review the meteorological and air quality data in regarding to their Environmental Protection Notice's (EPN 7153/3, PCE 9084 & Rosebery Dust Mitigation Plan) only pursuant to the terms of our engagement letter dated 28 June 2022. We disclaim all responsibility to any other party for any loss or liability that the other party may suffer or incur arising from or relating to or in any way connected with the contents of our report, the provision of our report to the other party or the reliance upon our report by the other party.

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APPENDIX E: ANNUAL NOISE AND VIBRATION REVIEW (TARKARRI, 2021)

MMG Limited

Rosebery mine
Environmental noise, ground vibration and air blast overpressure annual monitoring data review
2021-2022

Report No. 5684_ACVIB_R

TARKARRI ENGINEERING PTY LTD
PO Box 506
Kings Meadows TAS 7249

September 2022

Tarkarri Engineering
Air Quality • Acoustics • Environment • Vibration

DOCUMENT CONTROL

MMG LIMITED
ROSEBERY MINE
ENVIRONMENTAL NOISE, GROUND VIBRATION AND AIR BLAST OVERPRESSURE ANNUAL MONITORING DATA REVIEW
2021-2022

Report No.	Library Code
5684_ACVIB_R	ACVIB
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Revision History

Revision No.	Date Issued	Reason/Comments
0		

Distribution

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Keywords environmental noise, dBA, L_{Aeq}, ambient, background (L_{A90}), GV, ABO

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References

[1] Tasmanian Department of Primary Industries, Water and Environment (July 2004) Noise Measurement Procedures Manual.

[2] 5577_ACVIB_R_MMG - Rosebery mine environmental noise, ground vibration and air blast overpressure annual monitoring data review 2020-2021.

Executive Summary

Tarkarri Engineering was commissioned to conduct an annual review of noise, ground vibration and air blast overpressure data collected over the 2021-22 financial year at MMG's Rosebery mine.

Average $L_{Aeq,15min}$ levels recorded by five fixed noise monitoring stations were commensurate with last year.

An exceedance of the lower air blast overpressure (ABO) limit set for blasting under EPN 7153/3 occurred on 1 occasion during scheduled blasting times, however, this was not a breach of the EPN condition as blasting occurred at depths of 1 km underground with ABO levels likely controlled by gusty weather conditions and or precipitation at the time. Exceedances of the ground vibration limits set for blasting under EPN 7153/3 didn't occur.

The noise, ground vibration and air blast overpressure levels reviewed show that there remains no indication of performance changes in environmental noise emission levels or blasting generated by Rosebery mine.

1 Introduction

MMG Limited commissioned Tarkarri Engineering to undertake an annual review of continuous environmental noise monitoring and of ground vibration (GV) and air blast overpressure (ABO) monitoring of blasting at their Rosebery mine. The review is a requirement under Environmental Protection Notice (EPN), no 7153/3, condition G7 for the mine.

The relevant sections of the mines EPN are provided below:-

G7 Annual Monitoring Review and Management Report

1 Unless otherwise specified in writing by the Director, an Annual Monitoring Review and Management Report, covering a 12 month review period from 1 July of the preceding year to 30 June of the following year, must be submitted to the Director by 30 November 2011 and every subsequent year by September 30 thereafter. The Annual Monitoring Review and Management Report must be made publicly available by the person responsible for the activity.

2 The Annual Monitoring Review and Management Report must be compiled for the activity using the ISO 14001 Environmental Management System (EMS) Framework to demonstrate continual improvement and compliance with legal requirements (including this Notice) and must include, but not be limited to:

2.6 a review of the monitoring requirements contained within Attachment 2 of this Notice for the review period, including a detailed comparative review of monitoring locations, including discharge and ambient monitoring points that illustrate significant trends. Include a review of the accuracy of the sampling procedures, sampling schedule, sample locations and test methods applied;

Noise Control

N1 Continuous Noise Monitoring

1 Unless otherwise approved in writing by the Director:

1.1 noise emissions from the activity must be monitored applying the MMG Rosebery Mine continuous monitoring program at the locations specified in Table 13 of Attachment 2 and locations shown on Attachment 7, based on equivalent continuous (Leq) and L10 and L90 A-weighted sound pressure levels measured over a period of 15 minutes or an alternative time interval specified by the Director;

1.2 noise level measurements must be taken in the presence of ambient noise normally existent in the area;

1.3 measured noise levels are to be adjusted for tonality and impulsiveness in accordance with the *Tasmanian Noise Measurement Procedures Manual 2004*, or any future revision of this manual, issued by the Director;

1.4 all methods of measurement must be in accordance with the *Tasmanian Noise Measurement Procedures Manual 2004*;

1.5 noise from the activity must not cause an environmental nuisance, at any domestic residence or commercial activity in other ownership;

1.6 an indicator of whether environmental noise nuisance has occurred will be based on the record of any noise complaints received by MMG Rosebery Mine; and

1.7 If a noise complaint is received, the person responsible must:

1.7.1 address the complaint including the use of appropriate dispute resolution if required; or if necessary; and

1.7.2 implement noise abatement measures so that nuisance noise emissions from the activity do not result in ongoing environmental nuisance occurring

1.8 Results of the continuous noise monitoring program and noise related complaints must be reported in the Annual Monitoring Review and Management Report.

Blasting

B1 Blasting Control
Ground vibration due to blasting must not result in environmental nuisance occurring at any domestic residence or commercial activity in other occupation or ownership. Ground vibration management must be controlled by the combination of monitoring, at the location shown on Attachment 7 and for the parameters specified in Table 13 of Attachment 2.

B2 Blasting - noise and vibration limits

1 Blasting on The Land must be carried out in accordance with blasting best practice environmental management (BPEM) principles, and must be carried out such that, when measured at the curtilage of any residence (or other noise sensitive premises) in other occupation or ownership, airblast overpressure and ground vibration comply with the following:

1.1 for 95% of blasts, airblast overpressure must not exceed 115dB (Lin Peak);

1.2 airblast overpressure must not exceed 120dB (Lin Peak);

1.3 for 95% of blasts ground vibration must not exceed 5mm/sec peak particle velocity; and

1.4 ground vibration must not exceed 10mm/sec peak particle velocity.

2 All measurements of airblast overpressure and peak particle velocity must be carried out in accordance with the methods set down in *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, Australian and New Zealand Environment Council, September 1990.

ATTACHMENT 2 (9 OF 9)

NOISE & VIBRATION MONITORING SCHEDULE

Table 13 Noise and vibration monitoring

Location	Description	Continuous Measurement
N1	Police house	Noise: LAeq, LA10, LA90
N2	Cohen Street	Noise: LAeq, LA10, LA90
N3	Clemons Street	Noise: LAeq, LA10, LA90
V1	Hospital	Peak Particle Vibration: mm/sec

This technical memo presents the results of the annual review for the period 1 July 2021 to 30 June 2022.

2 Site description

The MMG Rosebery mine is located on the lower south-west slope of Mount Black. The township of Rosebery borders the mine's above ground ore processing and train loading facilities to the south, south-west and west. Tailings storage facilities for the mine are located approx. 1.7 km north-west of the Rosebery township and to the south of the township on the southern side of the Murchison Hwy.

The mine produces zinc, lead, copper concentrates and gold dore bars via mechanised underground mining methods and employs crushing, grinding and flotation processes in their above ground processing facility.

Unattended monitoring of environmental noise is conducted at 5 locations across the township of Rosebery with GV and ABO monitored at a single location.

Table 2-1 presents spatial information for the environmental noise, GV and ABO monitoring locations. The table also provides location information on the weather stations for the mine that were used to filter environmental noise data. Figure 2-1 and 2-2 provide aerial views showing the monitoring locations with residential zones shaded in yellow.

Table 2-1: Information on environmental noise, GV and ABO and weather monitoring locations.

Environment noise; GV and ABO; and weather monitoring location information		
Number	Location	Coordinates (MGA)
Environmental noise		
N1	Police House	378530, 5373726
N2	Cohen St	377812, 5374410
N3	Mt Black	379195, 5374213
N4	Murchison St	379063, 5374101
N5	Alec St	378988, 5373396
GV and ABO		
V1	Hospital	378827, 5374072
Weather stations		
W1	Bobadil	376839, 5376290
W2	Overflow Carpark	378748, 5374012
W3	2/5 Dam	378491, 5372628

EPN 7153/3 monitoring locations.

NB: Positions N4 and N5 are additional monitoring locations not specifically required under EPN 7153/3. They were implemented to monitor truck movements to and from the level 3 waste rock dump (WRD) (truck movements to and from this area seldomly occur as the WRD is no longer used) in the case of position N4 and the construction of the 2/5 Dam (as required under Permit Conditions Environmental no. 9084 (R1)), in the case of position N5.

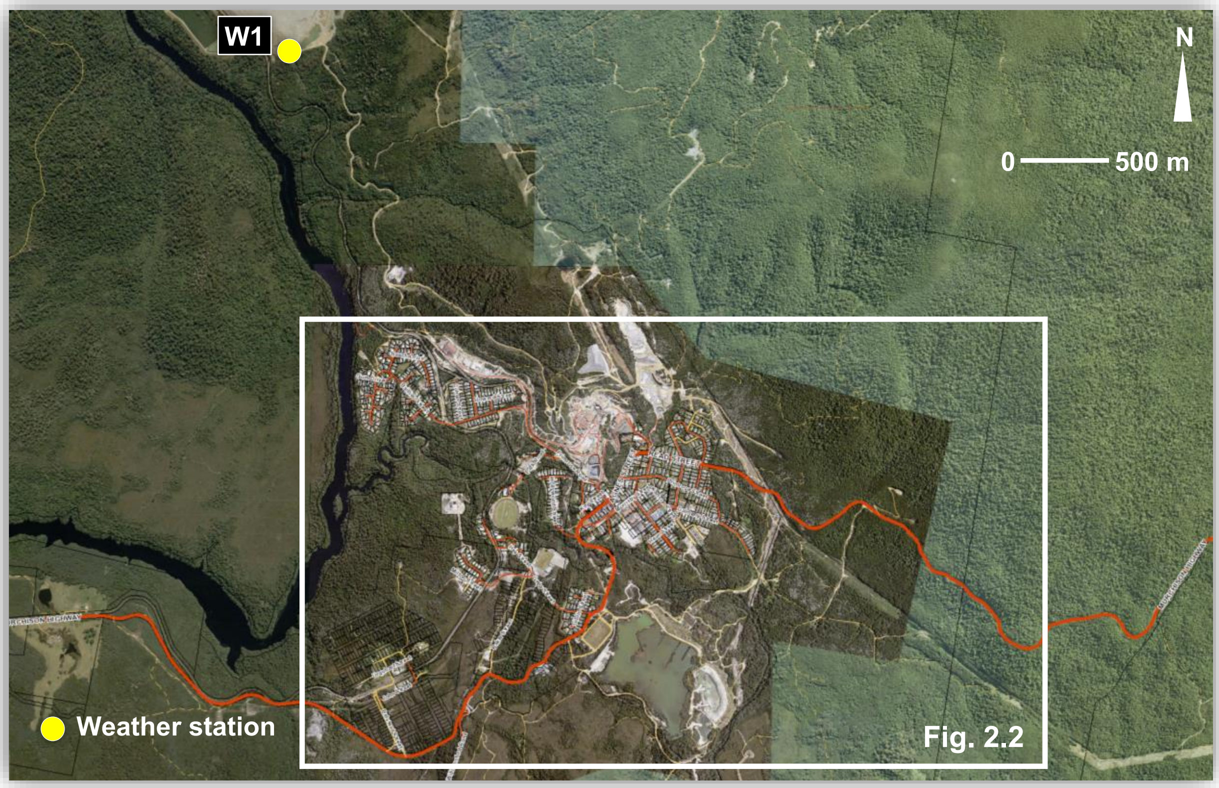

Figure 2-1: Aerial view of Rosebery and surrounds with the location of weather station 1 and the extent of Figure 2.2 marked.

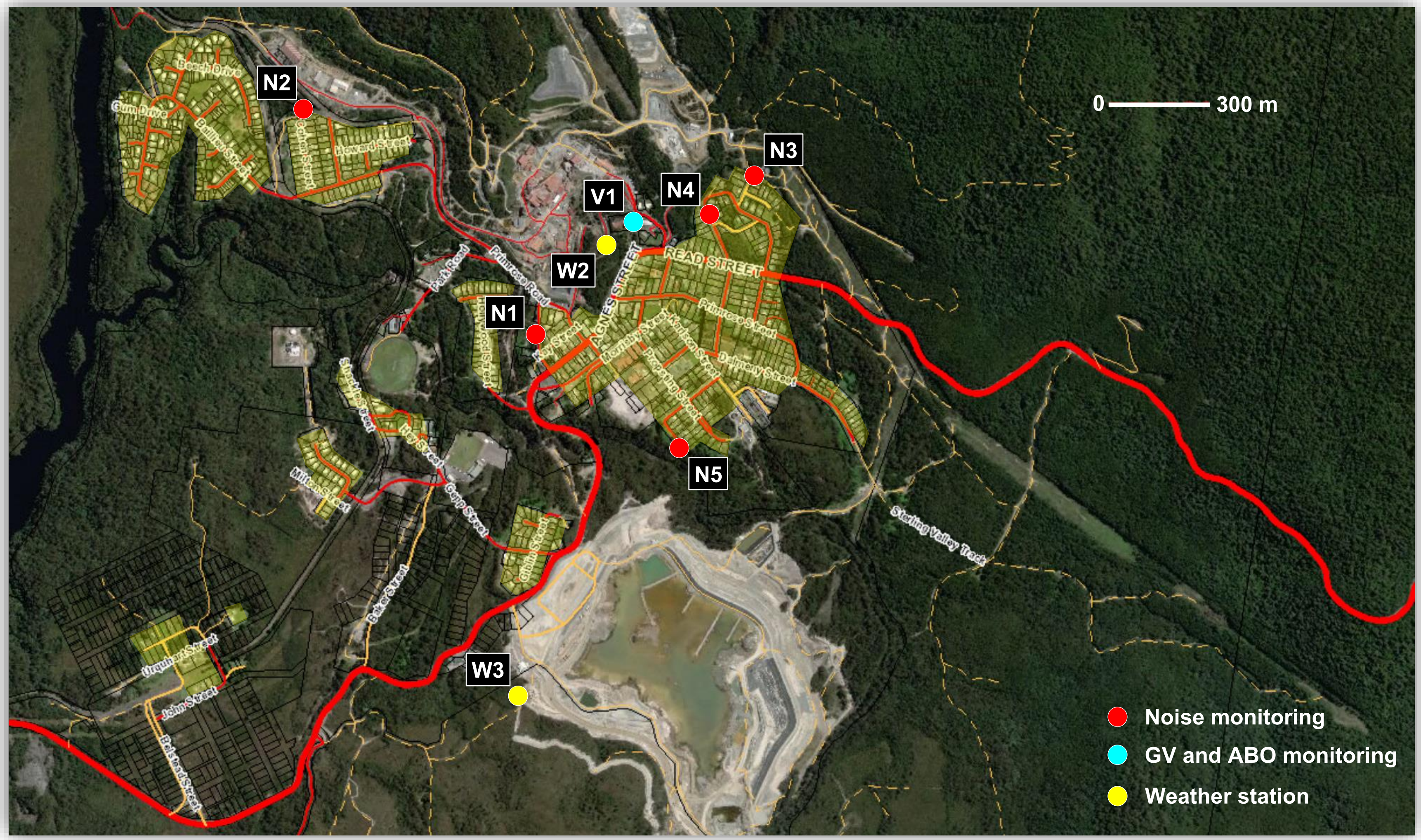

Figure 2-2: Aerial view of Rosebery with environmental noise; GV and ABO; and weather monitoring locations marked.

3 Environmental noise monitoring

Unattended continuous noise monitoring is conducted at 5 locations across the township of Rosebery as shown in Figure 2.2. Acoustic Research Laboratories Ngara Type 1 noise loggers are used to record fast response A-weighted sound pressure levels with 15-minute equivalent continuous (L_{eq}), min, max and 8 Ln-statistic levels (including L_{A90}, L_{A10}) extracted during post download data processing.

Field calibrations are completed approximately weekly, and factory calibration completed once every 2 years by a National Association of Testing Authorities (NATA) accredited laboratory. All monitored data presented here was from NATA laboratory calibrated loggers (calibration certificates, including field calibrators units, are provided in the appendix of this report).

The 5 environmental noise monitoring stations are in general accordance with requirements of section 4 and section 5.2 of the *Tasmanian Noise Measurement Procedures Manual* (July 2004)[1].

Available 15-minute interval data sets for each measurement location were filtered for erroneous data and poor weather conditions (i.e. winds speeds in excess of 5 m/s and precipitation), based on 10-minute weather data recorded at the three weather stations shown in Figures 2.1 and 2.2. To achieve time-series consistency between the weather data and noise data a Python time-series function was applied to the weather data to resample from 10-minute to 15-minute data via linear interpolation of overlapping events.

3.1 Data sets

Table 3-1 presents overall data availability as a percentage of the 35,040 possible 15-minute intervals available for analysis over the past monitoring year. Available data has subsequently been filtered against adverse weather conditions and measurement overload errors.

Table 3-1: Environmental noise monitoring data set summary.

Environmental noise monitoring data set summary				
Location	Recorded intervals		Intervals post filtering	
	count	%	count	%
Alec St	34,019	97.1	26,512	77.9
Cohen St	35,026	99.9	27,358	78.1
Mt Black	32,982	94.1	25,605	77.6
Murchison St	34,540	98.6	27,070	78.4
Police House	34,446	98.3	26,873	78.0

Data availability was generally greater than 97 % except for Mt Black where a number of USB and data conversion errors occurred.

After filtering out adverse weather conditions and meter overloads, approx. 78 % of possible intervals were available for analysis, up from 66 to 71 % available from the previous year's data[2].

3.2 Summary Monitoring results

Table 3-2 provides annual arithmetically averaged L_{Aeq}, L_{A90} and L_{A10} 15-minute levels calculated from the filtered data sets for each measurement location. Levels for the day, evening and night periods are provided with each period defined as follows:

- Day: 0700 to 1800 hrs
- Evening: 1800 to 2200 hrs
- Night: 2200 to 0700 hrs.

Annual average levels from the 2020/2021 year[2] are also provided for comparative purposes.

Table 3-2: Environmental noise monitoring summary data.

Environmental noise monitoring summary data, average 15-minute Ln-statistics (dBA)										
Location	Period	2021/2022			2020/2021			Difference (dB)		
		L_{Aeq}	L_{A90}	L_{A10}	L_{Aeq}	L_{A90}	L_{A10}	L_{Aeq}	L_{A90}	L_{A10}
Police House	Day	53	48	54	53	48	54	0	0	0
	Evening	52	48	52	52	48	52	0	0	0
	Night	50	48	51	50	48	50	0	0	1
Cohen St	Day	52	49	52	53	50	54	-1	-1	-2
	Evening	50	49	51	51	49	51	-1	0	0
	Night	49	48	50	50	49	50	-1	-1	0
Mt Black	Day	46	41	47	45	40	45	1	1	2
	Evening	42	39	43	43	40	44	-1	-1	-1
	Night	40	38	41	42	40	42	-2	-2	-1
Murchison St	Day	48	41	48	47	41	47	1	0	1
	Evening	46	40	46	45	41	45	1	-1	1
	Night	43	39	43	42	40	42	1	-1	1
Alec St	Day	45	38	45	45	38	46	0	0	-1
	Evening	41	37	42	42	37	43	-1	0	-1
	Night	39	36	40	39	36	40	0	0	0

Average annual noise levels were generally within 1 to 2 dB of levels seen in the 20/21 monitoring year.

The following subsections provide graphs of monthly average $L_{Aeq,15min}$ day, evening, and night levels (from filtered data) measured at each of the 5 monitoring locations.

3.2.1 Police House

Figure 3-1 presents monthly average 15-minute day, evening, and night L_{Aeq} levels at the Police House monitoring location.

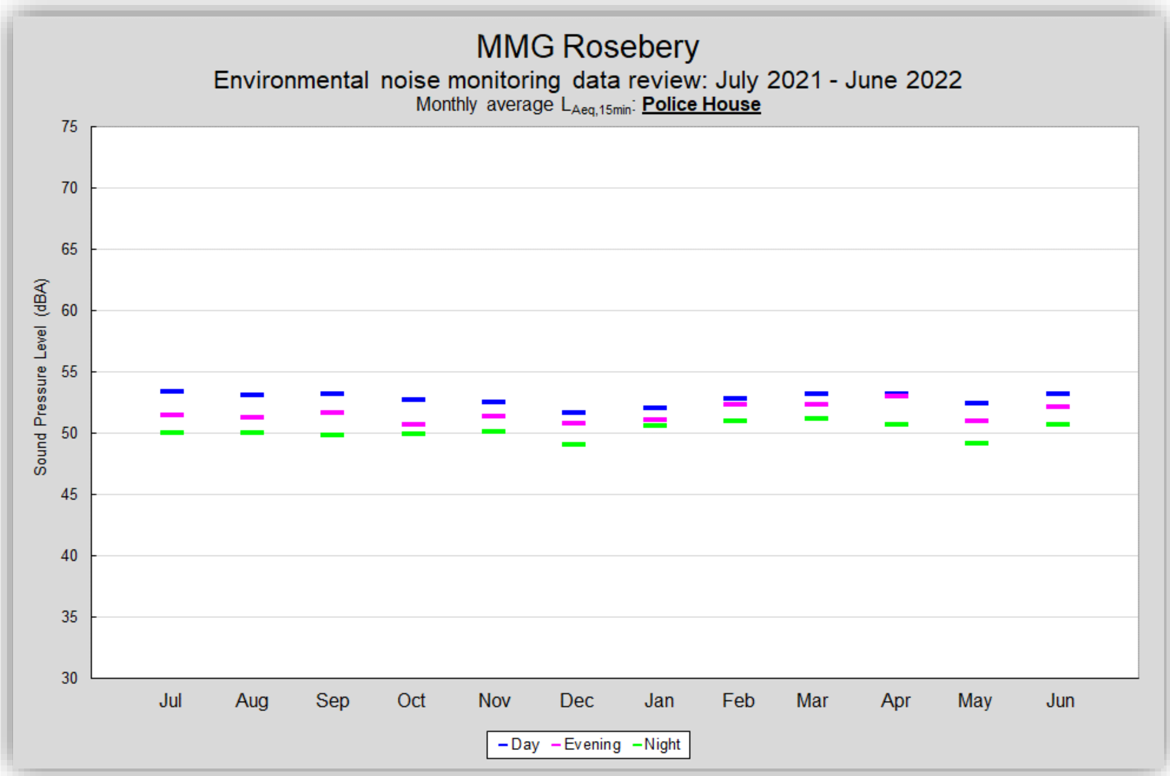

Figure 3-1: Monthly average $L_{Aeq,15min}$ levels for day, evening and night periods, **Police House** (N1).

Monthly average $L_{Aeq,15min}$ noise levels were relatively stable throughout the year. During most of the year, measured levels were bounded between 52 dBA at night and 54 dBA during the day suggesting a stable noise environment.

3.2.2 Cohen St

Figure 3-2 presents monthly average 15-minute day, evening, and night L_{Aeq} levels at the Cohen St monitoring location.

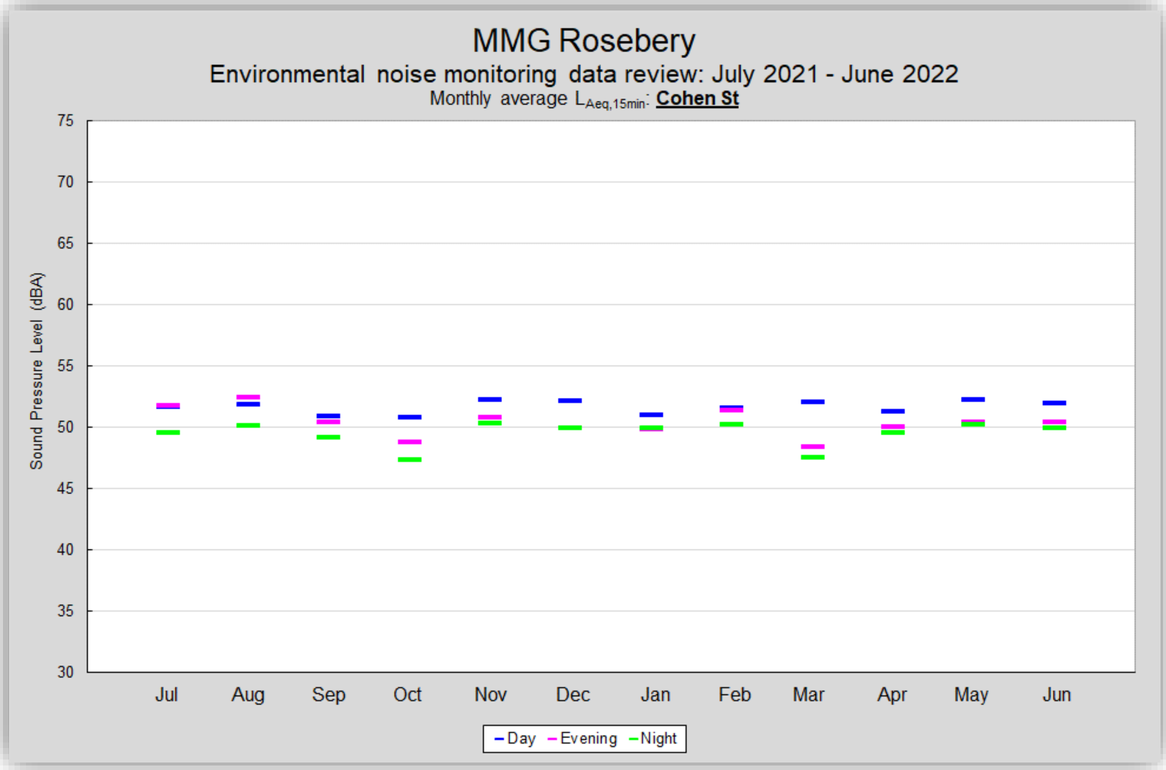

Figure 3-2: Monthly average $L_{Aeq,15min}$ levels for day, evening and night periods, **Cohen St** (N2).

Monthly average day, evening, and night $L_{Aeq,15min}$ levels were relatively stable throughout the year with levels bounded between 49 – 53 dBA. Exceptions to this are seen in October and March where evening and night L_{Aeq} levels where lower than during other months.

3.2.3 Mt Black

Figure 3-3 presents monthly average 15-minute day, evening, and night L_{Aeq} levels at the Mt Black monitoring location.

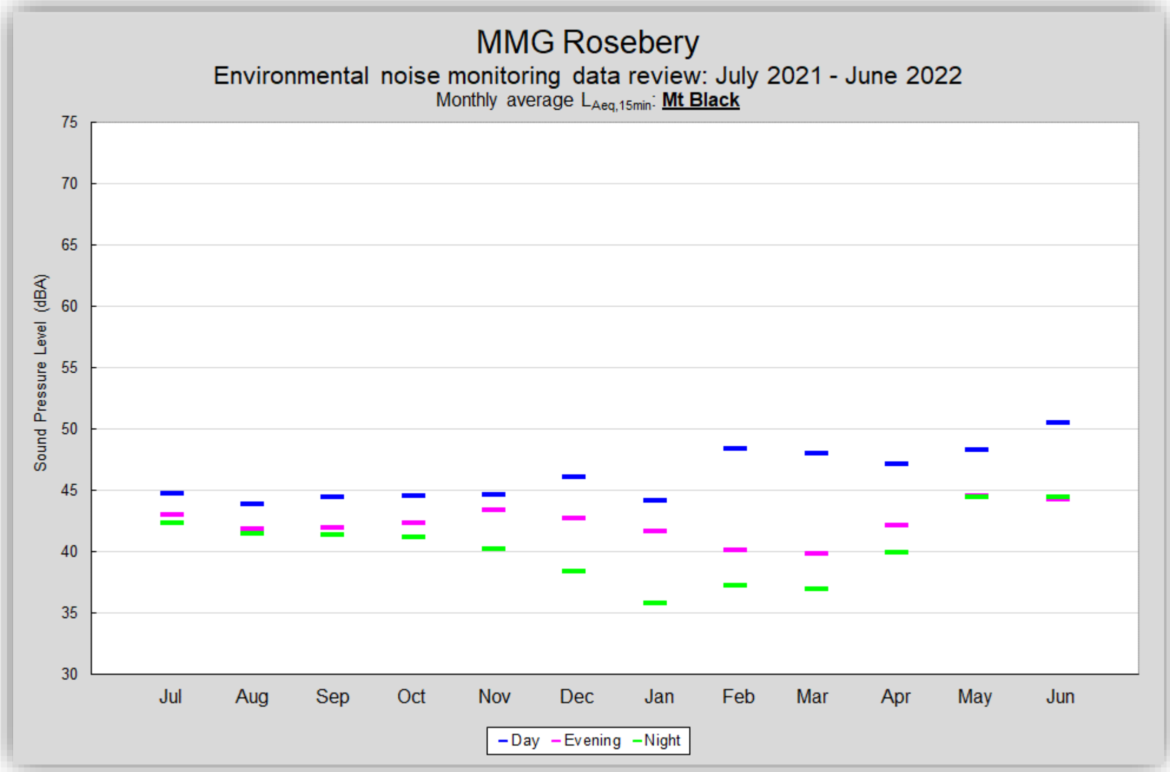

Figure 3-3: Monthly average $L_{Aeq,15min}$ levels for day, evening and night periods, **Mt Black** (N3).

Monthly average day, evening, and night L_{Aeq} levels were fairly consistent at this location during the first half of the year. In the second half diurnal noise levels become very variable between December and April with very low night levels and high day levels. A reduction in significant noise generating activity at the mine is potentially responsible for the lower evening and night levels while elevated day levels may have been generated by TasWater activity at a nearby holding tank.

3.2.4 Murchison St

Figure 3-4 presents monthly average 15-minute day, evening, and night L_{Aeq} levels at the Murchison St monitoring location.

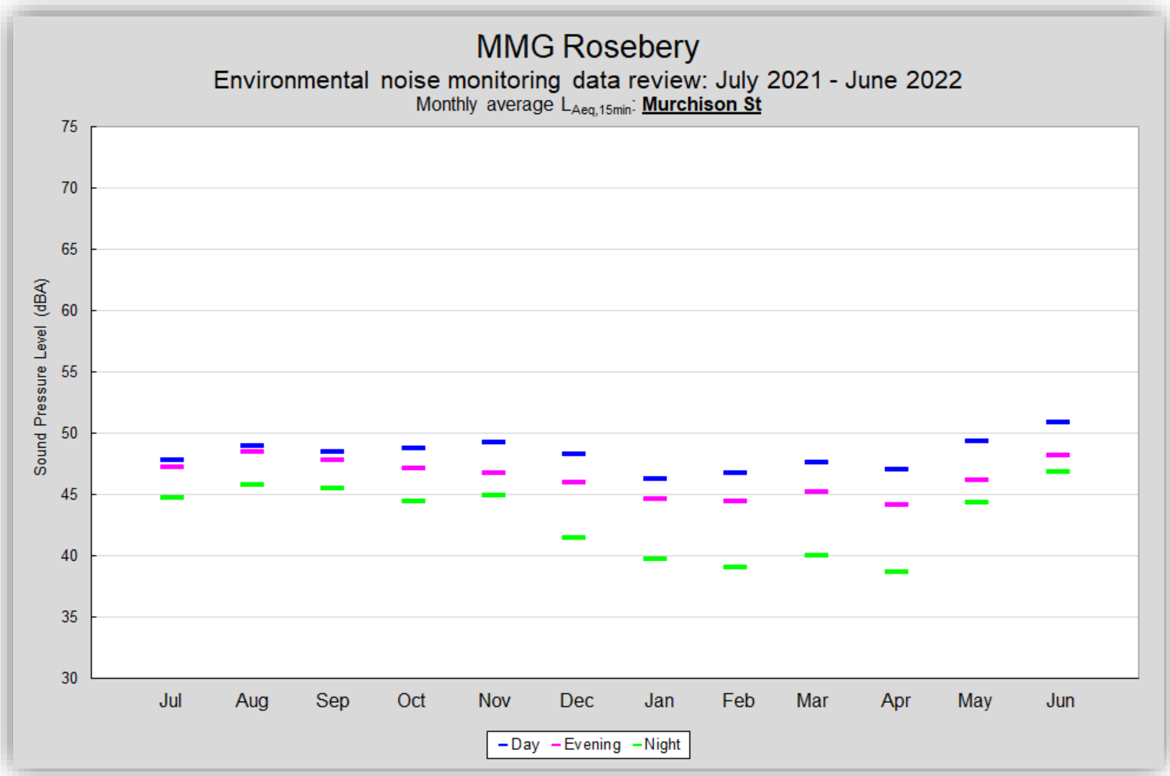

Figure 3-4: Monthly average $L_{Aeq,15min}$ levels for day, evening and night periods, **Murchison St** (N4).

Day, evening, and night levels were consistently 3 dB above Mt Black station data (170 m NE from this station) through the first half of the year.

Significantly lower night-time levels were measured between December and April along with slightly lower day and evening levels. A reduction in significant noise generating activity at the mine is potentially responsible.

3.2.5 Alec St

Figure 3-5 presents monthly average 15-minute day, evening, and night L_{Aeq} levels at the Alec St monitoring location.

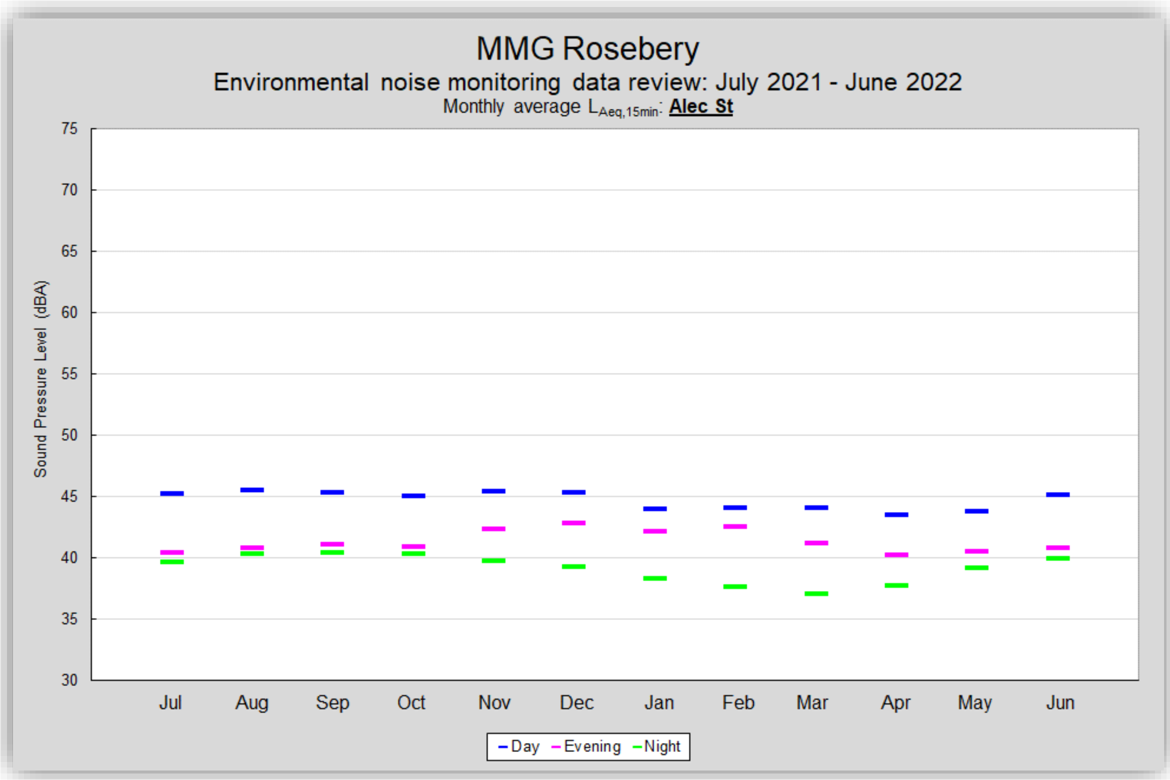

Figure 3-5: Monthly average $L_{Aeq,15min}$ levels for day, evening and night periods, **Alec St** (N5).

Day, evening, and night monthly average L_{Aeq} levels were consistent through the year while generally showing the highest diurnal variation of the 5 monitoring locations. This suggests that transient noise sources (e.g. traffic) controlled the noise environment at this location.

A reduction in night levels between December and April roughly correlates with the dip seen at Murchison St and Mt Black.

4 Blast monitoring

GV and ABO is monitored at a single location on the western side of the Rosebery Hospital. An Instantel Minimate Plus monitor and an Instantel Minimate Pro 4 monitor were used with an International Society of Explosives Engineers (ISEE) standard triaxial geophone and ISEE linear microphone. 15-minute peak particle velocity (mm/s) and peak linear sound pressure levels (dBL) are recorded. Blasting at the mine occurs during 2 time periods on a daily basis as follows:-

- 0645 to 0700 hrs
- 1845 to 1900 hrs

Monitoring is undertaken in general accordance with the relevant guidelines including the *Australian and New Zealand Environment Council* (ANZECC) *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (September 1990), *Australian Standard AS 2187.2-2006 Explosives storage and use. Use of explosives* and the Tasmania *Quarry Code of Practice* (May 2017).

The measurement of GV and ABO is in general accordance with the provisions of the Appendix J sections J3.2 and 3.3 of *AS 2187.2-2006* with the exception of the location of the microphone which is close (approx. 5 – 10 cm) to the western wall of the Rosebery Hospital.

The Minimate Plus units is calibrated annually at a NATA accredited laboratory and all data presented here is from within the period of calibration. The Minimate Pro 4 unit was a new purchase and was calibrated by the manufacturer prior to shipment.

4.1 Data set

Of the possible 35,040 15-minute data intervals within the monitoring year, 28,269 (80.1 % of the intervals) were available for analysis; This is an approx. 16 % drop in data availability over last year's data[2].

During the last financial year MMG implemented a cloud-based data management system removing the need to manually download data and reducing the chance of data loss due to human error for the blast monitor.

The following summarises the significant periods of missing data from the previous financial year:

- 2021-10-22 - 2021-11-24
- 2021-12-21 - 2022-01-18
- 2022-05-01 - 2022-05-12

4.2 Ground vibration monitoring

Figure 4-1 presents 15-minute peak particle velocity levels measured at the Hospital monitoring location (the highest value of the three orthogonal measurement directions was selected for each interval). Figure 4-2 presents measured levels at scheduled blasting times only. Results are assessed against the following limits applicable under EPN 7153/3:-

- 5 mm/s for 95 % of blasts
- 10 mm/s for 100 % of blasts

Both limits are marked on graphs for the complete data set (Figure 4-1) and during scheduled blasting times (Figure 4-2):

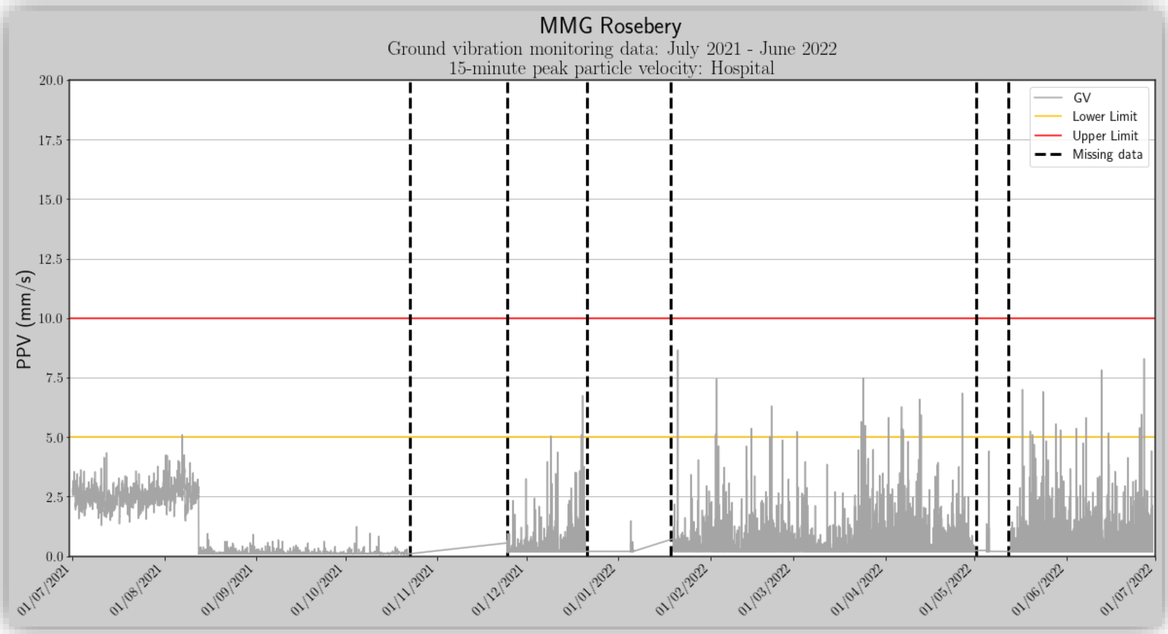

Figure 4-1: 15-minute peak particle velocity levels, **Hospital** (V2).

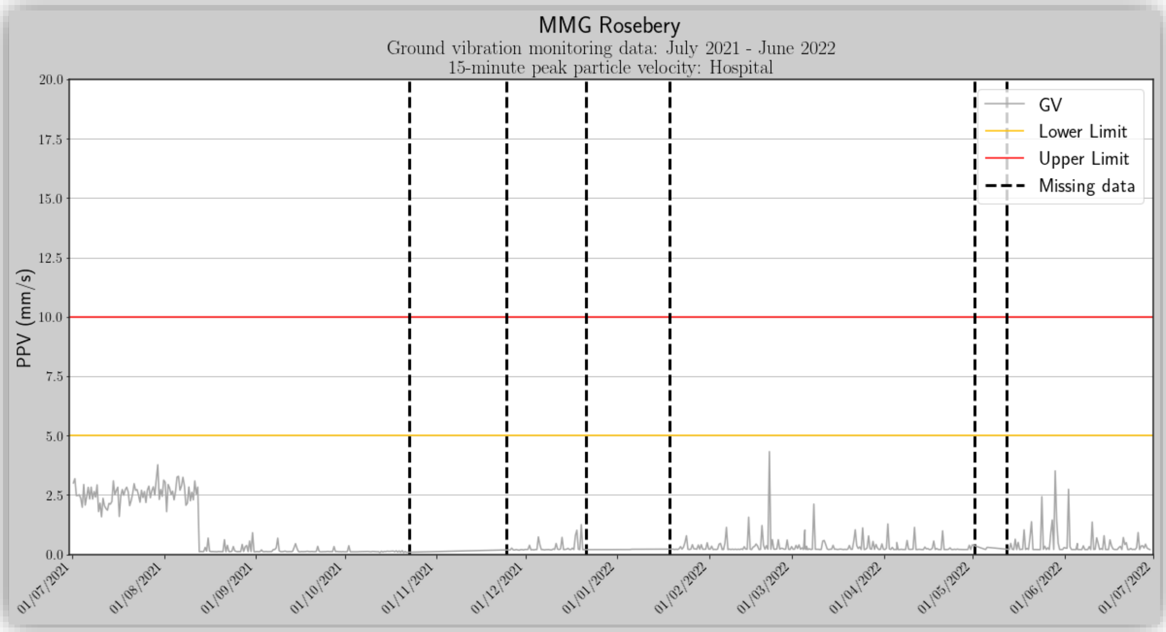

Figure 4-2: 15-minute peak particle velocity levels during scheduled blasting times, **Hospital** (V2).

From the above, Tarkarri Engineering notes no exceedance of the EPN limits occurred during scheduled blasting times.

4.3 Air blast overpressure monitoring

Figure 4-3 presents 15-minute peak linear sound pressure levels measured at the Hospital monitoring location. Figure 4-4 presents measured levels at scheduled blasting times only. Results are assessed against the following limits applicable under EPN 7153/3:

- 115 dBL for 95 % of blasts
- 120 dBL for 100 % of blasts

Both limits are marked on graphs for the complete data set (Figure 4-3) and during scheduled blasting times (Figure 4-4):

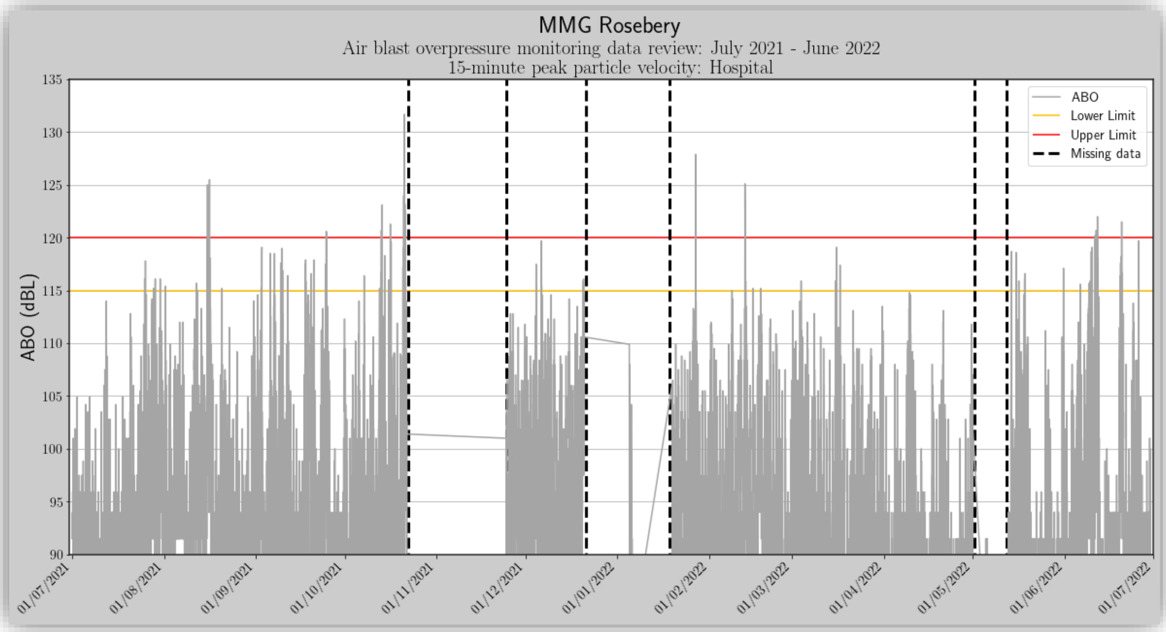

Figure 4-3: 15-minute peak linear sound pressure levels, **Hospital** (V2).

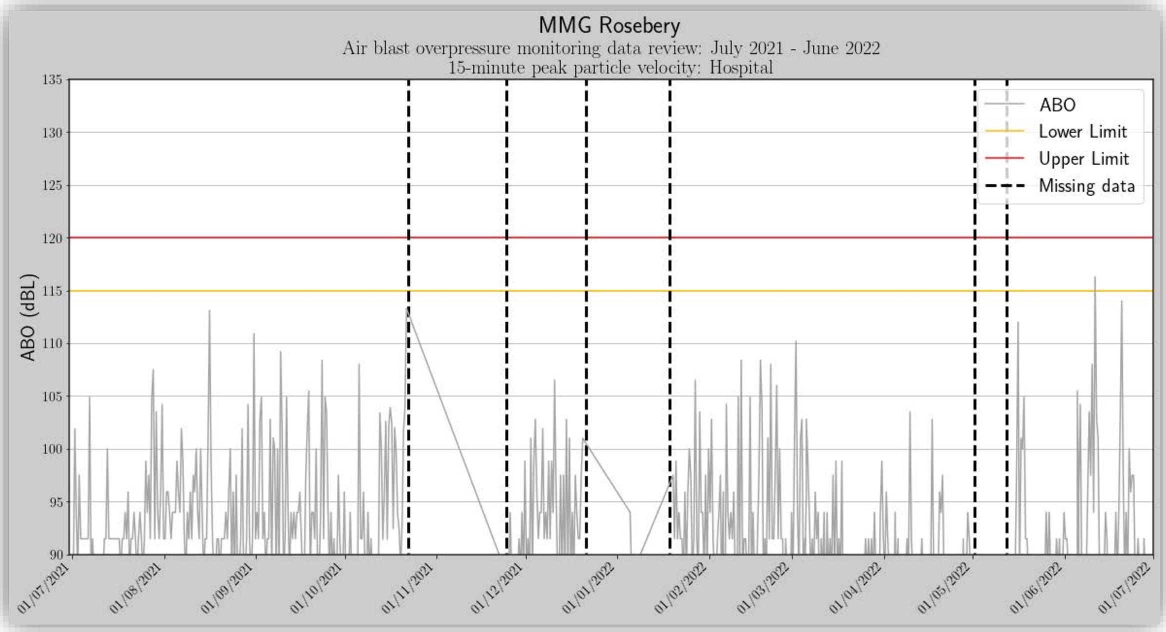

Figure 4-4: 15-minute peak linear sound pressure levels during scheduled blasting times, **Hospital** (V2).

1 exceedance of the 115 dBL limit occurred within scheduled blasting times at the mine and no exceedance of the 120 dBL limit. Analysis of weather data from the 3 MMG weather stations indicates that poor weather conditions (i.e. windspeeds were in excess of 5 m/s and/or rainfall was measured) are likely to have been responsible for the exceedances and not blasting actives.

5 Community noise nuisance

Table 5-1: Community noise nuisance events.

Community noise nuisance events			
Date	Complaint	Investigation	Corrective Action
28/12/2021	Noise from rock breaker on level 4	Operational hours of rock breaker	Not required - Rock breaker was working within operational hours
13/01/2022	Dust and Noise at 2/5 Dam	Ongoing discussions	A solution has been agreed with the complainant.
25/02/2022	Noise from 7am drilling activities	Generator was still operational	Generator turned off
31/03/2022	Noise from generator left on at night	Construction occurring within specified time	N/A
30/06/2022	From Rosebery resident regarding noise impacts from 2/5 Dam construction works	Ongoing discussions	A solution has been agreed with the complainant.

6 Conclusions and recommendations

Tarkarri Engineering has conducted a review of environmental noise, GV and ABO monitoring data recorded by MMG Rosebery between 1 July 2021 and 30 June 2022.

The environmental noise monitoring data typically showed annual averages for the L_{Aeq}, L_{A90} and L_{A10} 15-minute levels at monitoring positions N1, N2, N3, N4 and N5 similar to those measured in the previous year[2].

GV and ABO data showed that levels recorded during blasting times at the mine were below the EPN limits with only 1 recorded exceedance of the lower EPN ABO limit that was not related to blasting activities and likely due to weather impacts.

6.1 Recommendations

6.1.1 Noise monitoring

Under the site EPN an environmental noise survey is required on a tri-annual basis and the survey methodology requirements under the EPN call for a 10-minute measurement interval (condition N3 3.3.). Tarkarri Engineering recommends that loggers at the 5 monitoring locations are changed to record 10-minute intervals rather than the current 15-minute intervals to bring survey and unobserved monitoring data in line. Approval for this change should be sought from Director of the EPA as per condition N1 1.1 of the mine's EPN (see section 1 of this report).

Tarkarri Engineering notes that condition N1 1.3 states 'measured noise levels are to be adjusted for tonality and impulsiveness in accordance with the Tasmanian Noise Measurement Procedures Manual 2004, or future revisions of this manual, issued by the Director'. For tonality to be addressed as required an '… A-weighted frequency response, a one-third octave spectrum must be measured'[1]. and for impulsiveness to be addressed as required measurements '…using a sound level meter set initially to fast and then impulse time response'[1] must be taken. The current monitoring systems employed by MMG do not have the capability of measuring a 1/3-octave band spectrum or recording concurrent impulse time response noise levels.

NB: Tarkarri Engineering notes that without observation or directional noise measurement it would not be possible to determine the source of any tonal or impulsive noise emissions with any accuracy.

Lost data and inconsistencies in the data records indicate that download and calibration procedures utilised by MMG for the noise monitoring stations requires review and potential retraining of personnel to minimise loss of data. It should be noted that data retention was vastly improved from last year indicating that improvements have been made. Particular focus should be on the following:

- Procedures drafted to assist future MMG personnel in properly downloading data. This may include leaving data on the meter until it has been properly transferred to MMG's data repository and reviewed.

The following reminders are provided based on issues seen in previous years:

- Care is taken in handling the microphones at each monitoring station as these are delicate and easily damaged during calibration.
- Ensuring that the field calibrator is activated prior to calibration being initiated and that care is taken during calibration.
- Check of connection points (i.e. cable connections to preamp and sound level meter unit) to ensure no water ingress, corrosion or other damage has occurred.

6.1.2 GV and ABO monitoring

As discussed in section 4 of this report, the current measurement location does not fully comply with the provisions of Appendix J sections J3.2 and J3.3 of *AS 2187.2-2006*. Tarkarri Engineering recommends that the monitoring equipment be relocated to a more suitable position and notes that MMG have submitted a request to the EPA in relation to this and are awaiting a response. An investigation was conducted in March 2021 and detailed in Tarkarri Engineering report 5514_VIB_R which provides recommendations regarding new monitoring location options.

7 Appendix

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Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C20696

Client Details MMG Rosebery
PO Box 21
Rosebery Tasmania 7470

Equipment Tested/ Model Number : ARL Ngara S-Pack
Instrument Serial Number : 8780FE
Microphone Serial Number : 319691
Pre-amplifier Serial Number : 28099

Pre-Test Atmospheric Conditions		**Post-Test Atmospheric Conditions**	
Ambient Temperature :	22.7°C	**Ambient Temperature :**	22.6°C
Relative Humidity :	48.7%	**Relative Humidity :**	48.4%
Barometric Pressure :	100.9kPa	**Barometric Pressure :**	100.8kPa

Calibration Technician : Lucky Jaiswal
Calibration Date : 2 Dec 2020
Secondary Check: Max Moore
Report Issue Date : 19 Jan 2021

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*±0.12dB*	*Temperature*	*±0.2°C*
1kHz	*±0.11dB*	*Relative Humidity*	*±2.4%*
8kHz	*±0.13dB*	*Barometric Pressure*	*±0.015kPa*
Electrical Tests	*±0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Accredited for compliance with ISO/IEC 17025 - calibration.

The results of the tests, calibrations and/or measurements included in this document are traceable to SI units.

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Sound Level Meter
IEC 61672-3.2013
Calibration Certificate
Calibration Number C21056

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878135
Microphone Serial Number : 321284
Pre-amplifier Serial Number : 28263

Pre-Test Atmospheric Conditions		Post-Test Atmospheric Conditions	
Ambient Temperature :	24°C	**Ambient Temperature :**	24.3°C
Relative Humidity :	50%	**Relative Humidity :**	50.9%
Barometric Pressure :	100.13kPa	**Barometric Pressure :**	100.1kPa

Calibration Technician : Jeff Yu
Calibration Date : 5 Feb 2021
Secondary Check: Max Moore
Report Issue Date : 9 Feb 2021

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*±0.12dB*	*Temperature*	*±0.2°C*
1kHz	*±0.11dB*	*Relative Humidity*	*±2.4%*
8kHz	*±0.13dB*	*Barometric Pressure*	*±0.015kPa*
Electrical Tests	*±0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C21408

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878139
Microphone Serial Number : 320268
Pre-amplifier Serial Number : 28142

Pre-Test Atmospheric Conditions
Ambient Temperature : 22.9°C
Relative Humidity : 47.7%
Barometric Pressure : 101.87kPa

Post-Test Atmospheric Conditions
Ambient Temperature : 23.6°C
Relative Humidity : 46.2%
Barometric Pressure : 101.9kPa

Calibration Technician : Jeff Yu
Calibration Date : 22 Jun 2021
Secondary Check: Harrison Kim
Report Issue Date : 28 Jun 2021

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*±0.12dB*	*Temperature*	*±0.2°C*
1kHz	*±0.11dB*	*Relative Humidity*	*±2.4%*
8kHz	*±0.13dB*	*Barometric Pressure*	*±0.015kPa*
Electrical Tests	*±0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C21492

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878112
Microphone Serial Number : 321297
Pre-amplifier Serial Number : 28265

Pre-Test Atmospheric Conditions		Post-Test Atmospheric Conditions	
Ambient Temperature :	20.9°C	**Ambient Temperature :**	20.7°C
Relative Humidity :	45.4%	**Relative Humidity :**	45.4%
Barometric Pressure :	100.43kPa	**Barometric Pressure :**	100.43kPa

Calibration Technician : Jeff Yu
Calibration Date : 27 Jul 2021
Secondary Check: Max Moore
Report Issue Date : 28 Jul 2021

Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*0.12dB*	*Temperature*	*0.2°C*
1kHz	*0.11dB*	*Relative Humidity*	*2.4%*
8kHz	*0.13dB*	*Barometric Pressure*	*0.015kPa*
Electrical Tests	*0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C21561

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 8780CC
Microphone Serial Number : 322088
Pre-amplifier Serial Number : 28547

Pre-Test Atmospheric Conditions		**Post-Test Atmospheric Conditions**	
Ambient Temperature :	22.8°C	**Ambient Temperature :**	23°C
Relative Humidity :	38.8%	**Relative Humidity :**	38.3%
Barometric Pressure :	100.6kPa	**Barometric Pressure :**	100.6kPa

Calibration Technician : Lucky Jaiswal **Secondary Check:** Max Moore
Calibration Date : 26 Aug 2021 **Report Issue Date :** 27 Aug 2021

Approved Signatory : [signature] Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*0.13dB*	*Temperature*	*0.2°C*
1kHz	*0.13dB*	*Relative Humidity*	*2.4%*
8kHz	*0.14dB*	*Barometric Pressure*	*0.015kPa*
Electrical Tests	*0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Level Meter
IEC 61672-3.2013
Calibration Certificate

Calibration Number C21585

Client Details MMG
C/o De Bryuns Transport Depot 8 River Road
Wivenhoe TAS 7320

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 8780FD
Microphone Serial Number : 322285
Pre-amplifier Serial Number : 28229

Pre-Test Atmospheric Conditions		Post-Test Atmospheric Conditions	
Ambient Temperature :	23.7°C	Ambient Temperature :	23.6°C
Relative Humidity :	38.9%	Relative Humidity :	38.9%
Barometric Pressure :	100.3kPa	Barometric Pressure :	100.3kPa

Calibration Technician : Lucky Jaiswal **Secondary Check:** Rhys Gravelle
Calibration Date : 13 Sep 2021 **Report Issue Date :** 13 Sep 2021

Approved Signatory : [signature] Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*±0.13dB*	*Temperature*	*±0.2°C*
1kHz	*±0.13dB*	*Relative Humidity*	*±2.4%*
8kHz	*±0.14dB*	*Barometric Pressure*	*±0.015kPa*
Electrical Tests	*±0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Level Meter
IEC 61672-3.2013

Calibration Certificate

Calibration Number C21741

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 8780CD
Microphone Serial Number : 322710
Pre-amplifier Serial Number : 28201

Pre-Test Atmospheric Conditions		Post-Test Atmospheric Conditions	
Ambient Temperature :	25.2°C	**Ambient Temperature :**	25.5°C
Relative Humidity :	44.4%	**Relative Humidity :**	37.6%
Barometric Pressure :	101.6kPa	**Barometric Pressure :**	101.5kPa

Calibration Technician : Lucky Jaiswal
Calibration Date : 3 Nov 2021
Secondary Check: Harrison Kim
Report Issue Date : 4 Nov 2021

Approved Signatory : [signature] Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
12: Acoustical Sig. tests of a frequency weighting	*Pass*	17: Level linearity incl. the level range control	*Pass*
13: Electrical Sig. tests of frequency weightings	*Pass*	18: Toneburst response	*Pass*
14: Frequency and time weightings at 1 kHz	*Pass*	19: C Weighted Peak Sound Level	*N/A*
15: Long Term Stability	*Pass*	20: Overload Indication	*Pass*
16: Level linearity on the reference level range	*Pass*	21: High Level Stability	*Pass*

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2013, for the environmental conditions under which the tests were performed.

However, no general statement or conclusion can be made about conformance of the sound level meter to the full requirements of IEC 61672-1:2013 because evidence was not publicly available, from an independent testing organisation responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2013 and because the periodic tests of IEC 61672-3:2013 cover only a limited subset of the specifications in IEC 61672-1:2013.

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
125Hz	*0.13dB*	*Temperature*	*0.2°C*
1kHz	*0.13dB*	*Relative Humidity*	*2.4%*
8kHz	*0.14dB*	*Barometric Pressure*	*0.015kPa*
Electrical Tests	*0.10dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Calibrator

IEC 60942-2017

Calibration Certificate

Calibration Number C21057

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : Pulsar Model 105
Instrument Serial Number : 75585

Atmospheric Conditions
Ambient Temperature : 23.7°C
Relative Humidity : 49.8%
Barometric Pressure : 100.13kPa

Calibration Technician : Jeff Yu
Calibration Date : 05 Feb 2021
Secondary Check: Max Moore
Report Issue Date : 9 Feb 2021

Approved Signatory : [signature] Ken Williams

Characteristic Tested	Result
Generated Sound Pressure Level	*Pass*
Frequency Generated	*Pass*
Total Distortion	*Pass*

Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
94	1000	93.98	1000.30

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942 2017 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed.

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.14dB*	*Temperature*	*±0.2°C*
Frequency	*±0.09%*	*Relative Humidity*	*±2.4%*
Distortion	*±0.09%*	*Barometric Pressure*	*±0.015kPa*

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

* The tests <1000 kHz are not covered by Acoustic Research Labs Pty Ltd NATA accreditation.

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Sound Calibrator
IEC 60942-2017

Calibration Certificate

Calibration Number C21128

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : Pulsar Model 105
Instrument Serial Number : 63709

Atmospheric Conditions
Ambient Temperature : 22.2°C
Relative Humidity : 53.4%
Barometric Pressure : 99.8kPa

Calibration Technician : Lucky Jaiswal **Secondary Check:** Max Moore
Calibration Date : 05 Mar 2021 **Report Issue Date :** 8 Mar 2021

Approved Signatory : Ken Williams

Characteristic Tested	Result
Generated Sound Pressure Level	*Pass*
Frequency Generated	*Pass*
Total Distortion	*Pass*

Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
94	1000	94.03	1000.40

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2017 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed.

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.14dB*	*Temperature*	*±0.2°C*
Frequency	*±0.09%*	*Relative Humidity*	*±2.4%*
Distortion	*±0.09%*	*Barometric Pressure*	*±0.015kPa*

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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Sound Calibrator

IEC 60942:2017

Calibration Certificate

Calibration Number C21765

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : Pulsar Model 105
Instrument Serial Number : 78234

Atmospheric Conditions

Ambient Temperature : 24°C
Relative Humidity : 40.4%
Barometric Pressure : 99.6kPa

Calibration Technician : Lucky Jaiswal
Calibration Date : 15 Nov 2021
Secondary Check: Harrison Kim
Report Issue Date : 17 Nov 2021

Approved Signatory : Ken Williams

Characteristic Tested	Result
Generated Sound Pressure Level	*Pass*
Frequency Generated	*Pass*
Total Distortion	*Pass*

Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
94	1000	94.08	1000.30

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2017 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed.

Least Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.11dB*	*Temperature*	*±0.1°C*
Frequency	*±0.18%*	*Relative Humidity*	*±1.9%*
Distortion	*±0.50%*	*Barometric Pressure*	*±0.014kPa*

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Calibrator

IEC 60942:2017

Calibration Certificate

Calibration Number C22112

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : Pulsar Model 105
Instrument Serial Number : 63709

Atmospheric Conditions
Ambient Temperature : 24.8°C
Relative Humidity : 61.8%
Barometric Pressure : 100.42kPa

Calibration Technician : Lucky Jaiswal
Calibration Date : 28 Feb 2022
Secondary Check: Max Moore
Report Issue Date : 28 Feb 2022

Approved Signatory : Ken Williams

Characteristic Tested	Result
Generated Sound Pressure Level	*Pass*
Frequency Generated	*Pass*
Total Distortion	*Pass*

Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
94	1000	94.24	1000.40

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2017 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed.

Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.11dB*	*Temperature*	*±0.1°C*
Frequency	*±0.07%*	*Relative Humidity*	*±1.9%*
Distortion	*±0.50%*	*Barometric Pressure*	*±0.014kPa*

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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Sound Calibrator

IEC 60942:2017

Calibration Certificate

Calibration Number C22111

Client Details MMG - Rosebery Mine
7 Hospital Road
Rosebery TAS 7470

Equipment Tested/ Model Number : Pulsar Model 105
Instrument Serial Number : 75585

Atmospheric Conditions
Ambient Temperature : 24.8°C
Relative Humidity : 64.8%
Barometric Pressure : 100.42kPa

Calibration Technician : Lucky Jaiswal **Secondary Check:** Max Moore
Calibration Date : 28 Feb 2022 **Report Issue Date :** 28 Feb 2022

Approved Signatory : Ken Williams

Characteristic Tested	Result
Generated Sound Pressure Level	*Pass*
Frequency Generated	*Pass*
Total Distortion	*Pass*

Nominal Level	Nominal Frequency	Measured Level	Measured Frequency
94	1000	94.10	1000.30

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2017 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed.

Uncertainties of Measurement -

Specific Tests		Environmental Conditions	
Generated SPL	*±0.11dB*	*Temperature*	*±0.1°C*
Frequency	*±0.07%*	*Relative Humidity*	*±1.9%*
Distortion	*±0.50%*	*Barometric Pressure*	*±0.014kPa*

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

This calibration certificate is to be read in conjunction with the calibration test report.

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NATA Report No.: 19536-0-cal-01 ***Report Date:*** *20 Aug. 21* ***Calibration Date:*** *23 Aug 2021* ***Page 1 of 7***

Calibration Report on:

Instantel

Model: *Minimate Plus*

Blast Seismometer & Geophone

Serial Number: *BE14128 & BG13072*

Accredited Laboratory Number: 676

Accredited for compliance with ISO/IEC 17025-Calibration.

NATA

Testing Officer: ______________________

Firezewed Antachew

Approved. Signatory: ______________________

Daniel Hruszecky

Calibration Certificate

Part Number: 720A2301
Description: Minimate Pro 4
Serial Number: MP14425
Calibration Date: JAN 2 6 2022
Calibration Reference Equipment: Kiethley 1350688

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications.

Instantel further certifies that the measurement instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology; or National Research Council of Canada. Evidence of traceability is on file at Instantel and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

Please note that the sensor check function is intended to check that the sensors are connected to the unit, installed in the proper orientation and sufficiently level to operate properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an authorized service and calibration facility for annual calibration.

Calibrated By: Mary Nichols
Mary Nichols

Instantel 309 Legget Drive, Ottawa, Ontario, K2K 3A3, (613) 592-4642

APPENDIX F: BIOLOGICAL CONDITION OF LAKE PIEMAN: SPRING 2021 (FRESHWATER BIOMONITORING 2021)

Lake Pieman - Bobadil discharge zone

Biomonitoring Report: Summer 2022

Report to:

MMG Pty Ltd, Rosebery Mine

Stephen Mallick
March 2022

fbm

Freshwater
Biomonitoring
Consulting Service
ABN 6087593224

18 Stoney Steps, South Hobart,
Tasmania, Australia 7004
Phone: 0429 343 097
Email:mallick.fbm@gmail.com

Summary

- This report details the 2022 results of the annual survey of shore biota in Lake Pieman in relation to the Bobadil TFS discharge.
- Sampling was conducted at 15 sites along the eastern shore zone of the Lake Pieman on 31 January - 1 February 2022.
- Chlorophyll-a levels were generally low in Lake Pieman on the day of sampling. In the context of these low background levels, algae growth in Lake Pieman showed no apparent response to the inflow of the Bobadil discharge in summer 2022.
- The macroinvertebrate fauna collected from the lake shoreline in summer 2022 was also characterized by relatively low diversity and abundance. As was the case for algae, the macroinvertebrate fauna in 2022 showed no spatial pattern that can be attributed to a localised toxicological impact in the vicinity of the Bobadil discharge.
- Sampling in 2022 was conducted in summer (Jan – Feb) in an attempt to minimise the effects of fluctuating lake level, as levels in Lake Piemen are generally less variable in the summer months. Sampling was also timed to follow a two-week period of relative stability in lake levels.
- Over the two weeks prior to the first day of sampling (31 January) lake levels had been relatively stable (+/- 30 cm), but dropped ca. 80 cm overnight prior to the second day of sampling on 1 February (Figure 6).
- Despite this drop in lake levels, visual inspection of the shoreline during sampling suggested a good level of accumulated detritus within the sampling zone on both days capable of supporting a robust shoreline biota.
- This is borne out by the increased diversity and abundance of macroinvertebrates and increased algae growth in summer 2022 compared to previous sampling events situated in the spring months.
- It is recommended that sampling in 2023 is also conducted in the January - February period to coincide with a period of lake-level stability.

1. Introduction

This report details the 2022 results of the routine annual survey of shore biota in Lake Pieman in relation to the Bobadil discharge. This biological monitoring program assesses the ecological status of the area in Lake Pieman influenced by the discharge from the MMG Rosebery mine Bobadil Polishing Pond facility. Sampling is conducted annually as per condition E3 of EPN 7153/3, to “document on-going environmental conditions in the Lake, increase understanding of temporal, special and seasonal biological changes, and progress the development of site specific toxicity guidelines for sulphate and zinc in Lake Pieman”.

Previous surveys at this location, including those for the previous operators (Zinifex, Ozminerals), have been reported for spring and/or autumn every year from 2004/05 to 2020 The current operator (MMG) is required to report on a single annual survey of lake-shore biota in upper Lake Pieman.

Sampling is conducted at 15 locations along the eastern side of the upper Lake Pieman reach, upstream and downstream of the Bobadil discharge point.

1.1 *Context to biological monitoring in Lake Pieman*

The Bobadil discharge enters the upper arm of Lake Pieman on its eastern shore, approximately five kilometres downstream of Hydro Tasmania’s Bastyan dam on Lake Rosebery. This arm of the lake is frequently highly ‘fluvial’ (river-like) and experiences large and fluctuating flow rates throughout the year. It also experiences substantial fluctuations in level which are mainly dictated by seasonal variation in inputs to the lake from its catchment and variations in power station throughput at Reece Dam.

The mixing behaviour of the Bobadil discharge is locally complex, with periods of rapid downstream dispersion and dilution during releases from the Bastyan power station and/or spill from Lake Rosebery, as well as periods of relative stagnation in which a measure of local pooling and multidirectional dispersion occurs within the receiving lake reach, especially in near surface waters. This means that localized biological effects of these discharges may be manifest both ‘upstream’ and ‘downstream’ of the point of discharge in the lake, though with impacts likely to occur in a predominantly downstream direction.

This variation in dispersion behaviour has a significant influence on the nature and variability of in-lake biological exposure to discharge components. Biological monitoring of the lake in relation to the localised effects of specific discharges is also made difficult due to this variability as well as the inherent dynamics of the Lake's fauna and flora.

Benthic algae and fauna associated with lake edges and near-surface snags can be readily sampled from a boat (Davies et al. 2005) and have been routinely monitored for this program since 2005.

1.1.1 Bobadil discharge

Prior to 2016, the Bobadil dam received wastewater from the Rosebery sewage system (Davies et al. 2005). This contribution of nutrients from town sewage into the Bobadil discharge represented a significant nutrient resource with the potential to locally enhance benthic algal production and lead to shifts in macroinvertebrate fauna.

Analyses of data in the pilot study in autumn 2005 led to the conclusion that the shore fauna and algal density in the vicinity of the Bobadil discharge was a balance between eutrophication effects of raised nutrient levels (increased algae), and potential toxicity of the discharge from mine contaminants leading to reduced diversity of macroinvertebrates (Davies et al. 2005). This toxicological impact of the Bobadil discharge on macroinvertebrate diversity and abundance, while observable, did not appear to be severe (Davies et al. 2005).

With the commissioning of the Rosebery Waste Water Treatment Plant (WWTP) in 2016, sewage wastewater has been diverted away from the Bobadil dam to the Taswater WWTP situated on the lower Stitt River. The Bobadil discharge therefore no longer contains elevated nutrient levels from sewage wastewater, and is currently a composite of mine contact stormwater, dewatered underground water, treated process water, and decanted tailings supernatant.

As a result, since 2016 the potential impact of the Bobadil discharge on algal growth and macroinvertebrates no longer includes potential eutrophication effects of raised nutrients from sewage treatment water, but is in the uni-direction of potential toxicity (depression) effects of mine contaminants in the discharge.

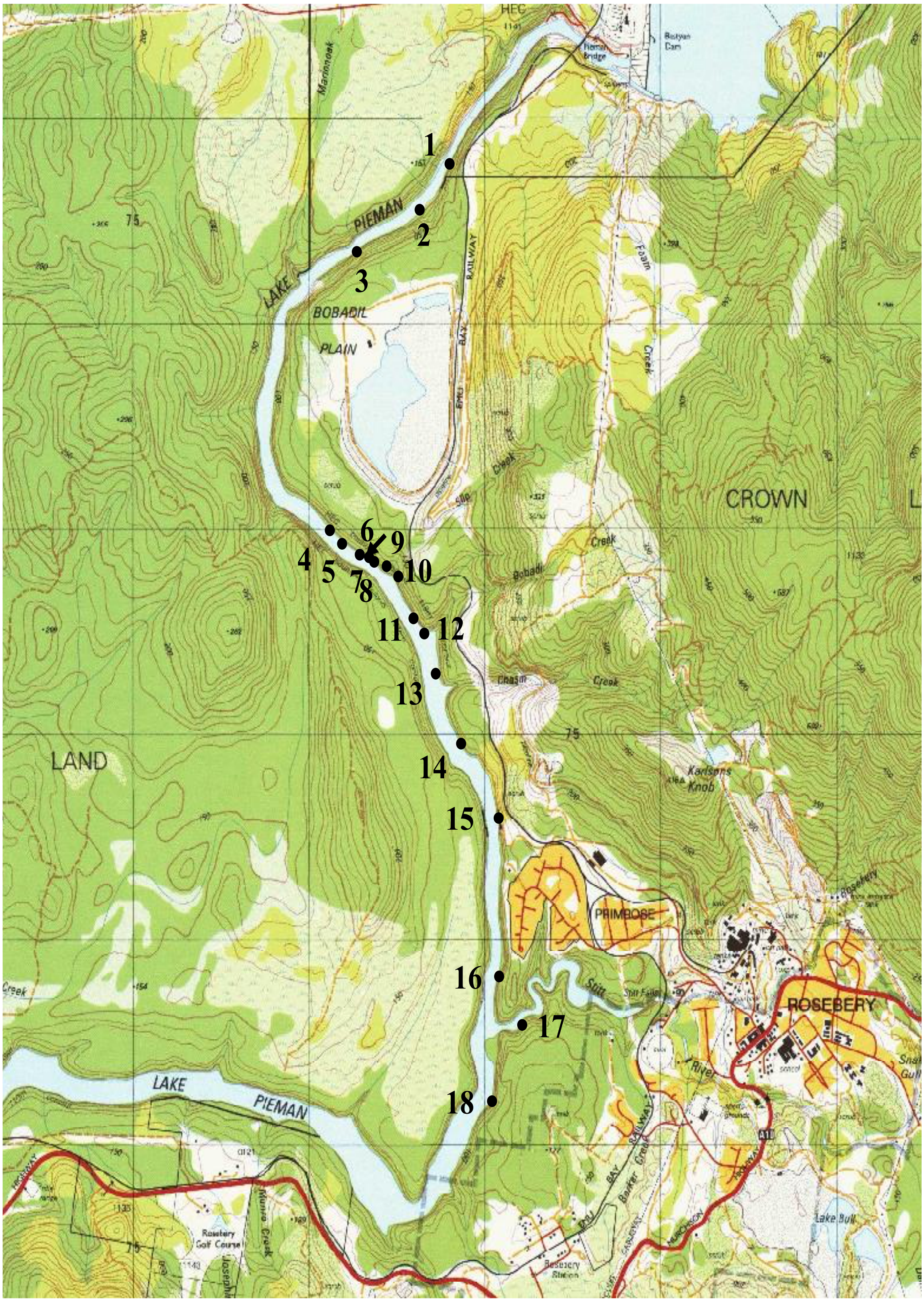

Figure 1. Location of sampling sites in Lake Pieman.

Black arrow indicates location of discharges for MMG at Bobadil. Sites 1-15 are MMG monitoring sites; sites 16-18 are TasWater sites inapplicable to this report. 1:25000 map scale, grid squares = 1 km^2.

Table 1. Sampling site locations in Lake Pieman. See Figure 1 for map. Shading shows location of Bobadil discharge to Lake Pieman. * Sites sampled on January 31. All other sites sampled on February 1.

Site	Easting (GDA 1994)	Northing (GDA 1994)
1	376914	5377951
2	376744	5377727
3	375237	5377539
4	376229	5376187
5	376299	5376097
6	376396	5376081
7	376457	5376035
8	376491	5376003
9	376535	5375973
10	376593	5375947
11	376710	5375746
12*	376765	5375672
13	376862	5375437
14	377004	5375113
15*	377197	5374778

1.1.2 Algae

Benthic algal growth in Lake Pieman is limited to well lit, shallow shore zones, since light attenuation by high levels of natural dissolved organic compounds is strong. Bowling et al. (1986) reported attenuation to the point that euphotic depths (depths to which photosynthetically active radiation, or PAR, could penetrate and stimulate algal growth) in humic western Tasmanian lakes were only of the order of 0.5 to 2 m depth.

The shoreline of Lake Pieman is complex and highly variable in substrate stability and composition, making it unsuitable for systematic benthic algal sampling. However, surfaces of tree snags located away from the immediate shading effect of overhanging forest do provide a suitable habitat for algal sampling. Such sampling can provide information on the relative magnitude of algal biomass in the vicinity of the Bobadil discharge (Davies et al. 2005).

Surface filamentous algal growth can act as a surrogate indicator for the influence of the Bobadil discharge on the assumption that lake levels have been reasonably stable, or declining slowly, prior to sampling. Note that rapid changes in lake level prior to sampling may confound any toxic effects of the discharge on algae growth.

1.1.3 Benthic macroinvertebrates

Macroinvertebrates can also be sampled from surfaces along the shore-zone or from snags. Their assemblage composition, diversity and abundance may reflect the effect of the Bobadil discharge depending on the toxicity of the discharge material.

As for algae sampling, changes in benthic macroinvertebrates are an indicator of the extent of the Bobadil discharge on the assumption that lake levels have been reasonably stable, or declining slowly, prior to sampling, and rapid changes in lake level prior to sampling may confound any toxic effects of the discharge on macroinvertebrate abundance and/or diversity.

2. Methods

2.1 Sampling time

Previous Lake Pieman sampling has been conducted in either spring or autumn seasons (see Davies et al. 2005 and subsequent reports). The inherent variability in the lake level has made it difficult to situate sampling in a period of relative lake stability, and following the most recent sampling event (October 2020) a recommendation was made to shift sampling to the summer months. Lake levels are generally more stable during the Dec – Feb period, although level fluctuation still occur. As a result, sampling in 2022 was conducted in late January/early February, with the date of sampling chosen to coincide with a period of relatively stable lake levels over the preceding 14 days (see Figure 6).

2.2 Sites

Sampling was conducted at the 15 MMG sites along the eastern shore zone (Figure 1, Table 1) on 31 January (sites 12 and 15) and 1 February 2022 (all remaining sites).

Three sites (sites 1-3) are located well upstream of the discharge point in the vicinity of reference sites used for measuring background water quality conditions. Four sites are located in the reach immediately upstream of the discharge point (sites 4 – 7), and five are located along the reach downstream of the discharge point as far as Bobadil Creek. Three sites (sites 13 – 15) are located between Bobadil Creek and Rosebery township, with site 15 considered to be the most downstream location that could be sampled without the potential for a sustained upstream influence of the water quality from the Stitt River.

2.3 Sampling methods

Sampling was conducted as follows:

2.3.1 Snag algae

A fixed-area benthic pad scourer (Davies and Gee 1993) was used to sample benthic algae on snag surfaces, with five sample units taken per location within 30 – 50 cm of the water surface. Individual sample units were analysed for total chlorophyll-*a* (by a modified acetone extraction-spectrophotometric method - APHA 1993). Mean total chlorophyll-*a*, corrected for phaeophytin, as a surrogate for algal biomass was calculated.

2.3.2 Shore-dwelling benthic invertebrates

Sampling was conducted by kick and sweep net sampling with a standard kick net (250 micron mesh) along a 5 m section of shoreline, with one sample collected per site. The resulting material was preserved in formalin.

All macroinvertebrate sample material was floated in a saturated calcium chloride solution, with hand-sorting of the residue. The floated material was then sub-sampled to 20% using the Marchant box-sub-sampler (Marchant 1989). The sub-sample was hand-sorted under magnification. All fauna were counted and identified to family level, with the exception of Nematodes, Oligochaetes, Copepoda, Turbellaria, and Acarina which were not resolved to lower taxonomic levels.

The macroinvertebrate data were analysed as patterns in diversity (number of taxa), abundance and community composition. Macroinvertebrate variables and mean chlorophyll-a values were examined graphically.

3. Results

3.1 Lake levels on and prior to sampling

In the two weeks prior to sampling, lake levels were relatively stable, fluctuating between 0.3 - 0.6 m below spill level. Lake levels dropped abruptly by ca. 80 cm overnight on first day of sampling (31 January) and were then stable on the second day of sampling (1 February) (Figure 6).

3.1 Conductivity

Conductivity levels in Lake Pieman ranged from 37.2 – 140.1 microS/cm (Table 1, Figure 2), which is a similar range to previous years.

Table 2. Conductivity in Lake Pieman (microS/cm). * denotes two sites sampled on Jan 31, all other sites sampled on Feb 1.

Site	Conductivity
1	37.2
2	37.2
3	37.7
4	84.4
5	140.1
6	44.2
7	41
8	40.9
9	42.4
10	41
11	40.7
12	51.7*
13	40.2
14	40.5
15	55.9*

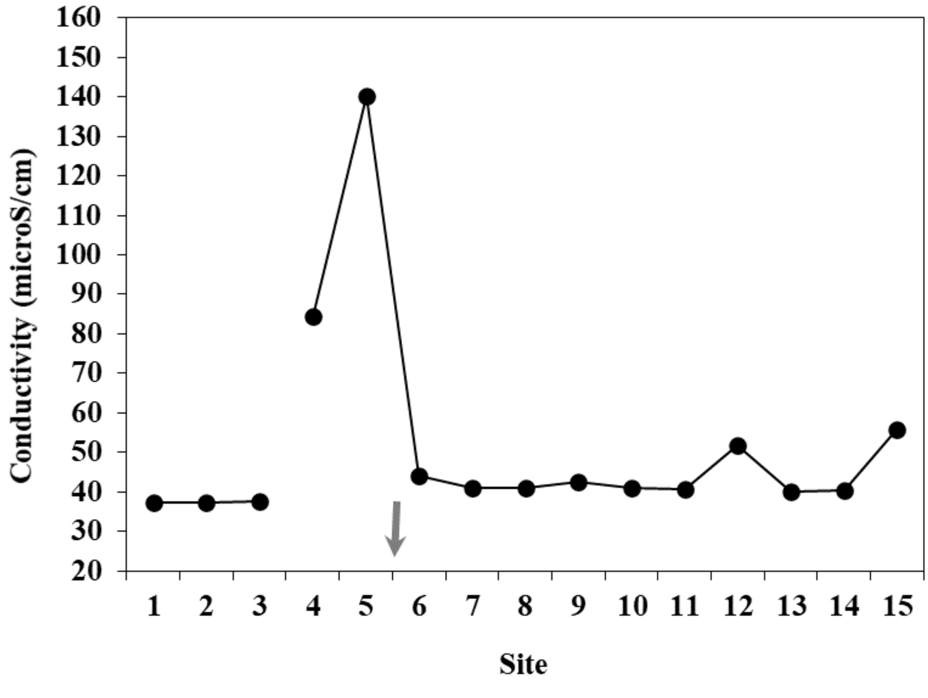

Figure 2. Conductivity levels in Lake Pieman in summer 2022. Arrow indicates location of Bobadil discharge.

There was a spike in conductivity at the site immediately 'upstream' of the Bobadil outfall, with the raised conductivity extending to site 4 ca. 200 m 'upstream' of the outfall (Figure 2).

The 'flow' direction of Lake Pieman is predominantly in a downstream direction. However, there are periods of relative stagnation and multidirectional dispersion, so the effects of the discharge may be manifest both 'upstream' and 'downstream' of the outfall. On the day of sampling the sites around the outfall (1 February), the lake level was steady after a fall of ca. 80 cm the day before, and there was a clear dispersion current in the upstream direction, leading to raised conductivity 'upstream' rather than 'downstream' of the Bobadil outfall.

3.1 Algae

Chlorophyll-a values in summer 2022 were generally low in Lake Pieman (overall mean of 6.32 mg/m^2 chlorophyll-a per site; Table 3) and varied substantially between sites (ranging from 0 – 21.2 mg/m^2 chlorophyll-a per site; Figure 3). However, the mean chlorophyll-a value in 2022 was substantially higher compared to the last three sampling events conducted in the spring months (Table 3).

Overall, there was no apparent pattern in chlorophyll-a levels that could be related to impacts of the Bobadil outfall (Figure 3). A two-way t-test indicated no statistically significant difference in mean chlorophyll-a levels downstream of the Bobadil discharge (sites 14 and 15) from the upstream reference sites (sites 1-3) or the mixing zone (sites 7-13) (all $p > 0.5$).

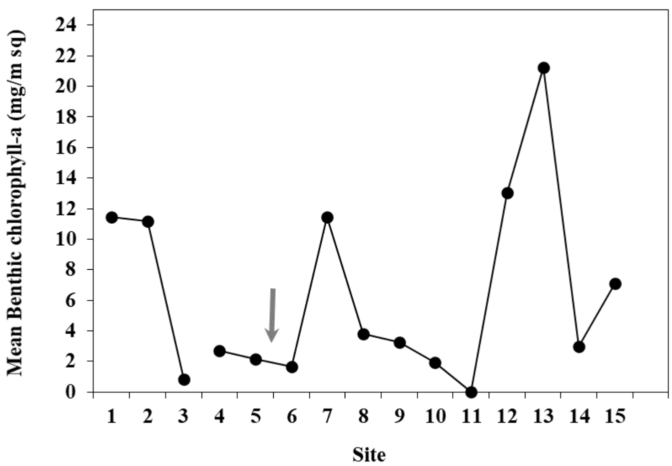

Figure 3. Distribution of mean chlorophyll-a on snag surfaces in Lake Pieman in summer 2022 as means of 5 measurements for each shore site. Arrow indicates location of Bobadil discharge.

Table 3. Chlorophyll-a levels in Lake Pieman: 2005 - 2022.

Location	2022	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005
1	11.43	0.00	3.54	2.99	33.48	2.99	17.80	8.87	6.32	6.42	6.70	1.14	1.52	0.65	3.81	1.80	2.45
2	11.16	2.18	4.36	1.63	36.20	2.18	21.01	10.34	7.84	2.99	3.97	0.49	2.89	10.34	1.09	7.51	2.77
3	0.82	0.82	2.99	1.91	16.33	3.54	18.46	16.55	5.93	5.17	5.61	1.53	1.63	5.50	1.69	5.01	0.76
4	2.72	0.54	1.63	3.54	3.81	1.09	6.32	6.42	2.29	10.73	9.96	1.74	2.67	0.76	2.50	5.33	1.20
5	2.18	1.36	1.36	1.91	2.45	4.36	14.92	5.12	5.93	9.53	12.68	2.50	7.57	0.76	4.19	10.07	2.67
6	1.63	10.62	1.09	2.18	2.45	1.09	6.15	3.65	5.93	16.50	3.48	3.75	2.18	1.63	5.06	6.42	0.82
7	11.43	0.27	3.54	13.61	3.54	1.36	2.99	0.98	8.06	24.17	9.64	6.75	3.70	1.85	9.04	7.08	3.05
8	3.81	1.91	3.81	0.82	3.27	2.18	5.12	2.01	2.99	9.09	2.39	11.49	5.23	1.79	4.74	4.96	4.19
9	3.27	0.00	0.82	0.00	2.99	2.18	7.84	3.43	1.20	32.23	18.02	5.88	19.71	3.92	4.25	3.38	18.95
10	1.91	0.00	0.00	0.54	2.99	2.99	9.04	1.36	0.98	19.16	6.75	2.45	7.29	20.96	5.01	1.91	11.54
11	0.00	1.91	1.09	2.99	2.45	8.17	3.48	1.58	2.07	16.77	7.18	7.78	2.88	1.96	3.43	6.64	1.47
12	13.07	1.36	2.99	2.18	2.99	7.08	21.61	3.21	4.46	21.29	4.74	2.89	5.06	4.95	4.79	2.67	1.74
13	21.23	3.54	0.27	4.90	2.72	1.91	19.87	7.62	2.34	17.20	10.45	2.89	4.46	16.11	3.97	3.76	8.87
14	2.99	3.54	0.82	0.82	20.42	5.99	13.66	5.01	7.02	17.31	6.42	2.62	6.75	8.82	4.36	5.94	5.88
15	7.08	0.00	1.09	1.09	6.26	1.91	6.59	0.38	1.63	17.96	0.82	1.25	0.82	2.72	1.74	0.76	0.60
Mean	6.32	1.87	1.96	2.74	9.49	3.27	11.66	5.10	4.33	15.10	7.25	3.68	4.96	5.52	3.98	4.88	4.46

3.2 Macroinvertebrates

As has been the case in previous years, samples of macroinvertebrates collected from the Lake Pieman shoreline were characterized by low diversity and abundance (Table 4, Figures 4 and 5).

The total diversity of benthic aquatic taxa over all sites was 6.4 taxa/site in 2022, which is substantially higher compared to the mean diversity recorded in 2020 (2.9 taxa/sample). The most common taxa were chironomid larvae, with a range of crustacean and insect families also represented.

Within the context of a generally low diversity, there was a no obvious pattern in variation in diversity of macroinvertebrates associated with the Bobadil outfall (Figure 4). A two-way t-test indicated no statistically significant difference in mean number of taxa downstream of the Bobadil discharge (sites 14 and 15) from the upstream reference sites (sites 1-3) or the mixing zone (sites 7-13) (all $p > 0.5$).

Total abundance of macroinvertebrates per sample ranged between 2-193 animals/sample, with a mean of 27.3 animals/sample (Table 3, Figure 5). As for diversity, there was no obvious pattern in variation in abundance of macroinvertebrates associated with the Bobadil outfall (Figure 5). A two-way t-test indicated no statistically significant difference in mean abundance downstream of the Bobadil discharge (sites 14 and 15) from the upstream reference sites (sites 1-3) or the mixing zone (sites 7-13) (all $p > 0.5$).

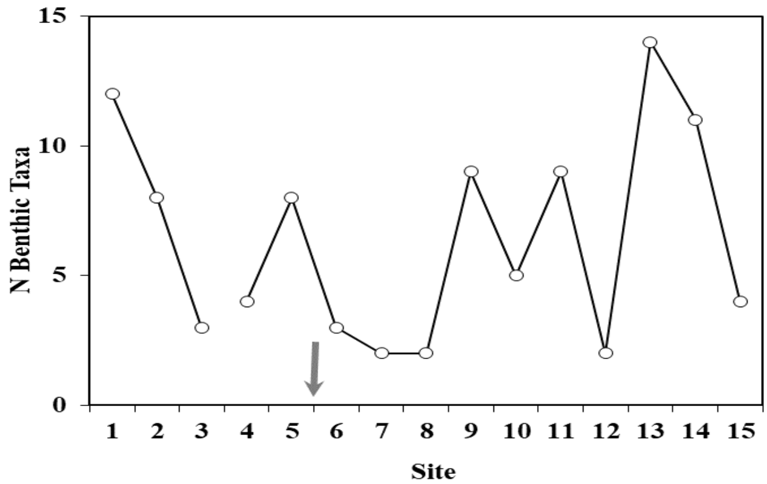

Figure 4. Number of taxa/sample of macroinvertebrates in Lake Pieman samples in summer 2022. Arrow shows location of Bobadil outfall

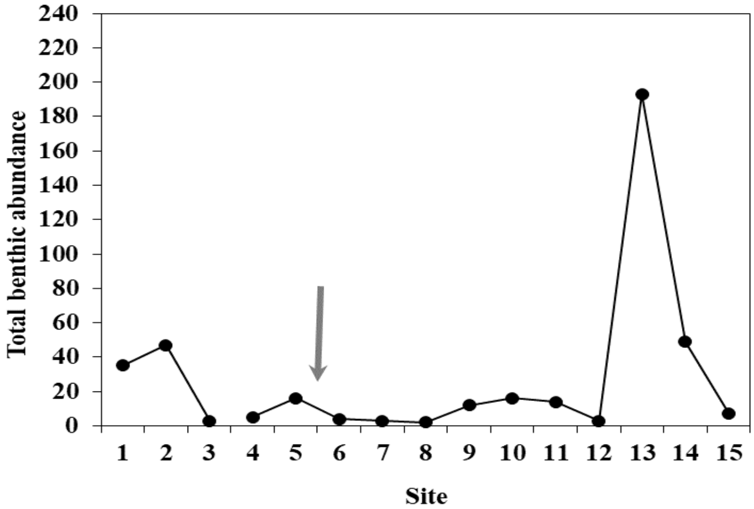

Figure 5. Abundance/sample of macroinvertebrates in Lake Pieman samples in summer 2022. Arrow shows location of Bobadil outfall

4. Discussion

4.1 Algae

Chlorophyll-a levels were generally low in Lake Pieman in summer 2022. Within the context of generally low chlorophyll-a levels, there was wide variation in chlorophyll-a levels between sites both upstream and downstream of the Bobadil outfall. Overall, in summer 2022 there was no apparent benthic algal response to the inflow of the Bobadil discharge.

4.2 Macroinvertebrates

The macroinvertebrate fauna collected from the Lake Pieman shoreline in summer 2022 was characterized by generally low diversity and abundance, although both diversity and abundance were higher in summer 2022 compared to previous sampling events conducted in the spring months.

Table 4. Macroinvertebrate data from eastern shore zone sampling sites in upper Lake Pieman in summer 2022. Abundances are n per 20% of 5 m kick sample (approx. n per 0.6 m^2 shoreline habitat).

			Site														
Class	**Order**	**Family**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Annelida	Oligochaeta		6	2				1			3	6	1		5	15	2
Arachnida	Acarina		1														
	Amphipoda	Ceinidae				2	1	1	2		1		4			3	3
	Isopoda	Janiridae					1										
	Plecoptera	Gripopterygidae	7	1									1		5	2	
	Ephemeroptera	Leptophlebiidae							1								
		Baetidae								1							
	Odonata	Hemicorduliidae													5		
	Hemiptera	Veliidae	1	1	1		7	2			1	2			1	4	1
		Corixidae		4			1				2	1			24	1	
		Notonectidae				1											
	Collembola		1		1		1										
	Diptera	Chironomidae:															
		Chironominae	11	30		1	3				1	6	1		105	16	1
		Orthocladiinae	1										1		2	1	
		Podonominae									1						
		Tanypodinae	2	2		1				1			2	1	35	3	
		Ceratopogonidae									1						
		Dip. Unid. Pup.	1	6											3	2	
	Trichoptera	Ecnomidae		1			1						1			1	
		Leptoceridae	2										2	2	1	1	
		Philorheithridae	1								1	1					
	Coleoptera	ElmidaeA													1		
		DytiscidaeA	1		1		1				1		1		3		
		CurculionidaeA													1		
		DytiscidaeL													2		
		Total Abundance	**35**	**47**	**3**	**5**	**16**	**4**	**3**	**2**	**12**	**16**	**14**	**3**	**193**	**49**	**7**
		N Taxa	**12**	**8**	**3**	**4**	**8**	**3**	**2**	**2**	**9**	**5**	**9**	**2**	**14**	**11**	**4**

The macroinvertebrate fauna of the majority of samples from Lake Pieman was dominated by chironimid midge larvae, with a range of other crustacean and insect taxa also present. As was the case for chlorophyll-a levels, there was wide variation in both the diversity and abundance between sites both upstream and downstream of the Bobadil outfall. Overall, in summer 2022 the near-surface shoreline of Lake Pieman showed no apparent response in the macroinvertebrate fauna to the inflow of the Bobadil discharge.

4.3 Evaluation of shift to summer sampling

Previous annual sampling events in lake Pieman have been conducted in the spring months (Sep – Nov), and have often coincided with large fluctuations in lake level, both in the weeks leading up to sampling and on the day prior to sampling. Substantial fluctuations in lake level are believed to prevent a stable shoreline algae/fauna zone from developing, and likely confound any potential impacts of the Bobadil discharge on lake biota (Mallick 2020).

Sampling in 2022 was shifted to summer (Jan – Feb) in an attempt to minimise the effects of fluctuating lake level, with levels in Lake Piemen generally less variable in the summer months. Sampling was timed to follow a two-week period of relative stability in lake levels (levels fluctuating within a range of +/- 30 cm; see Figure 6).

Over the two weeks prior to the first day of sampling (31 January) lake levels had been relatively stable but dropped ca. 80 cm on the second day of sampling on 1 February (Figure 6).

Despite the drop in lake levels, visual inspection of the shoreline during sampling suggested a good level of accumulated detritus within the sampling zone on both days capable of supporting a robust shoreline biota. This is borne out by the increased diversity and abundance of macroinvertebrates and increased algae growth in summer 2022 compared to previous sampling events situated in the spring months.

It is recommended that sampling in 2023 is also conducted in the January - February period to coincide with a period of lake-level stability.

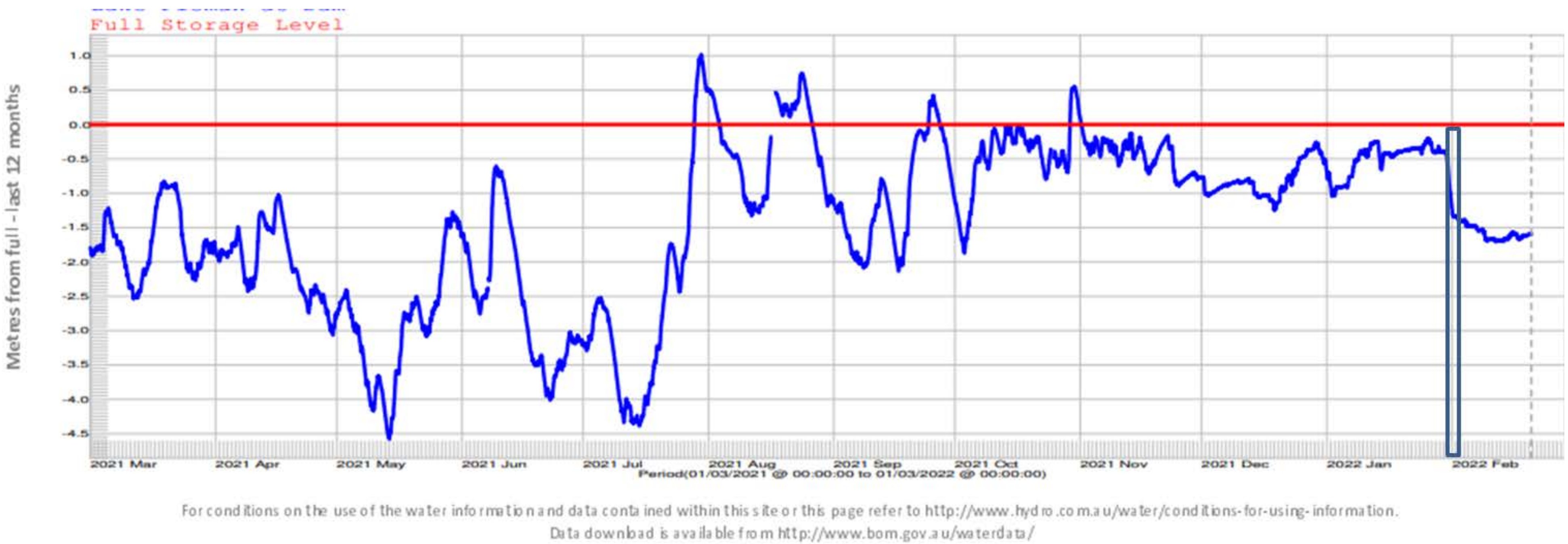

Figure 6. Lake levels of Lake Pieman from March 2021 to February 2022. Sampling date (Jan 31 – Feb 1) is shown by vertical bar. Source: Hydro Water: https://www.hydro.com.au/water/lake-levels.

5. References

APHA 1993. Standard Methods for Water and Wastewater Analysis. APHA-AWWA, Vol. 19., Princetown USA.

Bowling LC, Steane MS and Tyler PA 1986. The spectral distribution and attenuation of underwater irradiance in Tasmanian inland waters. Freshwat. Biol. 16:313-335.

Davies PE, Cook LSJ and Sloane T 2005. Definition of Bobadil discharge mixing zone in Lake Pieman by in-lake biological sampling. Report to Zinifex Pty Ltd, Rosebery Mine. March 2005. 22 pp.

Davies PE, Cook LSJ and Sloane T 2006a. Lake Pieman - Bobadil discharge zone Biomonitoring Report Autumn 2006. Report to Zinifex Pty Ltd, Rosebery Mine. September 2006. 18 pp.

Davies PE, Cook LSJ and Sloane T 2006b. Lake Pieman - Bobadil discharge zone Biomonitoring Report Spring 2006. Report to Zinifex Pty Ltd, Rosebery Mine. 18 pp.

Davies PE, Cook LSJ and Sloane T 2007. Lake Pieman - Bobadil discharge zone Biomonitoring Report Autumn 2007. Report to Zinifex Pty Ltd, Rosebery Mine. July 2007. 19 pp.

Davies PE, Cook LSJ and Sloane T 2008. Lake Pieman - Bobadil discharge zone Biomonitoring Report Autumn 2007/08. Report to OzMinerals Pty Ltd, Rosebery Mine. September 2008. 23 pp.

Davies PE, Cook LSJ and Sloane T 2009. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2008/09. Report to OzMinerals Pty Ltd, Rosebery Mine. August 2009. 22 pp.

Davies PE, Cook LSJ and Sloane T 2010. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2009/10. Report to MIM Pty Ltd, Rosebery Mine. August 2010. 22 pp.

Davies PE, Cook LSJ and Sloane T 2011. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2010/11. Report to MIM Pty Ltd, Rosebery Mine. July 2011. 20 pp.

Davies PE and Cook LSJ 2012. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2012. Report to MMG Pty Ltd, Rosebery Mine. July 2012. 22 pp.

Davies PE and Cook LSJ 2013. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2013. Report to MMG Pty Ltd, Rosebery Mine. August 2013. 21 pp.

Davies PE and Cook LSJ 2014. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2014. Report to MMG Pty Ltd, Rosebery Mine. July 2014. 20 pp.

Davies PE and Cook LSJ 2015. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2015. Report to MMG Pty Ltd, Rosebery Mine. July 2015. 20 pp.

Davies PE and Mallick S 2016 Lake Pieman - Bobadil discharge zone Biomonitoring Report 2016. Report to MMG Pty Ltd, Rosebery Mine. September 2016. 20 pp.
Davies AL and Gee JHR 1993. A simple periphyton sampler for algal biomass estimates in streams. Freshwat. Biol. 30, 47-51.
Mallick, S. 2018. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2018. Report to MMG Pty Ltd, Rosebery Mine. November 2018. 12 pp.
Mallick, S. 2020. Lake Pieman - Bobadil discharge zone Biomonitoring Report 2020. Report to MMG Pty Ltd, Rosebery Mine. November 2020. 8 pp.
Marchant R 1989. A subsampler for samples of benthic invertebrates. Aust. Soc. Limnol. Bull. 12, 49-52.

APPENDIX G: THE RING AND STITT RIVERS: SPRING 2021 AND AUTUMN 2022 (FRESHWATER BIOMONITORING 2022)

Biological Condition of the Ring and Stitt Rivers: Spring 2021 and Autumn 2022

Report to MMG, Rosebery

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July 2022

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Summary

- The Ring and Stitt Rivers were surveyed for macroinvertebrates and fish in spring 2021 and autumn 2022.
- The Ring River remains in a degraded condition, particularly in the lower reaches. Diversity in the Ring River declines moving downstream of Williamsford, with a concomitant decline in the AUSRIVAS O/E scores.
- Both Bakers Creek and Dolcoath Creek remain in a highly degraded condition.
- The primary reason for the poor condition of river fauna communities in the Ring River continues to be pollution from the Hercules mine via Bakers Creek.
- Overall, the Stitt River is in a substantially better ecological condition than the Ring River.
- There appears to have been some improvement in the condition of the lower Stitt River over recent years, with a range of clean-water macroinvertebrate taxa now recorded at all sites including in the lower reaches.
- However, there continues to be a decline in diversity and O/E ratio between the upper and lower reaches of the Stitt River, likely due to ongoing seepage of mine contaminants into the lower Stitt from a range of sources.
- Adult and juvenile brown trout have been regularly recorded in the lower reaches of the Stitt River since autumn 2020, although the numbers of trout remain consistently lower compared to the upper reaches of the river.
- The consistent capture of adult and juvenile tout at all sites in the Stitt River indicates that a self-sustaining population of trout now occurs throughout the Stitt River including in the lower reaches.

Introduction and Aims

This report describes the results of surveys conducted in 2021/22 in the Ring and Stitt Rivers, comprised of one spring 2021 and one autumn 2022 seasonal sampling event for macroinvertebrates and fish.

This report forms part of what is now a routine biomonitoring exercise for the Ring and Stitt catchments required under EPN 7153/3. Surveys under this program have been previously reported for autumn and spring annually from 2005/06 to 2019/20 (Davies et al. 2005a, b; 2006a, b; 2007 – 2017; Mallick 2018, 2019, 2020, 2021).

The primary aims of this monitoring are to:

- describe the status of macroinvertebrate and fish assemblages in the Ring and Stitt Rivers; and
- evaluate changes over time and relate these to environmental conditions (especially habitat and water quality) and management actions associated with MMG mine operations.

The current monitoring program follows the protocol used by Davies et al. (2004), with sampling of instream fauna at a number of sites in the Ring River and selected tributaries, in the Stitt River both upstream and downstream of pollution sources, and in a reference river, the Sterling River.

2. Methods

2.1 Field sampling

A survey was conducted of benthic macroinvertebrates and fish moss in the Stitt and Ring Rivers, at:

1. Four sites in the mid to lower Stitt River, located:
    - downstream of the outflow of the wetlands associated with 2 & 5 Dam (Bull Lagoon) (site S3);
    - adjacent to the Rosebery sports ground (S4); and
    - immediately upstream of Stitt Falls (S5).
    - downstream of the Stitt Falls (S6) - as part of a survey of WWTP wastewater effects requested by TasWater, the results of which are also reported here;
2. Five sites in the Ring River located:
    - at Williamsford (site R1)
    - upstream of the Bakers Creek junction (R2)

- downstream of Bakers Creek (R3)
- upstream of the Dolcoath Creek inflow (R5); and
- at the Murchison Highway Bridge (R6).

3. Two sites in Ring River tributaries:
   - In Bakers Ck and Dolcoath Creeks upstream of their junction with the Ring (sites B1 and D1).
4. Four reference ('control') sites:
   - three in the Stitt River upstream of the Bull Lagoon outflow (sites S0, S1 and S2 – with S0 added since autumn 2012); and
   - one site on an adjacent river system unaffected by acid drainage (the Sterling River, site STR1).

Site details are provided in Table 1, and locations shown in Figures 1 to 3. Spring 2021 sampling was conducted on 20 – 23 November 2021. Autumn 2022 sampling was conducted on 1 – 4 March 2022.

Table 1. Details of stream study sites sampled for macroinvertebrates in the catchments of the Ring, Stitt and Sterling Rivers. 'Distance from source' is stream length measured on 1:25,000 map from the head of the stream drainage.

River or Creek	Site Code	Description	Easting (AGD)	Northing (AGD)	Distance from source (km)	Catchment area (km^2)	Altitude (m)
Ring River	R1	Williamsford Rd	376387	5368471	3	2.6	400
	R2	u/s Baker Ck	375587	5367946	4.25	5.5	340
	R3	d/s Baker Ck	375512	5367858	4.5	7.6	330
	R5	u/s Dolcoath Ck	371423	5371009	12.5	31	126
	R6	Murchison Hway	371312	5371495	12.9	34.9	120
Baker Ck	B1	u/s Ring R junction	375612	5367821	1.13	1.85	335
Dolcoath Ck	D1	u/s Ring R junction	371337	5371083	2.38	3.4	125
Sterling River	STR1	Murchison Hway	384453	5374898	5.5	16.6	170
Stitt River	S0	at top bridge	379451	5371735	5.2	19.8	190
	S1	u/s Mountain Ck	379687	5372833	6.8	33	145
	S2	u/s tailings	379387	5373173	7.3	35.9	140
	S3	d/s tailings	379072	5373181	7.6	36.5	137
	S4	Sports Gd footbridge	378287	5373533	8.6	36.7	128
	S5	road bridge	378187	5373871	9	37	120
	S6	d/s Stitt Falls	378012	5373883	9.2	39.9	101

2.1.1 Environmental variables

Several environmental variables were also measured at each site for use in bioassessment and analysis of relationships with the biota. These include % area of the study reach as riffle, run, pool and snag mesohabitats and of stream substrates (boulder, cobble, gravel, sand, silt and bedrock), as well as % cover of silts, moss, algae, and organic detritus, conductivity, temperature, channel gradient and dimensions, and ratings for bank erosion, and riparian, aquatic and trailing vegetation density.

2.1.2 Macroinvertebrates

At each site, two types of sampling for benthic macroinvertebrate were conducted – quantitative (surber) sampling, and semi-quantitative AUSRIVAS sampling. These methods give different types of information. Surber sampling provides a strictly quantitative assessment of abundance. AUSRIVAS sampling provides indices of difference in community composition from an ‘expected’ fauna under undisturbed ‘reference’ conditions.

The two sampling methods were conducted as follows:

Quantitative sampling: benthic macroinvertebrates were quantitatively sampled in riffle habitats, by taking 10 ‘surber’ samples of the benthos, by hand disturbance of the stream bed to a maximum depth of 10 cm into the substrate within a 30 x 30 cm quadrat immediately upstream of a 500-micron mesh net surber sampler. The 10 sample units were pooled at each site to provide a single composite sample, which was preserved in neutral buffered formalin (10%) prior to processing in the laboratory. Samples were subsequently elutriated with saturated calcium chloride solution, and the floated material (eluant) was separated. The remaining residue and the eluant were both hand sorted. All animals preserved were counted under magnification without identification.

AUSRIVAS sampling: rapid assessment protocol (RAP) sampling of benthic macroinvertebrates was conducted using the standard Tasmanian AUSRIVAS sampling protocol, in riffle habitat (fast flowing, typically cobble-bed, shallows). Sampling was conducted by foot-disturbance the stream substrate immediately upstream of a 250 micron mesh kick net, over a total length of 10 m of riffle. Samples were live-picked on site using the standard Tasmanian AUSRIVAS protocol, with picking for 30 min, maximizing the diversity in the picked sample of animals present in the kick net sample, while also preserving the relative abundance of the dominant taxa.

All quantitative and AUSRIVAS macroinvertebrate samples were identified and counted at the family level without identification.

2.1.3 Fish

Quantitative electrofishing was conducted in the Sterling (STR1) Stitt Rivers (S1-S5) in both spring 2021 and autumn 2022 to establish the abundances and fish species present. Electrofishing at S0 was ceased in Autumn 2020 due to the high energy nature of the site making fish results heavily dependent on flows. Sites were surveyed using a Smith-Root backpack electroshocker for a standard 20-minutes battery time. The survey involved moving slowly up- or down-stream at a site and attempting to cover the major habitat types present (riffle, runs, pools, edges). All captured fish were identified, assigned to an age class (juvenile/adult) and released at site of capture.

2.2 Data analysis

Several forms of data analysis are conducted for macroinvertebrates.

2.2.1 Abundance and diversity measures

Taxon richness (number of families) was derived from AUSRIVAS samples. Total abundance data was derived from quantitative Surber counts.

2.2.2 AUSRIVAS analysis

Spring and autumn season macroinvertebrate RAP data were entered into Tasmanian AUSRIVAS presence/absence models to derive O/E (observed over expected) scores. O/E scores allow deviations from reference condition to be quantified based on changes in the presence of expected taxa within the sample.

2.2.3 Tasmanian River Condition Index (TRCI) Aquatic Life Condition Assessment

For the TRCI assessment, sampling and data analysis followed the protocol described by NRM South (2009, 2009a). The TRCI Aquatic Life Macroinvertebrate Indicator (MI) provides an integrated score for the condition of benthic macroinvertebrate communities. The score takes into account three key aspects of macroinvertebrate community condition:

- *Expectedness* - the proportion of taxa expected to occur at the site under unimpaired conditions that are actually observed at the site (O/Epa scores), combined with the ratio of observed to expected scores for pollution sensitivity of the sampled community - the ‘SIGNAL’ score;
- *Abundance* - the density of individuals per unit area of river bed; and
- *Composition* - the proportion of environmentally sensitive taxa from the ‘EPT’ taxonomic grouping in the sample.

The above values were entered into the TRCI aquatic life condition scoring and integration algorithm (NRM South 2008) to generate scores for individual metrics and integrated scores and ratings for the overall condition of macroinvertebrates.

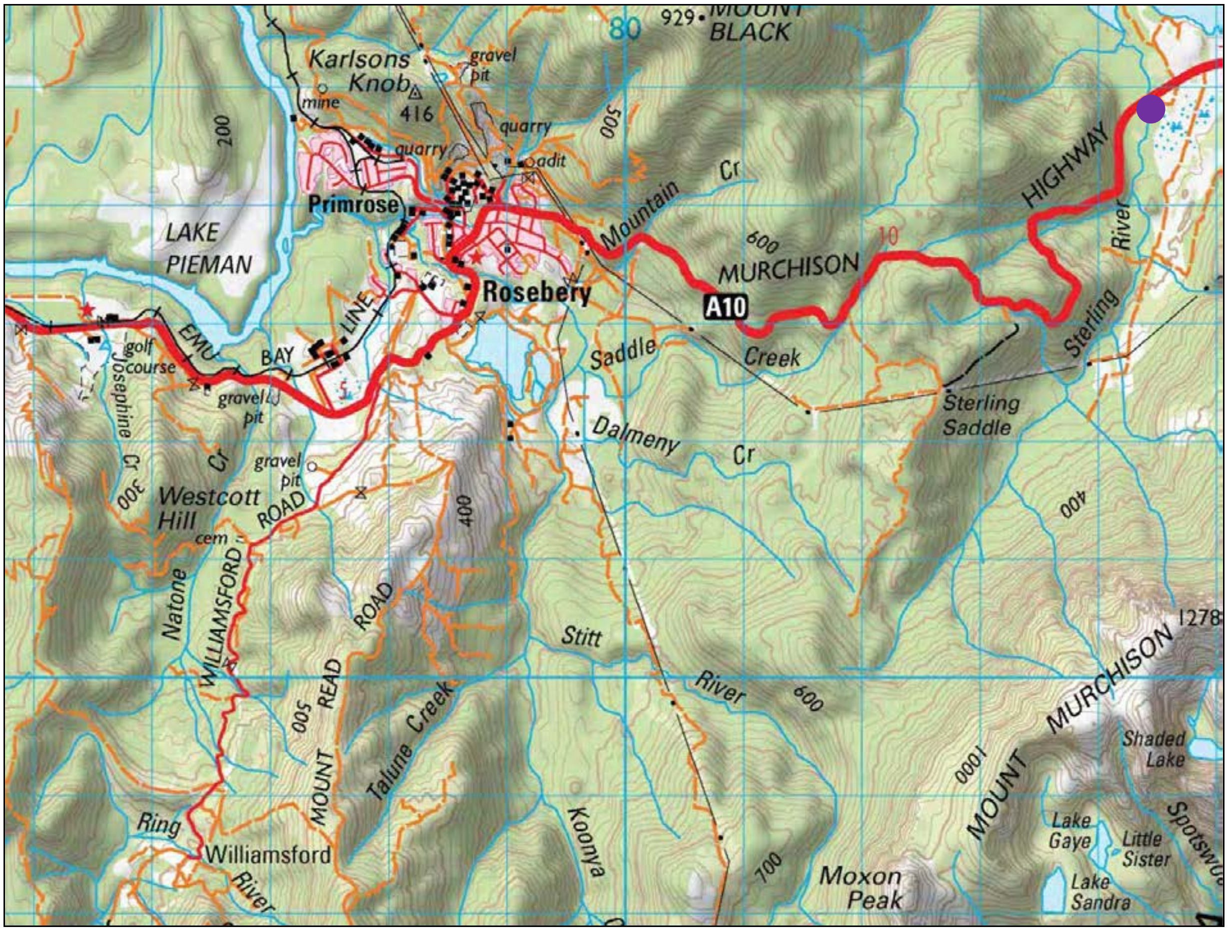

Figure 1. Map of study area showing location of Sterling River reference site (purple circle) in relation to the Stitt River and upper Ring River.

Grid squares = 1 km. Map scale 1:100 000 (TasMap).

Figure 2a. Map of study sites in the upper Ring River catchment. Blue arrow shows point of confluence between Bakers Creek and the Ring River.

Figure 2b. Map of study sites in the lower Ring River catchment. Blue arrow shows point of confluence of Dolcoath Creek and the Ring River

Figure 3a. Map of study sites in the upper Stitt River catchment.

Figure 3b. Map of study sites in the lower Stitt River catchment.

3. Results

3.1 Reference sites

The macroinvertebrate fauna of the reference sites in the Sterling (STR1) and upper Stitt River (sites S0, S1, S2) continues to be relatively healthy and diverse (Tables 2 and 3). Overall reference means for family–level taxa per site (AUSRIVAS samples) were slightly higher in spring 2021 (mean number of taxa/sample = 17.3) compared to autumn 2022 (mean number of taxa/sample = 14.8) (Tables 2 and 3). Mean abundances (from Surber samples) in reference sites were relatively low in both seasons (mean abundances per square meter of stream bed = 495 in spring 2021 and 455 in autumn 2022, respectively) (Table 5).

The reference-site fauna continues to be dominated by Leptophlebiid mayflies, chironomid midges, Grypopterygid stoneflies, elmid beetles and a range of caddis larvae (Tables 2 and 3). This ‘clean water’ fauna has remained broadly consistent in composition since 2004. Several of these groups are sensitive to metals and acid mine drainage, and are generally absent or severely depressed in abundance when exposed to pollutants.

The results of the AUSRIVAS analyses for the Sterling River and three Stitt River reference sites are given in Tables 2 and 3. For both seasons, reference sites were placed either in the upper range of impairment band B (‘similar to reference’), or in impairment band A (‘equivalent to reference’).

Table 2. Macroinvertebrate data from AUSRIVAS sampling in Spring 2021, for the Stitt, Sterling and Ring Rivers, and for Bakers Creek and Dolcoath Creek. #1 and # 2 are replicate AUSRIVAS samples.

		Stream:	**Ring River**										**Baker Ck**	**Dolcoath Ck**
		Site:	R1		R2		R3		R5		R6		B1	D1
Class	**Order**	**Family**	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#1
Oligochaeta			2	2										
Arachnida	Acarina		1	2		1								
Insecta	Plecoptera	Eustheniidae	28	12	4	3	1			1	2	3		
		Austroperlidae	1	2							1			
		Gripopterygidae	20	14	30	6	2	4	10	9	16	9		
		Notonemouridae	6	14	21	32			18	17	5	27		1
	Ephemeroptera	Leptophlebiidae	1	3	2				1					
	Hemiptera	Corixidae									1			
	Lepidoptera	Pyralidae								1				
	Diptera	Chironimidae												
		subfam: Orthocladiinae	21	2	3	6				1				
		subfam: Podonominae		9	8	4								
		Simuliidae		1	4		2		1					
		Tipulidae		2	1	1								
		Empididae									1			
	Trichoptera	Hydrobiosidae	1			1								
		Hydropsychidae	2	1										
		Leptoceridae	1								1			
		Philopotamidae			1	1								
	Coleoptera	ElmidaeA								1				
		DytiscidaeA												1
		ScirtidaeL	5	2	7	8				1	1			
		N Taxa	**12**	**13**	**10**	**10**	**3**	**1**	**4**	**7**	**8**	**3**	**Nil**	**2**
		O/Epa	**0.54**	**0.59**	**0.44**	**0.44**	**0.15**	**0.05**	**0.15**	**0.15**	**0.25**	**0.10**	**-**	**0.05**
		Band	**B**	**B**	**C**	**C**	**C**	**D**	**C**	**C**	**C**	**D**	**-**	**D**
		SIGNAL O/E	**1.11**	**1.05**	**1.12**	**1.16**	**1.28**	**1.33**	**1.12**	**1.16**	**1.25**	**1.33**	**-**	**1.00**
		EPT	**0.67**	**0.46**	**0.50**	**0.50**	**0.67**	**1.00**	**0.75**	**0.43**	**0.63**	**1.00**	**-**	**0.50**

Table 2 (cont)

		Stream:	Sterling River		Stitt River													
		Site:	STR1		S0		S1		S2		S3		S4		S5		S6	
Class	Order	Family	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
Oligochaeta			1	4			2	2	2	1	3	3		5	2	2	4	3
Arachnida	Acarina			2	1	2		1	2				1	1				1
Crustacea	Amphipoda	Paramelitidae	14	10	8	5	13	5	12	7	4	5	3	3	1	3	1	
Insecta	Plecoptera	Eustheniidae	3	3	5	12	6	7	4	2		2		3			1	
		Austroperlidae	1	3			3	1	3					1	1	1		
		Gripopterygidae	18	15	13	24	12	12	18	25	15	20	4	10	20	22	15	8
		Notonemouridae															4	15
	Ephemeroptera	Leptophlebiidae	22	21	12	12	7	18	12	16	10	16	22	16	4	16	2	9
		Baetidae	1	4	14	12	2	1	5	10	9	10	4	4	7	1	2	
	Odonata	Telephlebiidae		1		1		1										
		Austrocordulidae																
	Diptera	Chironomidae:																
		subfam: Chironominae	9	5		1	1		2	3	1	1		2	1	3		
		subfam: Orthocladiinae	6	9	2	3	3	3	2	7			3	4	9	13	17	22
		subfam: Podonominae			6	4	6	1		1	6	8	6	8	7	5	5	2
		subfam: Tanypodinae														1		
		Simuliidae			1		3	2	2	2	1	3		1	4	2		
		Tipulidae	3	1	1	1		2	1		2		3	3			1	
		Athericidae															2	
		Blephariceridae				2							1					
		Ceratopogonidae								1								
		Empididae				1												
		Dip. Unid. Pup.													2	2	2	1
	Trichoptera	Calocidae			1													
		Conoesucidae				1												
		Hydrobiosidae	6	13	10	14	12	187	23	15	23	27	21	12	12	9	9	5
		Hydropsychidae	1		4	4	4	4	2				2				1	
		Hydroptilidae		1														
		Leptoceridae	1	1		1	1	1	2		3	3	1	3	1	2	2	1
		Philopotamidae	3	1			1							1				
		Philorheithridae	2			1		5	2	1	1		3	6	1	3	2	3
	Coleoptera	ElmidaeA	4		1	1	6	5	5	2	9	5	15	4	1	1	2	3
		DytiscidaeA									1							
		ElmidaeL									2							
		ScirtidaeL	2	3	1		2	1			4	5	8	3	4	8	16	19
		PsepheniidaeL	2	2						1								
		N Taxa	**18**	**18**	**15**	**19**	**17**	**19**	**17**	**15**	**16**	**13**	**15**	**19**	**16**	**17**	**18**	**13**
		O/E	**0.89**	**0.89**	**0.74**	**0.93**	**0.84**	**0.94**	**0.84**	**0.74**	**0.74**	**0.64**	**0.74**	**0.94**	**0.74**	**0.79**	**0.79**	**0.54**
		Band	**A**	**A**	**B**	**A**	**B**	**A**	**B**	**B**	**B**	**B**	**B**	**A**	**B**	**B**	**B**	**B**
		SIGNAL O/E	**1.00**	**0.99**	**1.01**	**1.03**	**0.96**	**1.02**	**1.00**	**0.94**	**0.90**	**0.90**	**0.95**	**0.98**	**0.91**	**0.89**	**0.98**	**0.95**
		EPT	**0.56**	**0.50**	**0.47**	**0.47**	**0.53**	**0.47**	**0.53**	**0.40**	**0.38**	**0.46**	**0.47**	**0.47**	**0.44**	**0.41**	**0.50**	**0.46**

Table 3. Macroinvertebrate data from AUSRIVAS sampling in Autumn 2022, for the Stitt, Sterling and Ring Rivers, and for Bakers Creek and Dolcoath Creek. #1 and # 2 are replicate AUSRIVAS samples.

		Stream:	Ring River										Baker Ck	Dolcoath Ck
		Site:	R1		R2		R3		R5		R6		B1	D1
Class	**Order**	**Family**	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#1
Arachnida	Acarina		1										1	
Crustacea	Amphipoda	Paramelitidae									2			9
Insecta	Plecoptera	Eustheniidae	8	10	1	1			3	4		1		
		Gripopterygidae	1	1	4							1		
		Notonemouridae	20	22	7	55	12	6	2	1		2	2	4
	Ephemeroptera	Leptophlebiidae			1									
	Diptera	Chironomidae:												
		subfam: Chironominae				4								
		subfam: Orthocladiinae				1						1	3	
		Simuliidae	3											
		Culicidae									1			
	Trichoptera	Conoesucidae		1										
		Hydrobiosidae	1											
		Hydropsychidae	2	1										
		Leptoceridae			1							1		1
		Philorheithridae	1			1								1
	Coleoptera	ElmidaeA		1					2	1		2		
		DytiscidaeA												1
		ScirtidaeL	2	3		2	1							
		DytiscidaeL												3
		N Taxa	**9**	**7**	**5**	**6**	**2**	**1**	**3**	**3**	**2**	**6**	**3**	**6**
		O/Epa	**0.53**	**0.41**	**0.41**	**0.35**	**0.12**	**0.06**	**0.17**	**0.17**	**0.06**	**0.34**	**0.17**	**0.23**
		Band	**B**	**C**	**C**	**C**	**D**	**D**	**C**	**C**	**D**	**C**	**C**	**C**
		SIGNAL O/E	**0.99**	**1.04**	**1.04**	**0.89**	**0.65**	**0.97**	**1.20**	**1.20**	**0.33**	**1.09**	**0.66**	**0.80**
		EPT	**0.67**	**0.71**	**1.00**	**0.50**	**0.50**	**1.00**	**0.67**	**0.67**	**0.00**	**0.67**	**0.33**	**0.50**

Table 3 (cont.)

		Stream:	Sterling River		Stitt River													
		Site:	STR1		S0		S1		S2		S3		S4		S5		S6	
Class	Order	Family	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2
Arachnida	Acarina		2	2	3	1	5	1	6		1	1	3	1	3	2	8	2
Crustacea	Amphipoda	Paramelitidae			7	4	17	4	9	17	5	6		1				
Insecta	Plecoptera	Eustheniidae			6	8	2	8	3	2	3			1				3
		Austroperlidae	1		5					3								
		Gripopterygidae			2	1	2	3	1				1	1	2	1	4	8
		Notonemouridae	4	1							21		1	1		5	1	1
	Ephemeroptera	Leptophlebiidae	12	10	12	12	5	18	6	5	6	7		5	9	18		
		Baetidae		1	3	3	3	2	1					1				
	Odonata	Telephlebiidae				2				2								
	Hemiptera	Veliidae										1						
	Diptera	Chironomidae:																
		subfam: Chironominae	2	5	3	6	1	10	1	1	2	2	1	1	1	2		
		subfam: Orthocladiinae	1			2	3	1	1								2	
		subfam: Podonominae																
		subfam: Tanypodinae											1	2				
		Simuliidae				1		1			1			3				
		Tipulidae	1	1		2		1			2					1		
		Athericidae	3														1	1
	Trichoptera	Calocidae			1						2							
		Conoesucidae			2	3	1	8	3	4	2						1	
		Helicopsychidae		1														
		Hydrobiosidae	1	2	2	2	6	8		3	9	1	1	7	2	1	10	7
		Hydropsychidae			1	2		3		3								
		Hydroptilidae	3	1	1				3									
		Leptoceridae	8	2		6	6	18	26	8	23	5	29	30	30	13	6	2
		Philorheithridae				2	1	5	5	8	7	3	1	9	7	6	2	
	Coleoptera	ElmidaeA		1	3	9	3	3	7	6	5	2	7	14	1		2	2
		ElmidaeL				1	1			1			1					2
		ScirtidaeL	1	10	1		6	1	1		1	2	6	10	3	2	6	17
		PsepheniidaeL		1			2				1							
		N Taxa	**12**	**13**	**15**	**18**	**16**	**17**	**14**	**13**	**16**	**10**	**11**	**15**	**9**	**10**	**11**	**10**
		O/E	**0.65**	**0.71**	**0.81**	**1.05**	**0.93**	**0.99**	**0.74**	**0.74**	**0.91**	**0.51**	**0.62**	**0.85**	**0.50**	**0.55**	**0.61**	**0.55**
		Band	**B**	**B**	**B**	**A**	**A**	**A**	**B**	**B**	**A**	**B**	**B**	**A**	**B**	**B**	**B**	**B**
		SIGNAL O/E	**0.90**	**0.88**	**0.97**	**0.99**	**0.94**	**0.92**	**0.88**	**1.14**	**0.97**	**0.84**	**0.90**	**0.91**	**0.95**	**0.95**	**0.99**	**1.05**
		EPT	**0.50**	**0.54**	**0.67**	**0.50**	**0.50**	**0.53**	**0.57**	**0.62**	**0.50**	**0.40**	**0.45**	**0.53**	**0.56**	**0.60**	**0.55**	**0.50**

3.2 Ring River

3.2.1 Conductivity

In both spring 2021 and autumn 2022, conductivity in the uppermost Ring River site (R1 at Williamsford) was comparable to the Sterling River reference site (Figure 4). In both seasons, conductivity in the Ring River increased sharply immediately below Bakers Creek (R3), then declined to lower levels by the two most downstream sites. The conductivity in Dolcoath Creek was at intermediate levels in both seasons (spring 2021 and autumn 2022 conductivity: 177.4 and 179.9 microS/cm, respectively), while the conductivity in Bakers Creek was again very high in both seasons (spring 2021 and autumn 2022 conductivity: 575 and 576 microS/cm, respectively) (Figure 4).

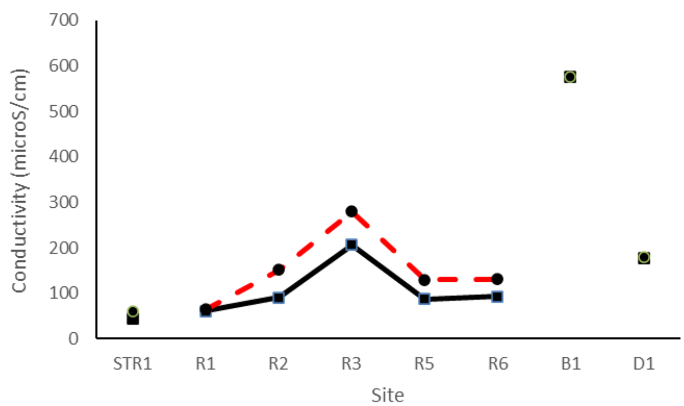

Figure 4. Conductivity (µS/cm) at the five Ring River sites (R1-6), plus the Sterling River reference site (STR1), Bakers Creek (B1) and Dolcoath Creek (D1), in spring 2021 (solid line) and autumn 2022 (dashed line).

3.2.2 Macroinvertebrates

In spring 2021, the trend in macroinvertebrate abundance was similar to previous years, with a decline in abundance downstream of R1 and very low abundance in the lower reaches of the Ring River (Figure 5). In autumn 2022, the estimate of total macroinvertebrate abundance was lowest at the upstream Ring River site (R1). There was a slight decline in abundance downstream of Bakers Creek and again at the site upstream of Dolcoath Creek, with abundance rising again at the most downstream site R6. Macroinvertebrate abundance in Bakers Creek was extremely low (< 5 animals/m^2 in both seasons), as has been the case in previous years.

Macroinvertebrate diversity (from AUSRIVAS samples) tended to decline between R1 to R3 in both seasons, with a partial recovery in taxon richness at the two most downstream sites R5 and R6, particularly in spring 2021 (Figure 6). Taxon richness in Dolcoath Creek was very low in spring 2021 (2 taxa), and improved to be comparable to the lower reaches of the Ring River in autumn 2022. Taxon richness was consistently very low in Bakers Creek, as has been the case in all previous years (Figure 6).

The faunal composition of samples from the most upstream site R1 at Williamsford included a range of stoneflies and beetles, but lacked a range of caddisfly and mayfly families which were present at reference sites (Tables 2 and 3). In general, the low abundance of pollution-sensitive taxa (e.g. Leptophlebiid mayflies and caddisflies) across all Ring River sites including the most upstream site R1 indicates that the Ring River continues to experience a degree of water quality impairment associated with metals.

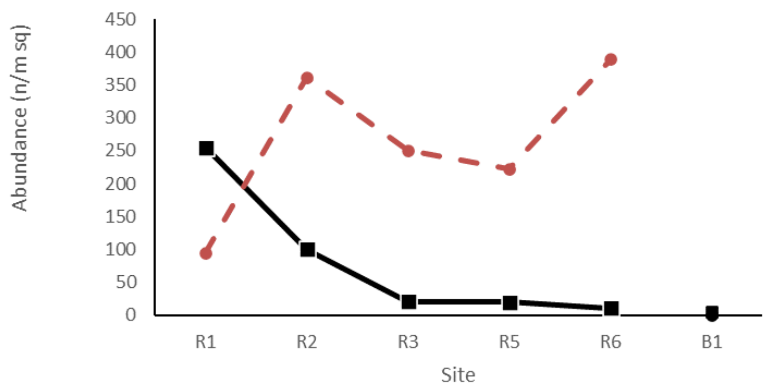

Figure 5. Trends in total benthic macroinvertebrate abundance (from Surber data) in spring 2021 (solid line) and autumn 2022 (dashed line) at the five Ring River sites (R1-6), and in Bakers Creek (B1).

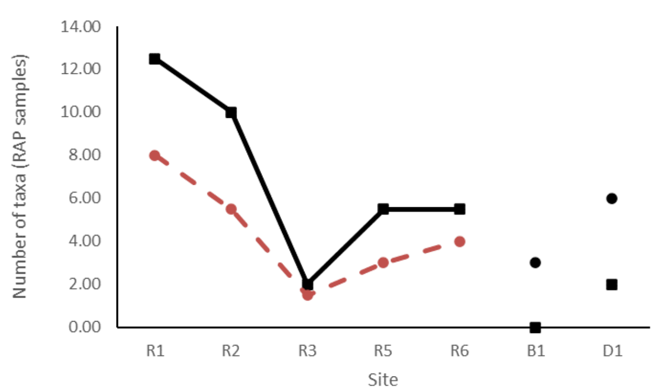

Figure 6. Trends in taxon richness (mean of two RAP samples) in spring 2021 (solid line) and autumn 2022 (dashed line) at the five Ring River sites (R1-6), and in Bakers Creek (B1) and Dolcoath Creek (D1).

The results of the AUSRIVAS analyses for the Ring River are given in Tables 2 and 3 for spring 2021 and autumn 2022, and are presented graphically in Figure 7 for the autumn seasons from 2018 to 2022. In all years including autumn 2022, the uppermost Ring River site at Williamsford has been located in the mid to lower range of AUSRIVAS impairment band B ('near reference condition') or in the upper range of impairment band C ('moderately impaired'). In autumn 2022 as has been the case in most years, there a trend for O/E values to decline moving downstream from R1 to R3 (downstream of Bakers Creek), with O/E values then increasing slightly at the two lower Ring River sites R5 and R6.

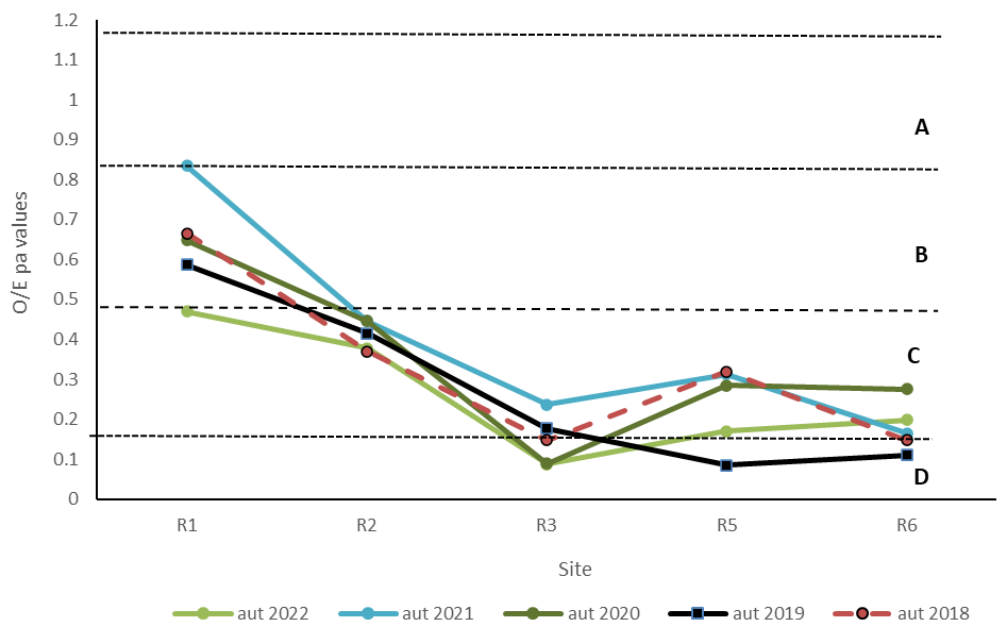

Figure 7. Trends in O/Epa values at the five Ring River sites in the autumn seasons for 2017 to 2021. O/Epa values are the mean of two RAP replicates. AUSRIVAS impairment bands A - D are also shown.

3.3 Stitt River

3.3.1 Conductivity

Conductivity levels in the Stitt River in spring 2021 ranged between 45.2 to 58.2 µS/cm, with a slight overall trend for increasing conductivity moving downstream (Figure 8). In autumn 2022, conductivity levels in the Stitt River sites S0 – S3 were similar to spring levels, with a sharp rise in conductivity between sites S3 and S4 and again between sites S5 and S6 (Figure 8).

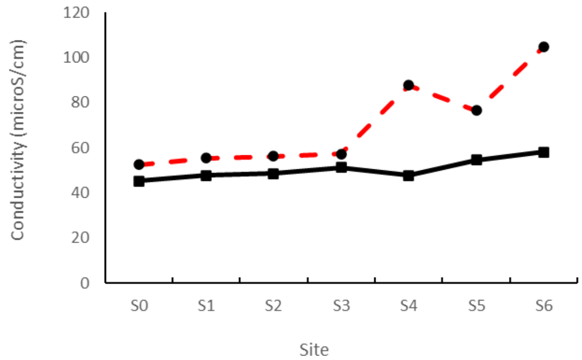

Figure 8. Conductivity (µS/cm) in spring 2021 (solid line) and autumn 2022 (dashed line) at the Stitt River sites S0 to S6.

3.3.2 Macroinvertebrates

Total macroinvertebrate abundances for the Sterling River (STR1) and Stitt River reference sites (S0, S1 and S2) and for the downstream Stitt River sites (S3-S6) are shown in Figure 9. Total abundances varied substantially between sites in both seasons (Figure 9). In spring, abundance estimates were relatively similar across all sites, ranging between 394 – 611 animals/m^2. In autumn 2022, abundance varied widely between sites. Abundance was very low at the top reference site S0, and as well as very low downstream of S4.

Macroinvertebrate diversity in the Stitt River in spring 2021 and autumn 2022 is shown in Figure 10. In spring 2021, there was a slight decline in taxa diversity moving downstream, while in autumn 2022, the decline in taxa diversity moving downstream was more pronounced. In spring 2020, the mean number of taxa for reference sites and downstream Stitt River sites was 14.5 and 16.0 taxa/site, respectively, with the difference being not significantly different (two-way t-test, $t = 1.38$, $P > 0.05$).

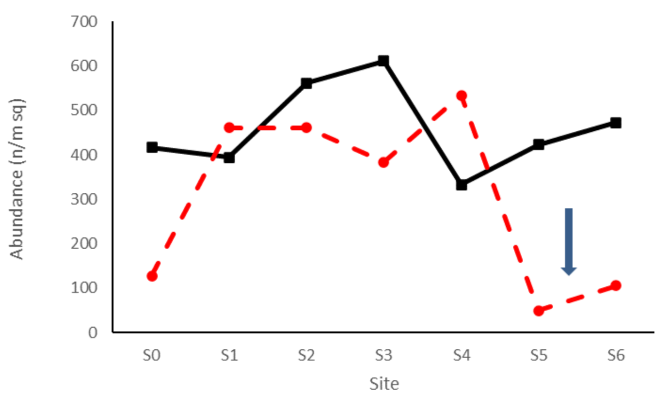

Figure 9. Trends in total benthic macroinvertebrate abundance (from Surber data) in spring 2021 (solid line) and autumn 2022 (dashed line) in the Sterling River (STR1) and in the Stitt River sites S0 to S6 (S6 was not sampled in spring 2021).

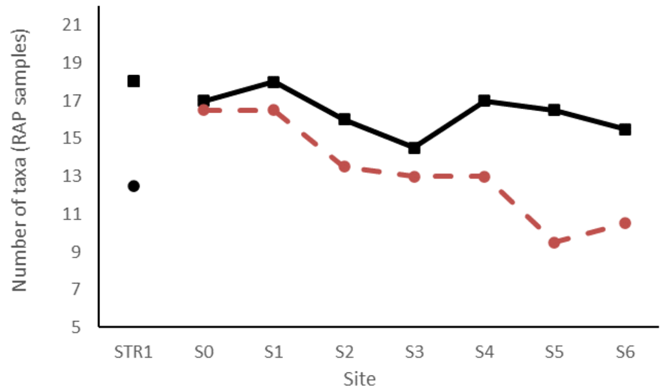

Figure 10. Trends in taxon richness (mean of two RAP samples) in spring 2021 (solid line) and autumn 2022 (dashed line) in the Sterling River (STR1) reference site and in the Stitt River sites S0 to S6.

The results of the AUSRIVAS analyses for the Stitt River are given in Tables 2 and 3 for the spring 2021 and autumn 2022 seasons, and the trends in the O/E ratio are shown in Figure 11. In both seasons, there was a general decline in the O/E ratio moving downstream, with the decline in O/E ratio more pronounced in autumn 2022 (Figure 11).

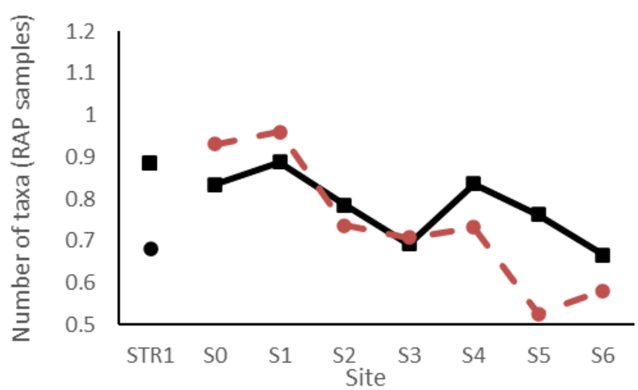

Figure 12. Trends in O/Epa values for the Stitt River sites S0-6 and the Sterling River (STR1) reference site in spring 2021 (solid line) and autumn 2022 (dashed line).

3.2.3 Fish

Fish were surveyed in Stitt River sites S1 to S5 and in the Sterling River in both seasons, with site S6 also fished in spring 2021 (Table 4). In spring 2021, adult brown trout were recorded at all Stitt Rivers sites down to and including S6 (note that S3 was not fished in spring 2021), with juvenile trout also captured at S5 (Table 4). In autumn 2022, adult brown trout were recorded at all Stitt River sites (site S6 not fished), although in lower numbers at sites downstream of S2. In addition, juvenile brown trout were also recorded at all three downstream sites S3, S4 and S5 (see Figure 13, suggesting a self-sustaining population of brown trout is now present in the lower reaches of the Stitt River.

Table 4. Fish caught in spring 2021 and autumn 2022 in the Sterling and Stitt Rivers.

(a) Spring 2021

		River: Site:	Sterling River at Murchison Hway	Stitt River u/s Mountain Ck	u/s tailings	d/s tailings	at footbridge	at road bridge	d/s falls
Species	**Life stage**		STR1	S1	S2	S3	S4	S5	S6
Salmo trutta	Adult		11	18	10	-	3	11	1
	Juvenile		0	0	0	-	0	2	

(b) Autumn 2022

		River: Site:	Sterling River at Murchison Hway	Stitt River u/s Mountain Ck	u/s tailings	d/s tailings	at footbridge	at road bridge
Species	**Life stage**		STR1	S1	S2	S3	S4	S5
Salmo trutta	Adult		54	15	10	3	3	1
	Juvenile		36			1	1	3
Galaxias truttaceus			1					

Figure 13. Adult and juvenile brown trout captured in the lower Stitt River (site S5) in spring 2021.

3.4. TRCI River Condition assessment

A TRCI analysis was carried for the autumn 2022 survey results. Macroinvertebrate monitoring results used as inputs to the TRCI scoring are shown in Table 5. The results of the TRCI assessment of macroinvertebrate community condition are shown in Table 6.

The condition of the macroinvertebrate community in the Ring River in autumn 2022 was rated as either Poor or Extremely Poor for all sites (Table 6). Most sites in the Stitt River were also rated as Poor condition, with the only exception being S1 which was rated Moderate condition (Table 6).

Table 5. Results for macroinvertebrates used to derive TRCI Indicator and Metric scores for all sites in autumn 2022.

	Ring River					Bakers Ck	Dolcoath Ck	Sterling River	Stitt River						
AUSRIVAS	R1	R2	R3	R5	R6	B1	D1	STR1	S0	S1	S2	S3	S4	S5	S6
Mean O/Epa	0.47	0.38	0.09	0.17	0.20	0.17	0.23	0.68	0.93	0.96	0.74	0.71	0.73	0.53	0.58
Mean O/Epa Band	C	C	D	C	C	C	C	B	A	A	B	B	B	B	B
Mean SIGNAL O/E	1.01	0.97	0.81	1.20	0.71	0.66	0.80	0.89	0.98	0.93	1.01	0.91	0.90	0.95	1.02
Mean EPT	0.69	0.75	0.75	0.67	0.33	0.33	0.50	0.52	0.58	0.51	0.59	0.45	0.49	0.58	0.52
Abundance (per m^2)	94	361	250	222	389	4	0	822	128	461	461	383	533	50	106

Table 6. TRCI Macroinvertebrate scores for autumn 2021.

Stream	Site	Expectedness MIe	Abundance MIa	Composition MIc	Condition MI
Ring River	**R1**	Moderate	Low	High	**Poor**
	R2	Moderate	Low	High	**Poor**
	R3	Low	Low	High	**Extremely Poor**
	R5	Moderate	Low	High	**Poor**
	R6	Low	Low	Moderate	**Extremely Poor**
Sterling River	**STR1**	Moderate	High	High	**Poor**
Stitt River	**S0**	Moderate	Low	High	**Poor**
	S1	High	Low	High	**Moderate**
	S2	Moderate	Low	High	**Poor**
	S3	Moderate	Low	High	**Poor**
	S4	Moderate	Low	High	**Poor**
	S5	Moderate	Low	High	**Poor**
	S6	Moderate	Low	High	**Poor**

4. Discussion

4.1. Ring River

The Ring River remains in a degraded condition. In both spring 2021 and autumn 2022, diversity declined moving downstream with a concomitant decline in the O/E scores moving downstream from the Williamsford site. The TRCI macroinvertebrate assessment rated all Ring River sites in Poor or Extremely Poor condition due to low abundance and the absence to a number of expected families.

Both Bakers and Dolcoath Creeks remain in a highly degraded condition. Bakers Creek is the principal source of contaminants for the Ring River, and Bakers Creek continues to have very high conductivity and extremely low macroinvertebrate abundance and diversity. The primary reasons for poor condition of river fauna communities in the Ring continue to be pollution from the Hercules mine area via Bakers Creek.

4.2 Stitt River

Overall, the Stitt River is in a substantially better ecological condition than the Ring River. There appears to have been some improvement in the condition of the lower Stitt River over recent years, with a range of clean-water macroinvertebrate taxa now present at all sites in the Stitt River including in the lower reaches.

The results from spring 2021 and autumn 2022 were generally consistent with this trend, with a range of clean-water macroinvertebrate taxa present at all sites in the Stitt River including in the lower reaches. However, there continues to be a decline in diversity and O/E ratio between the upper and lower reaches of the Stitt River, likely due to ongoing seepage of mine contaminants into the lower Stitt from a range of sources.

Adult and juvenile brown trout have been regularly recorded in the lower reaches of the Stitt River since autumn 2020, although the numbers of trout remain consistently lower compared to the upper reaches of the river. Nevertheless, the consistent capture of adult and juvenile tout at all sites in the Stitt River indicates that a self-sustaining population of trout now occurs throughout the Stitt River including in the lower reaches.

5. References

Davies AL and Gee JHR 1993. A simple periphyton sampler for algal biomass estimates in streams. Freshwat. Biol. 30, 47-51.

Davies PE and Cook LSJ 2002. Aquatic bioassessment of the Savage River catchment. 2001 Survey report. SRRP Project 038. Final Report to DPIWE, January 2002. 55 pp.

Davies PE, Cook LSJ and Sloane T 2004. Biological Condition of the Ring and Stitt Rivers: Survey of fish and macroinvertebrates, 2003/04. Final Report to Pasminco, 37 pp.

Davies PE, Cook LSJ and Sloane T 2005a. Biological Condition of the Ring and Stitt Rivers: Survey of macroinvertebrates, autumn 2005. Final Report to Pasminco, 24 pp.

Davies PE, Cook LSJ and Sloane T 2005b. Biological Condition of the Ring and Stitt Rivers: Survey of macroinvertebrates, spring 2005. Final Report to Pasminco, 16 pp.

Davies PE, Cook LSJ and Sloane T 2006a. Biological Condition of the Ring and Stitt Rivers: Survey of macroinvertebrates, autumn 2006. Final Report to Pasminco, 26 pp.

Davies PE, Cook LSJ and Sloane T 2006b. Biological Condition of the Ring and Stitt Rivers: Survey of macroinvertebrates, spring 2006. Final Report to Pasminco, 22 pp.

Davies PE, Cook LSJ and Sloane T 2007. Biological Condition of the Ring and Stitt Rivers: Survey of macroinvertebrates, autumn 2007. Final Report to Zinifex, 25 pp.

Davies PE, Cook LSJ and Sloane T 2008. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2007 and Autumn 2008. Final Report to OZ Minerals, Rosebery, 29 pp.

Davies PE, Cook LSJ and Sloane T 2009. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2008 and Autumn 2009. Final Report to OZ Minerals/MMG, Rosebery, 31 pp.

Davies PE, Cook LSJ and Sloane T 2010. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2009 and Autumn 2010. Final Report to MMG, Rosebery, 31 pp.

Davies PE, Cook LSJ and Sloane T 2011. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2010 and Autumn 2011. Final Report to MMG, Rosebery, 32 pp.

Davies PE and Cook LSJ 2012. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2011 and Autumn 2012. Final Report to MMG, Rosebery, 33 pp.

Davies PE and Cook LSJ 2013. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2012 and Autumn 2013. Final Report to MMG, Rosebery, 34 pp.

Davies PE and Cook LSJ 2014. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2013 and Autumn 2014. Final Report to MMG, Rosebery, 34 pp.

Davies PE and Cook LSJ 2015. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2014 and Autumn 2015. Final Report to MMG, Rosebery, 40 pp.

Davies PE, Mallick SA and Cook LSJ 2016. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2015 and Autumn 2016. Final Report to MMG, Rosebery, 34 pp.

Davies PE, Mallick SA and Cook LSJ 2017. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2016 and Autumn 2017. Final Report to MMG, Rosebery, 34 pp.

Davies PE, Mitchell N and Barmuta LE 1996. The impact of historical mining operations at Mount Lyell on the water quality and biological health of the King and Queen River catchments, western Tasmania, Mount Lyell Remediation R&D Program, Supervising Scientist Report 118, Office of the Supervising Scientist, Barton ACT.

Mallick SA and Davies PE 2018. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2017 and Autumn 2018. Final Report to MMG, Rosebery, 34 pp.

Mallick SA 2019. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2018 and Autumn 2019. Final Report to MMG, Rosebery, 34 pp.

Mallick SA 2020. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2019 and Autumn 2020. Final Report to MMG, Rosebery, 30 pp.

Mallick SA 2021. Biological Condition of the Ring and Stitt Rivers: Survey of aquatic biota, Spring 2020 and Autumn 2021. Final Report to MMG, Rosebery, 30 pp.

NRM South (2009). Tasmanian River Condition Index Reference Manual. NRM South. Hobart.

NRM South 2009a. Tasmanian River Condition Index Aquatic Life Field Manual. NRM South. Hobart.